In the making of effective decision making in public health domain with business intelligence dashboard

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Abstract. The easy access towards public health information system is one of the most important aspects in improving general health public. Today, people have more privilege to travel than a few decades ago as flight cost is getting cheaper and the economic situation for many people are better. However, this also brought some consequences that disease also easily move from one place to another. Hence, for many countries, it is necessary for many public health institutions to be able to check current health information system in more accurate and can answer problems that often happened. One of the approaches that have been used to improve the readability of public health information is through Business Intelligence (BI). BI allows health administration to get a good quality of information that can help them to decide. BI has its role as a decision support system that is based on collected facts. However, there are still lots of challenges in implementing BI for public health information system that needs to be addressed. In Indonesia, public health data are collected, but then some studies have suggested that data that have been collected just sitting idle in the repository, and have not been used effectively to help health administration managing the public health. We proposed a system that can help health administration to decide what needs to be done to improve the public health. This information is able to help health administration to show problems and allows them to assign priority to improve the overall public health condition.

Keywords — public health information system, business intelligence, decision support system

1. Introduction
In the past decade, Indonesia has seen tremendous adaptation in technology. A survey conducted by APJII [1] showed that more than half of Indonesia population have been connected to the Internet. The growth in the internet adoption also increases what it called as Over-the-top content (OTT) [2] where users are starting to consume many kinds of things over the internet. New technology also plays part in the healthcare section. Public health is an ongoing issue within the technology adoption spectrum that also needs to be tackled down to improve overall healthcare experiences in Indonesia.

Health care institutions in Indonesia are under a pressure to serve public health well. Even though the number of communal diseases such as dengue fever, tuberculosis, and other diseases has decreased, public health communities are continuously seeking ways to make sure that information is deployed efficiently to improve the quality of patient care. Information in public health is considered to be a very essential in helping authorities to get better approaches [3]. Most importantly, decision-making in public health field requires the timely availability of valid and sound data [4].
Many public health organisations in Indonesia have already implemented information system that records data and information. However, in many occasions, even though the data are in comprehensive collections, but they are only in a raw data form without any specific pattern that users are able to interpret them easily. It is quite often that data is presented in a complex, fragmented, and do not portray a representative look to needs. Other than that, some inconsistencies are often found in how the report is organized and how it affects the availability of valid and consistent data or information [5]. This chaotic organization of public health data will lead to a new level of difficulty for those who have the responsibility to make the decision in public health organizations [6].

Timely and accurate data has an important role as the foundation of the knowledge base for health information system [7]. The knowledge will be used as the source of decision making where the best decision is formed when all relevant data are considered well. One of the technology that is capable to transform data into information that can help decision making process is data warehouse [8]. A data warehouse is a process to extract data periodically and transform them into a certain format and then inserted into a central data storage to create a business intelligence (BI) information system. This data warehouse will be the source of information in a form of ad-hoc report, portal, or a dashboard [9].

The concept of BI has attracted many healthcare organizations and professionals. BI that uses data warehouse approach has been used in many businesses and industries to analyze the data within certain time frame [6]. Recently, data warehouse is generating traction as today information is presented in a more attractive form that is easier to read e.g. via charts and diagrams [10]. Hence, it also makes sense that public health field also uses data warehouse approach to make health data easily accessible in a more effective and efficient ways.

In this paper, we present a practical solution in presenting public health data in community health centre in one of districts in Yogyakarta, Indonesia. The dashboard provides information on national health with the source of the data has been transformed with certain schemes. This dashboard is presented in a way to improve the performance, effectiveness, and the efficiency of public health management.

2. Related Literatures

2.1. Overview of Business Intelligence
With the emerging of Big Data, BI has reserve itself in a nice spot of information technology field [11]. BI itself is a tool that has been used by organizations to make a better understanding of how the activities found from raw data behave, how they run, etc. [12]. BI incorporates many categories of methodologies, applications, and technologies by providing them with an easy interface for faster and more accurate business decisions. BI is often considered as the natural successor of Decision Support System (DSS) as it provides similar results from a DSS [13], but with one very distinguished difference which is unstructured data sources. Traditional DSS have limitations with unstructured data sources while BI do well on both structured and unstructured data sources [5], [14].

In the context of public health, BI needs to be introduced as part of improvement effort in healthcare information system [6]. While information system implementation in other fields has reached a mature level, public health information system is often in opposite place. It is found that healthcare information system unsuccessfulness is impeded by the fact that underlying data that construct the information system is not well structured. BI has been seen as a new and useful technology with their ability to help decision makers in healthcare organizations to make better decisions. BI works by extracting set of data and store them in a system called data warehouse. During extraction process, data is transformed and simplified with techniques according to the need of business analysis. The transformation leads to pattern and behavior of the processed data. BI extracts the data sources and presents working data, transactional data, or others into knowledge and has the ability putting the right information at the right time to support decision-making process and to achieve the vision of the organization.

The results of the transformation and simplification are then presented to end users especially those who have the responsibilities to make the decision. The decision is no longer based on intuition and
quantitative experiences which often found in many organizations [15], but based on the facts data [16]. BI works by incorporating these steps:

- Identify business problems that need to be tackled with data warehouse and decide which data is needed [17]
- Transform the data from multiple sources into consistent format [18]
- Retrieve the transformed data from centralized database and insert them to data warehouse [19]
- Create systems or applications that will query or analyze transformed data e.g. with online analytical processing (OLAP) [20]
- Visualize the results [21]

3. Methods

3.1. Data Source

Our study uses data from community health centre, at Puskesmas Tempel II, Sleman, Yogyakarta. The information system used by the community health centre collects many kinds of data such as patients’ medical records, mothers and babies’ health care, etc.

3.2. System Design

In order to have a good outcome of the system, we design our system first with use case diagram, database design, and interface design. Figure 1 shows a use case diagram (in Bahasa Indonesia) which define how users interact with the system. The scenario is, once a user logged in the system, this user will be able to use all information, able to drill-down each report, and can download the raw tables.

![Use Case Diagram](image)

**Figure 1. Use Case Diagram**

3.3. ETL (Extract, Transform, Load)

ETL is a set of process that related with a way to fetch the data from its sources as presented in Figure 2, which then will be transformed before it then being loaded into data warehouse. Once the data is loaded into the data warehouse, BI tools will use them as needed. An example of ETL is merging two tables or more to create calculation of their aggregates. Varcellis [22] explains the detail of ETL process, and those are:

- **Extraction**
  Extraction is a cleaning up process for data that is gathered from homogenous or heterogeneous sources which then being extracted to make the structures or the patterns of the expected information from data.
- **Transformation**
  Transformation is a process to select, clean up, and add more attributes so that the data that has been extracted can be loaded according to the correct format or after the data warehouse structure.

- **Load**
  Load is a process to insert data into data warehouse after being processed in transformation phase. After the data is formatted and structured according to the structure set in the data warehouse, the loading process begins. Data came from staging area will be moved to the pre-defined site in data warehouse.

![ETL Process](image)

**Figure 2.** ETL Process

### 4. Results

#### 4.1. Data Warehouse Architecture

Our data warehouse architecture has the characteristics of object-oriented, integrated, has time variance, and non-volatile (once data is loaded, it’s permanent). We use top-down methods where the process is started with data collection from the data sources. Once the data is collected, it will be loaded in staging area (a temporary storage) so that data can be customized and then we generate a sequence of data before being processed and loaded to data warehouse [8] as presented in Figure 3.

![Data Warehouse Architecture](image)

**Figure 3.** Data Warehouse Architecture

#### 4.2. Data Warehouse Consolidation

Data warehouse consolidation is our effort to cluster data. The consolidation part is designed using OLAP technique that will explain the content of fact table and dimension table from the data sources. There are four fact tables and 23-dimension tables and each of fact tables is created with OLAP Cube.
techniques. We then assign each four fact tables with few of 23-dimension tables. We use the OLAP Cube techniques to show data in a multi-dimensional form. The OLAP uses star-scheme against 4 fact tables. Once all tables are consolidated, the system then creates a BI dashboard that uses data from the data warehouse. The user who logged into the system will be able to read the information from our prepared scheme in the BI dashboard.

### 4.3. BI Dashboard

The dashboard presents all facts designed in the OLAP i.e. facts on staffs’ load, mothers and babies health data, geographical mapping of the patients, patient’s trend, public health screening, etc. In Figure 4 (shown in Bahasa Indonesia), we present how the community health centre targeting surrounding community to have their own initiative in improving health-aware environment. It shows the target, and the achievement so far. From the figure, it was found out that smoking inside a house is commonly found. Hence, the community health centre can decide that they should aim more to alleviate the smoking inside a house problem. Figure 5 presents mother and babies health data. One of the information that can be concluded is that the number of mothers who has been vaccinated with Tetanus Toxoid (TT) vaccine is still low. This can pose serious problem in the future.

![Community Improvement Public Health](image)

Figure 6 provides information on where are the patients from. This information is really important for community health-centre decision makers. They can see where are the blank spot of the patients, where they can promote more. Figure 7 presents staffs’ load distribution. This can help management people to decide how the organization is going to be run.

All facts are presented as in those above dashboards (not all are shown here due to page limitation of the paper). All information is shown in a form of pie charts, maps, bar diagrams, and others which can help decision makers to decide and set strategy for future development and set up priority for public health in the district.
5. Conclusion
We have successfully created a BI system that complement a public health information system. As all information is now presented in a graph and chart form along with simple and short analysis, people who have responsibilities on public health decision making will have a better understanding on how public health in Indonesia is running. Charts are easier to read than tables. Moreover, we no longer see the unstructured data, instead user is presented with nice and sleek graphics which even allow user to understand of what is happening in the public health field at a glance. Difficulties to understand how public health run in the district of Tempel, Yogyakarta, is gone. BI technology serves as an assisting
framework in decision making process. Hence a right approach in timely manner is expected with the use of BI systems. Our study is without limitation. The system needs to enrich itself by incorporating from multiple related sources. The national bureau of statistics actually provides private data that is more comprehensive than its public version. We also preparing our system to be able to look up for disease trajectory. This will be particularly very important to prevent the disease from spreading further or to prevent it from happening as we can learn the pattern from collected data in the past.

Acknowledgment
Authors would like to thank the Ministry of Research and Higher Education for the generous support in the research funding.

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