Emerging economies, emerging challenges: Mobilising and capturing value from big data

Amankwah-Amoah, Joseph

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ABSTRACT

As technology advances and voluminous new data are generated on a daily basis, the ability to harness and utilise big data not only enhances firms' competitiveness but also equips governments for the twenty-first century. This study examines how governments can utilise big data to combat health challenges. The study focuses specifically on the Ebola outbreak in West Africa to illustrate how various technologies and techniques were utilised jointly to combat and contain the outbreak. An integrated technology roadmappping approach was developed which encompasses digital surveillance systems and traditional monitoring techniques to articulate how governments can capture value from big data to combat such contagious diseases. Policy and practical implications are identified and discussed.

Keywords: Big data; technology roadmapping; technology; governments; Ebola

1 Introduction

In recent years, the advancement of information technology coupled with globalisation of the world's economy has ushered in the dawn of the field of big data (Goes, 2014; McAfee & Brynjolfsson, 2012; Woerner & Wixom, 2015). The emergence of large and often unstructured data has become an increasingly common feature of the global economy. As such, harnessing and utilising insights from big data cannot only enhance firms' competitiveness but also lead to effective government policies (Amankwah-Amoah, 2015; Wamba & Akter, 2015; Bhimani, 2015). The dawn of big data has been accompanied by increasing consensus that government can play a pivotal role in utilising big data to not only protect the public but also formulate effective public policy (Davidian & Louis, 2012).

Although past studies have indicated that the time when public policymakers and top executives "could profess ignorance about the power of data has long passed" (EIU, 2012, p. 19), the precise mechanisms for governments and policymakers to harness and utilise big data to combat social issues remain unclear. Surprisingly, much of the academic literature on big data has focused mainly on techniques and methods without articulating how it can be utilised to combat health issues.

Accordingly, the objective in this paper is to explore how government can utilise big data to combat healthcare issues. The study focuses specifically on combating contagious diseases and reviews the technologies utilised. The paper utilises the recent Ebola outbreak in West Africa as a lens through which to demonstrate how big data aided the drive to report, contain, control and halt the spread of the virus. The focus is mainly on the Ebola outbreak in West Africa, but not exclusively.

The study makes at least two key contributions to big data and technology roadmappping literature. First, although scholars recognised that big data should play a pivotal role in combating diseases (Hay et al., 2013), the roadmap for doing so has thus far been inchoate. In this direction, the study fills this gap in the literature by integrating the streams of research on technology roadmapping (Phaal, Farrukh & Probert, 2004) and big data (George, Haas & Pentland, 2014; McAfee & Brynjolfsson, 2012) to demonstrate how technology roadmapping can equip governments and public policymakers in responding to such adverse shocks. The paper employed the case of the Ebola outbreak to offer a step forwards in demonstrating how big data can be harnessed to solve social issues.

Second, in spite of the recognition among scholars that technology roadmap is a powerful tool of strategic planning (Phaal et al., 2004; Geum et al., 2015), there remains a limited insight into how it can be utilised to help emerging economies combat emerging challenges. The study juxtaposes the two streams of research on big data and technology roadmappping to develop a framework with potential to further illuminate our understanding of the subjects. The study also provides unique insights on how governments can mobilise and capture value from big data.

The rest of the article is structured as follows. In the next section, a review of the existing literature on technology roadmapping and big data is presented. Then the method of data collection is explained. The penultimate section presents an overview of a range of tools/techniques utilised towards predicting and containing the Ebola outbreak. The final section discusses the implications of the findings for public policy.

2 Technology roadmapping and big data: A review

A roadmap can be seen as a "layout of paths or routes that exists (or could exist) in some particular geographical space" or a "traveler's tool that provides essential understanding, proximity, direction, and some degree of certainty in travel planning" (Kostoff & Schaller, 2001, p. 132). Roadmaps encompass the identification of tools and techniques required to address issues/problems as well as enhancing preparedness of organisation and agencies for future eventualities (Galvin, 2004; Lee, Song & Park, 2015). Technology roadmaps can be viewed as a tool for strategic planning which entails linking resources and expertise to future courses of action (Kostoff & Schaller, 2001; Phaal et al., 2004; Galvin, 2004). A technology roadmap can be defined as an "extended look at the future of a chosen field of inquiry drawn from the collective knowledge and imagination of the groups and individuals driving change in that field" (Galvin, 2004, p. 101). The term technology roadmapping refers to the process inherent in the evolution of roadmaps which helps fine-tune decisions and concentrate resources on key areas (Kostoff & Schaller, 2001). It can be seen as a unique framework for mapping processes and approaches towards achieving particular short- and long-term objectives. Over the years, the scope of technological roadmapping has been expanded to include the role of the state in formulating public policy (Vishnevskiy, Karasev & Meissner, 2015; Walsh, 2004).

One important stream of research has uncovered that technology roadmapping can help firms' better respond to adverse environmental shocks by providing routes for scanning the business environment as well as tracking the performance of employees (Phaal et al., 2004). Indeed, it is widely recognised that technology roadmaps and the roadmapping processes can enhance "a firm's, regions, or industry's competitive advantage by providing a process that senses the competitive landscape, identifying opportunities, risks, threats, and competitor ability" (Walsh, 2004, p. 162; Geum, Lee, Lee & Park, 2015). This also helps in the public policy arena by helping governments to channel their limited resources more effectively and by pinpointing areas with pressing needs (Kerr, Phaal & Probert, 2013).

Another line of research has demonstrated that roadmapping can help to garner support and forge consensus around the technology requirements and future needs, and in so doing produces synergistic benefits (Kostoff & Schaller, 2001; Garcia & Bray, 1997). Consequently, roadmapping can equip decision makers with the tools and approaches to make better investment decisions (Kostoff & Schaller, 2001). Some scholars have indicated that technology roadmapping can enhance a country's or organisation's preparedness in meeting future challenges (Garcia & Bray, 1997). However, inability to map out a clear path to the future can affect a country's ability to develop and disseminate valuable knowledge as well as prepare for future challenges (see McDowall, 2012). Indeed, such failure can lead to declining performance of governments and firms.

2.1 Technology and evolution of big data

Since the turn of the century, the term big data has gained wider currency not only within academic circles but also among practitioners (Lohr, 2012b; Hay et al., 2013). The concept big data has emerged from the corridors of technology firms to take centre stage within the mainstream management discourse (George et al., 2014). Big data can be defined as the "ultralarge bodies of data that have not been prospectively limited in size or scope by the intent to address specific research questions or disease conditions, and that grow continuously and rapidly" (Ghani, Zheng, Wei & Friedman, 2014, p. 976).

Big data includes information from sources such as social networks, tweets, blogs and cellphones. Some of the distinctive features of big data include the volume, variety and velocity (Chen, Chiang & Storey, 2012). The notion of big data encompasses not only data collection but also analysis of data on a large scale to inform organisational decisions and public policies (McAfee & Brynjolfsson, 2012). The collections and management of large data is not new and can be traced back more than 7,000 years (EIU, 2011).

However, the speed and mechanisms through which data can reach governments and businesses have changed. The digital age has been accompanied by a surge in the amount of data available to governments and businesses (Brennan, Oelschlaeger, Cox & Tavenner, 2014). It has been suggested that the world creates around five exabytes of data every 48 hours which is equivalent to the amount of data created between the beginning of civilisation and 2003 (EIU, 2012; Wakefield, 2013). In this fastchanging world, big data is now at the cornerstone of not only public policy formulation but also business strategies and marketing tools (Amankwah-Amoah, 2015). Big data also presents an opportunity to better understand complexities inherent in today's world.

Past studies have demonstrated that the ability to collect, analyse and comprehend both structured and unstructured data can enhance firms' competitive advantage and a country's preparedness for future crises (McAfee & Brynjolfsson, 2012). A stream of research indicates that big data methods necessitate the use of advanced techniques and technologies to facilitate data capture, storage, distribution and analysis to help make informed managerial and health decisions (Ghani et al., 2014). Business analytics entails "the techniques, technologies, systems, practices, methodologies, and applications" employed to analyse big data (Chen et al., 2012, p. 1166). The techniques encompass machine learning and data mining (Ghani et al., 2014).

Big data analytics encompasses assembling of multiple data and analysing them to identify unique patterns to make decisions and inform public policy. By monitoring individual behaviour and activities, data can be utilised to assemble experts such as doctors and nurses in a timely manner. By using the power of modern computing, countries can make a leap forward in solving problems such as crime, terrorism and public health (Marcus & Davis, 2014). Juxtaposing the technology roadmapping and big data literatures, Figure 1 was developed. The figure demonstrates technology roadmapping as a mechanism for making sense of big data, identifying patterns, sources of learning and mechanisms for knowledge diffusion.

Insert Figure 1 about here

Recent studies have indicated that the integration of the global economy has been accompanied by new and old contagion risks, and this poses major challenges to governments (World Bank, 2013). The incidence of global epidemics had brought to the fore the need to harness big data to help tackle such risks. For governments, the advent of large databases means that extracting value from big data is essential for future success. Although past studies have illuminated our understanding of roadmaps, little insights have been provided on how governments can marshal technologies in meeting future challenges.

More recently, some scholars have suggested that “the next step of roadmapping applications involved using this tool to introduce new and emerging technological solutions to social goals” (Vishnevskiy et al., 2015, p. 434). Over the past few years, more governments’ resources have been deployed to not only assemble but also analyse big data as the basis for informed public policy (DBIS, 2013). Despite these important observations, scholars have made little progress in the application of the technology roadmapping approach to combating social issues. This study seeks to fill this gap in the literature.

3 Research design and data sources

3.1 The research setting: Ebola

The epicentre of the Ebola outbreak was in three countries, namely Guinea, Liberia and Sierra Leone. This setting is appropriate partly because provides a background to demonstrate how governments and agencies utilised multiple arrays of data sources to address healthcare issues and emergence. At the time of the outbreak, the health systems in the three severely countries were generally seen as under-resourced, understaffed and disjointed to contain such outbreaks or respond to emergencies (Save the Children (STC), 2015). Indeed, Guinea spent a mere $62 per person on health annually compared with $3,364 in Britain, whereas Sierra Leone had two doctors per 100,000 people compared with 245 in the United States (The Economist, 2014f).

By examining how governments and multiple agencies mobilised and utilised data from multiple sources could enhance our understanding of how modern technologies could help underdeveloped countries improve their decision making process, governance and combat healthcare emergence (Chandler et al., 2014; Milinovich, Magalhães & Hu, 2015). In a nutshell, the case-specific event demonstrates how multiple sources of big data were utilised to make key contributions to wider efforts to address healthcare emergence in emerging economies characterised by underdeveloped healthcare system.

Nonetheless, the effects extended outside the West African region. Indeed, air passengers from the three mainly affected countries were screened prior to take-off alongside those with symptoms resembling Ebola (Carter & Meisel, 2014). Most international direct flights to the three affected countries were suspended (Mabey et al., 2014). As more of the catastrophic effects of Ebola on people and the countries' economies came to light, there was a need to explore how big data could help to contain the outbreak. Prior to 2014, Ebola was largely seen as a neglected disease, but feared largely due to the high mortality rate. When the Ebola outbreak emerged, it was followed by attempts by the international community to contain the disease and prevent new infections.

Amassing and disseminating knowledge about the disease was beyond the capacity of any of the affected countries; therefore collective efforts across countries were required in helping to map resources and expertise to potentially risky areas. Such a collective approach provided a sound foundation for resources to be marshalled to help the wider international community be better prepared to manage such risks. Given that the incubation period for Ebola is 2 to 21 days and there is no effective cure, the ability to utilise technology to help contain an outbreak was seen as an effective means to mitigate the impact on wider society (BBC, 2014).

Given that health systems of many developing countries are unable to provide people with essential services and suffered from misallocation of resources (STC, 2015), harnessing big data can help to ensure that resources are deployed in a timely and efficient manner. Technological breakthroughs and the emergence of powerful software for data analytics have created conditions and approaches for large datasets to be analysed and utilised for the social good. These have helped to improve the quality of decisions towards tackling global health issues.

By early 2015, the outbreak was gradually being brought under control but the devastating effects for the industry were evident. In addition, the declining cost of data collection and storage enhanced the appeal of big data to public policymakers (Komorowski, 2014). By collecting and analysing of reported cases of new diseases and locations of victims, government could formulate an effective policy to help allocate resources and treatment. This can also serve as an early-warning system to help public policy officials in designing their responses.

3.2 Data sources

A case-based research method (Yin, 2003, 2011) was employed to shed light on the subject. The paper focuses specifically on the Ebola outbreak in West Africa and technologies utilised to help control, contain and eradicate the outbreak. As Galvin (2004) suggested, the process for assembling and choosing the content of technology roadmaps entails the examination of multiple issues and stakeholders to help develop a more robust approach. Given the Ebola outbreak and its impacts on many countries, archival approach was adopted which entails examining publicly available records of governments and international agencies (see Welch, 2000; Ellis, 1993). Such archival sources are "critical and under-utilized research resource" which can be employed to illuminate our understanding as well as advance a perspective on past events (Forbes & Kirsch, 2011, p. 589; Amankwah-Amoah & Durugbo, 2015).

Furthermore, such archival approach has been found to be effective in seeking to generate new theories, approaches and "explaining processes of change and evolution" (Welch, 2000, p. 198). To ensure wide coverage of the voluminous data on the Ebola outbreak, this study adopted three steps from data collection to data analysis, as illustrated in Table 1. This encompassed a review of the affected countries' press releases, locating actions of governments, analysis of technologies and strategies employed to combat the outbreak, and reporting key technologies used.

The archival records included data on strategies, government policies, surveillance systems and monitoring techniques from organisations such as the World Bank, World Health Organisation, International Air Transport Association, African Civil Aviation Authority, International Civil Aviation Organization and US Centers for Disease Control and Prevention. The press releases of the affected companies and governments on techniques, strategies and technologies were also examined.

Insert Table 1 about here
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4 Technology and tools for predicting and containing the outbreak

The following sections outline out a range of digital surveillance/internet-based surveillance systems and traditional monitoring techniques utilised to help combat the disease and outline a path into the future.

4.1 Digital surveillance systems

Digital surveillance systems often employ modern technologies and seek to analyse big data in the digital domain to help inform public discussions as well as public health issues (Milinovich et al., 2015). Emerging technologies can also provide promising opportunities for equipping nations to help fight contagious diseases. In this direction, technologies that allow easy access to information in a timely manner provide a good starting point. A number of contemporary technologies were utilised to identify and contain the outbreak. Social media such as blogs, Twitter, Facebook and online forums presented voluminous data on current societal perceptions and trends which were monitored in tandem with fieldwork to help formulate public policy. Such data also have potential to help institute early-warning signs of potential outbreaks. Indeed, social media can provide real-time information on people movement (Wakefield, 2013).

4.1.1 Mobile mapping

One of the techniques that have been identified to aid the containment effort of Ebola by governments, medical charities and non-governmental organisations is mobile mapping (Wall, 2014). Mobile phones are used widely across the developing world. Mobile phone networks produce call data records (CDRs) which encompass "the phone numbers of the caller and receiver, the time of the call and the tower that handled it—which gives a rough indication of the device's location" (The Economist, 2014g, p. 17). Such information can then be utilised to determine people's mobility as well as identify where to build treatment centres.

One of the advantages is that CDRs are immediate and updated in real time which can be utilised by researchers to gauge potential areas of spread (The Economist, 2014g). This was very much evident in the recent Ebola outbreak where mobile phone data was used to map out affected areas. Indeed, a sudden surge in the number of phone calls to "a helpline from one particular area would suggest an outbreak and alert authorities to direct more resources there … The level of activity at each mobile phone mast also gives a kind of heatmap of where people are and crucially, where and how far they are moving" (Wall, 2014, p. nd).

One of the consequences of this is that policymakers were able to decide the best places to set up treatment centres as well as identify areas to restrict travel to help the outbreak (Wall, 2014). Mobile phone data can be utilised to determine population movements and therefore how a virus might spread. The ability to provide instant and timely information can also help potential victims of such viruses to take precautionary measures to minimise the spread and improve their own chances of survival.

Nevertheless, to date, privacy concerns have often curtailed researchers' ability to use data stemming from CDRs in many areas (The Economist, 2014g).

Despite the wider usage of mobile phones and Africa having one of the highest growth markets, governments in the three Ebola-affected countries were among those that have largely underutilised mobile data usage to frame public policy. Mobile-phone data have long been utilised by epidemiologists in combating the spread of the contagious disease. Indeed, such technology has been utilised to map malaria outbreaks in African countries such as Kenya and Namibia, and modelled population movements during a cholera outbreak in Haiti in 2010 (The Economist, 2014g).

Furthermore, the use of mobile data faces a number of constraints. First, most mobile phone users in the affected countries tend to be the young which meant that mobile data captured only a section of the wider population in an area. Another avenue relates to governments' ability to force mobile operators to grant researchers access to such data which restricted efforts to contain the outbreak (The Economist, 2014g). By being able to identify the high-risk populations, countries would then be able to target their limited resources to such groups. This would also help in countering the potential for misinformation. In the case in question, the "Ebola alarmists" contended that the claims by scientists that the disease was difficult to catch was an attempt to downplay the risk associated (The Economist, 2014c). The misinformation played a significant role in hampering demand for air travel in unaffected countries in the regions (Chandler et al., 2014). These suggest that by gleaning insights from big data, governments would be able to design effective evacuation and quarantine measures to help contain the spread of such a virus. Such data can also help to identify local areas for public health programmes ads.

4.1.2 *Ebola-tracking app*

In the last few years, the ability to pinpoint and isolate the exact location of an outbreak has been identified to equip policymakers to isolate the spread in a timely manner (Smartdatacollective, 2014). This also helps in deploying resources to combat and contain outbreaks. One major technological breakthrough in the case of the Ebola outbreak was the emergence of an "Ebola-tracking app" to help in combating the spread (Wall, 2014). Such innovations in the private sector have proven to be particularly effective in helping governments to harness data to help solve social issues. The app helped governments in deciding where to allocate their limited resources. The timely updates also helped healthcare professionals to upgrade their advice on preventative and control measures to contain the spread. By marshalling and utilising big data, governments were able to identify and isolate areas, and thereby provide a basis for better public policy formulation.

During the outbreak, voice and text data were also utilised to gain an understanding of population movements of people in the affected areas (Smartdatacollective, 2014). Mobile phones also provided an avenue for health care information to be disseminated to the wider population. Furthermore, mobile phones can also be utilised to help transmit information about people's location and positions to form quarantine measures. Mobile phones also provided mechanisms for government to urge citizens to volunteer information to help contain the spread. Such an approach can help in advising people to remain in a particular area to help control the spread of the virus. To an extent, people felt part and parcel of disease control and information-disseminating efforts. These initiatives and efforts helped to ensure efficient utilisation of limited government resources as well as dissemination of technical advice to health workers on the ground.

4.1.3 Trend mapping and search engine firms

Over the years, big data has been playing an increasingly important role in forecasting outbreaks to help governments to be able to devise policies and measures to contain outbreaks. Search engine firms have increasingly been using technology to forecast flu outbreaks. For instance, multiple internet searches using terms such as “cold”, “fever” and “Ebola” in a local area can provide a possible indication of an outbreak. For instance, Google Flu Trends work by combining phrases and words such as “flu” and “flu symptoms” used to search data collected by search engines (Helft, 2008). The Google service employs a basket of keywords and phrases connected to flu such as flu symptoms, chest congestion, muscle aches and so on (Helft, 2008). The billions of flu- and other virus-related searches are being used to help provide up-to-date information on potential outbreaks.

By combining the words used in a geographical area, it is possible to provide an early-warning signal of a potential flu outbreak (Helft, 2008). As Crovitz (2013) points out, Google has now amassed expertise which is better than the US Centers for Disease Control at forecasting flu outbreaks. For instance, Google collects billions of search terms such as “best cough medicine” and adds location details to track outbreaks (Crovitz, 2013). The Chinese internet giant Baidu (with more than 160 million daily users) and the Chinese Centre for Disease Control and Prevention have also explore the use of big data to forecast flu outbreaks (Deng, 2014).

Recently, search engine firms such as Google and Yahoo have expanded the scope of their operations to include not only combating viruses that affected computers but also humans (Newman, 2011). One piece of technology adopted that has emerged in recent years is Google Trends which can allow individuals, forecasters and scientists to track the popularity of search words and terms (Helft, 2008). It has been suggested that keywords and phrases used to search such search engines actually represent people’s “most immediate intentions” (Helft, 2008, p. A1). Indeed, thousands of people search using terms such as “Ebola symptoms” and “Ebola vaccine” in a rural area can help provide an indication of people’s intention and real-time information. This can be used in tandem with other hospital records in the area to help inform government decisions.

The rapid expansion and usage of social media means that more and more people are providing instant messages of their feelings, thoughts and environment to the wider world. This can then be tapped into to help trace and contain diseases. This also helps to overcome local traditions where individuals may opt to harbour individuals affected by the virus, thereby providing the conditions for spreading it to close family members and then the wider community.

Although many Ebola potential victims might remain isolated at home, Google search results provide an avenue by tracking the number of times individuals within an area search for key terms or phrases. Indeed, internet search volume surged during the embryonic stage of the outbreak and most Google searches during 2014 for the term “Ebola” originated from the three affected countries, namely Guinea, Liberia and Sierra Leone (Milinovich et al., 2015). Data analytics can be fed into wider policy formulation to help countries prepare for the future eventualities (BBC, 2013). Access to data such as web pages, browsing habits and smartphone location trails has the potential to enrich our understanding of human behaviour (Lohr, 2013).

By replicating such access and strategies to gain data, governments would be able to coordinate activities with healthcare professionals to design and implement successful rapid response as well as being able to contain potential spread. This also means doctors and public health officials would be able to gain access to data and thereby design a strategy to ensure implementation. Indeed, in the past Google Flu Trends was able to “detect the spread of the flu as accurately as and more quickly than the US Centers for Disease Control and Prevention” (Marcus & Davis, 2014, p. A23).

4.1.4 HealthMap

Another major project geared towards assembling and utilising big data is the HealthMap project which is associated with the Children's Hospital Boston supported by Google.org (Helft, 2008). The project searches through data from an array of sources including blog posts, articles and newsletters, and then utilises the raw data to create a map that tracks infectious diseases (Helft, 2008, p. A1). By sifting through millions of social media posts and other online sources, HealthMap was able to predict the Ebola outbreak about nine days ahead of the World Health Organization formally declaring it as an epidemic (Smartdatacollective, 2014). HealthMap was able to detect the outbreak partly based on online news stories and local news stories broadcasting a mysterious fever in Guinea (Milinovich et al., 2015). HealthMap had the potential to provide real-time access to information and prediction to contain outbreaks.

By building a digital copy of the physical world, decisions were then made based on assembled data (Wakefield, 2013). However, such big data analytics required access to rich data such as clinic reports, media updates and social media which can then provide a basis for identifying danger spots more accurately and thereby guiding resource deployment decisions (Smartdatacollective, 2014).

Another technology utilised in combating other diseases include Earth-observing satellites. Indeed, scientists have been using space data in tandem with fieldworkers to predict the risk of diseases such as malaria and dengue fever (Amos, 2015). The use of such data to track the dynamics of diseases had been demonstrated to help governments make better and more informed decisions. This can also enable public policymakers and government to glean knowledge and insights from unstructured big data to formulate an effective public policy. Scientists have been using satellite information to predict where infections are likely to occur and thereby enabling governments to tailor their limited resources to where they are most needed (Amos, 2015).

Another explanation suggests that the rise of social media sites such as Twitter and Facebook, in tandem with globalisation and accessibility of cheap mobile phones, has been accompanied by an explosion of data such as twits, comments and opinion posts (EIU, 2012). The growth of big data is partly stimulated by the increasing use of social media and rapidly improving access to new sources of data. The explosion in availability of social media has meant that there is now more promising opportunities for government to assemble such data to better understand human behaviour and attitudes. As the influence of social media continues to grow and proliferate through global societies, increasingly more promising opportunities are being provided for big data to be harnessed to address social problems. As such, data from search engines and mobile phones helped provide faster access to information on the outbreak (Deng, 2014). This also provides an opportunity to disseminate information on quarantine measures to the wider population.

4.2 Traditional monitoring system

In addition to above, governments of the affected countries also relied on traditional methods of data collection through hospitals and government agencies. Data from hospitals, schools and government agencies were utilised to gauge the nature of disease spread as well as to help ensure efficient deployment of government resources. The ability to track outbreaks within the population can equip countries in devising effective measures to contain them. Under such circumstances, equipping doctors, workers and frontline staff with the expertise to be able to make sense of big data appeared essential. This is very important because at times the traditional monitoring system through surveillance from local hospitals often fails to identify individuals who fail to go to hospital to get professional treatment or advice. This means there is a need for an effective national strategy that aligns closely the relationship between data collection and data analysis leading to public policy formulation (Amankwah-Amoah, 2015). Doctors have often turned to large datasets to help better understand only human behaviour.

The use of CDRs was partly a shift from the traditional reliance on surveys and national census data. This means the vast reservoir of data can then be disseminated to the fieldworkers to inform tactical and strategic actions. As such, the ability to chart a clear map for combating such outbreaks in the future can equip countries. It is worth noting that the countries have historically demonstrated an ability to collect data, but quality of analysis for some is generally weak and not effectively linked to resource allocation and deployment. The above arguments led to the identification of a roadmap showing how big data can be utilised to help improve healthcare delivery and combat such outbreaks.

Based on these, an integrated roadmapping of harnessing big data to combat the contagious disease was developed, as illustrated in Figure 2. The basic structure for utilising big data includes key building of identifying the data sources, data analytics and public policy formulation.

Insert Figure 2 about here

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5 Integrating monitoring systems and extracting value from big data

Big data analysis can shed light on subtle correlations which smaller data sets might overlook (Marcus & Davis, 2014). It is apparent that neither the emerging technologies alone nor traditional methods can effectively combat the spread of contagious diseases. It is worth noting that crunching data alone is insufficient in fostering understanding of complex datasets.

Based on the technologies employed to combat the outbreak, big data can be utilised in both a proactive and reactive processes, as demonstrated in Figure 3. The reactive mode focuses on adapting and responding to the outbreak. Dissemination of information in a timely manner can equip healthcare professionals to diagnose and recommend appropriate treatment or courses of action to help contain any potential spread. Information diffused in a timely manner can help in not only taking corrective measures but also to minimise misallocation of attention and resources associated with not sensing potential problems sooner. The proactive process entails using technologies such as mobile information to help to identify geographical location areas for potential outbreaks. This means employing complementary competences and deploying resources to help quarantine efforts.

One key tenet is that the ability to make sense of and utilise the wide reservoir of data can equip countries to prepare for disasters. For such underdeveloped countries, acquiring knowledge and disseminating it in a timely manner is essential to enhance their preparedness for future outbreaks (WDR, 1998). Harnessing and utilising big data could accelerate the pace at which knowledge is created and disseminated across national borders. This helps to bridge the knowledge and information gaps that often exist between developed and developing countries. An integration of both the proactive and reactive approaches appears essential for future success.

Insert Figure 3 about here

In today's globalised economy, countries with access to a wider range of data about the spread of diseases and locations of potential victims stand a better chance of being able to spot problems and take contingence measures. However, to date relatively few countries are able to extract value from big data often due to the underdeveloped workforce and obsolete skills (Amankwah-Amoah, 2015). Furthermore, governments' ability to craft effective policy is partially rooted in the ability to synthesise and utilise big data. Figure 4 demonstrates a framework for extracting value from big data.

Insert Figure 4 about here
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6 Discussion and conclusions

The study was designed to explore how government can harness and utilise big data to combat healthcare issues. Using insights from the Ebola outbreak in West Africa, the analysis indicates that the ability to harness and utilise big data partly depends on governments' ability to bring structure and clarity to the data to generate awareness and responsiveness. The ability to synthesise insights from both the traditional monitoring systems and modern technologies offers a path towards facilitating knowledge diffusion and effective government policies. Furthermore, the integration of both the internet-based surveillance systems and traditional monitoring techniques is essential for governments seeking to extract value from big data whilst concurrently combating infectious diseases.

6.1 Contributions to practice

From a public policy standpoint, the study indicates that governments can establish national centres to coordinate and disseminate knowledge on latest technologies about such outbreaks. Such centres can inform the wider public about new preventative measures, and bring together best practices. There is also a need to utilise emerging technologies as a key mechanism through which to disseminate information about other outbreaks.

Perhaps even more importantly, there is also a need for effective coordination between healthcare professionals to help bring together related competences to utilise big data to address healthcare challenges. This suggests a need to ensure that future plans to contain any spread of an outbreak should entail cross-functional teams with expertise from government, industry and academia. In addition, the analysis also suggests the need for countries to upgrade workforce skills in key aspects of data analytics and data management to be able to extract value from big data. Building big data analytics capability can help countries develop knowledge to ensure timely delivery of services.

By narrowing information and knowledge gaps between developing and developed countries, such emerging or developing economies would be better equipped for such outbreaks (WDR, 1998). Furthermore, the analysis indicates that big data alone cannot fight all contagious diseases. As Ghani et al. (2014, p. 977) put it: “big data is not a panacea for all the unanswered questions regarding the delivery, access, and quality of health care”. This needs to work in tandem with other traditional approaches such as fieldworkers and nurses to help contain the spread of such viruses.

6.2 Limitations and directions for future research

A possible limitation of this study is that the story of the Ebola outbreak occurred in West Africa, the findings reported here might be generalised to other context. In addition, this study is largely exploratory and therefore further examination of the approaches and techniques is required. One area that has garnered less attention is how big data can be further utilised in developing countries where technological infrastructure is often at a nascent stage of development such as the three countries affected by the outbreak.

A promising line of future research would be to examine mechanisms through which government resources can be orchestrated to accrue maximum value from big data. It is hoped that this study serves as a preliminary step towards a better understanding of how big data can be utilised to enhance the capacity of nations to combat contagious diseases.

References

Amankwah-Amoah, J. (2014). A unified framework of explanations for strategic persistence in the wake of others’ failures. Journal of Strategy and Management, 7(4), 422–444.

Amankwah-Amoah, J. (2014). Old habits die hard: A tale of two failed companies and an unwanted inheritance. Journal of Business Research, 67(9), 1894–1903.

Amankwah-Amoah, J. (2015b). A unified framework for incorporating decision-making into explanations of business failure. Industrial Management and Data System, 115(7), 1341–1357.

Amankwah-Amoah, J. (2015c). Explaining declining industries in developing countries: The case of textiles and apparel in Ghana. Competition and Change, 19(1), 19–35.

Amankwah-Amoah, J. (2015d). Solar energy in sub-Saharan Africa: The challenges and opportunities of technological leapfrogging. Thunderbird International Business Review, 57(1), 15–31.

Amankwah-Amoah, J., & Debrah, Y. (2014). Air Afrique: The demise of a continental icon. Business History, 56(4), 517–546.

Amankwah-Amoah, J., & Debrah, Y. A. (2010). The protracted collapse of Ghana Airways: Lessons in organizational failure. Group and Organization Management, 35(5), 636–665.

Amankwah-Amoah, J., & Zhang, H. (2015). "Tales from the grave": What can we learn from failed international companies? Foresight, 17(5), 528–541.

Amankwah-Amoah, J., 2015a. Safety or no safety in numbers? Governments, big data and public policy formulation. *Industrial Manag. Data System*, 115(9), 1-10.

Amankwah-Amoah, J., Durugbo, C., 2015. The rise and fall of technology companies: The evolutional phase model of ST-Ericsson's dissolution. *Technol. Forecast. Soc.* http://dx.doi.org/10.1016/j.techfore.2015.04.005.

Amankwah-Amoah, J., Sarpong, D., 2015. Historical pathways to a green economy: The evolution and scaling-up of solar PV in Ghana, 1980-2010. *Technol. Forecast. Soc.* //dx.doi.org/10.1016/j.techfore.2015.02.017.

Amos, J., 2015.Satellites track snail disease risk. (Available at: http://www.bbc.co.uk/news/science-environment-31483629. Accessed: 1 May 2015).

BBC. 2013. Big data: Predicting and preventing rugby injuries. (Available at: http://www.bbc.co.uk/news/health-24836161. Accessed: 2 June 2014).

BBC. 2014. Ebola outbreak: Asky bans flights in West Africa. (Available at: http://www.bbc.co.uk/news/world-africa-28550906. Accessed: 2 Jan 2015).

Bhimani, A., 2015. Exploring big data's strategic consequences. *J. of InfoTech.* 30, 3066-3069.

Brennan, N., Oelschlaeger, A., Cox, C., Tavenner, M., 2014. Leveraging the big-data revolution: CMS is expanding capabilities to spur health system transformation. *Health Affairs*, 33(7), 1195-1202.

Chandler, C., Fairhead, J., Kelly, A., Leach, M., Martineau, F., Mokuwa, E. ... & Wilkinson, A., 2014. Ebola: limitations of correcting misinformation. *The Lancet*, 385 (9975), 1275-1277.

Chen, H., Chiang, R. H., Storey, V. C., 2012. Business intelligence and analytics: From big data to big impact. *MIS quarterly*, 36 (4), 1165-1188.

Crovitz, G. L., 2013. Why 'big data' is a big deal. (Available at: http://www.wsj.com/articles/SB10001424127887324077704578364632408717740. Accessed: 2 Jan 2015).

Davidian, M., Louis, T. A., 2012. Why statistics? *Science*, 336 (6077), 12.

DBIS (Department for Business, Innovation and Skills). 2013. *Seizing the data opportunity: A strategy for UK data capability*. London: DBIS.

Deng, C., 2014. Baidu turns to big data to forecast flu outbreaks. (Available at: http://blogs.wsj.com/digits/2014/06/10/baidu-turns-to-big-data-to-forecast-flu-outbreaks/. Accessed: 2 Jan 2015).

EIU (Economist Intelligence Unit). 2011. *Big data: Harnessing a game-changing asset*. London: EIU.

EIU (Economist Intelligence Unit). 2012. *Big data: Lessons from the leaders*. London: EIU.

Ellis, J., Ed., 1993. *Keeping archives*. Rr Bowker Llc.

Forbes, D., Kirsch, D., 2011. The study of emerging industries: Recognizing and responding to some central problems. *J. of Bus. Vent.* 26, 589–602.

Galvin, R., 2004. Roadmapping - a practitioner's update. *Technol. Forecast. Soc.* 71, 101-103.

Garcia, M. L. & Bray, O.H. 1997. *Fundamentals of Technology Roadmapping.* Albuquerque, NM: Sandia Nat. Labs (SAND97-0665).

George, G., Haas, M. R., Pentland, A., 2014. Big data and management. *Acad. Manag. J.*, 57 (2), 321-326.

Geum, Y., Lee, H., Lee, Y., Park, Y., 2015. Development of data-driven technology roadmap considering dependency: An ARM-based technology roadmapping. *Technol. Forecast. Soc.* 91, 264-279.

Ghani, K. R., Zheng, K., Wei, J. T., Friedman, C. P., 2014. Harnessing big data for health care and research: are urologists ready? *European Urology*, 66 (6), 975-977.

Goes, P. B., 2014. Big Data and IS Research. *MIS Quarterly*, 38 (3), iii-viii.

Hay, S. I., George, D. B., Moyes, C. L., Brownstein, J. S., 2013. Big data opportunities for global infectious disease surveillance. *PLoS medicine*, 10 (4), e1001413.

Helft, M., 2008. Google uses searches to track flu's spread. *New York Times*, November 12, A1

Kerr, C.I.V., Phaal, R., Probert, D.R., 2013. Roadmapping as a Responsive Mode to Government Policy: A Goal-Orientated Approach to Realising a Vision. In M. G. Moehrle, R. Isenmann and R. Phaal (Eds.). *Technology Roadmapping for Strategy and Innovation: Charting the Route to Success*. Berlin Heidelberg: Springer-Verlag.

Komorowski, M., 2014. A history of storage costs. (Available at: http://www.mkomo.com/cost-per-gigabyte. Accessed: 2 Jan 2015).

Kostoff, R. N., Schaller, R. R., 2001. Science and technology roadmaps. *Engineering Management, IEEE Transactions*, 48 (2), 132-143.

Lee, C., Song, B., Park, Y., 2015. An instrument for scenario-based technology roadmapping: How to assess the impacts of future changes on organisational plans. *Technol. Forecast. Soc.* 90, 285-301.

Lohr, S., 2012a. The age of big data. *New York Times*, February 12, SR1.

Lohr, S., 2012b. *How Big Data Became So Big.* Aug 11, *New York Times*, BU3.

Lohr, S., 2013. Big data is opening doors, but maybe too many. March 24, New York Times, BU3.

Lohr, S., 2014. In big data, shepherding comes first. Dec. 14, *New York Times*, B1.

Mabey, D., Flasche, S., Edmunds, W. J., 2014. Airport screening for Ebola. *BMJ*, 349, g6202.

Marcus, G., Davis, E., 2014. Eight (no, nine!) problems with big data. April 6, *New York Times*, A23.

McAfee, A., Brynjolfsson, E., 2012. Big data: the management revolution. *Harvard Business Review*, 90 (10), 60-68.

McDowall, W., 2012. Technology roadmaps for transition management: The case of hydrogen energy. *Technol. Forecast. Soc.* 79 (3), 530-542.

Milinovich, G. J., Magalhães, R. J. S., Hu, W., 2015. Role of big data in the early detection of Ebola and other emerging infectious diseases, *The Lancet Global Health*, 3(1), e20- e21.

Newman, A. A., 2011. Using Google's data to reach consumers. *New York Times*, December 23, B3.

Phaal, R., Farrukh, C.J.P., Probert, D. R., 2004. Technology roadmapping - A planning framework for evolution and revolution. *Technol. Forecast. Soc.* 71, 5-26.

Save the Children. 2015. *A wake-up call: Lessons from Ebola for the world's health systems*. London: Save the Children.

Smartdatacollective (2014. What the Ebola crisis has taught us about big data. (Available at: http://smartdatacollective.com/gilallouche/286011/what-ebola-crisis-has-taught-us-about-big-data. Accessed: 2 Jan 2015).

The Economist. 2014a. Unintended consequences. 412 (8903), 50

The Economist. 2014b. Ebola and travel: Flying fear. (Available at: http://www.economist.com/blogs/gulliver/2014/10/ebola-and-travel-0. Accessed: 2 Jan 2015).

The Economist. 2014c. The Ebola alarmists. 413 (8908), 36.

The Economist. 2014d. Ebola's global reach. (Available at: http://www.economist.com/blogs/graphicdetail/2014/10/daily-chart-5. Accessed: 2 Jan 2015).

The Economist. 2014e. Panicking only makes it worse. 412 (8900), 50.

The Economist. 2014f. Fever rising. 412 (8900), 48–50.

The Economist. 2014g. Call for help. 413 (8910), 17.

The Economist. 2015. The toll of a tragedy. (Available at: http://www.economist.com/blogs/graphicdetail/2015/02/ebola-graphics. Accessed: 2 Jan 2015).

The White House. 2014. Big Data and Privacy Working Group Review. Press releases. Washington: Office of the Press Secretary.

Vishnevskiy, K., Karasev, O., Meissner, D., 2015. Integrated roadmaps and corporate Foresight as tools of innovation management: The case of Russian companies. *Technol. Forecast. Soc.* 90, 433-443.

Wakefield, J., 2013.Tomorrow's cities: How big data is changing the world. (Available at: http://www.bbc.co.uk/news/technology-23253949. Accessed: 2 Jan 2015).

Wall, M., 2014. Ebola: Can big data analytics help contain its spread? (Available at: http://www.bbc.co.uk/news/business-29617831. Accessed: 2 Jan 2015).

Walsh, S.T., 2004. Roadmapping a disruptive technology: a case study: the emerging microsystems and top-down nanosystems industry. *Technol. Forecast. Soc.* 71, 161–185.

Wamba, S. F., Akter, S., Edwards, A., Chopin, G., Gnanzou, D., 2015. How 'big data' can make big impact: Findings from a systematic review and a longitudinal case study. *Int J. of Pro. Eco.* (doi:10.1016/j.ijpe.2014.12.031).

WDR (World Development Report) (1998). *Knowledge for Development.* Washington, D.C.: World Bank

Welch, C., 2000. The archaeology of business networks: the use of archival records in case study research. *J. Strateg. Markt*. 8 (2), 197–208.

Woerner, S. L., Wixom, B. H. 2015. Big data: extending the business strategy toolbox. *J. of InfoTech.* 30, 60-62.

World Bank. 2011. *World Bank 2011: Conflict, Security, and Development*. Washington, DC: World Bank.

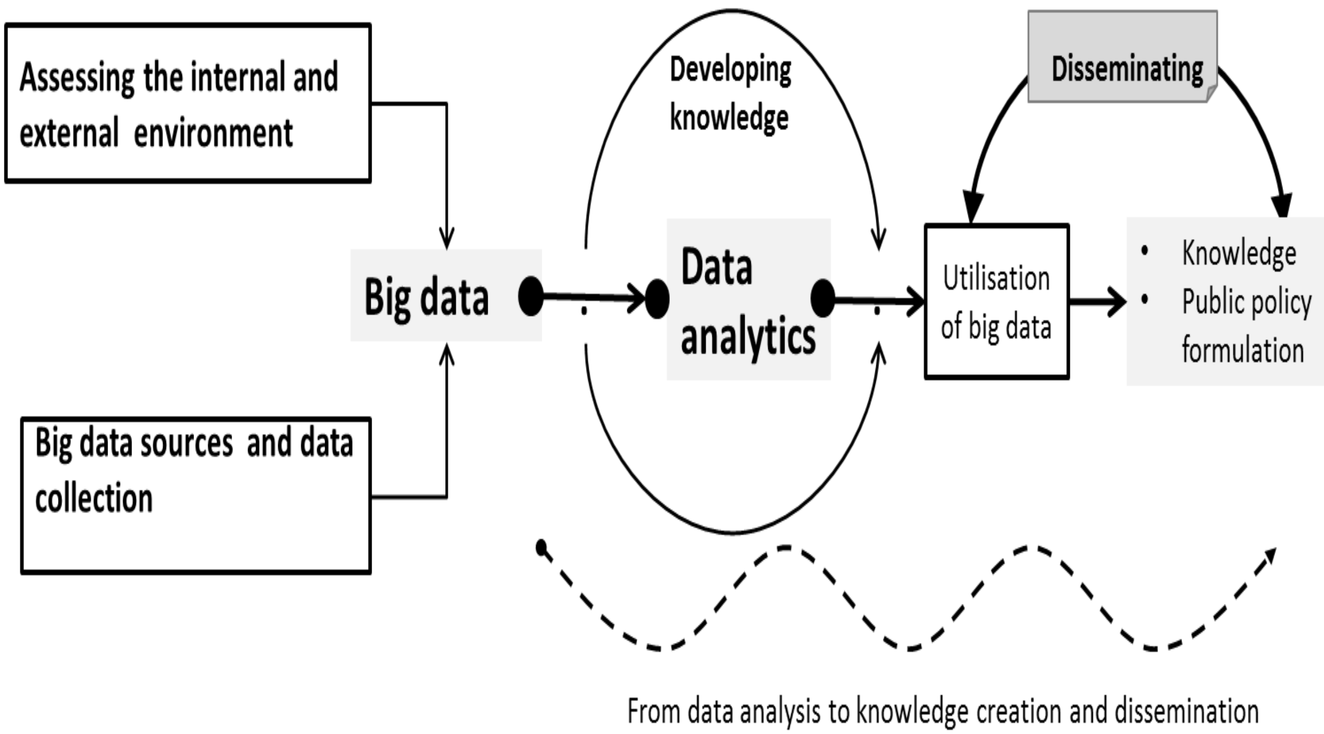
World Bank. 2013. *Risk and Opportunity: Managing Risk for Developmen*t. Washington DC: International Bank for Reconstruction and Development/World Bank.

World Bank. 2014. Ebola: New World Bank Group study forecasts billions in economic loss if epidemic lasts longer, spreads in West Africa. (Available at: http://www.worldbank.org/en/news/press-release/2014/10/08/ebola-new-world-bank-group-study-forecasts-billions-in-economic-loss-if-epidemic-lasts-longer-spreads-in-west-africa. Accessed: 2 Jan 2015).

Yin, R. K., 2003. *Case study research: Design and methods*. Third edition, Thousand Oaks, CA: Sage Publications.

Yin, R. K., 2011. *Qualitative Research from Start to Finish*. New York: The Guilford Press.

Figure 1: Big data to knowledge dissemination



Data sources: synthesised from: Ghani et al., 2014; Goes, 2014; McAfee and Brynjolfsson, 2012; Woerner and Wixom, 2015; EIU, 2011, 2012.

Figure 3: The processes of extracting value from big data

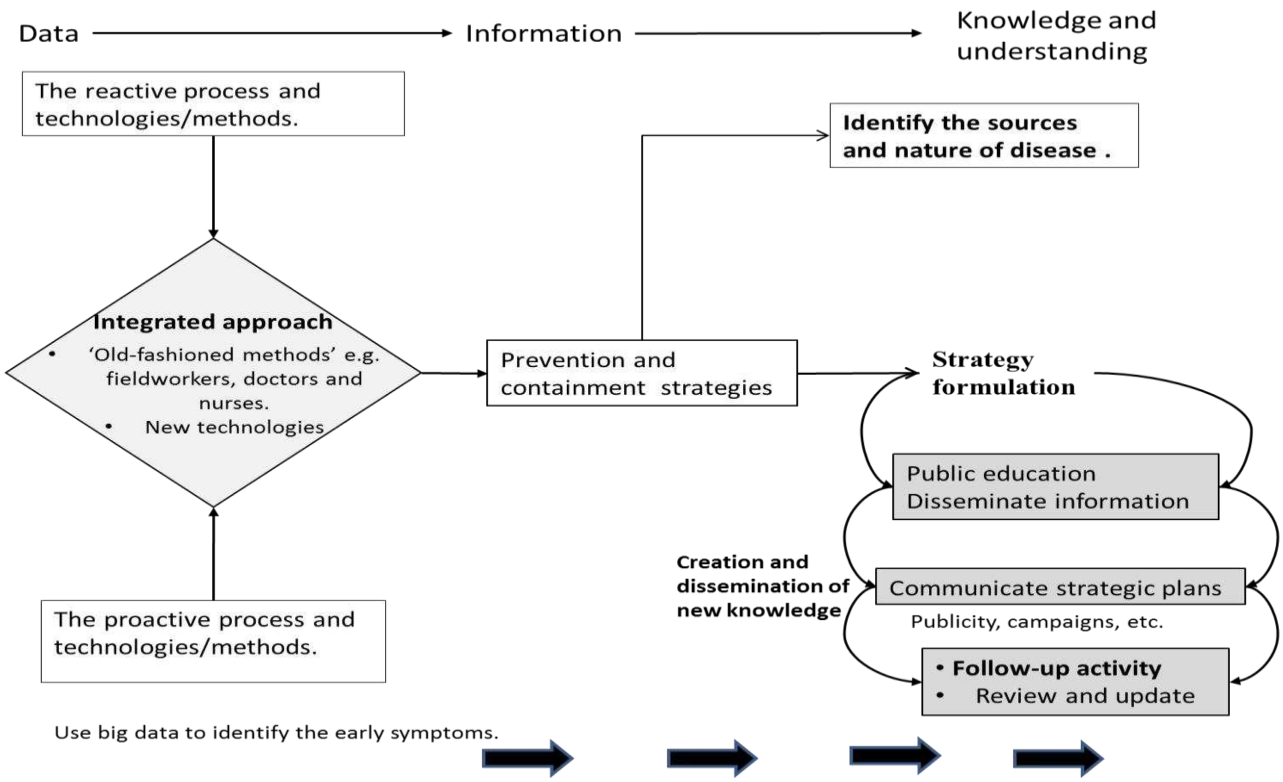


Figure 4: A framework for extracting value from big data

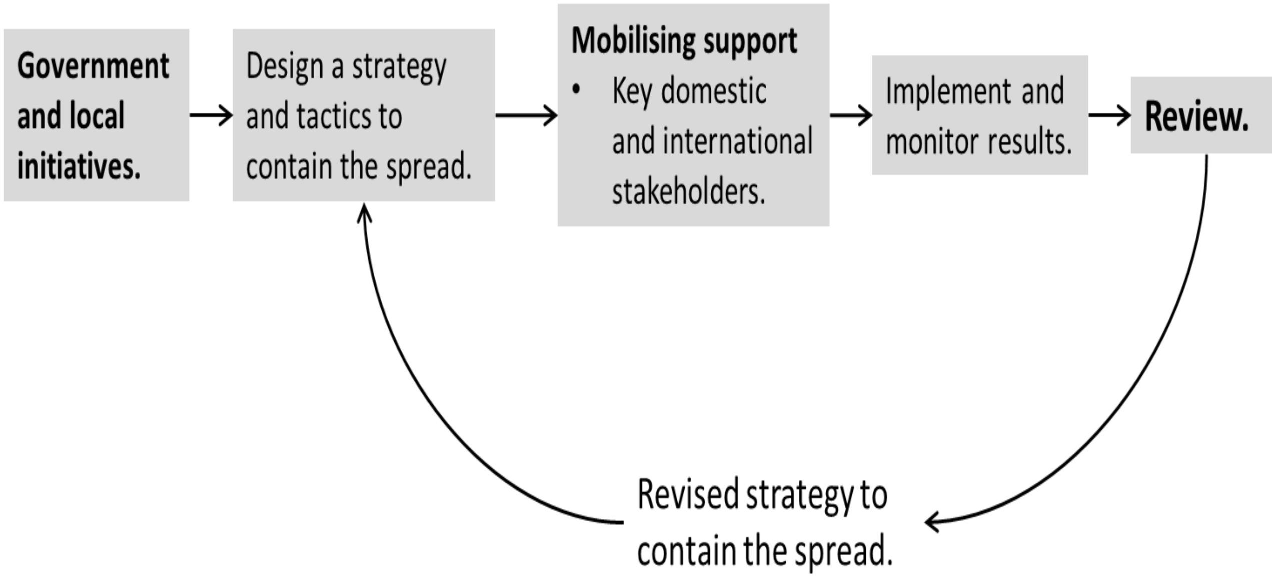


Table 1: The approaches to data collection and analysis

Steps	Descriptions
Inclusion criteria	Ebola-related technologies used. Technologies utilised to contain spread and prevent the spread of the outbreak.
Stage 1: Searching	Exploration and review of Ebola-related press releases by governments and international organisations. Examination of containment measures and technologies adopted by governments. Locating other actions by governments in the affected countries.
Stage 2: Screening	Screening and analysis of the data assembled in stage 1. Screening and analysis of technologies and strategies employed to combat the outbreak.
Stage 3: Synthesis and findings	Data analysis: making sense of data. Utilisation of data from multiple sources to inform the analysis. Employment of diagrams and figures to convey relationships between factors and issues.

Steps column: synthesised by from: Amankwah-Amoah & Durugbo, 2015; Ellis, 1993; Welch, 2000; Yin, 2003, 2011.

Figure 2: Roadmapping for moving from data collection to knowledge creation and dissemination