How Enterprise Architecture Enhances the National Health Information System in Supporting the COVID-19 Response in Indonesia

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Abstract

The COVID-19 pandemic has negative impacts on human well-being with significant consequences on social, economic, political, legal, and technological aspects of society. A key challenge in managing the pandemic particularly in developing countries is the lack of integrated health data. Previous research indicates that an Enterprise Architecture (EA)-driven national initiative has the potential to mitigate data integration issues. However, in-depth study of how EA initiatives provide a systematic solution to national health data integration in the context of COVID-19 data management is lacking. Using Indonesia as a study context, we conducted an in-depth case study to systematically explore factors affecting the current COVID-19 data integration issues and investigate how EA helps overcome the problems. In this research in progress paper, we present our initial research findings and outline our future research plans. When completed, our study contributes to IS research specifically in the EA domain and has important practical implications.

Keywords: COVID-19, health data integration, interoperability, enterprise architecture, Information Systems.
1 Introduction

Developing countries are facing significant ‘people and health’ threats to general well-being created by the COVID-19 pandemic. Compared to other South-East Asian countries, Indonesia is most affected recording 44.3% of total cases and 60.7% of the death toll (Worldmeters 2020). The inability to provide an effective response to COVID-19 cases can be largely attributed to the limited health data integration across various information systems (Karunia 2020). Indonesia is the world’s fourth most populous country with over 270 million people in 34 provinces and 541 districts. Integrating numerous islands of data and information systems from across this archipelago poses a significant challenge and is compounded by a heavy reliance on manual systems. Consequently, Indonesia has not been able to access reliable data to assist with effective control and management of COVID-19 cases despite the significant effort made by its government (Purwondanu 2020). The government has acknowledged the mismatch of COVID-19 data between the central and district government (Karunia 2020). The President also emphasized the importance of data accuracy to mitigate the impacts of the COVID-19 (Purwondanu 2020).

Enterprise Architecture (EA) describes an enterprise from an integrated business and Information Technology (IT) perspective that is used to bridge the communication gap between business and IT stakeholders (Kotusev 2018). EA is an IT management technique in both public and private sectors to guide the management of business process, information systems and technology infrastructure and delivers several benefits including improvements with business and IT alignment (Schmidt and Buxmann 2011). Specifically, information architecture taxonomies offered by prevalent enterprise architecture frameworks i.e., Zachman (1999) and TOGAF (Open Group, 2018), provide the requisite models and techniques to clearly articulate entity relationships and data structures. Therefore, EA offers the potential to help enhance data and system integration to enable effective data sharing in the Indonesian COVID-19 context providing a holistic approach to managing business process, information systems and technology infrastructure (Nugraha et al. 2017; OpenHIE 2020).

Previous research in EA has focused on ‘how’ EA techniques contribute to IT management and the delivery of value in the context of developed countries (e.g. Agarwal et al. 2020; Ahmad et al. 2020; Bakar et al. 2016; Kurnia et al. 2020a, 2020b). Noran (2014) offers a generic EA framework for emergency management while other studies identify factors required for general emergency and disaster response (Bharosa and Janssen 2015). However, currently little is known about how EA can address health data integration specifically in developing countries and in-depth investigations into this area are lacking.

This research aims to explore possible roles that EA can play in supporting the COVID-19 response in Indonesia. We conducted an in-depth case study to explore factors contributing to the current COVID-19 data integration and how EA helps overcome the problems. Our research questions are: 1) What are the factors contributing to COVID-19 data integration issues in Indonesia? and 2) How can EA be used to address COVID-19 data integration issues? A preliminary case study was conducted during August-October 2020, involving the Special Region of Yogyakarta, Province of Indonesia. Lessons learned from this case are likely to be valuable to other developing countries, particularly in the Southeast region with similar conditions as those of Indonesia.

This paper is structured as follows. First, we provide a brief review of current practice relating to COVID-19 response management and the value of EA in healthcare information systems. Then, we describe the research methodology and present our findings. Finally, we draw conclusions and describe the next steps of our research.

2 COVID-19 Response Management: Current Practice

To manage the COVID-19 response effectively and based on World Health Organization recommendations digital technologies have been adopted in three areas: testing, tracing, and treatment (WHO 2020). We have reviewed the existing literature to learn what COVID-19 response practices have been adopted in other jurisdictions. Recent research conducted in the development of electronic data systems such as COVID-19 Reporting and Data System have been noted (Turcato et al. 2020). Further, Weemaes et al. (2020) stated that one of the hospitals in Belgium showed the acceleration of the process of completing the examination of COVID-19 samples was found to be more effective by integrating the laboratory system with Electronic Health Records.

In terms of tracing, personal-oriented digital technology is considered easy to use to assess risk and to raise awareness of potential transmission. For example, the use of big data and mobile internet technologies allows every registered resident online to get a green, yellow, or red code according to their risk profile (Pan 2020). Meanwhile, in case management, the Thai government uses the CMC-19 Hospital information system which shows real time data from all COVID-19 referral hospitals (Intawong et al. 2021). For treatment, a Self-Screening Application resulting from collaboration between the Faculty of Public Health, Chiang Mai University, National Research Council of Thailand and the Department of Ministry of Public Health is used to control the COVID-19 spread. The application informs decisions on bed capacity and transfer requirements. Similar studies also report the effectiveness of using Web-based applications for ICU Bed Management (de Morais Barroca Filho et al. 2020).
The literature informs that a diverse range of digital technologies are required to support COVID-19 response management. This presents a significant challenge with the data integration necessary for effective response management (Mbunge 2020). Further, this issue is experienced in both developed and developing countries and data integration to support COVID-19 responses have been reported in countries including, South Korea, Germany, Singapore, Australia, Colombia, Egypt, Ghana, Austria, and Israel. In Indonesia, efforts have been made to integrate data to support contact tracing activities such as the creation of SILACAK (data entry by appointed contact tracers) and PeduliLindungi (data entry by citizen). Both applications aim to trace close contacts of positive confirmed cases. The data from the two applications is stored at the Ministry of Health. In Australia, the Queensland Department of Health (2015) requires that information sources be managed according to the information architecture to ensure that data availability is controlled for subsequent use by other health agencies.

3  EA Value in Healthcare Information Systems

To meet the challenges presented by COVID-19 and to access the information requires a holistic approach to the deployment of IT capability to provide the requisite management information, process enablement and infrastructure. The role of EA is to describe the various aspects of a business, in this case the health eco-system, in a holistic manner to facilitate interoperability of business process, information systems and technology infrastructure (Ahmad et al. 2020; Kurnia et al. 2020b). Previous studies have examined EA implementations in the healthcare sector and have proposed several EA frameworks and designs for various healthcare use cases, including electronic health record integration (Li et al. 2015; Roehrs et al. 2017), disease research (Melament et al. 2011), specific disease care (Ranade-Kharkar et al. 2018), and nation-wide healthcare information system integration (Li et al. 2015; Le Pape et al. 2017). However, how EA addresses COVID-19 data integration challenges are not adequately understood.

According to previous studies, healthcare EA implementation is primarily driven by healthcare-service related needs (Li et al. 2015) and perceived benefits (Katehakis and Kouroubali 2019). A key benefit of healthcare EA implementation lies in the interoperability of data (Gaynor et al. 2014). A well-designed architecture provides a taxonomy that helps healthcare to comply with various health data standards that routinely change over time (Barbarito et al. 2012). Prior studies also acknowledge that even though the implementation of EA is more complex and therefore more costly than a singular application development, greater benefits are realized in the long term (Gaynor et al. 2014). EA provides an organizational capability to design adaptable systems which in the long term are cost effective and better able to respond to the dynamics of evolving healthcare standards and regulations which invariably require system changes. A fully interoperable system can also improve healthcare capability in providing services, such as disease research, patient monitoring, and treatment, and for specific diseases requiring intensive monitoring and coordination between patients and caregivers (Katehakis and Kouroubali 2019). To date, there is insufficient understanding of how EA can promote the interoperability of COVID-19 data.

A lack of data integration leading to data interoperability challenges have been identified as a major challenge in healthcare (Noura et al. 2018) and as a critical challenge in the COVID-19 pandemic situation. Previous studies inform that implementation of EA in the health sector aims to align business processes and objectives with IT infrastructure so that interoperability between systems can be achieved and would enhance the effectiveness of the COVID-19 response management (Tambouris et al. 2012). However, prior studies indicate that healthcare data and information are usually scattered and non-standardized thereby hindering integration (Gebre-Mariam and Bygstad 2016). Accurate and complete data is critical for analytic and effective decision making by health stakeholders and institutions in responding to COVID-19.

An effective COVID-19 response must be Immediate and is dependent on having a flexible architecture that enables an agile response (Higman et al. 2019; Mbunge 2020). However, health institutions typically have a complex and inflexible IT infrastructure (Olsen 2017). The World Health Organization suggests that the EA approach should be deployed in designing and implementing national Health Information Systems across health communities to enhance decision-making which would lead to improved patient care and achievement of national goals (Higman et al. 2019). Consequently, an adaptation of the EA framework has been combined with a community-based bottom-up approach to build an open health information exchange community (OpenHIE 2020).

There are limited studies investigating how EA, including OpenHIE, can help mitigate COVID-19 data integration issues in developing countries. In this project, we identify issues emerging in covid-19 data connectivity and integration and noted that OpenHIE has been a discussion in both national and international levels related to COVID-19 solutions. Therefore, we initiated this exploratory study to address the current gap in research and practice related to EA and COVID-19 data management referencing the OpenHIE framework. This research also complements existing literature on healthcare EA with a more contextualized EA implementation and lessons learned in response to the pandemic.
4 Research Method

Case study is deemed the most appropriate research method as it enables in-depth access to the study context to enable understanding the contemporary phenomenon of COVID-19 data management, the issues related to health data integration, and how EA can help enhance national health information systems to support COVID-19 response in Indonesia as an example of a developing country (Yin 2016).

Yogyakarta Province or Daerah Istimewa Yogyakarta (DIY) has a population of around 4 million consisting of four districts and one municipality that has special status based on Law Number 13 of 2012 concerning the Privileges of DIY. This province is known as a city of students, a city of tourism and has a high Human Development Index and public health index. The unique characteristics of Yogyakarta itself and the case number are sufficient as a pilot project to discuss data connectivity issues in Indonesia. Hence, we conducted a preliminary case study in Yogyakarta, as a suitable case to examine the phenomenon of interest.

Data collection techniques used included interviews, observations and a questionnaire. First, interviews and observations were conducted to explore current situations and discuss challenges from stakeholders’ perspectives in relation to COVID-19 response management. Interviewees were stakeholders involved in COVID-19 data management policy making, working in a Health Office or the Communication and Informatics Office in Yogyakarta, or are involved in application development. In total, 12 stakeholders were selected purposely and interviewed in four clusters, namely healthcare facilities, health sector policy maker, information technology policy maker and community. Second, we distributed an online questionnaire to survey the use of applications and impact of COVID-19 to the essential health services in Primary Health Centers and Hospitals. The questionnaire was developed based on the World Health Organization’s 2020 interim report (WHO 2020). Topics covered include the use of applications in data management and impacts of COVID-19 on other essential services in health care facilities. All questions are closed-ended questions ranging from binary to multiple choice questions. We targeted the Heads of Primary Health Centre’s or Hospitals in Yogyakarta Province resulting in 160 completed questionnaires, with a response rate of 72.8%. After data cleaning, there were 147 usable responses available for descriptive analysis. The project team also visited the Primary Health Centers and hospitals to observe specific applications used by the health facilities at the district level. In total, seven observations were conducted. The findings, derived from interviews, observations, and questionnaires, are presented below.

5 Findings

5.1 Overview of technologies deployed and issues in the COVID-19 response

Our study indicates that there are several types of applications supporting the COVID-19 response in Yogyakarta. These are provided at the central, provincial, and local levels of government. At the central government level, there is a need for data which is then accommodated using the New All Record and RS Online applications. At the provincial level, the COVID-19 Task Force created an application for the integration of data between districts/cities. The provincial office of Communication and Information Technology has adopted the CMS application initiated by the Yogyakarta City Health Office. Recommendations for the use of CMS are strengthened by the Governor’s endorsement. At the local level, health facilities generally have an internal information system for data management. Responding to the pandemic, several regional health policy makers (District/City Health Office) created a COVID-19 data recording application to manage data and assist in policy making.

Our survey identified four types of applications and associated data types used by Primary Health Centers (PHCs) 1. Case reporting: New All Record (to report confirmed case data individually) and RS Online (to report aggregate case data) applications. 2. Epidemiology investigation and contact tracing: SIS-KLB and COVID-19 Tracer, local-based applications to store and manage the COVID-19 data. 3. Logistic and human resource reporting: Each hospital enters the data through RSOnline application for reporting to the Ministry of Health. 4. Community based screening: JogjaPass as a regional screening application to be applied in various places such as offices or tourist attractions. Our data shows that Primary Health Centre facilities use local applications created by their district governments these are deemed to better meet the needs than those provided by central government. One participant stated "...the local application like CovidTracer is easier to enter the data, compared to the CMS". Interestingly, unlike Primary Health Centres, Hospitals used more central applications to report data. Our data shows that Hospitals use central applications more frequently compared to Public Health Care.

Because of the various applications and systems deployed at the central, provincial, and local levels of government and PHCs, there has been a proliferation of disparate information systems. These various stand-alone applications are not integrated, lack interoperability and were not designed to consider standard architecture principles. Consequently, health care facilities inputting the data are required to perform data entry several times in different applications and reformating for migrations. This fragmentation and lack of a shared architecture creates further issues of data duplication, inconsistency, error, incompleteness, and limited data access for effective for pandemic
response and control policy formulation. As indicated by a healthcare worker: "duplication is mostly in names, ID number, address, relationship with the patient, the last contact, rapid swab examination date. It's the same, with what we input to CovidTracer and CMS. Again and again. Say, if ... we just need to input into one application, then the information will stay there and we can use them easily, it will also minimize the data errors".

Designing COVID-19 response systems on EA principles and standards potentially facilitates the interoperability that is required to support an effective response.

5.2 Factors contributing to COVID-19 data integration issues

Our analysis identified five key factors that contribute to COVID-19 data integration issues, which in turn inhibit interoperability and lead to data inconsistency, as elaborated below.

1. Applications were not designed for integration - There are several different applications initiated and created by different stakeholders, in different healthcare facilities, and for different purposes. A pandemic crisis requires timely and reliable data for decision making in response to public health surveillance. Consequently, different stakeholders develop applications within a specific time and context without considering integration and interoperability factors. This results in disparate data structures.

2. Each level of government develops different COVID-19 surveillance information systems - Decentralization regulation allows districts to make policies for pandemic response, including innovation to develop applications for data analysis and collection. This facilitates the creation of systems based on conflicting requirements coupled with a general parochialism at each government level to maintain their own respective applications. Compounding this, health facilities have developed ICT to support patient services prior to the COVID-19 pandemic and are highly reliant on their legacy systems which lack the requisite flexibility to respond.

3. Ineffective coordination of systems development and absence of data standards - Although health facilities have electronic information system, local, provincial, and central governments require collection of COVID-19 data in their own applications and there is no standard for developing COVID-19 information functionality. Consequently, each system is developed to locally perceived requirements. "The central government needs to have one particular policy to accommodate many existing applications" (Health Policy Maker).

4. Privacy concerns regarding sharing personal data and patient’s data - Health Law Number 36 of 2009 stated that the health data sharing can be carried out based on a public interest or in response to an emergency. However, there was concern that patient data transmission to other institutions is a violation of patient data privacy. One IT policy maker reported "When we have not solved all problems, there is another problem of not allowing outsiders to be involved in the process of managing medical record data, especially for large hospitals".

5. Limited resources to collect and compile COVID-19 data - Health workers need to maintain patient care health service levels and data collection is an additional task. Thus, data is being collected after hours and is resulting in inaccuracy, incompleteness and can be out of date as data-entry often occurs the day after. This results in discrepancies between the data in the system and in the paper-based reports. An IT policy maker remarked "the number [of human resources] is inadequate to handle data entry into applications".

5.3 Role of EA in addressing COVID-19 data integration issues

The Indonesian health system is currently supported by multiple and fragmented applications, databases, and practices, many of which are manually based. COVID-19 requires an integrated approach, and the current fragmentation and disparate sources of data presents several significant challenges. The role of EA is to describe the various aspects of a business namely the interoperability of business process, information systems and technology infrastructure (Ahmad et al. 2020; Kurnia et al. 2020b). EA offers a framework from which to identify and integrate the technological and operational aspects required for effective COVID-19 response. An EA framework allows specific examination of the business, information, application and technology architecture domains and provides, reference models and techniques needed to understand and develop the integrated data, business processes and reporting analytics required of an effective health record management system.

Of greatest importance in any COVID-19 response is access to accurate and timely data which, in turn, provides the management information required for agile and effective health response decisions. A core dimension of any EA is the data architecture. EA provides rigorous structures and standards for managing and integrating otherwise fragmented data, in turn enabling analytical interrogation and supports business process efficiencies, (applications) including contact tracing, response and treatment management. EA also considers the technology infrastructure and provides assurance that the platform will provide for reliability and interoperability.

An adaptation of the EA framework combined with a community-based bottom-up approach to build a health information system has been identified in the OpenHIE (2020). As OpenHIE is already operational in the health sector it provides the logical EA framework for COVID-19 adaptation and deployment.
6 Conclusion and Next Steps

The COVID-19 pandemic has created a health and well-being crisis, and this is an opportune time to adopt EA and revise the National Health Information System to overcome current operational shortfalls. To overcome the challenges identified above, we recommend that the OpenHIE framework be adopted as the architecture framework to address data management, governance, integration, and interoperability issues relating to COVID-19 data (OpenHIE 2020). To adapt the OpenHIE approach, collaboration between communities is needed, which would include all stakeholders i.e., government, community, academia and industry.

In the next stage of our research, we plan to conduct studies in other regions and collect data at different levels of Government to better understand how OpenHIE can address data integration issues. Furthermore, this preliminary study is limited to the Yogyakarta context and some results may not be directly applied and generalized to other regions or levels of Government. Extending the study scope will provide a more comprehensive understanding. For example, investigating data integration flow in cities with the highest case numbers and analyzing the impact of commissioned or proposed IT innovations would enrich the findings of this study and future studies would build understanding of the role of EA in proving solution to the data integration issues.

Through this in-depth case study in Yogyakarta, this paper contributes to the body of knowledge of the extent of the COVID-19 data integration issue, factors contributing to COVID-19 data integration issues and how enterprise architecture can be used to address COVID-19 data integration. At the completion of our research, building upon the OpenHIE framework we expect to develop a practical guideline that can be used by government and relevant practitioners to apply EA principles to enhance current HIS implementations. The ultimate research outcomes are likely to be useful to other developing countries in the Southeast region that have similar social, economic, political, cultural, and technological conditions as those of Indonesia.

7 References


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