Hospital Resource Management Interoperability for Pandemic Management: Research Development

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***Abstract*—Pandemic is a medical disaster that affects almost all countries in the world. The front line for handling this pandemic is none other than the hospital as a service provider and the government as the coordinator. Despite the maximum efforts of each party, gaps are still found between the capacity of medical facilities and the large number of requests for patients. One of the shortcomings observed by the researchers was that there was no information exchange protocol that allowed the government and all participating hospitals to exchange information on the actual availability of resources, which allowed all patients to be directed quickly to health facilities that still had service capacity. This study attempts to design a hospital resource information exchange protocol that can be used to handle the distribution of pandemic patients more quickly and accurately. The research method used is the Expert System Development Life Cycle. The testing conducted with White Box Testing Method which done by the developer. The results of this study are in the form of 3 things, including: 1. Cross-hospital interoperability network topology that can be mediated by the government or certain agents, 2. Standard data structures that can be transmitted via a web service, 3. Standard Operating Procedures that can guide all participants to perform exchange the following resource data with patient distribution.**

Keyword—interoperability, healthcare management, pandemic

I. INTRODUCTION

A pandemic is a situation where an infectious disease spreads on a large scale and is no longer able to be contained effectively. An epidemic condition whose spread can no longer be controlled at the regional level will be declared a pandemic by the international agency WHO (World Health Organization). Handling a pandemic situation involving many countries certainly requires handling efforts that involve cooperation between countries as well. For every country affected by the pandemic, the respective governments must coordinate closely with regard to the count of victims, their status, their location, available resources, the number of patients, patients currently being hospitalized, patients who have been cured, patients who have died, and future predictions of the situation. [14]

Apart from the role of the government and health service providers, mitigating the pandemic situation also requires community participation to minimize the impact of spread through social distancing. According to the latest reports on COVID-19 at the time of writing, almost every country in the world has been affected by the disease. Even though it originated in the city of Wuhan in China, the disease managed to escape from observation due to the lack of preparation and vigilance of the government and the community. Other countries that have failed to prevent the entry of the disease are also responsible for the outbreak of the pandemic within their respective countries, which can be seen from reports that the epicenter of the pandemic can move from one country to another even though they are not geographically adjacent.

In managing this pandemic situation, the hospital can rely on the role of the management information system to be able to identify and manage patient information, whether infected with a pandemic disease or not and organize special resources for handling the pandemic to ensure that all patients received can still be served with the capacity there is. The majority of the information systems available in the field can vary according to the needs and capabilities of the hospital in developing or acquiring them from the party when they are [15].

The information managed by the hospital management information system is very diverse, starting from patient data, employee data, doctors and nurses, data on supporting resources such as laboratory and radiology, drug data and medical devices. The diversity of these resources makes the design of the information system that is implemented also varies between hospitals. This minimizes the chance for some hospitals to be able to establish a coherent suite of data to deal with a pandemic situation. According to the latest report at the time of writing, many hospitals were found that were no longer able to handle the number of requests for pandemic patient care, while several other hospitals were still unemployed pandemic management resources.

This indicates that it is important to have continuous cooperation between hospitals that can be mediated by cross-hospital information system technology that allows them to exchange information about the availability of resources. In the case of Indonesia, efforts to coordinate the handling of pandemic patients have been attempted through the pandemic management task force program by collecting resource data from each participating hospital and manually directing the patient to a referral hospital. Although this step can be considered good, it is not optimal for a pandemic situation where the number of victims and their distribution has

exceeded the management capacity of the appointed task force.

So it is important for researchers to find a method with integrated technology media to facilitate each participating hospital to be able to independently and collectively manage information on the availability of medical resources for handling pandemic situations. This study aims to produce an interoperability design for health service resource information that can be applied generically to general health services and specifically for handling pandemic situations.

II. Literature Review

Several previous studies have tried to involve the integration of information on hospital resources, especially for cases of handling pandemic situations in South Africa. Research sponsored by Dramowski (2020) shows that there are three types of interventions that can be carried out by the government and hospitals, such as: Administrative Intervention, Engineering Intervention, and Protective Equipment Intervention. These findings can help governments and hospitals to be able to implement emergency regulations for handling pandemic situations that can minimize the risk of bad treatment and seek adequate resources by sharing information across hospitals. What is considered still lacking from this study is the absence of concrete guidelines on how best to integrate information across hospitals, which allows them to exchange information about the availability of resources and readiness for handling future pandemic patients.

An example of coordinating the availability of hospital resources for handling a pandemic in Indonesia is carried out by the COVID-19 Handling Task Force which actively collects information from all hospitals designated as referral for pandemic patient services and coordinates patient absorption rates for each of these hospitals, and transferring patient referrals to hospitals that still have service capacity. This effort is also assisted by BPJS Kesehatan (Badan Pelayanan Jaminan Kesehatan) the Social Security Administering Body which is a state-owned company by opening up information on the availability of inpatient beds for patients who need inpatient services. As far as this writing is written, these two instruments are still the mainstay of the government and Indonesian society for handling pandemic victims. Although there have been continued efforts of the government to develop the coordination of hospital information systems, but still ad-hoc or situational which among participating hospitals have not fully implement the integration of information resources independently and autonomous (can not exchange information directly).

III. Research Method

In order to develop a system which may be used for cross-coordinating resources between bodies of organization, particularly in healthcare service, researcher should look for a method which satisfy following characteristics:

1. Allow the development of a system that accommodates cross-organizational coordination
2. Help developer reduce the risk of mismanagement or misconduct by human resources
3. Ease the phases from planning, prototyping, testing and up to release.

According to prior references and consideration, the researcher decided to observe the Expert System Development Life Cycle Method proposed by Agarwal (1990) with following detailed stages:

1. Assessment
   a. Defining the problem
   b. Defining the general purpose and scope of the system
   c. Verifying suitability Expert systems withproblems
2. Knowledge Acquisition
   a. Determine sources of knowledge
   b. Get knowledge related to issues to be discussed
   c. Conduct interviews withexperts
3. Design
   a. Build design concepts
   b. Determine development strategies
   c. Choose development platforms
4. Testing
   a. Perform system simulations
   b. Conduct conformity testing
5. Documentation
   a. Make information structure
   b. guides Make workflow guides
6. Maintenance
   a. Makesystem maintenance manual

A. Assesment

1) Defining the Problem

Setiaji (2014) research findings identified several problems and challenges in implementing healthcare information system in Indonesia which are considerably similar to the observed problems by the researcher on the field, like the following:

- There is a service capacity gap between hospitals designated to serve pandemic patients
- There are hospitals whose patient care requests exceed available capacity
- There are hospitals that has a capacity that exceeds the level of patient service requests
- Patients who fail to find a hospital that can serve do not know how to find an alternative hospital
- Each hospital management cannot know in real time the service capacity of other hospitals
- The task force is formed by the government is overwhelmed in coordinating supply and demand between hospitals and patients

2) Defining research objectives and scope

- Generating a workflow design for data resource integration across hospitals
- Generating an information technology infrastructure design to support integration
- Generating a standard data format for the exchange of hospital resource information

3) Verifying the suitability of the expert system with the problem

According to the Ministry of Health of the Republic of Indonesia (2019), the availability of a database of positive victim information, the number of deaths, patients who are being treated, patients who are under monitoring and quarantine, along with the hospital and all its resources are the means that It is important to support the government in responding to a pandemic and reducing the number of victims. This research is not to ensure the adequacy of information on health facilities for the response to a pandemic, but rather to seek open access to information resources across hospitals to support a better distribution of patient handling burdens.

B. Knowledge Acquisition

1) Determining sources of knowledge

To obtain appropriate study material for this research, it is important for researchers to observe the parties involved in handling a pandemic situation, from strategic to technical levels, such as:

- Previous research on the integration of resource information across hospitals, especially regarding pandemic handling
- The Ministry of Health and its task force and policies.
- Several referral hospitals that are directly involved in the technical handling of pandemic patients.
- Some open source software designs specifically for data integration across organizations, especially in health services

2) Gaining knowledge related to the discussion

- Conducting a literature review to study previous findings about interoperability across hospitals
- Conducting questions and answers with the COVID-19 handling task force and reviewing their SOP (Standard Operational Procedure) documents
- Conducting questions and answers with referral hospital officers directly handle patient administration
- Conduct in-depth review of open source software that provides data integration

3) Conducting interviews with experts

Researchers have tried to communicate with several colleagues of the Ministry of Health and from the results of the conversation it was found that every day at certain hours the officers collect and collect data on the number of victims per day which they can get from hospitals, community health centers, and BPJS Health (Social Security Administering Body). This information is collected to be able to calculate the cumulative number of victims such as how many victims today, how many positive patients today, how many deaths so far, how many patients died per day, how many patients are being hospitalized / quarantined, how many the number of patients who do self-isolation, how many and how many people are being monitored, the identities of all patients who are known to be positive for infection, and family data of patients who may be infected.

Provided with all the raw data, the government can process the available quantitative data to produce information such as the growth trend in the number of positive victims for future predictions, data on the geographic distribution of positive COVID-19 patients, tracking the potential distribution both within the neighborhood and between regions, knowing the ratio of differences between the number of patients recovered and who died, and many other forms of conclusions that can be revealed through data and statistics.

Provided with descriptive and analytical information, the government can be more confident in making decisions such as which regions and community groups should receive special attention, which hospitals should concentrate on aid funds, medical personnel, and all supporting facilities, and other forms of policies that allow reduction. the trend of increasing casualties and reducing the likelihood of positive patients dying. As far as this research has been written, the task force established by the government must manually collect data along with its updates. Current information cannot be obtained in real time.

Researchers have tried to communicate with administrative officers who are responsible for organizing hospital resources, both medical personnel such as doctors and nurses, as well as supporting facilities such as rooms, medical equipment, equipment, medicines, and personal protective equipment. In coordination with the government, the referral hospital must always record and make daily reports about patients, doctors and nurses on duty, resources used, estimated costs that must be billed to patients, insurance, or the government, and all other information that can be used by government and outsiders to channel resource assistance.

For hospitals that have reached their maximum capacity, the government will be notified that the hospital can no longer accommodate additional referral patients and it is hoped that the task force can help these new patients to be directed to other hospitals that still have service capacity, according to the referral hospital list data. that the government owns.

IV. Research Findings

A. Design

1) Building design concepts

To be able to make a good system design, it is important for researchers to identify who are the parties who participate and interact with the system, including:

- Hospitals. In this integrated system design, the hospital will always update the data related to the list of resources they have, the patients that are being treated, and the number and types of resources that are being used for patient care. In addition, the status of the resources that are being used, are in need of repair, are over / under capacity, and others.
- Government. The task force for handling COVID-19 which was formed by the Ministry of Health was given the role and responsibility to provide a

media for collecting data that could be used to coordinate the distribution of patient handling burdens.

Regarding infrastructure design, it is important for all participants and government agencies to agree on what integration platform will be used together in the long term, such as process flows, integration data formats and connection channels that can be used for data transmission. For example, the data format can use JSON / XML, data transmission can use REST / SOAP. Because there are differences in infrastructure design between hospitals, each participant should be free to manage their own information technology infrastructure. The topology of this integration design is:

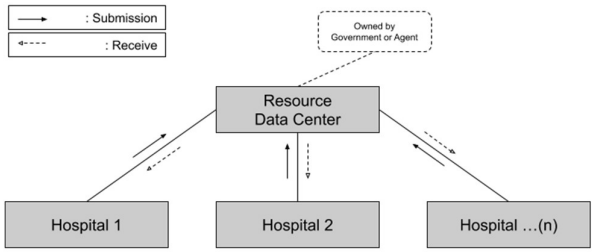

Fig. 1. System Integration Topology

In the chart above we can see an information communication topology design involving all parties who will participate in the integration of cross-hospital data resources. The first party is the government represented by the Ministry of Health or a specific agency that can be assigned responsibility for managing the hospital resource data center. In this case the government must provide a complete server facility with a database where all resource information will be stored. The government can determine its own technology specifications to be used while the choice of technology can support data integration objectives, such as servers, operating systems, databases, programming materials, software, and network providers.

At the bottom of the chart is the interaction scheme of each participating hospital. Each hospital must provide its own technology infrastructure whose specifications can be determined independently according to the hospital's capacity, while being able to support collective data integration. The line connecting each hospital with the data center indicates that each participating hospital must send data updates to the data center to then be managed and informed to all other participating hospitals. With this topology, each participant can know the actual situation of the resources at other hospitals.

Interoperability of information across organizations requires standardization of data formats and structures to be exchanged [10]. This study does not aim to dictate to the government, hospitals, or other parties but rather recommends interoperability designs produced through scientific methods. To be able to produce an ideal information structure, it is important for researchers to identify all elements of information that must be involved regarding resources for handling pandemic patients.

The general hospital resource information is described in the following table:

TABLE I. HOSPITAL RESOURCE INFORMATION ELEMENT INFORMATION

Element	Description
Origin	Is information that indicates the source of resources such as the name of the hospital, hospital code, hospital address, and other additional information
Type	Is information that indicates the general type / category of resources such as rooms, medical devices (ventilator, oxygen cylinder), etc.
Name	Is information that shows the unique identity of these resources such as the name of the room, the name of the bed / ward, the name of the medical device in question, including specifications and brands.
Amount	Is information that shows the quantity of resources in units the smallest number such as the number of beds / wards available and the number of medical devices in the name of the resource.
Status	Is information that shows the factual and actual status of these resources in the hospital such as' used ',' available ',' under repair ',' damaged ', or other status

Provided with knowledge of elements For this information the researcher can compile a standard data structure for exchange in JSON format as follows:

```
{
  "origin": 160014, # Unique code of participating hospitals
  "type": 2, # Reference: 1. Bed / ward, 2. Medical Devices, 3. Other
 "name": "Ventilator", # Can add information on specifications and brands
  "amount": 14, # The smallest number of units of the resource referred to
  "status": 2 # Ref: 1. Available, 2. Used, 3 Repair, 4. Broken, 5. Others
}
```

The design of the above data structure requires consensus between the government as the provider of the data center and all hospital participants, which means that the data design can be changed according to agreement. After the data structure is mutually agreed upon and becomes the standard for exchange, all participants must always follow the standard to maintain consistency in the data that will be exchanged [13].

After designing the infrastructure topology and data structure standards for exchange, the next researcher's task is to design a process flow that can guide all parties involved to carry out interoperability of information resources across hospitals [2]. As previously mentioned, the two groups of parties involved in this interoperability effort are the government as the liaison and temporary coordinator of the hospital as the owner and manager of their respective resources. In this study, researchers will use a Business

Process Management framework to help researchers formulate and design a good process flow.

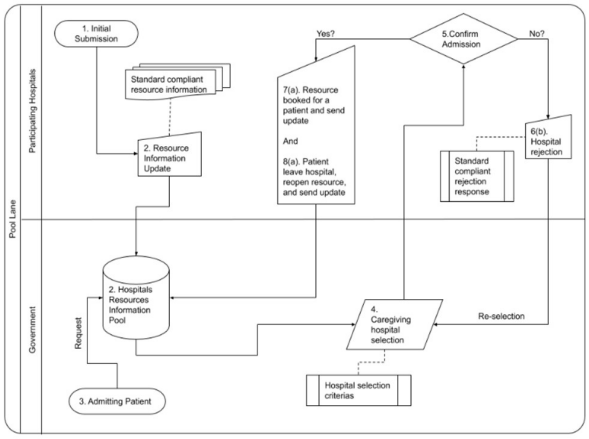

Fig. 2. Interoperability Process Flow of Hospital Information Resources (Riky, 2020)

In the chart above is shown a 'pool' consisting of two 'lanes' represented by the government and the hospital. The details of each step in the process include:

- Initial Submission

Is the initial process in which each participating hospital sends information on the list of resources they have to a data center whose formatting is adjusted to the standards set by consensus beforehand.

- Resource Information Update

It is a process whereby each participating hospital updates their list of resource information to a data center whose format is in accordance with established standards. Partially, the hospital can fill in this information manually, but it is better if it is automated by each information system to ensure that the actuality of data can be maintained while avoiding / reducing the potential for human error.

- Hospital Resource Information Pooling

Is the stage where a central server provided by the government passively collects all initiative submissions or updates sent by each participating hospital. At this stage the data center can send data updating information to all other participating hospitals both passively and actively through mutually agreed data distribution methods, so that the hospital can also know the actual situation of the availability of other hospitals. The government can design its own strategy and visualization software for all the collected data, as well as for each participating hospital.

- Request for Patient Admission

Is the stage where there are newly infected positive patients who need assistance from the government to which hospital these patients should be taken. This patient admission can come from the patient initiative, the health facility, the local level, or from a mass clinical trial conducted by the government on a community group.

- Selection of referral hospital

It is the stage where representatives of the government make the selection of the hospital to which the patient will be directed. The task force established by the government can determine its own screening criteria and priority scale for the best ranking. For example, the selection of a referral hospital for patients who are geographically closest to the patient to be directed. Or choose a hospital based on the level of patient emergency, where more critical patients can be directed to a referral hospital with more complete means of care. The results of the screening and sorting can be used as a basis for consideration by the task force to then send notification of requests for new patient care to several alternative hospitals that the patient will go to.

- Response to service requests

Through a mutually agreed data communication method between the data center system and the hospital, participating hospitals will passively receive notification requests for patient services from the data center and are asked to respond to the patient's admission approval. The organization can independently decide whether to accept these patients or not according to certain criteria that they can determine independently. The branch of the decision is to accept or reject.

- Rejection by the hospital

The hospital can make response decisions with rejection of patients on the basis of certain considerations by sending back request rejection information which can be attached with details such as the date, person in charge, and reasons for rejection. The quick response from the task force coordinator will allow the task force to immediately select an alternative hospital that can handle it.

- Hospital acceptance

Participating hospitals decide to accept requests for new patient care. With this the hospital is ready to receive these patients and updates the list of availability information to be sent to the data center, where the cycle of information dissemination from the data center to all referral hospitals will be repeated and allows each referral hospital to know the changes in the situation of the latest collective resource availability.

Similar to the design of information technology infrastructure and standard data format structures, the design of this process flow is open and can be adjusted according to mutual agreement between the government as the coordinator and each hospital as a participant.

2) Determining a Platform Development Strategy

In order to realize the previously mentioned design, it is important for researchers to determine the information interoperability system development strategy. In this case the researcher tries to make an example of a server-side application that can be used to test the concepts that have been designed. The programming language used by researchers is Javascript, the engine used is NodeJS 18.4.1, the database used is MongoDB, and the interface used to access the application is REST [11]. This server-side application is deliberately designed without a graphical display because it only acts as a web service. The system logic is made simple where there are several lines of code with the CRUD (Create, Read, Update, Delete) function to perform database operations.

B. Simulation and Testing

1) Perform system simulation

Using a simple prototype that the researcher developed independently, the researcher succeeded in exchanging data between the client device and the server via the REST interface. In this case, both government-owned servers as data centers and each hospital-owned server are web services that are connected to each other and free each participant to choose their own platform while the API (Application Programming Interface) used remains REST [12]. Researchers have successfully tested data transmission from the hospital server to the data center and the data center sends data updating information to all other hospital servers that are connected.

2) Conducting a suitability test

The researcher brought the server application prototype to a private hospital in Riau-Indonesia Province to be tested. provided with inpatient room data, medical devices, and other facilities at their disposal, the researchers documented it in JSON (Javascript Object Notation) format and tried to exchange data through the web service of each server. As a result, resource data can be collected on a data center server and distributed on several sample servers on other computers. With this, researchers believe that the design of the hospital resource information interoperability system for handling pandemic situations has been successfully simulated and is feasible to implement.

C. Documentation

1) Making information structure guidelines

Based on the design points described earlier, the researcher has drafted a textual guide on information infrastructure design, information structure standards for interoperability, information exchange process flow, and the design of a web service application example to simulate the data exchange. The total number of manual pages is 12 pages, accompanied by descriptions and illustrated narration.

D. Maintenance

Maintenance of the hospital's resource information interoperability system for handling pandemic situations is a shared responsibility to be designed, developed, managed, and maintained. Carrying out their respective roles in accordance with the agreed rules will ensure that the interoperability system is viable and reliable in the long term and will play a major role in a critical period of a pandemic. Meanwhile, the design, development, management and maintenance of each hospital's web service is the responsibility of each participating hospital, and this study does not attempt to dictate how each hospital's best practices are to do so.

V. CONCLUSION

Starting from the identification of the gap in the availability of resources in several hospitals observed in Indonesia, the researcher concludes that the main problem lies in the lack of opportunities for hospitals to exchange information on the availability of resources in real-time.

There have been several previous studies where the researchers put forward arguments related to the problem of coordinating the availability of hospital resources for handling the pandemic along with managerial solutions. While the researchers here identify that the problem lies in the coordination facilities between hospitals, especially those based on information technology.

Based on the researcher's study of various development research methods, the Expert System Development Life Cycle is the most capable method to help researchers answer these problems. The result of this study is a concept of a hospital resource information exchange protocol that can cover the gap between the availability of service resources and the demand for services at the hospitals involved in the exchange protocol.

The results of this study have been tested for feasibility through the White Box Testing method where the test subjects are software and application developers where the concept can be run. The test results show that the concept can be implemented if each participant in the system agrees on what data structure will be exchanged.

The shortcoming of this research is the lack of Black Box Testing which involves participants from the hospital or the government who can act as a hub in this data exchange concept.

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