# Big Data in Public Health Context of Social Marketing: A Case Study Regarding the Ebola Outbreak

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***Abstract***

*Big data has the potential to see and determine significant value in health care by providing data from many different sources. Big data can held identifying spread of epidemic, improve public health decision making and develop new action-making strategies. In this case study researchers provide explanations on the role of big data to determine the spread and detection of Ebola outbreak. For disasters such as the current Ebola crisis, this means accessing health clinic reports, media updates, social media posts, and information from public workers on the ground, transactional data from retailers and pharmacies, and travel ticket purchases alongside helpline data. Big data analysis is all about combining information from many different sources and analyzing them collectively to identify the patterns. The results of this study reveal that big data represents many opportunities to determine the extent of the Ebola epidemic. The study has significant implications about to how health organizations and practitioners benefit from big data applications.*

***Keywords:*** *Big data, outbreak, epidemic, Ebola, data mining, big data in epidemic.*

## Introduction

The Ebola outbreak has transformed into the worst health crisis of the 21st century. According to Health Map by 24 December 2014, there have been 19465 reported cases of Ebola virus disease, with 7580 reported deaths (http://healthmap.org/ebola/#timeline). Until now, all previous Ebola outbreaks were small and localized within rural communities, but the 2014 epidemic has bucked this trend, spreading as it has across densely populated urban environments, from Guinea into Liberia, Sierra Leone, Nigeria, U.S. (http://omnifeed.com), and Spain. The Centers for Disease Control and Prevention (CDC) now estimates that 1.4 million people could be infected by January if swift action isn't taken to scale up the response. Because the fatality rate around 50 percent -varied from 25% to 90% in past outbreaks- (WHO, 2014), World Health Organization, private firms, public organizations and non-profit organizations track the spread of the Ebola cases by different data sources.

The era of big data is underway (Boyd and Crawford, 2012). There is no doubt that organizations are swimming in an expanding sea of data (Davenport, Barth and Bean, 2012). Todays, many scholar in different academic discipline, in information technology, in corporate boardrooms and in governmental level are talking about big data. It is impossible to know whether earlier detection may have helped contain the spread of Ebola, but many scientists say this type of "big data" approach can be useful in curbing epidemics. In 2014 spring, big data played an important role in the initial detection of the Ebola outbreak. There are some significant and insightful studies currently being done that involve big data (Boyd and Crawford, 2012), but it is still necessary to know about epidemics over world or

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region. In this paper researchers provide an explanation on the role of big data to determine the spread and detection of Ebola outbreak, as a case study.

## Big Data, Health and Outbreak

"Big data refers to large, diverse, complex, longitudinal, and/or distributed data sets generated from instruments, sensors, internet transaction, e-mail, video, click streams, and/or all other digital sources available today and in the future" (Floridi, 2012, p.435). According to Rubinstein (2013) big data refers to "novel ways in which organizations, including government and businesses, combine diverse digital datasets and then use statistics and other data mining techniques to extract from them both hidden information and surprising correlations" (p. 74). Additionally, Dumbill (2013) offered broader and conceptual definition as "big data is data that exceeds the processing capacity of conventional database systems. The data is too big, moves to fast, or doesn't fit the strictures of your database architectures. To gain value from this data, you must choose an alternative way to process it" (p. 1-2).

There are many rich sources related to big data. Gobble (2013) indicates that data are obtained from social media interactions, digital images, transaction records of banking and retailing, sensors, GPS signals, and countless other sources. McKinsey published a global report about diffusion and amount of big data over the world. According this report in 2011, people create nearly 12 terabytes each day in tweets alone. Ninety percent of the data in the world was created in the last two years and there will be 44 times more of it by the year 2020 (Manyika et al., 2011).

Again, as mentioned above, big data are large information sources consisting of smart phones, web sites, signs of cellular, sensors, camera videos, etc. Additionally, new types of remote sensors are generating new streams of digital data from telescopes, video cameras, traffic monitors, magnetic resonance imaging machines, and biological and chemical sensors monitoring the environment. Moreover, again, millions of people generating roaring streams of personal data from their smart phones, laptops, web sites, transaction in social media (Facebook and Twitter) and other digital devices (Bollier, 2010). Big data solutions can reliably store real-time data from sensors, RFID tags, GPS locators, and web logs, thereby enabling near real-time Access to millions of individuals simultaneously (Palem, 2014).

Big data also encompasses everything from shopping transaction data to genomic and proteomic data from biological research and medicine (Davenport, Barth and Bean, 2012).For instance, Wal-Mart has learned a hurricane strikes an area not only from flashlights increase but also Pop-Tarts sales (Hayashi, 2014). Today, the use of big data include a wide range of cases such as health care (through home based continuous monitoring and through integration across providers), urban planning (through fusion of high-fidelity geographical data), intelligent transportation (through analysis and visualization of live and detailed road network data), environmental modeling (through sensor networks ubiquitously collecting data), energy saving (through unveiling patterns of use) smart materials (through the new materials genome initiative), education (particularly with online courses), homeland security (through analysis of social networks and financial transactions of possible terrorists), and so on (Jagadish et al., 2014).

Big data is high-volume, high velocity and high-variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision

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making (Schaeffer and Olson, 2014). Volume refers to the sheer amount of data being created. Variety refers both to the types of data being gathered and to the lack of uniform structure in the data (Hoy, 2014). Velocity aspect of big data requires high speed connectivity and broad bandwidth. In addition, big data is inherently high variety (Schaeffer and Olson, 2014).

Use of big data applications in the health field has become widespread in recent years. Big data could be useful in improving health in two significant ways-population health and personalized health care. In terms of public health, big data is a useful tool of monitor the spread of certain diseases such as the flu(Bollier, 2010) and Ebola. For instance Google Flue helps identifying the diffusion of contagious diseases. Alike, Health Map try to amass geographic portraits of disease incidence (Bollier, 2010). Also, Hoy (2014) assumes that in the near future patients may receive a diagnosis or have their treatment based on findings from big data analysis systems. Moreover, big data has the potential to create significant value in health care by improving outcomes while lowering costs (Roski, Bo-Linn and Andrews 2014).

Big data can held identifying spread of epidemic, improve public health decision making and develop new action-making strategies. The developments of data-driven health diagnosing have changed in recent years. This data-driven diagnosing gives patient and their physicians powerful tools for using the personalized health care strategy. It can use this data-driven approach to make decision about using exactly the right dose of medication. Big data technologies allow governments or organizations to target their strategies on people around of epidemic.

For public health and safety, WHO uses different types of data, like smart phones, Twitter, blogs, Facebook, records oflocal authority etc.As indicated by Carter (2014), to maximize reach WHO and US Centers for Disease Control and Prevention (CDC) provide information to Nigeria's health ministry, local healthcare organizations, popular bloggers, and others with large numbers of Facebook and Twitter connections. The data obtained from various sources may give clues about how people's behavior changes during outbreaks of disease. Several organizations are analyzing current mobile phone data. In Senegal, anonymized data from 150 000 handsets were sent to the Swedish non-profit Flow minder to map population movements in the region (Carter, 2014).

Researchers at the John Hopkins School of Medicine, for example, found that they could use data from goole flu trends to predict surges in flu-related emergency room visits a week before warnings came from CDC. Similarly, Tweter updates was used to comfirm reports at tracking the spread of cholera in Haiti after the january 2010 earthquake (McAfee and Brynjolfsson, 2012). Similarly, Ji, Chun and Geller (2012) monitored five popular epidemics (tuberculosis, listeria, influenza, swine flu, and measles) by tracking users' tweets. As reported by Carter (2014), Marisa Eisenberg, a mathematical epidemiologist at the University of Michigan said that "The CDC (US Centers for Disease Control and Prevention) and WHO use a range of different kinds of data to produce a variety of models, from models built on case reports to others built on mobile data, social media data, and even airline data".

Traditional or smart phones are vital in battle against Ebola. Mobile phones could be invaluable-not just in themselves, as devices that can be used to send people public-health information or let them call helplines, but also because of the data they generate. Moreover, the telephone data were able to identify the places that had the highest

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probability of spreading the disease-useful information for Kenya's hard-pressed health service (The Economist, 2014).

As big data becomes more common tool in decision making, a number of new social perils and ethical consideration arise (Bollier, 2010). Another aspect to be considered is the personal privacy of big data. The most obvious is the risk of privacy violations (Bollier, 2010). Big data also presents new chalenges to how we try to protect the individual's privacy (Bottles, Begoli and Worley, 2014). For instance, Target recentl revealed a teen's pregnancy to her family by mailing her coupons featuring baby cloting and supplies. This happened because Target's computer system can predict, with startling accuracy, when a woman is pregnant. Retail systems are not the only big data privacy concern. Practically, big data can be used by malicious applications groups. Health care, social networking, and government systems also contain large amounts of sensitive information (Hoy, 2014).

Despite the many advantages of big data, big challenges or problems faced by the data as well. Such as, the tool known as Google flu has limitations such as overestimating the impact of flu in 2013 and not helping with tracking new disease like H1N1 and SARS (Bottles, Begoli and Worley, 2014). Big data is a two-pronged wand. For this reason, the issue of big data should be carefully handled and applied.

## Method

The purpose of this study is to analyze Ebola outbreak based on big data perspectives as a case study. Case study method was applied because this type of approach is useful to investigate contemporary phenomena within a real life context, especially when the boundaries between the phenomenon and the context are not clearly evident (Silvestre and Dalcol, 2010; Yin, 2003). Case study as a research is more suited to how and why questions which can be explanatory in nature (Kose, Tokay Argan and Argan, 2011). Case research allows the researcher the opportunity to tease out and disentangle a complex set of factors and relationships, albeit in one or a small number of instances (Easton, 2010). Yin (1989, p. 23) defines a case study as ‘‘an empirical inquiry that investigates a contemporary phenomenon within its real-life context when the boundaries between phenomenon and context are not clearly evident and in which multiple sources of evidence are used’’ (Halinen and Törnroos, 2005). Silvestre and Dalcol state that a case method can sharpen existing theory by identifying gaps and fill them in, and also provide theoretical contributions when employed as illustrations. According to Cutler (2004) research based cases are used to investigate activities or complex processes that are not easily separated from the social context within which they occur. To select a case to this study, researchers have chosen to use judgmental sample which is a non-probably sampling method that allows us to select the case that seems most suitable to answer our research questions (Kose, Tokay Argan and Argan, 2011). Based on this method, Ebola outbreak was chosen as a case.

Case research can employ many data collection methods, either quantitative or qualitative, depending on the variables being studied (Cutler, 2004). Voss, Tsikriktsis and Frohlich (2002) point out that employing multiple data sources elicits increased reliability of data and stronger substantiation of constructs and propositions (Barrat, Choi and Li, 2011). Data in the study was collected from primary as well as secondary data sources. The main data collection techniques employed weresecondary internet data, journal and newspaper articles, fields reports,interviews with people in the outbreak regions, and health map. According to Dubé and Paré (2003) using multi investigators is another form of

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triangulation. Barratt, Choi and Li (2011) suggested that the use of multiple investigators leads to a better ability to handle the richness of the contextual data and more confidence in research findings (Kose, Tokay Argan and Argan, 2011). This case study was applied by three investigators. This approach can be evaluated as sign of reliability (Kose, Tokay Argan and Argan, 2011) and validity.

## Results and Discussion

Official numbers are frightening for Ebola viruses. Ebola outbreak caused 224 deaths and there were 425 reported human cases until March 2014 (https://datafloq.com/read/big-data-cure-ebola-outbreak/18). After March 2014, Ebola virus spreadvery fast and more than 13.000 people have been infected and nearly 5.000 of them died in 2014. It was easy to say that these numbers would go up if we took underreporting issues into consideration.More than that, because of underreporting issues, officials made warnings about many more have been infected and died from the viral hemorrhagic feverin the villages of Sierra Leone, Liberia, and Guinea. Especially among some countries, misinformation has caused dangerous misconceptions(Scroxton, 2014).

Reviews claim that big data analytics help to fight with Ebola outbreak. Diseaseswere already subject to big data. Big data has been used before in order to determine and prevent spreading in flu outbreak. Generally maps for diseases are provided using literature such as reports of the institutions. These reports are mostly about determining the reported cases. However, to predict the possible spread and its direction happened to be more important. The main question is if could big data analytics help to prevent the spread. A growing number of data scientists believe it can (Wall, 2014).

The data they used weregenerally gathered from the cell phone networks which is relatively developed in West Africa (Woodie, 2014). Big data analysis was mainly based on Mobil technology which is the most powerful communication platform in Africa. SMS and voice messages were used as a powerful tool while most of the people own mobile phones. Regular SMS and voice messages do not require smart phones particularly so created technology in order to collect data was sufficient for big data analysis. In addition, the effort to make the information anonymous, like Orange Telecom provided, both increased the amount and the reliability of collected data. The company distributed anonymized voice and text data from 150,000 mobile phones to Flowminder, a Swedish non-profit organization, which was then able to draw up detailed maps of typical population movements in Africa (Wall, 2014).After all, by this way valuable information was collected as Uyi Stewart, chief scientist at IBM's Africa research lab, said "based on the data we started to see a lot of people calling in about corpses on the streets and in their homes. It was the number one concern" (Scroxton, 2014).Supportingly, Nuria Oliver, scientific director at mobile phone company Telefonica stated as "we have never had this large-scale, anonymized mobile phone data before as a species".

Some of the institutions or companies provided needed equipment for the data. Such as Microsoft and Facebook have given technology and money donations in order to help detection and fighting Ebola. Microsoft announced its cloud computing program Azure available to researchers to fight (Lever, 2014). IBM, saying "we saw the need to quickly develop a system to enable communities directly affected by Ebola to provide valuable insight about how to fight it," donated software and services to the government officials in several countries in order to provide better ability to collect, analyze, and disseminate

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information. IBM system was particularly important because almost half of the population in Sierra Leon is illiterate while the system they provided was able to collect information as voice messages. IBM system was supported by a mobile phone operator Artiel that has given a phone number people could send messages and report and the data was stripped out and anonymized by Kenyan start-up Echo mobile service provider. IBM has also donated a license to Connections to some organizations in Nigeria. Even though Nigeria declared that the country was Ebola free, they declared that they still plan to use IBM social networking software to support gathering information from the people. It is important as Nigerian Minister of Communication Technology Omobola Johnson stated that technology and social media were key to their country being declared Ebola-free. He also said “A combination of the use of an Android app, Facebook and Twitter were instrumental in Nigeria's fight to contain the Ebola virus. With Ebola, time was very important. The phone app helped in reducing reporting times of infections by 75 percent. Test results were scanned to tablets and uploaded to emergency databases and field teams got text message alerts on their phones informing them of the results.

Big Blue worked with Open Government Initiative in order to create a system so people could report Ebola using SMS or voice call. Information gathered through SMS and voice calls were used to create heat maps by IBM so it might have been possible to determine where Ebola started.Esri, geographic information systems company, have also provided technology to collect call details from cell phone towers, and then plotting data from Ebola-related calls with its GIS software.Esri’s chief medical officer said “When you have a dense urban setting where the health system is struggling to cope with an outbreak like this, such geography tools become crucial to help guide the limited health care resources.” Esri helped CDC to visualize this data and overlay other existing sources of data from censuses to build up a richer Picture (Wall, 2014). Experts saw the importance of the methods for collecting data in various ways as they indicated as "We have health clinic and physician reports, media reports, comment on social media, information from public health workers on the ground, transactional data from retailers and pharmacies, travel ticket purchases, helpline data, as well as geo-spatial tracking."Marisa Eisenberg, a mathematical epidemiologist, who has used data models to study other outbreaks, like the cholera epidemic in Haiti, said“big data has a big potential for fighting Ebola and Twitter messages, airline data, emergency calls and other available health data might be used as an important tool.Important issue do be dealt is to find a way to analyze the data in a large scale” (Lever, 2014).

Woodie (2004) says that “big data played a role in the initial detection of the Ebola outbreak this spring”. By this way, government and social sites were tracked and by this way, EBOLA has been identified before it has been officially revealed. Similarly, Lever (2014) states that, in Guinea, scientists found out spreading fever nine days earlier than official declaration. It can be said that even though the findings were not validated at the same level authorities’ findings, catching up the spread wasan important issue. Researchers claimed that even though it was impossible to know if early detection may have stopped spread, but it was still important to control it. Technology and using big data mainly helped to early detection. However, marketers may use it better to fight with diseases like Ebola. By this way, marketers might prepare targeted advertising, music and videos to explain people about the disease and how to inform the authorities.These efforts are important because there are small outbreaks everywhere but it is a lifesaving activity to determine when it will be serious. Using big data and making sufficient forecasting about where the spread starts and what could be done to prevent the spread. Probably, it will be more than that and the

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cure will be found through the help of big data as “Tim Gamble”, principal consultant at Datamonitor Healthcare, tells us that big data analytics will also prove essential to understanding the genetics of the virus, why some strains are more deadly, and why some people seem to be more resistant to it than others”.Additionally, he states that "Anti-retroviral treatment for HIV didn't really take off until many people started to die from AIDS. I worked on Pfizer's HIV product and we found that some populations in Scandinavia had more resistance to the disease than others. "We were then able to develop a drug that mimicked the way those people resisted the disease, He also believes that same thing could be applied to Ebola (Wall, 2014).

## Conclusion

Big data represents many opportunities to determine the extent of the Ebola epidemic. Many organizations such as the WHO develops and uses a range of databases that contain a range of detailed health information on epidemics over the world. As a result, analysis on epidemics by big data-driven approach occupy an increasingly important role in public health.As Jagadish et al. (2014) points out, ultimately decision makers has to interpret the results of big data analysis in order to reach ideal target. Big data must be utilized the various data coming from different geographic areas and sources not just for prevent Ebola but also follow the spread of the Ebola outbreak and take measures.

Significantly, many area of health industry are now moving to a big data driven decision making. The main goal of using big data in health sectors has the potential to improve the quality of people’s lives. However, there are a number of challenges that must be addressed to allow researchers or practitioners to exploit the potential of big data.

Significantly, since data from different sources make epidemics more predictable and get out to deal with. It is important to note that coordination could happen among organizations, like security, health ministries, emergency response centers, hospitals, transportation administration, drug supply departments, and so on.  In other words, the success of big data in the determination of the epidemic and monitoring may require combination of different types of data to make decisions. In order to provide the most reliable decision, many practices and policies related to data use, access, sharing, privacy and stewardship need to be revised (Roski, Bo-Linn and Andrews 2014).

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