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Catching the Flu: Syndromic Surveillance, Algorithmic Governmentality and Global Health Security

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A thesis submitted to the University of Sussex in fulfilment for the degree of

DOCTOR OF PHILOSOPHY

Department of International Relations

School of Global Studies

July 2017

Declaration

This work has not been previously accepted in form or substance for any degree and is not being concurrently submitted in candidature for any degree.

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Abstract

This thesis offers a critical analysis of the rise of syndromic surveillance systems for the advanced detection of pandemic threats within contemporary global health security frameworks. The thesis traces the iterative evolution and ascendancy of three such novel syndromic surveillance systems for the strengthening of health security initiatives over the past two decades: 1) The Program for Monitoring Emerging Diseases (ProMED-mail); 2) The Global Public Health Intelligence Network (GPHIN); and 3) HealthMap. This thesis demonstrates how each newly introduced syndromic surveillance system has become increasingly oriented towards the integration of digital algorithms into core surveillance capacities to continually harness and forecast upon infinitely generating sets of digital, open-source data, potentially indicative of forthcoming pandemic threats.

This thesis argues that the increased centrality of the algorithm within these next-generation syndromic surveillance systems produces a new and distinct form of infectious disease surveillance for the governing of emergent pathogenic contingencies. Conceptually, the thesis also shows how the rise of this algorithmic mode of infectious disease surveillance produces divergences in the governmental rationalities of global health security, leading to the rise of an *algorithmic governmentality* within contemporary contexts of Big Data and these surveillance systems. Empirically, this thesis demonstrates how this new form of algorithmic infectious disease surveillance has been rapidly integrated into diplomatic, legal, and political frameworks to strengthen the practice global health security – producing subtle, yet distinct shifts in the outbreak notification and reporting transparency of states, increasingly scrutinized by the algorithmic gaze of syndromic surveillance.

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For their inspiration, love, and most importantly, laughter—always.

I looked, and there before me was a pale horse! Its rider was named Death, and Hades was following close behind him. They were given power over the earth to kill by sword, famine and plague.
-Book of Revelation 6:8

Our problem is to mark off a space in which we can observe the emergence of order and disorder.
-Luhmann, 1997

Introduction: Syndromic Surveillance, Algorithmic Governmentality and Global Health Security

Introduction

Within the early years of the twenty-first century, the contingent threat of pandemic illness looms large on a future horizon of uncertainty. From the first clinical observations of HIV/AIDS in the urban centres of North America in the early 1980s, to the emergence of the Ebola Virus Disease (EVD), the Hanata Virus, various coronaviruses including SARS and the Human Coronavirus HKU1, MERS, novel mutations of human and zoonotic influenza (H1N1 and H7N9), bovine spongiform encephalopathy (BSE), and the Zika virus, the governing of health and population security throughout the late twentieth and early twenty-first centuries have been increasingly challenged and problematized by a seeming ‘epidemic of epidemics’ (Bartlett, 2014). Novel infectious disease threats have increasingly emerged from a variety of environmental and medical contexts, including insect-borne infections, fungal infections, imported infections, vaccine preventable diseases as well as foodborne infections and illness (ibid).

Of particular concern however, within contemporary initiatives to securitize the imminent threat of pandemic illness, are pathogens of a zoonotic profile. Zoonotic diseases (zoonoses) are broadly defined as illnesses that can be transmitted between animals and humans through either direct or indirect contact (Public Health England, 2014). Occurring at the interface of human and animal biological processes, zoonotic infections are complex and have witnessed a resurgence in global rate of infections throughout the late twentieth-century, owing to a variety of inter-connected factors including ecotourism, increased exposure of populations to animals due to hunting, farming/food chain intensification, the globalization of trade and increased urbanization, the breakdown of public health and surveillance systems, patterns of climate change and alternations in ecosystems and biodiversity (Cascio et al., 2011:336-337). The reoccurrence of globalised infectious zoonotic outbreaks has had severe economic ramifications for states and systems of economic circulation over the past two decades. From 1995-2008, the estimated economic losses of these types of public health emergencies globally have exceeded US\$ 120 billion (Budke et al., 2006). A localised epidemic of SARS in Toronto, Canada in 2003, resulted in an overall loss of 0.5% of the city’s pre-existing gross domestic product (Cascio et al., 2011:336-337).

Of the various highly infectious diseases which have emerged from the 1970s onward, the most infamous of these pathogens, HIV/AIDS, avian and swine influenzas, and Ebola all are categorised as zoonotic infections, having origins in a single case inter-species transmission between animal and human. In late 2002/2003, a novel coronavirus was transmitted to human hosts in Guangdong Province, China, transpiring into the first globalised epidemic of the new millennium, initially misdiagnosed as *atypical pneumonia*, the virus was later identified as the severe acute respiratory syndrome (SARS).

Five years later in 2009, the WHO (WHO), declared that the H1N1 swine influenza pandemic constituted a *public health emergency of international concern* (PHEIC), following the transmission of pathogenic influenza from swine livestock to humans. From 2014-2016, the West African Ebola Virus Disease (EVD) Outbreak, with its origins in the dense forests of southeast Guinea, resulted in the deaths of 11 310 persons and the total infection of 28 000 mainly within the epicentre of the outbreak in Guinea, Liberia and Sierra Leone (Centers for Disease Control and Prevention, 2016b). In 2016, as the Ebola Virus Disease outbreak had waned, the WHO declared that the global outbreak of the Zika virus with subsequent cases of microcephaly and Guillain-Barré syndrome (GBS), constituted the most recent public health emergency of international concern.

Heightened present concerns regarding the emergence of uncontrolled pandemic illness have been central to the reformulation and understanding of the practice of security over the past several decades within international relations. The foundation of the World Health Organization (WHO), as a specialised agency of the newly formed United Nations in 1948 represented a seminal event within the politics of health and infectious disease. The practice of health and population-security against infectious disease had previously operated at the sovereign and national level of states, with existing albeit limited frameworks for the control of diseases such as cholera, facilitated in bilateral or multilateral agreements between states. Contrastingly, the mandate of the WHO from 1948 onward sought to elevate the place of health and prevention of illness to the highest level of the international, for the attainment by all people of the highest possible level of health (Constitution of the World Health Organization, 2006).

The formation and mandate of the WHO gave rise, mid-century to the concept and practice of global health, defined by Koplan et al. (2009), as constituting ‘an area for study, research and practice that places a priority on improving health and achieving health equity for all people worldwide.’ Furthermore, Kickbusch (2006) has emphasised global health as ‘those health issues that transcend national boundaries and governments and calls for actions on the global forces that determine the health of people.’ Within the latter twentieth century, the WHO actively partnered with its member states towards global health objectives. The 1978 International Conference on Primary Care, which produced the Alma Ata Declaration, furthermore called for the urgent action of ‘all governments...and the world community to protect and promote the health of all the people of the world’. Moreover, the most noteworthy of these successes was the global eradication of smallpox officially declared by the WHO in 1980.

The growing practice and objectives of global health from the founding of the WHO has significantly challenged and altered previous understandings within the field and study of international relations. As outlined by McInnes and Lee (2012:1-2), historically, the politics of health and the study of international relations have largely existed as separate academic and policy arenas. Accordingly, the study of health has been concerned with ‘the physical, mental and social state of an individual and population groups...on determinants of health [including]...personal health practices, health services,

income and social status...and social and physical environments.’ By contrast, according to Fidler (1997:37), the traditional study and practice of international relations has focused on sovereign states, their pursuit of power, a premium on the possession of military power...and their machinations in peace and war. Conventionally, the politics of health and of infectious disease have remained within the ‘low politics’ of social and development agendas, in contrast to the ‘high politics’ of international relations, which were predicated upon issues of war and peace, competition for power, the dilemma of national security and the fight for survival in anarchy (Fidler, 2005:180).

The Expanding Nexus of Health and Security

The emergence of the global HIV/AIDS pandemic in the early 1980s, occurring in tandem with the emergence of a host of new infectious diseases, as well as the disintegration of nuclear-oriented security praxis following the collapse of the Soviet Union in 1991 applied significant re-configurations and considerations of the scope of security practices, and facilitated the novel rise of ‘global health security’. Occurring within the fragmented context of the post-Cold War era, novel security praxis sought to address the new phenomenon of *non-traditional security challenges*. Unlike the preceding era of the Cold War, whereby the perception of future nuclear threat could be anticipated or calculated, non-traditional security challenges are non-military in nature, transnational in scope, expand rapidly as a result of globalization, and cannot be prevented entirely but rather *mitigated* through coping mechanisms (Caballero-Anthony, 2010).

Faced with progressively complex and inter-connected public health emergencies from the 1980s onward including a global AIDS pandemic, increasing fears of the spread of avian influenza, outbreaks of Ebola and associated haemorrhagic fevers in Africa and the re-introduction of cholera into the Western Hemisphere, high-income states, intergovernmental health authorities and global philanthropic groups have been swift to elevate the subject of health and infectious disease to the ‘high-politics’ of security and defence policies of states. Subsequently, this reconfiguration of security perspective to now include that of emergent and re-emergent health threats has been termed *global health security*.

As defined by the WHO (2007b), this concept seeks to prepare for and address ‘acute public health events that endanger the collective health of populations living across geographical regions and international boundaries. Global health security embraces a wide range of complex and daunting issues...including the health consequences of human behaviour, weather-related events, and infectious disease, natural catastrophes, and man-made disasters.’ What is more, the Global Health Security Agenda (GHSA), founded in 2014 additionally states that systems of global health security aim to strengthen ‘both the global capacity and nation’s capacity to prevent, detect and respond to human and animal infectious disease threats whether naturally occurring, accidentally, or deliberately spread.’

In recognising the interconnected threat and implications represented by pandemic for systems of national and international security and population well-being, global health security now represents an expanding site of scholarly work, investigation and discussion within international relations. Empirically, a number of noteworthy transitions and developments within international relations and security praxis have further concretised the understanding of health/infectious disease as a contemporary security problem. In terms of funding and financial support, development assistance for health and health priorities internationally have quadrupled from US\$5.59 billion in 1990 to US\$21.79 billion in 2007, similarly initiatives for addressing global health problems over the past decades have increased dramatically to an estimated 90 ongoing initiatives (Fidler, 2011:2). As a further seminal event within global health security, in 2000 the United Nations Security Council (UNSC) adopted Resolution 1308 which stressed that the current HIV/AIDS pandemic, if unchecked posed a risk to international security and stability, marking the first time in which a health threat was discussed before the UN body mandated to maintain international peace and security (Fidler, 2005:181).

Furthermore, in building upon this momentum, in 2004 the United Nations published the UN Secretary-General's High-Level Panel on Threats, Challenges and Change in which it discussed threats emanating from key areas including terrorism, transnational crime, environmental degradation, poverty and infectious disease. The panel recommended the need for an effective global defence against 'overwhelming natural outbreaks of deadly infectious disease', and further advised that the UN Security Council intervene during epidemics to mandate greater compliance from states with needed public health responses and to support international action to assist in quarantine measures' (cited in Fidler, 2005:181).

In the United States, following the terrorist attacks of 11 September 2001, and the subsequent mailing of anthrax-laced letters to political institutions across the United States, the management of contingent health threats emerged as a double-pronged security response, seeking to pre-empt and prepare for both occurrences of infectious disease outbreaks, as well as enhancing the surveillance and preparedness for bioterrorist attacks. Following the 11 September terrorist attacks, funding significantly increased for biodefense with the passing of the Bioterrorism Act of 2002 which provided the Centers for Disease Control and Prevention (CDC) additional resources and research to prepare states and health care systems adequately for potential biological agent dissemination (Grundmann, 2014: 180). In 2005, following surveillance and response shortfalls on part of the Government of China during the 2002/03 global outbreak of SARS, the WHO, in consultation with its member states, ratified the revised International Health Regulations (IHR, 2005), seeking to bolster the timely identification and addressing of probable public health emergencies with newly established norms of conduct and reporting of disease outbreaks by its member states. The revised regulations also put into practice, the concept of a public health emergency of international concern (PHEIC), as a guiding response mechanism for coordinated action on disease outbreaks. As of 2017, this formal emergency declaration has been issued by the WHO during four public health episodes: the 2009 swine influenza pandemic;

the 2014 resurgence of wild poliomyelitis after its near-eradication; the 2014 outbreak of the Ebola Virus Disease (EVD) in West Africa; and in 2016 following the emergence and spread of the Zika virus.

The rise of ‘global health security’ throughout the late twentieth century has further re-contoured relations between sovereign states, as well as state relations with intergovernmental health organisations, represented most prominently by the WHO in the context of this thesis. In 2016, the International Air Transport Association forecasted the annual travel of 3.6 billion passengers for the coming year. This annual figure was an increase of more than 800 million people reported to have travelled via the international air transport infrastructure in 2011 (IATA, 2016). Furthermore, on 21 February 2003, a physician from Guangdong spent a single day in a Hong Kong hotel, during which time he transmitted an infection to 16 other guests, the novel and highly infectious SARS coronavirus rapidly would spread to infect over 8000 persons, in 26 countries, across 5 continents, originating from the index patient and facilitated by the dense and widely accessible international airline network (Tatem et al., 2006:5).

Justifiably, in an era of increased uncertainty of an emergent global pandemic, states and intergovernmental organisations alike now seek to enhance the real-time reporting and identification of emergent infectious diseases, to enable timely and proportionate responses to mitigate the destructive effects of a probable pandemic on populations and global economic circulation. Cited as the ‘cornerstone of public health’ (Lee and Thacker, 2011), the practice of health surveillance has long been utilised as an apparatus in which to forecast and inform health intervention and policy, and estimate potential health episodes. The WHO has emphasised that the early warning functions of surveillance ‘are fundamental for national, regional, and global health security. Recent outbreaks such as the severe acute respiratory syndrome (SARS), avian influenza, and potential threats from biological and chemical agents, demonstrate the importance of effective national surveillance and response system’ (WHO, 2006b:1). The WHO has further stated that all member states should work to enhance their national surveillance systems for communicable diseases to meet various objectives (ibid).

Despite advancements within the politics of global health over the past two decades, infectious disease surveillance programmes continue to falter, represented for example by an emergent coronavirus¹ which infected and killed at least 17 people in Saudi Arabia in 2012 and for which there exists presently no effective treatment vaccine (Gorman, 2013). In a globalised and highly networked world, it is essential for infectious disease surveillance systems to rapidly amass, analyse, and disseminate crucial data for epidemic intelligence to estimate and respond to the scope of a probable pandemic outbreak. And yet, despite the widespread acceptance of the linkage between the health of national populations on one hand, and national or international security on the other, the practice of infectious disease surveillance remains problematized in a number of key areas. Scientific and technical impediments to effective and responsive health surveillance systems continue to impact upon the timely

¹ This novel coronavirus was later identified as the Middle East Respiratory Syndrome (MERS) coronavirus.

identification of new and re-emergent pathogens in many parts of the world. Most recently, this has been demonstrated by the lack of technological and scientific resources required for the surveillance reporting and effective identification of the Ebola Virus Disease (EVD), in West Africa in 2014, whereby laboratory testing, case-data collection, and information technology for data collection, processing and synthesis all were lacking during the crucial early days of the outbreak (McNamara et al., 2016).

More broadly, despite the extensive revisions implemented towards the enhancement of surveillance and reporting included in the International Health Regulations (2005), by 2012, fewer than 20% of WHO member states had met the target goals for the coordinating and sharing of epidemic intelligence data (CDC, 2016a). According to a CDC report, in 2015, nearly 70%, of WHO member states were unprepared to effectively detect, assess and respond to potential public health threats (ibid). Additionally, as noted by Briand et al. (2011:1-3), functional surveillance systems for seasonal human influenza can generally be located within medium and well-resourced global areas but are less prevalent in less-resourced areas. The gap in effective surveillance systems was further demonstrated in the weeks before the emergence of the H1N1 swine influenza pandemic in 2009 in which 54% of the 193 WHO member states had no or very limited seasonal influenza surveillance capacity. Adding to this, less than 20 member states had developed plans for ongoing monitoring throughout a pandemic (ibid). Moreover at the interface of the national and the local, significant challenges and gaps exist for integrated systems for the disseminating and sharing of infectious disease surveillance data. As a report by Chatham House (2014), on data-sharing in disease surveillance identifies, 'while having data, and putting it to use, is important for effective infectious disease surveillance at local and national levels...not enough data are collected and/or reported...[and] the failure to clean, analyse, and use data that are collected in countries with a high disease burden is also considered a significant problem that thwarts the potential of surveillance data to inform public health planning and action.'

In addition to scientific and technical obstacles to global health infectious disease surveillance, the relation between states and intergovernmental health authorities further present a significant *political* problem for the practice of health surveillance systems. For much of its history prior to the ratification of the revised IHR (2005), the relationship between the WHO and its member states was predicated upon the principle of sovereignty in international relations. The WHO sought to respond to and mitigate the global threat of infectious disease outbreaks but required both epidemic intelligence data as well as the authorisation to declare an infectious disease outbreak from the government of the sovereign member state in which the outbreak was occurring. What this meant was global health authorities, through existing agreements and legislation with member states, were reliant on the transparency and openness of states to be forthcoming in producing and sharing epidemiological knowledge of disease outbreaks. As demonstrated however (Keusch et al., 2009), states experiencing a public health emergency have frequently withheld much-needed infectious disease information and data or have obfuscated data sources, reflecting a range of disincentives to report an outbreak including conflicting

economic, cultural, or political disincentives to report an outbreak up the chain, exemplified by the failure of Chinese state leadership to be forthcoming with epidemic intelligence during the crucial early months following the emergence of the novel SARS coronavirus in 2002/2003.

Syndromic Surveillance in the Era of Pandemic Threat

The origins of infectious disease surveillance developed within Europe in the seventeenth century and consisted of the early collection, analysing, and interpreting of data and figures to protect the health of the public (Lee and Thacker, 2011:1). These early forms of public health surveillance were oriented towards the control and mitigating of recurrent pandemics including cholera, plague, and smallpox which had spread to Europe as a result of expanding global trade and transport links. Moreover, these emergent apparatuses of security, designed to estimate and forecast the rates of infection among a population were largely informed by the role of the medical practitioner and the generation of statistical epidemic intelligence. The founding of the WHO and the emergence of global health in the mid-twentieth century was further predicated upon the collection, analysis, and dissemination of epidemic intelligence to WHO officials via national health institutes and health ministries of member states. The emergence and rapid spread of the novel HIV/AIDS pandemic in the 1980s further intensified infectious disease surveillance with the development of the National HIV/AIDS Surveillance System in the United States (ibid). As this thesis discusses, this form of traditional health surveillance has been problematized in a number of crucial areas including the *willingness* and *capacity* of states to comply and transparently share infectious disease knowledge and data when faced with significant disincentives to report (Davies, Kamradt-Scott and Rushton, 2015:10-11).

Occurring in correspondence with the need to respond to increasingly complex and globalised disease outbreaks, the birth of the digital era, the growth of Big Data², the development of the Internet and the innovation of online technologies have rapidly changed the way in which health information and epidemic intelligence for infectious disease outbreaks can be accessed, presented and disseminated (Paquet et al., 2006). The growth of the Internet from 1994 onward and the subsequent generation of infinite streams of online, open-source data, in forms of online media reporting, forums, electronic communication, and increasingly *metadata*, that is ‘data which is about data...the data that is generated automatically by computer systems themselves’ (Rouvroy, 2016a:7), has steadily provided new shortcuts to traditional reporting and surveillance mechanisms that travel through the various levels of public health administration and infectious disease surveillance programmes (Paquet, et al., 2006). What this signifies is that increasingly, health authorities and indeed, sovereign governments are no longer in full control of an information environment that puts technicians, journalists, politicians and

² Big Data is a term describing the storage and analysis of large and or complex data sets using a series of expanding digital techniques. Big Data refers to the size and volume of new datasets, as well as the complexity and structure of these datasets. The tools and techniques used to process sizeable or complex datasets are also critical factors in discussions and definitions of ‘Big Data’ (Ward and Barker, 2013).

the public in direct contact with increasingly complex and voluminous streams of raw data (ibid). New systems for information processing and surveillance have now emerged across the landscape of global health seeking to capture exponentially expanding forms of online data, and to organise and analyse these data sets to gain foresight on the emergence of contingent pandemic threats.

The rapid advancements in automated and digital information generation in the late twentieth and early twenty first centuries have therefore been central to the rise and proliferation of a novel type of *digitised* surveillance within the pre-emption and management of infectious disease and pandemic: *syndromic surveillance*. Representing a significant, yet overlooked body of research within global health security, the practice of syndromic surveillance has emerged and proliferated with the growth of the Internet and the generation of Big Data to provide ‘the ability...to harness information in novel ways to produce useful insights’ (Mayer-Schönberger and Cukier, 2013:2). Presently, in the United Kingdom, Public Health England (2015) defines *syndromic surveillance* as ‘the process of collecting analysing and interpreting health-related data to provide an early warning of human or veterinary public health threats, which require public health action.’

While there is still considerable variance in the term of syndromic surveillance, with Morse (2012:9) noting ‘confusion about terminology’, the practice of syndromic surveillance seeks to address the absence of techniques designed to detect spatial and temporal disease outbreaks in real time (Mostashari and Hartman, 2003: i2-i3). As such, despite the observation of Henning (2004:1-2) that specific definitions for syndromic surveillance are lacking, and the name itself, imprecise, most definitions of syndromic surveillance highlight the use of unofficial, ‘non-diagnostic data—information on possible health events before, or without definite laboratory confirmation (Morse, 2012:9). Syndromic surveillance is non-diagnostic. In an era whereby traditional health surveillance systems have become increasingly outpaced by the emergence and rapid spread of virulent illnesses, the ability to detect outbreaks in a timely manner remains the ultimate objective of these novel surveillance systems (Mostashari and Hartman, 2003: i2-i3).

In the early 2000s, following the terrorist attacks of 11 September, emergent practices of syndromic surveillance were further closely correlated with the concepts of emergency preparedness and bioterrorism which permeated national security policies, particularly within the United States as seen by the development of the National Bioterrorism Syndromic Surveillance Demonstration Program which sought to create ‘an open-source system...that uses data to identify unusual clusters illnesses and support rapid public health follow-up’ (Yih et al., 2004:43). The practice of syndromic surveillance has since extended considerably to now consider non-bioterror specific health threats, including that of infectious disease and pandemic.

Syndromic surveillance therefore marks a novel and recent departure from the traditional systems of health and infectious disease surveillance which relied upon the curating and reporting of official, verified scientific and statistical knowledge utilised to forecast probable health emergencies. Contrastingly, the practice of syndromic surveillance functions through the digitised, constant,

omnipresent and (near) real-time monitoring, collection of a range of non-diagnostic (often open-source) data to detect early indicating signals of a potential or actual infectious disease outbreak (Roberts and Elbe, 2016:47). Moreover, unlike previous surveillance systems which generated *knowledge* about contingent pandemic threats through labour-intensive and usually lengthier processes of direct clinical and laboratory confirmation, syndromic surveillance systems have monitored and analysed a wide-range of indirect data—including A&E logs, hospital admission records, sales of medicines and antivirals from pharmacies, telephone queries and logs with health advice providers in order to identify aberrant patterns or cluster signs that an infectious disease outbreak or bioterror attack may be in progress. Seeking to aggregate and report upon a range of new data-sources which have expanded digitally with the rise of the Internet and of Big Data, within the past two decades, the practice of syndromic surveillance has increasingly sought to harness the growing volume and availability of open-source public health news and information that is now widely available and/or exchanged over the Internet (Zhang et al., 2009:509).

And still, the ability for syndromic surveillance systems to collect, process, and derive meaning from progressively complex digital data sets in real-time temporalities has become more and more challenging as the type and availability of mass-data becomes ever more voluminous, diverse and expanding. In a globalised context whereby contingent threats loom large, and where the world is not only awash with more information than ever before, but where information is constantly increasing (Mayer-Schönberger and Cukier, 2013), syndromic surveillance systems for infectious disease surveillance over the past two decades have become progressively more automated, reflecting the broader trend within security studies of ‘securing via algorithms’; the deployment of algorithmic techniques for the gathering of data and intelligence and the production of new form of knowledge for security (Amoore and Raley, 2016). Within contemporary global health systems, whereby rationalities of disease surveillance now resonate with the notions of ‘early detection’, ‘pre-emption’, and ‘response’, and where infinite opportunities exist for the transforming of digital data into operational information (Rouvroy, 2016a:10), for addressing future-situated uncertainty, the digital algorithm has seemingly emerged as a *creditable knowledge logic* for managing the means through which this new form of information is produced, circulated and consumed in a complex informational society (Gillespie, 2013:191).

However, this digital shift in the surveillance of future-situated disease contingencies produces many novel queries for the contemporary practice of global health security. How for example, does the production of knowledge for potential pandemic threats via syndromic surveillance systems differ from previous statistically guided methods of traditional health surveillance? What are the novel rationalities of governing pandemic threats which underpin the deployment of these next-generation health sentinels? How does this new form of digitised knowledge challenge the way in which previous governmental systems cultivated and disseminated knowledge for the governing of infectious disease outbreaks? And, what are potential consequences or new implications produced within international

relations and present systems of global health security as a result of a growing recourse towards algorithmically-informed health surveillance systems?

It is therefore at this junction between global health security and syndromic surveillance that this thesis begins its investigation. Specifically, this research thesis seeks to present and trace the origins, design and function of three novel syndromic surveillance systems for the strengthening of global health security and the advanced identification of pandemic-threats: (1) the **Program for Monitoring Emerging Diseases (ProMED-mail)**, an Internet-based reporting system, established in 1994 as an initiative of the Federation of American Scientists; (2) the **Global Public Health Intelligence Network (GPHIN)**, a multi-lingual, semi-automated, early-warning system for infectious disease outbreaks, initially launched in 1997 as a partnership between then Health Canada and the WHO; and (3) **HealthMap**, an automated online health surveillance system developed in 2006 by researchers and software developers at Boston Children's Hospital which processes, integrates, filters, visualizes and disseminates online information about emerging diseases in nine languages³.

In examining the iterative evaluation of these syndromic surveillance systems over the past two decades, the research generated within this thesis will present how each new system, in addressing the increasing proliferation of digital and open-source data streams, has moved steadily towards a greater recourse to the integration of digital and algorithmic processing and observation as central surveillance functions, in order to continuously mine, filter, process, and *make sense* of ever expanding and diversifying streams of mass-data in order to forecast upon the earliest indications of a probable emergent pandemic. As this thesis will discuss, the evolutionary shift in health surveillance systems towards digitised and algorithmically-informed surveillance processes signals a significant and novel transition in the development of novel [digital] security technologies for the generation of epidemic intelligence for the strengthening of global health security systems. In seeking to render secure, populations, systems of economic circulation, and *unknowable* futures through the increased utilisation of digital algorithms for the processing and translation of infinite data-scapes to identify data correlations indicative of pandemic threats, the rise of these algorithmically-guided syndromic surveillance systems, as it will be demonstrated, generate new insights and understandings into how knowledge for the governing of forthcoming pandemic threats is problematized, produced and utilised for the further strengthening of contemporary global health security systems.

Algorithms, Global Health, and Security

Following therefore, the gradual remaking of perspectives which now link the circulation and emergence of pathogens with the security of economic systems and population well-being, global health has developed as a diverse and expanding field of scholarship, constructed in order to understand and

³ About HealthMap (2017).

explain how the politics of health and infection, occurring at local, national, and international interfaces produce emergent implications for contemporary global systems which are both highly networked, yet vulnerable to sudden or unforeseen disruptions. Despite the ‘rise’ of global health over recent decades, epitomised for example by seminal ratification of *Resolution 1308* of the United Nations Security Council (UNSC), the concept of global health, despite its widespread application in areas of research, has remained in dispute, and the exact meaning remains ‘fluid, imprecise and ambiguous’ (Elbe, 2010b), with the true scope and aim of global health still in flux (Rushton, 2011). Reflecting the ambiguity of this concept, contemporary research on themes of global health expand across a broad spectrum. Recent research within areas of global health have expanded to the areas of diplomacy, governance, and institutions (Kay and Williams, 2009; Lee and Kamradt-Scott, 2014; McInnes et al., 2014; and Youde, 2015), in the generation of new strategies and concerted responses to health complexities pertinent at the global level. Global health has also emerged as a field of research in which to discuss and uncover processes of marginalization which exist outside mainstream efforts to expand global health including within the politics of gender (Harman, 2011; 2016), and within practices of neglect (Nunes, 2016).

Following the momentum established by the ratification of UNSC Resolution 1308 in 2000, the term global health has increasingly been held in association with emergent security practices and discourses, which have developed due to the emergence and re-emergence of infectious diseases with global pandemic potentialities in the late twentieth century. Global health security has emerged as a term used in which to investigate new correlations of health and security in an era of ‘explosive pandemic potential’ (Gostin and Ayala, 2017). Research within global health security has focused on the construction and identification of emergent or non-traditional health threats including bioterrorism (Enemark, 2010a; 2010b), pandemic (Elbe, 2008; 2009; and Enemark, 2009), and subsequently on the development of new security mechanisms and measures to address the insecurity inherent in these emergent problems of security including the development of medical counter measures (MCMs) (Elbe et al., 2014; 2015; and Roemer-Mahler and Elbe, 2016), and through the exercise and normalization of preparedness for uncertain events (Lakoff and Collier, 2011; Samimian-Darash, 2013; 2016).

In recent years, a growing area of investigation within global health security has also focused upon the centrality and function of surveillance, as a process in transition following the emergence of new problems of pandemic threats circulating at global levels. Discussions have focused upon the emergence of new surveillance rationalities and techniques following the emergence and rapid re-emergence of epidemics and pandemics which contest traditional divisions between the national/sovereign and the global (Davies and Youde, 2016), as well as the impact of new surveillance technologies on the sovereignty and conduct of states (Davies, 2008; 2012a). Elsewhere, the study of the surveillance systems within global health security have discussed the piloting of new techniques and models for the enhancement and strengthening of surveillance systems operating to detect pandemic at global levels (Fearnley, 2008; French, 2009; 2014; Castillo-Salgado, 2010; French and Mykhalovskiy, 2013, Lakoff, 2015; and Wenham 2015; 2016).

Despite these contributions within themes of surveillance and security in global health, the gradual evolution and transformation of syndromic surveillance systems over the past two decades, in part to strengthen global health system, with increased recourse to integration of the algorithm represents an unexplored area of research within present global health scholarship. In further situating the centrality of the algorithm within emergent digital surveillance systems for the strengthening of global health security, this thesis further denotes the vast and contrasting definitions of what constitutes an algorithm. Indeed, as noted by Hill (2015, cited in Middlestadt et al., 2016: 3-4), an algorithm can refer to any procedure or decision process to generate knowledge and insight on a given outcome, the best action to take in a given situation. What is more, various classes and types of algorithms further diversify and challenge concise and unified understandings of what algorithms are, or what they actually seek to do. There are for example, profiling and classification algorithms which can determine how individuals or groups are shaped and managed (Floridi, 2012), as well as data-mining algorithms which are said ‘to show promise in helping make sense of emerging streams of data generated by the ‘Internet of Things’ (Portmesss and Tower, 2014:1 cited in Middlestadt et al., 2016:1-2).

While providing a concise and accepted definition of algorithms lies beyond the scope of this research thesis, this thesis, takes as its central point of investigation, a particular class of algorithms, known as data-mining algorithms. According to Middlestadt et al. (2016:3-4), these digital decision-making processes ‘augument or replace analysis by humans, often due to the scope or scale of data and rules involved. [These algorithms] generally make reliable (but subjective and not necessarily correct) decisions based upon complex rules that challenge or confound human capacities for action and comprehension...and identifies relationships and small patterns across vast and distributed datasets (Floridi, 2012). Although early research on syndromic surveillance systems sought to assess the over-arching utility of these new surveillance systems in correctly identifying pandemic (Henning, 2004; and Stoto, 2005), this thesis alternatively seeks to discuss and present how the production of knowledge for the governing of [future] pandemic contingencies by these syndromic surveillance systems is steadily transformed with the steady implementation of security algorithms.

While present discussions of algorithmic programming for security knowledge production remain nascent in current global health security scholarship (Roberts and Elbe, 2016), the emergence of the digital algorithm for the assessing of uncertain futures has been broadly accounted for by critical security theorists across a broad spectrum of security practices (Amoore and De Goede, 2008; De Goede, 2008; Amoore, 2011; Aradau and Blanke, 2015; and Heath-Kelly, 2016). Building upon this body of established research, this research thesis, in assessing the rise of syndromic surveillance systems over the past two decades will seek to uncover novel rationalities and new modes to produce future-situated pandemic knowledge, increasingly afforded via new computational processes which situate algorithmic programming gradually at the core of these novel health surveillance systems. In presenting the rise and increased saliency of these syndromic surveillance systems, informed by emergent [algorithmic] security logics, this thesis develops and presents an original contribution within new

security technologies for strengthening global health systems and in rendering future pathogenic uncertainties knowable.

Central Research Question and Theoretical Framework

The central research question which this thesis seeks to address and investigate is thereby as follows: How do new surveillance technologies for the advanced detection of pandemic threats transform contemporary practices of global health security?

To address this research enquiry, this thesis begins with an assessment of the existing academic body of research and literature on the evolution of global health security, and the government of infectious disease control and surveillance. In doing so, this thesis will demonstrate the various techniques of control and mitigation, as well as the forms of knowledge produced for the addressing of infectious disease threats, which have developed throughout historical eras. The development of various mechanisms of security, namely health surveillance systems from one era to the next, reveals the very fundamental challenge of continually knowing and controlling pandemic threats, since pathogens themselves, designate ‘a fundamental limit to the capacity of *knowing* ...the matter of concern is no longer an identifiable actual disease but the event of emergence itself’ (Opitz, 2016:5).

Subsequently, practices of security have continually generated novel technologies designated to tackle, understand, and thereby *govern* the unknown. These technologies in themselves do not offer the promise to repeal completely, the threats of radical uncertainty but rather, retain ‘degrees of uncertainty to accommodate the highly uncertain event of a potential pandemic’ (ibid). The rise of global health security, resulting from the need to urgently securitize emergent health threats in the late twentieth century, combined with the inability of traditional health surveillance systems to address: 1) outbreaks of highly pathogenic disease and; 2) to capture and disseminate timely, epidemic intelligence and data in an era of ever-expanding infinite Big Data, have therefore given rise to the design and proliferation of new surveillance systems, operating within the pre-emptive security logic of the twenty-first century. The subsequent proliferation of these data-driven technologies in the era of SARS, avian influenza, Ebola, MERS, Zika, and mounting multi-drug resistant pathogens indicate the emergence of new governmental rationalities towards the productions of new forms of infectious disease surveillance for the of *knowing* future-situated pandemic threats.

This thesis will therefore demonstrate that: 1) a novel transition has occurred in infectious disease surveillance practices for the identification of pandemic threats, as generated by the syndromic surveillance systems increasingly reliant on algorithmic logic; 2) in seeking to strengthen contemporary practices of global health security, and the governing of future uncertainties, global health actors, most notably the WHO have moved swiftly in seeking to access and authorise the utilisation of these new forms of pandemic knowledge in relation to its member states ; and 3) that new regimes of infectious disease surveillance disseminated and afforded by these novel syndromic surveillance systems produces

subtle, albeit nuanced implications for the conduct of states⁴ in reporting processes and dissemination of epidemic intelligence of forthcoming infectious disease outbreaks.

A Foucauldian Analysis of Health Security, and Surveillance

The research presented within this thesis and perspective of the theoretical framework is greatly influenced by the analysis and conceptualisations of Michel Foucault, specifically his research and development of the concepts of *biopolitics* and *governmentality*. Critically, within the scholarship of infectious disease, health security and the practice of surveillance, the research generated by Foucault, notably during the lecture series *Security, Territory, Population*, and *The Birth of Biopolitics*, have presented new ways of thinking in the transformation of power relations and security practices from the 18th century onward in Europe, in which new objectives of government emerge, which in turn, facilitate the piloting of new techniques of security, focused on the aleatory, the uncertain or the event (Aradau and Blanke, 2010:44). Central to theoretically situating this thesis in presenting new techniques for governing the uncertain threat of pandemic, is Foucault's genealogy of the development of the concept of *population* from the period of early modernity onward, in which, population emerges 'as the correlate of power and the object of knowledge'...resulting from 'an interplay between techniques of power [which] carves out, as a field of reality, population and its specific phenomena' (2007:79). For Foucault, the emergence of population as a living reality to be managed, regulated and optimised towards productivity differed significantly from previous economies of power which were predicated upon the legitimacy of the sovereign to rule, the demarcation of territory, and the exercise of disciplinary government.

Foucault's biopolitical understanding of the government population as a new power modality was therefore linked with the emergence of new techniques of security, technology and practice, orientated around the concept of the *milieu*, or rather the newly emergent questions about how to govern early liberal societies through security (O'Grady, 2014:515). Accordingly, practices of population security now sought to address and regulate the natural emergence of a host of phenomena (food scarcity, epidemics) which occurred at the conjunction of a geographical, climatic and physical milieu with the human species (2007:23). Significantly, these new apparatuses of security (*dispositifs*) unlike proceeding economies of power including legal which prohibits, and discipline, which prescribes, the function of security, and the piloting of technologies of security 'let things happen'. They regulate processes and occurrences of phenomena in such a way which seeks to nullify, limit or check the effect

⁴ Significant scholarship has sought to discuss and understand what is constituted by the term *state*. Indeed, as Mitchell (1991), has maintained, the state has always been difficult to define with various contending theories on its composition. However, it remains beyond the scope and objective of this thesis to engage extensively with these contending theories and understandings of state. The term *state* within the context of this thesis refers therefore to sovereign and legally-bounded entities which, in ratifying the *Constitution of the World Health Organization*, are independent member states of the WHO. In 2017, the WHO was comprised of 191 independent member states.

of certain phenomena on populations, through a process of forecasting and foresight through the development of the normal and the abnormal and the application of statistical science (2007:47-63).

Foucault's genealogy of the development of technologies and practices of security against future-oriented infectious disease threats provides therefore a particularly relevant lens in which to present and understand the evolution and objective of systems of health surveillance at national/sovereign levels. Traditional health surveillance systems, highlighted by Foucault, have largely been informed through the accumulation of statistics, which in turn have generated health interventions including public health, sanitation and vaccination campaigns— for much of the twentieth century. Specifically, within early systems of infectious disease control, official laboratory confirmations and statistical reports generated by health institutes of member states of the WHO have composed the main instruments of infectious disease surveillance and reporting for much of the twentieth century in the addressing of probable pandemics. Through an extensive engagement with the conceptual work afforded by Foucault in way of biopolitics and governmentality, this research thesis traces the evolution of health security systems and practices of surveillance which have emerged in tandem with the refinement of the modern state. Algorithmic Governmentality, Syndromic Surveillance and Global Health Security

And yet, demonstrated within the rise of syndromic surveillance systems over the past two decades, security systems for accelerated data collection and processing via algorithms afforded by the rise of novel digital technologies; seem to have promoted the emergence of new kinds of knowledge for addressing contemporary threats of radical uncertainty (Rouvroy, 2014). The growing capacity to harness infinitely expanding digital data streams with increasingly sophisticated automated tools for data aggregation, now appears to differ significantly from previous understandings of the production of knowledge via statistical calculation from Foucault's lectures on governmentality, and the rise of systems of security at the Collège de France.

Consequently, the intensification of Big Data and of algorithmically-powered syndromic surveillance systems provide an interesting and relevant opportunity to theoretically examine and discuss emergent nuances and divergences in how knowledge for future health uncertainties are produced and disseminated by these increasingly digitised syndromic surveillance systems in a method which differs and extends beyond the original parameters of governmentality and role of security presented by Foucault. Subsequently, while this thesis draws extensively on the contributions and work of Foucault notably in the areas of governmentality studies in uncovering the rationalities and objectives which underpin the proliferation of syndromic surveillance systems, it turns additionally to the research

work of Antoinette Rouvroy, a Belgian social/legal theorist, with particular reference to further developing the concept of *algorithmic governmentality*, in order to understand how the proliferation of syndromic surveillance systems, and the production of algorithmically-guided open-source epidemic intelligence represents an epistemic shift in the curation of knowledge and processes of surveillance in addressing uncertainty, thereby extending beyond the original parameters of governmentality presented by Foucault.

Accordingly, in a contemporary world which is simultaneously subsumed by the ever-constant generation of data and in which the expiated identification of looming contingency of future threats emerge as new rationalities of government, Rouvroy has advanced the concept of *algorithmic governmentality*, as representing a novel, emergent and epistemic break in understanding how knowledge for uncertainty is produced and presented in the era of Big Data. Unlike previous governmental systems discussed by Foucault, which utilised statistical sciences to generate probabilities and understandings of yet-unforeseen events, and to render the contingent governable through processes of normalization, the increasingly availability of massive, infinite sets of data, means that knowledge does not have to be produced anymore, everything is always already present, latent in datasets, and awaiting to be ‘discovered’ by the grace of algorithms which have increasingly proliferated as forecasting technologies across contemporary security scapes (Rouvroy, 2015a:2). Resulting from a strategic convergence of technological and socio-political evolutions and divorced from statistically-guided truth regimes which have preceded it, algorithmic governmentality is presented as

‘an apolitical rationality founded on the automated collection, aggregation, and analyses of Big Data so as to model, anticipate, and pre-emptively affect possible behaviours....it is an unprecedented mode of government fuelled mostly with signals (raw data and meta-data)...and emancipated from the yoke of representation, from all kinds of tests, even statistical norms (in data-mining and machine learning, even the quantitative notion of the average—and the normative figure of the average man—disappear. Algorithmic government has no ethnic impurity, leprosy, plague, mental disease...as targets (as biopolitics of populations had, according to Foucault) but radical uncertainty *as such*. Algorithmic governmentality is above all, a strategy of actualization, or an exhaustion of the potential. Pre-emption replaces prevention: the systematic actualisation and thus neutralisation of what only exists as potentiality or virtuality dispenses from dealing with the causes of phenomena’ (Rouvroy and Berns, 2013:6; Rouvroy, 2015a:1-2).

In seeking to understand the rationalities and functions of these novel and increasingly algorithmically-informed syndromic surveillance systems, this thesis seeks to develop further Rouvroy’s algorithmic governmentality as it relates to the development and increasing centrality of syndromic surveillance systems as forecasting agents of potential pandemic threats. What is more, in charting the emergence of an algorithmic governmentality, amid the rise of these syndromic surveillance systems, this thesis will advance new perspectives and understandings of health security sentinels which have proliferated since the death of Foucault, and appear to diverge from traditional understandings of technologies of government in a number of critical areas.

Methodology

The primary research method employed during the composition of this thesis was a comprehensive review of secondary source material and empirical case-studies from within the fields of global health security and surveillance studies. These primary sources included peer-reviewed articles published within high-impact journals, the *International Journal of Infectious Diseases*, the *Lancet*, *Social Sciences & Medicine*, *Security Dialogue*, the *Journal of International Relations and Development*, *Global Public Health*, the *Journal of Epidemiology and Global Health*, the *Canadian Journal of Public Health*, *Health Security*, *Emerging Infectious Diseases*, *Health Policy and Planning*, and *Surveillance and Society*, to list a few. A comprehensive engagement and review of articles within these journals provided a crucial step forward at understanding the development and trajectory of the fields of global health security and surveillance studies, and further provided an understanding of the overlapping and correlated nature of the two fields of practice.

In seeking to understand the empirical aspects of syndromic surveillance systems and their operation, this thesis also developed a systemic review and engagement of grey literature produced by governments, intergovernmental health organisations, research centres, and technical agencies to comprehend and present the broad implications produced by syndromic surveillance systems. In this regard, consulted materials consisted of security and policy whitepapers from high-income states, including the National Risk Register of the United Kingdom, Canada's National Security Strategy as well as the National Strategy for Pandemic Flu, issued by the Government of the United States of America.

Further still, health and research institutes including the Centers for Disease Control and Prevention (CDC), and the various sub-agencies of the WHO served as important resources in the accessing of empirical data and reporting on a wide range of infectious disease profiles from the mid-twentieth century onward. Specifically, the Bulletin of the World Health Organization provided precise insight and information not only on specific outbreaks of infectious diseases, and the challenges that such outbreaks pose to international security, but moreover the publication served as an important resource in knowing what practices of security and novel forms of surveillance (including syndromic surveillance) were being applied to mitigate the threat of pandemic illness. Similarly, reports and pieces issued by the CDC served as a valuable lens in which to observe the growth and increasing sophistication of infectious disease surveillance systems over the course of the past fifty years against the emergence of a host of increasingly complex, novel infectious diseases.

As indicated within this introduction, the theoretical positioning of this research thesis is largely influenced by the work of Foucault, specifically regarding the study of biopolitics, governmentality and population security. As such, in providing the linkages between the development of population as an object to be securitized, and the subsequent apparatuses of security which formed in response, Foucault's lecture series *Security, Territory, Population* (1977-1978), provided the foundation of this

thesis in exploring the development of novel security and surveillance mechanisms in the government of infectious disease. The further works of Foucault, including *The Birth of Biopolitics* (1978/1979), *Society Must Be Defended*, *Power/Knowledge: Selected Interviews and Other Writings 1972-1977*, *Discipline and Punish*, and *the History of Sexuality*, vol. 1, served additionally as resources to expand upon and add to concepts and ideas from the Security, Territory, Population lecture series.

The three syndromic surveillance systems assessed and presented within this thesis are ProMED-mail, GPHIN, and HealthMap. These novel infectious disease surveillance systems were included as case-studies within a larger discussion on the production of knowledge for future contingencies for a number of key reasons in demonstrating the development of a new trajectory of health surveillance for pandemic preparedness. Established in 1994, ProMED-mail was the first of kind, novel syndromic surveillance system, which sought to develop new channels of knowledge curation and dissemination on health events through the design of an online global health forum. Although the surveillance processes and curation of health reports within the ProMED-mail system were entirely sustained by human analysis and observation, the infectious disease reporting system nonetheless established a new rationality and in the collection, presentation and dissemination of infectious disease data via a new technological medium—the Internet, thereby paving the way for the later development of more advanced and increasingly, automated syndromic surveillance systems.

Subsequently, this evolution in novel technologies and approaches for infectious disease surveillance continued with the launch of GPHIN in 1997, an initial project by the then Health Canada in conjunction with the WHO. Significantly, building upon the innovation established by ProMED-mail, GPHIN became the first online syndromic surveillance system to seek to harness the powers of algorithmic logic and automation in order to enhance its precision of forecasting potential or probable disease outbreaks. Within an era of the expanding World Wide Web, and increasing data generation and complexity, GPHIN was therefore the first reporting system to utilise and apply information retrieval algorithms to ‘identify signals of emerging public health events and filter out irrelevant data considered as ‘noise’ (Dion et al., 2015:2). In doing so, the GPHIN system set the scene for the gradual and expanding inclusion of algorithmic logic and programming into surveillance systems for managing emerging health threats.

Within the context of this thesis, the launch of HealthMap in 2006 represents the most significant recourse to algorithmic rationality and automation of the three presented syndromic surveillance systems. With an automated operating system supported by retrieval and relevancy-assigning algorithms, HealthMap represented the possibility to further ‘extract structure algorithmically from a variety of disparate data sources’ (Freifeld et al., 2008:151) to forecast and, *visualize* emergent public health threats across different dimensions and temporalities (date, location and disease), according to the geographic location, disease and type of outbreak (ibid). Significantly, the aspect of automated visualization of data, captured by algorithms and developed by the HealthMap system represents a step further in new forms of surveillance offered by these systems, presenting a new method

of *seeing* and understanding networks of contagion, and of potential disease threats via emergent technologies of global self-observation and pandemic simulation (Opitz, 2016).

Collectively then, the selection of these three syndromic surveillance systems, as case-studies within this thesis form a significant iterative evaluation in the production of new forms of surveillance for addressing future-situated pathogenic uncertainties, increasingly guided by algorithmic forecasting, and oriented towards rendering unknown contingencies governable. Therefore, while further syndromic surveillance systems have proliferated as forecasting sentinels over the past two decades, ProMED-mail, GPHIN, and HealthMap serve as poignant and illustrative cases-studies within this thesis not only in demonstrating the iterative rise of a novel form of health surveillance guided via algorithms, but also for the continued longevity of these systems as digital health sentinels, as well as the political and research prominence associated with the piloting and reporting-record of these next generation health systems from 1994-2006.

Argument and Structure of Thesis

How do new surveillance technologies for the advanced detection of pandemic threats transform contemporary practices of global health security? In addressing this research question, this thesis is divided into six thematic chapters; three of which include empirical case-studies which present the origins, evolution, and function of three syndromic surveillance systems implemented within global health security frameworks since 1994. This thesis will argue that the rise of syndromic surveillance systems – increasingly informed by the gaze of the algorithm – produce new forms of algorithmic surveillance for the anticipation and forecasting of pathogenic threats in global health systems. Conceptually, the thesis situates the rise of these novel surveillance systems within an emergent [algorithmic] governmentality which increasingly utilises the aggregation and pre-emptive capacities of digital algorithms to expedite the generation of knowledge for forthcoming pandemic uncertainties. This increasing recourse to algorithmic logic demonstrated by these syndromic surveillance systems produces new ways in which to consider the practice of government, originally informed by Foucault, in the era of Big Data. Empirically, the rise of an algorithmic surveillance for global health security, as will be demonstrated further in this thesis, has produced emergent implications for states and intergovernmental health organisations in transparency and conduct towards early outbreak reporting of emergent infectious diseases.

Chapter One commences with an extensive review of literature and genealogical account of the development and evolution of the practice of global health security. Specifically, the chapter works to present the formulation and emergent practice of global health security as a relatively recent transitioning of security logic away from the traditional security concerns of state and military and towards that of the non-traditional security threat of pandemic illness. What is more, the chapter demonstrates how, while recurrent pandemics have devastated human communities for thousands of

years, the articulation of the threat of ‘foreign’ pandemic infections and the need to collectively produce containment measures, and to develop new techniques to halt the spread of disease occurred only in Europe in the mid-nineteenth century. The control of infectious disease outbreaks expanded considerably towards the global within the early twentieth century with the development of a number of multilateral agreements towards disease containment between European states. Within this era, health remained the remit of the state with an emphasis of containment at the border.

Moreover, Chapter One introduces and presents how a greater emphasis on the addressing of pandemic threat and infectious disease occurred with the founding of the WHO in 1948. It discusses the central role of the WHO as an agent of global health politics and how, via instruments of diplomacy and policy, the organisation sought to incentivise its member states in the development of necessary reporting and surveillance mechanisms for addressing contingent pandemic threats now proliferating increasingly at a global level.

However, despite the rise of a new global health authority represented by the WHO in the mid-twentieth century, this chapter further presents how discrepancies within existing surveillance systems and assertions of sovereignty on part of member states continued to problematize the global governance of infectious diseases for most of the past century. The chapter then proceeds in presenting the emergence of health threats, specifically that of the emerging or highly infectious disease threat as constituting a non-traditional security threat, resultant from the complex emergence of a host of novel infections globally at the end of the twentieth century. In doing so, the chapter identifies and presents how this shift in understanding the government of the uncertain, resulting from an ‘epidemic of epidemics’, highlighted ‘global’ health as a new site of security practice and observation, requiring the development and application of a host of new security and surveillance techniques for the advanced detection and pre-emption of contingent pandemic threats.

Chapter Two continues with presenting the linkages between the practice of global health security and the surveillance systems requisite for the maintenance of this form of security praxis. The chapter draws associations with early practices of health and infectious disease surveillance as being grounded within the emergence of population-oriented statistics, traced by Michel Foucault. Early health surveillance systems sought to regulate occurring natural phenomena including outbreaks of infectious diseases through the calculation of statistical norms within populations, to estimate the scope and potentiality of disease outbreaks.

The chapter identifies how within early governmental systems, population emerged not only as a new potentiality of power, but also as an object of surveillance in the vigilance against disorder and disruption. Informed by Foucauldian scholarship and governmentality studies, this chapter therefore demonstrates how early systems of global health were sustained by the supply of statistical knowledge in the form of health reporting and outbreak notifications conveyed to the WHO by its member states. In doing so, it highlights further, how this form of contingent-oriented knowledge was frequently compromised, altered, or withheld by recalcitrant member states, facing negative implications from

reporting disease outbreaks, representing new and sustained ‘problems’ in the expanding government of global infectious disease control.

Increasingly confronted with unmanageable disease outbreaks, limitations in the accessing of epidemic intelligence data, and the increasing proliferation of open-source surveillance systems, this chapter identifies how the WHO sought to develop new channels in accessing the potentiality of advanced forecasting capacities of new syndromic surveillance systems, represented by the rise of ProMED-mail, GPHIN and HealthMap from 1994 onward. It presents the 2002/03 outbreak of SARS as a particularly notable watershed moment, both in expanding systems of global health governmentalities, and in the growing recourse of global health agents to harness the expanding automated capacities of syndromic surveillance systems to legally obtain the forecasting and knowledge curated by these new reporting systems, and increasingly afforded by the integration of digital algorithms.

Chapter Three develops and presents a theoretical framework for discussing and situating the recent and novel proliferation of these syndromic surveillance systems, which have gradually integrated algorithms into key surveillance operations. In engaging with the research of Foucault, specifically biopolitics and governmentality, this chapter asserts that these syndromic surveillance systems can be conceptually understood as governmental technologies for the management of population security and economic circulation in a number of key areas. These novel technologies for example operate with the rationality of population regulation and the addressing of pandemic threats as surveillance objectives; they operate within a broader and more complex arrangement of security management, rather than through disciplinarian or legal power models, and they seek to operate discreetly, promoting systems of global *circulation*, through the practices of prediction and predictability, forecasting and foresight (Thacker, 2009:137).

And yet, the rise of digital technologies, the advent of algorithmic analytics within mechanisms of security and the proliferation of new data sources for estimating pandemic threat, have significant implications for the traditional production of knowledge and practices of health surveillance. This chapter therefore extends beyond the original theoretical contributions of Foucault’s understanding of biopolitics and governmentality, and engages further with the conceptual work of Antoinette Rouvroy, in advancing the framework of *algorithmic governmentality* in seeking to present how the rise of increasingly automated and algorithmically-informed syndromic surveillance systems raise key questions, and produce new insights in how algorithmically-informed syndromic surveillance systems re-contour surveillance practices, and produce knowledge for the governing of future pathogenic contingencies in methods which extend beyond the traditional parameters of biopolitics and governmentality. In doing so, this chapter advances how new algorithmic modes of government aimed at the pre-emption of the contingent produce new implications for the generation of knowledge and techniques of surveillance for governing infectious disease outbreaks in present systems of global health.

Chapters Four, Five, and Six comprise the empirical case-studies of syndromic surveillance systems for this research thesis. Chapter Four begins with presenting the Program for Monitoring Emerging Diseases (ProMED-mail), launched online during the early years of the Internet in 1994. The chapter discusses the central place of ProMED-mail as the original prototype for the emerging practice of syndromic surveillance, and demonstrates how the novel function and design of the system differed significantly from previous health surveillance systems via the production of increasingly diffuse, open-source surveillance for assessing pandemic contingencies. Building upon this, Chapter Five discusses the Global Public Health Intelligence Network (GPHIN), a syndromic surveillance system which was piloted by Health Canada and the WHO starting in 1997. In doing so, this chapter demonstrates the steady turn towards new modes of automation and algorithmic logic apparent in the period between the launch of ProMED-mail and of GPHIN in 1997. Significantly, it presents GPHIN as the first of these syndromic surveillance systems to integrate processes of automation and algorithmic retrieval of data sources into its surveillance operation platform, demonstrating a gradual recourse to harnessing the algorithm in order to structure and make sense of an increasingly complex and infinite data landscape to inform health security practices. Empirically, Chapter Five also discusses the centrality of the GPHIN system as a sentinel of forecasting and epidemic intelligence during the 2002/03 global SARS outbreak. During this public health emergency, the GPHIN system demonstrated its capacity for issuing timely disease alerts in advance and beyond the control of Chinese health and government authorities, representing a powerful and emergent new security tool for global health authorities, with the potential to overcome previous political problems of reticent state governments in enforcing transparency and expedited processes of infectious disease reporting.

Chapter Six extends the discussion of knowledge production and infectious disease threats to the third case-study, HealthMap, an online, interactive system launched in 2006 which not only reports upon emergent health trends derived from data-streams, but further, via algorithmic programming visualizes this data onto a simulated web-interface powered by Google Earth. Within the context of this thesis, Chapter Six presents HealthMap as the most advanced syndromic surveillance system yet, largely sustained by automation and algorithmic operations to harness, process, to report and to visualize infectious disease data in a method never previously feasible through the sole utilisation of human analytics and observation. The chapter notes in addition, the role of HealthMap in correctly forecasting, via the retrieval of digital data via algorithm, in advance of traditional surveillance systems, the emergence of a mysterious viral haemorrhagic fever in remote south-eastern Guinea in March 2014.

Collectively, the three case-studies will point towards the generation of novel forms of surveillance and epidemic intelligence, aided by the algorithm for the advanced detection of pandemic threats in a contemporary world increasingly concerned with the ability to govern and forecast upon future uncertainties. The evolution of these surveillance technologies will demonstrate how the ‘computational shift’ in the practice of security exhibited by gradual, yet sustained integration of algorithms produces a type of knowledge for pandemic preparedness which differs significantly from

preceding systems of government in a number of key areas. In turn, the increased interest of global health agents in accessing this novel type of knowledge curated by syndromic surveillance systems will be shown to generate emerging implications between such agents and state governments within present systems of global health security.

Chapter One: The Rise of Global Health Security

Introduction

What relationship can be drawn between the health of populations, and the national security interests of states? How have the sudden emergence and re-emergence of circulating pandemic threats in the late twentieth and early twenty-first centuries including avian influenza, Ebola, HIV/AIDS, SARS, MDR-

TB, and MERS re-contoured conventional security perspectives within international relations? Over the course of the past two decades, global health security has evolved into an expanding field of research within an era of increasingly complex and interconnected international security dilemmas facilitated by the end of the Cold War and the acceleration of processes of globalization. From the first clinical observations and spread of the HIV/AIDS virus in the early 1980s, to the re-emergence of cholera in Peru in 1991, followed by global outbreaks of SARS, avian and swine influenzas, and Ebola in the twenty-first century, initiatives to enhance and strengthen the mitigation of infectious disease outbreaks have produced a novel understandings and practices of *global health security*. The rise of global health security has, for example facilitated new strategic partnerships between states towards the securitization of infectious disease threats including the Global Health Security Initiative (2001), the Asia Pacific Strategy for Emerging Diseases (2010), and the Global Health Security Agenda (2014).

Elsewhere, at national levels, global health has emerged as a heightened security priority within Canada's National Security Policy (2004), the United States' National Strategy for Pandemic Influenza (2005), and has routinely featured on the Government of the United Kingdom's National Risk Register for Civil Emergencies (2013; 2015). The practice of global health security is oriented towards the recognition of new forms of threats in an increasingly globalised and networked world, moreover, this novel security logic is informed by 'the emergence and spread of new microbes...the globalization of travel and trade...the rise of drug resistance... [and] the potential use of laboratories to make and release—intentionally or not—dangerous microbes' (CDC, 2014).

The syndromic surveillance systems analysed and presented within this research thesis are rooted within recent health security contexts, and the design and proliferation of these new surveillance technologies has occurred within a larger and expanding context of global health security in the twenty-first century. In seeking to identify and generate forward-situated knowledge about probable or occurring infectious disease outbreaks, these novel surveillance systems are reflective of the concepts of *preparedness* and *real-time*, which exist at the heart of practices of global health security (Gostin, 2004; Wyber et al., 2015). In the gradual development of a global health security framework over the past two decades, surveillance systems and programmes which emphasise early outbreak detection and rapid-time dissemination of infectious disease information have expanded significantly, notably under the operational activities of the World Health Organization (WHO), which has increasingly sought to assume a central position as the primary active agent within the politics of global health, and has exhibited high-level interest in attaining and making actionable, the increasingly digitised and algorithmically-guided epidemic intelligence afforded by emergent syndromic surveillance technologies. Among its numerous global health surveillance endeavours, the centre-piece of present WHO involvement in facilitating global health security included the launch of the WHO's 'network of networks', the Global Outbreak and Alert Response Network (GOARN), a multidisciplinary technical collaboration of global health, technical, and scientific networks, dedicated to expedited infectious disease surveillance and reporting. Additionally, in 2005, following years of contention and debate, the

member states of the WHO accepted sweeping revisions to the existing *International Health Regulations* (1969), with a renewed emphasis towards preparedness, surveillance and response (Nuttall, 2014:1).

The rise of global health security as a pre-emptive security logic, facilitated by novel and expanding governmental concerns towards pandemic threat, has been central to the proliferation of these syndromic surveillance systems and the growing recourse to digital automation of these systems to address complex, health threats from 1994 onward. The growth of global health security and its sociotechnical surveillance apparatus results from the emergence of a complex series of historical, socio-economic and political problems of government within public health and international relations over the course of the last century.

This chapter therefore seeks to present the construction of global health security, as emergent from a series of novel problematizations within then existent systems for infectious disease control and population security. Subsequently, in seeking continued security for both population health and economic circulations into the twentieth century, the development of new security perspectives under the rubric of global health, the re-contouring of the spatiality of security praxis, and the problematization of systems of knowledge generation for the knowing of pandemic threats have facilitated the subsequent development and implementation of data-driven syndromic surveillance systems as key technologies of this new practice of security.

A Genealogy of Infectious Disease Control

The rise of global health security provides the context and origins of syndromic surveillance systems, and underpins the wide proliferation of such systems since 1994. However, despite the popularity and widespread use of the term across defense and security strategies, white papers, bulletins, scientific reports and press-briefings of national, regional and intergovernmental groups and organisations, the scope of *global health* and its relation to security praxis is expansive, and indeed, a concise and uniform meaning of the term as maintained by Weir (2012: 322), is surprisingly elusive. What is more, Aldis (2008:369-370), has highlighted that although the ‘concept of health security is becoming accepted in public health literature and practice, there is no agreement on scope and content...[and] that an incompatible understanding of the concept between developed and developing countries sets the stage for breakdown in global cooperation.’ Additionally, Aldis has noted the divergence and conflation of distinct yet similar terms of ‘health security’, ‘human security’ and ‘global public health security.

In presenting the origins of global health within preceding historical health systems of hygiene, public health and tropical medicine, Koplan et al. (2009:1993-1995), assert that global health can be thought of as: 1) a notion (the current state of global health); 2) an objective (a world of healthy people, a condition for global health); 3) or a mix of scholarship, research, and practice with many questions, issues, skills and competencies. Reflecting this, the authors advance a working definition of the term

which recognises global health ‘as an area for study, research and practice that places a priority on improving health and achieving equity in health for all people worldwide’ (ibid). Alternatively, Beaglehole and Bonita (2010:1-2), present a condensed definition for global health as the ‘collaborative trans-national research and action for promoting health for all.’ The WHO’s World Health Report (2007b:1) defines global public health security as ‘acute public health events that endanger the collective health of populations living across geographical regions and international boundaries. Global Public Health Security embraces a wide range of complex and daunting issues from the international stage to the individual household including the health consequences of human behaviour, weather-related events and infectious diseases, and natural catastrophes and man-made disasters.’

As the extensive body of research on global health denotes, the concept is both multifaceted and robust with far-reaching applications across the social sciences including within international relations. As such, it is beyond the scope and aim of this research thesis to engage with the entirety of literature on global health and its dimensions of security in search of a precise definition. Alternatively, and by example of Weir (2012: 322-323), this chapter presents the construction of global health security via its historical formation, emergent rationalities, and specificity. The contemporary proliferation of syndromic surveillance systems will be situated and presented as resultant from twentieth century historical, political and epistemic transformations within the politics of health and security, represented most prominently by the increased correlations of infectious disease and pandemic as exceptional threats which problematize the economic and security interests of states, and emerge in increasingly *globalised* contexts. This analysis will ‘enable a characterization of global health security as an epistemological break in global public health and global biopolitics’ (ibid).

Populations and Pestilences: Before ‘Global Health’

Throughout history human communities have been continually infected by occurring and re-occurring outbreaks of pathogenic diseases and infection, the most prominent of these endemic illnesses were smallpox, plague, and cholera. *Variola major/minor*, commonly known as smallpox, a highly infectious deadly and disfiguring disease was thought to have emerged and spread within human communities an estimated 3000-6000 years ago (Geddes, 2006:152). Reoccurring outbreaks of smallpox within European cities, facilitated by early trade networks frequently killed 30% of infected patients (ibid). Until the late 18th century, smallpox epidemics across Europe killed as estimated 400 000 Europeans annually (Eyler, 2003:1-2). Correspondingly, the exposure and high mortality rate of Indigenous

Americans and Caribbean peoples when exposed to smallpox by patterns of European colonialism are further well established and documented (ibid). The transition of rural-urban migratory patterns, the growth of industrial cities across Europe, and expanding global trade and colonial routes further provided ideal vectors in which the transmission and rapid spread of smallpox could be facilitated.

Additional to the threat of smallpox epidemics in human communities in largely pre-modern eras, reoccurring outbreaks of Bubonic plague, referred to colloquially as plague represented one of the most devastating and destructive pandemics in recorded history. Facilitated and spread via bites from rodent fleas, pandemics of plague across human communities were associated with high susceptibility and mortality. The most well-documented of these pandemics is known as the Black Death, the second global plague pandemic of the fourteenth century (1347-1350), resulted in over 50 million deaths centred in Europe and across Africa and Asia (WHO, 2000). Following the most destructive outbreak of plague which significantly lowered the populations of European states and cities, epidemic plague would re-emerge and recede in patterns facilitated by steamships and trade routes. Between 1894-1903, plague entered 77 seaports on five continents, the widespread prevalence of bubonic plague in Colonial India resulted in an estimated 6 million deaths between 1898 to 1908 (WHO, 2000). Presently, although a reduced global health threat, plague remains endemic within certain global regions including parts of Central Asia, Central and Southern Africa and the Indian Subcontinent (CDC, 2015).

Further still, a third deadly disease, cholera infected human communities in re-occurring intervals in the pre-modern and early modern era. Throughout the nineteenth century, cholera was widely referred to as 'Asiatic Cholera'; the centre of the disease was India, where it exercised 'habitual domination' (Briggs, 1985:153). The disease was facilitated once more by burgeoning trade links and the navigation of land and sea by colonial parties, the highly infectious disease spread out of India, throughout the Middle East, Russia, Europe, and Africa throughout the 1800s, cholera it was said, 'mastered every variety of climate, surmounted every natural obstacle, conquered every people' (ibid). Although the condition of cholera had been observed since ancient times in India, precise medical understanding of the disease and its virulence and transmission only began to be uncovered in the nineteenth century. From the 1800s onward, six recurrent global cholera pandemics killed millions of people on every continent, the current (seventh) cholera pandemic emerged in 1961 in South Asia, it subsequently spread to Africa in 1971 and reached the Americas in 1991, to present, cholera remains endemic in many global regions (WHO, 2016b).

What remains significant within the distinct histories of these three classic pandemic diseases is how the emergence and re-emergence of these infections during early modernity propelled the problematization of infectious outbreaks into new dimensions of international control, cooperation and regulation in the interests of broadened [health] security practices. Reflective of Michel Foucault's (2007) description of the emergence of *population* as the central object in which to be secured against naturally occurring phenomena, including plague and epidemics, early European initiatives towards the infectious disease control of outbreaks of smallpox, plague, and cholera featured nascent national

programmes aimed at the enhancement of population well-being as well as novel, international cooperation aimed at the stemming of global pandemics and preserving expanding nodes of trade and global capital. In response to outbreaks of plague, facilitated largely through sea transport and trade, the early practice of quarantine began and was accepted between states and regions from the fourteenth century onward. These new public health regulations which accompanied trade routes soon spread and became uniform across trading states with an advised 40-day period of isolation implemented on transport carriers suspected of plague infection (World Health Report, 2007:2). Although the early measures of transport quarantine have largely been regarded as ineffective to stemming the spread of infectious disease, they significantly represent a novel, albeit rudimentary attempt by states to cooperate on matters of international infectious disease control, and economic self-interest.

Within the period of early modernity, smallpox remained a highly pathogenic and disfiguring disease. It remained endemic in much of the world including across Europe, however in 1796 novel perspectives in exposure to smallpox and regulation of these epidemics took new form in the practice of population inoculation, following the development of a vaccine derived from cowpox virus piloted by Edward Jenner, an English physician. As observed by Michel Foucault during his tenure at the Collège de France, the development of a smallpox vaccination and the subsequent inoculation campaigns represented an epistemic shift in the governance of the health of populations.

According to Foucault (2007), a new technology of control, distinct from practices of segregation (as in the case of leprosy) or quarantine (with outbreaks of plague) had emerged through systems of population immunisation against future or forthcoming outbreaks. The new mode of governing contingent infectious disease outbreaks now was predicated on seeking to derive emergent statistical knowledge at the level of *population*, about how many people suffered from smallpox, at what age, with what the social consequences and what associated mortality rates existed (Elbe, 2009:66-67). Moreover, the introduction of wide-spread vaccination practices of smallpox in Europe provided new insight on how vaccination would affect the distribution of the disease across populations (ibid).

In the context of cholera, as highlighted by Huber (2006), processes of early securitization against infectious disease within Europe began to move away from more primitive and obstructive methods of disease control such as the quarantine, in the interest of grander economic circulation and financial opportunity, which accompanied the European Age of Expansion and the development of modern industrial capacities. In seeking to develop a concerted ‘international’ response to the problematization of infectious disease and economic circulation which affected trading states within Europe at the time, the first international cooperation initiatives on health diplomacy, represented by the first International Sanitary Conference was held in Paris on 23 July 1851.

Motivated by the deadly outbreaks of cholera within European cities and across the continent which had originally been transmitted via transport and trade routes from India, a central rationale for the first International Sanitary Conference derived from the reality that ‘if both cholera and its prevention were international concerns, a solution could not come about on a national level’ (Huber,

2006:457). While seeking a concerted approach among then European powers in the development of common prevention practices and pre-emption against future outbreaks of cholera, the central objective of the conference sought to ‘harmonize and reduce to a safe minimum the conflicting and costly maritime quarantine requirements of different European nations’ (WHO, 2011), or rather as Beigbeder (1998:73, in Davies et al., 2015:4) has observed, these meetings attempted to ensure the defense of Europe against exotic pestilence, while removing hindrances to international commerce and transport.

Representing the first of kind in international initiatives to address the potentially catastrophic effects of infectious disease and pandemic upon economies and populations, the first International Sanitary Conference of 1851 would propagate further developments towards early global health including sanitary conferences in Venice (1892), Dresden (1893), Paris (1894), followed by the 1897 conference in Venice which adopted a new international convention on addressing the prevention of the spread of plague. Following the consolidation of further conventions and additional meetings, in 1907 an Office international d’Hygiène publique (OIHP) was given a permanent presence in Paris (Huber, 2006:457). As noted by Liverani and Coker (2012:916-917), the establishment of the early European sanitary conferences ‘laid down the [emergent] bases of the modern framework for international health cooperation’, and further recognised the transnational threat of infectious disease outbreaks such as cholera at the time.

Collectively then, the three advancements at addressing classic international pandemics, described above, demonstrated by the development of quarantine measures to control the spread of plague, the novel widespread campaigns towards immunisation of smallpox from the 1800s onward, to the advent of the International Sanitary Conference in 1851 to address measures to control cholera, are representative of early and evolving ‘international coordination in order to strengthen global public health security’ (World Health Report, 2007:6). As highlighted by Brown et al. (2006:62), ‘by the late 19th century and early 20th century, international health was already a term of considerable currency...it referred primarily to a focus on the control of epidemics across boundaries between nations.’ These varied ‘international’ health initiatives further indicate a nascent recognition of the inability for states and states alone to successfully manage health affairs and contain contagion when faced with a virulent outbreak of disease, largely facilitated through growing networked interconnectedness. Building upon the growth in international momentum towards the monitoring of infectious disease control, the Health Organization of the League of Nations was established in 1923, following a move towards internationalism in the wake of the First World War, completing the first and initial act in what Fidler (2001:843), has conceptualised as ‘an evolution in international cooperation on infectious diseases’ that had produced numerous novel processes, rules and institutions for [early] global health governance.

Fostering Cooperation towards Global Health: Enter the WHO

Following the end of the Second World War, in 1948 the World Health Organization (WHO), was founded as a specialised agency of the recently formed United Nations (UN), to ‘act as the directing and co-ordinating authority on international health work...to assist Governments, upon request, in strengthening health services [and]...to stimulate and advance work to eradicate epidemic, endemic and other diseases’ (Constitution of the World Health Organization, 2006). From 1948 onwards, the newly formed WHO would come to assume the role of the primary active agent in the development, maintenance and surveillance of an emergent regime of global health in which the occurrence of infectious disease outbreaks increasingly were imagined and presented as shared, destabilising global threats. As the collective sum of its member states, the WHO from its inception was vulnerable to shifts and dynamics within the sovereign politics of its members. This was widely demonstrated for instance by the politics of the Cold War era, when in 1949, following the withdraw of the Soviet Union and its communist allies from the United Nations, and therefore the WHO, the organisation entered a period whereby the United States and its allies were able to exert significant control and influence over agenda setting and policy objectives of the organisation (Brown et al., 2006:65).

Within the politics of global health and infectious disease surveillance and reporting, the WHO sought to develop comprehensive frameworks to assist and guide member states response to control and self-monitor outbreaks of highly infectious diseases. This was accomplished first through the approval of the International Sanitary Regulations (1951), which bound member states to report on six quarantinable infectious diseases: plague, cholera, yellow fever, smallpox, typhus, and relapsing fever, in order to ‘ensure maximum security against the international spread of disease with the minimum interference with world traffic’ (International Sanitary Regulations, 1951).

In 1969, following revision of the earlier International Sanitary Regulations, the WHO adopted the first International Health Regulations (1969), which mandated that member states ‘are obliged to notify WHO for a single case of cholera, plague or yellow fever, occurring in humans in their territories, and give further notification when an area is free from infection’ (International Health Regulations, 1969). Seeking to establish and streamline emergent practices towards the advanced securitization of pandemic threat, the first International Health Regulations included mandatory reporting for member states to WHO authorities of any outbreak of cholera, yellow fever or plague occurring within 24 hours of discovery of the outbreak. While member states of the WHO accepted the conditions within the first International Health Regulations, and supported in principle, a move towards enhanced infectious disease reporting and notification, this mid-twentieth century approach to expanding global health would be problematized in several key areas.

First, the reduction of mandatory reporting illnesses contained within the first International Health Regulations severely limited transformative action in infectious disease response and surveillance in strengthening processes of global health security. Despite the widespread, highly

contagious profile of polio-myelitis, the disease was not included with cholera, yellow fever and plague on the IHR's obligatory disease notification register. Directly, this meant that the WHO was now in a less assertive position to address and query the spread and outbreak of polio, and to access requisite epidemiological data supplied by health institutes of member states. This oversight thus did very little to stem the growing global threat of emergent and re-emergent infectious disease. Consequently, in the 1970s, three waves of polio outbreaks occurred within the United States following the importation and transmission of wild polio-myelitis from the Indian Subcontinent (Andrus et al., 2010:1-2).

The lack of inclusion of a virulent disease such as polio into global health frameworks was reflected several years prior to the passing of the first International Health Regulations whereby, following an outbreak of wild polio in Guinea, West Africa, it had taken seven months for a consultant to reach the field in 1967/68. Following eventual arrival in Guinea it was noted '5-6 months earlier, there had been an outbreak of over 200 paralytic cases. But the WHO had requested —fruitlessly— epidemiological data about the polio outbreak three times during July 1967' (Weir and Mykhalovskiy, 2010:115). Exemplified by polio, the original International Health Regulations of the WHO would be ill-suited in addressing the emergence of novel and complex disease outbreaks in the decades following the implementation of the regulations, including the emergence of Ebola and HIV/AIDs in the early 1980s, followed by fears of bioterrorism, novel strains of avian and swine influenza, and a host of novel drug-resistant infections.

Furthermore, the concept of surveillance, as contained within the first International Health Regulations was severely limited in scope, oriented away from the concept of the global and rather relied exclusively on information provided by governments of the member states of the WHO (Baker and Fidler, 2006:1058). This meant that the information and data quality supplied from national surveillance processes often focused on containment at the border policies of infectious disease control, rather than a global health 'containment at the event' (Andrus et al., 2010:2). In the face of frequent reporting non-compliance by states fearful to report an infectious disease outbreak due to trade and economic downturns, the WHO was often unable to enforce disease reporting protocol and to access the correct epidemiological data to guide responses to public health emergencies. A prominent example of this inability of the first IHR to enforce emerging global health norms occurred once more in Guinea following a severe outbreak of cholera in 1970.

Unlike the previous outbreak of polio which had occurred in Guinea in 1967/68, cholera was a mandatory reportable infectious disease contained within the IHR (1969). However, regardless of these reporting regulations and despite repeated requests from the then WHO Director-General, 'who had received reliable information from nongovernmental sources, the government of Guinea did not confirm that a cholera epidemic was occurring within its borders' (Weir and Mykhalovskiy, 2010:74-75). Significantly, owing largely to the proliferation of media outlets and international journalism throughout the 1960s and 1970s, the expanded role of the press and the generation of news media reports detailing disease outbreaks had begun to generate a novel channel of outbreak information and

knowledge to be utilised by global health agents such as the WHO. Despite the noncompliance of the Guinean government to disclose this outbreak, authorities within the WHO were steadily able to gain a awareness of the ongoing outbreak from the generation of media coverage.

In response to the ongoing cholera crisis in Guinea, eventually the WHO Director-General, for the only time in the history of the WHO, ‘publicly disseminated information about the cholera outbreak despite having received no information from its government on the outbreak (Fidler, 2004:64). Resultant from this unprecedented move on part of the WHO, a firestorm of controversy ensued ‘with several member states threatened to resign from the WHO, with the result that the WHO never again broadcasted a report based on unofficial information during the period in which the IHR (1969) was in effect’ (Weir and Mykhalovskiy, 2010:74-75). The outbreak of cholera in Guinea in 1970 therefore provided nuanced points on the emergence of a more concerted system of global health and surveillance in the mid-twentieth century.

Firstly, it demonstrated the dominant state-centric approach to disease reporting and notification contained within the first IHR. Without the consent to report and receive epidemiological data from its member states, the WHO was unable to enforce and expand responses to serious infectious disease outbreaks. Secondly, the scope of the IHR (1969), excluded all other forms of reporting and dissemination of information save for that which existed between the WHO and its member states. Thirdly, the WHO was increasingly out of pace with the rise of new forms of open-source information and health data represented by global media outlets of the 1970s onward. The rise of global media franchises emphasised that control over the act of reporting ‘was not simply a dyadic one between the WHO and its sovereign country members. Rather, the 1970 conflict was triangular and consisted of the WHO, sovereign states and the press...where the press operated as a social actor capable of disseminating news of outbreaks independently of the WHO and its country members (Weir and Mykhalovskiy, 2010: 74-75).’

Lastly, the Guinean example illustrated the new radical nature of how surveillance information could now be gathered from non-governmental sources in emergency contexts, serving as a reservoir for global health authorities on a broad range of emergent and re-emergent disease threats (Fidler, 2004). The unofficial role of the media and its generation of infectious disease reporting continued to informally guide WHO awareness on continued disease outbreaks throughout the 1970s, including a 1978 outbreak of cholera in the Maldives, in which an article entitled ‘The Maldives Ordeal by Cholera’ appeared in the publication *The Statesman* (Weir and Mykhalovskiy, 2010:71).

Geopolitically, and in terms of the limitations contained within the first IHR, the WHO was constricted in advancement of the concept and practice of global health, as well as the normative behaviour and expectations upon states that accompanied such an emergent framework. The terms of the International Health Regulations meant that health and the politics of infectious disease reporting remained largely within the jurisdiction of the sovereign member states of the WHO. For Gostin (2005:419), the construction of the IHR (1969) led to stagnation in expanding global health governance

and further entrenched existing power structures among developed and developing states. Despite new and potentially strategic health-data sources being generated rapidly by international media sources, the WHO was left in a position of inaction if it was unable to obtain authorisation from its member states to disclose information related to an emergent infectious disease outbreak. Simply put—the implementation of the International Health Regulations did little to foster a concrete sense of collective action in the field of global health in a historical era of rapid change and shifting threats. In the subsequent decades, marked transformations within the practice and imagining of security threats and the emergence of new international challenges for states would re-configure the place of health and disease as previous social and development items, resulting in significant transformations within security perspectives linking national sovereignty and global health security.

Infectious Disease: Emergence of the Non-Traditional Security Threat

The growing practice of global health security has involved an epistemic shift in the understanding and imagining of the politics of health in which infectious disease and pandemic are re-formulated as constituting existential security threats to populations and states. This shift moves the politics and threats of health away from previous moorings within the developmental and social frameworks of states towards the *high politics* of national and international security agendas from the mid- twentieth century onward. In addressing this transformation, Barnett and Sorensen (2011:166), have located the re-conceptualisation of health as a non-traditional security risk within the context of a post-Cold War era which has increasingly, ‘shifted discourses of security away from the previously narrow and restricted frame of nation-state to the vast global theatre.’ Equally, Rushton (2011:5), has noted the development of a ‘comparatively young concept of health security’ as the result of a gradual intertwining of health and security practices over recent years as well as ‘foreign and security policy communities, particularly in the West [which]...have vastly expanded their remits and range of interests in the post-Cold War era’ (ibid).

The transformation in which perspectives and understandings of security have undergone to presently include the security threat of highly infectious disease outbreaks and pandemic have been centred and galvanized from the 1970s onward, and have focused on an emergent scope of novel threats ranging from bioterrorism (Madad, 2015; Fidler, 2002), to the emergence of HIV/AIDS (Elbe, 2006, 2009; McInnes and Rushton, 2013; Feldbaum et al., 2006), as well as the accelerated emergence and re-emergence of novel infectious diseases (Schoeman, 2000; McConnon, 2003;and Morens et al., 2010), and the growing threat of antimicrobial resistance (Zhang et al., 2006; Laxminarayan et al., 2013).

Although the early twentieth century had sought to elevate health to the level of the international, as maintained by Pereria (2008:2), health initiatives and infectious disease control ‘primarily relied at the national scale, on health departments, and, at the international level, on the World

Health Organization.’ While early global initiatives including the International Sanitary Conferences and the establishment of a permanent health secretariat sought to elevate the politics of health within the international, these endeavours were first hindered by the onset of the World Wars and following 1945, by the onset of the ideologically narrow, Cold War (1947-1991). Within this era, the conceptualisations of security and of existential threats were formulated along conservative and constrained lines, reflective of a realist reading of international relations. As articulated by Leander and van Munster (2006:6, in Elbe, 2009:154-155), ‘[d]uring the bipolar Cold War, the security order was closely tied to the...paradigm of sovereignty. The focus on nuclear weapons and the great power competition made (international security) appear as a quintessentially public responsibility to be provided through practices as the arms race, diplomacy, alliance building, containment, border control and policing.’

Furthermore, as outlined by Buzan (1991:433), during the Cold War, ‘international security was dominated by the highly militarized and highly polarized ideological confrontation between the superpowers. Because their rivalry was intense and the danger of war was real, political/military concerns dominated the security agenda.’ Subsequently, although national health institutes and the World Health Organization acted as the primary agents of international public health during this period, initiatives of global health were viewed as external to then contemporary security practice. The politics of health remained moored within social and developmental frameworks and were viewed insofar as only occasionally strategic political agendas within the development aid and military agendas during the Third World post-independence waves and the bipolar West-East confrontation (Pereira, 2008:2).

Occurring alongside the narrowed scope of the Cold War era, substantial developments occurred within the politics of infectious disease and health which further distanced agendas of health from the praxis of defense and military. Firstly, as identified by Fidler (2007:243), ‘the establishment of the WHO coincided with an unprecedented convergence of traditional but proven public health measures (for example, epidemiological surveillance and urban sanitation) and by rapid scientific progress in medicine (for example, vaccines, antibiotics). These developments lessened the need for foreign policy makers to concern themselves with the threats to the health of their respective populations.’ Secondly, shifting perceptions of health uncertainties within medical and research fields in high-income industrialised states would once more re-contour the dynamics of health and illness away from the field of security.

Owing in large part to technological and scientific innovation throughout the twentieth century, developed health infrastructures mid-century experienced successes in a range of novel areas from improved hygiene and sanitation, to optimisation of nutrition and lifestyle, to access to health services and facilities, vaccination and inoculation initiatives and successful disease eradication in the case of smallpox by 1980 (Bhattacharya, 2010:1602). Such rapidly delivered results stemming from successful health initiatives during this period resulted in a shifting *epidemiological transition* (Tulchinsky and Varavikova, 2000:42-43), in which mortality rates from infectious and communicable disease in

developed countries fell significantly and were alternatively replaced by an up-swing in acute and chronic diseases including cancers, heart disease and diabetes. So explicit was this transition within the politics of health mid-century that in 1967, William Stewart, the Surgeon General of the United States of America declared, ‘The time has come to close the book on infectious diseases. We have basically wiped out infection in the United States’ (WHO, 2008).

Accordingly, a marginalisation of the health agenda within foreign and security policy was sustained during the years of the Cold War, in which a preoccupation with an explicitly *militarised* threat dominated perceptions and discourses regarding international security. Simultaneously, an epidemiological transition within health systems within high-income states towards the addressing of acute and chronic illness, rather than infectious disease research and surveillance further emphasised the gulf between the politics of foreign and defense strategies on one hand and an expanding project of global health on the other, represented by the 1978 Declaration of Alma Ata which recommended as the ‘main social target of governments, international organizations and the whole world community in the coming decades should be the attainment by all peoples of the world by the year 2000 of a level of health that will permit them to lead a socially and economically productive life’ (Declaration of Alma Ata, 1978).

While the politics of health had remained separated from the practice and perspective of international security through much of the Cold War era, this status quo entered a period of rapid transition from the late 1970s onward indicative of a novel *security/disease* nexus. Firstly, the emergence of a novel and previously clinically unobserved retrovirus in the large urban centres of the United States from 1980 onward, classified as HIV (human immunodeficiency virus), would come to represent the first and most prominent watershed event in the reformulation of infectious disease as an international security threat towards the end of the twentieth century. Not only for example had the virus emerged within urban populations of industrialised states during the 1980s, but the virulent rate of infection of this deadly and incurable disease breached the traditional developmental and social framework of health policy. Within the early years of the emergent HIV/AIDS pandemic, response language and proposed initiatives to the emergent virus increasingly utilised the language of security and the need to securitise an emergent and foreign threat. The New York Times, (Keller, 1985) reported for example, that the US Defense Department announced the mandatory testing and screening of all incoming prospective military recruits for the AIDS virus and rejecting positive applicants from service, citing that the presence of infected service persons ‘could overwhelm the military medical system.’ The sudden emergence, escalating case-infections, and global spread of the novel HIV/AIDS virus increasingly, unlike previous pandemics began to overlap with ‘the core traditional concerns of national security policy—such as the military, armed conflict, state stability, and even international peace-keeping operations’ (Elbe, 2011:850). Presenting new and previously unconceived problematizations to the government of populations and economy, at a *global* level represented by the spread of an unregulated novel pandemic.

Critically, the spread of the HIV/AIDS pandemic, galvanized further emergent logics which melded pandemic fears with understandings of state and international security. The Institute of Medicine's (IOM) seminal publication *Emerging Infections: Microbial Threats to Health in the United States* (Lederberg et al., 1992: v), in referencing the security threat of HIV/AIDS, warned that 'in the context of infectious diseases, there is nowhere in the world from which we are remote and no one from whom we are disconnected. Consequently, some infectious diseases that now affect people in other parts of the world represent potential threats to the United States because of global interdependence, modern transportation, trade, and changing social and cultural patterns.' Moreover, though a medical/scientific publication, the IOM's piece utilised a nuanced language of security, presenting 'drugs, vaccines and pesticides' as 'important weapons...in the battle of infectious disease' (ibid).

Beyond this, the rapid spread of HIV/AIDS would force states to reflect upon the destabilizing impacts of an HIV/AIDS pandemic which could occur on a global scale if continually ignored by security analysts. During the mid-1990s for example in response to the outbreak, there were increased national anxieties about the persistence of HIV infected military persons within African Sub-Saharan states, which questioned whether attempts to devolve peacekeeping to regional powers may be 'hamstrung' by a high HIV prevalence, particularly among key African armies such as those of South Africa and Nigeria (McInnes, 2006:323; Elbe, 2002:166-167). HIV/AIDS also became a prominent analytical point of security deliberations, linking state capacity with the potential for large-scale HIV/AIDS infections to undermine national economies and weaken state institutions, or to provoke 'new interstate political conflicts over access to expensive, life-prolonging medicines' (Elbe, 2009:42-49).

The inability for states to successfully contain and limit the spread of HIV/AIDS in an era of population mobility, compressed air travel time, and an increasingly sophisticated global transport infrastructure further elevated the HIV/AIDS pandemic to a new place at the top of security agendas of the post-Cold War era, generating new considerations of how novel responses and techniques could contain or regulate the spread of the virus. Most significantly, following years of deliberation and debate, in 2000, the United Nations Security Council (UNSC), the main organ of the United Nations (UN) whose remit is the maintenance of international peace and security, adopted *Council Resolution 1308: Responsibility of the Security Council in the Maintenance of International Peace and Security: HIV/AIDS and International Peace-keeping Operations*. This ratification of Resolution 1308, the first of kind to ever explicitly seek to securitize HIV/AIDS as an existential threat with global ramifications stressed 'that the HIV/AIDS pandemic, if unchecked, may pose a risk to stability and security' and presented this infectious disease risk as relevant to 'the Council's primary responsibility for the maintenance of international peace and security.'

The adoption of UNSC Resolution 1308 represented at the highest international level, how the politics of health and infectious disease have been central to the re-formulation of the imaginings and practice of a new rationality of security within international relations of the late and post-Cold War

periods. The significance of UNSC Resolution 1308, clearly indicated a new association of security and infectious disease which moved health beyond the purview of being traditionally the private concern of the individual, to carrying significance for the security of the state and society as well (Kittelsen, 2007:124). Although certainly the most referenced and cited health event of the twentieth century, HIV/AIDS alone was not the only infectious disease to force security and policy practitioners towards a reconsideration of how national and international security understandings were increasingly problematized by the spectre of global pandemic uncertainties.

For Nicholas King (2002:764) , the spread of HIV/AIDS in the 1990s occurred within a larger and expanded transition in security known as the emerging infectious disease (EID) worldview, in which ‘American scientists, public health officials and defence experts argued that ‘emerging diseases’ presented a threat to American national security, international development and global health...They expressed American anxieties about living in a globalizing world, in which the assumptions and institutions of the Cold War era no longer seemed adequate to the task of ensuring the safety and interests of US citizens.’ Thus, both emerging and re-emerging⁵ infectious diseases beyond HIV/AIDS were further crucial components to a re-working of security perspective including novel strains of avian and human influenza and the emergence of drug resistant infections such as Tuberculosis-MDR. What is more, on a global scale, an additional 20 established infections including malaria and cholera have emerged since 1973 in more virulent or drug-resistant forms or have spread geographically to new regions (Tucker, 2001:82), problematizing the capacities of governments to effectively regulate the health of populations and the circulation of economies against a myriad of globally circulating pandemic threats.

The Politics of Post-Cold War Security Praxis

The rapid emergence and spread of the HIV/AIDS pandemic globally within less than a decade, as well as the emergence and re-emergence of a host of new infectious pathogens, produced significant ramifications on the practice and understanding of international security towards the end of the twentieth century. The formal end of the Cold War era, culminating in the dissolution of the Soviet Union in 1991, re-focused security analysis into a new era, independent of the bipolar politics and nuclear threat of the period which had preceded it. The post-Cold War years of the 1990s produced new intellectual discussions and ways of recognising security and threat within and across states, largely stemming from ‘the change in threat perception in the West—from overt attacks against national territorial integrity by an inimical state or alliance of states to ‘new threats’ of a de-territorialized and

⁵ Diseases previously thought to be contained through vaccination and employment of antibiotic regimes.

multiform nature—health and other human-related dimensions were growingly inserted into Western defence agendas’ (Pereria, 2008:2).

Moreover, the 1990s presented a host of non-traditional security threats previously contained within the binary stratum of the Cold War. The novel conceptualisation of the non-traditional security (NTS) threat, would come to include a host of challenges to traditional state sovereignty and governance and would include ‘non-military sources, such as climate change, resource scarcity, infectious diseases, natural disasters, irregular migration, famine, people smuggling, drug trafficking and transnational crime. Aside from these issues being non-military in nature, they also share common characteristics, namely: that they are transnational in scope; come at very short notice and are transmitted rapidly due to globalization’ (Caballero-Anthony, 2008:510). For Dobros (2011:2-3), the rise of non-traditional security threats was markedly global, interlinked, less visible and less predictable. Unlike within previous arrangements of the Cold War era, where the security threat was represented by ‘defined adversaries’, responses to new or non-traditional security threats of the post-Cold War era, including pandemic influenza, were problematized by a ‘deficiency of perception’ in the capacity to identify and respond to novel and complex security challenges effectively, and in advance.

Moreover, academic communities, intellectuals and both policy-makers and practitioners within international relations and security studies additionally have engaged in discussions and reformulations of security perspective across the post-Cold War landscape. Prominently, the work of Barry Buzan and colleagues of the Copenhagen School of Critical Security Studies offered an expanded scope of security and of security threats in light of the new era of security praxis. In addition to security existing within the realm of the state/military nexus, the theorists of the Copenhagen School would assert that four novel independent sectors of security, and threats to security existed: including political, economic, environmental and societal (Buzan, Wæver and de Wilde, 1998:7). Though reforming in its re-reading of security, the Copenhagen School did not assert the notion of health and infectious disease as constituting a relevant sector of security praxis and threat as identified by Yuk-ping and Thomas (2010), but rather, laid the conceptual groundwork in which emergent new security dilemmas including pandemic contingencies, could now be considered and extended.

Despite the marginalization of health as a sector of security within the original analysis of the Copenhagen School, the health/security nexus gained increased currency during the 1990s. This was perhaps most evident in the emergent, post-Cold War conceptualisation of *human security*, which departed significantly from received realist understandings of security perspective in earlier decades. Presented in the 1994 United Nations Development Programme’s *Human Development Report*, which stated that, ‘[f]or too long, the concept of security has been shaped by the potential for conflict between states...security has been equated with threats to a country’s borders...has for too long been interpreted narrowly: as security of territory from external aggression, or as protection of national interests in foreign policy or as global security from the threat of nuclear holocaust’ (UNDP, 1994:11-22). The report further highlighted the growing need to address contours of *health security* in providing security

from infection and death from communicable diseases, and further referenced the potentially catastrophic threat of an unmonitored HIV/AIDS global pandemic, asserting that total global costs associated with an HIV/AIDS pandemic by the year 2000 could total \$500 billion dollars/annum, equal to 2% of global GDP (UNDP, 1994:28).

A decade following the dissolution of the Soviet Union and the ushering in of post-Cold War security politics, a further epistemic shift would suddenly occur on the international landscape of security practice and the politics of infectious disease and pandemic. The paradigm-shifting terror attacks on the United States of 11 September 2001, further escalated Western-held anxieties about the probability of uncontrolled and unforeseen security challenges represented by non-state actors across globalized networks, and would further draw associations between infectious disease outbreaks on one hand, and the maintenance of national and international security on the other, bringing the two concepts together under the novel rubric of *preparedness*. The 11 September attacks on New York and Washington D.C. successfully demonstrated the ability of non-state entities to penetrate existing state-security apparatuses and inflict large-scale damage on civilian and economic targets in the post-Cold War era.

Moreover, these attacks, as well as the subsequent September/October 2001 anthrax letters attacks (Amerithrax), the first domestic bioterror attacks on American soil, as Khan (2011:953) writes, ‘uncovered weaknesses in the US national public health infrastructures...exposed additional deficiencies in local, state and federal responses. The attacks emphasised national vulnerability to the use of weapons of mass destruction and made public health a new subject of security discussions. This led to the emergence of health security as a new legislative focus as Congress recognized the need to expand the resiliency of public health systems to respond to national security threats.’

Galvanised further with the disclosure in the 1990s, that Russia had inherited a maintained, offensive biological weapons programme from the Soviet Union (Nuclear Threat Initiative, 2015), as well ongoing concerns regarding discovery of a military bioweapons programme in Iraq (Davis, 1999), and the sarin gas terror attacks on the Tokyo underground in 1995 (Okumura et al., 1998), the politics of infectious disease and of security practice within the United States became increasingly aligned with the emergent security concepts of 1) health security: the nexus where public health and security meet; and 2) biosurveillance, an expansive and novel security concept, which places ‘emphasis on the use of information for early detection and warning of events that are the result of a bioterror attack, or other weapons of mass destruction, an emerging infectious disease, pandemic, environmental disaster, or a food-borne illness’ (Moore et al., 2013:xi).

The concept of preparedness within the United States and throughout the West referred to new objectives ‘to improve a nation’s ability to detect and respond to an array of public health emergencies, including bioterrorism, emerging infectious diseases, and natural disasters’ (Hodge et al., 2007: 1708). Taking an ‘all-hazards’ approach to the probable threat of infectious outbreaks, systems of preparedness within the United States involved all levels of national government, federal, state, local, and tribal.

Beyond only the involvement of state institutions, these disease preparedness initiatives sought the ‘collective expertise’ of multiple disciplines including epidemiology, health policy, economics, law, environmental science and bioethics to support responses to major health challenges (Novotny, 2006:11). In highlighting the elevated position of medical and public health communities and professionals within an expanding security logic of *preparedness*, the Centers for Disease Control and Prevention (CDC) in its strategic plan for *Biological and Chemical Terrorism Preparedness and Response* (2000:2), emphasised that successes of new practices of preparedness when faced with the deliberate dissemination of biological or chemical agents, ‘hinges on strengthening relationships between medical and public health professionals and on building new partnerships with emergency management, the military, and law enforcement professionals...to address national security threats.’

Strategically, the expanding practice of preparedness in American and Western defence agendas at the start of the twenty-first century following the terrorist attacks of 11 September situated and intensified emergent forms of health surveillance for the forecasting of bioterror and pandemic contingencies known as *syndromic surveillance*. Much of the early research and policy attention directed to novel syndromic surveillance systems from 2001 onward as underlined by Mandl et al. (2004:141-142), have been largely directed at facilitating the early detection of a covert bioterrorist attack, but the technology demonstrated reporting potential to be useful for public health, clinical medicine, quality improvement, patient safety, and research. Highlighted for the growing capacity of emergent syndromic surveillance systems to capture, in real-time, health patterns potentially indicative of an emergent infectious disease outbreak or deliberate bio/chemical terror attack, through the use of non-traditional health and data sources, and conveyed through digital and technological channels, the Government of the United States post-11 September, ‘embraced syndromic surveillance’, as the best hope for detecting a bioterror attack or a pandemic outbreak at the earliest stage (Eban, 2007).

This growing recourse to syndromic surveillance practices within a larger security paradigm of preparedness into the early years of the twenty-first century was accompanied by a further proliferation of syndromic surveillance systems, seeking to supplement approaches to traditional surveillance methods which were based upon physician and laboratory reporting (Chretien et al., 2009:1360-1361). In addition to the launch of ProMED-mail in 1994 and GPHIN in 1997, the proliferation of further ‘syndromic’ surveillance systems and pilot programmes were located across approximately 100 health departments within the United States in 2003 (Buehler et al., 2003:1-8), seeking to rapidly obtain advanced warning and crucial epidemiological knowledge on potential outbreaks or deliberate releases of pathogens including inhalation anthrax, botulism, tularaemia, pneumonic plague, smallpox, and strands of viral haemorrhagic fevers (ibid). Additional syndromic surveillance technologies within the post-11 September 2001, security context of the United States included the New York City’s emergency department (ED)-based syndromic surveillance system, the Real-Time Outbreak Disease Surveillance system (RODS); the Electronic Surveillance System for the

Early Notification of Community-Based Epidemics (ESSENCE); and the National Bioterrorism Syndromic Surveillance Demonstration Project (Lober and Karras, 2004).

In sum, through the increased subsuming of the politics of infectious disease and health which occurred with growing speed in the years of the post-Cold War era, the early origins of many syndromic surveillance systems were initially developed for the early detection of a large-scale releases of biologic agents in the revised security agenda of post-11 September United States (Henning, 2004:5-6). The growing recourse of governments including the United States towards the application of syndromic surveillance systems at the start of the new millennium thus was representative of the ongoing and critical transformations occurring within the alignment of health and global security agendas of the twenty-first century, as well as the generation of new security technologies represented by syndromic surveillance systems to effectively enhance the practice of global health security in responding to the problematizations represented by globally circulating pathogens and knowledge deficiencies of these [forth-coming] events in the twenty-first century.

Global Health and Security: A Twenty-First Century Nexus

In late 2002, a novel coronavirus emerged within human populations in Guangdong Province, Southeast China. Initially misdiagnosed and presented as *atypical pneumonia* by Chinese health officials, the virus evaded the gaze of traditional surveillance systems and subsequently was rapidly transmitted to densely populated urban centres across Guangdong Province, and spread beyond the borders of China via international air transport networks in the months following its initial emergence. By early 2003, the newly identified severe acute respiratory syndrome (SARS) had spread to 26 countries across Southeast Asia, the Americas, and Europe; ballooning to more than 8000 reported cases of infection globally, with dense cases of human-to-human transmission in across Guangdong Province, Hong Kong, Taiwan, Singapore, Vietnam and Toronto, Canada (WHO, 2012). In the post-11 September world, increasingly orientated towards the practice of preparedness for yet-unforeseen security threats, SARS significantly represented the first globalised epidemic of the twenty-first century (LeDuc and Barry, 2004).

Moreover, following the widely documented reticence of the Chinese government, during key moments of the public health emergency, to be transparent and forthcoming with epidemic intelligence and data detailing the scope of the outbreak, the unfolding global crisis brought forth by the emergence of SARS confirmed that traditional, ‘state-dominant conceptions of security were insufficient to meet the international community’s needs’ (Curley and Thomas, 2004:30). The Chinese government’s lack of will to understand the broader global economic, political, and social implications stemming from the SARS outbreak clearly demonstrated to the international community how one state’s internal inadequacy to contain a public health emergency could rapidly transpire into a global human security threat (ibid).

In the aftermath of the SARS outbreak, a new international commitment to the maintenance and further development of a responsive global health security framework was enacted. The centrepiece of this new understanding of the crucial links between the practice and imagining of complex security threats and the spread of infectious diseases was the revision and eventual ratification of the *International Health Regulations* of the WHO in 2005. Reflecting a new perspective informed by transformations in the understandings of health, security and globalization, as well as the emergent security techniques requisite for addressing pandemic uncertainties, the IHR (2005) contained within it a range of new innovations and expectations upon its member states. The range of these significant revisions included: a) a scope not limited to any specific disease or manner of transmission, but covering ‘illnesses or medical conditions irrespective of origin or source that could present significant harm to humans’; b) State Party obligations to develop certain core public health capacities; c) obligations on State Parties to notify WHO of events that may constitute a *public health emergency of international concern* (PHEIC) according to defined criteria; and d) provisions authorizing WHO to take into consideration unofficial reports of public health events and to obtain verification from State Parties concerning such events (IHR, 2005:1-2).

Furthermore, in December 2006, the Congress of the United States of America and the President signed and enacted the Pandemic and All-Hazards Preparedness Act (PAHPA). With a mandate to ‘improve the Nation’s public health and medical preparedness and response capacities for emergencies, whether deliberate, accidental, or natural’ (Department of Health and Human Services, 2014), the enactment of PAHPA established a new Assistant Secretary for Preparedness and Response; provided new authorities on a number of new health programs, including the advanced development and acquisition of medical countermeasures (MCMs); and called for the establishment of a National Health Security Strategy (ibid). In 2007, the WHO’s Annual World Health Day theme was international health security. Citing emerging infectious diseases including SARS, and avian influenza, the WHO highlighted the connection between public health emergencies on one hand, and international security on the other, asserting the potential for infectious disease threats to devastate peoples, societies, and economies worldwide, and urging governments, organisations, and businesses to ‘invest in health [to] build a safer future...and to find a way forward in effective collaboration’ (WHO, 2007a).

Conclusion

This chapter has outlined the emergence of a logic and practice of security expanding within the twenty-first century—global health security. In doing so, it has been demonstrated that although associations between health and population well-being have been long held, contending international priorities and geopolitical preoccupations emphasising the militaristic/territorial aspects of traditional security agendas have for long periods, segmented the politics of health and the practice of security into separate conceptual domains. This chapter has traced the emergence of international cooperation on health

affairs and infectious disease from the twentieth century onward and has asserted further, how significant transformations within foreign and defence agendas, notably the conclusion of the Cold War era, the emergence of HIV/AIDS, and the attacks of 11 September 2001 have re-contoured security perspectives to focus on the proliferation of a range of complex non-traditional security threats, of which infectious emergent and re-emergent diseases constitute some of the most pressing security challenges across networked geographies. International reactions and responses to unfolding public health emergencies including HIV/AIDS and SARS have galvanised systemic reform, innovation and investment into a range of new global health-oriented technologies and governance frameworks within the twenty-first century which seek to enhance the addressing, forecasting and indeed, governing of circulating pathogenic threats at the global level, among them, the emergence of syndromic surveillance systems, and the implementation of the revised International Health Regulations.

In the ongoing effort to identify probable pandemics and public health emergencies in real-time temporalities, the transformation of health, from once an item within development and social policy, into a high ranking priority of security and defence agendas worldwide, reflects what Hooker and Harris Ali (2009:101-103) have presented as the ‘new normal’ in security praxis, used to denote ‘an ongoing state of uncertainty—of quasi-emergency—in which the ‘landscape of fear’ has changed due to a diminished level of confidence that the world is as safe and secure as it once was...insecurity exists at all levels of existence: in biology, in intimate relations...and in governmental and economic systems.’ Reflecting upon this ‘new normal’ of security practice which now addresses the uncertainty of global health threats, the subsequent chapter seeks to discuss how novel systems of surveillance—namely, digital syndromic surveillance systems have emerged among others, as strategic technologies aimed at identifying and responding to a complex range of future-situated health threats in the twenty-first century.

Chapter Two: Surveillance and Global Health

Introduction

As the preceding chapter has discussed, the emergence of complex, transnational security challenges, have been central to the readdressing of the logic and perspective of security to now include virulent outbreaks of pandemic illness, presenting novel problematizations to the security of populations and economy in the early twenty-first century. While the late twentieth century witnessed a reforming of the understanding of security and health, in step with the rapid global transformations which had accompanied the end of the bi-polar Cold War era, including HIV/AIDS, the early twenty-first century witnessed the emergence and re-emergence of a host of highly pathogenic outbreaks which spread rapidly as a result of expanding processes of globalization. The first of these public health emergencies

was the appearance of the novel coronavirus, known as SARS, which had emerged ‘from the viral broth of dense animal/human interactions ecology’ (Nguyen, 2016:124) of Southeast China in 2002/03. Resulting in a subsequent globalised public health emergency, the outbreak of SARS was indicative of the failure of China’s domestic disease surveillance operations to accurately recognise the lethality and contagious profile of the new coronavirus. What is more, through the refusal of Chinese government and health authorities to transparently share crucial health surveillance data and epidemiological information with global health agents including the WHO, SARS quickly spiralled into a global public health emergency by the early months of 2003.

In 2005, pandemic alerts were sounded once more with the global spread of a highly pathogenic strain of H5N1 avian influenza. The H5N1 influenza subtype was identified by the WHO for its high pandemic probability in causing severe and fatal infections when transmitted to humans, with mortality rates ranging from 33% to over 50% in reported cases (Schünemann et al., 2007:21-22). The potential for the global spread of H5N1 had been observed in a preceding study three years earlier by Guan et al. (2002), in which the emergence of multiple new genotypes of the H5N1 influenza virus had been noted in poultry and geese in retail markets in Hong Kong. From 2005 onward, the avian influenza virus and all subtypes were elevated to the status of greatest public health concern by the World Health Organization (WHO, 2005).

In 2009, surveillance systems operating at the interface of human-animal transmissions failed to accurately identify the emergence and subsequent global spread of the Influenza A subtype H1N1, which originated in swine and was transmitted to humans from its original site in the village of La Gloria, Veracruz, Mexico. As with previous disease outbreaks, the emergence and spread of H1N1 in the 2009 influenza season posed major challenges for systems of pandemic preparedness and population security. As Collignon (2011:1-4) writes, gaps in health surveillance measures in detecting H1N1, which resulted in ‘late diagnosis’ of the disease profile meant that attempts at successful containment of the spread of the disease would be highly unlikely or impossible. Before H1N1 had been fully identified, it had already been widely circulating in populations. Furthermore, the 2009 ‘swine flu’ outbreak exposed the chronic lack of intensive care and additional capacity for hospitals worldwide when faced by an upsurge of outpatient demand (ibid). Five years following the global spread of swine flu, the WHO, operating through the protocols of the revised International Health Regulations (2005), declared the 2014 West African Ebola Virus Disease (EVD) Outbreak to constitute a ‘public health emergency of international concern’ (PHEIC), following the rapid spread of the disease from its origin in rural Guinea into Sierra Leone, Liberia, and a host of isolated international cases. Although the initial Ebola epidemic began in Guinea in December 2013, insufficient surveillance sentinels and channels of communication resulted in a further three-month lag until the WHO was officially notified of the evolving health crisis by the Government of Guinea on 23 March 2014.

Systems of surveillance exist at the core of a larger overarching apparatus of global health security. At the level of the local, health surveillance systems serve as the cornerstone to public health

initiatives which seek to respond to existing, emerging, and evolving health threats (Nuzzo and Ravi, 2016:109). At the level of the global, infectious disease surveillance data is aggregated and analysed by chief global health actors including the WHO to strengthen responses and preparedness against the outbreak of diseases with the potential to develop into global pandemics. The WHO (2016c), has defined surveillance as practices which constitute ‘the continuous, systemic collection, analysis and interpretation of health-related data needed for the planning, implementation, and evaluation of public health practice. In addition to providing advanced warning of the potentiality for the emergence of pandemic illness, infectious disease surveillance systems can contribute to enhanced *awareness*, the capacity to process information regarding the scope, origin, and profile of the pathogen during a public health emergency and, can significantly reduce response costs and provide an elucidation of other aspects of coordinating a complex international response (Deshpande et al., 2016:111).

Looking back however, over the last century, the form, practice, and scope of infectious disease surveillance, as well as the dissemination of analysis and findings derived from surveillance operations have transformed considerably considering advancements in interconnectivity, technology, and availability of new data sources. The evolving and expanding nature of global health surveillance and the sharing of infectious disease surveillance data within the late twentieth and early twenty-first centuries have been further contested by a number sovereign states within international relations, viewing the presence of a globalised health surveillance framework as an infringement upon sovereignty.

This chapter therefore seeks to trace and present the evolving practice and technique of infectious disease surveillance over the last century, which has informed and contributed to the contemporary state of infectious disease surveillance in the twenty-first century. In doing so, this chapter considers the significant transformation from *national* to *global* health surveillance strategies which emerged in the mid-twentieth century and accelerated onward under the stewardship of the WHO, and highlights the sites of political contestation which occurred in response to this growing shift. Moreover, in outlining the epistemic turn towards a system of global health surveillance throughout the twentieth century, the chapter presents how novel governance and operational frameworks for enhanced surveillance have developed and proliferated in response to an expanded and problematized geography of health risks in a globalised world. It addresses further, the growing recourse and evolving techniques of security towards open-source and digitised syndromic surveillance systems in deriving health-warnings and signals from streams of Big Data in opening decades of the twenty-first century.

A Century of Surveillance: Early Surveillance Technologies and Infectious Disease Control

Occurring alongside the refinement of the modern-state, emergent rationalities for the development and practice of health surveillance were orientated towards the securitization of populations against the

spread of infectious disease and plague. In reflecting upon the politics of health in early modernity, Foucault (1980:166-167), observed the novel emergence of a medical politics ‘drawing support from structures of power and concerning itself with the health of a collectivity.’ With the growing realisation of the population or sum of individuals as a living and governable reality, the early politics of health and population in the modern state developed according to Foucault as a ‘double-sided process.’ On one hand, there is the new practice of individualized health service, or rather ‘[t]he development of a medical market in the form of private clienteles, the extension of a network of personnel offering qualified medical attention...[and] the emergence of a clinical medicine strongly centred on individual examination, diagnosis and therapy...the exaltation of ‘private consultation’ (ibid).

Concurrently, with the growth of early clinical medicine, the proliferation of statistical knowledge gives rise to the presentation of health and sickness as ‘characteristics of a group, a population, problematized through the initiatives of multiple social instances in relation to which the State itself plays various roles’ (ibid). This new politics of health therefore encompasses both private medicine supported by emergent medical markets and the consultation of the individual, as well as the new practice of socialised medicine, which sought to understand and regulate the health of state populations through endeavouring to ‘organise a global, quantifiable knowledge of morbid phenomena’ (1980:167-168). Health and infectious disease therefore emerge in early modernity as novel problems of government, the politics of health figure ‘as a problem with a number of different origins and orientations, being the problem of the health of all as a priority for all, [and] the state of health of a population as a general objective of policy’ (ibid).

Subsequently, the origins of socialised medical practices and the birth of the régime of a population⁶, facilitated early practices of health and infectious disease surveillance towards the securitization of contingent pandemic. Supported by the proliferation of new statistical sciences and demography which revealed arcs and correlations in disease patterns, population ‘with its numerical variables of space and chronology, longevity and health’ emerged not only as a problem of government but also a new ‘object of surveillance’ (1980:171-172). New mechanisms for public health surveillance to regulate the health of populations therefore drew upon and were guided from ‘demographic estimates, the calculation of the pyramid of ages, different life expectations and levels of mortality...the body of populations—appears as the bearer of new variables...the biological traits of population become relevant factors for economic management, and it becomes necessary to organise around them, an apparatus which will ensure not only their subjection but the constant increase of their utility’ (ibid). Measures of population-oriented surveillance extended into new domains of observation of urban spaces within the ‘pathogenic city’, including open sewers, drainage, water, and ventilation systems,

⁶ According to Foucault (1980:175), this régime of a population contained the disappearance of the great epidemic tempests, the reduction of the death-rate and the extension of the average life-span and life-expectation for every age group, as its triple objective.

and gave rise to new public health practices of inoculation and vaccinations, and governing through processes of normalization.

This practice and form of early public health surveillance described by Foucault therefore continued to develop into the early twentieth century. As Castillo-Salgado (2010:94) has identified, the practice of public health surveillance of infectious disease outbreaks in the early twentieth century were largely exercised by institutions of sovereign states, and infectious disease reporting was disseminated in the form of ‘weekly reports’ of diseases of critical health or strategic importance related to the security of the population. Within the era preceding the founding of the WHO, the Health Bureau of the League of Nations published the first issue of *Weekly Reports* in 1926. These curated health information reports included the prevalence and mortality rates of five known highly infectious diseases: plague, cholera, yellow fever, typhus and smallpox, additionally this form of infectious disease surveillance and reporting was transmitted via telegram to health authorities. Informationally, the practice of public health surveillance and the dissemination of infectious disease knowledge was underpinned and sustained exclusively by statistical process control paradigms (Velsko and Bates, 2016:189), in which the astute clinician and national institutes of health served as the primary curators of infectious disease knowledge.

Moreover, emergent forms of public health surveillance during the early twentieth century were almost exclusively controlled and developed independently by states seeking to stem the spread of infectious diseases within national jurisdictions. In 1911, the United Kingdom, for the first time, began to analyse National Health Insurance Data for ongoing infectious disease surveillance (Declich and Carter, 1994). Additionally, throughout the early twentieth century, the nascent League of Nations facilitated infectious disease surveillance systems through its regional bureaus including the Far Eastern Bureau, which used wireless reports to broadcast epidemiological data and alerts in telegraphic code covering 56 health administrations and 156 ports and detailing 46 different infectious diseases (Weir and Mykhalovskiy, 2010:66).

Informed by medical case-reporting, clinical observations of patients, and the ‘political arithmetic’ of statistics (Choi, 2012:7), early public health surveillance systems of the twentieth century sought to identify outbreaks of known historical pathogens—cholera, plague, polio, yellow fever, and to understand the prevalence of these infectious diseases among populations in order to limit the spread and severity of the outbreak. Following the dissolution of the League of Nations and the founding of the WHO in 1948, the newly formed was ‘more consciously *inter-national* than the League of Nations, recognizing the primacy of the nation state as the appropriate agent for carrying out such policies [of disease control] (Amrith, 2006:12). With the ratification of the International Sanitary Regulations (1951), all member states of the new WHO were made legally obligated to notify WHO authorities of any known outbreak of plague, cholera, yellow fever, smallpox, typhus and relapsing fever, gradually extending the biopolitical objectives of infectious disease surveillance towards a global level. Notifications of the occurrences of these listed diseases would be undertaken exclusively by the national

health administrations of member states to the WHO, and as Weir and Mykhalovskiy (2010:67), have highlighted ‘[o]nly sovereign states could legally report quarantinable diseases, and each sovereign state could only report on those that occurred within its own territory... [n]otification was thus a sovereign act.’ In addition, the International Sanitary Regulations (1951), provided new frameworks for the timely reporting of public health surveillance; reports of notifiable (urgent) diseases were required to be sent, via telegram to WHO authorities within 24 hours of the identified outbreak (ISR, 1951: Art. 3).

Correspondingly, as the WHO sought to enhance the conduct and self-reporting capacities of its member states, the centrality and role of the practice of *surveillance*, was being redefined by American epidemiologist, Alexander Langmuir. Whereas previous systems of health surveillance of the early modernity referred to the close observation of individuals with suspected smallpox, plague, or cholera (Henderson, 2016:381), Langmuir’s redefinition of the scope of health surveillance practice, sought to elevate the concept away from the observation of individuals, operating instead at the plateau of population, and ‘asserted that its proper use in public health meant the systematic reporting of infectious diseases, the analysis and epidemiologic interpretation of data, and both prompt and widespread dissemination of results’ (ibid). Working within the newly created Centers for Disease Control and Prevention (CDC), Langmuir presented a new definition and criteria for the practice of public health surveillance, which deviated from the early detection of individuals ‘with diseases such as diphtheria, viral encephalitis, anthrax...so that they might be expeditiously isolated and other preventative measures taken’ (ibid), and instead maintained that activities of public health surveillance should be applied to ‘specific diseases rather than specific individuals.’ Accordingly, Langmuir’s revised definition of public health surveillance, when applied to a specific disease referred to:

‘[t]he continued watchfulness over the distribution and trends of incidence through the systematic collection, consolidation, and evaluation of morbidity and mortality reports, and other relevant data. Intrinsic in the concept is the regular dissemination of the basic data and interpretations to all who have contributed and to all others that need to know. The concept, however, does not encompass direct responsibility for control activities. *Those traditionally have been and still remain with the state and local health authorities*’ (Langmuir, 1963:182-183).

Langmuir further identified a number of infectious diseases to be further analysed using new proposed frameworks for public health surveillance initiatives and included malaria, poliomyelitis, and influenza. Langmuir’s reformulation of the understanding and role of infectious disease surveillance as a cornerstone of public health further attracted the interest of emerging global health authorities, and the newly revised concept of surveillance was selected as a topic of technical discussions at the 1968 World Health Assembly (Henderson, 2016:382). The Twenty-First World Health Assembly of the WHO in 1968 defined surveillance as ‘the systematic collection and use of epidemiological information for the planning, implementation, and assessment of disease control...[in this sense] surveillance implies information for action’ (WHO STEPS, 2003:1).

The subsequent adoption of the IHR (1969), further established the centrality of this new form of public health surveillance developed by Langmuir. Among other things, the IHR (1969:5) placed an

increased emphasis on ‘epidemiological surveillance for communicable disease recognition and control...to strengthen the use of epidemiological principles, as applied internationally [and] to detect, reduce or eliminate the sources from which infection spreads.’ Informationally, the adoption of the IHR (1969) built upon technological and communicative advancements to further enhance surveillance practices which had not been feasible a decade before with the passing of the ISR (1951).

The new international health regulations sought to expedite public health surveillance reporting from member states at the earliest sign of a health event and made available to member states, an automatic telex reply service for automatic transmission to any national health administration calling the appropriate telex number (1969:67). Each Friday, important information received during the week and intended for publication in the Weekly Epidemiological Record was summarised and fed into the telex machine for automatic transmission. Health surveillance data supplied by member states was subsequently fed into the Weekly Epidemiological Record of the WHO, published every Friday morning, in English and French, and disseminated to national health administrations by the fastest means possible, containing epidemiological notes and brief reviews of communicable diseases of international importance (*ibid*).

Despite advances in surveillance policy and the merger of surveillance practices with then cutting-edge technology including the telefax, ongoing ‘problems’ both external to and within practices of global health surveillance impeded the timely identification and response to emergent infectious disease outbreaks. Firstly, recalling Weir and Mykhalovskiy development of the reporting of infectious disease outbreaks by WHO member states as a ‘sovereign act’, systems of global health surveillance within the mid-twentieth century were still largely problematized politically by the tenuous relationship between the WHO on one hand, and its member states on the other. While frameworks for infectious disease surveillance and reporting had been established, the preservation of state sovereignty at the heart of the WHO/member state nexus meant that for much of the twentieth century, the WHO and like-minded national governments were effectively reliant upon the transparency and capacity of other state governments to rapidly and accurately report upon new infectious disease outbreaks, in accordance with the IHR (1969). Frequently, the disincentives for member states to be forthcoming and transparent in disease reporting and official notification have resulted in expanding public health emergencies, threatening population security and economic disruption, and have damaged the credibility of the WHO. Moreover, despite the establishment of new techniques and frameworks to guide responses to infectious disease outbreaks within the IHR (1969), many states still operated response measures to disease outbreaks which contravened global health standards and impacted heavily on states which reported the initial outbreak.

As Cash and Narasimhan (2000:1358-59) write, ‘[i]naccurate disease surveillance reports continued to be made by developing countries because of a fear of unduly harsh treatment from the world community.’ Exemplifying this, in 1969/70 the Government of Guinea refused to disclose officially, the presence of growing cholera outbreak within its national jurisdiction. The unprecedented

move by the WHO to report the outbreak without first receiving consent to do so via the Guinean government resulted in a crisis of legitimacy of the WHO so severe, that several of its member states threatened resignation.

Furthermore, in January 1991, an epidemic of cholera emerged in Peru, sparking the first widespread and sustained cholera epidemic in the Western Hemisphere in nearly a century (Sepúlveda et al., 2006:5). Again, failure for the Peruvian Government to disclose the severity of the outbreak resulted in the unprecedented rapid spread of cholera, firstly across jurisdictions in Peru, with 13 provinces within the country having reported more than 45 000 cases and 10 000 hospital admissions in the first month of the outbreak, with an eventual spread across the American continents with 391 220 cases in 16 countries, including Ecuador, Colombia, Panama, Guatemala, Bolivia, El Salvador, and Chile (ibid). Not only had the outbreak in Peru reintroduced the disease into North and South America, but the independent reactions of states external to WHO policy guidelines had exacerbated the outbreak impact on infected states. For Peru, regarded as the epicentre of the outbreak, economic losses on trade alone at the end of 1991 were estimated at more than US\$700 million (Cash and Narasimhan, 2000:1363).

Some years later, in 1994, Bubonic plague emerged in the city of Surat, a port city in the Indian state of Gujarat for the first time in 28 years (Fritz, 1996:30). The resulting social panic which was generated by the reporting of plague in Surat would see hundreds of thousands of the residents of the city fleeing to other large Indian cities including New Delhi and Mumbai. Although the Government of India officially alerted the WHO via IHR (1969) protocols, Indian health officials were unable to collect reliable health information sufficiently to inform others of the nature of the outbreaks in a timely fashion (ibid). Moreover, in certain areas, Indian health officials were faced by a lack of functioning diagnostic laboratories which led health officials to use ‘excessively sensitive clinical diagnoses rather than to confirm diagnoses through culture’ (ibid), which drove the number of confirmed cases significantly higher. As with the outbreak of cholera in Peru, international reactions to the reporting of the outbreak in Surat were swift and severe. Following the closure of trade-links, ports, and international airports to Indian carriers and travellers, total economic loss for India in 1994, as resultant from the outbreak of Bubonic plague totalled US\$ 2 billion (Brahmbhatt and Dutta, 2008:7).

The three examples of Guinea (cholera), Peru (cholera), and India (plague) serve to illustrate and to highlight, the limit of the then current authorised practices of infectious disease surveillance, as well as the gaps which existed between programs of infectious disease control at national levels, and the larger aim of effectively managing infectious disease outbreaks, occurring globally, which was emerging under the stewardship of the WHO from the mid-twentieth century onward. The case-studies emphasise the realities of the political challenge of sovereignty and disincentives to report infectious disease outbreaks by states when faced with swift and punishing downturns on national legitimacy, as well as commercial, economic and trade activity. Owing to the firestorm of controversy which stemmed from the unauthorised disclosure of cholera in Guinea, the WHO was often politically hamstrung by its

provisions of sovereignty via its member states, meaning it was unable to report an ongoing public health emergency, even if aware or alerted of such an incident.

Reflecting on the failure of traditional surveillance practices and the impediments to the global surveillance of infectious disease, Cash and Narasimhan (2000:1363), identified a number of extenuating problematizations to the effectiveness of surveillance systems authorised by the WHO which included: 1) the inability to acquire timely and accurate information early in an outbreak because of low diagnostic capacities in poorer areas and the use of extremely vague case definitions in diagnosis; 2) the rapid spread of press reports that are often inaccurate, sensationalist and lacking in sound advice; 3) the failure of countries to adhere to international standards, including the International Health Regulations and WTO regulations relating to appropriate conduct and response to disease outbreaks and; 4) lack of substantive support for developing countries economically damaged by disease outbreaks.

Diversified Disease Threats and Expanding Surveillance Sources

Throughout the progression of the twentieth century, techniques of infectious disease surveillance authorised by the WHO fell increasingly out of sync in the ability to effectively gain requisite epidemic intelligence on disease outbreaks from its member states, and to rapidly respond to potentially disruptive pathogenic threats as they were reported. The capacity for the WHO to operate responsive infectious disease surveillance systems as part of an expanding government of global health, were frequently compromised on a number of key fronts, including the political acquiescence of its member states to report outbreaks; the persistent gaps in surveillance systems and diagnostic technology which existed between high-income and low-income member states; and the inability of the WHO to officially utilise non-state sources of outbreak information to guide responses to infectious disease outbreaks.

From the 1970s onward, medical practitioners, health researchers, and scientists witnessed the expansion of novel infectious disease threats, previously unobserved with high rates of mortality and rapid contagion. This expanding agenda of new and highly pathogenic diseases further complicated efforts to bolster global infectious disease surveillance as all the new conditions fell outside the remit of the IHR (1969). During the 1970s and 1980s, novel infectious diseases unaddressed within the previous IHR were emerging at a rate never previously witnessed within medical history, and included HIV/AIDS, Ebola and associated haemorrhagic fevers, Chikungunya virus, and highly pathogenic avian

influenza. Through encoding and data-set analysis from 1980-2013, Smith et al. (2014:3-4), have observed 12 102 outbreaks of 215 types of human infections, compromising 44 million human cases in 219 countries over the past three decades, of which zoonotic infections accounted for 65% of diseases within the dataset, collectively causing 56% of all global infections. Collectively, these new emergent infectious diseases were easily disseminated, transmitted from person to person, resulted in high infection and mortality rates, and held the potential for major public health impacts, as well as public panic and societal disruption (CDC, 2007).

Concurrently, as diversified health threats in the form of emergent and re-emergent infectious diseases proliferated from the 1970s onward, so did expanding non-official sources of data, which could serve as potentially indicative of an emergent health event. The first of which, was the international and increasingly 24-hour media syndicate which gradually produced information and findings on infectious disease outbreaks, albeit, unofficially, often in advance of official health reports curated by either national health institutes or the WHO. The circulation of international media reporting for example played key roles in the WHO requests for further information on cholera outbreaks in Ethiopian refugee camps in 1985, and in Algeria in 1987, and was further demonstrative that emerging unofficial health surveillance streams were neither controlled by the WHO nor by its member states (Weir and Mykhalovskiy, 2010). Further to the growth of international media outlets, technological innovations including the debut of the Internet in the 1990s have afforded new channels of transnational and diffuse infectious disease surveillance, and strategies for the strengthening of global health security and pandemic preparedness which differed significantly from the previous operations of health surveillance, predicated on the continuous, systemic collection, analysis and interpretation of population health data, produced and disseminated by clinicians, and controlled by sovereign governments.

Via the conduit of the early World Wide Web, in 1994 the Program for Monitoring Emerging Diseases (ProMED-mail), the first-of-kind digital syndromic surveillance system for infectious disease monitoring went online, seeking to innovate infectious disease surveillance towards the advanced detection of disease outbreaks through the open-source, digitised exchange and uploading of global health reporting. That same year, plague emerged in the Indian city of Surat, generating international panic and fears of the onset of pandemic. In April 1995, an outbreak of a highly contagious haemorrhagic fever in Kitwit, Zaïre was widely reported internationally ‘through a network of informal channels before it could be confirmed as the re-emergence of the Ebola virus (Calain, 2007:3-4). Accordingly, this widely reported public health emergency elevated the revision of infectious disease surveillance to the core of global health agendas of the 1990s, and led to the revival of interest in the IHR (ibid).

Further in 1995, the World Health Assembly, in light of the expanding emerging infectious disease threat, and in recognising the growing inability of traditional surveillance systems to rapidly identify potential pandemic threats, passed Resolution 48.13, in which the assembly expressed concern ‘for the lack of coordinated global surveillance to monitor, report, and respond to new, emerging, and

re-emerging infectious disease, by the general absence of the diagnostic capabilities necessary to identify accurately pathogenic microorganisms and the insufficient numbers of trained healthcare professionals to investigate these infectious diseases' (WHA, 1995). The World Health Assembly further passed Resolution 48.7 in 1995 which called for a comprehensive revision of the existing International Health Regulations in light of expanding emerging disease threats and the narrow scope of legally notifiable diseases contained within the regulations, and in October 1995, established a new Division of Emerging Viral and Bacterial Diseases Surveillance and Control, later to be renamed as the Department of Communicable Diseases Surveillance and Response (CSR).

SARS, Syndromic Surveillance and the International Health Regulations (IHR)

Confronted with increasingly frequent pathogenic outbreaks circulating globally from the latter twentieth century onward, practices of infectious disease surveillance and the sources of data which sustained these surveillance activities transformed considerably, with the emergence of novel techniques and practices of surveillance. The practice of clinical health surveillance, which had been the hallmark of early modern health systems remained a central pillar of public health security initiatives, however new apparatuses of health security began to increasingly orientate surveillance practices towards the level of the global biopolitical, in which detection, assessment, and immediate reporting, as well as timelier information and data on a varying range of health threats (Ziemann et al., 2015:2), were emphasised as foundational elements to any emergent system of global health.

Correspondingly, from the 1990s onward, technological innovations and the advent of the World Wide Web, significantly expanded global interconnectivity and digital communications resulting in the growth of Eysenbach (2003:1-2) has conceptualised as *population health technologies*; 'an umbrella term for technology applications that have a population focus and the potential to improve public health. This includes the Internet, but also other technologies such as wireless devices, mobile phones, smart applications, or smart homes...[i]n the context of an outbreak or bioterrorism attack, such technologies may help gather intelligence, and detect disease early, and communicate and exchange information electronically worldwide.' Reflective of expanding sets of open-source and unofficial epidemiological information being generated by digitised population health technologies, the WHO sought to expand and supplement existing disease surveillance by entering into partnership programmes with its member states to access and utilise emerging infectious disease data sources being conveyed by non-governmental sources.

Therefore, in addition to the debut of ProMED-mail in 1994, 1997 saw the launch of the Global Public Health Intelligence Network (GPHIN), an online, partially automated early-warning system that sought to alert its subscribers to a wide-range of information about potential outbreaks as close to real-time as possible (Mykhalovskiy and Weir, 2006). GPHIN, which was resultant from a partnership

between the WHO and Health Canada, the first of such partnerships towards new methods of enhanced surveillance, demonstrated publicly, the first recourse of the WHO towards harnessing unofficial infectious outbreak data via new channels of *syndromic surveillance*. Unlike traditional clinical health surveillance which were predicated on a classification of cases based on clinical diagnosis, case-reporting, as well as and laboratory, and epidemiological testing, which were utilised to enable the identification of possible, probable and confirmed disease outbreaks (Ziemann et al., 2015:2-3), emergent practices of syndromic surveillance, as defined by the Triple S-Age project, a European Union initiative to increase the capacity of real-time or near real-time surveillance of health events, constitute: ‘The real-time (or near real-time) collection, analysis, interpretation, and dissemination of health-related data to enable the early identification of the impact of potential human public health threats that require public health action. Syndromic surveillance is not based on the laboratory-confirmed diagnosis of a disease by on non-specific health indicators including clinical signs, symptoms as well as proxy measures. The data are usually collected for purposes other than surveillance and, where possible, are automatically generated so as not to impose an additional burden on the data providers. Syndromic surveillance tends to be non-specific yet sensitive and rapid, and can augment and complement the information provided by traditional test-based surveillance systems’ (2011:1833).

Moreover, as the Triple S-Age report highlights, the concept of syndromic surveillance was first presented in the late 1990s with the aim of providing early-warning of disease outbreaks and potential bioterrorist actions. The report further recognised the vast quantities of potential data sources served as an important early rationality towards the development of syndromic surveillance systems (ibid). The engagement of the WHO in the development and piloting of GPHIN from 1997 onward therefore placed new emphasis on the necessity of accurate and timely surveillance to have knowledge of any potential health threat (Wenham, 2015:108), and indicated a further strategic and political move via syndromic surveillance practices towards the collection and assessment of largely transnationalised, digitised and open-source health data to address the probabilities of future pandemics.

2002/03 witnessed the emergence and ‘sudden bolting’ of SARS out of its origins in Guangdong Province, China, where the novel coronavirus quickly overwhelmed existing public health infrastructures, spreading internationally in the short span of weeks, spiralling into a globalised public health emergency. The emergence of SARS once again served to highlight the shortcomings with the practice and implementation of global infectious disease surveillance at the onset of the new millennium. Despite earlier calls by the WHO to bolster and further enhance lagging infectious disease capacities, the Chinese health system, very much the product of post-Maoist pursuits of economic development had side-lined investments in health expenditure, resulting in the downgrading and de-emphasis of crucial public health instruments, including responsive and timely health surveillance.

Furthermore, while the failure of effective and transparent reporting of infectious disease outbreaks on part of the Chinese government has been widely documented, what remains significant is the degree in which domestically and via channels of its sovereignty, China sought to obfuscate details of the emerging public health emergency in the early days of SARS. Not only did Chinese authorities for example issue directives on the banning of media coverage of SARS (Zittrain, 2004), but media

outlets in China, deferring to authorities, did not attribute blame to the government nor offer critical reporting on the SARS outbreak (Hong, 2007:698). What is more, as the profile of the novel coronavirus fell outside the scope of the then unrevised International Health Regulations, as a technicality, China was not obligated to disclose this epidemic information to global health authorities.

Within the context of the SARS public health emergency, practices of syndromic surveillance once more emerged as a novel and strategically valuable channel in the gathering and assessment of epidemic intelligence to prepare for exceptional health events. The SARS outbreak occurred correspondingly within the growing online and digital era of the 2000s which saw the proliferation of ‘countless applications of new techniques in analysing and exploiting Big Data...accumulated in real-time’ (Rouvroy, 2016a:3-8). Exemplifying this informational transition in infectious disease surveillance, the Canadian based syndromic surveillance system GPHIN, through its automated web-crawling and mining capacities, and algorithmic filtration system, was the first public health sentinel to detect cases and reports of a circulating atypical pneumonia, derived from Chinese online media sources several months in advance of any reference of the public health episode from Chinese health authorities.

Significantly, from its algorithmically guided scanning and filtration of unstructured digital data, GPHIN was further able to continuously monitor and provide information about the number of suspected and probable SARS cases reported worldwide on a near real-time basis. GPHIN’s information was $\approx 2-3$ days ahead of the official WHO report of confirmed and probable cases worldwide (Keller et al., 2009:691). Demonstrating the emerging capacity of these digital syndromic surveillance systems to effectively bypass obstacles by reticent WHO member states, and to generate crucial epidemic intelligence to guide responses and contingency planning towards the threat of pandemic and the management of circulating pathogens. Emergent syndromic surveillance technologies therefore could potentially be utilised not only to supplement the need to timely and routinely identify aberrant global disease patterns, but could now additionally help to enforce new standards of reporting and monitoring protocols in the practicing of global health security and infectious disease surveillance in ‘naming and shaming’ recalcitrant governments (Kamradt-Scott, 2015:122).

In the wake SARS and the inability of the Chinese Government to effectively mitigate the spread of the coronavirus, consensus and international momentum swung strongly in favour of the need to address and revise the International Health Regulations, and to bolster systems of infectious disease surveillance in preventing pandemic illnesses. Following the acquiescence of member states to consider much needed improvements to the existing regulations, a new draft of the International Health Regulations was accepted in 2005. On 15 July 2007 the revised IHR (2005), entered into force, obligating 196 State Parties to detect, assess, report, and respond to potential public health emergencies of international concern (PHEIC) at all levels of government, and to report such events rapidly to the WHO to determine whether a coordinated response is required (Katz and Dowell, 2015: e352).

Significantly, not only did the revised regulations expand the list of notifiable infectious diseases to include: smallpox, wild poliomyelitis, novel subtypes of human influenza, SARS, cholera,

pneumonic plague, yellow fever, viral haemorrhagic fevers, and West Nile fever, but the ratification of the IHR (2005), sought to transform the role and practice of infectious disease surveillance in a globalised ‘world on alert’, increasingly concerned with pandemic threat. In seeking to address the shortfalls for the notification of a health event, the revised IHR (2005) significantly expanded the provisions for accessing emergent alternative forms of epidemic intelligence and data to assist in the reporting of probable public health emergencies, and in the governing of future pandemic contingencies. Unlike previous editions of the health regulations, the IHR (2005) now explicitly authorised the use of novel syndromic surveillance data and associated ‘unofficial’ health reporting systems. Specifically, Article 9.1 of the regulations authorises the WHO ‘to take into account reports from sources other than notifications or consultations and shall assess these reports according to established epidemiological principles and then communicate information on the event to the State Party in whose territory the event is allegedly occurring.’

Even prior to the outbreak of SAR, the WHO had been moving to develop alternative surveillance systems via the utilisation of increasingly diffuse and digitised open-source data to further strengthen the governing of pandemic threat. As early as 1999, the WHO and Health Canada agreed that GPHIN would henceforth provide the WHO with all its disease monitoring data, and that the WHO would use this information as the foundation for wider disease control (Wenham, 2015:111). GPHIN also became a founding surveillance system in 2000 with the WHO’s creation of the Global Outbreak Alert & Response Network (GOARN). While the digitised epidemic intelligence supplied by syndromic surveillance systems including ProMED-mail and GPHIN had been discreetly utilised by the WHO from the late 1990s onward, the inclusion of this novel type of infectious disease surveillance data, contained within Article 9.1 of the revised International Health Regulations signalled further the growing saliency of algorithmically produced syndromic surveillance data in both overcoming issues of accessing epidemiological information, which previously had been problematized during public health emergencies and in the continued vigilance against future-situated pathogenic threats.

While the practice of syndromic surveillance has been increasingly integrated into expanding regimes of global health surveillance—both the gaze of syndromic surveillance, as well as the sources of intelligence it seeks to observe have evolved and transformed considerably via the increased utilisation of algorithmic programming for data acquisition and presentation over the past two decades. Syndromic surveillance emerged as an alternative channel of obtaining information and knowledge about probable health events through a methodology which deviated significantly from the traditional processes of statistical knowledge generation. As Mykhalovskiy and Weir (2006:43) have discussed, the early design of GPHIN originated among officials and staff of Health Canada, whom had observed that during the 1994 outbreak of plague in Surat, India, e-mails exchanges via physicians for real-time reporting and situational updates significantly outpaced official country and government notification and communication of similar public health emergencies. Correspondingly, these early syndromic surveillance systems sought to re-orientate and apply the gaze of surveillance to incorporate a novel

and broad scope of alternative data sources to indicate aberrant health patterns or ‘clusters’ in progress. As such, the early practice of syndromic surveillance sought to harness and assess a variety of unofficial health data including paper or digitised reports of over-the-counter drug prescription sales, school or workplace absenteeism, media reports, A&E visit logs and phone-calls to healthcare providers (Henning, 2004).

The first of kind online syndromic surveillance system, ProMED-mail originally served as an inter-connected online forum wherein health reports, queries, observations, could be uploaded and exchanged via the real-time medium of the Internet and e-mailing lists. A further transition in harnessing epidemic intelligence via syndromic surveillance systems occurred in the early 2000s with the rapid generation of digitised open-source health data produced by online activities. Specifically, as Eysenbach (2006:244-245), has highlighted the systemic collecting and analyses of health information data from the Internet in the growing digital era ‘has considerable potential to be used for syndromic surveillance...[and that] [t]racking web searches on the Internet has the potential to predict population-based events relevant for public health purposes.’ While the study noted that previous systems of syndromic surveillance had utilised data sources from ‘clinical encounters with health professionals’, it additionally maintained that until 2004, there was no ‘prior evaluation of the use of Internet search data for syndromic surveillance’ (ibid).

As highlighted by Paterson and Durrheim (2013:44), from 2005 onward, there was a second wave of policy and research interest in practices of syndromic surveillance, with a noted decrease in the number of publications addressing the topic in relation to bioterrorism, shifting in focus to emergent diseases and pandemics. Significantly, within the rise of the Big Data era, technological advancements including increased automation and recourse to the power of algorithmic filtration, sorting and presentation have been progressively applied and integrated into syndromic surveillance systems. As Antoinette Rouvroy (2016a:10), has explained, the term and era of Big Data ‘refers not only to the huge volumes of complex, rapidly accumulated digital data, but also the new software techniques (data mining, machine learning, social network analysis, predictive analytics, ‘sense making’, natural language processing visualization etc.) without which the data would tell us nothing.’ As both the volume and variety of open-source infectious disease data continue to generate infinitely in the wake of the Big Data shift, it is at this junction in the practice of syndromic surveillance and the pre-emption of contingent pandemic that the algorithm seems to emerge as a practical ‘objective’ tool and purveyor of varied, voluminous and expedited data sources against future infectious disease threats.

In seeking to address the future-situated threat of pandemic illness, algorithmically-guided syndromic surveillance systems have increasingly proliferated across the landscapes of global health to ‘access, organize, and glean discoveries from huge volumes of digital data’ (Lerman, 2013:59), and to produce meanings and insights from data-correlations about yet-unforeseen public health emergencies, representing new ‘truth-telling- technologies for the governing of future events. When contextualised alongside the rise of Big Data, the digital era, and increasingly algorithmically-informed technologies

for security, practices of syndromic surveillance which initially emerged in the mid-late 1990s for public health purposes have transformed significantly over time and reflect ‘a dynamic evolution from the collection, the interpretation of data, and dissemination of data’ for the early detection of emerging health threats (Paterson and Durrheim, 2013:46). Reflecting the growing capacity for algorithmic programming to seamlessly observe and report upon health events and alerts mined from a plethora of digital data sources, on 14 March 2014, the syndromic surveillance system HealthMap disseminated a health alert via its website detailing the emergence of a strange haemorrhagic fever which had emerged in Macenta, Guinea, 800km from the capital of Conakry. Nine days later, the Ministry of Health of Guinea gave official notification of a rapidly evolving outbreak of Ebola haemorrhagic in the heavily forested areas of the country.

Conclusion: Algorithmic Government and Infectious Disease Surveillance in the Twenty-First Century

This chapter has situated the development and practice of infectious disease surveillance as an integral component within larger governmental systems of global health security. In doing so, it has considered the evolution of various mechanisms and technologies for population security which have been implemented to assess and forecast upon uncertain futures and yet-unforeseen pandemic threats. In reviewing a century of infectious disease surveillance, this chapter has highlighted the significance Foucault’s population-centred health surveillance, and the emergent technologies of security which informed the politics of infectious disease control at national. Emergent security practices of statistical calculation and the generation of population tables, birth and death records, registers of epidemiology and disease profiles produced understandings of disease and contagion patterns requisite to monitor the arcs and distributions of probable pandemic, and these practices of statistical ‘truth-telling’ were further utilised to guide public health interventions to minimise pandemic illness and to halt and regulate the ‘sudden bolting’ of pandemic phenomena across populations and systems of economic circulation.

The founding of the WHO in 1948 and the elevation of the concept of ‘global’ health as a biopolitical project beyond borders of the sovereign member states of the WHO however, problematized the established practice and steadfastness of clinical health surveillance and the channelling of epidemic intelligence for infectious disease outbreaks. Despite, its role as the primary active agent which sought to solidify new biopolitical practices of ‘global’ health mid-century onward, the WHO, was frequently

unable to acquire the requisite epidemiological knowledge needed for the timely and proportionate responding to a host of infectious disease outbreaks occurring across its network. In a number of incidents non-compliant member states failed to supply global health authorities with infectious disease data due to a number of extenuating political, technical, and scientific impediments to effective and transparent infectious disease reporting, all of which represented the emergence of new problems in the governing of global populations from the mid-twentieth century onward. With the continued acceleration of globalization, and the new and interconnected complexity of emergent and re-emergent infectious diseases, the WHO was increasingly out of pace in the surveillance and response of highly infectious pandemic illness. For Weir and Mykhalovskiy (2010:118), '[o]utbreak and epidemic control occurred in local time and place, were weakly articulated to both official and unofficial knowledge in the first weeks of onset, and were incorporated in national and global time after the fact.'

Corresponding with epistemic shifts within the emergence of non-traditional security threats, the politics of infectious disease surveillance increasingly are now imbued with emergent technological advancements in addressing the shortcomings of traditional statistical surveillance to unveil and present incalculable and increasingly uncertain futures (Amoore and Raley, 2016:1-2). Owing in large part to the unprecedented scope of technological and digital innovation, as well as the infinite production of diffuse data streams of the 1990s, open-source syndromic surveillance systems have emerged and proliferated in response to a series of interconnected and complex problematizations within governmental systems of global health. While the first of these systems, ProMED-mail sought to provide an online and interactive forum for the exchange, uploading and dissemination of curated open-source health reports, and relied exclusively on human analytics and labour, what significantly emerges with the iterative evaluation of these syndromic surveillance systems from ProMED-mail-→GPHIN-→ HealthMap over the course of more than a decade, is the power and rise of the algorithm in these security technologies for generation of future-situated knowledge of pandemic events, and the overall strengthening of systems of global health security.

The emergence of the algorithm within surveillance systems of the early twenty-first century is salient in several key areas. Foremost, they are representative of a new rationality of security, developed from the understandings of urgency and expediency which fostered systems of global health security and a world on 'alert' from the 1990s onward. With the capacity to expand the scope and gaze of automated surveillance in methods previously unfeasible through the sole utilisation of statistical calculation and human analytics, algorithmic infectious disease surveillance systems have emerged as part of a larger global context of general securitization. As Ayşe Ceyhan (2008:103) identifies 'security technologies which were previously used in pilot programs such as border controls...and on specific, marginal populations have now broadened their scope to embrace the whole population...[h]eterogeneous security technologies have been accepted as a universal security enabler in an environment characterized by uncertainty, the unknown and risk generated by globalization, and reinforced by 11 September.' The creeping and discreet presence of algorithmic programming within

syndromic surveillance systems from GPHIN onward is indicative of a broader and growing practice of automated and algorithmic-driven security within international relations whereby algorithms form components of new digital security assemblages aimed at addressing the uncertain and the future contingent, which also include biometrics, and body scanners, computers, files and databases (Amicelle et al., 2015:293).

Unlike traditional forms of infectious disease surveillance which documented and sought to signal alerts of the physical/pathogenic world, the distinct form of algorithmic health surveillance is located within the digital world. Whereas traditional public health surveillance sought to generate and collect scientific data and to subject this laboratory testing and verification to generate population-specific infectious disease knowledge, the operation of algorithmic surveillance within an expanding context of Big Data ‘immediately evoke a change in the approach to the detection, classification and predictive assessment of events in the world...therefore, a new way of making the world predictable’ (Rouvroy, 2016a:17). What this means is that within an era of inexhaustible data supply, and increasingly sophisticated digital algorithms for collecting, archiving, processing, organising and reporting upon data sets, algorithmic infectious disease surveillance increasingly informs interventions and actions of the *physical* world with correlations and patterns derived from the external *digital* world.

Algorithmic surveillance systems for infectious disease therefore re-contour the margins and zones of what or who is to be surveyed, applying the gaze of surveillance to the streams of online digital data, increasingly bypassing any interaction with the human or the physical subject as in previous eras, and operating solely on a regime of alerts, signals and correlations between data in the construction of temporal bridges between present and possible security futures (De Goede et al., 2014:411). The exponential increase in processing capacity, storage capacity and communication capacity of algorithmic surveillance systems over the past two decades has thus in turn generated new capabilities for pre-emptive analysis and automated decisions (Rouvroy, 2016a:5-18). With the capacity to survey, capture, process and present relevant data-findings at a real-time rate never previously possible in history, algorithmic surveillance systems are increasingly able to indicate and alert the anticipation of forthcoming events or uncertainties, rather than simply reacting to them, pulling the future-uncertain into that of the present.

Lastly, it is important to consider the ways in which the rise of this new form of algorithmic surveillance for infectious disease reporting re-contours the governing and security policies of global health in the twenty-first century. The overall biopolitical objective of a responsive and effective global health surveillance framework therefore, has frequently been impacted by a number of problems of government, most significantly the non-compliance of states via the WHO to openly and transparently report upon infectious disease outbreaks and pathogenic threats occurring within national jurisdictions. In seeking to address these challenges to the government infectious disease, algorithmic surveillance has increasingly emerged as an effective technology of security for the timely identification of future pandemics as well as enforcing compliance and self-regulation of WHO member states.

Politically, the ratification of the IHR (2005) and the growing recourse to data supplied by algorithmic syndromic surveillance systems provided in Article 9.1, served as the strongest confirmation of the strategic value of this new practice of infectious disease surveillance. Legally, what this further signified was that this type and practice of open-source health surveillance would not simply operate independently on the margins of global health security practices, but alternatively would be centralised and integrated into the operating platform of the WHO's central disease sentinels, including GOARN, which would be used not only to scan future horizons of coming or probable pandemics, but could be utilised further to strengthen the overall objectives and function of governmental systems of global health.

The ratification of the IHR and the coming into effect of the regulations in 2007 further codified the legal power of algorithmic syndromic surveillance systems as new pandemic forecasting technologies. The WHO would now be cleared to seek data supplied by these security devices, and member states of the WHO, while theoretically still sovereign, would now be legally obligated to respond to any further information inquests from WHO authorities within a 24-hour timeframe (Article 10.1). In codifying a zone of operation for these syndromic surveillance systems within the International Health Regulations, member states of the WHO themselves would now be adherent to a new regime of increased visibility and self-regulation enhanced by the authorised presence of data-crunching algorithms across the global health landscape. Recalling the transformative surveillance effects on process and regulation of the *Panopticon*, as originally described by Jeremy Bentham and later presented by Foucault, reflects new shifts within the conduct of infectious disease reporting through the increased capacity to anticipate pandemics and 'name and shame' non-compliant states, in 2013 during the H7N9 epidemic, Chinese authorities were commended globally for their rapid response and transparency to the epidemic (Wei et al., 2016:2), only a decade on from the SARS public health episode. This chapter therefore, has discussed the evolving and contrasting practice of infectious disease surveillance over the course of a century. This discussion has set into context, how novel and distinctive forms and applications of surveillance have developed as a response to the growing problematizations and expanding scope of security challenges represented by pandemic illness from one period to the next.

This chapter has considered in addition, the long-standing correlation between technological advancements and increasingly sophisticated or cutting-edge surveillance systems, and has further highlighted the common objective of all surveillance systems to continually harness and accumulate ever-greater volumes of data and epidemic intelligence in the forecasting of probable pandemic illness, to know, and thus effectively govern the emergence of these events. It has outlined additionally, that within the practice of international relations and the expanding site of global health security, the sovereignty of states within the international has recurrently represented a *political* problem towards securitizing uncertain futures and contingent public health emergencies. Resultant from this refinement of security perspective from the late twentieth century onward, the novel practice of *syndromic*

surveillance emerged and expanded from the 1990s, seeking to generate new channels of disseminating epidemic intelligence and to harness and process the increasingly voluminous streams of digitised and open-source data which had proliferated as a result of the rise of the Big Data era. The practice of syndromic surveillance from 1994 onward has become increasingly automated, with algorithmic processing emerging as an underpinning operational logic within these syndromic surveillance systems to continually harness and forecast upon the volume, variety, and velocity represented by infinite sources of digitised and diffuse data streams, which may indicate the sudden emergence of pandemic threats.

Algorithmically-informed syndromic surveillance systems have yielded uncertain futures visible in the advanced forecasting of public health emergencies including SARS in 2002/03 and the Ebola Virus Disease in 2014. Subsequently, the expanding practice of global health security led primarily by WHO, has rapidly legitimised and expanded new legal and diplomatic provisions for the accessing, utilisation, and harnessing of this novel type of surveillance data in an era of globalised threat and pandemic circulation. The succeeding chapter of this thesis seeks therefore to introduce and present an analysis and conceptual framework in which to discuss the rise of syndromic surveillance systems, as novel technologies of security within overarching systems of global health. Utilising an initial framework, provided by Michel Foucault, inspired broadly by his conceptualisations of biopolitics and governmentality, the chapter considers further how emergent [algorithmic] governmental rationalities brought forth by the increased recourse of algorithmic programming and logic demonstrated by these systems from 1994-2006, produce divergences in thinking conceptually, in relation to the rise of these new health surveillance technologies.

Chapter Three: [Algorithmic] Governmentality and Infectious Disease Surveillance

Introduction

This chapter examines the theoretical discussions which emerge following the steady recourse to automation and algorithmic-programming seen within the syndromic surveillance systems presented in this thesis over the past two decades. This chapter discusses what, for example, are the political rationalities which have facilitated the design, emergence, and proliferation of these online health surveillant technologies? Furthermore, what are the potential wider security contexts in which these surveillance models have arisen as new apparatuses of global health security? The subsequent framework of this thesis will initiate a broad analysis of these novel syndromic surveillance systems through utilising the frameworks introduced by French social theorist, historian, and philosopher, Michel Foucault, (1926-1984). Specifically, the theoretical framework of this research thesis will seek to discuss and present the relevancy of Foucault's conceptualisations of key themes including *biopolitics*, and *governmentality* in relation to the iterative evolution and steady recourse towards automated health surveillance processes exemplified by ProMED-mail, GHPIN, and HealthMap.

The theoretical framework begins with an introduction of Foucault's analysis of economies of power, which will further explain and present the rationalities of population-oriented health surveillance. In doing so, this chapter introduces and presents Foucault's conceptualisation of

biopolitics, utilised to explore and consider how these syndromic surveillance systems represent the most recent development of techniques that focus on the management of healthy and productive populations, regulating the circulation of people, commodities, diseases, crimes etc. (Munro, 2011:346), increasingly at the level of the global. Moreover, the concept of biopolitics is central to the shift described by Foucault (2007), in which during the eighteenth century, the emergence of problems of government and the designing of biopolitical techniques aimed at the optimisation of population, gave rise to a novel economy of power, which Foucault refers to as the ‘the apparatus of security’.

Accordingly therefore, with the new emergence of a biopolitical modality of power, which had as its political end, the regulation of healthy populations, biopolitics for Foucault is marked as a the development of a ‘regime dominated by techniques of government [which] revolves around population...which has led to the development of a series of specific governmental apparatuses (appareils) on one hand, and on the other hand, to the development of a series of knowledges (savoirs) (Foucault, 2007:106-108). In thinking therefore in relational terms to the syndromic surveillance case-studies within this research thesis, ProMED-mail, GPHIN, and HealthMap will be broadly conceptualised as next-generation health security systems, which have as central operating rationalities, the biopolitical regulation of the health of populations.

Subsequently, in unpacking biopolitics following the rise of algorithmically-driven syndromic surveillance systems, this theoretical framework engages further with the extensive research conducted by Foucault on the practices and form of *governmentality*, a novel logic of power and management which was informed and foregrounded in ‘how in the eighteenth century the population emerged as a ‘natural-cultural reality’ resulting from an integration of biological and economic knowledge’ (Villadsen and Wahlberg, 2015:1), which in turn, marked an epistemic transition away from the disciplinarian forms and exercise of power which had preceded the governmental state in early modernity. For Foucault then, governmentality was indicative of the development of an assemblage of novel rationalities, approaches, and techniques which emerged as responses to the governing of innumerable dynamics and uncertainties which accompanied the rise of the modern state, which included novel perspectives and techniques in addressing economic circulation, food scarcity, and the problem of sudden or naturally reoccurring epidemics and pandemics.

While governmentality referred to the assemblages of new techniques and perspectives of governing to markedly *new* problems of government, biopolitics, represented the generation of new forms of power and knowledge towards the regulation and maintenance of a healthy and productive population, and sought to develop systems of security no longer oriented towards the demarcating, fixing, protecting, or enlarging of sovereign territory (Foucault, 2007:64-65), but rather towards addressing a *crises of circulation*. For Foucault, this represented a new problem of government ‘of allowing circulations to take place, of controlling them, sifting the good and the bad, ensuring that things are always in movement...continually going from one point to another, but in such a way that the inherent dangers of this circulation are canceled out’ (ibid). Moreover, essential to governmental

rationalities and emergent biopolitical techniques, was the novel generation of statistics and statistical information which emerged as specific forms of knowledge in the sixteenth century and increased in scope in the seventeenth century.

Referred to as the ‘science of the state’, the generation of statistical knowledge in European states, informed new methods of regulation on populations and were utilised to *unveil* and render visible, ‘knowledge of the state in its different elements, dimensions, and the factors of its strength...[s]tatistics enables the specific phenomena of population to be quantified. This means that the population will be the object that government will have to take into account in its observations and knowledge, in order to govern effectively in a rationally reflected manner’ (2007:101-106). Correspondingly, in considering the perspectives of governmentality and biopolitics presented by Foucault, this thesis works to present new syndromic surveillance systems emergent governmental technologies of security which seek, reflective of the scholarship of Foucault, emerge within a new collection of global health security actors, and operate to generate knowledge of contingent infectious disease threats for the continued securitization of population well-being and economic circulation.

And yet, while the contributions of Foucault within the areas of population management, infectious disease surveillance and techniques of government are well-documented and discussed broadly within the social sciences, this research thesis is further interested in developing new considerations of governmentality which have emerged from various technological transitions within the digital era, particularly with projects related to digital technologies (Rodrigues, 2016:1). Certainly, much has changed since the death of Foucault in 1984, including rapid advancements in telecommunications, the extension of innumerable digital, electronic and surveillance platforms and the subsequent ‘flattening’ of the world into a highly interconnected system of globalised networks, indicate vast changes which have occurred since the death of Foucault, and thus, new areas of critical discussion remain unaddressed. Indeed, as Aradau and Blanke (2015:1) highlight , ‘the emergence of ‘Big Data’ have rekindled questions about how security practices are deployed in a digital age, and with what political effects.’

How therefore, can Foucault’s understandings of the form and rationalities of governmentality be readdressed or extended into the present when considered alongside the increasing commonplace of automation and algorithmic-programming within a range of novel technologies for addressing insecurity, which include syndromic surveillance systems? In departing for example, from the supremacy of statistics, which guided and informed preceding governmental practices and biopolitical initiatives, how are techniques of knowledge creation and discovery transformed with the present ‘capacity for analytics to derive the subject of interest from clusters or patterns in large volumes of data, otherwise imperceptible to human reading’ (Amoore and Piotukh, 2015:341)? How do new forms of knowledge for addressing pandemic uncertainties, facilitated by algorithmic processes and disseminated by these syndromic surveillance systems transform the nature of analysis and knowledge...and the governing of economic, social, and political life (ibid)? Does the rise of these new

syndromic surveillance systems, guided via algorithms indicate shifting governmental rationalities in present systems of global health?

In seeking therefore to extend Foucault's original contributions of governmentality within systems of infectious disease surveillance, the theoretical framework argues that new forms of data collection and processing, increasingly afforded by digital technologies including the algorithm, have generated new practices of infectious disease surveillance and generation of knowledge through automation and calculation for the addressing of pathogenic uncertainties in the twenty-first century. Consequently, while this research thesis considers the ways in which these new syndromic surveillance systems *are* representative of governmental technologies, it develops a further critical discussion on how the rise of syndromic surveillance systems, powered via algorithms depart from traditional understandings of governmentality within several critical areas.

In considering the emergence of increasingly algorithmically guided syndromic surveillance systems, designed for the strengthening of global health security over the past two decades, the theoretical framework further seeks to engage with the research and conceptualisations of a novel *algorithmic governmentality*, presented by Belgian political-legal theorist Antoinette Rouvroy, which has increasingly taken form, resultant from a convergence of heightened anxieties of uncertain threats in a globalised era of hyper-circulation on one hand, as well as the emergence of new security techniques oriented towards mining infinite data-scapes to derive correlations indicative of future-situated, and forthcoming emergencies on the other. Situated in the present era of Big Data, and represented by new tools with the capacity to aggregate, filter, process, and translate potentially strategic data streams for meaning at a rate never previously possible in preceding systems of government, this theoretical framework, vis á vis Rouvroy's conceptualisations of algorithmic governmentality will assert that the increased integration of algorithmic programming within contemporary syndromic surveillance systems therefore indicates a significant and novel governmental shift within three key areas which diverge considerably from previous systems of governmentality presented by Foucault.

Biopolitics

In accordance with the conceptualisation of Foucault traced during the lecture-series' of *The Birth of Biopolitics*, and *Security, Territory, Population*, biopolitics refers to the development of a significant, yet finite perspective of power, related to the recognition of the potentiality of population as an object of governance during the birth of the modern nation state in which a nascent form of liberalism sought maximum effectiveness by governing less, at the level of population, and in accordance with the naturalness of specific phenomena to be governed (Foucault, 2004). Regarded as a new perspective which guided forms of power from the birth of the modern state onward, biopolitics thus seeks to address and respond to a collection of related questions posed by Foucault: What happens to the political rationalities and technologies of power, to the problematization of security, and to the character of

security technologies when— taking species life as its referent object— power comes to strategise human beings politically? (Dillon and Lobo-Guerrero, 2008: 266).

With the modern recognition of populations as new objects for regulation, and optimisation via emergent forms of knowledge production and technique, biopolitics therefore would come to represent specific formations of power, which had as objectives, the regulation and optimisation of population. The emergence of biopolitics marks a further conceptual departure away from the preceding forms of disciplinary power, or the ‘anatomy-politics of the body’, as outlined by Foucault (2004), in his 1975/76 lecture-series, *Society Must Be Defended*.

The practice of power and regulation upon the body within new biopolitical initiatives therefore would occur no longer through direct discipline on the body of the individual, but rather would be transformed into novel biopolitical techniques for the management of populations, as living realities. Biopolitics developed new techniques for the management of variations and occurring phenomena within populations, and included natural and organic sciences and medicine such as demography, psychiatry, criminology, and eugenics (Munro, 2011:346). What is more, with the birth of the biopolitical gaze toward the optimisation of a productive population, the new art of statistics assumed a critical role and was utilised to unveil truths or realities of the population in question. Statistical science within biopolitical techniques, established a mode of governing and regulating the population known as *normalization*.

Unlike therefore, in preceding disciplinary systems where ‘one started from a norm and it was in relation to the training carried out with reference to the form that the normal could be distinguished from the abnormal’ (Foucault, 2007:63), the generation of statistical normalization and governing through biopolitics involved ‘a plotting of the normal and the abnormal, of different curves of normality, and the operation of normalization consists in establishing an interplay between these different distributions of normality and [in] acting to bring the most unfavourable in line with the more favourable...These distributions will serve as the norm...what is involved here is no longer normation, but rather normalization in the strict sense’ (ibid). The interplay and dynamic of curves, arcs, and of the norm, informed and guided by statistics would now serve as the regulating element in the biopolitical regulation of population, through the implementation of specific apparatuses of security, informed by new liberal perspectives of modernity, these biopolitical security apparatuses sought to regulate and survey populations at distance, to govern within the natural intervals of population health, and to allow the positive aspects of both population and economy to *circulate* naturally.

Biopolitics therefore refers to the responses and regulation of specific and complex problems of modern government. Biopolitical perspectives of government generate therefore, appropriate and responsive security techniques which simultaneously optimise positive circulation and the productive well-being of populations, which also seek to reduce or negate potential threats through statistical analysis, probability, pre-emption and intervention. As Dillon has argued, ‘Biopolitics is a *dispositif de sécurité* which secures—that is to say regulates, strategies, and seeks to manipulate the circulation

of species life—by instantiating a general economy of the contingent throughout all the processes of reproductive circulation which impinge upon species existences as such’ (2007 cited in Aradau and Blanke, 2010:44).

Within a twenty-first century, highly globalised context, with ever increasing uncertainty within areas of economy, health, and population, biopolitics understood as the securitization of populations and the governance of biological life from probable or as yet unforeseen threats including HIV/AIDS, avian influenza, Ebola, and bioterrorism through the development of regulating security mechanisms continues to serve as a relevant and significant analytic tool. The rise of the syndromic surveillance systems of ProMED-mail, GPHIN, and HealthMap for example, have occurred within broader global biopolitical discourses of the late twentieth century have increasingly highlighted the interconnected nature of population well-being, and economic circulation with looming and probable threats of pandemic outbreak, highlighted for example by the Emergencies Preparedness Response Program of the World Health Organization (WHO, 2016c), which has maintained that due to ‘ the increase in global transport, as well as urbanization and overcrowded conditions, epidemics due to new influenza viruses are likely to quickly take hold around the world.’

Indeed, the increased complexity for the governing of infectious disease threats in the era of global health security have produced new biopolitical techniques aimed at the regulation of population and economy, and the mitigating of pandemic potentialities. Not only have new biopolitical techniques for governing of pandemic threats emerged in the forms of the development of medical counter measures (MCMs) and the role of pharmaceuticals for population security (Elbe et al., 2015), and in the facilitation of new partnerships and multilateral initiatives linking population security and economy, as well as the creation of Global Health Security Agenda (GHSA) in 2014, but the rise of these syndromic surveillance systems too share a common grounding in biopolitical responses to increasingly uncertain future events facing populations and systems of economic circulation.

In sharp contrast to the previous systems of traditional health surveillance which sought to regulate the health dynamics of known and notifiable clinical conditions among populations, the practice and form of syndromic surveillance emerged as a new biopolitical method in the early 1990s, orientated around the problematization and widely recognised failures of previous health surveillance systems in their capacities to rapidly detect and forecast upon the sudden onset of new pathogenic infections, as well as the increasingly [seemingly] probable threat of bioterrorism across high-income states. Indeed, the birth and rise of syndromic surveillance systems in the late twentieth century is rooted in biopolitics, these systems have designed, and indeed function and operate at the junction of public health considerations, and the practice of security, to control (not to prevent or defend against) the disorders of deliberate or naturally occurring epidemics (Fearnley, 2005:4). Biopolitics, therefore provides a relevant and useful lens for discussing the initial rise of these next-generation surveillance instruments in an era of increased global circulation and uncertainty whereby the spectre of disruptive pandemic looms large. The politics of the governance of life, and the rise of the biopolitical technique

can be further situated and understood within the broader context of *governmentality*, whereby the development of novel security apparatuses to regulate population vitality and processes of circulation, constitutes one of the faces of the governmental state (Piotukh, 2015:43).

Governmentality

The concept of governmentality, as a mode in which to govern in relation to power, knowledge and emergent problematisations, was originally introduced by Foucault during the lecture-series, *Security, Territory, Population*, which Foucault presented in 1977-78 at the Collège de France in Paris. This particular lecture-series, which was designed by Foucault and introduced the idea of governmentality, sought to focus on ‘the genesis of a political knowledge that put the notion of population and the mechanisms for ensuring its regulation at the centre of its concerns’ (Defert and Ewald, 1978 in Foucault, 2007). Foucault’s introduction of governmentality begins with an attempted historical uncovering of the development and transformation of the processes and function of the state from the medieval period to the birth of the modern European nation-state from approximately the eighteenth century onward. Specifically, governmentality or techniques of government developed as a response to the novel problematizations of government which arose through the transformations of territory and systems of power over historical periods. Moreover, and specific to this research thesis, Foucault’s analysis of governmentality ‘examined how linkages between a) the health of the population and b) the economic and political security of the state resulted in distinct biopolitical strategies for representing and acting upon populations across liberal governmentalities’ (Holmer-Nadesan, 2008:93).

Through analysis of the concept of governmentality, Foucault discusses the transformation in the role of sovereign power over several centuries and through a number of distinct shifts. The concept of sovereignty throughout the Middle and Pre-modern era was contingent upon the successful demarcation of territory and the fixing of obedient subjects. In this context, Foucault identifies the Prince who sought to maintain the safety (*sûreté*) of his legitimacy to rule as well as the integrity of his territory (Foucault, 2007:65). The configuration of territory and power in this instance, according to Foucault rested upon a *sovereign-subject axis*, in which the sovereign effectively ruled over a demarcated territory, supported through systems and institutions of law, which prohibited certain acts and behaviour, and enacted disciplinary mechanisms against or upon dissenting individuals within the territory. Within these economies of power, the individuals ruled over by the sovereign were not in themselves yet conceptualised as a *population* per se.

The understanding of population, as noted by Foucault, had existed previously, more or less as a loose and imprecise notion from ancient times. Former understandings of population were vague, and the manner in which it was raised in relationship to power structures was essentially a negative one (2007:67). In previous periods, population was understood ‘as the movement by which a deserted territory was repopulated after a great disaster, be it an epidemic, war, or food shortage, after one of

these great dramatic moments in which people died with spectacular rapidity and intensity...the population was posed in relation to the desert or desertification due to major human catastrophes. In other words, the question of the population was not at all grasped in its positivity and generality' (ibid).

Through Foucault's assessment however, what begins to emerge following the gradual refinement of the state, was a completely different approach to the formation of government. Foucault outlines how for example, towards early modernity, perspectives begin to shift towards the analysis of new problematizations related specifically to population. Namely, Foucault discusses the emergence of the town as a problem to be considered, as well as management and regulation of re-occurring 'natural' processes including food scarcity and epidemic diseases. These novel revelations, combined with the advent of statistical knowledge and the subsequent 'avalanche of statistical numbers' (Thacking, 1982), gave rise to the new reality in which 'man as a living being emerges at the centre of political calculation in a particular aggregated form' (Foucault, 1990:143). Thus, it is the realisation of population that is at the centre of the embryonic point of governmentality and of the security state at the end of the sixteenth century up to the eighteenth century onward, giving rise to what Foucault referred to as the 'threshold of the modern state' (2007:165).

The politics of health and of populations therefore form the basis for the development of new governmental rationalities in the early-modern state. The 'new personage of population' and its 'remarkable entrance' (2007:67), during the eighteenth century as a living reality contained within it a reality, with 'a birth-rate, a rate of mortality, a population has an age-curve, a generation pyramid, a life-expectancy, a state of health, a population can perish or grow' (2007:160). As Villadsen and Wahlberg (2015:4) note, it was 'the interweaving of biological and economic knowledge in which population was conceptualized in the eighteenth and nineteenth centuries where terms like 'natural laws', 'the natural cause of things' and 'the naturalness of society' were frequent. The newly arrived concept of population further brought with it 'the mass of juridical, political and technical *problems*, in which the reality of population problematized former domains of knowledge (*savoirs*) including political economy, natural history, and biology (2007:76-77). The development and generation of novel practices and knowledge in order to 'know' the 'thick natural phenomenon' of the population was further motivated by the fact that a population 'is constantly accessible to agents and techniques of transformation, on condition that these agents and techniques are at once enlightened, reflected, analytical, calculated and calculating' (2007:71). The concept and definition of governmentality employed within this thesis thus remains consistent with the original design of the term by Foucault which refers to:

'the ensemble formed by the institutions, procedures, analyses and reflections, the calculations and tactics that allow the exercise of this very specific albeit complex form of power, which has as its target population, as its principal form of knowledge political economy, and as its essential technical means apparatuses of security' (2007:108).

The advent of the reality of population therefore informed the development of new governmental techniques and strategies in response to addressing the circulation of natural phenomena including food scarcity, population growth, and specifically, the ‘sudden, circular bolting’ (Foucault, 2007:61), of epidemics throughout history, including plague and leprosy. These *naturally* occurring events, food scarcity, town planning, and infectious disease outbreaks, referred to by Foucault as the problems of ‘the road, grain, contagion’, problematized the art of government, in that they posed significant threats to the well-being of populations, and that they further propagated an uncertain, future-situated risk toward the positive processes of circulation including of goods, people, and capital. Thus, within emergent governmental systems, the effective management of the population occurred in tandem with the consideration and preparation of naturally-occurring, future-orientated phenomena, such as an outbreak of pandemic and its potentially devastating implications upon population. The understanding and centrality of the notion of circulation, within the governmental systems discussed by Foucault is a double-edged sword, with the promotion or the allowing of things ‘to circulate’ including persons, trade-routes, and capital served as a prospering element, specifically for early liberal economies.

Yet, promoting circulation through laissez-faire governmental techniques also recognises the inevitable and unexpected risks that accompany these systems of government. Unlike previous economies of discipline presented by Foucault, which operated through ‘enclosure and circumscription of space, [the practice of] security requires the opening up and release of spaces, to enable circulation and passage’ (Elden, 2007: 565). The practice of security and the broadening of systems of circulation led Foucault then to discussing ‘the problem of the event’, represented by the aleatory or contingent future events stemming from circulatory systems. Epidemics are thus ‘an exemplary case’ (Thacker, 2009:135), for discussing the governmental challenge to securing of populations and laissez-faire systems of circulation. Epidemics, in themselves, ‘are not simply a particular manifestation of the living (human host, microbial parasite, animal vector), but rather a whole network of vital forces that course through the human in ways that function at once at the macro-scale and the micro-scale (global travel, inter-species contagion, protein-protein interactions)’ (ibid).

Within novel governmental systems, in which security emerges as governmentality’s ‘essential technical instrument’, a shift occurs within the management of populations and the securitization of pandemic disease threats. Whereas previous systems of government sought to eliminate or entirely halt the occurrence of potentially destabilising natural phenomena, the art of government from the eighteenth century onward, with its emphasis on liberal circulation, and population optimisation, becomes increasingly preoccupied with governing through contingency (Dillon, 2007:46).

This transition in the understanding of the management of dynamics of infectious disease has been documented further by Foucault within the *Security, Territory, Population* lecture-series. Utilising a history of epidemics, Foucault contrasts early modern responses to outbreaks of the smallpox virus, and the subsequent mechanism of variolation (inoculation with the virus of smallpox) which informed wide-scale vaccination campaigns (Elden, 2007:566; Foucault, 2007:60-61), with earlier responses to

outbreaks of leprosy and plague in preceding historical eras. Through this analysis, Foucault demonstrates how governmentality, with its essential technical instrument of security, seeks to manage the contingent threat of infectious disease through novel considerations and techniques of government. Unlike the juridical-legal response to leprosy which Foucault documents in the fourteenth and fifteenth centuries, which was predicated upon exclusion, and later, the disciplinary response mechanisms to plague in the sixteenth and seventeenth centuries which featured the implementation of segmentation and quarantine, a new system of forward-oriented management and the development of pre-emptive health campaigns characterised novel modern responses to smallpox (Foucault, 1991:195-200; Foucault, 2006:3-8; and Butler, 2007:475-476). Accordingly, to Foucault, the new management of epidemics and pandemics consisted of:

‘knowing how many people are infected with smallpox, at what age, with what effects, with what mortality rate, or after-effects, the risks of inoculation, the probability of an individual dying or being infected...and the statistical effects on the population in general. In short, it will no longer be the problem of exclusion, as with leprosy, or of quarantine, as with the plague, but...the medical campaigns that try to halt epidemic or endemic phenomena’ (2007:10)

The new governmental questions which concern the life of the population therefore operate upon a different axis and rationality than in previous regimes of power, asking new questions to government and developing new techniques and responses. Governmentality, which has population as its central logic, recognises the essentiality of circulation to population well-being and economy, while simultaneously conceding that naturally occurring, contingent events such as pandemic, cannot be completely eradicated or halted. Thus, no longer the eradication of the threat of disease, rather the governance of the contingency of pandemic, or the regulation of the milieu, becomes the biopolitical aim of government (Foucault, 2007:29-30). In order to then regulate the acceptable distribution of an infectious disease outbreak, ‘security mechanisms have to be installed around the random element inherent in a population of living beings so as to optimise a state of life’ (Foucault, 2003:246). Moreover, the development of these apparatuses of security within governmentality, aimed at the regulation of as yet unforeseen threats, were informed and guided by the ‘political arithmetic’ of the population, or the process of statistical ‘truth-telling’ (Dillon, 2007:44-45).

The extensive utilisation of statistics in early-modern states sought to render the contingent as a tangibly *knowable* and therefore *governable* reality. Governmentality, through ‘the accumulation of statistical data, the compiling of statistical tables, the employment of probability analysis to derive socially relevant meaning from data already collected...allowed new productive connections to be made between different aspects of the life of populations and new strategic formations of government to emerge’ (ibid). What is more, the generation of statistical knowledge about yet unknown disease threats including smallpox, sought to develop an intelligible grid, a horizontal scope for potential future problems and subsequent responses, and locate it within the present. No longer then is the management of the politics of infectious disease predicated on exclusion, quarantine or regulation, but alternatively, the government of the contingent is situated within a specific relation to time ‘to the temporality of

circulation and flows, and, in particular the temporality of prediction and predictability, forecasting and foresight (Thacker, 2009:137).

Governmentality and Global Health: The Apparatus of Security and Infectious Disease

How then, can the rise of data-driven syndromic surveillance systems be situated and conceptualised in a globalised ‘world on alert’, which seeks to securitize populations and circulations of capital, economy, and services from pandemic uncertainties? Does the rise of these novel surveillance systems for health security indicate larger transitions in governmental strategies for global health? Locating the origins of these syndromic surveillance systems within the late twentieth and early twenty-first centuries, in a context of heightened anxieties of the onset of globalised disease outbreaks marked by HIV/AIDS, MDR-TB, SARS, avian and swine influenzas, MERS and Ebola, these open-source syndromic surveillance systems broadly conform and can be theorised initially within Foucault’s understandings of governmentality and biopolitics, operating and practicing formations of security, in a number of significant areas.

Firstly, open-source syndromic surveillance systems, including ProMED-mail, GPHIN, and HealthMap can be broadly conceptualised as *governmental technologies*, which have as their central objective, the surveillance and monitoring of health-trends and emergent infectious diseases within and across populations. These surveillance models for example, do not seek to detect or report upon individual cases of an illness or an outbreak, with the aim of isolating or quarantining suspected cases, but rather monitor the potential emergence of probable health emergencies across populations at the *global level*. Central to Foucault’s understanding of governmentality is the epistemic shift to the management and regulation of the collective population...the government and regulation of populations is, ‘completely different from the exercise of sovereignty over the fine grain of individual behaviours’ (2007:66).

Looking then, at the operational objectives of the three syndromic surveillance systems within this thesis further reveals the governmental aim embedded in their surveillant processes. The objective of ProMED-mail (2010), for example is ‘dedicated to the rapid global dissemination of information on outbreaks of infectious disease and acute exposures that affect human health.’ The strategic naming convention for GPHIN, emphasising the joined notion of *global* and *public health* further denotes an emergent global governmental rationality towards infectious disease control, while the HealthMap system seeks ‘to achieve a unified and comprehensive view of the current global state of infectious diseases and their effect on human and animal health’ (HealthMap,2016). Correspondingly then, global health rationalities are further governmental and biopolitical in this sense since such methods of government ‘aim at the conservation of populations...within and across sovereign states...a cosmopolitan [logic] of securing human health for all the peoples of the world’ (Weir and

Mykhalovskiy, 2010:5). In an era of uncertainty and complex global interconnectedness, in which traditional security agendas have been widened considerably to now consider the welfare of a global population, these novel syndromic surveillance systems, as highlighted by Elbe (2010a:12), are recent ‘technological manifestations of this [governmental] shift towards managing and protecting populations in the realm of infectious disease.’

Secondly, these syndromic surveillance systems exist within a larger political phenomenon which Foucault referred to as the *governmentalization of the state*. Central to the concept of the governmentalization of the state was the novel role in which the governmental state assumed, as a multi-form manager of public life towards the optimisation and welfare of populations, and away from the previous understanding of the state as the ‘cold monster’ (Foucault, 2007:109). As Elbe (2010a:16) has noted further, the governmentalization of the modern state was marked by the emergence and growing involvement of many new actors and agencies which sought to manage the welfare of populations, additional to the organs and functions of the state.

This new range of governmental actors included the providers of insurance schemes, as well as doctors and administrators of hospitals and clinics, and even individuals of the state who participate in the taking out of insurance schemes and opting for vaccination against infectious disease. In the era of vigilance and global health security, the concept of the *assemblage*, serves as a useful tool to present and to understand the emergence of various actors and forces in the late twentieth and early twenty-first centuries which have shaped the regulatory structures, social practices, and knowledge formations constituting global health (Brown et al., 2012:1186).

The emergence of these new health agencies and actors form a complex network of providers and generators of health security practice and knowledge additional to the state and include the recent ascendancy of agencies such as the World Bank, and the Bill and Melinda Gates Foundation, new multilateral organisations including the United Nations Joint Program on HIV/AIDS, the Global Alliance for Vaccines and Immunisation, UNTAID, the Global Fund to Fight AIDS, Tuberculosis and Malaria, as well as civil society groups including Medecins Sans Frontières (MSF), which implement global health programming and exert substantial political pressure (De Cock et al., 2013:1192). Elsewhere, Elbe (2010b) has traced the expanded role in which medical practitioners have come to assume as global health security consultants on a variety of health and security programming from the Global Health Program at the Council of Foreign Relations in New York, to the Global Health, to the Security Initiative at the Nuclear Threat Initiative and the Centre on Global Health Security, Chatham House, London.

The features of the governmentalization of the state and expansion of health security practices described above can also be found within the rise of syndromic surveillance systems. Firstly, they have emerged as novel technologies within a shifting context which elevates the concept of population and the securitization of infectious disease to the level of the global, in which many actors and agents now hold stake. In themselves, these syndromic surveillance systems are compromised by varying

partnerships and initiatives towards the securitization of contingent pandemic threats. ProMED-mail is used by many national and state governments currently as a crucial source of infectious disease knowledge and is supported by the International Society for Infectious Disease. The Global Public Health Intelligence Network (GPHIN) was created out of a partnership of Health Canada and the WHO in 1997. The outbreak alert reports and notifications produced by the GPHIN system further continue to inform the Global Outbreak Alert and Response Network (GOARN) of the WHO, established in 2000. Lastly, the HealthMap project which has also collaborated extensively with ProMED-mail, receives substantial funding from additional global health security agents including the Bill and Melinda Gates Foundation, Google, and the Skoll Global Threats Fund. Broadly speaking, these novel syndromic surveillance systems exist within a biopolitical 'international apparatus that links human actors, microbial phenomena, political powers, laws, forms of knowledge and organizations' (Weir and Mykhalovskiy, 2010:5), under the expanding rubric of global health security.

Thirdly, syndromic surveillance systems can be additionally regarded as governmental technologies which seek to regulate and manage global systems of *circulation* in an era of uncertainty. In his assessment of the shift towards the modern governmental state, Foucault had underlined the development of economic liberalism and the subsequent laissez-faire approach to governance which lay at the heart of governing systems of circulation including the circulation of bodies, capital, and economy. The novel problematization of circulation was marked by a crisis of circulation (2007:61), a regular and sudden bolting which emerged naturally and presented a significant threat to the continuance of circulatory nodes. Foucault was therefore interested in how these sudden emergencies caused by the transmission of infection and plague for example, could be addressed or checked by the implementation of a 'higher natural mechanism', or of an artificial mechanism of security.

The concept of circulation and the challenges within this complex form of government developed by Foucault serve therefore as highly relevant within the politics of infectious disease surveillance in the early twenty-first century. Advanced globalization brings with it many benefits through its interconnected nodes of circulation including economic growth, innovation, and interconnectivity. On the other hand, challenges and threats within these same systems include compressed air-travel, large-scale population mobility, sustained rural-urban migratory patterns across lower and middle-income countries and changing relations of ecosystems and human/animal proximity. The outbreak and rapid spread of the novel coronavirus known as SARS in 2002/03 'followed a pattern of infection that spanned continents, socioeconomic status, sex and ethnic origin' (Saker et al., 2004:52).

These syndromic surveillance systems therefore seek to regulate and survey the emergence and re-emergence of infectious disease phenomena through a series of methods which reflect the government of circulations presented by Foucault. Firstly, the surveillance processes of these systems do not seek to monitor or pin down populations or infectious disease within fixed or demarcated territories (2007:65) as in previous disciplinary/sovereign modes of government, but rather these systems assess and regulate population health trends at the global level, permitting the constant flow of populations

and alerting global health agents only when a probable public health emergency has emerged, indicated for example by an arc or aberrant cluster pattern in influenza reporting.

Secondly, these novel surveillance systems essentially permit circulation ‘to happen’. Rather than enforcing surveillance procedures at national borders, within airports, sea terminals etc., these systems function discreetly and omnipresently, and at the level of the digital, collecting, monitoring and reporting upon online digital signs and correlations in data indicative of potential disease threats, rather than intervening directly on the physical surface of the population.

Simply speaking, rather than physical interventions, these surveillance systems operate by ‘mining beneath the subject’s awareness and by quarrying with techniques that the subject has little or no grasp over’ (Reigeluth, 2014:250), producing in effect, new governmental forms of power for the governance of contingent pandemics, that are digitised and invisible. More broadly, the health reporting and knowledge generated by these systems are increasingly utilised by a wide-array of global health actors and agents which seek to mitigate and contain the outbreak of infectious disease globally, and further formulate forward-oriented calculations, policies and systems of preparedness directed at the securitization and continuation of global circulation systems (capital, critical infrastructure, economy), when faced with probable ‘sudden bolting’ of pandemic threat.

Introducing Algorithmic Governmentality

Scholarship within the fields of security and surveillance studies have therefore traced much inspiration to the conceptual frameworks presented by Foucault, most widely on his understanding of modern power formations, of governmentality, and biopolitics, for the governing of contingent uncertainties. Following the death of Foucault in 1984, much has changed within the politics of infectious disease surveillance, and within the practice and imagining of health security politics. What is more, the advent of the ‘digital era’, the deluge of open-source information produced by the new digital innovations of Big Data, and the growing recourse to automated computing technologies in security and surveillance processes, bring forward new considerations and sites of investigation in an attempt to understand contemporary social and technological developments in surveillance and society (Caluya, 2010:621).

Contextually, how might Foucault’s key conceptual understandings be advanced or extended into the contemporary era of proliferating digital technologies and infinite streams of accessible data, whereby surveillance and risk assessment have become the centrepiece of security policies since 9/11 (Ceyhan, 2008:103)? If the conceptual frameworks afforded by Foucault did much in the way of explaining how novel apparatuses of security, which sought to address govern contingent threats through the accumulation of statistics, and through biopolitical strategies in the governmental state developed, how might these same methods of governing infectious disease threats shift or transform in the present digital era whereby open-source data, produced by technical innovations emerge as a new object of government?

In seeking to situate and explain the emergence of novel political and governmental rationalities towards the pre-emption of highly infectious diseases via new syndromic surveillance systems, this research thesis extends discussion beyond the original contributions of Foucault's understanding of governmentality and biopolitics. It seeks to engage further with the conceptual work of Antoinette Rouvroy of *algorithmic governmentality*, as an analytical framework in which to highlight novel political rationalities, and shifts in techniques of security which have emerged and have given rise to the proliferation of data-driven security devices. In doing so, this thesis considers further, the revelatory 'promise of Big Data' to produce objective 'truths' and reduce the 'relative indeterminacy of the [uncertain] future to a predictable and computational sequence of *that which is to come*' (Reigeluth, 2014:245).

Rouvroy's concept of algorithmic governmentality is therefore situated in the present era of Big Data. In order to proceed further with Rouvroy's shift in practices of governmentality in light of digital technologies and algorithmic forecasting, a working definition of Big Data is required. The term 'Big Data', as maintained by Leszczynski (2016:4), has emerged in the early twenty-first century as a nebulous placeholder in reference to:

The contemporary pervasiveness of data—digital abstractions of observations, computations, experiments [and records] of phenomena in the spaces and practices of everyday life (Kitchin, 2014:2)... This pervasiveness has conventionally been characterized in terms of the sheer volume, variety, and velocity (the three V's') of continuous, real-time flows of information commensurate with the rise of content, the cloud, mobile computing, distributed sensor networks, and the digitization of records (Mayer-Schönberger and Cukier, 2013).

Big Data informs and guides algorithmic governmentality. Reflecting upon the increasing volume of open-source information and digital data streams which have been continually generated as a result of the recent revolutions in Big Data, Rouvroy begins with extending Foucault's original premise of governmentality through recognising that the era of Big Data now provides novel opportunities for data aggregation, analysis and correlation, and therefore marks an epistemic transition away from traditional statistical perspectives, central to the construction of knowledge systems for addressing the contingent (Rouvroy and Berns, 2013:1).

Predicated upon the reality that new, vast amounts of digital data exist latently, and contain within innumerable streams, indicators and correlations of future potentialities if processed and presented accurately, Rouvroy's algorithmic governmentality suggests the emergence of a new regime of 'digital truth', distinct from the 'truth telling' governmental technologies of statistical sciences, presented by Foucault, which rendered populations and the aleatory forces which faced them, knowable and *governable* realities. Algorithmic government and its regime of digital rather than statistical truth, is alternatively driven and exemplified by the proliferation of novel automatic and algorithmic computing systems, classified as algorithmic disclosure devices (Krause-Hansen and Flyverbom, 2015:885), which function within the temporalities of 'real-time', and utilise emergent and increasingly

sophisticated digital technologies, including algorithmic filtration and processing, to produce a novel form of knowledge which is devoid of any relation to the understanding of ‘the average’ or the norm (Rouvroy and Berns, 2013:1-2). Within the present era, whereby data can no longer be visualized in its totality through the former use of human analytic capacities and statistical probability (Anderson 2008:1-2), algorithmic governmentality refers very broadly to an emergent and distinct political rationality and response founded:

[O]n the automated collection, aggregation and analysis of Big Data so as to model, anticipate, and pre-emptively affect possible behaviours. Algorithmic governmentality produces no subjectification, feeding upon data which are meaningless on their own and seek to minimize or eradicate uncertainty, thus relinquishing the ambition of giving meaning to events (Rouvroy and Berns, 2013:1-7).

Algorithmic governmentality emerges from a contemporary context in which the aleatory or the scope of potential futures is increasingly complex, and whereby potentially strategic sets of revelatory data patterns are increasingly infinite and unintelligible, without the employment of advanced and innovative digital technologies to produce meaning from data-streams. In a globalised world of increasing and inherently unknowable uncertainty, an emergent, infinite ‘data-intensive paradigm of knowledge production for ‘actionable intelligence’ relies more than ever on highly complex automated systems that operate beyond the reach of human analytical capacities...algorithms can search for patterns and correlations that have been hitherto impossible to detect’ (Andrejevic and Gates, 2014:185-186). Within the era of Big Data, two novel political rationalities of security now emerge, 1) to capture as much data as possible about everything, to use in novel ways—for assessing disease distributions, tracking business trends, mapping crime patterns, analysing web traffic, and predicting everything from the weather to the behaviour of financial markets and 2) to recognise further that humans simply cannot do that kind of data analysis unassisted (ibid).

Subsequently, through employing algorithmic governmentality as a lens in which to understand present transformations in syndromic surveillance systems, this research thesis looks to re-discuss and extend governmentality in the era following the ‘avalanche of statistical numbers’ which characterised early modernity and influenced much of Foucault’s original perspectives on the development of the governmental state and apparatuses of security. The growing recourse and reliance upon algorithmic programming for knowledge production demonstrated by the evolution of the syndromic surveillance systems discussed in the following case-studies, from ProMED-mail in 1994, to GPHIN in 1997, to the launch of HealthMap in 2006, are indicative of a significant governmental shift in the underlying problem, nature and role of knowledge for future-situated pandemic threats within contemporary global health security policy (Roberts and Elbe, 2016). Rouvroy’s concept of algorithmic governmentality is therefore particularly helpful in illuminating the emergence of new governmental techniques and perspectives observed within shift in syndromic surveillance systems towards the implementation of digital and algorithmic technologies for the foreshadowing of pathogenic threats in the era after Foucault.

The problem of knowledge: From scarcity to excess

The centrality of increased algorithmic programming and automation within these syndromic surveillance systems indicate a shifting rationality towards the problematization of *knowledge* within security apparatuses oriented towards the identification of future potentialities. Within the era of statistical science, traditional systems of health and infectious disease surveillance were moored within national health institutes and infectious disease laboratories. Even within high-income states, the process of utilising sole statistical analysis to derive meaning and trends from data, through collecting and amassing disease sampling, producing population health reports and logs, as well as executing testing and scanning procedures based upon traditional laboratory reporting (Public Health England, 2015), were highly time-consuming and costly to produce, and were entirely reliant on human observation and analytics for curation. What is more, traditional health surveillance systems are often ‘costly, complicated to apply and prone to both intentional and unintentional misclassification’ (Klompas and Yokoe, 2009:1). Moreover, the emergent global health security regime throughout the late twentieth and early twenty-first centuries has been problematized by *scarcity* of infectious disease knowledge in the forms of outbreak notification alerts and awareness reporting as provided by member states of the WHO.

In each instance, states experiencing public health emergencies have either lacked the requisite diagnostic capacity to inform the WHO of outbreaks, or intentionally withheld, misrepresented or downplayed infectious disease findings over state-centric concerns of potential economic, trade or tourism disincentives (Davies et al., 2015). Prominent examples of this scarcity of essential infectious disease knowledge since the founding of the WHO in 1948 include: a large-scale outbreak of cholera in Guinea in 1970 (Fidler, 2004; Youde 2010); the ‘official’ diagnosis of HIV-AIDS in the Soviet Union in 1987 (Rich, 1987:3); the re-emergence of cholera in Peru in 1991 (WHO, 2016b); and the emergence and rapid global spread of SARS from Southeast China in 2002/03. What these examples together demonstrate is that within previous governmental systems, traditional health surveillance practices sought to curate and create new forms of knowledge, in order to further govern the health of populations and regulate the outbreaks of pandemic. These initiatives occurred within historical contexts where very little or no such previous knowledge was available. Generated knowledge for population health in addition to being scarce, was frequently problematized by a number of other factors.

The rise of algorithmic government, by contrast, responds to a novel and entirely distinct problematization of knowledge. Exemplifying this, in 2009, a novel strain of the Influenza A virus (H1N1) emerged. In response, and reflective of traditional surveillance protocol, the Centers for Disease Control and Prevention (CDC), requested all doctors log and inform the CDC of suspected new cases of this virus. This practice of information supply was insufficient, occurring at a time when the CDC produced weekly reports and tabulated figures of suspected cases of influenza. Occurring just weeks before the emergence of H1N1 was recognised, Internet giant Google published an article in *Nature*, in

which it successfully predicted the coming arc of seasonal winter influenza several weeks in advance of the CDC through the automated matching and comparing of 50 million of the most common search queries and terms associated with influenza from 2003/08. Producing 450 million mathematical models, Google was able to track cases and locations of suspected cases of influenza in real-time, the novel approach to crunching mass-data sets through recourse to automation and algorithmic guidance ‘proved to be a more useful and timely indicator than government statistics, with their natural reporting lags’ (Mayer-Schönberger and Cukier, 2013:2-3). The parable of Google and H1N1 demonstrates the reverse relationship and problematization of knowledge in the digital era of global health vigilance.

Subsequently, the ‘deluge of Big Data’ rather than the ‘avalanche of statistical numbers’ poses new problematizations to the governance of populations in the twenty-first century. Instead of seeking to collect and amass statistical information to inform and develop a future horizon of probabilities, the belief in the growth of Big Data, as Rouvroy writes (2012:1) ‘is that, provided one has access to massive amounts of raw data (and that the world is actually submersed by astronomical amounts of digital data) one might be able to anticipate most phenomena of the physical and digital worlds thanks to relatively simple algorithms allowing, on a purely inductive basis to build models of behaviours or patterns without having to consider either causes or intentions.’ Knowledge for the government of the contingent therefore is no longer solely determined through the traditional employment of statistical forecasting, but can be located and extracted from innumerable digital data streams, in which the algorithm and automated data processing emerge as the new instruments of government.

The rise of syndromic surveillance systems has demonstrated this steady recourse to algorithmic government from 1994 onward. A central objective for these new systems has been how to effectively capture and process ever-increasingly infinite data streams online, and to accurately forecast probable emergent outbreaks. In 1994, ProMED-mail, the proto-type model for syndromic surveillance effectively became the first surveillance system to recognise the shifting problematization of knowledge in the increasingly digital era, and to pilot the use of an online digital platform for the uploading, exchange, and query of infectious disease and outbreak knowledge derived from open-source data. This signified the first move towards harnessing open-source, digitised knowledge which lay beyond the statistical generating conducted by national health institutes. ProMED-mail also digitally connected these new exchanges of health information through then cutting-edge mediums of the personalised computer, Internet connectivity, and through e-mail, however all of ProMED-mail’s analytic and processing capacities were undertaken via human labour and assessment, thus the ‘algorithmic turn’ of syndromic surveillance systems was yet to come. In 1997, responding to the increasingly complex informational ecology of the expanding World Wide Web, the Global Public Health Intelligence Network (GPHIN), became the first syndromic surveillance system to turn towards the logic of algorithmic programming, implementing new forms of digital algorithmic management in order to ‘search, aggregate, and cross-reference large data sets’ (Boyd and Crawford, 2012:663), and to convey retrieved online information further to a human support team for analysis and assessment.

The GPHIN initiative in 1997, was the first system to recognise the emergent double-pronged problématique of the coming Big Data era, that vast quantities of open-source data online were both a potential benefit and hindrance to the strengthening of global health security and surveillance regimes, and that in order to capture and effectively derive meaning from these new informational sources, new instruments and techniques of government needed to be developed—enter the digital algorithm. Nine years following this, in 2006, the launch of HealthMap would represent a further intensification of the recourse to algorithms within syndromic surveillance systems.

Marking the most sophisticated implementation of algorithms within the scope of this thesis, the HealthMap system featured a centralised and expanded role of algorithmic programming, implementing algorithms and automated processing to ‘to scour tens of thousands of social media sites, local news, government websites, infectious-disease physicians, social networks, and other sources to detect and track disease outbreaks. Sophisticated software filters irrelevant data, classifies the relevant information, identifies diseases and maps their locations with the help of experts’ (Public Health Watch, 2014). The gradual and consistent implementation of algorithmic programming within these syndromic surveillance systems from 1994-2006 thus indicates a turn in governmental rationality in the problematization of knowledge for governance of the contingent—in this context, of the phenomena of pandemic. Rather than the generation of ‘statistical’ knowledge for the governing of emergent natural phenomena, where previous knowledge was scarce or did not exist (Foucault’s example of the vaccination campaigns against smallpox from the eighteenth century onward), the growing utilisation of the algorithm within these syndromic surveillance systems seeks to address and ‘tame the chaos’ of infinite sources of information found within continually generating sets of digital data. These syndromic surveillance systems therefore can be understood as distinct technological manifestations which respond to a novel and reversed problematization of governmental knowledge—not one of scarcity, but of excess.

Proxy Data—or ‘knowledge without truth’

Differing from previous governmental systems, the gradual and expanding reliance on algorithms within these syndromic surveillance systems also produce and present a new *type* of knowledge for the government of infectious disease threats. Rouvroy (2012:3), asserts that where ‘each epoch had its own privileged way to build evidence and render the world meaningful, previous governmental strategies were based on statistics and were systems of quantification to reduce or manage uncertainty, of what is present and available to human senses.’ With the computational and digital recourse towards the utilisation of Big Data and the crunching of data via algorithms to render the future horizon of events visible and manageable, Rouvroy contends that previous relationships toward knowledge are now in transition. With the increased and increasing ability for algorithms and automated computing to reveal new insights that previously remained hidden from human perception (Cukier, 2010), a new form of governmental knowledge begins to emerge in which ‘algorithms unveil’ (Rouvroy, 2012:4).

Central to this new form of knowledge is the suggestion that ‘knowledge’ is no longer produced via human analytics and does not appear as a ‘production of the mind’, but knowledge exists latent in mass-data sets, in which it is merely, automatically ‘discovered’ thanks to algorithmic operations, rendering invisible correlations operational (Rouvroy, 2012:3-4). Resultant from this recourse to algorithms within the governmental management of the contingent, this new form of knowledge retrieved from data sets and streams is no longer evaluated on the basis of ‘traditional criteria of authenticity, historical coherence or critical apperception, but on the merits of immediate operability, plasticity, flexible adaptation to changing circumstances, and immediate availability...the crunching of numbers appears as a victory of rational thought over emotionally, politically, racially biased human perception’(ibid).

Within systems of algorithmic governmentality, knowledge is no longer traditionally gathered and constructed to generate certain ‘truths’ via statistical reporting about things and phenomena. If captured and processed with the appropriate digital harnessing technology, this emergent form of knowledge, ‘does not seek to presuppose or reinforce any hypothesis about the world, but merely appears as an agnostic, pragmatic, highly operational effective manner to structure, in an anticipative way, the possible field of actions’ (2012:6-7). Algorithmic governmentality is thus, less concerned with the causes of particular phenomena at hand, and oriented instead towards pure observation of correlations derived from data. Significant here, is that the knowledge unveiled and presented by algorithmic processing now bypasses the previous types of trials, tests, examinations, experiments, as well as other challenges or *épreuves* which have been in the past, essential to attest to the robustness, truth, validity of claims and hypotheses which were utilised to formulate the securitization of uncertain futures.

Conceptually then, the syndromic surveillance systems described within these case-studies align to a new form of knowledge production as described by Rouvroy. Unlike previous governmental techniques which were characterised exclusively by the generation of knowledge for managing pandemic threats via statistical analysis and probability, which rendered patterns of pathogenic circulation visible, the underlying rationalities of syndromic surveillance systems differ considerably in the approach to knowledge production. Through the utilisation of retrieval and sorting algorithms and the aggregation of open-source data, syndromic surveillance systems are part of an emergent knowledge regime which consists of electronic and digitised codes and signs. Significantly, unlike the statistically informed health reports and outbreak alerts issued by national ministries of health, syndromic surveillance systems utilise data models that do not rely on confirmatory laboratory testing of patient samples...[t]he general advantage of these systems is the provision of data that are timelier than traditional laboratory reporting, i.e. ‘real-time’ (Elliot, 2009:2).

Subsequently, syndromic surveillance systems produce and supply a novel digitised *surface knowledge* (Weir and Mykhalovskiy, 2010), for pandemic preparedness consisting of indirect signs and proxy signals from correlations determined by algorithmic structuring of infinite streams of data.

Similar to Rouvroy's presentation of the rise of *knowledge without truth*, the surface knowledge produced by these syndromic surveillance models generate new governmental forms of knowledge for the pre-emption of infectious disease outbreaks which is open-source, located in the digital realm, and subsequently when data-mined, bypasses the traditional channels of trials, tests, and hypothesis which were practiced within statistical government.

The emergence of this novel 'real-time' surface knowledge derived from open-source digital data commenced in 1994 with the launch of ProMED-mail. As the first system to depart from previous statistical analysis of disease trends across populations, ProMED-mail developed an early electronic platform with the objective to process, curate and upload non-official, non-clinical open-source infectious disease knowledge within near real-time temporalities. ProMED-mail also significantly expanded the scope of the inclusion of criteria for suitable outbreak data that could now be assessed and presented. Building on increased online connectivity and the growing commonplace of the World Wide Web, GPHIN thus harnessed digital interconnectivity and became the first of these emerging systems to implement and increasingly rely upon the use of retrieval algorithms which scanned online media data sets, at a rate and level of precision not previously feasible, to generate a more refined 'surface' knowledge of contingent disease threats.

The further development of HealthMap in 2006 featured the introduction of a next-generation syndromic surveillance system which was largely automated, with a diminished role for human analytics in the capturing, processing and visualization of surface knowledge of emergent or forthcoming outbreaks. Within HealthMap, the implementation of algorithmic logic enabled the system to further visualize and construct a digital topography on real-time global health trends informed entirely by proxy data and signals within data sets. If GPHIN represented the first step towards harnessing the algorithm for the curation of new knowledge forms for the strengthening of global health security, the launch of HealthMap, with its intensified automated surveillance represented an 'unshackling' of algorithmic power to produce actionable knowledge for coming health threats. Overall, the iterative expansion of these syndromic surveillance systems, demonstrative of a gradual recourse to algorithmic programming to address infinitely generating data sets, are less premised on the transcribing actual cases of illness and/or outbreaks and more oriented toward the interception of unmediated data-flows—always seeking to harness data points and correlations towards greater intelligibility and visibility of the probable (Roberts and Elbe, 2016:11), and to bring this contingent future threat into the 'real-time' temporalities of the present, through the generation of new and distinct forms of governmental knowledge for the governing of infectious disease uncertainties.

From the normal to the exceptional

Lastly, the rise of the algorithm, occurring with evolution of syndromic surveillance systems indicates a shift further in the *role* that knowledge performs in governing emergent threats in global health security practices. In assessment of the transition from previous disciplinary forms of power towards

the governmental state, Foucault (2007:63) was interested in the methods in which populations are ‘normalized’ through the identification and modification of risk groups and abnormalities. Foucault (ibid), explained that in previous disciplinary power systems ‘an ideal norm is imposed from the outside, and the distinction between the normal and the abnormal is undertaken according to the ‘artificial’ norm.’

Contrastingly, within this emergent economy of security, increasingly oriented towards algorithmic forecasting, an epistemic shift further occurs away from this process of governing via normalization discussed by Foucault towards the detection of the exceptional within the government of the contingent through new modes of surveillance guided via algorithms. Foucault described the process of normalization as ‘the plotting of the normal and the abnormal, of different curves or normality, and the operation of normalization consists in establishing interplay between these different distributions of normality’ (ibid). Elsewhere, Fearnley (2008:1617), has noted that such programmes of normalization were central within governmental public health strategies, in the establishment of regulatory mechanisms which aimed to develop an average or equilibrium within the overarching government and optimization of population health. These systems of health however were also frequently limited by costs, external conditions, and most significantly, limitations within existent possibilities of knowledge.

The proliferation of data-driven syndromic surveillance systems however represents a new departure from the norm or the average, described by Foucault. Within previous systems of normalization, it was through statistical knowledge that a normal or optimal level could be determined and contrasted with that of the *abnormal*, and governmental strategies for regulation of the future contingent were derived from this interplay of curves and arcs, providing a knowable field of distribution of occurring phenomena including pandemic. In reflecting upon the rise of statistical information and new forms of knowledge represented by ‘different bureaus of statistics’ in the late nineteenth century, French sociologist and criminologist Gabriel Tarde wrote that ‘[a]t present, Statistics is a kind of embryonic eye, like that of the lower animals which see just enough to recognise the approach of foe or prey (1890:136 cited in Pasquinelli, 2015). Subsequently, through the development of a working norm, contrasted to the abnormal and guided by statistics, governmental systems of the modern era sought to gain insight and understanding of the type of forward-facing natural phenomena which might emerge to threaten circulatory patterns and population well-being. The departure point for governmental medical interventions, which no longer consisted on exclusion or quarantine, now rested ‘on determining probabilities and establishing averages [of possible events] through the use of statistics’ (Butler, 2007:476).

In contrast, modes of algorithmic government mark a further departure from previous governmental systems, through a re-orientation towards detection and pre-emption of the *exceptional* rather than the cultivation of the norm in the situating of future probabilities. With the increasing capacity of digital technologies to address the complex data-infrastructure of the twenty-first century, algorithmic governance within security systems, according to Rouvroy now take into account a new

perspective which is ‘devoid of any relation to the average or the norm’ (Rouvroy and Berns, 2013). Rather than trying to determine an average or understanding of a normal or acceptable distribution within a population, the aim of these new data systems is ‘no longer to exclude anything that does not fit the average but [rather] to avoid the unpredictable’ (ibid). Novel algorithmic technologies no longer focus on seeking to cultivate and present a statistical average informed through ‘deductive rationality linking observable phenomena to their causes’ (Rouvroy, 2012:6). Rather, algorithmic security technologies are indifferent to both the phenomena itself, and to the idea of an average. Algorithmic governmentality directly looks to detect that which is the exceptional or the abnormal through the correlation and observation of data collected in a variety of heterogeneous contexts (ibid).

The influence of Rouvroy’s algorithmic governmentality can be seen further within the research of Pasquinelli (2015), in the field of anomaly detection and pattern recognition within the metadata society. As Pasquinelli discusses, unlike previous governmental eras which utilised the *embryonic* eye of statistics to establish governing norms for fluctuations across populations, the emergence of an infinite data-scape of the twenty-first century, and the piloting of new technologies seeking to make sense of and generate knowledge from this new digital geography have given rise to a ‘new form of augmented perception called *algorithmic vision*’ (2015:3). Reflective of Rouvroy’s transition away from the statistical norm in new governmental systems, Pasquinelli highlights *anomaly detection* as constituting a hallmark of this emergent perception of algorithmic vision, in which detection of the aberrant within digital data-streams emerges as a new governmental objective ‘from social networks, to weather forecasting, from war scenarios to financial markets’ (ibid), and further within the surveillance of infectious disease and pandemic.

Both Rouvroy’s algorithmic governmentality and Pasquinelli’s algorithmic vision demonstrate a distinct governmental rationality which is divergent from previous systems which developed and governed from the concept of the norm. Both concepts seek to make sense and construct meaning from infinite data-scapes using cutting-edge digital technologies. Whereas the concept of the norm was constructed and derived from statistics from information available to human analytics, novel algorithmic processes become a ‘vehicle for exploration that extends beyond the limit of perception’ (Terzidis, 2003 in Parisi, 2013:66). New forms of government, made possible by the rise and implementation of the algorithm within security apparatuses including syndromic surveillance systems, are now premised less on the idea of the *norm* or the *average*, and alternatively are oriented towards anomaly detection within constantly expanding data sets. Thus, power in the era of algorithmic vision, as Pasquinelli writes ‘is about steering along these vectors and navigating an ocean of data by recognising waves of patterns, and in doing so, taking a decision anytime an anomaly is encountered’ (2015:8).

These syndromic surveillance systems therefore depart away from the centrality of the norm and of the optimal arc of distribution in which Foucault had previously highlighted as a new technology for the governance of population security and the contingent. This initial transition away from

statistically informed traditional public health surveillance was exemplified in the original rationale for the design of ProMED-mail which—accordingly—operated to locate and report upon *emergent* infectious disease outbreaks, rather than seeking to regulate the distribution and averages of known or existing disease trends.

Building from the establishment of ProMED-mail, the launch of GPHIIN was further orientated not towards the generalised assessment and reporting of population health, but rather sought to derive and generate knowledge from increasingly complex digital data-streams. It became the first of the discussed syndromic surveillance systems to implement the sorting and foreshadowing capacities of a retrieval algorithm to observe and detect anomalies within data patterns. The most famous of which was the early observation of unusual patterns of online media activity denoting the irregularity of a form of *atypical pneumonia*, later classified as SARS in November 2002. Further still, with the capacity of the HealthMap system to algorithmically extract data from 20 000 websites hourly, the system moved instead to capture and to visualize *aberrations* in global health trends, derived from online data-streams, rather than averages or optimal norms distributed across populations. This was illustrated by HealthMap’s advanced detection of a ‘mysterious fever’ which had emerged in Macenta, Guinea on 14 March 2014, occurring over a week before the official notification by of an outbreak of the Ebola Virus Disease (EVD) in the Nzérékoré Region of Guinea with epidemiological data confirmed by the Guinean Ministry of Health.

In sum, the evolution and gradual recourse to algorithmic programming demonstrated within these three syndromic surveillance systems since 1994 are indicative of the shift away from central understandings such as the norm and the average within governmentality studies. Whereas within previous governmental systems in which the central objective was to bring what was considered abnormal into the fold of the ‘norm’, the central logic of the norm disappears completely within algorithmic governmentality, with the capacity for algorithmic logic and data-crunching to effectively capture and present all relevant data relationships which might indicate an aberration. Illustrating this shift, Rouvroy writes that within this new data-oriented governmental rationality, knowledge for the government of the contingent are ‘no longer to be conveyed by references to the average... [but rather] the system follows a *screening* rather than a diagnostic approach: the aim is not to miss any true positives, irrespective of the rate of false positives’ (Rouvroy and Berns, 2013:9).

Unlike therefore in previous eras whereby points or patterns which deviated too far from the central or common finding were disregarded, the infinite scope and capacity of algorithmic programming, to navigate vast data-scapes, now means that even the most isolated or singular of aberrations or exceptional points can be taken into greater analysis and account (Rouvroy, 2015a). Within present global health security frameworks, the rise of increasingly algorithmically-guided syndromic surveillance systems extend therefore, into new objectives of government, no longer function along understandings of distribution and normalization, but seek alternatively, via algorithms, to rapidly

foreshadow and pre-empt coming future events through processes of pattern recognition and anomaly detection within data-streams.

Conclusion

This theoretical chapter has sought to explain and present emergent rationalities towards the management of infectious disease outbreaks which have facilitated the rise of syndromic surveillance systems, within global health security frameworks over the past two decades. In doing so, work of Foucault and his understandings of biopolitics and governmentality have served as significant analytical points in considering the broader political rationalities which underpin these novel syndromic surveillance systems. Through engagement with the work of Foucault, these health surveillance systems can be firstly conceptualised and understood as broadly *governmental* technologies in three key areas. Firstly, these systems have been seen to continue the historical transition presented by Foucault in which strategies of government shift away from the *sûreté* of the sovereign towards the practice of *sécurité*, in which population emerges as the objective and end of government, and in which statistical sciences render the population a living and knowable reality. The syndromic surveillance systems within this research thesis continue to have as a central biopolitical aim, the securitization of populations against the forward-situated threat of pandemic and crises of circulation.

Second to this, the rise of syndromic surveillance systems and the proliferation of similar future-oriented early outbreak detection devices conform to Foucault's discussions of the *governmentalization* of the state, in which, resultant from the emergence of a complex set of future uncertainties and milieus, numerous novel actors, agencies, and techniques external to the institutions of the state now emerge to monitor and regulate the emergence of natural phenomena such as infectious disease and pandemic. Thirdly, the concept of circulation presented by Foucault, as a further site of intervention within governmentality, how positive aspects of circulation (economy, persons, trade) might be promoted while negative aspects of circulation (crime and infection) are regulated and minimised, remain as objects of government for emergent syndromic surveillance systems. The permitting of positive, non-invasive circulation remains a central logic of these novel health systems, reflected by the broader context of an emerging global health security regime which seeks to securitize populations and nodes of circulation.

However, as this thesis further advances, rise of the Big Data era and of the increasing recourse-towards digitised and automated forms of surveillance within the strengthening of global health practices, has brought the original points of Foucault forward in a new conceptual light. In seeking to

extend the discussions and relevancy of governmentality into the present, the concept of Antoinette Rouvroy's *algorithmic governmentality* serves as particularly illuminating in demonstrating how these novel and increasingly data-oriented syndromic surveillance systems are conceptually divergent from Foucault's original understandings of the role and function of the security apparatus within governmental systems. Through an extensive engagement with the framework of algorithmic governmentality as a novel governmental rationality, this theoretical discussion has analysed and developed the nuanced ways in how syndromic surveillance systems diverge from traditional governmentality in three key aspects: 1) through a shift in the problematization of knowledge, no longer of scarcity, but one of excess; 2) through a transition away from traditional processes of statistical generating, the validation of hypothesis, and towards the increased utilisation of proxy data, giving rise to a form of *knowledge without truth*; and 3) that these syndromic surveillance systems no longer seek operate upon a statistically informed concept of the distributed norm or of normalization, but alternatively crunch and mine infinite-data sets for that which constitutes the exceptional or the abnormal within digital patterns and correlations.

Informed by this theoretical framework, the subsequent case-studies within this thesis will further present and explain the histories, contexts and evolution of ProMED-mail in 1994, GPHIN in 1997, and HealthMap in 2006. In doing so, the iterative evolution and emergence of an algorithmic vision within these forward-situated health surveillance systems will be presented

Chapter Four: Before the Algorithm (ProMED-mail)

Introduction

The sudden emergence and re-emergence of infectious diseases and drug-resistant pathogens within the late twentieth and early twenty-first centuries, combined with the acceleration of processes of globalization and networked connectivity, have been central to the re-configuration of the practice of global health security, and have advanced calls for the enhancement of new forms of surveillance systems for addressing and forecasting these contingent, future-situated threats. A historical examination has so far demonstrated how, the object of population and its status of overall health emerged as a new logic of observation and objective of government from early modernity onward. Sovereign nation-states, concerned with the *securing* of national populations traditionally have enacted public health campaigns including vaccination regimes and sanitary operations as a means of regulating pandemic phenomena within given populations, with the larger aim of mitigating possible disruptions to systems of positive circulation which could result from the spread of a sudden and virulent infectious disease outbreak. The traditional agents of infectious disease surveillance within this era comprised of organs of the state and government, its national health institutes as well as scientific and medical

agencies. Drawing from an in-depth engagement with the research of Foucault's conceptualisations of *biopolitics* and *governmentality*, this thesis has so far demonstrated the centrality of statistical collection, translation and forecasting which informed the core practices of infectious disease surveillance, as well as served as an integral overall component to a 'governmental rationality of political rule that continuously seeks to anticipate myriad circulatory threats to the welfare—including their overall levels of health' (Elbe et al., 2014:440).

Within an era of expanding globalization and vital systems of networks and economy, governments and state leadership alike have expressed renewed interests in the potentiality to gain advanced and precise warnings of yet-unforeseen public health emergencies—including infectious diseases outbreaks to bolster the resilience of population health and economy and capital against circulating pathogenic threats. From 1948 onward, the WHO has increasingly assumed the role of the central, global agent within the politics of health, balancing the interests of securing and promoting population health and welfare on one hand, with the avoidance of unnecessary interference with international nodes of circulation on the other. For much of the twentieth century, the government of infectious disease and pandemic remained static—the cultivation and assessment of statistical sciences informed governmental planners of potential arcs or spikes across population sets, indicative of a potential health event. The 'sudden circular bolting' of pandemic phenomena was regulated through systems of normalization which included health inoculation campaigns which sought to bring the risk of potential pandemic within populations into manageable and knowable range. In turn, this particular form of governmental planning and consideration was the remit of the modern nation-state, which generated forms of knowledge for the regulation and response to pandemic contingencies, via its national health institutes and increasingly following the establishment of the WHO, was required, by legislative and diplomatic conventions to transparently share and disseminate epidemic intelligence in favour of intensifying the biopolitical project of global health from the mid-twentieth century onward.

Subsequently however, this shift from the national 'government of infectious disease' towards the practice of 'global' health security from the mid-twentieth century onward has produced unforeseen implications for previous systems of infectious disease surveillance and the generation of future-situated epidemic intelligence. The re-orientation of security perspective to now account for the destabilising impacts of circulating pathogenic threats, and the rise of the practice of *health security* into the early twenty-first century has additionally witnesses the emergence of new governmental problems related to the scope, practice and range of data sources requisite to obtain advanced insight and *knowing* of future-situated pandemic threats. What is more, the intensification of digital technology, as well as the production of open-source data resultant from the increasing commonplace of the Internet throughout the decade of the 1990s provides a site in which the governmental rationalities towards the surveillance and control of pandemic threat might be re-contoured and expanded in light of a globalised security challenge, expanded sources of data, as well as the proliferation of novel digital technologies and online interconnectivity.

This chapter therefore introduces the first of three case-studies which trace the rise of syndromic surveillance over the past two decades. The first of these systems was the Program for Monitoring Emerging Diseases (ProMED-mail) which launched online in 1994. Finding its origins within the fledgling days of the World Wide Web and the Internet, ProMED-mail was designed on part of the Federation of American Scientists to enhance emerging practices of global health surveillance in an era of increased vigilance regarding the spread of an infectious disease outbreak. The chapter will demonstrate how, by its design and upon its launch, ProMED-mail differed significantly from preceding systems of health surveillance in a number of noteworthy areas including the scope of the system in addressing pandemic threats, the range of data sources utilised for the generation of outbreak knowledge. In contrasting the role of ProMED-mail in ushering in this new form of surveillance and knowledge curation for global health security, the case-study also demonstrates how this surveillance technology became the first of three within this thesis to indicate a new, albeit subtle shift towards an increasingly algorithmically informed mode of health surveillance for addressing pandemic uncertainties.

The Origins of ProMED-mail

The origins of ProMED-mail can be located within a period of the late twentieth century in which then-current rationalities of security emphasised the growing incapacity for traditional systems of health surveillance to identify and correctly forecast sudden and increasingly globalised outbreaks of novel and re-emergent pathogens which had proliferated over the preceding decades. What is more, as highlighted within the Institute for Medicine's (IOM) seminal report *Emerging Infections*, 'the key to recognizing new or emerging infectious diseases, and to tracking the prevalence of more established ones, is surveillance' (Lederberg, Shope et al., 1992:113).

Reflecting upon the considerable attention which had increasingly come to focus upon emerging infections within national and international security contexts, in 1994 the WHO, citing the past 'deterioration of surveillance efforts...in the capacity of developed and developing countries to maintain surveillance activities for communicable diseases, and respond to outbreak situations' recommended a global approach in the strengthening of global surveillance of infectious diseases within a new era of globalised and expanding pathogenic threats (Bulletin of the World Health Organization, 1994:845-846). This increasing awareness and anxiety regarding the surveillance capacities of global health agents to effectively and timely identify coming pandemic contingencies was further buoyed throughout the 1990s by the 'coverage of international outbreaks of exotic infectious diseases, including Ebola haemorrhagic fever in Zaïre, pneumonic plague in India, a new strain of avian influenza in

Southeast Asia, Bovine Spongiform Encephalopathy (BSE) in Western Europe, and the West Nile Virus in the North-eastern United States' (King, 2002:768-769).

Moreover, discussions within this thesis have so far demonstrated, existent governmental systems for the management and surveillance of infectious disease outbreaks throughout much of the twentieth century had been recurrently problematized by significant and ongoing challenges. Specifically, governments and states which have sought to attain early-warning knowledge in advance of a probable health emergency have in past been heavily reliant on the cooperation and transparency of other states to provide requisite health and epidemic intelligence to guide response and preparedness initiatives to address and understand the potential spread of disease.

As highlighted further by the case-examples of polio and cholera outbreaks in Guinea, and the emergence of SARS in China, at varying points through the late twentieth and early twenty-first centuries, the political sovereignty of states has frequently represented a serious 'political' obstacle to the development of a more effective surveillance system of global outbreak detection. Furthermore, both the narrow legislative and diplomatic conventions which maintained the relationship between states and intergovernmental health authorities such as the WHO, which emphasised the sovereignty of member states as a central principle, meant that global health authorities were vulnerable to and overly reliant on 'nationally curated health information, within global health surveillance initiatives' in seeking to mitigate pandemic threats at a global level (Roberts and Elbe, 2016:49). Reflecting upon the International Health Regulations, adopted in 1969 to regulate outbreaks of cholera, plague or yellow fever, Weir and Mykhalovskiy (2010:118), have highlighted that '[r]ather than actively shaping responses to infectious disease outbreaks, the Regulations were routinely ignored or bypassed.'

Additional to the 'political' complications posed by state sovereignty, further resource and logistical challenges have also hindered the further enhancement and design of health surveillance systems at a global level. Traditionally, effective systems to mitigate infectious disease outbreaks have been challenged in low and middle income states as a result of their limited surveillance and healthcare resources (Li et al., 2010). What is more, processes which involve the secure collection of microbe and virological samples, conducting complex laboratory analyses as well as the channelling of epidemiological data through the bureaucratic systems have often represented a costly and time-consuming process, prone to delay or error and out of pace with the speed of virulent outbreaks.

As outlined by Morse (2012: 7), traditional systems of health surveillance are labour intensive and relatively expensive, but often only limited resources are available. With the proliferation of a new host of infectious pathogens within the late twentieth century including the emergence of Ebola, HIV/AIDS, sub-types of avian and human influenza, multi-drug resistant infections, and renewed fears of bioterrorism following the collapse of the Soviet Union, interest was therefore generated in developing faster detection systems that would move infectious disease outbreak surveillance closer to 'real' time temporalities (Lakoff, 2015). Within the new era of globalised pandemic threat, whereby microbes and pathogens could be easily and rapidly transmitted and facilitated globally via the conduits

of an expanding international air transport network, emergent systems of global health security would now need to consider the how scope and practice of new health surveillance operations could be innovated at the level of the global, as well as how data and health intelligence sources could be extended, collected and more rapidly disseminated via innovative communication channels before the arrival of the next globalised pandemic.

The Program for Monitoring Emerging Diseases (ProMED-mail)

Emergent initiatives towards global health and population security within the late twentieth century therefore were challenged by a diverse host of factors ranging from the political ‘problem’ of state sovereignty, to inconsistencies of technological and diagnostic capacities. While agents such as the WHO generally lacked enforcement measures from non-complying member states, vital epidemiological and diagnostic information detailing the nature and scope of disease outbreaks remained within the control of national health and scientific institutes. The inaugural launch of ProMED-mail in 1994 would represent one of the first attempts to address and remedy this complicated arrangement, and would seek further to incorporate and synchronise, local outbreaks of infectious diseases with the global time and space. In retrospect, ProMED-mail is now regarded as the original prototype of open-source syndromic surveillance systems for global health security (Zhang et al., 2009).

Making its online debut in 1994, the ProMED-mail project was designed and funded by the Federation of American Scientists, and functioned as ‘an Internet-based reporting system dedicated to rapid global dissemination of information on outbreaks of infectious diseases and acute exposures to toxins that affect human health, including those in animals and in plants grown for food or animal feed’ (ProMED-mail, 2010). The design and purpose of the ProMED-mail system differed significantly from previous systems of health surveillance which preceded its inception. As underlined by Madoff (2004:227), a founding principle of the new online surveillance system was that it would remain open to all global sources of outbreak reporting and not just official health data and reporting curated and provided by government health authorities, on a free of charge access basis.

Additionally, based online during the initial days of the Internet and the World Wide Web, ProMED-mail would also remain free of political constraints, bias or stonewalling of information which had characterised previous channels of epidemic intelligence and data. What is more, as the first of kind online surveillance platform dedicated to the exchange, access and uploading of epidemiological information indicative of potential disease outbreaks, the ProMED-mail system sought to gather information from a diversity of novel outlets including official government health and departmental reports, press briefings, bulletins from international organisations, as well as professional or personal observations and other open-source material from ProMED-mail members, media sources and even local rumours (Cowen et al., 2006: 1091). Critically, this meant that ProMED-mail would become the first health surveillance system to blend elements of official/unofficial health reporting and

epidemiological information to gain greater perspective and awareness of occurring or probable infectious disease outbreaks, and to exchange, present and disseminate these newly generated health alerts via an online expanding digital medium which at the time, lay beyond the jurisdiction of sovereign nation-states. This transition towards accessing a new range of potentially indicative open-source data further signalled the emergence of new governmental rationalities and techniques towards addressing pandemic contingencies via new channels of data, which had previously been unavailable within previous public health surveillance systems.

Specifically, the context surrounding the launch of ProMED-mail in 1994 is deeply rooted within the dramatic coming of age of the Internet (Madoff and Woodall, 2005:724). In seeking to extend global health surveillance and infectious disease reporting beyond the jurisdictions and political problems of the state and its health and scientific institutes, the ProMED-mail system would function by harnessing the growing power and capacity of personal computers, e-mail and the Internet to connect subscribers and to provide a networked communications platform, enabling subscribers to exchange, upload and access knowledge of potential disease outbreaks as such outbreaks occurred—irrespective of global location. Designed to encourage ‘the development of a global infectious disease surveillance system, which will identify and quickly respond to unusual outbreaks of infectious disease’ (Bulletin of the World Health Organization, 1994:849), the ProMED-mail system sought to bolster new systems of global infectious disease surveillance which had not been possible even a few years previous. Notably, ProMED-mail concentrated on rapid reporting of outbreaks rather than detailed epidemiological surveillance (Woodall, 2001:150), which indicated a further step towards the generation of near real-time ‘surface’ knowledge for the forecasting of pandemic uncertainties in the late twentieth century. The ProMED-mail project therefore would seek to supplement and generate crucial knowledge of potential outbreaks and enhanced forecasting in near real-time temporalities to enhance capacities for response measures and containment during public health emergencies.

ProMED-mail and the Curation of Pandemic Knowledge

ProMED-mail therefore, has alternatively collected and analysed submitted, open-source data from its membership base to gather and generate new forms of knowledge about probable infectious disease outbreaks and to subsequently curate web-accessible reports of occurring infectious disease outbreaks. Upon launch in 1994, the new surveillance system consisted of a web-based forum and e-mail list connecting 40 subscribers across seven countries, mainly from within the medical and scientific research fields. The first e-mail outbreak report of the ProMED-mail system was transmitted in August 1994 to all members, reporting the case of a laboratory infection in the United States with Sabia virus (Brazilian haemorrhagic fever), and indicated the need for greater biosafety measures in research laboratories (Madoff and Woodall, 2005:725). Emphasising a *one health* principle, in which plant, animal, environmental and human health patterns are correlated, the ProMED-mail system routinely

gathers and assesses received e-mails, observations, queries and local updates from its membership base and examines all incoming, open-source information for data indicative of a probable infectious disease outbreak occurring globally.

Designed during the period in which the emerging infectious disease discourse was highly salient, the surveillance objective of ProMED-mail was to track, report, and monitor outbreak information linked to emergent or unknown cases of highly infectious diseases. Previously identified pathogens however including HIV/AIDS and Tuberculosis are in most cases, not included within the surveillance scope of the ProMED-mail system which instead is geared towards the detection and identification of emergent pathogenic exceptions, as opposed to the routinized surveillance of known or established infectious diseases. Critically in this regard, the ProMED-mail system became the first of these next generation syndromic surveillance systems to seek to generate knowledge on *emergent* infectious diseases and exceptional health episodes, reflective of the view of Rouvroy (2009:8), in which these new syndromic surveillance systems are alternatively oriented towards the utilisation of data in order to visualize and locate, potentially exceptional events of radical uncertainty, rather than governing pandemic threats through previous statistically informed processes of normalization.

Following receipt of incoming, open-source health information into the ProMED-mail system, data subsequently is received and manually reviewed and assessed by the analytic staff of ProMED-mail, the majority of whom are medical practitioners or scientific researchers with applied and thematic expertise within bacterial, viral and parasitic diseases as well as animal and zoonic diseases, plant disease, and epidemiology. In addition to receiving incoming global health data from its membership base, the analytic team within ProMED-mail further routinely combs both the Internet and traditional media sources for indications of unusual disease trends or occurrences and further scan a variety of official and unofficial Web sites including ministries of health; federal, state and local departments and international organisations (Madoff, 2004:228). In utilising the connective power of the then emerging Internet infrastructure, the networked ProMED-mail analytic team consisting of numerous individuals across a number of countries, collaborate virtually, with all information relayed via the Internet using both e-mail and Web-based systems (ibid). Through the utilisation of human analytic expertise and as well as the mediums of the personalized computer, e-mail correspondence and the World Wide Web, the ProMED-mail system seeks to either verify or discredit submitted material and to scan incoming documents for accuracy and relevancy related to ongoing global disease trends. An estimated 30 daily disease notification reports are received from ProMED-mail subscribers, with an estimated 20 of these reports being forwarded onward to a designated Top Moderator (an infectious disease or public health specialist), on duty for further verification (Woodall, 2001:154; Madoff, 2004:229).

In the next step, the designated Top Moderator reviews the received health data and subsequently rejects reports which are irrelevant, outdated, unverified or duplicates of information contained in previous reports (Madoff, 2004:228-229). Reports which are confirmed as relevant by the Top Moderator are subsequently forwarded to expert area moderators within the ProMED-mail team

who further analyse and examine reports for scientific accuracy and creditability. In cases where further information or insight might be required, the ProMED-mail system contacts its base of additional outside experts who additionally moderate reports and offer further perspective and clarity. Once assessed by specialists, aggregated health notification reports are returned to the Top Moderator on duty who assigns an urgency tag to each report along a spectrum from red to green. A red rating indicates an emergent public health emergency of highest concern. When this occurs, reports are immediately uploaded onto the system's publicly accessible website, with further notification e-mails sent to the ProMED-mail subscriber base via the system listserv. Reports designated as yellow may or may not be uploaded immediately with further discretion left to the Top Moderator. Reports classified as green, or little or no health urgency are then sent to a support copy editor for further review and finalisation. On average, the health report generation and dissemination capacities of the ProMED-mail system publish and upload seven daily reports, 365 days per year, on occurring and probable infectious disease threats (ibid).

Launched during the early and expanding years of the Internet and the World Wide Web, ProMED-mail has become incredibly successful at attracting a growing global subscription. Furthermore it 'has helped to demonstrate the power of networks and the feasibility of designing widely distributed, low-cost reporting systems ('distributed surveillance') ...[t]hese concepts help to begin building the heavily networked surveillance systems that will be needed to deal with public health threats in an increasingly globalized and unpredictable world' (Morse, 2012: 10). Following ProMED-mail's advanced forecasting of an outbreak of the Ebola Virus Disease (EVD) in Kikwit, Zaïre in 1995, membership spiked to 3500 members in 90 countries. As the initiative approached its 10th anniversary in 2004, ProMED-mail membership reached 32,000 members across 150 countries. By 2014, 20 years after the first launch of ProMED-mail, the system consisted of more than 60,000 members across 185 countries globally (Madoff, 2004; ProMED-mail, 2010).

Critically, this expansion of subscription and coverage for the ProMED-mail system effectively generated a completely novel channel and form of surveillance for outbreak and infectious disease knowledge on a globally, increasingly digitised and diffuse, networked scale. Not only did the novel surveillance system seek to widely disseminate and develop comprehensive reports of aggregated health data, but it further provided scope for its connected membership base to 'recognise that what they [were] observing locally may be happening in other places as well' (Morse, 2012: 10). The steady growth of this novel online technology from 1994 onward further is indicative of transitioning governmental rationalities for the management of pathogenic threats in an era of globalization. In its innovative approach to the collection of online data sources for pandemic forecasting, the ProMED-mail system became the first of these three syndromic surveillance systems to utilise new and potentially strategic reservoirs of open-source data located online, reflecting further, the new relationship of data excess, rather than scarcity in the era of digital surveillance.

Subsequently, the marked move towards the use of open-source ‘indicative’, rather than diagnostic/statistical data by ProMED-mail reflects further the move to what Rouvroy has described as ‘knowledge without truth’ via digital proxy data. ProMED-mail’s further surveillance objective, which seeks to digitally capture and report upon *emergent* public health emergencies via the increased blending of human analysis, reflect a new mode of infectious disease surveillance, oriented towards the exceptional health event, and increasingly bolstered by technological advancements.

Expanding Networks in Infectious Disease Surveillance

In the two decades following the launch of ProMED-mail, the syndromic surveillance system has been noted for its significant role in demonstrating the value of a novel and direct mechanism for rapid generation and exchange of up-to-the-minute news from any source on emerging diseases of all species (Morse et al., 1996:137). Throughout the course of its significant growth as a digital syndromic surveillance system over the past two decades, ProMED-mail has expanded considerably not only within the growth of its own networked membership base, but within expanding the medium of global health and infectious disease surveillance via research and design, the generation of new budget funding and the engagement of new parties and groups seeking to harness the future-situated infectious disease outbreak reporting curated by the ProMED-mail system. ProMED-mail has continued to design, launch and partner in varied global public health intelligence programmes which seek to enhance the timely and effective reporting of ongoing infectious disease trends and to disseminate this new form of future-situated epidemic intelligence at a global level. Seeking to extend connectivity and accessibility of infectious disease reporting, the ProMED-mail system has further developed separate software and linguistic versions of the technology to further bolster surveillance capacities. As of 2016, in addition to English, the ProMED-mail system can be accessed in French, Portuguese, Russian and Spanish in order to support ‘regional efforts in South America, Africa, Russia and the former Soviet Union and southeast Asia’ (Morse, 2012: 10).

Moreover, ProMED-mail has further generated specific geographic and regional coverage to address problematic enclaves known as ‘infectious disease hotspots’ or global areas where both health information and the occurrences of highly infectious disease outbreaks have remained problematic. Along with the general global scope of the ProMED-mail interface, specific regional links specific to global geographies with a high disease-burden are now accessible through the system website. Specific geographical focus is given to Afrique Francophone and Anglophone Africa, the Middle East/North Africa, South Asia and the Mekong Basin, a region which collectively consists of Burma, Cambodia, China, the Lao PDR, Thailand and Vietnam.

In 1999, ProMED-mail was incorporated as an official program within the broader International Society for Infectious Diseases and has since gained increased substantial funding from a range of sources for its maintenance, research and development initiatives from a diverse range of new agents

and actors for the strengthening of global health security including the Gates Foundation, the Rockefeller Foundation, the Oracle Corporation, the Nuclear Threat Initiative, Skoll Global Threats Fund and the Wellcome Trust (ProMED-mail, 2010). Furthermore, in 2008, ProMED-mail along with HealthMap, a second-generation syndromic surveillance system was awarded a financial grant from Google as part of the *Predict and Prevent Initiative*. The aim of the initiative sought to ‘help prevent local outbreak of emerging diseases from becoming pandemics’, and further committed over \$30 million in grants to ‘support partners to identify hotspots where diseases may emerge, detect new pathogens and outbreaks earlier and respond quickly to prevent local threats from becoming global crises’ (Google, 2008).

ProMED-mail, Proxy-Data and the Generation of ‘Surface Knowledge’ Surveillance in Global Health

Since its launch, the ProMED-mail system has significantly re-contoured previous channels and methods of information exchange, curation of knowledge and new forms of surveillance within the global politics of infectious disease surveillance. Demonstrated by a large-scale outbreak of wild poliomyelitis in Guinean in 1967/68, despite its role as the primary active agent in global health affairs, the WHO during this era was effectively reliant and bound by on the political acquiesce of its member states to provide crucial epidemic intelligence during outbreaks of highly infectious disease. In many cases, requisite outbreak information requested from member states have been biased, revised or withheld completely with economic incentives for countries not to fully disclose the nature and extent of an outbreak (Wilson and Brownstein, 2009:829). Additional to this, concerns with the quality and veracity of supplied health data as well as the capacity for low and middle-income states to maintain costly and labour-intensive surveillance programmes have meant that in many parts of the globe, existent traditional surveillance capacities were fragmentary, lacking in coordination and geared towards identification of established diseases (Morse et al., 1996:137).

In seeking therefore to enhance the timely and effective monitoring and reporting of unknown and emergent infectious disease outbreaks through harnessing the near real-time platform of the Internet and the World Wide Web, ProMED-mail has also further re-appropriated the control of knowledge exchange and curation away from the exclusive remit of sovereign states or national governments. From 1994 onward, ProMED-mail has in many cases, forecasted urgent public health emergencies ahead of traditional public health actors, frequently in advance of several weeks. On 28 May 1996, a subscriber to the ProMED-mail system contributed media information reported in the Philippines of a large-scale outbreak of cholera which was occurring in Manilla. Following ProMED-mail’s posting of the health event, it was not until 14 June that the WHO has received the requisite clearance from the Government of the Philippines to confirm the ongoing outbreak in its electronic bulletin. Later that same year, the ProMED-mail system reported an outbreak of the Ebola virus in Gabon in advance of confirmations of

the outbreak by the WHO. As Madoff and Woodall (2005:725-727) highlight, the fact that these reports were later confirmed by WHO headquarters in Switzerland further testifies to the reliability of reports generated by ProMED-mail, and indicates new considerations towards openness and transparency that sovereign states must be aware of in light of the forecasting capacities demonstrated by ProMED-mail.

In 1997, ProMED-mail generated health reports which detailed the outbreak of meningococcal meningitis among Vietnamese migrants in Moscow. This outbreak was initially denied to ProMED-mail by the Russian State Secretary of Epidemiology but was later confirmed by the Director of the Laboratory for Meningococcal Infection and Bacterial Meningitis in Moscow (ibid). In 1999, the ProMED-mail system successfully reported the outbreak of cholera in 11 different countries, in advance ranging from 3 days to 8 weeks before the WHO was able to do so, due to pending clearance from member states. The surveillance system further reported outbreaks of plague across eight countries the same year in advance of the WHO because of the same reason. Following the terror attacks of September 2001, global health interest of ProMED-mail increased substantially still, due to an increased and newfound public awareness and anxiety related to terrorism and bioterrorism, following the anthrax attacks in the United States in October 2001. These incidents furthermore ‘erased the assumptions that the use of infectious pathogens as agents of biological warfare was a remote possibility’ (ibid).

The continued relevancy of ProMED-mail as an important sentinel within practices of global health surveillance would continue into the early twenty-first century. Between February 2003 and February 2004, there was a noted further 20% increase in new subscribers and contributors to the system (Madoff, 2004:231). Furthermore, ProMED-mail has been widely cited as among the primary systems which signalled the emergence of the novel severe acute respiratory syndrome (SARS), which originated in Guangdong, Southeast China in late 2002/03 (Cooke and Shapiro, 2003; Heymann, 2006; and Brownstein et al., 2008). During the height of the global SARS pandemic in 2003 alone, the ProMED-mail system generated 196 sequential reports detailing the progression, scope and nature of the ongoing public health emergency and disseminated this open-source information to its global membership base, health agencies and stakeholders in global health (Cowen et al., 2006:1098). In seeking to forecast the next global pandemic, in 2005, ProMED-mail extensively covered and reported upon the global spread of the H5N1 avian influenza (ProMED-mail, 2016). A decade following the spread of the H5N1 avian influenza, the ProMED-mail system actively tracked and comprehensively reported on the 2014/15 West African Ebola Epidemic and the 2015/16 Zika virus outbreak (ProMED-mail, 2016).

In advancing the forecasting of potential infectious disease threats into the temporality of near real-time, and in serving to emancipate the curation of epidemic intelligence from exclusive control of the sovereign state, the ProMED-mail system also became the first of kind digital technology to seek to generate a new form of infectious disease knowledge for the control and regulation of pandemic phenomena—that of *surface knowledge*. Lorna Weir and Eric Mykhalovskiy (2010:146-148), have

contrasted the concept of surface knowledge with that of earlier forms of epidemiological ‘depth’ knowledge for the management of pandemic contingencies which were statistical and case-based.

Juxtaposing this, the rise of surface knowledge for governing pathogenic threats is sourced in ‘non-medical, unofficial, digitized information rather than on diagnostic reports about pathologies occurring in the depths of the body, and it uses the digitized information of events as the basis for issuing alerts’ (ibid). Case-based surveillance which dominated the preceding government of infectious disease outbreaks was dependent on diagnostic information to both guide the politics and response to public health emergencies. Unlike traditional methods of surveillance, early syndromic surveillance systems including ProMED-mail began to indicate a differing rationality to infectious disease detection and the promotion of vigilance in attempting ‘to recognize outbreaks by identifying clusters of data...early warning outbreak systems including ProMED-mail were devised to have a global reach by the use of online, unofficial data sources that for the most part escaped national control.’

Through its recourse to a broad new scope of digital sources and contributions from its membership base via electronic medium, ProMED-mail was the first of these new surveillance models to begin to generate a form of indicative surface knowledge derived from unofficial sources to create new governmental knowledge and bolster the identification of pathogenic threats in a method which went beyond ‘clinical descriptions and laboratory results’ (ibid). The production of surface knowledge for the government of pandemic threats in global health, in the words of Weir and Mykhalovskiy represents ‘an epistemological shift within global public health reasoning’ in which emergent governmental rationalities seek to intercept non-traditional data sources to gain advanced warnings of potential exceptional health events, and to disseminate *knowledge* of these contingent threats within expedited near real-time mediums. Subsequently, this digital turn towards the incorporation of surface knowledge demonstrated by ProMED-mail within the politics of global health surveillance, has produced new implications for member states and their relations with the WHO from 1994 onward.

The expansion of ProMED-mail over the past two decades has presented new benefits of the development of new low-cost surveillance networks which allows membership ‘to find out, comment and disseminate reports on emerging disease threats through a freely available and open mailing list’ (Wilson and Brownstein, 2009:829). Significantly, the growth of ProMED-mail resulting from proliferation of the personal computer and Internet usage has meant that with reduced considerations for cost and increased reporting transparency of these reporting systems, many countries and national governments ‘have been placed in a position in which they cannot ignore or hide information about disease outbreaks that occur within their sovereign borders’ (Heymann, 2006:350). Despite the significant growth of new forms of pandemic knowledge produced by ProMED-mail, contestations over state sovereignty and the control and dissemination of this form of knowledge continue to occur. Indicating that within the era of globalised pandemic threat, the state has not faded as a relevant and indeed, potentially defensive agent of power.

In many areas of the globe for example where political or civil liberties of citizens are have been compromised, ethical discussions have developed around the security of persons within such states and their capacity to safely participate in the curation of specific forms of global health knowledge beyond the jurisdiction of the sovereign state. In 1997, ProMED-mail publicised the case of Dr Desi Mendoza Rivero, a Cuban physician who was imprisoned for publicly questioning the number of cases during a dengue outbreak in Cuba. Additionally, in 1998, ProMED-mail made public, the case of Dr Tan Poh Tin of Malaysia, who faced prosecution after releasing health information detailing 27 paediatric cases of fatal foot and mouth disease onto the ProMED-mail website without prior clearance of the Government of Malaysia (Madoff and Woodall, 2005:726). Both cases of the attempted prosecution by state of physicians who undermine state policy in the dissemination of outbreak knowledge demonstrate the continued contestation of control, production and ownership of knowledge within the politics of health and infectious disease which exist at the junction of the sovereign and the global.

ProMED-mail and Emergent Rationalities in the Governing of Pathogenic Threats

The design and rise of the ProMED-mail system as the first syndromic surveillance system of the late twentieth century occurred within the context of a specific problematization of then current global health systems for the government of contingent pathogenic threats. Within an era of expanding and accelerating globalization, and of an ‘epidemic of epidemics’, previous modes of health surveillance were increasingly viewed as inadequate and easily outpaced by the rapid spread of novel pathogenic infections, and were further problematized by the reticence of sovereign states to make available, crucial epidemic intelligence during times of pandemic threat. Within the politics of infectious disease therefore, what followed with the development and piloting of ProMED-mail and its recourse to open-source data streams and curation of health alerts was a significant shift in governmental rationalities in the curation and dissemination of global health knowledge via the development of novel, digital syndromic surveillance systems for the forecasting of pandemic threat from the 1990s onward.

Broadly, the original development of ProMED-mail as a surveillance instrument for the identification of new and emergent infectious diseases appeared congruent with then understandings of governmentality and security presented by Foucault. At its level of operation, ProMED-mail was designed as a governmental technology of power which had as its central surveillance objective, the

health of populations. Indeed, as stated on the ProMED-mail website (2010), ‘ProMED-mail is an Internet based reporting system dedicated to rapid global dissemination of information on outbreaks of infectious diseases and acute exposures to toxins that affect *human health*⁷.’ Moreover, the original rationalities which underpin the design of ProMED-mail continued to present the concept of population health as an ‘essential problem’ of government, and thus considered further, the techniques which must be developed to regulate the future, and not exactly controllable aspects of population (Foucault, 2007:20-21).

What is more, the growth of ProMED-mail over the past two decades, and the increasing interest demonstrated by high-income states as well as the WHO to harness the flows of open-source epidemic intelligence generated by the surveillance system demonstrates the role in which this novel syndromic surveillance system has come to assume in the securing of global *circulation* patterns. Operating online and beyond the jurisdiction of the sovereign state, ProMED-mail sought to promote the exchange, dissemination and communication of infectious disease knowledge on a *global* scale, conveying strategic health knowledge for pandemic uncertainties even in instances where certain states had sought to withhold such information for fears of economic turndown or loss of political legitimacy. In doing so, high-income states and intergovernmental health organisations concerned with population security on one hand, but also on the free circulation of trade, capital and economy, have now openly and increasingly turned to the forecasting capacities of the ProMED-mail system which were previously absent in the traditional arrangement of health diplomacy. Specifically, in the years following its launch, the WHO has steadily incorporated and frequently now utilises report alerts issued by ProMED-mail as a basis in which to investigate emergent or probable public health emergencies. Centrally, in this regard, the ProMED-mail system has been seen to serve grander global health means which ends include the preservation of systems of circulation internationally.

The history of ProMED-mail has also demonstrated the centrality of the prototype syndromic surveillance system within a larger process of global health security described by Elbe (2009), as the *governmentalization of the state*. As this thesis has so far discussed, the process of the governmentalization of the state, sees the state as now the regulator of a broad scope of population activities and dynamics. In seeking to manage and to optimise at the level of the population, the process of governmentalization sees the facilitation of much wider ‘alliances between states, international organizations, and a range of nongovernmental organizations’ (Elbe, 2009:21), in the addressing and management of population complexities. While ProMED-mail was launched as a novel surveillance technology aimed at the rapid curation and dissemination of digital epidemic intelligence, its development has corresponded with the emergence and commonplace of a range of new actors and agencies additional to the state, for addressing pandemic contingencies in the late twentieth and early twenty-first centuries. From 1994 onward therefore, ProMED-mail along with its network of

⁷ Italicise added

collaborative and research partners which include the Wellcome Trust, Skoll Global Threats Fund, Google.org, the Gates Foundation, the Rockefeller Foundation, the Oracle Corporation, the Nuclear Threat Initiative, and HealthMap, constituted larger processes of the governmentalization of global health in an era of increased pandemic vigilance.

And yet, as the first of the three syndromic surveillance systems discussed within this thesis, ProMED-mail also became the first of these systems to demonstrate a divergent governmental rationality, indicating the early emergence of an ‘unprecedented mode of government fuelled with quantifiable signals’ of raw data (Rouvroy, 2015a). In recognising the failure of past systems to effectively manage and identify pathogenic threats through the sole utilisation of statistical ‘depth’ knowledge supplied by national health institutes, new governmental perspectives for the generation of epidemic intelligence began to form within the era of the emerging infectious disease (EID) worldview.

Of the syndromic surveillance systems presented within this thesis, ProMED-mail thus marks the first and earliest manifestation of a new instrument of security for the forecasting of infectious disease contingencies. In seeking to harness the potentially indicative points contained within open-source data, collected and supplied on the new forum of the Internet, the ProMED-mail system diverged from the previous regimes of ‘statistical science’ described by Foucault, and seeks alternatively, to construct knowledge and understanding of yet-unforeseen public health emergencies through a novel recourse towards digitised, open-source, non-official and indicative online data. In doing so, ProMED-mail also shifted the scope and nature of what could be considered as relevant sources of data for the surveillance of epidemics and pandemics. It challenged further, the long-held assumption that public health knowledge could only be generated and supplied from the organs of the state including ministries of health and scientific institutes, and it utilised the emergent Internet infrastructure as a new medium in which to disseminate this form of knowledge informed by open-source, indicative, data rather than diagnostic confirmation.

The launch of ProMED-mail also indicated a new epistemic shift in relation to the collection and processing of data requisite for the generation of knowledge for the government of infectious disease. While previous systems sought to generate knowledge of forthcoming pandemics via consultations with states, and through official health records, laboratory confirmations, and population records, the veracity of these data sources were in question, and data itself was often scarce. Contrastingly, the coming of the digital era, the rise of electronic interconnectivity, and the generation of open-source data at the time of ProMED-mail, also indicated a new mode government for the surveillance and knowing of probable public health emergencies.

Correspondingly, the debut of ProMED-mail in a new era of open-source, online data therefore corresponded to a new problem of government in the digital age, one of data excess rather than scarcity. Innovatively, ProMED-mail built upon new opportunities provided by technological growth, combined with human analytics to collect, process, report and exchange epidemic intelligence derived from its surveillance operations at a rate not previously feasible through previous modes of human observation

and statistical analysis. Specifically, the advent of the Internet and of e-mail listservs provided effective new channels in which increased flows of open-source data could be obtained, processed, and exchanged across a networked, globalised surveillance grid, seeking to process a maximum of new open-source data to produce specific disease alerts of emergent or future uncertainties.

Finally, in its drive to capture, process, and report upon increasing streams of open-source data from its membership base and from the World Wide Web, the ProMED-mail system has indicated a shift in relation to data, away from the processes of normalization described by Foucault, and alternatively towards the detection of the exceptional or the singular event within emerging digital governmental models. As Rouvroy and Stiegler (2016:12-13) have explained, the digital era and the growth of online interconnectivity have resulted in the automatization and acceleration of the production of knowledge from data. The proliferation of open-source data, combined with the ability of ProMED-mail to collect and disseminate information from these new data reservoirs marks a new departure ‘from the traditional practices of statistics in which points far from the average or from the line of reparation were ignored as noise or perturbation...new abilities to manage large datasets by computers means everything is potentially useful or taken into account. Even what is the farthest from the average, what is the most singular’ (ibid). The development of ProMED-mail therefore corresponds with this epistemic shift in [algorithmic] governmentality, away from the statistically informed processes of normalization which guided previous governmental responses to outbreaks of disease, and instead orientates towards the surveillance of the emergent or the exceptional pandemic threat. In operational terms, ProMED-mail sought to collect, process, and report upon as much online data as possible, through a mixed-method approach of human and emergent digital processes to report upon emerging or novel infectious disease events, highlighted for example, by the emergence of Ebola in Kikwit, Zaïre in 1995. Considering, a widened array of new data sources in which all points could be taken into account and assessed, the system moved away from the selectivity and narrowed scope of previous systems of governing pandemic threat via deductive logic and processes of normalization, turning alternatively to the increasing non-selectivity of online data in its objective to monitor emerging infectious diseases and exceptional health episodes occurring at the global level.

Conclusion

A review of ProMED-mail over the past two decades situates the emergence of a novel rationality and form of infectious disease surveillance for the governing of increasingly virulent and globalized pandemic threats in the late twentieth century. Differing significantly from previous systems of surveillance which curated epidemic intelligence on probable outbreaks, the launch and rise of ProMED-mail from 1994 onward has been shown to produce new implications and shifts for the practice of global health security and the dissemination of forward-situated pandemic knowledge. Over the course of the past two decades, the prototype syndromic surveillance system has been incredibly

popular and has expanded significantly due to peaked interest in the reporting activities of the system demonstrated by global health agents and actors seeking to accelerate the temporalities of identification, reporting, and response to looming pandemic threats to both populations and systems of international circulation.

Drawing influence from Antoinette Rouvroy's concept of *algorithmic governmentality*, this chapter has so far demonstrated how the launch of ProMED-mail, as the first online, open-source health surveillance technology reflected novel governmental rationalities which differed significantly from the original tenants of governmentality presented by Foucault. Influenced by past public health emergencies whereby statistical sciences and knowledge of pandemic occurrences were either compromised or stonewalled by reticent states, the launch of ProMED-mail not only generated a new Internet forum which was beyond the jurisdiction of the sovereign state, but the health surveillance technology was the first model to harness potentially predictive information contained within open-source data collected online and submitted by its membership base. This growing recourse to unofficial data and online reporting critically, 'emancipated' the curation and dissemination of infectious disease knowledge from its moorings within organs of the state, and created a new regime of intelligibility and visibility of infectious disease outbreaks in global health security systems in which states increasingly were unable to fully control. ProMED-mail served as the first surveillance technology which considered, how future public health emergencies could be expediently known and addressed through the filtration and assessment of open-source indicative data, beyond the statistically-informed, depth-knowledge conveyed by member states of the WHO.

Significantly, the large-scale utilisation of open-source data rather than statistics by the ProMED-mail system has not only bypassed sovereign authorisation to release or withhold such data, but ProMED-mail's curation of infectious disease outbreak knowledge via unofficial, open-source data further is indicative of the rise of a new form of knowledge within global health security, presented as Rouvroy (2009:2), as *knowledge without truth*, in which the ability for surveillance systems like ProMED-mail to receive, organise, process, draw meaning from open and unofficial data-sources, diminished previous governmental processes including the 'test', 'trial', examination', 'assessment', or 'épreuve' which were central to the statistical rendering of phenomena and future events knowable in the modern state. ProMED-mail as the prototype syndromic surveillance system also became the first of these next generation health surveillance systems to indicate the emergence of a novel algorithmic governmentality, differing from previous systems in the recourse to steadily expanding, open-source data streams, in which all signals can be processed to reveal yet unforeseen correlations of occurring or probable health events.

The launch of ProMED-mail has generated a successful reporting record which in many cases occurred in advance of the traditional reporting and dissemination activities of member states of the WHO. Epistemically, this shift produced an emancipated channel of increasingly digitised knowledge of outbreaks in which the WHO was now able to readily access and utilise in its surveillance and

reporting operations. The subsequent incorporation of the ProMED-mail system within the WHO's 'network of networks', known as the *Global Outbreak Alert and Response Network* (GOARN), further solidified the role of ProMED-mail as a novel security technology for the open-forecasting of circulating pandemic threats within an emergent global health regime of the late twentieth century.

However, as examples within this chapter have demonstrated, the rise of ProMED-mail as the first digitally oriented health surveillance system has emphasised and in some cases exacerbated tensions between the sovereign and the global in establishing novel security apparatuses for the forecasting of infectious disease. On one hand, the prosecution and jailing of medical practitioners in Cuba and Malaysia whom in contravention of government policy, disseminated health data via ProMED-mail indicated the capacity of sovereign states to attempt to still control the curation and dissemination of infectious disease knowledge within national jurisdictions, while on the other, the open-source reporting streams of ProMED-mail and its increasingly centralised reporting role within a larger global health security framework has generated new parameters of visibility and scrutiny in which sovereign states were now increasingly subjected to, and needed to be aware of. While states had previously feared economic downturns and disproportionate blockades as a result of reporting outbreaks, in the coming era of increasingly digitised and globalised disease surveillance, the rise of new forecasting technologies including ProMED-mail with the capacity to report in advance of probable outbreaks meant that states were now increasingly convinced that it was their responsibility (and in their interests) to consistently deliver on effective outbreak response regardless of their health system capacity and their other political interests (Davies et al., 2015:14-15).

In retrospect, the launch of ProMED-mail thus marked a significant development within the practice of infectious disease surveillance as a pioneering effort to harness emergent technologies for faster and more extensive surveillance of infectious disease outbreaks across the world (Weir and Mykhalovskiy, 2010:88). In terms of temporalities of report and outbreak notification, ProMED-mail sought to address the formidable gaps between the emergence of an infectious disease and the official notification of an occurring outbreak and this sought to move closer to a regime of near real-time reporting by introducing a cycle of daily reporting online.

Informationally, it became a first of kind health surveillance system to harness digitised information online due to the novel growth of technologies including the Internet and the World Wide Web. Beyond this, through the utilisation of open-source information and curation of daily disease reports, the ProMED-mail system allowed the public to have greater access to health surveillance information (Wilson and Brownstein, 2009:830). Significantly, the incorporation of ProMED-mail into the Global Outbreak Alert Response Network (GOARN), at the start of the twenty-first century represented a renewed initiative to address and overcome both the political and technical obstacles to global health surveillance, namely to bypass attempts by states to obfuscate, or to delay, the confirmation of an outbreak due to their fears over trade and travel repercussions: and, in other instances, to assist states that lack the means to detect and respond effectively to outbreak events

(Davies, 2012a:96). Subsequently, through its open accessibility via a personal computer and Internet connection, ProMED-mail, in geographic terms could achieve an ever-greater coverage and monitoring of ongoing infectious disease trends, generating a regime of *visibility* and surveillance previously unfeasible through the exclusive use of traditional health surveillance initiatives.

From 1994 onward, rationalities informing the practice of global health security also appeared to shift following the debut of ProMED-mail. Beneath its novel operating system, ProMED-mail marked a departure from previous governmental operations described by Foucault, and developed further towards an increasingly novel mode of government as outlined by Rouvroy. Oriented towards the rapid identification of future-situated pathogenic threats, ProMED-mail became the first of these systems to deviate from existing governmental processes for the cultivation and dissemination of knowledge and surveillance practices of infectious disease outbreaks in a number of significant areas. ProMED-mail broke with traditional governmental systems for health in its novel turn towards harnessing the steadily increasing streams of open-source data which had only been recently made possible with the launch of the Internet and the World Wide Web, in doing so, the surveillance system was able to access an ever-increasing reservoir of potentially indicative digital health data. Subsequently, with the capacity to harness, upload, and disseminate more potentially indicative health data than was previously feasible, the objective of ProMED-mail shifted from seeking to govern the health and security of populations via processes of normalization as informed by the generation of statistical knowledge to inform the practice of health security, alternatively towards the securitization of populations and circulation through the identification and forecasting of *exceptional* and emergent health events, including avian influenza, Ebola, and SARS, from increasingly diffuse, non-official supplies of surface knowledge in the digital era.

Looking back then, ProMED-mail was the first of kind syndromic surveillance technology of the coming digital era which sought to address new governmental considerations of pandemic risk in an increasingly globalised and vigilant ‘world on alert.’ Then fledgling digital and technological innovations including the medium of the personal computer as well as the Internet served as channels in which to shift the curation and dissemination of knowledge of infectious disease outbreaks away from previous moorings within organs of the state, and to produce a novel form of future-situated health surveillance derived from open-source information located online. ProMED-mail’s recourse to alternative sources of data, its open system of knowledge curation, and its orientation towards detection of exceptional global health events has further led to new avenues of discussion on the parameters of governmentality in the digital era, and as shown, uncovers new implications for the state as a source and curator of knowledge in global health security frameworks.

Critically however, while ProMED-mail was the first health security technology to substantially re-situate the production and dissemination of knowledge requisite for the addressing of pandemic threats from 1994 onward, and facilitated early, yet significant transitions in governmental techniques towards greater *visibility* and *intelligibility* of global geographies of risk, it remained a surveillance

system still extensively reliant upon human analytic and observational capacities in order to aggregate, analyse, and disseminate new health alerts on emergent or probable pathogenic threats. As such, while the history of ProMED-mail has suggested new governmental rationalities which have underpinned the creation and launch of syndromic surveillance systems over the past two decades, the system did not yet make extensive use of forthcoming algorithmic technologies for the forecasting of infectious contingencies.

Chapter Five: Harnessing the Algorithm (GPHIN)

Introduction

Three years following the launch of ProMED-mail, in 1997 a new syndromic surveillance system known as the Global Public Health Intelligence Network (GPHIN) was developed in partnership with the World Health Organization (WHO) and Health Canada, and aimed to ‘increase awareness and capacity for the early detection of emerging public health events’ (Dion et al., 2015:1). Unlike however, its earlier counterpart ProMED-mail, which monitored and curated knowledge of emergent disease threats through the generation of alert reports derived from information submitted from its global membership base and collected from increasingly abundant open-source online data, GPHIN alternatively sought to develop an online surveillance system which harnessed the availability of media sources online, as a result of the explosion in information content available on the World Wide Web throughout the late 1990s and into the twenty-first century (Morse, 2012:10). In recognising the potentially strategic reservoir of data contained within open-source and online media reports, the operational objective of the GPHIN system was therefore ‘to determine the feasibility and effectiveness of using news media sources to continuously gather information about possible disease outbreaks worldwide, and to rapidly alert international bodies of such events (Keller et al., 2009:2).

Unlike its earlier counterpart ProMED-mail, the launch of the GPHIN system occurred within a rapidly diversifying realm of digitised information and technological innovation following the earlier debut and expansion of the Internet and growth of the digital era. Faced therefore, with an increasingly complex online infrastructure, the GPHIN system would develop and integrate further methods and technologies in the practice of health surveillance to enhance the curation and dissemination of knowledge for infectious disease outbreaks as the twentieth century drew to a close. Significant among these developments, GPHIN would be the first of kind syndromic surveillance system to design, integrate and rely upon increasingly available digital algorithmic technologies within its surveillance and outbreak alert operations.

Responding to the proliferation of expanding and increasingly unintelligible digital media content, as well as the ‘radical transformations which have occurred in the conditions for knowing and responding to global disease threats’ (Mykhalovskiy and Weir, 2006:42), a novel sorting algorithm at the centre of the GPHIN initiative would filter and aggregate ‘data that provides potential signs of emerging public health events which [were] then reviewed by a multilingual, multidisciplinary team’ (Dion et al., 2015:1). Accredited for its early utilisation of algorithmic processing, linguistic translation capacities and of harnessing the foreshadowing capacities of Big Data to accelerate the surveillance of pandemic contingencies, GPHIN rapidly established a central role as an early-warning health sentinel in emerging public health emergencies of the early twenty-first century. GPHIN has been accredited as central provider of advanced outbreak detection knowledge during numerous public health emergencies including the discovery of a novel strand of human influenza in the northern region of the People’s Republic of China in 1998, during the apex of the 2002/03 SARS outbreak, the initial discovery of MERS-CoV, through to the identification and tracking of swine (H1N1) and avian influenza (H5N1), the 2014 outbreak of polio in Equatorial Guinea and during the 2014/15 West Africa Ebola outbreak (Mawudeku and Blench, 2006; Mawudeku et al., 2007; Mykhalovskiy and Weir, 2006; Keller et al., 2009; Anema et al., 2014; and Dion et al., 2015).

Moreover, if ProMED-mail served as the first syndromic surveillance system to indicate shifting governmental rationalities in relation to the diversifying forms of data, through new processes of knowledge curation, and in the transition to the detection of exceptional health episodes contained within open-source streams of data, the launching of GPHIN in 1997 would represent a new intensification of an increasingly *algorithmically* informed mode of government, aimed at the advanced identification and addressing of future-situated, and potentially disruptive health phenomena. While ProMED-mail served as a prototype technology for open-source data, and indicated that new digitally curated forms of health surveillance could serve as feasible alternative outbreak sources during times of public health emergencies, the design and function of GPHIN reflected a growing capacity to *digitise* and *automate* the collection, filtration, translation and dissemination, and indeed, observation of online data, indicative of an exceptional health event, occurring globally.

Significantly, the novel implementation of a digital sorting algorithm, for the accelerated filtration and processing of data sources within the GPHIN system from 1997 onward, signified the new and increasingly complex relationship between sources of data and the governmental processes to produce *knowledge* of health events via new syndromic surveillance systems: Data is located everywhere, and all data could be useful or strategic, however new techniques and technologies would need to be deployed to comb increasingly complex sets of data in order to identify the singular needle within the growing haystack. Unlike ProMED-mail which initially sought to develop new channels of communication for the uploading and dissemination of knowledge forms for infectious disease threats but relied extensively on human analytic and observational processes to generate knowledge forms, the new problematization of knowledge faced by the GPHIN system would be in how to capture and process strategic data correlations related to infectious disease outbreaks across a now seemingly ‘infinite datascape’ (Pasquinelli, 2015:5). It is within this particular problematization of expanding online data sources in which the digital algorithm, implemented as a central function within GPHIN, therefore emerges as a new governmental technology, and an antidote for the foreshadowing of opportunities and threats...[and to derive] the probable from the untameable excess of uncertainty (Rouvroy, 2016b).

This chapter therefore seeks to locate and present the contextual origins and the underpinning rationalities of the GPHIN project through its development and increasingly centrality as a health surveillance sentinel for global health authorities into the twenty-first century. In doing so, this chapter extends further discussion on how the growth of GPHIN from 1997 onward, and its novel recourse to increasingly algorithmically informed modes of health surveillance, have continued to expand and transform governmental rationalities for global health security, which have in turn, produced new and increasingly refined forms of syndromic surveillance.

Plague in Surat, Diffusions of Data, and the Origins of GPHIN

The concept of the GPHIN initiative traces its origins to 1994 during an outbreak of pneumonic plague in Northwest India. In September 1994, the first case of urban plague re-emerged in India (Anderson, 1994: A10). On September 22, cases of plague were reported in Surat, a city in the extremely densely populated state of Gujarat with an estimated population of 2 million. As reports of the outbreak gained momentum, the health episode resulted in an unparalleled panic with severe international and economic ramifications. Within days of the initial reporting of the outbreak, hospitals and care-facilities were inundated with patients. Local newspapers and media outlets estimated that the total number of plague cases had reached 1061 (Dutt et al., 2006:755). While control and response measures were initiated by public health practitioners, as well as federal and state agencies, the perceived rapid spread of the Surat Plague resulted in an outward mass flight of an estimated quarter of the population of the city and into other major urban centres such as Delhi, Calcutta, Maharashtra and Mumbai (Dutt et al., 2006:759;

Byrne, 2008:542-543), thus facilitating and increasing the risk of secondary infections, transmission and introduction of plague into new territories in a process known as relocation diffusion.

Although the Surat Plague did not represent the first public health emergency of its kind in India, it did serve to provide an example of how traditional public health and infectious surveillance processes were lagging behind in an age of increasingly complex information flows and global media coverage. As recounted by Ron St John, former Director for Emergency Preparedness at the Public Health Agency of Canada, when the outbreak of plague occurred in Surat '[w]e were sitting in Ottawa watching CNN showing pictures of people fleeing...we had no capacity to respond to outbreaks on our own, or to even deal with the information coming in...[a]ll we had was a fax machine' (Burns, 2006:769).

Significantly, the outbreak of plague in Surat in 1994 coincided with the emergence of an expanding global media presence towards the end of the twentieth-century, which was steadily generating new streams of knowledge of potential health emergencies at a rate which increasingly outpaced the previous reporting and confirmation protocols of national health institutes. What this meant was that media organisations such as BBC and CNN with a global audience now reported in near real-time temporalities on the plague situation in Surat, and would widely disseminate such unofficial health knowledge to their viewers. Subsequently, unlike prior outbreaks, in which crucial epidemiological data was obfuscated by governments and national health institutes, '[t]he Surat epidemic received international publicity through established newswire services such as Reuters, through radio channels such as the BBC and through the newer form of global portable satellite television such as CNN International, which had been established in 1985 to cover global news on a 24-hour, 7 days a week basis. Newspapers in major urban centres across the world, including the *Global North* ran stories about the outbreak...[s]atellite TV had created information about the outbreak faster and had generated responses well before epidemiological communications had officially been communicated by India' (Weir and Mykhalovskiy, 2010:81-82).

While some media coverage of the Surat outbreak had exaggerated or sensationalised elements of the outbreak which had lent to disproportionate panic both within India and abroad, the near real-time coverage and generation of knowledge of the event by these non-traditional reporting channels captured the progression and perspective of the outbreak which had not been previously feasible utilising existent health surveillance systems. For example, the mass proliferation of unofficial reporting of health data by international media outlets now provided for a rich database of material which could potentially be utilised to connect the operational dots between the early origins of the disease in Surat and lend further clarity to the scope and progress of the outbreak, enhancing awareness as well as increased preparedness and response planning. Building upon this, through communication and e-mail exchanges with a locally based physician in Surat during the outset of the plague, the founding team of the GPHIN project discovered the surveillance potential of the new forms of online information,

including media reports that could outpace official country notifications (Mykhalovskiy and Weir, 2006:43).

The 1994 outbreak of plague in Surat thus represented a significant shift of governmental rationalities within the politics of infectious disease surveillance and global health. The public health episode first highlighted that new techniques of surveillance were required in order to amass and disseminate crucial infectious disease knowledge needed to respond to disease threats such as plague and pandemic influenza that could kill millions. Within this problematization of future-situated knowledge for disease outbreaks, Dr Thomas Grein, then a medical officer within Alert and Response Operations at the WHO stated that ‘in the age of real-time electronic media and television, journalists became a vital source of instant information that public health authorities could use to detect outbreaks, in addition to information from governments, nongovernmental organizations and healthcare workers’ (Burns, 2006:769). Moreover, the conceptualisation of the GPHIN project, resulting from the outbreak of plague, as asserted by Wenham (2015:109), marked an important shift in surveillance, as policymakers and planners within global health systems began to understand that surveillance of infectious and emergent diseases needed a more global approach that could bypass the state entirely.

Launching GPHIN

Following the observations which stemmed from Surat in 1994, surveillance considerations now focused towards the development of new electronic systems which could effectively utilise unofficial mass media sources and open-source online data, and translate this information into timely and actionable knowledge for the addressing of infectious disease outbreaks. The problématique shifted therefore, away from how to work with states in concert to attain relevant epidemic intelligence toward ‘how to search through the maze of thousands of reports filed by journalists every day’ (Burns, 2006:769). Subsequently, Ron St John and Rudi Nowak, officials from then Health Canada then partnered to propose the development and feasibility of a prototype computerized system which would ‘collect raw news data from international news agencies such as Agence France Presse, Associated Press and Reuters, and to scan these feeds automatically to find news of disease outbreaks. Moreover, the early conceptualisation of GPHIN occurred in junction with a period in which the Government of Canada was increasingly interested in the development and potential of new initiatives for using the Internet. In 1996 the GPHIN project was awarded \$500 000 CDN from a funding grant through a competition hosted by the Canadian Federal Treasury Board.

The objective of the GPHIN pilot which was developed and designed between 1996 and 1998 sought to ‘demonstrate the use of the Internet for accessing and exchanging health surveillance information’ (Burns, 2006; Mawudeku et al., 2007:304; Weir and Mykhalovskiy, 2010:84-85). Building on the early groundwork established by the previous piloting of ProMED-mail, new emergent rationalities which underpinned the design of GPHIN sought to expand the operability of new surveillance technologies which could function exclusively within the temporality of the World Wide Web, amassing, filtering, and disseminating crucial signals of potential outbreaks at an accelerated pace, and at a global level.

The GPHIN system was designed to amass, aggregate and scan incoming data sources derived from international media reports to gain greater awareness of emergent or probable disease outbreaks. Unlike its earlier predecessor ProMED-mail, which sought to manually aggregate submitted reports, queries and observations via its website, the GPHIN project alternatively sought to access and harness the data-rich contents of media aggregation systems which were debuting on the Internet towards the end of the 1990s. If ProMED-mail sought to develop new surveillance techniques for the uploading and curation of knowledge of infectious disease outbreaks, GPHIN sought to further accelerate and intensify the new methods of reporting and knowledge curation via increasingly sophisticated digital means. Most notably, GPHIN made innovative use of two media aggregation models called *Factiva* and *Al Bawaba* to supply the system with a large variety of national and local newspapers and select news letters from around the world (Dion et al. 2015:3). Factiva functions as an online, multi-lingual, media content service owned by the Dow Jones & Company, whereas the Al Bawaba service amasses and makes available media reporting content in Arabic and English. Building upon new methodologies towards data observation and collection, the GPHIN platform automatically scans these media aggregating sources every 15 minutes for input data to be processed further through the combination of human analytics, as well as automated and algorithmic programming (Mawudeku and Blench, 2006:9).

Upon launch, the GPHIN system was extremely successful at initially attaining streams of incoming digital global health information located online. Reflecting on this, founder Ron St John stated, ‘[w]e were astounded at how much information we could get...but the information had to be verified, and incorrect information discarded’ (Burns, 2006:770). Unlike its ProMED-mail counterpart which sought to curate knowledge of outbreaks during a period in which such information was lacking or scarce, the launch of the GPHIN project was faced with a novel and expanding challenge, to obtain relevant infectious disease outbreak intelligence from proliferating of data and digital sources which had accompanied the acceleration and growth of the Internet. This online information moreover was more often than not unstructured and difficult to interpret and this required the utilisation and development of advanced data processing and computational techniques in order to effectively implement (Wilson and Brownstein, 2009:830).

The initial digital, operational and linguistic development of the GPHIN software platform at the time drew upon the unique technological and intellectual strengths and resources which were

specific to a Canadian context. Within the late 1990s, Canada was an early adopter and innovator of Big Data for the initial identification of emerging infections (Dion et al., 2015:2). Moreover, the development of the surveillance prototype focused on the translating and uploading of relevant infectious disease reporting in both official languages of Canada, English and French. The development of a fluently bilingual GPHIN operating system was the product of extensive prior research undertaken in digital and automatic linguistic translation of computerized texts which had been initiated within the Département de linguistique et de traduction at the Université de Montréal in Quebec. The provision of machine-learning and automatic (ENG→FR/FR→ENG) translation services produced by GPHIN from its launch additionally doubled the generation of surveillance findings and health alerts curated by the system, producing automated infectious disease alerts and disseminating them globally in English and French formatting.

From 1997, the GPHIN prototype system was put into development as a partnership between Health Canada and the WHO. Operating within government office hours, the online surveillance technology scanned and assessed digital health-relevant data from aggregated global media sources in English and French. The incoming sources of information for the early GPHIN system consisted of websites, news wires as well as local and national newspapers (Blench, 2008:300-302). The early GPHIN team at the onset of the project comprised 2 human analysts who manually reviewed and assessed incoming material on a frequent but not continual basis. In this regard, GPHIN became the first system to systematically ‘pull’ relevant data sources detailing an outbreak, and to subsequently ‘present’ these digital findings to human analysts, bypassing many of the previous onerous and time-consuming elements of traditional knowledge generation which hindered previous health surveillance systems. In blending the specific expertise of human resources with innovations in digital and electronic technology, the early GPHIN system utilised both increasingly automated processes of data collection and surveillance with human calculation and analytics to report upon probable or emergent public health emergencies. The automated process of the GPHIN operating platform ‘pulls’ articles circulating within global media outlets on a reoccurring 15-minute interval from the Al Bawaba and Factiva news aggregation services in partnership with the GPHIN system (ibid). The relevant public health media sources, which are collected through an established digital syntax system are subsequently filtered and sorted into computerized taxonomy categories which cover a broad spectrum of human, zoonotic, and plant diseases and further include natural disasters, biological threats, and chemical/radioactive incidents.

Following the process of automated classification by taxonomical category, GPHIN became the first health surveillance technology to implement a purpose-designed information retrieval algorithm, based upon predefined classification by taxonomy, in order to *automatically* processes and assign an initial ‘relevancy score’ by category to each incoming item. Significantly, this score is ‘derived from the proprietary algorithm utilizing the values attributed to the keywords and terms within the taxonomies or taxonomy it has been assigned to’ (Mawudeku and Blench, 2006; Blench, 2008:300-

302). Through this automated filtration and sorting process, articles which are allocated a high relevancy score are automatically uploaded or 'published' to the GPHIN database. Conversely, articles designated as irrelevant or redundant are 'trashed' and not considered for further assessment.

During the initial launch of GPHIN, human analytical and evaluative processes within the online surveillance system consisted of its small team of analysts who applied interpretative, linguistic and assessment expertise in determining the incoming articles of highest relevancy to be published onto the system's website. Through the utilisation of an information sorting algorithm, articles assigned a relevancy score of irrelevant were trashed while incoming articles assigned above the threshold of 85 were automatically uploaded and published to the GPHIN database for additional review and consultation. It is within this informational grey zone between article trashing and publishing that the role of human linguistic, interpretative and evaluative expertise within the GPHIN project functions. Within the GPHIN platform, articles assigned a relevancy rating of 20-85 require further manual assessment by on-site GPHIN analysts whom, through evaluation must further classify articles on a spectrum ranging from publish, to publish with alert to irrelevant. Following additional manual analysis, pertinent global health reports are then uploaded to the secure GPHIN website and can be accessed by GPHIN members 'through a password protected interface anywhere there is Internet access' (Mawudeku et al., 2007:308).

The launch of the GPHIN prototype was supported by a notable increase in subscriptions from both state governments and international organisations with specific stakes in population health and security. Early clients which sought to gain advanced insight of pandemic alerts produced by the GPHIN system included the Public Health Agency of Canada, (PHAC), the Canadian Food Inspection Agency (CFIA), the Centers for Disease Control and Prevention (CDC), and the World Organization for Animal Health (OIE) (Jebara and Shimshony, 2006:436-438; Mawudeku et al., 2007:310). In seeking to accelerate the process of data collection and production of knowledge of infectious disease outbreaks through the combined use of human analytics and the implementation of algorithmic processing to tame data excesses, the GPHIN system experienced high levels of advanced reporting success demonstrated from the period of July 1998-August 2001, whereby of the 578 disease outbreaks officially verified by the WHO, 56% of these were initially detected and reported by the GPHIN online system (Heymann and Rodier, 2001:349). In its early phases, GPHIN retrieved approximately 4,000 health alerts per week, of which roughly one half were posted on its website (Mykhalovskiy and Weir, 2006:43).

Significantly then, the debut of GPHIN in 1997 represented a further departure from previous governmental systems for infectious disease surveillance which had become increasingly problematized in the era of emerging globalised infectious disease threats. While GPHIN followed the original lead established by ProMED-mail in utilising and processing open-source data which had been previously unfeasible without the technical mediums of e-mail and the Internet, GPHIN would represent the expansion and intensification of a governmental mode of surveillance increasingly informed by

algorithmic processes. Through its implementation of algorithmic techniques for the filtration and presentation of relevant data into its core surveillance operations, GPHIN therefore signified a new orientation of syndromic surveillance systems towards new processes of pattern recognition and anomaly detection (Pasquinelli, 2015) of infinite data sets, increasingly guided and informed by the digital algorithm, in the generation of knowledge forms for pathogenic threats.

Expanding the [Digital] Gaze of Surveillance: GPHIN and SARS

The rise of GPHIN as an algorithmically informed surveillance technology would continue to expand into the early twenty-first century. The strategic value of the system for the generation of knowledge of infectious disease threats was further recognised by partnerships between Health Canada and the WHO, whereby GPHIN would begin to supply the WHO with its curated health reports on a permanent ongoing basis. The WHO in turn would then further seek to verify these suspected events in conference with national health institutes of its member states, creating a novel relationship of knowledge generation towards early outbreak detection which was not exclusively dependent on statistical reports supplied by national health institutes

In its drive to detect health abnormalities derived from data patterns online, a pivotal period in the history of GPHIN would occur in 2002/03, corresponding with the emergence of a then unknown coronavirus in Southeastern China. In November 2002, a mysterious respiratory infection, believed to have been transmitted to humans via a zoonotic infection, first occurred in Foshan, Guangdong Province, People's Republic of China (Enserink, 2013:1266). The symptoms of the infection which had originally been classified as *atypical pneumonia* by Chinese health practitioners included fever and high bodily temperature (over 38c), fatigue, headaches, chills, diarrhoea, muscle pain and in advanced infections, an increasing lack of oxygen in the bloodstream, leading to death in the most severe cases (National Health Service, 2014). Due to the perceived similarities within early symptoms of the virus with other forms of respiratory infections, as well as a lengthy viral incubation period of up to 10 days, Chinese public health officials initially were slow to recognise the expanding node of infected individuals across Guangdong in late 2002. Evaluating the early days of the outbreak the WHO stated that 'retrospective analysis of patient records has identified small clusters of cases, each traced to a different initial case that occurred independently in at least seven municipalities' (World Health Report, 2003:74).

The unfolding public health emergency represented by the unknown virus identified as the severe acute respiratory syndrome (SARS), emerged as the most serious infectious disease outbreak of the early twenty-first century. Unlike outbreaks which had preceded the advent of SARS which had been controlled or limited to specific or isolated geographic areas, the spread of SARS out of Southeastern China demonstrated the first globalised public health emergency of the new millennium. Not only was the spread of SARS rapidly facilitated by increasingly mobile populations and an airline

infrastructure at the start of the twenty-first century, but the highly virulent coronavirus was easily spread through face-to-face contact and transmitted via respiratory droplets from the coughing or sneezing of an infected person (CDC, 2012). As the outbreak expanded within Southern China in late 2002, a patient admitted to a hospital infected at least 88 health workers and 18 medical students. Another patient discharged from the same hospital started an outbreak affecting more than 200 residents of a housing estate (Nuttall and Dye, 2013:1287). As infection rapidly spread, SARS was transmitted out of the epicentre and across the Pacific Ocean and Southeast Asia via the conduits of air and land travel. By 2003, infections were reported in 37 different countries including Singapore, Vietnam, Taiwan, the Philippines, Canada and the United States, infecting an estimated 10 000 people (Smith, 2006:3113-3114).

The outbreak of SARS once more revealed the challenges of traditional public health surveillance to address and contain emergent and virulent disease outbreaks on a *global* scale. Operating within a period prior to the revision and ratification of the IHR (2005), the outdated International Health Regulations (1969), only compelled states to report to the WHO, outbreaks of plague, cholera and yellow fever. Consequently, as the SARS outbreak in China steadily gained momentum, ‘there was nothing that compelled China, or any other country, to tell the rest of the world what was happening within its borders early in 2003’ (Enserink, 2013:1266). Moreover, as outlined by Chan et al. (2010:2), the single-minded pursuit of economic growth by the Chinese leadership from the 1970s onward severely compromised the initial handling of the emerging SARS outbreak as it was believed by senior officials that admittance to the magnitude of the outbreak would have severe economic and trade consequences for the ever-expanding Chinese economy. Despite the first initial case of SARS occurring within Guangdong occurring on 16 November 2002, it was not until 08 February 2003 that the Provincial Government of Guangdong first informed the central government in Beijing of the occurring outbreak (ibid).

Despite the reticence of the Chinese Government to engage with the reality of the outbreak of SARS in late 2002/03, the GPHIN system would emerge during this health emergency as a new surveillance apparatus in which to forecast and inform upon the nature and spread of the virus. While informal sources and rumours indicating the outbreak of an unknown strand of *atypical pneumonia* had been widely circulating in Guangdong Province since late 2002, with the first identified case identified on 16 November, authorities within the WHO struggled to access correct information from Chinese health officials. From 11-14 February 2003, the Vice-Mayor of Guangzhou, the capital and largest city of Guangdong insisted to the WHO that an outbreak of atypical pneumonia occurring within the city had been effectively contained and that ‘no extraordinary measures are needed’, this was followed by a confirmation to the WHO by the Chinese Ministry of Health that the ongoing pneumonic outbreak in Guangdong was under control (Chan et al., 2010:2).

As unofficial reporting of the outbreak continued into 2003, the WHO expressed frustration at the perceived lack of information being conveyed by the Government of China and its health ministry

and on 11 March, the then WHO Director General Gro Harlem Brundtland cited member states concerns over the lack of health data supplied by China to the WHO and requested that this complaint be formally sent to the Chinese Ministry of Health via its WHO representative. That same day, the Special Administrative Region of Hong Kong formally notified the WHO of an outbreak of the coronavirus at the Prince of Wales Hospital. On 12-13 March, the WHO officially issued a global alert about atypical pneumonia which originated in Southeastern China with the pathogen being classified as SARS on 15 March (ibid).

Within the traditional channels of infectious disease surveillance, a crucial window period of four months passed from November 2002-March 2003 in which SARS remained largely unidentified and underreported by Chinese health officials and state institutions. While the scope of the outbreak was downplayed by Chinese authorities weary of potential economic ramifications, a public health emergency was facilitated through institutional complacency, the movement of increasingly mobile populations and accessibility to an advanced airline infrastructure at the start of the twenty-first century. Conversely, while traditional surveillance systems and infectious disease monitoring were slow to identify the expanding outbreak, the GPHIN system became the first online surveillance system to detect the unusual emergence of an unknown virus in China well in advance of its traditional surveillance systems.

Despite the stonewalling of information demonstrated by China in the wake of the SARS outbreak, the WHO's Global Influenza Surveillance Network (GISN), was placed on alert following a notification from GPHIN in late November 2002, following the systems detection of media reporting of unusual patterns of influenza occurring in mainland China (Heymann and Rodier, 2004:173; Heymann, 2006:351). Through its surveillance process of filtration, assessment and reporting on aggregated media data, assisted by the organisational and classification capacity of the algorithm, the GPHIN system detected the emergence of SARS in Guangdong in near real-time temporalities, preceding the Chinese Ministry of Health's official notification protocol of atypical pneumonia to the WHO which occurred on 07 February 2003, as well as the WHO's first official report on the progression of the outbreak occurring in China which was published on 25 February 2003 (Blench, 2008:300). Once more, the aim of the novel, algorithmically informed system was not to attempt to normalize the outbreak through traditional health interventions, but rather to identify and alert health authorities on the emergence of an abnormal health event, as observed through processes of anomaly detection derived from cluster media data.

Throughout the episode of SARS in 2002/03, the GPHIN system assumed a central role in the tracking of the outbreak. Despite the acknowledgement of the Government of China that an outbreak of SARS was occurring and had spread to other countries by early 2003, state officials and health authorities within China continued to withhold and misrepresent information and data as the outbreak progressed. On 03 April 2003, Health Minister Zhang Wenkang insisted that 'China is safe' despite the issuance of a WHO travel advisory to Guangdong Province (Chan et al., 2010:2). Moreover, on April

02, 2003, some five months after the first index cases of SARS were identified, an executive meeting of the Chinese State Council chaired by Premier Wen Jiabao declared that the SARS emergency had ‘already been brought under effective control’ (Huang, 2004:1-5). Despite the initiatives of the Chinese leadership to appear in control of the continued outbreak, the Chinese Politburo was increasingly powerless to control the flow of digitised information which ran contrary to official party directives. GPHIN throughout the course of SARS in 2003, as noted by Keller et al. (2009:691), ‘was further able to continuously monitor and provide information about the number of suspected and probable SARS cases reported worldwide on a near real-time basis. GPHIN’s information was \approx 2–3 days ahead of the official WHO report of confirmed and probable cases worldwide.’

Demonstrating a significant turn in conduct, from April 2003 onward, following mounting international criticism of the perceived mishandling of the SARS outbreak by Chinese authorities, intensive containment initiatives were enacted across China by governing officials in order to stem the further spread of infection. Commencing in May 2003, health and government authorities in Beijing alone had quarantined 18 000 persons suspected of being infected with SARS. Additionally, an emergency health fund of \$250 million USD was created for national SARS prevention and control. Further disciplinary measures were enacted against public and health officials for perceived lax prevention and communication efforts which led to the dismissal of 120 officials, as well as the sacking of Chinese Health Minister Zhang and Mayor of Beijing Zuenong (Huang, 2004:7; Chan et al., 2010:2). Beyond this, further mass hygienic campaigns and rural surveillance measures were enacted over the course of April/May 2003, with the wide-scale control measures enacted by the Chinese Government at the height of the SARS epidemic appearing to have eventually tamed the outbreak (Huang, 2004:7). On 05 July 2003, the WHO announced that the global SARS outbreak had been brought under effective control with a total infection rate of 8439 people have been affected and 812 subsequent deaths (WHO, 2003).

GPHIN, Algorithmic Surveillance and the Facilitation of Global Health Diplomacy

Throughout the course of the 2002/03 global SARS outbreak, the GPHIN system demonstrated its potential as an alternative and early-warning surveillance system by detecting and informing health authorities (e.g., WHO, Public Health Agency of Canada) of unusual health occurrences from open-source data, pulled online by digital algorithmic processing (Keller et al., 2009:691). What is more, the unique role assumed by GPHIN as an early-warning sentinel during the SARS outbreak was demonstrative of a new and significant shift in state conduct which occurred as a result of the mass proliferation of open-source online and media data of the digital era. Fidler (2003), asserts how the growth of open-source, non-governmental health data in the wake of the SARS outbreak facilitated an overall shift within the global governance of infectious diseases, in which the previous surveillance of

pathogens and the conveying of outbreak information was premised upon the sovereignty of states. The initial failure of the Chinese authorities therefore to be forthcoming and acknowledge the scope of the outbreak according to Fidler ‘cost the world dearly because China had acted Westphalian in a post-Westphalian world’ (2003:490).

Despite the initial hesitancy of China to be forthcoming with outbreak knowledge during the early months of SARS, the growing recourse to open-source and non-governmental information supplied by systems such as GPHIN to authorities within GOARN and the WHO, would result in a revision of Chinese state conduct and its relationship with the emergent global health governance framework post-SARS. While the previous International Health Regulations (1969), ‘left China’s sovereignty unfettered and to be exercised, for better or worse, as China’s leadership saw fit’ (Fidler, 2003:491), the miscalculated decision to obstruct the flow of outbreak knowledge and epidemic intelligence to the WHO proved in time to be a historic error for the Government of China. Economic losses within China’s lucrative tourism industry for example, totalled at \$4.82 billion USD in July 2003 as calculated by a division chief of the Beijing Municipal Government (Hai et al., 2004:61).

Moreover, despite the best efforts of Chinese authorities to obfuscate or revise outbreak data and reporting, the role of the GPHIN system which through the processes of increasingly digitised syndromic surveillance, in effect squashed the pyramid down to a flat plain in which information could come from any place at any time across now emergent digital geographies. What this signified was that reticent governments such as China, during the SARS outbreak were gradually seen now as less creditable sources of outbreak information, and were increasingly unable to contain the outward, accelerated and open-source flow of information detailing occurring or forthcoming public health emergencies (Mykhalovskiy and Weir, 2006:43). The fallout from these twenty-first century realities thus were key in facilitating the gradual turn of China towards engagement with new forms of global health governance. Accompanying the rise of new surveillance technologies for the advanced reporting of potential health threats, states including China, would ‘now be expected to perform differently; a general (although not yet legally formalized) feeling had emerged among states that outbreak information was to be shared and that when a government failed to live up to that expectation, other governments could legitimately institute travel and trade measures to contain the outbreak *in place of the affected state*’ (Davies et al., 2015:44-45). Significantly then, the emergence and capacity of GPHIN, bolstered by algorithmic capacities to rapidly collect, filter, and process digital data content meant that this increasingly digitised, open-sourced epidemic intelligence could further be utilised to strengthen and bolster global health security regimes into the twenty-first century, and to ensure that potentially problematic states would now be compliant in emergent reporting norms.

Premised upon its aspiration to be viewed and respected by the larger international community as a ‘responsible’ state (Chan et al., 2010:3), and furthermore, as a rising global economic power, with the largest population on earth, the unique position of China internationally also meant that it would be expected by the international community to play a better and more active role in health management

and infectious disease surveillance in the early twenty-first century (Chan et al., 2009:1). Subsequently, this new engagement took the form of China's increased cooperation with transnational health groups and authorities including the WHO, UNICEF, UNAIDS, the International Labour Organization, and the Global Fund to Fight AIDS, Tuberculosis and Malaria (ibid).

Additionally, domestically within China, the SARS experience was further key in the facilitation of a new national discourse regarding infectious disease and *non-traditional security threats*, and furthermore witnessed the increased annual spending of government expenditure on public health and surveillance initiatives by almost 100% between 2002 and 2006. In 2009, further indicating its willingness to participate in an expanding framework for the global management of infectious disease, China dropped its previous objections over territorial integrity and Taiwan's application for observer status at the WHO (deLisle, 2009:1-7; Chan et al., 2010:4).

These developments themselves do not indicate China's complete surrender of its sovereignty in health affairs in favour of a transnationalised form of infectious disease management and surveillance. However, they are significant still in demonstrating how in a globalised and digital, post-SARS landscape, Chinese state-centric concerns would now have to be increasingly considered with reference to the reporting capacity and scope of novel syndromic surveillance systems such as GPHIN and its dissemination of timely and indicative outbreak information. Moreover, this novel form of future-oriented information was increasingly being utilised, verified, and indeed, authorised through legislative and diplomatic processes by intergovernmental health authorities, exemplified most prominently in the case of the WHO in seeking to harness the digitised surveillance information generated by GPHIN in the addressing of forthcoming pathogenic threats.

A Digital Technology for Twenty-First Century Global Health

Following the central role in which GPHIN assumed during the 2002/03 SARS outbreak, further innovation and development commenced on expanding, refining and intensifying the power of the original GPHIN prototype, which still was not robust enough to continue supporting global public health surveillance activities across still rapidly expanding global networks and interconnectivities (Mawudeku and Blench, 2006). On 17 November 2004, a new version of the online surveillance system, GPHIN II was formally launched at the United Nations. Unlike the preceding system, which had begun to monitor media sources in the six WHO official languages – Arabic, Chinese, English, French, Russian and Spanish, but was unable to accommodate the presentation of information in the other languages besides English and French, the new multilingual GPHIN II platform utilised automatic machine-translation providing translated articles from English into Arabic, Chinese (Simplified), Farsi, French, Portuguese, Russian and Spanish. Non-English articles produced by the GPHIN system would be further translated into English (ibid). The system further established a constant monitoring and reporting process, operating 24 hours a day, seven days a week, going beyond the previous passive

health surveillance systems which were constructed around the 9-5 working hours of governments and national health institutes, and where ‘the WHO basically went home on the weekends’ (Weir and Mykhalovskiy, 2010:82).

In both linguistic and operational terms, the new developments and improvements to the GPHIN system sought to further extend this new, and algorithmically guided form of health surveillance towards the aspirations of *constant*, near-real time surveying of infectious disease. The expansion of linguistic capacities of the system to incorporate six globally prevalent languages broadened the pathways in which different sets of online data could now be consulted, scanned and conveyed, while the expansion of the surveillance technology towards an *automated* 24/7 surveillance regime, signified the diminishment of the centrality of human observation, assessment, and collection of data which sustained previous health surveillance frameworks. GPHIN moved increasingly therefore towards new modes of future-situated health surveillance which captured, processed, and reported upon signals derived from online data through a method and pace which was beyond that of governmental systems for health surveillance in the non-digital era.

With its refined functions, GPHIN II was further integrated as a key instrument within the global health surveillance practices of the WHO. Speaking at the GPHIN press conference held symbolically at the United Nations, Dr Corber, a WHO consultant, referencing the expanded system stated that ‘GPHIN had represented a *paradigm shift* for infectious disease surveillance. The prevention and control of infectious disease was a cornerstone of public health, and it was a basic mandate of the WHO to assist countries in controlling the international spread of infectious diseases. The key to successful outbreak control was effective detection and response at the source’ (United Nations Press Release, 2004). The original GPHIN prototype, highlighted further by Corber, had supplied initial reporting for 30 per cent of outbreaks of international concern identified and assessed by the WHO. The GPHIN system had previously been the WHO’s ‘single, most important reporting source for identifying these outbreaks’, and therefore, the expanded GPHIN II system ‘along with the essential contributions of healthcare professionals...would play a vital role in the WHO’s global surveillance of public health events of potential international concern’ (ibid). Funding sources for GPHIN II came from a range of agents and actors keen to invest in enhanced surveillance systems for pandemic preparedness, the Government of Canada provided \$800 000 CDN in research and development support towards the creation of GPHIN II, while the Nuclear Threat Initiative, a global security organisation donated \$560 000 CDN, further highlighting the emergence of a diverse scope of transnational actors and stakeholders within global health and population security which emerged towards the end of the twentieth-century (United Nations, 2004; Nuclear Threat Initiative, 2004).

Subsequent to the revisions of the IHR in 2005, GPHIN II was further established as one of the main sources of global health surveillance data on infectious disease outbreaks to the WHO, with important changes to the scope of GPHIN’s operations (Weir and Mykhalovskiy, 2010:87). Under Article 9 of the new IHR (2005), the WHO was now legally and diplomatically able to take into account,

to reference, and review sources and data coming from outlets beyond just that of the organs of its member states. While the WHO was then obligated to confer these findings and to seek verification from the member state in question, critically, the revised IHR (2005) expanded and formalized collaboration and data-sharing with non-state health surveillance systems such as GPHIN.

Conclusion

As this chapter has indicated, the design and underlying rationalities of the GPHIN system differed notably from the scope, operations and aim of preceding systems for health surveillance and the management of infectious disease threats. The launch of GPHIN in 1997, corresponded to a rise and intensification in digital connectivity as well as computational processing capacities, and further witnessed the expansion of the Internet and World Wide Web usage. Responding to these significant transformations in the accessibility and proliferation of digital and open-source knowledge, formidable portions of the GPHIN platform became reliant and utilised automatic-computing to bolster and inform the surveillance of infectious disease threats, which then employed secondary human analytical labour for observation, classification and reporting, significantly re-orientating the centrality of human observation and logic in the surveillance of emergent disease outbreaks. GPHIN, would be the first online system of its kind to utilise and rely upon the power of computerized machine-translation to translate and present its produced articles into English and French. Later, following the launch of GPHIN II in 2004, the system would apply this technology to an expanded multilingual platform.

Furthermore, unlike its predecessor ProMED-mail which provided an open-access web interface and relied on subscriber-based input for its infectious disease knowledge generation, the GPHIN initiative was the first online surveillance system to implement web-crawling technologies and retrieval algorithms to scan and mine the Internet for data sources potentially indicative of an infectious disease outbreak. The implementation of algorithms into the GPHIN system emerged strategically therefore as a new response to the problématique of a deluge of new online information following the expansion of the Internet and the launch of new digital technologies which generated more and more online data (Weir and Mykhalovskiy, 2010:91; Mordini and Green, 2013:53). In effect, GPHIN turned to new technological instruments, including the digital algorithm in its anomaly detection efforts, to ‘illuminate’ new and increasingly complex datascapes, and to extract meanings and signals contained within an ocean of new data sources (Pasquinelli, 2015:2-5).

Through utilising then cutting-edge digital technology in information processing, the GPHIN system could aggregate and automatize the data collection and filtration of infectious disease surveillance in a method which previously did not exist. As of 2016, through its automated data collection system, GPHIN gathers and analyses over 20 000 relevant online news reports, and 30 000 digital sources in nine languages worldwide, collected as the GPHIN system ‘scans’ and ‘pulls’ pertinent global health sources from the Internet and its supplied news aggregator systems in recurrent

15 minute intervals, 24 hours a day, seven days a week. The veracity and quality of this digitally amassed and organised global health data is then subsequently revised and reviewed by the human analytic team within GPHIN (Mordini and Green, 2013:53; Dion et al., 2015:2-3).

Through its early engagement and utilisation of open-source, digital information located online, GPHIN was among the earliest health security system to function within the context of Big Data. GPHIN's novel approach to online health surveillance upon its launch was further reflective of the three Vs: volume, velocity, and variety, which have been used to define Big Data (McAfee et al., 2012:61-67; Hay et al., 2013:2; Dion et al. 2015:2). The system aimed to amass global health data information beyond that which was possible through the sole utilisation of human labour, at a speed which reflected near real-time temporalities, and which drew from a diverse range of sources beyond the statistical reporting conducted by national health institutes and scientific laboratories. The computational turn demonstrated by the GPHIN system however would also encounter a new problematization of knowledge as it sought to enhance early-warning alerts for infectious disease preparedness. As discussed by Rouvroy (2012:1), although the growth of Big Data and of the digital era in which GPHIN originated meant that one has access to massive amounts of raw data (and that the world is actually submersed by astronomical amounts of digital data), operations of collection, processing and structuration of data for profiling circumstances of uncertainty are problematized by a 'flood' of potentially strategic, yet mass and unstructured information found online. The central logic to all syndromic surveillance systems, including GPHIN is the effective collecting of data to tackle public health problems (Cakici and Sanches, 2014:402).

Consequently, the GPHIN system thus became the first online health syndromic surveillance model to develop and integrate an information retrieval algorithm to enhance the collection, classification and filtration of incoming global health data-sources. What this signified was that the GPHIN system had effectively begun to harness the power of the algorithm for speeding up the collection and classification of incoming data in a way that ProMED-mail had not. Signalling the turn towards a new governmental rationality in which the algorithm emerged as a new apparatus of knowledge of contingent infectious threats. GPHIN thus became the first online system to refer to algorithmic logic to aid with the organisation and classification of knowledge towards the securitization of infectious disease. Moreover, the novel implementation of algorithmic logic into syndromic surveillance systems such as the GPHIN are further indicative of the growing saliency of the technology across a broad spectrum of security practices for the calculation of risk and probability which have been discussed elsewhere (Amoore, 2009).

Functioning within the internal operating platform of the GPHIN system, incoming global health data derived from GPHIN's news aggregator services and select websites are then addressed by an information retrieval algorithm with the capacity to receive and review a large number of digital documents. The functioning algorithm subsequently assigns a proportionate relevancy score to the individual report, which is then subsequently either trashed, forwarded to the human analytic team for

further assessment or immediately posted to the GPHIN web-interface if assigned a high level of urgency. What is significant about the integration of an information retrieval algorithm into GPHIN is that crucial components of infectious disease surveillance including the collection, observation and assignment of relevancy of global health data, long the remit of human analysts, had now become partially automated, reflecting a shift within the production of knowledge for future threats where by, 'relying on the apparent operationality of algorithms spares a series of individual and collective perceptual, cognitive, evaluative, conventional, institutional efforts or tasks' (Rouvroy, 2012:1).

Following the SARS outbreak of 2002/03 and the subsequent ratifications of the revised International Health Regulations in 2005, the GPHIN system continued into the twenty-first century as a strategic surveillance sentinel to produce early outbreak knowledge for pandemic preparedness, and served as a strategic instrument in which to convince states that the timely reporting of infectious disease outbreaks was increasingly, in best national interests. During 2009 for example, the GPHIN system unearthed a small media report in April, within the Mexican press detailing a 'strange epidemic' outbreak in La Gloria, a small town in the Mexican state of Veracruz. The GPHIN system picked up this report and following subsequent translation from Spanish language text, forwarded the alert to the WHO on 10 April. This alert notification was followed by immediate communication with WHO partners within GOARN, the Pan-American Health Organization as well as the Mexican Ministry of Health. Once more, the GPHIN system identified a potential health emergency in advance of traditional health surveillance institutes. On 17 April, the Centres for Disease Control and Prevention confirmed the presence of swine-lineage H5N1 influenza virus in Mexico (Brownstein et al., 2009:2156).

Overall, the development of the GPHIN project represented the first initiative to capture, aggregate and translate the potentially predictive correlations contained within Big Data by emergent syndromic surveillance systems. Significantly still, unlike its earlier counterpart, ProMED-mail, the design of GPHIN from 1997 onward marked a greater reliance on the integration and utilisation of algorithmic programming and logic to derive meaningful and strategic information infectious disease surveillance from increasingly unstructured and unintelligible mass data sets online. The formal integration of sorting and retrieval algorithms at the core of GPHIN's surveillance operations has further signified the speeding up of momentum towards a new algorithmic form of governmentality for the management of pandemic threats which developed initially with the founding of ProMED-mail, but was further intensified and made explicit with the launch of GPHIN.

Conceptually then, while the operational aim of GPHIN remained broadly governmental in that its surveillance initiatives sought to generate knowledge for the securitization of populations and economic circulation from potentially devastating outbreaks of pandemic, the launch of the surveillance technology indicated a clear and novel shift towards an intensive algorithmic governmental mode presented by Rouvroy, and gave rise to new epistemic spaces inaugurated by algorithms within systems of global health security (Pasquinelli, 2015:3-8). Within the new era of digital information complexity in which online data could be both meaningful and meaningless, and whereby rationalities of global

health security sought to accelerate and volumise the practice of surveillance towards the near-real time identification of threatening microbial circulation, the algorithm emerged as a strategic and ‘objective’ purveyor of crucial epidemic intelligence.

Empowered for the first time by digital algorithms for addressing online data streams, GPHIN once more shifted away from the classical forms of governmental health surveillance and knowledge generation practiced chiefly by sovereign states. For the GPHIN system, data, rather than statistics became the main reservoir in which to process and mine to generate *knowledge* of occurring or future-situated health threats. As discussions in this chapter have also revealed, the integration of algorithmic capacities for data collection and processing also signifies a novel shift towards a new form of governmentality in governing future disease threats. While traditional health surveillance sought to regulate populations through processes of normalization, or the normalization of abnormalities as described by Foucault, in the era of Big Data, new governmental rationalities, supplemented by infinite data streams as well as increasingly sophisticated algorithms to process these streams, shifts the governmental gaze away from processes of normalization, alternatively towards the objectives of pattern recognition and anomaly detection in new forms of algorithmic government (ibid).

Crucially, GPHIN reflected this new relationship with data and the detection of exceptional health events derived from data-clusters. It initiated, for the first time, the mining of data sets with integrated algorithmic technologies to generate forms of knowledge and warning signals of the emergence of exceptional health events including the emergence of SARS, H1N1, and MERS. Moreover, the new and *invisible* power of these algorithmic systems to capture, filter, and present warning signals for further verification increasingly bypassed once more, the previous processes of statistical aggregation, testing, confirmation and forecasting which had been practiced in traditional health surveillance systems. The acceleration of this process by the first-time integration of algorithms into the GPHIN system is therefore notably suggestive of Rouvroy’s presentation of new forms of *knowledge without truth*, generated in the practice of security and pre-emption of future events through the increased recourse to forecasting afforded by digital algorithms.

Iteratively then, within the context of the three syndromic surveillance systems presented within this thesis, GPHIN exists as the first syndromic surveillance system to harness the perceived prediction and foreshadowing capacities of algorithmic logic to derive intelligibility and correlation across increasingly complex and infinitely generating online data streams. Conceptually, the system demonstrated a subtle yet palpable shift towards new governmental rationalities orientated towards data, utilising increasingly sophisticated algorithms to derive signals and alerts of exceptional health events. In turn, the increased recourse to utilising GPHIN, by global health authorities including the WHO, has facilitated the rise of new regimes of scrutiny and visibility of infectious outbreaks, in which reticent states previously sought to obfuscate or deny. Empirically, GPHIN became the first of these novel health surveillance systems to produce a new algorithmically guided form of syndromic surveillance, with the capacity to extend beyond sovereign jurisdictions, as demonstrated in the case of SARS in China.

Reflecting on the political fallout which accompanied the emergence of SARS, and the subsequent revisions to the IHR (2005) which now legally authorised the official utilisation of knowledge produced by GPHIN, the launch and trajectory of GPHIN demonstrated how through the careful design of new algorithms increasingly afforded by advancements in technology – mass sets of unofficial, open-source news data could be translated into actionable indicators of a possible emerging infectious disease threat, utilised not only to forecast upon yet unforeseen pathogenic threats, but to further incentivise and align the new national and security interests of states in the twenty-first century with the timely and transparent reporting of circulating pathogens.

Chapter Six: Unshackling the Algorithm (HealthMap)

Introduction

Following the development of ProMED-mail in 1994, and GPHIN in 1997, 2006 would see the design and launch of a third syndromic surveillance system known as HealthMap. The advent of ProMED-mail and GPHIN were significant to the practice and imagining of global health security and surveillance, as well as the production of knowledge for future-situated threats for several significant reasons. ProMED-mail, as the first online health surveillance system, provided an alternative forum for the curation, exchange, uploading and dissemination of epidemic intelligence and outbreak data which had been previously unfeasible through the sole reliance on channels of infectious disease outbreak reporting of national health institutes, effectively reliant on human analytic and observational processes. The ProMED-mail system sought to amass and generate infectious disease knowledge and data to supplement preparedness from contexts where such information had previously been scarce or lacking, through a new recourse to emergent technological innovations including e-mail and the personal computer.

Subsequently, and corresponding to the growing commonplace of the Internet from 1997 onward, the GPHIN project sought to harness the infinite amounts of online data and media reporting,

and to filter and translate these data sets to capture potentially predictive indicators of future public health emergencies occurring globally. However, unlike its earlier counterpart, the GPHIN project became the first of kind syndromic surveillance system to address and begin to mine, the infinite and continually generating data landscape which was both potentially strategic and unintelligible at the same time. In responding to this problématique of knowledge acquisition, GPHIN demonstrated what Rouvroy (2012:2), has referred to as a computational turn in relation to knowledge, whereby the GPHIN system implemented for the first time, a novel *retrieval algorithm* to capture and process mass incoming online data, and to filter and organise this data according to pre-developed taxonomies. Through different outbreak detection and surveillant processes, ProMED-mail and GPHIN, in many cases were successful in the identification and reporting of emergent public health emergencies in advance of the traditional surveillance mechanisms. Consequently, the revisions and ratifications of the IHR (2005), additionally highlighted and authorised the utilisation of this novel form of surveillance supplied by these systems, and in effect, challenged the monopoly over control of epidemiological information by sovereign states which had existed previously.

While ProMED-mail and GPHIN sought to enhance the forecasting and reporting capacities for addressing pandemic uncertainties through utilising novel approaches to digital surveillance, HealthMap represented still, a step further in the innovation, refinement and indeed, intensification of open-source, algorithmically-guided surveillance for infectious disease detection. As identified by Brownstein and Freifeld (2007:1-3), although the launch of HealthMap had occurred a year after the revisions to the IHR (2005), global health initiatives to mitigate public health emergencies continued to be effectively challenged by a lack of both technical infrastructure and trained healthcare professionals in many disease hotspots around the world. While open-source and indicator based surveillance systems, including ProMED-mail and GPHIN now represented ‘a critical source of epidemic intelligence with all major outbreaks investigated by the World Health Organization are first identified through such sources’ (Brownstein and Freifeld, 2007:1-3; Grein et al., 2000; Heymann and Rodier, 2001; Morse, 2007), the digital and open-source information of syndromic surveillance reporting was ‘dispersed and largely unstructured’, precluding, in the words of Brownstein and Freifeld, the visualization of ‘an easily obtained global view of all ongoing disease threats’ (ibid). Developed and launched in 2006, within the context of an increasingly complex global technical infrastructure within the era of Big Data, HealthMap was therefore designed to ‘construct an integrated view of emerging infections...[through] a free multi-stream real-time knowledge management system that aggregates and maps health alerts across numerous key data sources’ (Brownstein and Freifeld, 2007; Brownstein et al., 2007).

Unlike previous surveillance systems, the HealthMap project would seek not only to report upon near real-time infectious disease outbreak occurrences but would further structure and upload this data through the further integration and expansion of algorithmic programming in order to *visualize* information flows and data-streams which could otherwise be overwhelming to the systems user-base

or that could potentially ‘obscure important elements of a disease outbreak in the era of continually-generating, mass unintelligible online data’ (Keller et al., 2009:691). Through the development of an online, digital global mapping system, unique to the system and supplemented by a Google Earth plug-in, the HealthMap project would move beyond the capacity to solely *report* upon emergent infectious disease outbreaks through the medium of the Internet, and would additionally move to *visualize* global health data onto an accessible and interactive online mapping forum, presenting for the first time, a near real-time visualization of global geographies of emerging health threats.

This chapter therefore presents and discusses the launch of HealthMap in 2006 as representative of the most intensified shift towards novel practices of algorithmically informed health surveillance systems within the context of the three syndromic surveillance technologies discussed within this thesis. In marking a significant transition and advancement from the initial implementation of algorithmic logic in its preceding counterpart, GPHIN, this chapter highlights further, the new centrality of algorithmic programming in the HealthMap project, in informing and sustaining a vast range of surveillance processes from data collection and aggregation, to filtration, organisation, and presentation of potentially indicative data correlations. Moreover, as will be presented, the launch of HealthMap has represented a new and intensified shift in rationalities for addressing circulating pathogenic threats. As afforded with increasingly sophisticated algorithmic programming at the time of its launch, the HealthMap system was the first and most advanced syndromic surveillance system to not only seek to *report* upon exceptional health events through open-source data, but rather to move towards the *visualization* of such public health emergencies through the curation and uploading of cutting-edge geographic information systems, simulating the physical world, yet drawing data, signals, and correlations continually from the realm of the digital. Conceptually, as this chapter will further present, the extensive implementation and reliance upon algorithmic logic to infinitely amass, process, and assign value and significance to continually expanding, and increasingly complex productions of data, signifies the most recent and refined formation of a novel algorithmic governmentality traced within the evolution of these syndromic surveillance systems, reflecting once more, epistemic transformations of understandings of governmentality via the new centrality and importance of data patterns, anomaly detection, and the creation of new forms of knowledge produced by the advancement of syndromic surveillance systems.

Launching HealthMap

The HealthMap system which was originally conceived and designed by John Brownstein of the Harvard Medical School, and Clark Freifeld, Research Software Developer at Boston’s Children’s Hospital made its online debut in September 2006. At the time of its launch, HealthMap debuted within a technologically interconnected and networked world in which a large-scale proliferation of indicator-based syndromic surveillance systems had occurred, including EpiSpider and BioCaster, which

followed the launch, relative success, and high policy-interest in systems such as ProMED-mail and GPHIN (Freifeld et al., 2008:150; Collier et al., 2008:2941; Lyon, 2011:25-28). HealthMap alternatively however, was designed to address a specific problematization in relation to the Internet and knowledge which was not predicated on scarcity but of excess. As explained by co-founder John Brownstein, although the rise and commonplace of the Internet in the early 2000s had resulted in an abundance of potentially predictive online data for infectious disease outbreaks, a major and novel problem was that these data streams were unstructured, unorganised, and untapped (Nelson, 2008:596).

This problématique was therefore exemplified by a retrospective view of the outbreak of SARS in Southeast China in late 2002/03. According to Brownstein, during this period in which SARS emerged and spread rapidly, numerous reports and rumours detailing the disease began to disseminate across the Internet from a variety of online outlets. However, despite the wide availability of this early-warning data, the various reports and data were scattered across so many different online directions, from such a diverse body of sources that the outbreak and spread of SARS was not immediately perceived as being the same incident (ibid). Increasingly therefore, the aim of HealthMap would seek not only to connect the predictive dots through data utilisation of a probable public health emergency, but would further need to address the risk that this mass of online raw data could become overwhelming and meaningless without the ability to transcribe and translate signals accurately, reliably, and accessibly (Rouvroy, 2015b). Thus, despite the increased currency of online and open-source data as useful sources for disease surveillance following the development of systems such as ProMED-mail and GPHIN, the explosion of infinite data sources meant that the '[r]eading and assimilating of a broad range and large number of reports as they appear... [online]... on a daily basis has already become increasingly burdensome' (Freifeld et al., 2008:150-151). HealthMap was launched therefore to 'provide access to the greatest amount of potentially useful health information across the widest range of geography and pathogens, without overwhelming the user with excess information or obscuring important and urgent elements' (ibid).

Upon its initial launch in 2006 therefore, the HealthMap system sought to enhance and intensify capacities of syndromic surveillance systems in advanced reporting and foreshadowing of pathogenic threats in era of Big Data. Speaking at a seminar hosted by Google Tech Talks in August 2008, HealthMap co-founder John Brownstein of the Harvard Medical School used an early outbreak of a case of Salmonella Saint Paul in the United States to demonstrate HealthMap's capacity for early disease detection. Brownstein noted that the earliest reporting sources which had detailed the spread of salmonella did not come from the CDC, but rather from local online news reporting of the outbreak, and more crucially, from the novel Google News service, which aggregated online news data from more than 4500 media sources, across 60 global regions in 35 different languages.

Reflecting on the era which preceded the development of HealthMap, founders Brownstein and Freifeld gave credit to the earlier reporting successes of ProMED-mail and GPHIN for transforming the access and curation of knowledge for pandemic preparedness. What is more, Freifeld et al. (2008:151),

have noted that in addition to existing online public health resources such as ProMED-mail and GPHIN, ‘the early years of the 2000s have seen the rise of ‘Web 2.0’ technologies.’ According to the authors, along with the increasing sophistication of the Internet, the innovation and development of these new digital tools created new opportunities for the development of ‘interactive software such as HealthMap’ and further allowed for greater possibilities to ‘extract structure algorithmically from a variety of disparate data sources’ (ibid).

The HealthMap system was designed as a multi-stream, near real-time syndromic surveillance technology which sought ‘to monitor and continually aggregate electronic health data on new and ongoing infectious disease outbreaks’ (Nelson, 2008:596). Designed for maximum access and surveillance scope, the HealthMap system was provided free of user fees and located through the medium of an Internet connection and a web browser.

With enhanced technological and digital capacities resulting from developments in web-crawling, and data aggregation methods, the HealthMap system could scan, amass and process data streams located online from an expansive set of digitised sources. Upon the launch of HealthMap, the system routinely amassed and integrated outbreak data of ‘varying reliability, ranging from news sources (such as Google News service), to curated personal accounts (such as ProMED-mail), to validated official alerts (such as the WHO) (Castillo-Salgado, 2010:98). Additionally, as noted by Keller et al. (2009:691), the HealthMap system additionally integrated online outbreak data from multiple electronic and digital sources including Really Simple Syndication (RSS) feeds, as well as multinational surveillance reporting including Eurosurveillance. While the initial HealthMap system like its predecessors ProMED-mail and GPHIN drew on a diverse array of unofficial sources of data as well as eye-witness reports, and expert curated discussions, the system became the first of kind surveillance platform in 2006 to integrate developing GIS (geographic information system) technologies into its surveillance processes ‘to achieve a unified and comprehensive view of the current global state of infectious diseases and their effect on human and animal health’ (HealthMap, 2016). GIS technology therefore refers to a computer system for ‘capturing, storing, checking and displaying data related to positions on Earth’s surface. GIS technology can show many kinds of data on one map. This enables people to more easily see, analyse, and understand patterns and relationships. Putting information into GIS is called *data capture*’ (National Geographic Society, 2011).

Receiving research and maintenance funding from a broad array of patrons including Google, the Centers for Disease Control and Prevention (CDC), the Bill and Melinda Gates Foundation, and the Skoll Global Threats Fund (HealthMap, 2016), the architects of the HealthMap would seek to design a more comprehensive and automated system which would not only possess the capacity to gather, process and upload health information from a World Wide Web, but would additionally render visible and present correlations and patterns of strategic data, effectively replicating physical geographies of risk onto digital simulation formats. Seeking to address how unofficial global health data could be further and uniformly categorised, the HealthMap project innovatively would channel aggregated data-

streams into an electronic, digitally interconnected platform featuring mapped global regions, comprehensively listing disease outbreaks and conditions by tagged geo-coding to their locations of occurrence. The HealthMap prototype would be the first of kind surveillance technology to not only report infectious disease outbreaks as they occurred through the mediums of alert notifications and report curation, but would further chart, map and visualize the data connected to these occurrences on a global, near real-time scale, giving the enhanced feature of visualization to increasingly refined syndromic surveillance systems, powered via algorithms.

Curating, Uploading and Visualizing Pathogenic Uncertainties

HealthMap has sought to address and effectively report upon the abundance of unstructured, and unorganised global health data sources which have rapidly proliferated with the growth of digital interconnectivity and the expansion of the Internet in the early twenty-first century (Nelson, 2008:596). To apply, and to make sense of the enormous and continually generating sets of data in attempts to receive, relay, and report upon infectious disease outbreaks, HealthMap has utilised and developed novel approaches to data acquisition, organisation, and presentation, previously unknown to earlier syndromic surveillance systems. Sorting algorithms as well as automated processing are core components of HealthMap's operating platform, which support the linking or eliminating of correlations or redundancies in data patterns, and which further optimise precision and specificity in regard disease profile or geographic location. Already, the large-scale integration and reliance of algorithmic processing at the onset of the HealthMap project is reflective of what Rouvroy (2011:12), has highlighted as the celebrated capacity [of algorithms] to detect, sort, evaluate and, most importantly, predict...needs and propensities, in an increasingly digitised, networked, and uncertain era.

Reflecting the initial turn towards accessing potentially strategic understandings of pathogenic threats derived from open-source data, which was established by ProMED-mail, and then accelerated via emergent algorithmic processing by GPHIN, the new HealthMap system via increasingly sophisticated automated software acquires online data algorithmically every hour, this aggregated open-source feed is subsequently 'characterised via text-mining to determine the disease category and location of the [infectious disease] outbreak' (Brownstein and Freifeld, 2007:1-3).

Unlike GPHIN, which initially implemented information retrieval algorithms to pull and filter potential global health warning signals from its reservoir of media aggregation providers, the advancement of the surveillance scope of HealthMap would see the full-scale utilisation of algorithms to effectively web-scrape and text-mine the vast datascape of the Web 2.0 Internet in its constant surveying of the emergence of exceptional health events. Operating on a system of automation which far exceeded the previous capacities of both ProMED-mail and GPHIN, HealthMap further possessed the ability to scan and collate early outbreak and infectious disease data from over 20 000 websites and digital sources per hour (Google Tech Talks, 2008: Nelson, 2008:596).

What is more, functioning through its combination of increasingly finite algorithmic processing and computer automation, between 2006-2007, HealthMap processed and disseminated more than 35 749 early outbreak alerts and reports detailing 171 disease classifications in 202 countries or semiautonomous or overseas territories (Keller et al., 2009:692). Through the employment of algorithmic logic to effectively and automatically capture, process, and present *knowledge* of pathogenic threats derived from the realm of the digital, the HealthMap system was now producing new forms of expedited infectious disease surveillance at a rate never before feasible with preceding syndromic surveillance systems, or within previous governmental health systems with their respective technoscientific apparatuses for the governing of pathogenic threats.

Significantly, the launch of HealthMap indicated a further and intensified step towards the giving over of an emergent governmental rationality which seeks to utilise algorithms to effectively classify and produce knowledge in addressing opaque and complex data streams which, as highlighted by Rouvroy would be otherwise impossible to capture and correlate through previous observational, statistical, or cognitive processes. HealthMap therefore represents the strongest manifestation of a new emergent algorithmic governmentality which sees the algorithm as the new agent of classification of knowledge for emergent infectious disease threats. Unlike therefore, in previous governmental systems for health surveillance, or even within preceding syndromic surveillance system. HealthMap now featured a distinct and heightened shift towards the wholesale employment of algorithmic programming to classify and present crucial epidemic intelligence on occurring probable health emergencies. Subsequently, while data captured automatically by the HealthMap system from online has routinely generated over 1800 disease patterns across 5000 global locations, a further problematization of knowledge occurred in seeking to identify and isolate data segments indicative of the most precise signal of a possible disease outbreak. Yet, faced with the routine inundation of disparate data sources, the HealthMap system further intensified the development of its automated precision capacities within its surveillance platform to filter and identify the most strategic and indicative data associations captured through its web-mining processes.

What followed therefore was an implemented and automated two-step processes in which incoming data was stripped and simplified by algorithmic processing. Data sets were reduced and matched automatically alongside an internal taxonomy system to determine global location and disease profile where the potential outbreak could be occurring. Following the internal determination of disease classification and location of the suspected outbreak, based on a tally of alerts, a designed proprietary algorithm then assigns a ‘heat-value’ of 1-10 to then be uploaded to the visualized geographic information map of the HealthMap interface.

Once more, in representing an advanced step forward towards an algorithmically informed system of health surveillance beyond that of ProMED-mail or GPHIN, the HealthMap project further sought not only report upon and disseminate these increasingly *digitised* knowledge forms for disease threats, but additionally generated new surveillance and monitoring techniques via processes of

visualization of algorithmically curated health alerts. Therefore, unique to the HealthMap system, the captured data-streams, attained by algorithmic-scanning, are the uploaded and overlaid on an interactive digital map, connected to the original health alert report (Keller et al., 2009:692). This new medium of surveillance visualization, enabled through the provision of a Google Earth plug-in thus provides a simulated and interactive interface which allows for the new observation and detailing of disease outbreaks across a networked and globalised scale.

Expanding the Medium of [Digital] Global Health Surveillance

Following launch in 2006, the HealthMap project was further differentiated from the preceding syndromic surveillance systems in a number of key areas. Unlike HealthMap, earlier syndromic surveillance models such as ProMED-mail and GPHIN, sought to utilise and convey open-source knowledge about emergent infectious disease threats through the then-available technologies of the Web 1.0 era (which included, e-mail, listservs connections, and chatroom forums through the medium of the personal computer), this form of communication with membership bases was often in uni- or bi-directional formats. Located however within a technologically more advanced era than its predecessors, HealthMap has built upon the distinctly collaborative nature of the Web 2.0 era in the generation of further research and design, enhancing expertise on reporting and dissemination practices and has sought to expand further, the means in which unofficial, open-source knowledge can be obtained, uploaded, exchanged, and reported across digital geographies.

By design, HealthMap does not generate its own independently verified infectious disease reporting, but rather through its networks of web-scraping/crawling technologies as well as its recourse to algorithmic programming for sorting and translation, utilises the open-source nature of the Internet to attain, aggregate and translate global health trends from across a varied scope of sources. In this way, HealthMap can be differentiated from ProMED-mail, which sought to independently collect, filter, verify and produce global health reporting through the sole reliance on human labour capacity and analytics. Building upon the practice established by the launch of GPHIN in 1997, HealthMap alternatively turns to the capturing of digital data sets and online sources via automatic, 24/7 programming to generate and visualize infectious disease contingencies via anomaly detection and pattern recognition of data.

Subsequently, from its reliance on large number of pre-existent data suppliers, HealthMap functions in tandem with many other surveillance systems within global health, emphasising an integrated approach to data-collection and information sharing to achieve a comprehensive awareness of the current and coming state of human and animal global health. A decade after the initial launch of HealthMap, the listed global health actors and agencies which the system consults and utilises for its operating and surveillance functions are diverse, and include: various reports, bulletins and media

releases from the World Health Organization (WHO), the World Organization for Animal Health (OIE), and the Food and Agricultural Organization of the United Nations (FAO).

Significant still, in 2008, both HealthMap and ProMED-mail were awarded a \$3M multi-year grant as part of Google's *Predict and Prevent* initiative. The key aim of this multi-year funding grant has been to combine 'HealthMap's digital detection efforts with ProMED-mail's global network of human, animal, and ecosystem health specialists...to assess current emerging disease reporting systems, expand regional networks in Africa and Southeast Asia, and to develop new tools to improve the detection and reporting of outbreaks' (ibid). Through this provision of research and collaboration funding via Google.org, the philanthropic arm of the technology giant, ProMED-mail has emerged as a key source of relevant data and reporting for HealthMap (Barclay, 2008:1026). While HealthMap is now a recipient of health-reports and alerts supplied by ProMED-mail, the current ProMED-mail website now also features an integrated and visualized Google Earth plug-in featuring the latest ProMED-mail health reports uploaded to the HealthMap digital interface.

In addition to funding supplied via Google's *Prevent and Predict* initiative, Google has emerged interestingly, as a significant partner and supplier of metadata and information for HealthMap. Not only has Google provided the technological support to generate the digital and geographic plug-ins needed for the uploading and visualization of the HealthMap interface, but the HealthMap system further is a recipient of global health alerts and reporting as supplied by Google News, the commercial news aggregation service provided by Google. Further to supplying HealthMap with relevant online data-sources, Google continues to provide additional software and technological support requisite for the functioning of HealthMap's operating and surveillance platforms. Google Earth provides the digital, geographic interface in which HealthMap alerts are uploaded and geo-coded according to location, while the Google Translate service provides automatic machine-translated reports and global health alerts via the HealthMap interface in Arabic, Chinese, English, French, Portuguese, and Russian (HealthMap, 2016).

These examples provide a continued opportunity of discussion of the role of the Google Corporation and its increasing involvement in the stakes of developing syndromic surveillance systems for global health. Unique among the three syndromic surveillance systems, HealthMap has continued to engage and partner with a host of multi-national private corporations beyond that of Google in acquiring support and funding to expand its open-source surveillance reporting. As of 2016, HealthMap identifies the following global, private corporations as among its prominent sponsoring partners: Amazon.com, Twitter, and Unilever. It receives additional financial funding from private philanthropic and non-governmental groups including the Bill and Melinda Gates Foundation, as well as the Skoll Global Threat's Fund (HealthMap, 2016). Additionally, HealthMap receives research and support funding for surveillance initiatives from traditional health partners and actors including the Canadian Institutes for Health Research/Instituts de recherche en santé du Canada (CIHR/IRSC), the Centers for

Disease Control and Prevention (CDC) and the United States Agency for International Development (USAID) (ibid).

Early syndromic surveillance prototypes including ProMED-mail and GPHIN were notably innovative in the development of alternative channels of communication and production of knowledge within the surveillance and reporting of infectious disease outbreaks. For both systems, central to this emergent shift in the communication and the generation of knowledge were the World Wide Web and the novelty of the Internet. Upon the launch of ProMED-mail, all which was required to access the curated health reports provided by ProMED-mail was a desk-top computer system, as well as a low-band connectivity to the World Wide Web, indeed, as highlighted by Madoff (2004:228), ProMED-mail was envisioned as a new means in which to exploit the emergent Internet in the service of detecting emerging infectious or toxin-mediated diseases. In 1997, GPHIN further refined online syndromic surveillance reporting, utilising then cutting-edge machine linguistic translation as well as algorithmic guided retrieval and filtration of incoming data to provide curated health reports for its client base. Like ProMED-mail, the generated infectious disease knowledge was made accessible through the portal of a personal computer, connected via the Internet.

While the previous syndromic surveillance reporting systems primarily utilised the tools of the Web 1.0 era, to enhance early-reporting and responses to global infectious disease outbreaks, the HealthMap system was launched and was situated in a notably different historical and technological context. The introduction of HealthMap coincided for example within a period in the early twenty-first century which witnessed the growth in ‘extensive interest in applying computational approaches to influenza surveillance led to the exploration of various online data sources, digital technologies and computational and data mining techniques’ (Nsoesie and Brownstein, 2015:2).

Consequently, though the initial HealthMap project sought in 2006, to visualize and present the real-time status of infectious disease trends globally via the interface of a personal computer, the project has since capitalised upon the social media and Smartphone revolutions of the mid-2000s to further expand and intensify the medium and gaze of algorithmically-guided syndromic surveillance, and to enhance and disseminate additional reporting and viewing technologies for HealthMap. In 2009, HealthMap designed and launched the application software programme *HealthMap: Outbreaks Near Me*, which is accessible free of cost and available on models including Google’s Android and Apple’s iPhone operating systems. In lessening the necessity and centrality of the desktop computer as the primary point of accessing, reporting global health surveillance, the HealthMap app further enables its users, located anywhere to access geo-specific and localised maps detailing emergent or ongoing infectious disease outbreaks, to browse up-to-date, real-time listings of curated disease reports, at local or global levels, and to design, upload and submit observed or suspected disease outbreaks occurring within the proximity of the user.

More broadly, HealthMap’s *Outbreaks Near Me*, reflects the context of surveillance located within the early twenty-first century characterised by the rise of *participatory surveillance*. As

maintained by Wójcik et al. (2014:1), within the twenty-first century, public engagement within the politics of infectious disease 'is being transformed through participatory surveillance systems that enable the public to directly report on diseases via the Internet. These systems encourage the regular, voluntary submission of syndromic, health-related information by the public using computers or smartphones. Reported data are aggregated and visualized in near real-time allowing immediate feedback to users and public health agencies.' The enhanced opportunities offered through this approach to surveillance and technological application include the provision of data more rapidly and the ability to engage the public and populations by communicating findings directly via the Internet (ibid).

In expanding this form of surveillance beyond the limits of the stationary desktop, the architects of HealthMap and of Outbreaks Near Me, have given rise to a form of widely distributed, mobile health surveillance, guided by algorithmic logic with the capacity to now capture the early onset of infectious disease outbreaks through the medium of a portable Smartphone. This strategic shift and integration of health surveillance technologies from desktop computers into personal Smartphones further offers unprecedented reporting, scope, and coverage potential for the surveillance of global infectious outbreaks, demonstrated further by the statistic which reported in 2016, the total number of global smartphone users would reach 2.08 billion (Statista, 2016). This statistic reflects further, a large segment of the global population which now possess the technological capacity to download and utilise such health reporting apps including Outbreaks Near Me, and to participate further within an expanding culture of widely distributed, and open-access global health surveillance and knowledge generation at a rate never previously possible.

In 2011, HealthMap, through additional collaboration with the American Public Health Association (APHA) and the Skoll Global Threats Fund launched *Flu Near You (FNY)*, a disease surveillance system for volunteer reports of influenza-like illness (Smolinski et al., 2015:2124). Like the HealthMap system, FYN maintains both a website and a mobile interface accessible through a program application. The system allows volunteers in the United States and in Canada 'to report their health information using a brief weekly survey. The system collects symptom data on a weekly basis, which it publishes to its website, while offering an interface to compare its data with data from the CDC (ibid). In addition to the aggregation of global health data to map and visualize the prevalence of influenza-like illness in North America, FYN additionally features a 'Vaccine Finder' application which enables users to locate vaccine provision across geographic areas for a number of illnesses including influenza, hepatitis A and B, measles, mumps and rubella (MMR) and meningococcal, and pneumococcal meningitis (HealthMap Vaccine Finder, 2016). The objectives of Vaccine Finder seek to use technology and Web tools to 'increase access to and awareness of influenza immunization, and further seek to connect vaccine-seekers to providers of desired vaccines...and to inform the public about the need for immunizations (Huston et al., 2015:8).

Visualizing [Digital] Health Anomalies: HealthMap and the West Africa Ebola Virus Disease (EVD) Outbreak

ProMED-mail and GPHIN have received extensive policy and research accreditation for the roles served as early-warning and outbreak sentinels throughout significant global health watershed events. In 1995, ProMED-mail became the first online system to correctly identify and disseminate outbreak information linked to an outbreak of the Ebola Virus Disease (EVD), in Kikwit, Zaïre⁸, in advance of national health institutes and global health authorities (Madoff and Woodall, 2005:725-728). In 2002, ProMED-mail was cited extensively by the WHO for the advanced reporting of an outbreak of measles in Papua New Guinea, diphtheria in Paraguay, as well as an outbreak of Yellow Fever in Bosnia-Herzegovina. Moreover, the same year, the ProMED-mail system's reporting of African horse sickness in South Africa and an outbreak of Foot and Mouth Disease in Syria were in advance of official reporting by national health institutes (*ibid*). Furthermore, GPHIN has been widely recognised as the first health reporting system which detected unusual patterns and reports of the emergence of a strand of atypical pneumonia which emerged in Guangdong Province, China in late 2002 (Brownstein et al., 2008; Dion et al., 2015; Eysenbach, 2003; Keller et al., 2009; Milinovich et al., 2014; and Mykhalovskiy and Weir, 2006). Through its comprehensive processing of online media and reporting articles via its algorithmic programming, the GPHIN system was able to detect the emergence of a novel coronavirus, later identified as the Severe Acute Respiratory Virus (SARS) more than two months in advance of any official publication of the outbreak by the WHO (Milinovich et al., 2015:160). ua

In December 2013, a two-year-old child, Emile Ouamouno, was infected and died of a mysterious viral fever following likely contact with an African fruit bat in the village of Meliandou in the forest region of southeast Guinea (Leach, 2015:817-818). Soon after Ouamonuno's family died from a similar fever, and retrospectively, the boy would be identified as the first case in what would rapidly develop into the worst outbreak of the Ebola Virus Disease (EVD) in human history. Following the index case, this mysterious fever spread quickly across the region, facilitated by an under-equipped rural health centre, and then through a health worker's funeral, and related kin, to trading networks, and others in this region of high mobility and sociability (*ibid*).

In early 2014, due to the porous nature of national borders between states of the Mano River Union⁹, Ebola was transported across national jurisdictions with localized outbreaks occurring in Liberia and Sierra Leone. Although the Ebola Virus Disease, which first emerged in Yambuku, Zaïre in 1976 (CDC, 2016b), and had re-emerged frequently in Central and East Africa over the past three decades, the virus had never been recorded in West Africa, and the initial emergence of the mysterious viral fever had been met with uncertainty by health practitioners. Following a period of initial hesitation by the global health community, in which response measures implemented by the WHO were

⁸ Presently the Democratic Republic of the Congo (DRC).

⁹ In 2016 Union members consist of Côte d'Ivoire, Guinea, Liberia, and Sierra Leone.

condemned retrospectively as ‘anemic’ (McInnes, 2015:381), rapid response measures on part of the WHO sought to control an already spiralling health emergency by summer 2014. On 08 August 2014, reflecting the protocol of the revised International Health Regulations, the WHO declared the West Africa Ebola outbreak as an extraordinary health event constituting a *public health event of international concern* (PHEIC) (WHO, 2014a). Following this, in September 2014, WHO Director-General, Margaret Chan stated that the ongoing Ebola outbreak in West Africa was ‘the largest, most complex and most severe we’ve ever seen’ (WHO, 2014b).

Building upon this international momentum and sense of growing urgency, in September 2014, the United Nations Security Council (UNSC) adopted Resolution 2177, which affirmed that the ‘unprecedented extent of the Ebola outbreak in Africa constituted a threat to international peace and security, the Security Council call[s] upon Member States to respond urgently to the crisis and refrain from isolating affected countries’ (UNSC Resolution 2177, 2014). What is more, on 07 September, US President Obama referred to the most recent outbreak of the Ebola Virus Disease in West Africa as a ‘national security threat’ and subsequently authorised the deployment of 300 American troops to Liberia for the mitigation of the outbreak under the banner of Operation United Assistance (Roemer-Mahler and Elbe, 2016:489). As Roemer-Mahler and Elbe maintain further, the ongoing Ebola outbreak further reflected how the language of security in relation to the politics of health were employed by international political leaders outside the immediately and most severely affected region of West Africa (ibid).

Despite these grand measures which were implemented following the rapid spread of the Ebola Virus Disease across Guinea, Liberia, and Sierra Leone, the global health response towards the outbreak ‘has been perceived as an inept, dysfunctional, even shambolic...so poorly has the organisation’s handling of these global health crises been viewed that each public health emergency of international concern (PHEIC), has spurred several independent external reviews of the organisation’s performance. Every review has subsequently concluded that there was an urgent need to reform the organisation’ (Kamradt-Scott, 2016:401). Although a delayed global response to the severity of the West Africa Ebola Outbreak eventually brought the outbreak under control with the Public Health Emergency of International Concern (PHEIC) designation for West Africa being lifted in March 2016, an Ebola Situation Report released by the WHO in June 2016 confirmed a total of 28 616 total cases of Ebola in Guinea, Liberia and Sierra Leone, the report further listed 11 310 deaths from the EVD outbreak (WHO: Ebola Virus Disease Situation Report, 2016).

The West Africa Ebola Virus Disease outbreak not only resulted in a significant and unnecessary loss of life and prolonged suffering for vulnerable populations in some of the world’s least developed countries (LDCs), but damaged the legitimacy and questioned the credentials of the WHO’s ability to manage global health security (Kamradt-Scott, 2016:401). Moreover, the global health collective had been slow to recognise and respond to the possibility of a large-scale, virulent Ebola outbreak in resource-poor settings, despite earlier forewarnings that Ebola outbreaks severely tested

local health surveillance initiatives in many parts of Africa where confirmation laboratories and treatment clinics remained rudimentary (Callaway, 2012).

Despite the framing of the outbreak of Ebola in West Africa as a ‘health disaster’ (Comes et al., 2015:82), HealthMap again emerged as a strategic syndromic surveillance system in the early days of the EVD outbreak. Although the lack of adequate disease surveillance systems in remote Guinea reduced the initial ability to respond locally and increased eventual global risk (Milinovich et al., 2015: e20), the HealthMap system was able to detect the outbreak at its earliest emergence, partly based on online news stories and local reports which broadcasted a mysterious fever which had occurred in Guinea (Amankwah-Amoah, 2016:171; Milinovich et al., 2015). Preceding the reporting and alerts issued by both the Guinean Ministry of Health and of the WHO, on 14 March 2014, the HealthMap system uploaded the following media report from the Guinean media outlet Africaguinee.com: **Santé: Une étrange fièvre se déclare à Macenta, plusieurs cas de morts signalé** (Africaguinee, 2014). The brief media report, picked up and uploaded by the HealthMap system exists as the earliest signal that an unusual health event was occurring in rural Guinea. The content of the report further indicated the possible presence of a haemorrhagic fever, observed through anal and nasal bleeding of the infected; however, the original report by medical practitioners speculated that the potential fever resembled that of Lassa fever, a contagious fever which had originated in neighbouring Liberia. The report additionally stated that eight deaths had occurred from this mysterious fever in Prefecture of Macenta, 800 km south of the Guinean capital, Conakry (HealthMap: Ebola Map, 2014).

Despite HealthMap’s advanced identification of an unusual emergence of a mysterious and deadly haemorrhagic fever detected in remote Guinea through local media reports on 14 March, official acknowledgements of the outbreak were not conveyed by the WHO until nearly 10 days following the initial report. On 23 March 2014, the press service of the WHO, following prior consultation with the Guinean Ministry of Health, confirmed the outbreak of the Ebola Virus Disease in forested areas of south-eastern Guinea. The press notification reported that as of 22 March, a total of 49 cases had been confirmed. Of these 49 cases, 29 had died, reflecting a fatality ratio of 59% during the initial days of the outbreak (WHO, 2014a). The release additionally noted that of the seven blood samples collected from infected cases and analysed further at the Institut Pasteur, six had tested positive for the presence of Ebola. Further genetic sequencing of blood sampling indicated a strong homology with the previously identified *Zaire ebolavirus* (ibid). Though the report stated that cooperation between the Guinean MoH and the WHO had commenced in developing measures aimed at stemming the spread of the disease and reducing cases of infection and exposure, it highlighted even at this early stage, the possibility that the virus might have spread to the border regions of Liberia and Sierra Leone, popularly referred to during the ongoing health crisis as the *hot zone*, ‘the area where the border of Guinea, Liberia, and Sierra Leone intersect, where transmission is intense, and where people in the three countries continue to re-infect each other’ (Chan, 2014:1183).

While the subsequent response to the expanding Ebola public health emergency has received extensive criticism, much of it levelled towards the WHO, HealthMap successfully identified and disseminated, via the power of the algorithm, the first knowledge of an unusual occurrence of a suspected haemorrhagic fever in West Africa, almost 10 days in advance the traditional health surveillance systems. This advanced detection on part of the HealthMap system of a future-situated and exceptional disease threat, further built upon the previous success of the HealthMap system in identifying aberrant disease patterns including its early reporting of the 2009 H1N1 influenza A epidemic (Brownstein and Freifeld, 2007; Brownstein et al., 2008; and Scotch et al., 2011).

Moreover, in informational terms, while the HealthMap system's early signalling went unnoticed and unutilised by active global health agents during the early days of the outbreak, the syndromic surveillance system would gain a significant level of policy and research interest for its increasingly automatic and algorithmic-driven surveillance capacities. Looking retrospectively at the emergence of Ebola in West Africa, a widely circulated media-release entitled *How This Algorithm Detected the Ebola Outbreak before Humans Could*, highlighted the effectiveness of HealthMap's information algorithms in early detection of an emergent viral fever 'after mining thousands of web-based data sources for clues' (Titlow, 2014). The article further highlighted HealthMap as representative of the 'promise of such machine intelligence' and maintained that in an era of increased infectious disease outbreaks and of increased, publicly accessible data, 'machines are getting smarter' (ibid). Elsewhere, a recent publication analysing the West African Ebola outbreak and the increasing recourse to the use 'of alternative information sources, especially digital data management to characterize epidemiological patterns of an infectious disease' (Todorova, Tskanova, and Ermenlieva, 2016:17-18), presented HealthMap as an increasingly salient technology in the utilisation of 'online informal source for disease outbreak monitoring and surveillance of emerging public health threats' (ibid).

Both the expanding significance of Big Data within global health, and the successful detection processes of the HealthMap project during the West African Ebola outbreak have been further discussed as alternative channels of forecasting and knowledge generation needed 'to improve surveillance in vulnerable regions, [in which] digital surveillance could present a viable approach' (Milinovich et al., 2015: e20). In considering the rise of the increasingly sophisticated, automated reporting and surveillance capacities of HealthMap, the impacts of the computational turn on governmentality traced within the rise of these syndromic surveillance systems, as Antoinette Rouvroy writes, are far from trivial (2012:1).

Indeed, through the lens of Rouvroy, the design and development of HealthMap from 2006 onward, in an era enriched with infinite and ever-expanding digital data sets is representative of '[o]perations of collection, processing and structuration of data for purposes of datamining and profiling, helping individuals and organizations to cope with circumstances of uncertainty or relieving them from the burden of interpreting events and taking decision in routine, trivial situations have

become crucial to public and private sectors' activities in domains as various as crime prevention, [and] health management' (ibid). HealthMap was designed as such as an emergent governmental technology of security, 'geared towards assembling and utilising Big Data...[b]y building a digital copy of the physical world...[and] to provide real-time access to information and prediction to contain outbreaks' (Amankwah-Amoah, 2016:171).

In seeking to digitally structure and present geographies of forthcoming pandemic risk, the HealthMap system became one of the first syndromic surveillance prototypes to pilot the use of 'evolving maps, in combination with the increased availability of novel digital data sources...dissected in the context of Big Data' (Hay et al., 2013:2). Through the utilisation of automated algorithmic technology HealthMap sought further to address the double-pronged problématique of the Big Data descriptors of 'volume, velocity, and variety' (ibid), to continually capture, process and visualize data correlations, indicative of a potential emergent health emergency, while simultaneously mitigating the potential for the generation of false positives or online noise through 'continual model fine tuning' (ibid), and machine-learning, the purpose of which as maintained by Rouvroy and Berns (2013), is to enable the production of hypotheses based on data..

In breaking rank and extending the centrality of the algorithm within its operating system, HealthMap not only sought to address and compress open-source data, but became the first of kind surveillance system to effectively, upload visualize and present aggregated global health data, reflecting a digital replication of infectious disease trends and circulating threats occurring globally and in near real-time. In effect, re-contouring, re-situating and extending intensity, view, and spatial dimensions of surveillance processes beyond what was possible in preceding governmental systems for the management of infectious disease. Unlike the systems of ProMED-mail and GPHIN, which sought to curate and generate infectious disease and global health *knowledge* in the form of health alerts and reporting which were developed via human analytics or combined human analytic and automated processes from then emerging technologies including the personal computer, HealthMap utilised cutting-edge automated approaches to the generation of early-outbreak knowledge, including the geo-positioning of suspected disease outbreaks, presented through the visualization of digital risk-maps, sustained and fed by algorithmic collection and filtration.

Additional to this, the visualization of HealthMap's maps of risk can be used as further instruments in order to illustrate or provide scope to the extent of a public health problem or of an emergent novel disease outbreak (ibid), or to serve as a tool of reference in assessing global health inequalities, or areas of high-disease burden (Dorling, 2007). The automated visualization processes of the HealthMap system can further transform the 'understanding of environmental determinants and help radically improve understanding of the factors which promote disease diversity and emergence' (Hay et al., 2013:3; Geurnier et al., 2004), generating further novel understandings and knowledge processes of sudden disease outbreaks in the twenty-first century.

Lastly, the generation of visualized risk-maps via the HealthMap system provides ‘a comprehensive atlas... of considerable benefit to improve future assessments of the burden of disease’ (Hay et al., 2013:3; Murray et al., 2012). As Hay et al., have noted further, the audience for visualized risk maps, generated by systems such as HealthMap, in an era of radical uncertainty, include agencies who need to prioritise limited resources and respond to changing disease patterns, public and private R&D groups who need to assess value and plan research strategy, logistic groups who need to optimise the rollout of new interventions/treatments, and clinicians who want to accurately diagnose infectious diseases in local populations and returning travellers (2013:3).

Significantly, as Hay and colleagues (*ibid*), have maintained, new processes of geo-positioning, data-visualization and mapping afforded by the proliferation of algorithmic organisation and prediction, exemplified by the HealthMap system has been ‘made tractable by automating many of the laborious steps in primary data acquisition and positioning’, further sustaining the point presented by Rouvroy and Berns (2013), that within these surveillance systems in which algorithmic governmentality serves as the central rationality, ‘knowledge production is now automated, which means that it requires minimal human intervention, and is uninformed by any pre-existing hypothesis (unlike traditional statistics used to substantiate a hypothesis)’.

Conclusion

This chapter has traced the launch of HealthMap as the third syndromic surveillance system within this thesis, and has outlined how the development of this next generation technology signified the latest shift in rationality to the integration of algorithmic logic and automation within syndromic surveillance systems. Unlike the syndromic surveillance systems which preceded HealthMap, which sought to disseminate and produce forward-situated understandings of disease threats in the forms of alerts and health reports, HealthMap was designed as an online instrument of surveillance ‘for the [novel] visual presentation of reported disease incidence by location’(Schwind et al., 2014:2).

Through addressing the double-edged problématique of infinite, yet potentially strategic mass-data sets, HealthMap represented the latest and most intensified digital turn in systems of infectious disease surveillance, developing automated data-collection and visualization capacities to ‘allow for greater possibilities in extracting structure algorithmically from a variety of disparate data sources’ (Freifeld et al., 2008:151). HealthMap’s largely automated surveillance platform guided by algorithmic processing, supported to an extent by human curation to correct miscalculations and examine geographic coverage (*ibid*), is further indicative of the increased central position over the past two decades in which algorithms and algorithmic programming have assumed within syndromic surveillance systems which aim to generate early-outbreak detection knowledge, ‘derived from clusters and patterns in large volumes of data, otherwise imperceptible to human reading’ (Amoore and Piotukh,

2015:341). As this thesis has maintained, the gradual, yet consistent implementation of algorithmic technologies within systems of infectious disease surveillance and outbreak reporting including HealthMap is reflective of a broader and sustained trend accounted for across the spectrum of the practice and imagining of security politics (Introna and Wood, 2004; Amoore, 2006; 2009; Leese, 2014; Curtis, 2016).

The capacity for automated and algorithmic-driven surveillance systems to rapidly detect exceptional health events from correlations and associations derived from complex digital data streams was further demonstrated by HealthMap, when it successfully identified the early origins of the largest and most deadly outbreak of the Ebola Virus Disease in human history, detailed as a mysterious fever occurring in Macenta, Guinea on 14 March 2014. In addition to the initial forecasting of an unusual health episode, the HealthMap system also revealed the ongoing discrepancy between official state surveillance reporting and local media surveillance (LMS). Despite HealthMap's advanced posting of the news article detailing a mysterious fever as reported by *Africaguinee.com*, this local media report went unobserved by global health authorities including the Guinean Ministry of Health and the WHO, with official confirmation of a possible outbreak occurring in delay of almost 10 days.

Therefore, the largely inadequate and delayed global health response to mitigate the West African Ebola Virus Disease outbreak provides an appropriate caveat for discussions of increasingly algorithmically powered syndromic surveillance systems within this thesis. While the gradual integration of algorithmic logic, iteratively within these new surveillance technologies has consistently empowered these systems to generate new forms of knowledge without truth, as well as generate advanced forecasting of pathogenic risks, extracted from complex data associations, the role of these technologies across broader global health networks remain *indicative* in nature. What this means is, while ever increasingly sophisticated algorithmic programming as documented in the case of HealthMap will continue to yield alerts and visualizations of probable or exceptional health occurrences, these generated digital indicators will fade without a reactive and responsible larger sociotechnical apparatus of global health security possessing the coherence, resources, and ability to rapidly intercept these digitised signals, and to channel them into actionable and equitable interventions aimed at mitigation and containment.

Within the context of this research thesis, HealthMap emerges as the most recent manifestation of an algorithmically informed health security technology which, while broadly governmental in the original understandings provided by Foucault, now demonstrates clear divergences and new avenues of discussion towards a novel form of algorithmic governmentality for addressing pandemic contingencies across uncertain geographies of the twenty-first century. While broadly concerned with the securitization of populations and the continuation of positive circulatory processes from pandemic threat, both the recourse to algorithmic vision and to mining of infinite online data sets demonstrated by HealthMap are indicative of the expansion of a new *algorithmic governance* seen within these health technologies (Rouvroy, 2009; 2014; 2015; and 2016a,b; and Pasquinelli, 2015), in which pattern

recognition (from data correlations), and anomaly detection emerge as new governmental rationalities for the knowing of forthcoming pandemic threats.

Therefore, in utilising the lens of algorithmic governmentality developed by Rouvroy, the knowledge formations and techniques of surveillance demonstrated by HealthMap since 2006 are indicative of new governmental practices across a number of key points. First, HealthMap continues the increasingly automated and digitised process via algorithms, of the production of a form of *knowledge without truth* or surface knowledge for governing pandemic, piloted by ProMED-mail, and accelerated by GPHIN, which as Rouvroy has highlighted, has increasingly bypassed the ‘truth-telling’ regimes and processes of testing, hypothesis, verification, and confirmation which sustained previous health surveillance practices. What is more, HealthMap further corresponds to the novel and distinct problematization of knowledge in the digital era as opposed to the era of statistics whereby the algorithm emerges as a particularly strategic and reassuring technology of security, seeking to derive actionable meaning and forecast from the chaos of infinite and *excessive* data sources.

Through extensively harnessing the deductive and organisational capacities of the algorithm to mine complex data sets for indicators of [exceptional] health events, the HealthMap system continued to shift the production of knowledge of future phenomena away from human analytics and the physical world towards the algorithmic gaze of digital datascares. Significantly, what this indicates in the context of these health surveillance systems, gradually supplemented by algorithmic logic is that knowledge is increasingly captured, processed, and presented by the algorithm, for secondary assessment by human analytic teams, signalling a diminishment of human analytical and observational processes in emergent systems of health surveillance which differed sharply from previous governmental models. With its cutting-edge capacities to now construct visualizations of aberrant data patterns, HealthMap additionally demonstrated how knowledge pulled and processed from invisible, datascares, now increasingly constructs, give awareness to and informs global health security practices of the physical and contemporary world.

HealthMap therefore marked the strongest shift towards new forms of governmental technique in the government of pandemic threat in the early twenty-first century. Reflective of Rouvroy’s algorithmic governmentality, whereby an epistemic transition occurs in which governmental techniques now shift to addressing digital data streams, HealthMap alternatively implemented extensive data-mining processes, undertaken by algorithms, to generate new knowledge forms for infectious disease threats, departing from previous methods of knowledge quantification via statistics (Rouvroy, 2012). In doing so, and as exemplified by its advanced signalling of the initial emergence of the Ebola Virus Disease in remote Guinea in 2014, the surveillance system with increased algorithmic capacities to crunch and scrape data streams, shifted further towards the detection of the exceptional as a new governmental objective, transitioning away from previous processes of governing potential threats through processes of governmental normalisation as conceptualised by Foucault and instead utilising

emergent security techniques towards new [algorithmic] governmental aims of anomaly detection and pattern recognition of circulating data streams.

Lastly, in its shift towards the employment of algorithmic programming to infinitely mine digital data streams to detect *exceptional* health patterns occurring globally, HealthMap once more appears to diverge from previous governmental strategies which sought to regulate biopolitical phenomena through processes of prevention via normalisation. The operations of HealthMap, which are largely informed and sustained by the algorithm alternatively seek to *pre-empt* rather than *prevent* radical uncertainty, represented by the emergence of a future exceptional health event. Indeed, these new surveillance systems, fed by algorithms, and operating within a new algorithmic mode of government appear concerned only with data, indifferent to the original subjects of biopolitics presented by Foucault, in which processes of normalisation sought to regulate: leprosy, plague, insanity, and food scarcity (Rouvroy, 2015). Exemplified by HealthMap as the most recent manifestation of a new algorithmic logic for the surveillance and regulation of infectious disease threats in the twenty-first century, the new gaze of these syndromic surveillance systems orientates towards digital data sets with the end logic of pre-emption, marking an epistemic transition away from the Foucauldian governmental tenants of prevention via biopolitical normalisation.

The launch of HealthMap in 2006 subsequently represented new and increasingly cutting-edge initiatives to intensify the forecasting and knowledge generating capacities of syndromic surveillance systems for the strengthening of global health security initiatives in the twenty-first century. Specifically, the development of HealthMap in an era of Big Data also represented new capacities for automation, the speed of calculation, as well as the access to massive quantities of data which such systems now demonstrated with harnessing the algorithm to strengthen surveillance and reporting initiatives. Conceptually, HealthMap's extensive integration of algorithmic programming into its core surveillance capacities has produced new techniques and presentations of knowledge of exceptional pandemic threats which, in turn has renewed and extended sites of discussions of governmental apparatuses for security in the contemporary era of data.

Empirically, as reviews within this chapter have demonstrated, with the new capacity of systems such as HealthMap, to operate across data-streams in a non-selective method in which *all* data is potentially useful, algorithmically-powered syndromic surveillance systems have increasingly generated advanced and precise forms of knowledge and alerts of future-situated health events, exemplified in this chapter by the advanced detection of Ebola in remote Guinea by an algorithm of the HealthMap system. What is more, this chapter has additionally situated the limitations of these algorithmically-powered surveillance systems in that they remain *indicative* instruments only within increasingly complex global health security regimes. Demonstrated by the failure of larger global health security agents to respond in time to the 2014 Ebola Virus Outbreak, these systems remain signalling sentinels of 'what could be', and cannot singularly pre-empt coming pandemic threats in a contemporary global health system which remains fragmented and imprecise.

Conclusion: Syndromic Surveillance, Algorithmic Governmentality and Global Health Security

Introduction

The aim of this thesis has been to discuss and present the rise of syndromic surveillance systems as new and responsive technologies for the forecasting and presenting of forward-situated pandemic threats which seek to strengthen global health security frameworks over the past two decades. In doing so, three syndromic surveillance systems for infectious disease detection have been presented as empirical case-studies within this thesis: the Program for Monitoring Emerging Diseases (ProMED-mail), the Global Public Health Intelligence Network (GPHIN), and HealthMap. The thesis has further traced the iterative evolution of these three systems from 1994-2006, in order to demonstrate the growing centrality of these novel surveillance systems within a complex technological/political framework of global health security, and to discuss the emergent technical and political implications for the practice of health security which have resulted from a steady recourse towards the increasingly future-situated, digital knowledge curated and disseminated by these systems. The central research question which has guided the investigation of this thesis has been: How do new surveillance technologies for the advanced detection of pandemic threats transform contemporary practices of global health security?

The rationality informing this research question is reflective of a number of significant transformations and epistemic shifts within contemporary international relations, as well as the practice and imagining of global health security. Firstly, faced with highly pathogenic and novel disease outbreaks from the late twentieth century to present including HIV/AIDS, avian and swine influenzas, Ebola, MERS, SARS and Zika, the practice and imagining of international security has been

increasingly re-contoured towards the addressing of pandemic threats as existential security challenges for the health of populations, and for the continued circulation of global economy and capital.

Moreover, the post-Cold War landscape of international relations has emerged as a productive site in which to discuss and consider the widening of the scope of security praxis to include issues of non-traditional security, represented within this thesis as the looming future threat of infection and pandemic. The mitigation of disruption to trade and travel links, as well as the continued securitization of populations from infection have been the underpinning rationalities which have facilitated rise of the practice of global health security and the establishment of a new health/security nexus from the mid-twentieth century onward. In turn, this gradual elevating of and construction of global health has shifted the topographies of infectious disease surveillance, as well as the parameters of security practice from the *national/sovereign* to that of the *global*. And yet, the growth and practice of this novel biopolitical project of global health security has been problematized in a number of key areas which have emerged as spatial management of population and economy has shifted previously from the *national* to the *global*. Surveillance systems for the regulation and knowing of patterns of distribution of infectious phenomena within populations have long existed as a key instruments within the practice of population security in modern nation states, and the research and conceptualisations presented by Michel Foucault on *biopolitics* and *governmentality* have contributed much in the way of understanding how traditional health surveillance systems, supported by statistical forecasting, made the spectre of pandemic a *knowable* and therefore *manageable* object within the governmental state, in its furtherance of population-oriented political and economic aims.

However, systems of traditional health surveillance and the capacity to generate and forecast knowledge of occurring or approaching infectious disease outbreaks have frequently been problematized by the emergence of new governmental problems as systems of global health security have expanded. Firstly, in many instances, the production and accessing of global health *knowledge* for the regulation of pandemic threat has been scarce, difficult to collect and has often been withheld by reticent states fearing downturns in their economies and trade following the disclosure of a disease outbreak occurring within national borders. Second, while traditional health systems have been predicated on the generation of verification and diagnosis of emergent pathogenic threats through processes of data-collection, statistical generation, and laboratory confirmation, these traditional methods of proven health surveillance have also been problematized by lengthy processing gaps, human analytical error or oversight, as well as a lack of diagnostic equipment in low-resource areas with high infectious disease burden.

While this thesis has maintained the place of traditional health and clinical surveillance systems as the cornerstone of any effective global health system, it has also demonstrated the shortfalls and challenges of traditional health surveillance when faced with a sudden and virulent disease outbreak, thus galvanising new security rationalities towards the development of novel surveillance technologies with the capacity to expedite the collection, production, and dissemination of epidemic intelligence for

the mitigation of disease outbreak, and the bolstering of health security systems. Third still, while the generation of knowledge for the management of pathogenic phenomena within traditional governmental systems has relied on governing through processes of normalisation and through assessments of patterns of distribution to generate an understanding of probable health threats, contingent pandemics of the twenty-first century have been frequently represented by the *exceptional* event, such as the two year old index patient in remote Guinea at the epicentre of the 2014 West African Ebola outbreak, or the Metropole Hotel ‘super-spreader’ patient in Hong Kong who transmitted the international spread of the novel coronavirus in 2003. Consequently, traditional health surveillance systems have been increasingly outpaced to detect that which constitutes the *exceptional* or the potential health threat in an era of networks, interconnections, rapidly expanding globalization, and hyper-circulation.

As this thesis has argued, the problematization of knowledge for the advanced detection of pathogenic threats, and the strengthening of global health security initiatives exists as a core rationality towards the development and proliferation of new surveillance systems and technologies of security for the effective government of [disruptive] pandemic threats in the twenty-first century. Within an expanding global health security regime over the past two decades, syndromic surveillance systems have emerged as novel technologies of government, orientated towards the advance forecasting and generation of knowledge of pandemic probabilities via new surveillance methods of aggregation, assessment and dissemination of findings derived from increasingly abundant open-source data, available as a result of the growth of the Internet, digital innovation and Big Data in the digital era.

In 1994, ProMED-mail launched as the prototype syndromic surveillance system, generating disease reports from medical and scientific specialists, and facilitating the channelling and exchange of non-official health data and information from its subscriber base connected via e-mail and the Internet. ProMED-mail therefore was the first system to seek to generate and disseminate a new form of knowledge, curated through emergent and distinct processes, beyond traditional health surveillance for addressing contingent pandemic threats in an increasingly networked global health system. While the reporting and forecasting capacities of the ProMED-mail project were initially very successful, the growth of digital technologies and the infinite generation of online data, potentially strategic yet increasingly unfeasible to harness meant that by 1997 with the launch of GPHIN, this second syndromic surveillance system would become the first of many similar security systems within the new era of *preparedness*, to develop and integrate emergent digital algorithmic capacities into its process of open-source health surveillance, in order to assist with the real-time ‘automatic detection, sorting and forward looking evaluation of the invisible opportunities and risks’ contained within growing data streams which had previously been unavailable to human perception (Rouvroy, 2015a:1).

Lastly, the launch of HealthMap in 2006, with its largely automated, data-processing surveillance system demonstrates further how within the evolution of these three syndromic surveillance systems for the forecasting of pandemic probabilities, the algorithm has emerged significantly as a ‘key security technology through which our current world is depicted, circumscribed

and rendered knowable' (Opitz, 2016:2). This increasing recourse to the perceived organisational and foreshadowing capacities of the algorithm as a fixture within present landscapes of preparedness and the practice of new security landscapes has already been widely documented across a wide spectrum of security practice in addressing *unknowable uncertainties* in airports, at national borders, in dealing with transient or marginalised populations, and in the contemporary practice of the securitization of terror threats (Daugman, 2004; Introna and Wood, 2004; and Amoore, 2009). Consequently, the rise of these syndromic surveillance systems from 1994, which have increasingly sought to utilise the algorithmic production of 'reality' (Rouvroy, 2012), have produced new ramifications and expansions of new sites of analysis for the practice of global health security, and for contemporary international relations.

Contributions to Ongoing Academic Research

In presenting the emergence and rise of syndromic surveillance systems as new technologies for the strengthening of global health security systems, this thesis has further sought to extend original analyses and make contributions across contemporary social sciences within a number of key research areas.

Global Health Security

As this thesis has developed, the emergence and rapid proliferation of novel syndromic surveillance systems over the past two decades, which has occurred in tandem with the expansion of a global health/security nexus, seeks to pre-empt and mitigate infectious disease outbreaks occurring globally, through the development of an overarching health security complex. Global health security as it exists in the early twenty-first century represents a multifaceted biopolitical project, operating at the level of the global through an extensive system of networks, interconnections, initiatives, and institutions, aimed at the preservation of overall population health from infectious disease and death, as well as the resilience and continued circulation of global economy through an assemblage of techniques, interventions, and technologies.

The expansion of still a relatively young realm of security praxis, global health security now represents an academic site of considerable research across the social sciences. Within recent scholarship and investigations of global health security, considerable research contributions have been generated within themes of global health governance (Kay and Williams, 2009; Rushton, 2011; Harman and Rushton, 2014; McInnes et al., 2014; Youde, 2015; and Busby et al, 2016), and the construction of new institutions and partnerships for the 'governing' of the politics of global health in the twenty-first century (Ruckert and Labonté, 2014; and Herrick, 2017). Extensive academic research within global health has further been conducted across topics including the meanings and ambiguities of 'global health' and security (Koplan, 2009; McInnes, 2015; and Weir, 2015) and how this form of security has

been constructed through evolving and interconnected historical and political transformations. What is more, global health security has additionally emerged as a new site in which research investigates how evolving processes, aimed at extending the securitization of populations from pandemic threats through novel processes of medicalization (Elbe, 2010b; Clark, 2014; and Elbe and Voelkner, 2015) Pharmaceuticalization (Bell and Figert, 2012; Elbe et al., 2015; and Roemer-Mahler and Elbe, 2016), and the generation of medical counter measures (MCMs) have emerged as new political objectives over the past two decades to make secure, uncertain [pathogenic futures] (Gostin, 2006; Lakoff and Collier, 2011, Elbe, 2010b; and Elbe et al., 2015, Hoyt, 2015).

Within present global health scholarship, the area of global health surveillance, and the development of new surveillance technologies to address uncertain and sudden emergences of diseases continues to be an area of considerable investigation, as seen in the works of Sara Davies (2008, 2012a;2012b), Martin French (2009; 2013; and 2014), Clare Wenham (2015; 2016), Henning Füller (2016), and Sven Opitz (2015; and 2016). While the research generated by global health scholars has presented and discussed the emergence of novel surveillance technologies, including syndromic surveillance systems such as ProMED-mail, GPHIN, and HealthMap in changing topographies of global health security, the emergence and gradual yet sustained recourse to algorithmic-powered surveillance within these health sentinel systems over the past two decades has remained a critical, yet undiscussed element in contemporary practices of global health.

Subsequently, a central contribution of this research thesis has been to clearly delineate and present novel and emergent infectious disease surveillance practices for the strengthening of global health security. Through comprehensively analysing the evolution of three syndromic surveillance systems for the advanced identification of pandemic threats over the past two decades, this thesis has demonstrated and argued that the gradual and marked reliance of algorithmic integration traced within these systems from 1994-2006 initiates a new form of infectious disease surveillance, sustained and afforded via algorithms, and underpinned by an emergent *algorithmic governmentality*. As this thesis has shown, this practice of health surveillance, manifested by syndromic surveillance systems, is fed by digital signs and signals, generates a certain *knowledge without truth* of contingent pathogenic threats, and is oriented towards the advanced detection of the exceptional global pandemic threats including SARS, avian influenzas and Ebola.

In presenting the rise of a novel form of algorithmic-powered infectious disease surveillance, this thesis further extends to discussions of algorithms as technologies of health security into contemporary global health scholarship. As indicated previously, while substantial scholarship in global health has developed around the generation of techniques and technologies to pre-empt potentially catastrophic outbreaks of pandemic, including recourses to medical countermeasures (MCMs), novel technologies for reporting and surveillance, and bioterror preparedness training, the centrality of the algorithm as a new and expanding technology in contemporary initiatives to securitize looming pandemic threats remains largely absent from global health security literature, and the contributions of

this thesis, seek to serve as a foundation of research in this critical and fertile site of global health security scholarship.

What is more, while global health scholars including Weir and Mykhalovskiy (2010), Davies (2012a; and 2012b), and Wenham (2015; 2016) have previously discussed the emergence of syndromic surveillance systems as new technologies for global health security, the research generated by this thesis has extended the analysis and understanding of these health surveillance technologies, highlighting, not only the unique ascendancy of the algorithm as a new security component within these surveillance systems, but further providing, in thick detail, an inventory and account of the specific historical context, design, and unique function of three prominent syndromic surveillance systems for the strengthening of global health security and the advanced forecasting of pathogenic uncertainties.

Critical Security Studies/Governmentality Studies

Critical Security Studies

Within the discipline of critical security studies and critical theory, a number of productive sites have emerged which seek to understand and present the emergence of novel technologies, techniques, and assemblages which seek to pre-empt, identify and render events knowable and thereby governable within expanding security nexuses and terrains of uncertainty. The *Securing Against Future Events (SAFE)* working group based at Durham University, headed by Professor Louise Amoore for example, seek to understand the changing form and emphasis of security in a contemporary world fixated with the uncertain, in which security practices are increasingly superceded by the pre-emption of future events through horizon-scanning, data gathering and projection, mobile profiles, and threat imagination, and whereby automated [security] decisions of the algorithm constitute new sites of investigation and critique in the politics of security and pre-emption.

Furthermore, in 2016, the international relations/international security journal *Security Dialogue* published a special issue entitled ‘Securing with algorithms: Knowledge, decision, sovereignty’, dedicated to assessing and understanding the new security function in which algorithms have increasingly assumed in the addressing uncertainty within a diverse range of disciplines. As Amoore and Raley have asserted (2016:4), the implementation of the algorithm across a broadening scope of contemporary security practices in the context of Big Data have been accompanied by a new set of promises for how the world might be rendered securable. As the special issue has further highlighted, the rise of new forms of algorithmic-led security practices produce new areas of enquiry and investigation beyond the conventional sites of the human, the state and sovereignty. In addition to *Security Dialogue*’s seminal publication on securing via algorithms, a number of other critical security theorists have focused upon the so called ‘computational turn’ in security governance, represented by capacities of data mining, predictive analytics, and algorithmic-decision making in the transformation

and practice of security towards addressing that which represents the future uncertain (Amoore, 2011; Rouvroy, 2011; 2012; De Goede, 2014; De Goede et al., 2014; Thomas, 2014; Aradau and Blanke, 2015; and Aradau and Blanke, 2016).

In presenting the rise of digital syndromic surveillance systems as emergent technologies for the securitization of [future] pandemic threats, increasingly supported by the algorithm, this thesis further makes a key contribution to scholarship within the field of critical security studies which assess the role of algorithmic programming in the practice and form of security. Significantly, while research on the role of the algorithm as an instrument of securitization in global health has remained largely absent in critical security studies (Roberts and Elbe, 2017), this thesis has presented how, corresponding with the emergence of syndromic surveillance systems over the past two decades, global health security has existed as one of the original sites in which the algorithm has arisen and propagated as a new antidote to the security threats of radical uncertainty, represented by pandemic illness.

Significantly then the rise of syndromic surveillance systems powered via the algorithm contributes to contemporary and expanding scholarship within critical security studies which seek to understand the rise of the algorithm as a new and increasingly central figure in the securing of future events, and in the generation of actionable knowledge to address the contingent. While much of the current research undertaken via the algorithm in contemporary security practices has focused upon the role of the algorithm within technologies of warfare, the pre-emption of terrorist attacks, and the creeping presence of security, increasing facilitated by the gaze of the algorithm, this research thesis has situated and discussed the steady and historical evolution of a form of algorithmic surveillance within the terrains of global health and the securitization of future pandemic, representing an overlooked site in which the algorithm has emerged as an new instrument of government, and yet developed discussions of this terrain increasingly scrutinized via the algorithmic gaze have remained absent. As such, and in contributing to the field of critical security studies, this thesis has argued, via the evolution of syndromic surveillance systems, that the same [emergent] tendencies to utilise the algorithm, to overcome the infinite complexities of Big Data, and to remedy or insulate against the radical uncertainty of the unknown, has long existed at the core of governmentalities of global health security, gathering increased momentum and precision within the politics and practice of pandemic preparedness over the past two decades.

Governmentality Studies

Moreover, this research thesis has contributed significantly to the discipline of governmentality studies, and contemporary Foucauldian scholarship by critically engaging with Antoinette Rouvroy's concept of algorithmic governmentality, as a new conceptual tool in which to explain the rise of syndromic surveillance systems, and further highlighting the emergence and ascendancy of this novel type of governmental rationality within contemporary global health scholarship.

Within the politics of health security, Foucault's biopolitics and governmentality have extensively influenced and informed scholarship on preparedness, and the government of insecurity (Lentzos and Rose, 2009), the emergence of techniques to manage contemporary systems of circulation (Munro, 2011), on real-time sentinels to address global public health emergencies (Lakoff, 2015), as well as the implementation of novel and contemporary global biopolitical/governmental strategies to enhance the regulation of populations and propagation of liberal governance (Dillon and Reid, 2001; Dillon and Lobo-Guerrero, 2008; Brown et al., 2012; Hagmann and Cavelty, 2012; and Vincent-Jappah and Smith, 2015). Indeed, while this thesis has drawn much intellectual inspiration from the conceptualisations of biopolitics and governmentality developed by Foucault, it has further sought to critically analyse Foucault's original parameters of governmentality into contemporary contexts in discussing the rise of syndromic surveillance systems for the advanced forecasting of pandemics. In doing so, this thesis has highlighted the advent and divergences of new governmental rationalities which have developed following the emergence of data as a new strategic object of contemporary government and practice of security, as well as the piloting of new security mechanisms which seek to harness data sources for the generation of actionable security knowledge.

Therefore, while a number of scholars (Fearnley, 2005; 2008; Weir and Mykhalovskiy, 2010; Cakici and Sanches, 2014; and Lakoff, 2015) have previously discussed the emergence of syndromic surveillance systems and the embedded governmental objectives and rationalities within these technologies, the analysis conducted in these research works has reflected a conventional understanding of syndromic surveillance systems and governmentality, drawing heavily upon the *Security, Territory, Population* lecture-series presented by Foucault at the Collège de France. Distinctively then, this research thesis has traced the iterative evolution of algorithmic programming as a key component which has occurred within the expansion of syndromic surveillance systems over the past two decades in health security.

Correspondingly, the thesis has developed and argued, through analytical engagement with the conceptual framework of Antoinette Rouvroy, that a *novel* [algorithmic] governmental rationality is emergent and increasingly at hand within digital syndromic surveillance systems as sentinels for forthcoming pandemic threats. Specifically, the thesis has worked to advance three divergences of algorithmically-powered syndromic surveillance systems which indicate the emergence of new governmental perspectives in infectious disease surveillance, distinct from the original parameters of governmentality presented by Foucault: 1) from the transformation in the problematization of knowledge, from one of previous scarcity to one of excess in which the algorithm emerges as an 'objective' technical solution to the growing complexity of Big Data and infinite data-streams; 2) through new recourses to the generation of a form of *knowledge without truth* or *surface knowledge*, of merely indicative, non-diagnostic health forecasts and alerts, curated by the power of algorithms within these systems, which seemingly bypass the traditional channels of testing, hypothesis, evaluation, human observation and statistical calculation which characterised traditional systems of infectious

disease surveillance and reporting; and 3) through the emergence of new perspectives on the government of contingent pathogenic threats, which have transitioned from a government which managed disease threats through processes of *normalization* via statistical analysis and calculation, towards the detection of the exceptional health event, derived from algorithmic analysis of infinite data-scapes and correlations, further conceptualised as the new politics of *anomaly detection* and *pattern recognition* afforded by increased algorithmic capacity in security systems (Pasquinelli, 2015).

The thesis therefore opens novel discussions and introduces broadened conceptualisations within governmentality studies. In considering how the rise of algorithmic logic re-contours previous understandings of governmentality and techniques of security, this thesis offers a new and original contribution through the development, illustration and engagement with Rouvroy's notion of an algorithmic governmentality, which underpins and informs the development and proliferation of these novel health surveillance systems as new technologies for global health security. While Rouvroy and colleagues have previously applied the conceptual framework of algorithmic governmentality to understand shifting governmental perspectives in light of technological developments in the legal/jurisdictive realms, and in reference to the digitisation of market and economy, this thesis has also extended the application of this distinct emergent form of governmentality into the previously unassessed area of health security in discussing the rise and new implications of syndromic surveillance systems.

Technology, Security and International Relations

Lastly, this thesis also makes an academic contribution to the study of international relations in presenting how technological developments, and the piloting of new security devices, produce significant changes in the conduct of states within contemporary systems of global health security. Here the thesis also contributes to the growing scholarly interest in exploring the intersections between Science and Technology Studies (STS) and International Relations. In presenting the rise of new sociotechnical apparatuses of security for the governing of global health (Weir, 2015:18-19), advancements in technology and digital innovation over the past two decades have been central to the proliferation and increasing intensity of new algorithmically-guided syndromic surveillance systems operating across contemporary landscapes of global health. Within this field of scholarship, syndromic surveillance systems have often been assessed and discussed for novel and innovative approaches to enhanced infectious disease surveillance and bioterror preparedness (Buehler et al., 2003; Sosin, 2003; Henning, 2004; Stoto, 2004; Eysenbach, 2006), and further research has focused on the centrality of these technologies in bolstering global health surveillance within the context following the ratification of the revised International Health Regulations (2005), of the WHO (Baker and Fidler, 2006; and Morse, 2012).

In discussing how technological advancements and innovations in digital interconnectivity produce new ramifications for actors within international relations, this thesis develops further, a novel account of how new technological devices in the form of syndromic surveillance systems reformulate security knowledge and re-contour modes of state conduct in processes of infectious disease reporting. Specifically, this thesis has traced the development of a new, and increasingly algorithmically-guided form of infectious disease surveillance, which has enabled syndromic surveillance systems to forecast upon emergent disease threats, beyond sovereign jurisdictions and in advance of traditional surveillance systems, new technological advancements represented by these systems has afforded global health agents, chiefly, the WHO, new capacities in the governing of future health threats, through advanced and near real-time forecasts of potential pandemic outbreaks.

Simultaneously, the new legal, institutional, and diplomatic recourses ratified to authorise the WHO to access, utilise, and act upon these new streams of knowledge have produced transformations in how states may opt to behave when subjected to the new surveillance gaze of these novel algorithmically-guided systems. As nuanced examples within this thesis have demonstrated, influential state powers including China have now increasingly opted for voluntary limitations of their sovereignty, albeit in moderation, with recent transformations in global health surveillance whereby WHO has sought to harness the algorithmically-powered forecasting of these systems and to accelerate the reporting capacities of its member states.

What is more, this thesis has also asserted that the rise of syndromic surveillance systems, and the emergence of new algorithmic surveillance capacities increasingly legitimised by the WHO, have produced modest, albeit significant shifts in the reporting capacities and transparency of states engaging within the politics of global health in the twenty-first century. A study by Chan et al. (2010), for example suggests that with the rise of syndromic surveillance reporting and the ratification of the IHR (2005), the timeliness of detection and outbreak discovery on part of member states of the WHO have improved by 7.3% in a period from 1996-2009. Elsewhere, Chretien et al., (2008), have documented the 4-fold increase in accessing health and outbreak information provided by syndromic surveillance systems in low and middle-income countries. What is more, as Mykhalovskiy and Weir (2006) have presented, even as early as 2006, 40% of all infectious disease outbreak data supplied to the WHO, had originated from syndromic surveillance systems—particularly GPHIN, indicating intensified WHO-led efforts to access and assess critical outbreak data with or, often without prior consultation with its member states.

Ultimately, the rise and proliferation of syndromic surveillance and the increasingly algorithmically-guided knowledge curated by these systems transform aspects at both national/sovereign and global dimensions of global health security in the twenty-first century. This is not to claim that the sovereignty of states in the affairs of infectious disease control have been nullified; one only needs to look to the 2014 EVD outbreak in West Africa and the proliferation of travel bans from affected regions which were issued by WHO member states in contravention of official WHO policy that such measures were regressive. However, what the rise of syndromic surveillance and of the

algorithmic gaze in systems of global health signify is not whether a state can conceal a public health emergency, but rather, should the state in question risk not reporting an outbreak, when knowledge of such an event can be digitally accessed and disseminated, now globally and within expedited [near] real-time temporalities. What is more, the WHO, as the primary global health agent of the twenty-first century has extensively recognised the strategic new power formations resultant from the rise of algorithmically-guided health surveillance systems, which now incentivise state conduct towards greater openness and transparency in the government of global health. Speaking in regard to the rise and value of non-governmental epidemic intelligence and digital surveillance systems, Dr Guénaél Rodier (in Davies, 2012a:98), then Director of IHR Coordination stated:

‘There are no police or fines here. There are however, strong incentives for countries to comply. *In today’s information society, you cannot ignore or hide a problem very long. You can perhaps ignore or hide an event for a day or two, but after a week it’s virtually impossible. WHO and its partners [now] have a powerful system of gathering intelligence that will pick up anything immediately.* The fear of being named and shamed by the media and other countries concerned by the situation is in itself, an incentive.’

Correspondingly, the syndromic surveillance systems within this thesis indicate the emergence of new forms of infectious disease surveillance which strengthen contemporary systems of global health security. Aided extensively by algorithms, functioning across digital data-scapes, and continually searching for the emergence of exceptional or uncertain health events occurring *globally*, these systems produce new, distinct, omnipresent, and continual surveillance procedures and regimes of visibility surveying not only viruses and microbes, but also *states* in seeking to create a more economic, rapid, and effective practice of health security and identification of pathogenic threats, which recalls the power and performativity of the gaze of the Panopticon, originally developed and presented by Foucault (1995:200-209). Distinct from previous systems of traditional health surveillance, which functioned and were generally limited by national/sovereign jurisdictions, the proliferation of syndromic surveillance systems, and the growth of the global Panoptic gaze afforded by these technologies via algorithms suggest new implications for the conduct of states in expanding governmental systems of health security. Reflecting upon this, as highlighted by Weir and Mykhalovskiy (2010:104), although sovereign states ‘did not disappear at the turn of the 21st century, they are now reactive to the presence of a transnationalized system of outbreak communication [and surveillance] that they themselves have politically and legally authorized.

Advancements in technology and in digital innovations exist therefore at the core of these novel transformations in the scope and practice of contemporary health surveillance systems and the rise of an algorithmic governmentality for governing pandemic threats. This thesis therefore has served as a site in which to discuss and engage critically with knowledge and techniques produced by emergent data driven security devices and digital technologies, and has additionally provided a nuanced account

of the new implications produced by these rise of these systems upon the conduct of states and other global health agents within the practice of international relations and health security.

Conclusion

Conclusively then, the aim of this research thesis has sought to develop a novel account of the ascendancy of new syndromic surveillance systems for the strengthening of global health security practices, and the regulation of future-situated pandemic uncertainties, and how the increased centrality of these novel, and increasingly algorithmically-guided health sentinels transform the contemporary practice of global health. Through presenting and assessing the rise of three such novel syndromic surveillance systems, ProMED-mail, GPHIN, and HealthMap, this thesis has developed key theoretical and empirical contributions to the ongoing scholarship of global health within international relations, resultant from the steady integration of these surveillance technologies as calculative and forecasting technologies in continued efforts to render secure, uncertain [pathogenic] futures.

Critically, the observed emergence and steady evolution of digital algorithms seen here for the production of security knowledge within these novel health technologies, highlights an important shift in the practice of global health security and the production of knowledge for the contingent, indicative of the emergence of a distinct mode of *algorithmic* government operating and embedded within contemporary surveillance systems of global health security. In turn, the forecasting capacities of these algorithmically-guided surveillance technologies have been increasingly integrated into an expanding government of global health in the twenty-first century which seeks both to securitize populations from pandemic threats, and to preserve networks of global economic circulation, while continually surveying digital datascares for the emergence of the exceptional or the aberrant. In continually retrieving and scanning data from the realm of the digital to inform actionable knowledge of pandemic threat in real-world environments, the algorithmically-informed syndromic surveillance systems presented within this thesis produce and extend new global topographies of surveillance and observation for the regulation of pathogenic contingencies on a global level.

In light of the rise of new syndromic surveillance systems for the identification of pandemic threats, this thesis has argued that the steady integration of digital algorithms within the evolution of syndromic surveillance systems from 1994 onward has facilitated the ascendancy of new algorithmically-informed practices of infectious disease surveillance, which has drawn upon the

frameworks of *algorithmic governmentality*, developed by Rouvroy. This thesis has asserted further, that the rise of algorithmically-led syndromic surveillance systems as new apparatuses for the governing of global health diverge from the traditional parameters of the understanding governmentality and the function of as developed by Foucault in several critical aspects.

Moreover, in highlighting new security terrains of global health in which the algorithm has emerged, via syndromic surveillance systems as new strategic purveyors of actionable knowledge of future or forthcoming events, this thesis has provided a subtle, yet nuanced account of how the rise of these new surveillance processes have been seen to re-contour elements of state conduct in the transparency of outbreak reporting and identification of potential public health emergencies. The ascendancy therefore of these novel surveillance processes, increasingly afforded and curated via algorithms, as it has shown, simultaneously then have strengthened contemporary efforts by global health agents to understand and anticipate horizons of epidemics and pandemics, and have, albeit in moderation, re-situated and negotiated the previous and traditional role of the state as the executive generator, curator, and conveyer of epidemic intelligence indicative of forthcoming pandemic phenomena, within expanding governmentalities of global health security.

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