Big Data Analytics and Public Health Strategies in Coping Covid-19 Outbreak

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Abstract: The use of big data analytics plays an important role in determining the public health strategies taken by a country in relation to the Covid-19 pandemic which is currently ongoing worldwide. The objective of this article is to present both conceptual analysis and analysis of the conditions of the Covid-19 pandemic that occurs worldwide to design a framework which shows the relationship between the use of big data analytics and public health strategies to cope with the Covid-19 pandemic. In fact, the public health strategy taken by a country is inseparable from both the public policies strictly taken by its government and the local culture. This way, this paper also discusses the variables of government policies and culture as moderating variables. This article uses the conceptual analysis method and literature review to develop a conceptual model which is followed by proposing three related propositions. In addition, this paper also presents several research opportunities as well as the possible research objects, the possible additional variables, and data analysis. This article has implications to assist and provide direction for future research to further examine other interesting topics related to the use of big data analytics in coping with the Covid-19 outbreak. Besides, it also has implications for stakeholders in making decisions and policies to use important variable, i.e. big data analytics, by considering government regulations and local culture in dealing with the Covid-19 outbreak.

Keywords: Covid-19, Big Data Analytic, Public Health Strategies, Government Policy, Culture.

1. Introduction

The Corona Virus Disease (Covid-19) outbreak started at the end of 2019. Covid-19 is a new virus that attacks humans, especially disrupting the respiratory system. This virus can be transmitted easily, thus spreading very quickly; from the beginning, it has been predicted to result in a global pandemic. Data until June 8, 2020 showed that the corona virus has infected 215 countries; 7,093,121 people in the world have been infected, 406,220 of them died while the remaining 3,462,284 people have recovered (source: https://www.worldometers.info/coronavirus/#countries).

Wong, *et al*. in [1] argued that the Covid-19 outbreak requires several measures and actions. That is because the public has been very concerned about the condition after the Covid-19 pandemic started. In fact, at the beginning of the infection, the new disease causes no specific symptoms but if not properly treated it may lead to serious conditions. Health workers are now working under huge pressure. Therefore, it is crucial to develop vaccine to cope with the Covid-19. The spread of the Covid-19 and its impacts in each country certainly vary, highly depending on various aspects related to the country concerned. These aspects include the forms of government, political systems, mastery of information technology, economic power, readiness of public health institutions, and cultural values [2-4]. The policies taken by a country are determined by considereng these aspects. China, especially Wuhan, implemented lockdown strictly and this policy was effective because this country is a communist-socialist state which has a unitary political system where the government has full and effective control capacity to its public and the lives of its citizens. It contrasts with the case in the United States and Europe, such as Spain, Italy, Germany, the United Kingdom, and other countries which generally implement liberal democratic system, allowing their citizens to have individual freedom.

Unfortunately, in these liberal countries, the lockdown policy cannot be run strictly, making it ineffective.

The mastery of information technology is one of the important aspects in the mitigation and preparedness, response, and recovery of the Covid-19 outbreak [5]. This is evident from what China and South Korea have done, i.e. using technology to cope with the Covid-19 outbreak which turns out to be successful in limiting the transmission of this virus [6]. Experts in China have also conducted an evaluation related to the possibility of implementing medical technologies such as Covid-19 Intelligent Assistant Diagnosis and Treatment Assistant Program based on Internet of Things (IOT) to diagnose Covid-19 and to help with the treatment [7-9].

In the era of big data, the use of big data analytics could assist governments in coping with the Covid-19 issue. Data can be collected from several sources, including from governmental institutions, private institutions, and the public. Wang, *et al*. in [10] mentioned that in Taiwan, to create big data for analysis, the database from the national health insurance has been utilized and integrated with the database from immigration and customs. A study by Zhou *et al*. in [11] showed that Geographic Information System (GIS) with big data can provide geospatial information to deal with the Covid-19 quickly. In addition, big data can also show its strengths in analyzing virus transmission and provide support for the decision making of the Covid-19 prevention. In relation to the health service sector in dealing with the Covid-19 outbreak, big data and analytics integration plays a pivotal role in successfully preventing the Covid-19 outbreak at hospitals in Taiwan [12].

In fact, some developed countries such as the United States, the United Kingdom, Singapore, Australia, the OECD member countries and the EU have also emphasized the potential of big data and they use big data as a tool to solve their problems [13]. Based on ICT-based policies, big data is utilized to formulate strategies in health and social service sectors. To cope with the Covid-19 pandemic, it is crucial to consider various aspects which are related to the formulation of various public health strategies, including the mitigation and preparedness, response, and recovery strategies. Governments together with their health departments should wisely and timely adopt various public policies, to be applied during the Covid-19 pandemic in their own countries. This is in line with the opinion of [14] and [15], stating that governments should formulate public policies to deal with the Covid-19 pandemic. In formulating public policies which aim to limit the spread of the Covid-19, Messner in [15] believed that public policy makers should consider the institutional and cultural contexts in each country. Shaw, *et al*. in [16] also mentioned that, even though the Covid-19 pandemic is a global phenomenon, the response is local so the key to successful policies to overcome the pandemic depends on local governance, socio-economic contexts, and culture. Any decisions or policies adopted should be culturally appropriate and sensitive to the population [10]. For example, culture can play a role in terms of exposure, early screening, and treatment of the Covid-19 [17]. In addition, the results of observations and analysis by [18] concluded that the combination of strong governance, strict regulation, and public participation is a key to the success of China in controlling the spread of the Covid-19 outbreak.

There have been many articles or studies related to the Covid-19 issue which has become a global pandemic nowadays. To deal with Covid-19-related uncertainties, model-based predictions can help policymakers to make wise and timely decisions [19]. Trend analysis, predictive modeling, curve analysis and approach analysis using Artificial Intelligence (AI) can also help, as discussed by [20] and [21]. In fact, a variety of mitigation strategies for the Covid-19 pandemic and various factors that affect these strategies, such as government policies and culture, are very crucial and needed, so there have been many researchers who discussed them, including [22], [19], [23], [17], [24], [25], [26], [27], [28], [15], [29], and [16]. In addition, there have also been many studies about the utilization of information technology and big data analytics which play a pivotal role in dealing with the Covid-19, including [20], [12], [30], [31], [10], and [11].

The fact that the Covid-19 has a high rate of transmission and has infected many countries and that the vaccines for this virus have not been discovered, many countries should carefully design some strategies for the mitigation and preparedness, response, and recovery of this outbreak, to reduce the transmission and the number of mortality due to the Covid-19. In addition, many countries face unavoidable economic recession which can worsen or trigger a global economic crisis, so it is crucial to make various priorities and fast actions in overcoming the economic impact of the corona virus [23]. In fact, studies or scientific discussions related to various factors which affect the strategies to cope with the Covid-19 are still needed.

In the current digital era, the use of information technology to overcome the Covid-19 is very beneficial. The extent to which information technology is used by a country to deal with the Covid-19 pandemic is

enhanced by strict government regulations and the culture of the country. As shown by Ditsa, *et al*. in [32], cultural factors are crucial for the success of the adoption and use of information technology and, on the other hand, information technology has the power to influence and change the culture of a country. When the use of big data analytics is strengthened by strict government regulations and local culture, it is likely that it will have more impacts on the prevention of the Covid-19 by adopting various public health policies. Emmanouil & Nikolaos in [33] also argued that it is still necesary to conduct research on the application of big data that could improve the effectiveness of the government sector. In addition, there are still many challenges in the data mining of crisis and disaster management.
Therefore, an analysis of the conceptual framework which is related to various factors that affect the formulation of public health strategies to cope with the Covid-19 pandemic is still relevant to be proposed.
The rest of this paper is organized as follow. First, discussing and reviewing the theories about big data, public health strategies, government policy, and culture, followed by the relevance of these theories to deal with the Covid-19 outbreak. Second, formulating propositions based on the results of the analysis of the Covid-19 pandemic conditions and reviewing previous literature studies to be used to design a conceptual model. Third, analyzing the conceptual model which uses several variables i.e. big data, public health strategies, government policy, and culture to draw conclusions and point out opportunities for future research.

2. Theretical Background

2.1. Big Data

Nowadays, data are valuable because when analyzed in such a way, data can be useful information to help make various decisions. All activities performed by humans could produce data. In fact, big data can source come from various things and fields in the form of either structured or unstructured data, either private or public data, stored by an individual himself or made available publicly. Big data is a term frequently used as several big-sized data. O'Reilly in [34] revealed that big data is data that exceeds the processing capacity of conventional database systems, moves too fast, and requires certain processing alternatives to get the value of the big data. Gandomi & Haider in [35] define big data according to the Gartner IT Glossary as is a high-volume, high-speed, and high-variation information asset which requires a cost-effective and innovative information processing to allow for enhanced insight and decision making. The definition of big data is characterized by five V's, yet it is always developing. The following is a summary of the definitions of big data according to [34], [35], [35], [37], and [38] who define big data as data which characterizes Volume, Velocity, Variety, Veracity, and Value. Volume refers to the size of the data. Velocity refers to the speed at which data is created and the speed at which data should be analyzed and digested. Variety refers to structural heterogeneity in a dataset of unstructured, semi-structured and structured data. Veracity refers to the reliability, source, and accuracy of the data. Value refers to the uncover of hidden values from large datasets. The five V's can be explained in Figure 1 as follows:

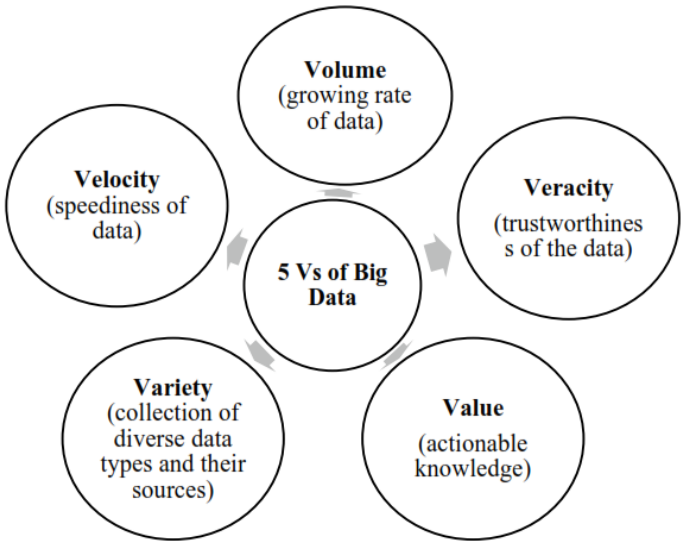

Figure 1. The Vs of Big Data [38]

According to Maciejewski in [14], big data method can be used in three approaches. First, historical approach, i.e. data shows a relationship at a certain time in the past. Public institutions can gain knowledge and make decisions based on information from the past. Second, real-time approach, i.e. data shows the present condition (with minutes or several hours delay). Public institutions can gain knowledge and make decisions based on the present information. Third, predictive approach, i.e. data can show what will occur in the future. Public institutions can make decisions based on future projections.

As explained in [39], big data analytics can assist organizations to utilize data and identify opportunities. Using big data analytics allows for cost saving as well as quicker and better decision making, and allows for seeking opportunities for example when the business sector can provide what customers need. In addition, big data analytics can also be utilized by governments or health sector, including patient records, health programs, insurance information and other health information. By using big data analytics, healthcare providers can make diagnosis and treatment options more quickly. In other words, the benefits of big data analytics are in terms of its speed and efficiency. Big data analytics is done by examining big data to uncover hidden patterns, correlations among data and other information, and by doing so, we will get an answer immediately [39]. In fact, there are various ways to analyze data. Gandomi & Haider in [35] mentioned that there are various analytics that can be done, including text analytics, audio analytics, social media analytics, and predictive analytics. Meanwhile, some of the big data analytic methods that can be done are Classification, Clustering, Prediction, and Association Rule [40]. In public sector or government, Maciejewski in [14] stated that the administrative function of big data application can be used for public monitoring, public setting, and public service provision.

O'Reilly in [34] and Minelli, *et al.* in [35] reviewed the use of big data in health sector. In fact, the healthcare industry has also had a lot of data across generations such as clinical studies, insurance data, hospital records and others. Besides, the healthcare industry has also started to be flooded with data including biological data, clinical data, and data contained in electronic health records (EHR), drugs data and health claims data. Therefore, big data can bring data-driven revolution in the healthcare industry more objectively as shown in Figure 2 below:

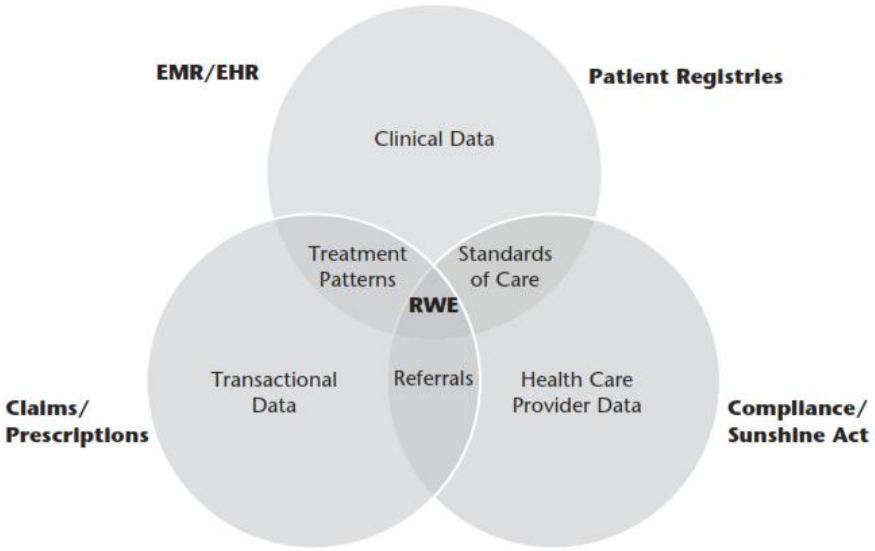

Figure 2. Data in the World of Health Care [35]

2.2. Public Health Strategies

Strategy is basically a tool or a variety of approaches which are related to the application and achievement of planned goals. In fact, dealing with the Covid-19 outbreak requires various public health strategies which are used to achieve the goal of overcoming the pandemic. This way, it is crucial to carefully prepare a variety of strategies and disaster management.

According to Pathranarakul & Moe in [42] there are three main activities in disaster management. The first is the mitigation and preparedness activities. Mitigation is structural and non-structural measures

which are performed to minimize the adverse effects of natural hazards, environmental degradation, technological hazards, and other disasters. Preparedness is comprised of activities and measures taken in advance to ensure an effective response to the impact of hazards, the issuance of timely and effective early warnings, and the temporary evacuation of people from threatened locations. The second is response activities, namely the activities of providing assistance or interventions during or immediately after a disaster occurs to fulfill the basic life needs of the people affected. The third is recovery activity which includes decisions and actions taken after a disaster has occurred of which the goal is to restore or improve pre-disaster living conditions of the affected people, while encouraging and facilitating everything needed to reduce disaster risks.

A number of public health strategies are formulated and applied in various countries that are adjusted to the economic power, IT mastery, data availability, the capabilities of health workers and local culture of these countries. The following are some examples of the application of public health strategies in terms of mitigation and preparedness, response, and recovery which are carried out in Indonesia during the present pandemic. Febriyandi in [42] showed the measures currently taken by the Indonesian government to cope with the Covid-19 pandemic, including: procuring and distributing free facial masks, procuring and distributing personal protective equipment, buying test kits for corona virus, buying millions of drugs for Covid-19 patients, disseminating information to the public to maintain physical distancing, disseminating information to the public to not travel outside the city, making a policy of school from home and scrapping national exams, making a policy of work from home, making a campaign of hand washing with soap, performing rapid tests for Covid-19 in various regions, spraying disinfectant in public places, establishing the criteria and special treatment (for people under surveillance, patients under treatment, patients with clinical symptoms of corona infected and patients with confirmed Covid-19), performing health examination to people who travel from outside the city, and adopting economic policies to maintain people's purchasing power.

2.3. Government Policy and Culture

Various measures to deal with the Covid-19 pandemic will run smoothly if strengthened by official policies adopted by the government at the right time. Policy, in sociological and political context, is usually related to government decisions because it is the government which has the legitimacy or authority to regulate the public and responsible for providing public services. With the legitimacy that it has, government has the right to adopt various sets of concepts and principles which serve as the guidelines for the implementation of certain works, leadership, and behavior in managing the lives of the public or its citizens. In fact, there are several definitions of what is meant by government policy, one of which is given by [43] who defined policy as an effort to achieve certain goals with certain targets and certain measures. Government policy is a decision which is systematically made by the government of which the intent and purpose are for public interests.

Any government policies which have been stipulated can be used as guidelines or technical instruction for field workers to achieve certain goals. The government of each country designs various policies for their own countries to achieve the goal to overcome the Covid-19. In policy making, the government should consider various things including the culture of the people. Culture can be defined as beliefs, philosophies, values, attitudes, habits, norms, rituals, general practices, and traditions which regulate the way of life of a group of people [32]. In the dictionary, according to [32] local culture is also defined as the total way of life established by a group of people, which is passed from one generation to the next generations. Meanwhile, culture according to Koentjaraningrat [44] is defined as a whole system of ideas, actions and human works in the context of community life which belongs to human by learning. Due to the complexity of culture and its wide scope, culture consists of seven elements, including language, knowledge system, social system, or social organization, living instrument and technological systems, livelihood systems, religious systems, and arts. If carried out continuously, the policy on the application of information technology will affect its users and, in the long run, can shape the culture of the use of IT. On the other hand, according to [32], culture is an essential element of the identity of IT products which affects the adoption and use.

Febriyandi in [42] mentioned that the pandemic should be coped with by considering socio-cultural aspects because the pandemic that attacks the community is related to socio-culture. The following are several examples of the measures taken by the Indonesian government to overcome the Covid-19 which consider the socio-cultural aspects. First, appealing for the formation of a task force at the RT (neighborhood) level. Second, making a campaign of overcoming Covid-19 by cooperation. Third, the government in this case the Directorate General of Culture creates a socialization video which

disseminates information on the prevention of Covid-19 by using traditional contents such as traditional songs, traditional performing art, etc. Fourth, the fact that the central government does not adopt the lockdown policy because it considers social aspects.

3. A Conceptual Framework on Big Data and Public Health Strategies

3.1. Proposition Development

3.1.1. Big Data and Public Health Strategies

The first major crisis in 2020, i.e. the Covid-19 outbreak, provides a great opportunity for digital technology [31]. There are more countries that prepare to use digital technology such as using data and algorithms in fighting against the ongoing Covid-19 pandemic [30]. Even, to identify people affected by the virus, to check their mobility, to reduce the risk of contamination, and to develop strategies and measures, various countries have used several innovative technologies [16].

Plasek, *et al*. in [45] stated that in responding to a pandemic, data has changed the game. In fact, big data can be combined with Artificial Intelligence, 5G technology and other new technologies [45]. Global data, such as data related to diseases and economic impacts, are important in facilitating local responses in dealing with pandemic. Covid-19 data is useful for public health personnel to make decisions in relation to the formulation of public health strategies (comprising of mitigation and preparedness, response, and recovery) that should be applied in an area.

Emmanouil & Nikolaos in [33] explained that there are many interesting approaches in relation to the use of big data in crisis management. First, big data for crisis prevention. Big data analytics will produce information which is helpful for anticipating a crisis or at least reducing any possible disaster risks. Second, big data for crisis preparedness. The use of big data analytics can assist in crisis management preparation to recognize hazzards and to provide a good strategic approach by each crisis manager. Third, in real-time, big data can identify the areas which require the most urgent attention. For example, big data analytics can provide appropriate guidance for people to avoid dangerous situations by using GIS and GPS. Fourth, big data for crisis recovery. Infrastructure will provide a large data source during recovery processes. In fact, information generated by big data analytics is very helpful for recovery procedure.

Several countries have started to integrate various types of data across departments in coping with the Covid-19 outbreak as mentioned in a study by [12], showing that the Taiwan government has integrated and analyzed some big data especially those from the National Health Insurance Administration, National Immigration Agency, and the Center for Taiwan Disease Control to provide real-time and accurate immigration and contact information.

There have been several studies on the impacts or benefits of big data analytics in dealing with the Covid-19 outbreak in various countries. Table 1 presents a summary of various opinions from previous articles or studies related to the utilization of big data analytics as Covid-19 countermeasures.

Table 1. Summary of Big Data Related to the Covid-19 Pandemic

Result	Author
In the prevention of the Covid-19 outbreak in Taiwan, the integration of big data and its analytics plays a pivotal role.	[12]
a. Big data analytics can support pre-pandemic. b. Big data analytics can support early prevention. c. Big data analytics can support the mitigation of infectious diseases.	[20]
a. Large-scale data collection could help control the spread of the Covid-19 pandemic. b. Big data is very important in dealing with the Covid-19 pandemic in the digital era.	[30]
To protect people from disasters, the utilization of reliable data analytics can be very helpful.	[46]
Many countries implement big data analytics to solve the problems related to social and health services, (for examples the US, UK, Singapore)	[13]
Nowadays various digital technologies including the Internet of Things (IOT), big data analytics, Artificial Intelligence (AI) and blockchain technology can be used to enrich and improve the public health strategies that have been set.	[31]
GIS with big data provides geospatial information to combat the Covid-19.	[11]

There are various public health strategies that can be formulated and implemented by the government or the department of health. Table 2 presents a summary of various opinions from previous articles or studies related to public health strategies and several examples of the activities which can be applied or performed in several countries, of which the main goal is to overcome the Covid-19 outbreak.

Table 2. Summary of Public Health Strategies Related to the Covid-19 Pandemic

Public Health Strategies	Public Health Strategy Activities	Author
Mitigation & Preparedness Strategies	a. Government can make model-based predictions to help in timely decision and policy making. b. Contact tracing is very important in the early stages to control the spread. c. Quarantine. d. The collection of ongoing data and epidemiological analysis. e. Prohibiting mass gatherings. f. Closing down education institutions or offices in which the infection has been confirmed. g. Self or regional isolation. h. Disseminating information to the public using various communication strategies on how to avoid the infection.	[19]
	a. Implementing closure and maintaining social distancing. b. Systematic updates via SMS and messaging applications to help people avoid particular areas or to conduct self isolation if alleged confirmed with corona. c. Using digital applications to control and track people's movements.	[6]
	Religious organizations around the world change the way they perform their religious practices to take part in the prevention of the virus.	[17]
	a. Public policy to stay at home. b. Social distancing. c. Enhancing testings *et al*l health clinics in all countries to reduce infection.	[47]
	As a part of this social distancing policy, the Chinese Government: a. Recommending people stay at home. b. Prohibiting mass gatherings. c. Canceling or postponing large public events. d. Shutting down schools, universities, government offices, libraries, museums, and factories. e. Extending the Chinese New Year holiday in China.	[25]
	Mitigation strategies: a. Cancellation of events and postponement of large events. b. Adoption of social distancing to reduce direct contacts among people. c. Travel restrictions, reduced flights and public transport, as well as route restrictions. d. Self quarantine voluntarily. e. Changes in funeral services to reduce attendance and exposure to the body fluids of deceased patients. f. Clear communication from both national and international health authorities to ensure that information does not contain false news or rumors that create panic.	[22]
	a. China enforcing “round the clock closed management” system. b. Italy declaring the “red zone” alert. c. France announcing “nationwide ban on gatherings”. d. USA implementing “containment areas” e. Enhancing transparency between government bodies and public in order to create awareness among its citizens of the risk of contagion.	[27]
	a. Protection from droplets (including the use of mask surgery, disposable clothes, hand gloves and protective safety glasses). b. All single rooms are available for patients c. Negative room pressure is available. d. Patients without symptoms or mild symptoms are advised to stay at home.	[29]

	e. Remote consultation is provided via video or conference call. f. SARS-CoV-2 tests are available for inpatients and outpatients. g. Healthcare workers monitor their own necessity for testings. h. Healthcare workers affected by confirmed Covid-19 are not allowed to work. i. Mobile hospital facilities. j. Protocols for medical staffs to follow emergency management guidelines.	
Response Strategic	a. Using antiviral drugs b. Developing vaccine c. Flattening epidemic curves to minimize morbidity and mortality	[19]
	a. A social tracking system th*et al*lows authorized bodies to update citizens with new cases. b. Mass testings and data are managed for treatment, quarantine, and tracking. c. Development of treatment and vaccine protocols.	[6]
	a. Authorized bodies need to track contacts and the movements of people. b. Healthcare service providers should identify high-risk cases. c. Researchers need to examine the efficacy of treatment, prognostic patterns and outbreak's epidemiological trajectory. d. Italy's experience shows that accurate and timely information is needed. e. Population-based monitoring: every citizen has a personal ID (based on tax number) which is linked to general physicians, local and regional health authorities. f. All services use the citizens' ID to connect the health records stored in a database of the local health authorized bodies to optimize healthcare. g. Decentralization when government bodies agree to share complete data and accept public monitoring and evaluation by independent authorities.	[24]
	a. Building public health infrastructure that can be launched during emergency crisis. b. Improving healthcare facilities and infrastructure. c. Learning how to be more prepared to deal with emergency crisis in the future. d. Building the center for quarantine, preparing more beds to accommodate patients, facilitating infection control. e. Procuring more health supplies. f. Schools and universities in the entire world have changed classroom meetings to online learning. g. In the US and Canada, all universities shut down classrooms and use virtual media.	[27]
Recovery Strategic	The government should take various recovery measures to recover the unavoidable economic recession due to the impact of the Covid-19 pandemic.	[19]
	1. Big data is used to identify groups of people infected with the virus. 2. Data of people mobility is used to identify the movement of people from one place to another place, which could help in decision making to lock down high-risk areas; during recovery process when shops or factories are allowed to reopen, this could be used to identify areas with risk potential.	[16]

There have also been many studies on Public Health Strategies. Various activities in the mitigation & preparedness strategies in dealing with the Covid-19 by [19], [6], [17], [47], [25], [22], [27], and [29]. The activities in the response strategies have been discussed comprehensively by [19], [6], [24], and [27]. Meanwhile, the activities in the recovery strategies in coping with the Covid-19 have been brought up by [19], and [16]. These strategies are formulated and implemented by considering various factors, one of which is the use of big data analytics. In fact, big data analytics has been used in several countries to deal with outbreaks, [13] and many studies have shown the benefits of using big data to deal with the

Covid-19 for examples [12], [20], [30], [31], [11]. Based on the conceptual analysis and some previous studies, the following proposition is proposed:

Proposition 1: The use of big data analytics affects public health strategies.

3.1.2. Big Data, Government Policy, and Public Health Strategies

The government administration system is running every day. This then results in the piling up of data, requiring more human resources to manage it. However, by using information technology that is currently developing, big data can be managed more efficiently. The big data that is created serves as an asset which can be used as a consideration in making policies more quickly, more accurately and more affordably. By using appropriate data analysis techniques, big data can be transformed into information which is helpful for the government in making policies based on facts that are found in the public. The awareness of the use of big data analytics in the business or government sector is currently growing rapidly. The government can collect data across departments and ministries. With good documentation of data, it is possible for all departments or bodies to participate in storing, preparing, exploring, and analyzing to create integrated solutions in dealing with problems, for example the Covid-19 pandemic which is still ongoing. Another effect of using big data analytics in the government sector is the presence of data transparency which is released to the public. In Wang, *et al*. [10], the government can convince the public by providing timely, accurate, and transparent information about the ongoing epidemic. Any available data can be used to predict the presence of a disease and the health level of its population globally. Big data should be fully utilized to monitor pandemics and make risk predictions, public opinion guidelines, and crisis management [20].

Lin, *et al*. in [48] uncovered that the global crisis related to Covid-19 has pushed governments worldwide to take extraordinary measures to cope with the pandemic. A team of trained and experienced officials could quickly recognize the crisis and activate emergency management structures to deal with the ongoing outbreak. In a crisis, government often makes difficult decisions under uncertainty and time constraints. Armocida in [49] mentioned that in dealing with the Covid-19 pandemic, a solid partnership between the private and public sectors shall be institutionalized. If amendment of the existing laws, regulations and policies is deemed necessary, then it should be done immediately. Huang, *et al*., in [20] gave examples such as the Law on the Prevention and Treatment of Infectious Diseases, National Plan for Quick Response to Public Health Emergency, and National Plan for Quick Response to Infection Disease. A study by [16] analyzed the responses of the East Asia countries, including China, Japan and South Korea which concluded that different countries have different governance.

The use of big data analytics in designing public health strategies will be more effective if accompanied with policies adopted by government. The government policies needed to enhance the formulation of public health strategies are in the forms of regulations for the implementation of the strategies in the field and regulations related to funding. It is mandatory for all related parties to adhere to any policies that have been legally issued by the government through a long process and analysis involving many departments. The public can also transparently see whether various public strategies adopted have been supported by government policies. Based on several studies and conditions in several countries, it can be concluded that the variable government policy may play a pivotal role to strengthen the use of big data analytics to successfully achieve public health strategies to deal with the Covid-19 outbreak. Therefore, the following proposition is proposed:

Proposition 2: Government policy can be a moderating variable for the effect of big data analytics on public health strategies.

3.1.3. Big Data, Culture, and Public Health Strategies

Anderson, *et al*., in [19] stated that individual behavior plays an important role in controlling the transmission of Covid-19. Individual culture will shape a shared culture of a community. The culture which exists among a community is likely to influence people's adherence to all the public policies or strategies adopted by the government. Introducing information technology in a country or region should consider the socio-cultural impacts [32]. In relation to the issuance of the policy to use big data analytics in formulating public health strategies to deal with the Covid-19, local culture will have influence on it, either supporting or not supporting these programs. This way, in formulating various public strategies to deal with the Covid-19 outbreak, it is necessary to incorporate the local culture to

minimize obstacles, allowing them to be well implemented. Wang, *et al*. [10] mentioned an example where the Taiwan government built a public health response mechanism th*et al*lows quick actions and these decisions are made in accordance with the local culture.
Hua & Shaw [18] argued that humanitarian issues should be prioritized without neglecting the geo-political, economic, and social consequences. Obtaining accurate and timely information is very crucial to stop and prevent the spread of the virus along with good governance and public participation, which serve as a key to successful combat against Coronavirus in the future. Wu & McGoogan in [50] and Yang, *at al.*, in [21] analyzed the Chinese culture of the Chinese New Year or Chunyun celebration during the Covid-19 pandemic. In terms of culture, it is the largest and most important holiday where mass migration takes place to see annual spring festival. However, China is committed to responding to the outbreak which threatens the public health, so this country adopts a policy which involves national interventions to implement isolation, quarantine, social distancing, and community detention.
Based on the concept and some previous studies, it can be concluded that the variable culture plays an important role in dealing with the Covid-19 outbreak, whether to weaken or strengthen the use of big data analytics to achieve successful implementation of any public health strategies adopted. This way, the proposition is proposed as follows:

Proposition 3: Culture can be a moderating variable for the effect of big data analytics on public health strategies.

3.2. Conceptual Model

The conceptual model proposed in this article is described in Figure 3. There is an independent variable i.e. use of big data analytics, moderating variables i.e. government policy and culture, and dependent variable i.e. public health strategies. The P1 proposes that the use of big data analytics affects public health strategies. There is a possibility that the higher the use of big data analytics, the greater the effects or benefits received by government in successfully applying public health strategies related to the mitigation and preparedness, response, and recovery of the Covid-19. Meanwhile, P2 proposes that government policy can mediate the effect of the use of big data analytics on public health strategies. There is a possibility that the government policy adopted in a country will improve or support the effect of the use of big data analytics on the success of public health strategies. Finally, P3 proposes that culture can moderate the effect of the use of big data analytics on public health strategies. There is a possibility that the local culture of a country will either increase or decrease the effect of the use of big data analytics on the success of public health strategies.

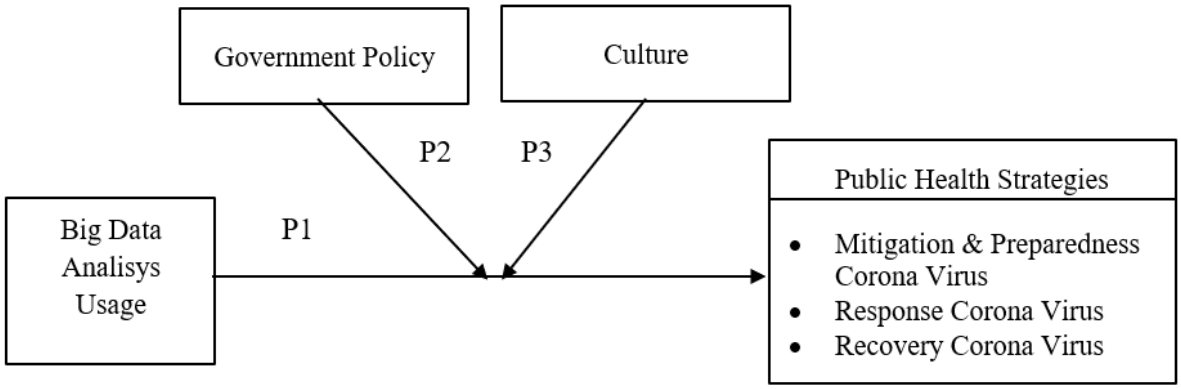

Figure 3. Conceptual Model

3.3. Comparison with other strategies

Table 3 presents a comparison of various factors which should be considered when coping with the Covid-19 outbreak in the conceptual model proposed in this article with those in previous studies.

Table 3. Comparison of variables analyzed with previous studies

No	Variable	[31]	[13]	[15]	[11]	Proposed Conceptual Model
1	Big Data	Yes	Yes	No	Yes	Yes
2	Public Health Strategies	Yes	No	No	No	Yes
3	Government Policy	No	No	Yes	No	Yes
4	Culture	No	No	Yes	No	Yes

There are some previous scientific articles or studies that discuss the variables used in the concept proposed in this study. An article written by [31] discusses digital technology related to big data and Public Health Strategies but it discusses neither government policy nor culture variables. A study by Song & Ryu in [13] discusses, in details, the variable big data in coping with the Covid-19, but it does not discuss the other three variables i.e. public health strategies, government policy and culture. Research by [15] uses neither big data nor public health strategies, but it discusses public policy and culture comprehensively. Meanwhile, an article written by [11] reviews, in details, GIS and big data in dealing with the Covid-19 but it does not cover public health strategies, government policy and culture. The strength of the conceptual model proposed in this study is presenting a new model which is more comprehensive because it considers the four variables, i.e. big data, public health strategies, government policy and culture.

4. Discussion

The Covid-19 outbreak has become a global public concern. The Covid-19 outbreak had never ocurred in the 20th century, [26]. This virus has infected lots of poeple in many countries and to make interventions with other countries, many international cooperations have been established. Sathya, *et al*. in [46] and Van Bavel, *et al*. in [51] argued that this pandemic requires careful measures because this pandemic has a high potential recurrence in the future which is potentially devastating. Therefore Wu & McGoogan in [50] argued that, to deal with the Covid-19 epidemic, proactive investment in infrastructure and public health capacity, increased international supervision, cooperation, coordination, and communication about massive outbreak are very important.

There are, in fact, many things to do to deal with the Covid-19. An example is the use of technology as a solution to reduce the Covid-19 crisis as implemented in China and South Korea [6]. Taiwan, however, has a promising approach to utilize big data analytics to respond to the Covid-19 crisis without triggering public distrust [30]. Not only in China, Taiwan and South Korea, the use of big data analytics has been applied in several other countries to deal with the Covid-19 outbreak. Many studies have also shown the benefits of using big data such as [12], [20], [30], [31], and [11]. Based on their studies, it can be concluded that in today's digital world, integrating big data and its analytics plays a key role. This is because big data analytics are used to support pre-pandemic and early prevention, support disease control, help manage pandemic, and improve health strategies. The application of various digital technologies such as big data, the Internet of Things (IoT), Artificial Intelligence (AI), blockchain technology, GPS, and Geographic Information System (GIS) can help health services to overcome the Covid-19 problems.

There have also been many analyses on Public Health Strategies. Various activities in the mitigation & preparedness strategies in dealing with the Covid-19 have been discussed by [19], [6], [17], [47], [25], [22], [27], and [29]. Based on these studies, various activities of public health strategies in terms of mitigation & preparedness include using predictive models in timely decision and policy making, disseminating information on the prevention of transmission of droplets from people with confirmed Covid-19 (such as by using face masks, gloves, protective goggles for disposable clothes, regular hand washing, funeral procedures), implementing public policies in the form of staying at home, extended holidays, quarantine (both for patients and health workers who are exposed to the virus), using digital applications to control and track people's movements, canceling large public events, shutting down any activities which encourage interactions (such as shutting down schools, universities, government offices, factories, places of worship), implementing social distancing policy, disseminating information by the government on how to avoid infection, adding more Covid-19 testings in all health clinics throughout the country, implementing travel restrictions (such as reduced flights and public transport), legalizing policies (such as lockdown, red zone, curfew), maintaining transparency from the government to the

public regarding the information on the spread of the Covid-19 outbreak, providing remote consultation for patients via phone or video conferencing and other preventive policies.
The activities in the response strategy have been discussed comprehensively by [19], [6], [24], and [27]. Based on these studies it can be said that various activities related to the response strategies include using antiviral drugs, developing Covid-19 vaccine, flattening the epidemic curve by minimizing morbidity and mortality, applying quarantine systems and tracking new cases, conducting mass testings, disseminating information which is accurate and timely to create public preparedness, conducting population-based monitoring, providing services using citizens' personal ID and storing the health records in databases owned by local health authorities to optimize health care, building and improving public health infrastructure during an emergency crisis, procuring more health supplies, as well as making better preparation to face possible emergency crisis in the future. In addition, healthcare workers also identify high-risk cases; researchers investigate the efficacy of treatment; schools and universities around the world have switched their learning system to using virtual media.
Finally, the activities of the recovery strategies in dealing with the Covid-19 have been discussed by [19] and [16]. Based on these studies, the recovey activities that can be carried out by the government include having data to identify the movement of people, safe areas, and high-risk areas to carry out the recovery processes (for example reopening schools, offices, places of worship and others), followed by taking various recovery measures to recover the unavoidable economic recession due to the impact of the Covid-19 pandemic. In addition to discussing the direct effect of the use of big data analytics on the formulation of public health strategies, there are some variables that can moderate the relationship. Based on some previous scientific reviews and by considering the conditions in several countries, it is believed that two variables, namely government policy and culture, may play a pivotal role either to strengthen or to weaken the use of big data analytics to achieve successful implementation of public health strategies adopted by the government in dealing with the Covid-19 outbreak.
Based on the reviews of all these previous studies, a new conceptual framework was formulated and this is different from those in these previous studies. In fact, the proposed model is more comprehensive because it considers the four variables, namely big data, public health strategies, government policy and culture. The proposed conceptual framework has many opportunities for future research, for examples collecting data from the field and conducting empirical testing, comparing the successful use of big data analytics to deal with the Covid-19 outbreak in several countries, using other types of digital technology as a variable such as the Internet of Things (IoT), Artificial Intelligence (AI), blockchain technology, GPS, and Geographic Information System (GIS), and developing the model by adding more variables such as forms of government, political systems, economic power, the preparedness of public health institutions, and others which could influence the formulation of public health strategies to cope with the Covid-19 pandemic. If the conceptual framework as proposed in this article is developed by collecting data from the field, then the data processing can employ Structural Equation Modeling (SEM).

5. Conclusion and Future Works

In fact, the concepts related to big data analytics which influences public policy making which includes mitigation and preparedness, response, and recovery programs in dealing with the Covid-19 outbreak which hits many countries are still interesting to be further analyzed. In discussing this relationship, it will be more comprehensive to consider both government policies which are strictly applied and the local culture of the people in a country. Practitioners can also get a benefit from the content of this article. As stated previously, some countries have applied big data analytics in dealing with the Covid-19 pandemic. In addition, this article has conceptually shown the importance of considering two factors namely government policies that are strictly applied and local culture. This article also has contribution to further research because it comprehensively presents propositions, conceptual models, various alternatives in relation to the types of research, as well as recommendations on data analysis.
However, this article has limitations because it is only limited to a conceptual framework that has not been empirically tested. This way, there are several opportunities for further research. First, future researchers can use the conceptual model discussed in this article, then develop it by collecting data in the field and testing the data empirically. Second, researchers can compare the success of using big data analytics in dealing with the Covid-19 pandemic in several countries. Third, researchers can examine not only big data variable but also other variables related to the use of digital technology such as the Internet of Things (IoT), Artificial Intelligence (AI), blockchain technology, GPS, and Geographic Information System (GIS). Finally, researchers can develop the model by adding more variables that

may affect public health strategies to deal with the Covid-19 outbreak such as the form of government, political systems, economic power, and the preparedness of public health institutions.

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