DATA GOVERNANCE MECHANISMS IN INDONESIA'S COVID-19 DATA INTEGRATION SYSTEM

Binti Azizatun Nafi'ah

Departemen Administrasi Publik, Universitas Pembangunan Nasional "Veteran" Jawa Timur
E-mail: binti.azizatun.adneg@upnjatim.ac.id

ABSTRACT. During a pandemic, policy decisions are made quickly and correctly. The need for COVID-19 data becomes an absolute basis for policymaking. This paper focuses on the mechanism of COVID-19 data management in the national COVID-19 task forces to be able to provide valid and realtime data. Researchers used qualitative analysis, with primary and secondary data collection. Researchers interview 3 information from the ministry of communication and informatics as a public communication team in the task force to accelerate the handling of COVID-19. The results showed that even data management was based on structural, procedural, and relational mechanisms. Structure mechanism has been formed strongly through the task force team from the national to the regions. Procedural data mechanisms, although changing procedures are now at the point of data integration. The relation mechanism shows that the coordination and communication relationship between member task forces has been done quite well where coordination is always done quickly.

Keywords: Mechanisms; Data Governance; COVID-19; Data Integration

MEKANISME TATA KELOLA DATA DALAM SISTEM INTEGRASI DATA COVID-19 INDONESIA

ABSTRAK. Dalam masa pandemi, pengambilan keputusan kebijakan dilakukan dengan cepat dan tepat. Kebutuhan akan data COVID-19 menjadi hal yang mutlak untuk menjadi dasar pengambilan kebijakan. Paper ini fokus pada mekanisme pengelolaan data COVID-19 pada gugus tugas nasional untuk dapat menyediakan data valid dan realtime. Peneliti menggunakan analisis kualitatif, dengan pengumpulan data primer dan sekunder. Peneliti mewawancarai 3 informan dari kementerian komunikasi dan informatika yang bertugas sebagai tim komunikasi publik di gugus tugas percepatan penanganan COVID-19. Hasil penelitian menunjukkan bahwa pengelolaan data telah berbasis pada mekanisme struktur, prosedural dan relasional. Mekanisme struktur telah terbentuk kuat melalui tim gugus tugas mulai dari pusat hingga daerah. Mekanisme prosedural data, walaupun berubah-ubah prosedur, namun pada saat ini telah menuju titik integrasi data. Mekanisme relasi menunjukkan hubungan koordinasi dan komunikasi antar gugus tugas telah dilakukan dengan cukup baik dimana koordinasi selalu dilakukan dengan cepat.

Kata kunci: Mekanisme; data pemerintah; COVID-19; integrasi

INTRODUCTION

The China-based COVID-19 outbreak has spread to more than one hundred countries in the world and has changed the status of a global health emergency. The COVID-19 outbreak has become the fastest virus spread, the most widespread infection, and the most difficult to overcome China for the past 70 years (Sun, et al., 2020). The virus is quickly transmitted from human to human, with a total of 94,124,612 confirmed cases and 2,034,527 deaths worldwide on 20 January 2020, triggering public fear and panic (WHO, 2020). However, until now there has been tested vaccine, and there are still many uncertainties such as the origin, nature, and details of the virus.

Although not yet able to ascertain the origin of the coronavirus, there are three characteristics can define this new virus. These characteristics are a very rapid rate of spread, aged and low immune people are more susceptible to this virus, and differential recovery rates (Shaw, et al., 2020, p. 1).

These characteristics make people more worried and panicked. The recovery rates of patients are relatively different. The global recovery rate is relatively low at 28% -30%. The healing rate of China, Korea, Japan has a relatively higher recovery rate than European countries, Iran, and the United States.

Several studies inform that the COVID-19 pandemic has an impact on people's mental health. Symptoms of anxiety and depression (16-28%) and stress (8%) are common psychological reactions to the COVID-19 pandemic (Rajkumar, 2020, p.1). These symptoms affect the quality of sleep so that it affects immunity. People's habits also turn into panic. Panic behavior can be demonstrated such as accessing the browser using keywords about COVID-19 rising and panic buying. The source of this behavior and mental change in society is misinformation as in Vieira's paper, et al (2020). One priority that has not been forgotten during the COVID-19 pandemic was misinformation (Vieira, et al., 2020, p.39).

Misinformation not only indicates inaccuracy of information but can also arise from information

from non-experts and commercially-driven interests. Misinformation can cause increased anxiety and emotional tension. Excessive fear due to information about the disease causes erratic behavior such as panic buying food supplies. Therefore, the availability of valid information is needed by researchers, academics, and even policymakers.

Policymakers need to predict the future of a pandemic, assess the impact of current interventions, and evaluate the effectiveness of alternative mitigation strategies to save lives (Xue, et al., 2020, p.2). This requires COVID-19 data. However, unfortunately, the number of persons under monitoring (ODPs), patients under surveillance (PDPs), deaths in Indonesia due to COVID-19, diseases caused by the SARS-CoV-2 virus, are considered to be far higher than official figures (Arif, et al., 2020). Delays in testing and treatment have caused many ODPs and PDPs to die before conducting the test so that it has not been recorded in real-time.

The rapid development of the epidemic requires big data technology to enable rapid responses and analysis. All about e-service in new age not exclude covid-19 data (Buchari, 2016). In this era of information and communication technology that continues to develop so fast, ditigal literacy competences are important to have, so that everyone is able to take advantage of the oppertunities that these develoments bring (Harnani, 2021). Immediate supply of information about the dynamics of the epidemic and an understanding of the development of the epidemic to provide timely support in the prevention and control of decisions and actions (Zhou, et al., 2020., p.86). This paper focuses on how data governance mechanisms in Indonesia to provide real-time integrated COVID-19 data.

Data Governance

The focus of our review literature is on the topic of data governance, where this topic will lead to how governments manage COVID-19 data to handle COVID-19 outbreaks through data publication. We have reviewed a variety of data governance literature and decided to use the concept of data governance that has been studied by Abraham, et al., (2019).

The definition of data governance according to Abraham, et al. (2019, p.426) is data governance establishes a cross-functional framework for managing data as a strategic asset of the company. In doing so, data governance determines the rights and accountability of decisions for organizational decisions about the data. Besides, data governance formalizes data policies, standards, and procedures and monitors compliance. Abraham, et al. (2019,

p.426) explains the definition of data governance has six parts. First, data management is a collaborative effort across functional and data areas. Second, data governance is a framework, which provides structure and formalization for data management. Third, data governance focuses on data as a strategic corporate asset. Fourth, data governance determines what rights and accountability decisions need to be made about data, how these decisions are made, and who in the organization has the right to make these decisions. Fifth, data governance develops data policies, standards, and procedures. Sixth, data governance monitors compliance, which means data governance as the implementation of controls to ensure that data policies and standards are adhered to.

These six sections show the difference between data governance and data management. Data governance refers to what decisions need to be taken and who makes those decisions, whereas data management is about making those decisions as part of the day-to-day implementation of data governance policies (Hagmann, 2013, p. 234, Khatri & Brown, 2010, p. 148; Otto, 2013, p. 96). COVID-19 data governance shows decisions using data integration from various sources both online/offline and task force teams as decision-makers. That's why researchers use the concept of data governance.

Data Governance Dimensions

Abraham, et al. (2019) explains data governance has 6 dimensions, namely governance mechanisms, organizational scope, domain scope, data scope, antecedents, and consequences. In this paper, the author focuses on governance mechanisms where this dimension is vital and strategic to develop COVID-19 data governance. Besides, following the objectives of the study, researchers focused on how the mechanism of COVID-19 data governance to provide one COVID-19 data across sectors.

The governance mechanism consists of a formal structure that connects business, IT, and data management functions; formal processes and procedures for decision making and monitoring; and practices that support active participation and collaboration among stakeholders. Abraham, et al. (2019, p.428) conclude that the data governance mechanism consists of a structural mechanism, procedural mechanism, and relation mechanism.

First, structural mechanisms include (i) roles and responsibilities and (ii) allocation of decision-making authority. The primary role and governance body consists of executive support, data governance leaders, data owners, data administrators, data governance boards, data governance offices, data

producers, and data consumers. The allocation of decision-making authority determines which organizational units have the mandate for actions related to data governance.

Second, procedural governance mechanisms aim to ensure that data is recorded accurately, stored safely, used effectively, and shared appropriately (Borgman, et al., 2016, p. 4903). Procedural mechanisms consist of (i) data strategies; (ii) policy; (iii) standard; (iv) process; (v) procedure; (vi) contractual agreements; (vii) performance measurement; (viii) compliance monitoring; and (ix) problem management.

Third, the mechanism of relational governance facilitates collaboration among stakeholders (Borgman et al., 2016, p. 4903). Relational governance mechanisms include (i) communication; (ii) training; and (iii) coordinating decision making.

The framework of the concept of data governance from Abraham, et. al (2019, p. 429) is as follows figure 1.
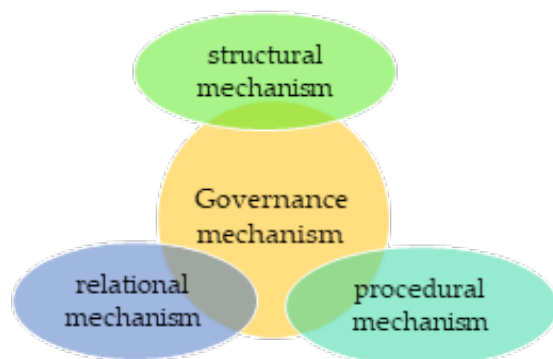
Source: Abraham, et.al (2019, p. 429), modified

Figure 2. A conceptual framework for the COVID-19 data governance mechanism in Indonesia

The conceptual framework the authors attach aims to understand the vital position of governance mechanisms in the large framework of data governance. The focus of the study uses the concept of governance mechanisms which include structural mechanism, procedural mechanism, and relational mechanism to explain how the COVID-19 data governance mechanism provides one COVID-19 data across sectors (Figure 2).

METHODS

This study used the qualitative method. The purpose of this study is to analyze the COVID-19 data governance mechanism in supporting the integration data policy. By understanding the existing structural, procedural, and relationship mechanisms, the researcher can deduce weaknesses to provide COVID-19 data to the public. this weakness can later become a suggestion for the Indonesian government to provide COVID-19 data with good data governance.

Purposive sampling was used in this study as a technique to determine the informants. This technique takes into consideration the direct involvement of the informants at the governance mechanism. The informants were determined based on their roles in the governance mechanisms, as many as three informants from the ministry of communication and information. Informan was chosen as the public communication team in the national task force for handling data COVID-19.

The procedures for collecting data in this qualitative study involved three types of strategies namely qualitative observations, qualitative interviews,
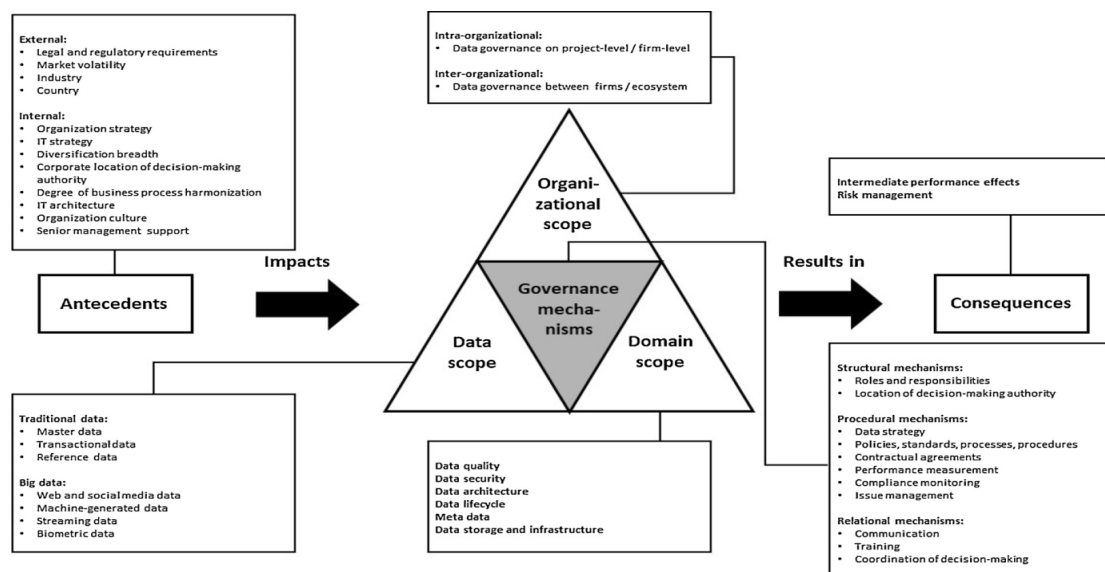
Source: Abraham, et.al (2019, p. 429)

Figure 1. A conceptual framework for data governance

and qualitative documents (Creswell, 2010, p. 267). Once data were collected, the validity of the data was confirmed by using triangulation techniques. The researcher used source triangulation and data collection triangulation techniques. The data obtained from the data collection results via interviews, observations and documentation studies in the research locations were then presented and analyzed. Data analysis employed a qualitative analysis technique approach of Miles and Huberman, which includes stages of data reduction, data models, and concluding.

RESULTS AND DISCUSSION

Before the COVID-19 pandemic, the Indonesian government had implemented an electronic-based government. The main regulatory basis used is Presidential Regulation Number 95 of 2018 concerning Electronic-Based Government Systems and Presidential Regulation Number 39 of 2019 concerning One Data. Discussion of the data in Presidential Regulation 95/2018 covers Article 2 paragraph 2 letters (f) one of the Electronic Based Government System (SPBE) elements is Data and information; Article 7 paragraph 4 letter (f) one of the domains of SPBE architecture is Data and Information; article 46 paragraph 1 letter (c) one of SPBE Management is Data Management.

Data management is government data management activities for government activities. During the COVID-19 pandemic, the public needs real-time COVID-19 data. The public feels anxiety and concern about the danger of the COVID-19 pandemic, the public accesses as much information about COVID-19 as possible. To prevent incorrect information and data, through the task force acceleration handling COVID-19 19 channel provides access to information about a single real COVID-19 data.

Indonesia's COVID-19 data governance mechanism will be explained covering three compositions. First, structural mechanisms include (i) roles and responsibilities and (ii) allocation of decision-making authority. The Government of Indonesia established a single unitary organization specifically dealing with COVID-19 in Indonesia. This organization was formed with the name of the task force for the acceleration of COVID-19 handling. The leading sector for handling COVID-19 is the National Disaster Management Agency (BNPB).

Based on the decision of the chief executive of the task force for the acceleration of handling COVID-19 no. 18/2020, involving 33 ministries / institutions / government agencies. Each ministry/institution has their respective duties and responsibilities.

Each stakeholder involved carries out their duties following their respective main tasks, for example, the Ministry of Home Affairs with population data and civil records supporting the Population Identification Number (NIK) data for tracking and mapping positive COVID-19, PDP, and ODP patients. The Ministry of Health with its Online Hospital supports data to https://data.covid19.go.id through the task force team. The Ministry of Communication and Information Technology supports the application of caring and protecting the creation of the portal https://covid19.go.id. National Cyber and Crypto Agency in terms of security and infrastructure. Each local government together with the Indonesian Army and police escorted and obtained data from the producer to be submitted to the task force team.

As for the management and publication of data related to COVID-19, the task force publishes the portal https://covid19.go.id. This portal provides COVID-19 data information to the public. The field that handles this data is the Field of public communication. The field of public communication has the task of carrying out public communication, setting the agenda-setting, carrying out monitoring of the news media, becoming a spokesperson for the Chair of the Task Force, and compiling daily reports. The coordinator in the field of public communication is the director-general of information and public communication, the ministry of communication and information technology. The Ministry of Communication and Information became a COVID-19 data management center through the portal https://covid19.go.id.

Decision-making authority regarding COVID-19 data is centered on the president. The President uses his authority to issue a Presidential Decree to accelerate the handling of COVID-19 through a task force. Through amendments to the Decree of the President of the Republic of Indonesia No. 9/2020 concerning amendments to Presidential Decree No.7 / 2020 concerning the task force for an acceleration of COVID-19 handling, the task force team accelerated data collection. The task force consisting of Penta helix across ministries, cross-agencies, cross-sectors, implemented a new application namely the Unite Against COVID-19 (BLC) system to facilitate analysis and future policymaking. This system is a sub-domain of the covid19.go.id portal. To facilitate and accelerate the delivery of daily data and information from Public health centers, hospitals, and regional health offices, the task force provides several channels for reporting. Patient / suspect / close contact daily data of COVID-19 at the

Community Health Centre can be reported directly from the Public health center to the task force via the task force information system website (https://data.covid19.go.id) or using a printed form for which data recapitulation can be sent via WhatsApp or email datacovid19@bnpb.go.id.

The highest decision making authority is exercised by the President through a presidential decree. Coordination of decision making is very fast. This is in line with the development of positive patients who are increasingly rising and massive. Various technical and non-technical matters were communicated with the team and decided together quickly and responsively. This can be seen from the field of public communication, where the data collection process is carried out massively, comprehensively, quickly, and accurately by involving various channels that can be done from various 'fields' of users. The task force team in the field of public communication also managed to integrate various variant data (online or manual) into one integrated data COVID-19. This certainly facilitates further decision making based on the integrated data. A positive thing that can be learned from decision-making authorities in emergency conditions such as the COVID-19 pandemic in Indonesia is the clarity of a single data that is realtime as a database for making policies quickly and accurately.

Second, procedural mechanisms consist of (i) data strategies; (ii) policy; (iii) standard; (iv) process; (v) procedure; (vi) contractual agreements; (vii) performance measurement; (viii) compliance monitoring; and (ix) problem management. Procedurally, COVID-19 data management Indonesia has implemented data strategies, policies, standards, processes, procedures, and problem management.

Data management strategy is done online or manually. COVID-19's data was provided by the Ministry of Health and the BNPB Expert Team. The online COVID-19 data management strategy is through the public communication team giving users and IDs to log in to each region. Then, each region reports the progress of the COVID-19 case through the website every day by entering a user and id to log in. Manual data management strategy by manually recording data from each region using WhatsApp, telephone, email, and health investigation forms.

Although there are still many data collection channels, they are always integrated both manually (sending data or automatically via Application Programming Interface (API)) and online. Regions have COVID-19 web sub-domains respectively. Based on data from the Ministry of Communication and Information, as much as 73.80% or 430 local governments already have COVID-19 subdomains. This shows that the provision of COVID-19 data services in the regions mostly uses website media, besides that the regions also use call centers.

The latest strategy in realizing one data that is integrated by using one channel is the website https://covid19.go.id/ for browser access and the Unified Opposition COVID-19 (Bersatu Lawan COVID-19/BLC) application for mobile phone access. Through the application, the public can see information such as the level of vulnerability at the sub-district level, looking for reference information and other up-to-date information. BLC has a system function which is to accelerate the flow of data recording at the level of health centers, hospitals, laboratories, and health offices from the regions. Not only that, but BLC can also function to find out the location of distribution in Indonesia, the distribution of COVID-19 cases, recording of results of rapid test (RDT) examination, and recording of needs and logistics distribution in hospitals, laboratories, and health offices.

Policies in managing data continue to improve quickly. In the period of January-May 2020, it has changed the COVID-19 data policy many times. The COVID-19 data management policy was initially carried out online with each COVID-19 health center reporting cases handled, but faced obstacles in areas that were difficult to signal the internet then reported manually. Datacenter management is also still done manually. Then as time went on with COVID-19 data which continued to rise sharply, the distribution of data also continued to spread widely throughout the country with channel variants used by each region, then the government directed the data on the integration of one COVID-19 data at the end of April 2020. On May 5, 2020, the application BLC can be downloaded on the Android system play store, for iOS has not worked together.

Initially, this policy did not have a separate Standard Operating Procedure for providing COVID-19 data until April 2020. At a limited meeting on April 13, 2020, the president directed the use of Data Integration Guidelines. This document is a reference for local governments in synchronizing data with the National Task Force for the Acceleration of COVID-19 Handling. Based on the results of the limited meeting then the data must be integrated or create a single real-time data.

The Provincial Government is expected to be able to collect data related to COVID-19 from all Regency and City Governments in their respective regions. The consolidated data is complete data by name by address. To support the acceleration of data distribution and data validation to optimize

the Office of Communication and Information Technology as an ICT technical team in the region in handling COVID-19, particularly in providing API (Application Programming Interface) and utilization of general applications for handling COVID-19, namely https://data.covid19.go.id. Reports are made in realtime.

To make uniform distribution of COVID-19 data available by region, the MOH and the team of task force experts have made an Epidemiological Investigation Form. The technical mechanism is that the Joint Task Force for Communications and Information is distributing Puskesmas, Lab, Health Service, and Hospital accounts through the Ministry of Communication and Information in the local government. Then after filling out the form, it is returned to the regional communication and information agency and then reported to the communication and information agency. The Ministry of Communication and Information then updates the COVID-19 data every second by the filling out of the form from the regional Communication and Information Agency. In principle, data is collected together and processed.

For centralized applications, data is collected in the web portal http://data.COVID-19.go.id. The web content https://data.covid19.go.id also retrieves data from the Online Hospital of the Directorate General of Health Directorate General of Health Services as additional data. Data is compared and cleared until it can be raised on https://COVID-19. go.id/peta-sebaran. Even so, there are still many incomplete data, for example, 91.6% do not include COVID-19 positive symptom data and 96.7% do not include COVID-19 comorbid conditions. Another limitation is that some areas have difficulty accessing applications via the website due to signal limitations. However, the task force team worked on these limitations by recapitulating data using the printed form that was provided then sent via WhatsApp or email dataCOVID-19@bnpb.go.id.

In overcoming the problem of inequality of COVID-19 data that has not been realtime, the task force team has been doing data integration quickly. The existence of a website channel and BLC application makes it easy for the government to determine the red, yellow, and green zone policies. However, it should be noted that the contents of the Epidemiology investigation forms that have been carried out are suspicious, PDP a COVID-19 data, at least it gives a picture of approaching the truth that occurs in society.

Third, the mechanism of relational governance facilitates collaboration among stakeholders (Borgman et al., 2016, p. 4903). Relational governance mechanisms include (i) communication; (ii) training; and (iii) coordinating decision making. The institutions involved are quite active and cooperative, although there are some technical obstacles such as signal limitations for the border area. Communication between institutions involved in the task force has gone quite well. This can be seen from the implementation of COVID-19 data delivery that is approaching realtime by changes in and out of COVID-19 patients throughout the hospital. Although most of the data submission is still manual.

There is training for data input at data. COVID-19.go.id by the Task Force Expert team. Limited forms of online and face-to-face training. Coordination is still ongoing. Based on the April 2020 communication and information circular addressed to all governors and regents/mayors, it contains the delivery of cavitation data guidelines19. COVID-19 data in Indonesia are not yet fully integrated. By the direction of the President of the Republic of Indonesia in a Limited Meeting on April 13, 2020, concerning the consolidation of national data in the handling of COVID-19 between the Regional Government and the Central Government, BNPB and the Ministry of Communication and Information, has compiled a Data Integration Guidelines.

The problem of relations between institutions is seen more in the process of socializing how to report COVID data for all regions in Indonesia. At first, it was very difficult to do reporting by relying on the awareness of each region to report. Even the task force team only recapitulates those who want to report, while other regions that do not report are considered green zones. Even though there are not necessarily cases where there have not been reported cases yet. Especially at this time data reporting is demanded in realtime, at any time there are changes to report. So the socialization of reporting procedures becomes the spearhead in conducting a realtime reporting approach. Building coordination in each region to be swift in processing data and reporting to the center so that the center can quickly do the processing and conveyed to the public.

CONCLUSIONS

Data management has been based on structural, procedural, and relational mechanisms. Indonesia's COVID-19 data management structure mechanism has been strongly formed through task force teams from the national to regional levels. COVID-19 data problem decision-making authority has been centered on the task force team.

In the procedural data mechanism, since the inception of COVID-19 in Indonesia, the data collection procedures vary according to conditions. Encouraged by the time the virus spreads, data collection is done online or manually and then managed together. At present data management has led to the point of data integration (Bersatu Lawan COVID-19/BLC).

The relation mechanism shows that the coordination and communication relationship related to data collection and data processing between central and regional task forces has been done quite well. Coordination is always done quickly, following changes in policy acceleration of COVID-19 data reporting

REFERENCES

Abraham, R., Schneider, J. & Brocke, J.V. (2019). *Data governance: A conceptual framework, structured review, and research agenda.* International Journal of Information Management 49, 424–438. https://doi.org/10.1016/j.ijinfomgt.2019.07.008

Arif, A., Hellen, S., Arlinta, D. & Piawai, D. (2020, April 23). Urgent Need for Transparent COVID-19 Data. *Kompas.* Retrieved from https://kompas.id/baca/english/2020/04/23/urgent-need-for-transparent-COVID-19-data/

Buchari, A. (2016). Implementasi e-service pada organisasi publik di bidang pelayanan publik di kelurahan Cibangkong kecamatan batununggal Kota Bandung. *Sosiohumaniora.* 18(3), 235-239. https://doi.org/10.24198/sosiohumaniora.v18i3

Creswell, J.W. (2010). *Research Design: Pendekatan Kualitatif, Kuantitatif, dan Mixed.* Yogyakarta: Pustaka Pelajar

Hagmann, J. (2013). Information governance-Beyond the buzz. *Records Management Journal*, 23(3), 228-240. https://doi.org/10.1108/RMJ-04-2013-0008

Harnani, N., Amijaya, D.H. & Setiadiwibawa, L. (2021). Digital literacy competences in improving the problem-solving skills in facing the industrial revolution 4.0. *Sosiohumaniora.* 23(2), 290-298. https://doi.org/10.24198/sosiohumaniora.v23i2

Khatri, V. & Brown, C.V. (2010). Designing data governance. *Communications of the ACM*, 53(1), 148–152. https://doi.org/10.1145/1629175.1629210

Otto, B. (2013). On the evolution of data governance in firms: The case of Johnson & Johnson consumer products North America. In S. S (Ed.). *Handbook of data quality* (pp. 93–118). Berlin, Heidelberg: Springer.

Rajkumar, R.P. (2020). COVID-19 and mental health: A review of the existing literature. *Asian Journal of Psychiatry*. 52 (2020) 102066. https://doi.org/10.1016/j.ajp.2020.102066

Shaw, R., Kim, Y. & Hua, J. (2020). Governance, technology, and citizen behavior in a pandemic: Lessons from COVID-19 in East Asia. *Progress in Disaster Science*. 6 (2020) 100090. http://dx.doi.org/10.1016/j.pdisas.2020.100090

Sun, S., Yu, K., Zhen. & Xiaoting, P. (2020). China empowers Internet hospital to fight against COVID-19. *Journal of Infection,* S0163-4453(20)30183-3 DOI: 10.1016/j.jinf.2020.03.061Vieira, C.M., Franco, O.H., Restrepo., & Abel, T. (2020). COVID-19: The forgotten priorities of the pandemic. Maturitas. 136 (2020) 38-41. https://doi.org/10.1016/j.maturitas.2020.04.004

World Health Organization. (2020). WHO Coronavirus Disease (COVID-19) Dashboard. June 2, 2020, retrieved from https://COVID-19.o./?gclid=EAIaIQobChMI6p6O1sHj6QIVFSUrCh1oKgeVEAAYASAAEgIRCvD_BwE

Xue, L. Jing, S., Miller, J.C., Sun, W., Li, H., Franco., Hyman, J., & Zhu, H. (2020). A data-driven network model for the emerging COVID-19 epidemics in Wuhan, Toronto, and Italy. *Mathematical Biosciences*. (pre-proof) https://doi.org/10.1016/j.mbs.2020.108391

Zhou, C., Su, F., Pei, T., Zhang., Du, Y., Luo, B., Cao., Wang, J., Yuan, W., Zhu, Y., Song, C., Chen, J., Xu, J., Li, F., Ma, T., Jiang, L., Yang F., Yi, J., Hu, Y., Liao, Y., & Xiao, H. (2020). COVID-19: Challenges to GIS with Big Data. *Geography and Sustainability*. 1 (2020) 77-87. https://doi.org/10.1016/j.geosus.2020.03.005