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Dashboarding the maternal and child health profiles for health supporting system

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Abstract. Various types of health data are routinely collected and published as national health profiles. However, these vast amounts of data are not always used effectively since they are presented in raw tabular data sets, fragmented, and are not well-equipped with the statistical data inferences and the trend of changes which are essential to explore some unknown previous information. In this paper, we propose how to manage the national open health data sets as a dashboard application to support the decision making for maternal and child health-care services in Indonesia. The research was conducted in four steps. First, we described what maternal and child health parameters are involved in relation to the availability of open and accessible data set. Second, we designed the dashboard application based on Kimball's four step dimensional modelling. Third, we implemented the schema modelling as data warehouse by executing ETL (extract, transform and load) and OLAP (On Line Analytical Processing) cubes. Fourth, we analyzed the results with the business intelligence approach. We explored the open data sets in four consecutive years (2014-2017) and determined seven types of business process, i.e. analysis of health profile on neonates, infants, and children, analysis of maternal health profile before, during and after pregnancy period, and analysis of health supporting factors. By applying data warehouse and business intelligence, our proposed system has the ability to integrate and extract a number of tabular and fragmented data sets into an easy and quickly inferred information about the current situation of maternal and children health care services.

1. Introduction

Maternal and child health are still a major problem in Indonesia [1][2]. This is indicated by the level of Maternal Mortality Rates (MMR) and Infant Mortality Rates (IMR), which are still far below the target of Sustainable Development Goals (SDG)[3]. SDG is an international agreement among countries aiming for joint development by 2030. In 2015, it is recorded that MMR in Indonesia was 305 per hundred thousand live births and the IMR was 23 per thousand live births [1][3]. This rate still highly exceeds the maximum set by SDGs of 70 per hundred thousand live births, with the neonatal mortality rate of 12 per thousand live births, and the under-five mortality rate of 25 per thousand live births [4].

On this account, it is necessary to explore and analyze maternal and child health profiles in accordance with the current trends in maternal and child health issues in Indonesia [2][3][5]. Several studies have shown the importance of exploring the maternal and child health data sets, such as to identify the impact of measles vaccination on the prevention of pneumonia [6] and to find the relationship of maternal health services to neonatal mortality rates [7][8]. Profiling these data sets may

also improve the health care environment and aid the government in budgeting and allocating finance and planning a better health system [9]. At the global level, exploration of these data sets may reveal the different quality of basic service between the public and private health facilities [10][11] and also show the health service gaps among districts in one country [12].

Annually, the Indonesian Ministry of Health publishes the national health profile which is open and accessible for anyone. This profile presents a comprehensive collection of health situation and condition from all 34 provinces in Indonesia, including a variety of data of maternal and children health care. A vast amount of health care data continued to be collected but these are not always used effectively due to its presentation technique. Data are published as raw tabular data sets, fragmented, and not yet equipped with the statistical data inferences and the changing trend. There are also some inconsistencies in how data are organized which were triggered by the incomplete and the poor quality of routinely collected data [7]. As a result, information that is needed by the decision makers to determine the direction of public health service policy has not been presented in an interpretable form. Hence, it is necessary to create a system capable of converging various types of health care data into meaningful information and presenting them in an appropriate and understandable mode. To achieve this, we propose a dashboard system for exploring the children and maternal health profiles. A dashboard aims to provide intense information to assist policy makers in recognizing and addressing maternal and children health problems and also to identify which parameters that require quick action to avoid adverse outcomes [13].

2. Literature Review

In this section, we elaborate a literature review in some existing dashboard systems, including dashboard system in maternal domain, in order to highlight the advantages of dashboard system as a decision support solution. Moreover, by doing so, it clarifies the contribution of our research in the area.

Dashboard has been widely used to give high supports in organizations' management. A dashboard allows simple, comprehensive, and interactive performance management. It also promotes continuous improvement in productive areas [15]. In [16], the developed dashboard provides real-time information on Emergency Department (ED) crowding, where the information given enables ED staff to judge whether corrective actions are required in an effort to avoid the adverse effects. The representation of the status of the entire ED and internal patients, allows providers to make more appropriate decisions. This will improved the awareness of the situation and allows rapid intervention when pre-determined care targets are not met and when a specific patient's status changes [17]. A novel concept on medical dashboard system called BESTBoard has been introduced [18]. The system is developed to cope with the user requirements at hospital ward, ICU, and ER. The system has been proven to be feasible and useful in delivering health information to healthcare professionals.

Getting more specific into the context of maternity dashboard, the Royal College of Obstetricians and Gynecologist (RCOG) in UK endorses an adoption of maternity dashboard in order to provide a local quality assurance system [19]. The dashboard helps to monitor outcomes on a monthly basis by comparing the observed outcomes with the pre-determined gold standards (i.e. goals) in three groups of parameters: activity; workload; and quality [13]. Moreover, it has been evaluated in term of its effectiveness, where it could improve clinical care, recognize good clinical care, disseminate information, and engages multidisciplinary team [13].

Our proposed system is developed with the spirit of getting the advantages of dashboard system in supporting organizational decision making. It is empowered by business intelligent engine. Our dashboard system is not only served as maternity/maternal dashboard, but also include children health profiles. Both information becomes a set of health monitoring system standard in Indonesia. Moreover, the parameter in the dashboard is specified based on the Indonesian's Ministry of Health guidance.

3. Methodology

The development of maternal and children health care dashboard is conducted on four activities as seen in figure 1. These activities include screening data sets, designing dimensional model, implementing data warehouse, and implementing business intelligence technology.
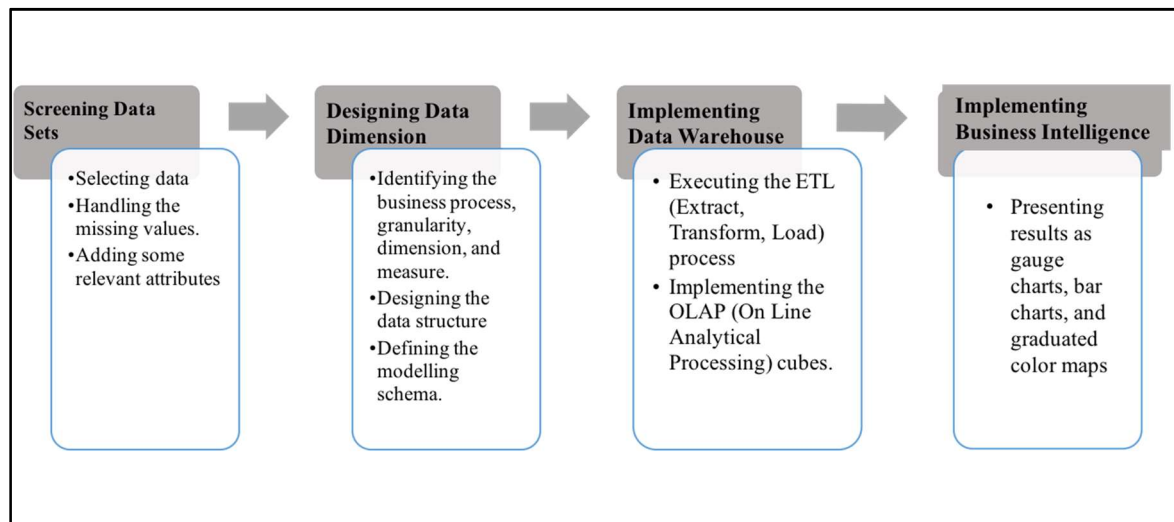

Figure 1. Four step of research methodology

3.1. Screening Data Sets

Data used in this paper was derived from the official website of the Ministry of Health's Data and Information Center, http://depkes.go.id. Data were displayed in tabular format and distributed as an open document, namely as Indonesia Health Profiles. An initial observation of health profiles in the last four consecutive years, 2014 – 2017, revealed some inconsistencies and incomplete of data reports. By applying a manual data screening, we found eight types of data in the section of family health that are consistently presented and in accordance with the Minimum Service Standard indicators set by the Health Minister's regulation in 2008 as shown by Table 1.

Table 1. Family Health Data Sets.

Nr	Main Theme	Supporting Data Set
1	Neonates visits	Two types of neonates visits, namely the first and the complete visits.
2	Vaccination for infants	Five types of compulsory vaccination on infants, namely BCG, Measles, Polio, DPT/HB1, and DPT/HB3.
3	Infectious diseases on children	Four types of infectious diseases on children, namely pneumonia, lepers, measles, and diphtheria.
4	Vaccination for fertile women	Five times of Tetanus Toxoid (TT) vaccination for childbearing women and two times of TT vaccination on pregnant women.
5	Maternity health service	Childbirth be assisted by trained health personnel and performed at at health-care facilities
6	Antenatal care	Two types of antenatal care, namely the first and the complete visits during pregnancy period.
7	Postpartum service	Midwifery complications and postpartum visits.
8	Family planning	Family planning participant and contraceptives users.

Data screening has also been done for data transformation by changing the initial data type that is a portable data format (pdf) to comma separated values (csv). The csv formats facilitate the data importing process and is compatible to be accessed by server machines. Another data pre-processing

has also been performed by adding a relevant attribute of the island for each data and handling some missing values.

3.2. Designing Dimensional Model

Data management with integrity and consistency design is the key to generate reliable information. To get an optimum database structure, we mapped these data sets by following Kimball's four step dimensional design which consist of [14]: (a) business process as a specific target of operational activities, (b) granularity as low level of data that determine the depth of query detail that will be executed in a data warehouse, (c) dimension tables as collection of attributes that share similar entities and are used to filter and group the facts, and (d) fact table that store the measurement of business process event and is presented as numeric data types.

The business process is determined based on the main data categorization. We identified that data can be categorized into seven themes, i.e. health care on neonates, health care on infants, health care on children, health care on prenatal, health care on pregnant women, health care on post-pregnancy period, and supporting factor such as medical personnel and health facilities. Each business process is having a granularity in provincial level as the lowest level of data presentation. Furthermore, one business process may have a number of dimension tables. On the contrary, one business process may only have one fact table which store several measurable values. This research involves 31 types of dimension tables and 34 types of measurement values. The summary of dimensional model based on Kimball's design is presented in Table 2.

3.3. Implementing Data Warehouse

The development of data warehouse involves two activities, namely ETL (Extract, Transform, Load) and OLAP (On Line Analytical Processing). ETL works as a back-end room to integrate various data sets, while OLAP cubes works as a front-end room that enable users to perform queries [14]. The ETL process consists of three activities, i.e. retrieving data from the data source (extract), converting the obtained data set into a consistent data format (transform), and sending these formatted data set into a centralized data storage (load). The ETL process was done using Microsoft SQL Server Integration Services (SSIS). The OLAP cubes consists of four activities, i.e. defining the cubes dimensions, defining measure attributes, defining dimension hierarchy, and defining the relationship between dimensions and cubes. OLAP cubes were implemented using Microsoft SQL Server Analysis Services (SSAS).

3.4. Implementing Business Intelligence

Business Intelligence (BI) is an extraction process on a set of operational data and collected it in a data warehouse. During the extraction process, data can be transformed with various techniques in accordance with the interest of business analysis. This research applies three types of data analysis, i.e. (a) descriptive as a method to describes the tabular data in accordance with the characteristics of data, (b) comparative as a method to describe data by comparing data between regions or with specific targets, (c) tendency as a method to describe data by comparing data over time in a fairly long period. Eventually, the BI implementation was done by using Microsoft Power Business Intelligence, a proprietary software for data analysis and reporting. This tool has also been integrated with SQL Server for data processing.

4. Results and Discussion

Dashboard has been implemented to provide information in effective and efficient mode. The result of data analysis is presented into multiple data visualizations, such as graphics, charts, and maps. These analyses are arranged and put in a single screen that enables the delivery of important information in a quick and easy access. It consists of three main information, namely maternal health profiles, children health profiles, and health supporting factor profiles.

Table 2. Dimensional Model Design.

Nr	Business Process	Granularity	Dimension	Measure
1	Analysis of health care on neonates	Coverage of neonates visit for each province	Neonates visit; Baby born alive.	First neonates visit. Complete neonates visit.
2	Analysis of health care on infants	Coverage of infant vaccination for each province	Basic vaccinationn; Complete vaccination; Universal Coverage Vaccination (UCI) villages; Baby born alive; Number of villages.	Percentage of five types basic vaccination, i.e. BCG, Measles, Polio, DPT/HB1, and DPT/HB3. Percentage of complete vaccination. Percentage of UCI villages.
3	Analysis of health care on children	Coverage of infectious diseases on children for each province	Pneumonia realization; Pneumonia target; New lepers; Lepers in children; Measles sufferers in children; Vaccinated measles on children; Diphtheria sufferers in children; Vaccinated diphtheria in children.	Percentage of pneumonia in infants. Proportion of leprosy defects level 1 and level 2 in children. Percentage of measles vaccination on group age of less than 1 year, 1-4 year, 5-9 year, and 10-14 year old. Percentage of diphtheria vaccination on group age of less than 1 year, 1-4 year, 5-9 year, and 10-14 year old.
4	Analysis of health care on prenatal	Coverage of vaccination for child-bearing women for each province	Tetanus Toxoid (TT) vaccination; Childbearing women.	Percentage of five types TT vaccination on child-bearing women, i.e. TT1, TT2, TT3, TT4, and TT5.
5	Analysis of health care during pregnancy period	Coverage of pregnant and postpartum services for each province	Tetanus Toxoid (TT) vaccination; Antenatal care; Child-birth; Postpartum visit; Obstetric complication; Pregnant women; Postpartum mother; Delivery mother.	Percentage of TT1 and TT2 on pregnant women. Percentage of first antenatal care. Percentage of complete antenatal care. Percentage of delivery at health-care facilities. Percentage of obstetric complications. Percentage of complete postpartum visit.
6	Analysis of health care on post-pregnancy period	Coverage of family planning program for each province	Family planning participants; Active contraceptives users; New contraceptives user; Couples of childbearing age.	Percentage of new participant of family planning program. Percentage of active participant of family planning program. Percentage contraceptives users of condom, injection, pill, implant, MOW, MOP, and IUD.
7	Analysis of health supporting factors	Coverage of health facilities and health personnel for each province	Health facilities; Health personnel; General populations.	Ratio of hospital and community health centers per 30,000 populations. Ratio of doctors, nurses and midwives per 100,000 populations.

4.1. Dashboard of Maternal Health Profiles
The maternal health profiles are summarized as Key Performance Indicator (KPI). There are 11 parameters are involved, i.e. coverage of first antenatal care, coverage of complete antenatal care,

coverage of TT Level 1 vaccination on pregnant women, coverage of TT level 2 vaccination for pregnant women, coverage of delivery at health facilities, coverage of postpartum visits, coverage of obstetric complications, coverage of new family planning participant, coverage of active family planning participant, coverage of TT level 1 vaccination on childbearing women, and coverage of TT level 5 vaccination on childbearing women.

To provide brief information, KPI is equipped with the traffic light colors associated with the level of parameter's achievement. Some parameters may have the national target, while others may not. However, we have set the upper and lower threshold for those without the national target. In this regard, green color indicates that goals have been met, yellow color indicates that the goals are not met but still within the upper threshold, and red color indicates that the lower threshold is violated. If the parameter is alerted as red, it means that there is a problem requiring a quick action. Meanwhile, the yellow color is a signal that some appropriate actions are needed as prevention prior to entering the red area.

As seen on figure 2, of these 11 parameters, only one parameter has performance above the national target that is coverage of active family planning participants. Meanwhile, there are five parameters are marked in red, i.e. coverage of TT vaccination level 1 and level 2 for the pregnant women, coverage of TT vaccination level 1 and level 5 for the child-bearing women, and coverage of new family planning participants.

One of the causes of maternal death and infant death is tetanus infection as a result of an unsafe childbirth process or from injuries obtained by pregnant women before delivery. To prevent tetanus infection, women of childbearing age are required to get five types of Tetanus Toxoid (TT) vaccination, i.e. TT level 1 to TT level 5, before she gets into the pregnancy period. TT vaccination is also given to pregnant women for two times, i.e. in the first and the second trimesters (TT1 and TT2). In this research, we found that coverage of TT vaccination level 1 for the pregnant women should receive more attention since the national average achievement is far below the national target, i.e. 19.25% of 85.35%.

A further analysis, i.e. comparative and tendency, of each parameter can be found on the coverage of active family planning participant based on the contraceptive method. As seen on figure 3, there is a comparison of contraceptive uses. Both active and new participant choose injection as the contraceptive method. Meanwhile, the tendency analysis can be found on the new family planning participant in the four years which present a similar trend of participant number from 2014 to 2015, which ranged from 75%. However, the number dropped in 2017 to 55%.
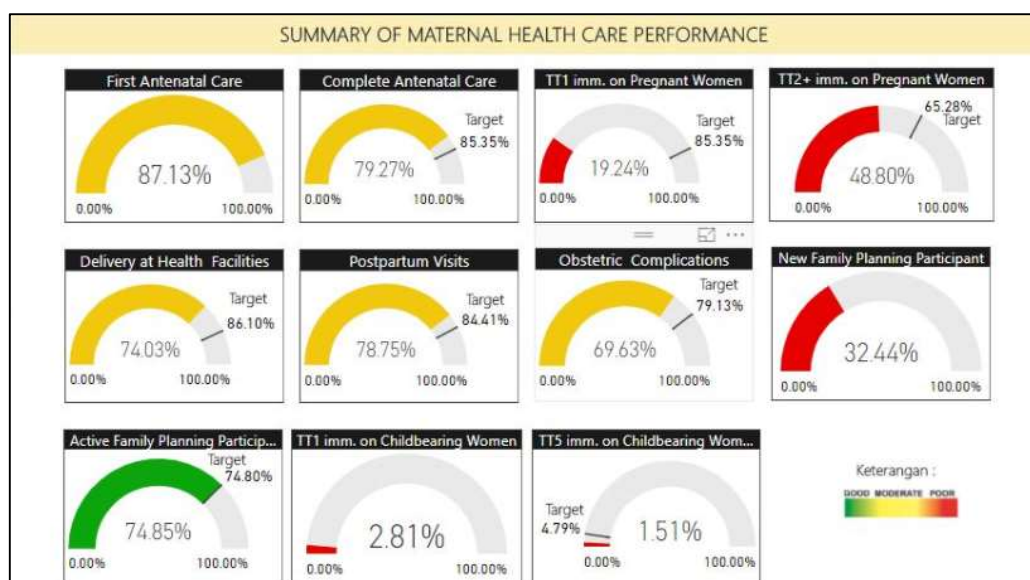

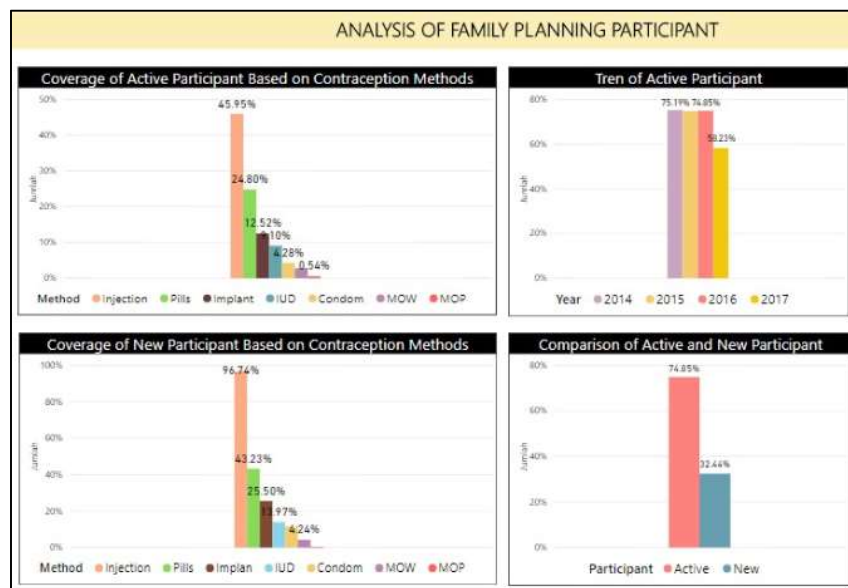**Figure 2.** Summary of maternal health performance

Figure 3. Comparative and analysis on family planning program

4.2. Dashboard of Children Health Profiles

The children health profiles are distributed into 12 parameters. It comprises coverage of five types of basic compulsory vaccination for infants, i.e. BCG, measles, DPT/HB1, DPT/HB3, and polio, coverage complete compulsory vaccination on infants, coverage of leprosy defect, the Universal Coverage Vaccination (UCI) for villages, coverage of vaccinated measles, coverage of vaccinated diphtheria, coverage of pneumonia findings, and coverage of first neonates visit.

As seen in figure 4, the summary of these 12 parameters shows that only two parameters that have performance above the national target, i.e. coverage of leprosy defects and coverage of UCI villages. Meanwhile, there are two parameters are marked as red, i.e. the proportion of measles vaccinated against measles findings and coverage of pneumonia findings.
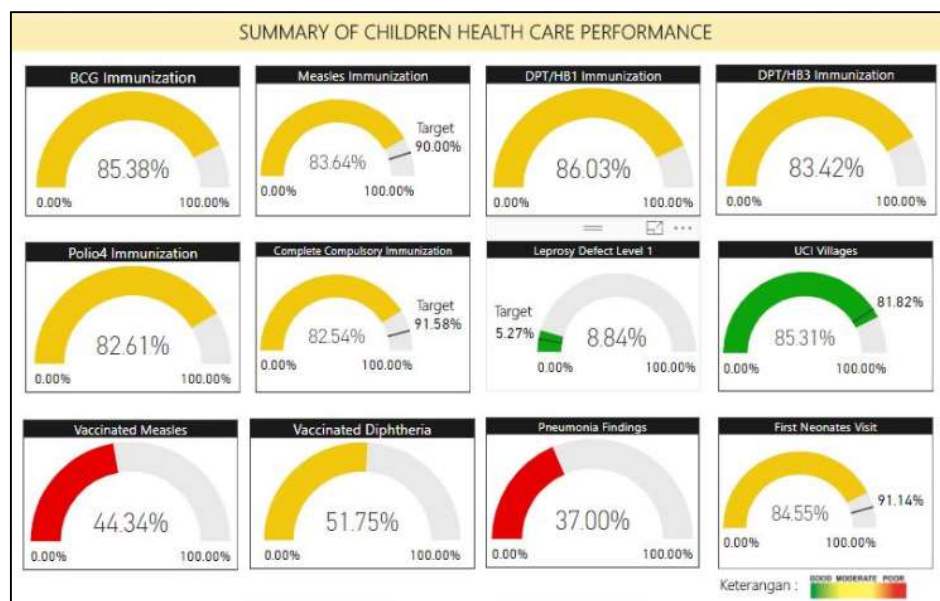

Figure 4. Summary of children health performance

The proportion of measles vaccination against measles findings can be explored further using the comparative analysis. It is based on the island and provincial entities as shown by figure 5. It is illustrated that among children aged 0 to 14 years, the highest proportion is found in Sumatra Island with the rate of 57.86% and the lowest proportion is found in Papua Maluku Island with the rate of 17.29%. However, this information only covers 24 of 34 provinces in Indonesia due to incomplete raw data set. For example, there is no data of measles findings for 3 of 4 provinces which belong to Papua Maluku Island. Therefore, comparison of the measles proportion rate based on island becomes invalid and unreliable information. On the other side, there is inferred information that can be drawn based on the comparative rates among the provinces. As seen on figure 5, there are 9 of 24 provinces (37.5%) are identified for having the proportion rate of more than 50%.
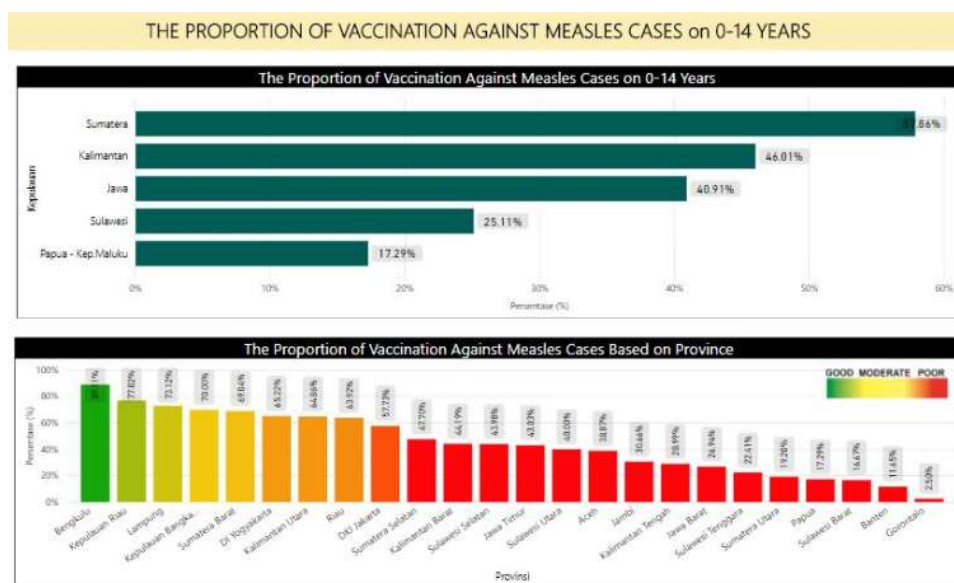

Figure 5. The comparative analysis of measles cases

4.3. Dashboard of Supporting Health Factors

The health support factor consists of five parameters, namely ratio of doctors per 100,000 population, nurse ratio per 100,000 population, midwife ratio per 100,000 population, hospital ratio per 30,000 population, and ratio of community health center per 30,000 population. Similar to the previous summary information, these parameters were also delivered as KPI to describe the current achievement. As can be seen on figure. 6, none of these supporting factors are able to achieve the national target. Nationally, the lowest performance belonged to the doctor's ratio of 19.86 from a target of 45 doctors per 100,000 population. It is also necessary to consider the ratio of midwife since its performance is still far from the target, i.e. 79.84 from 120 midwifes per 100,000 populations.

To illustrate the ratio distribution, we use a map as another visualization technique. This map consists of graded colors to highlight the health parameter performance. For example, we took the distribution of midwifes ratio for all 34 provinces. As seen on figure 7, most of Indonesia's territory is dominated by red color which indicates the low ratio of midwives to the number of population.

In general, we can state that this maternal and child health dashboard has a number of positive impacts, such as to aid the governments, both at central and regional levels, in identifying the health parameters with poor performance so as to determine the placement of health personnel and the development of health facilities can be determined more precisely. In addition, this application can also be an input for decision makers to define the priorities and the direction of health care policies for the community. In the end, government helped to identify what programs needs to better improved so that the quality of maternal and child health services can be better.
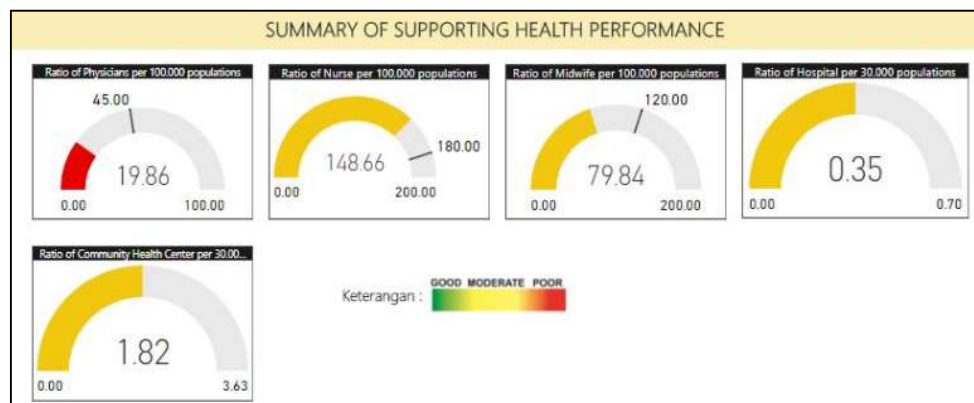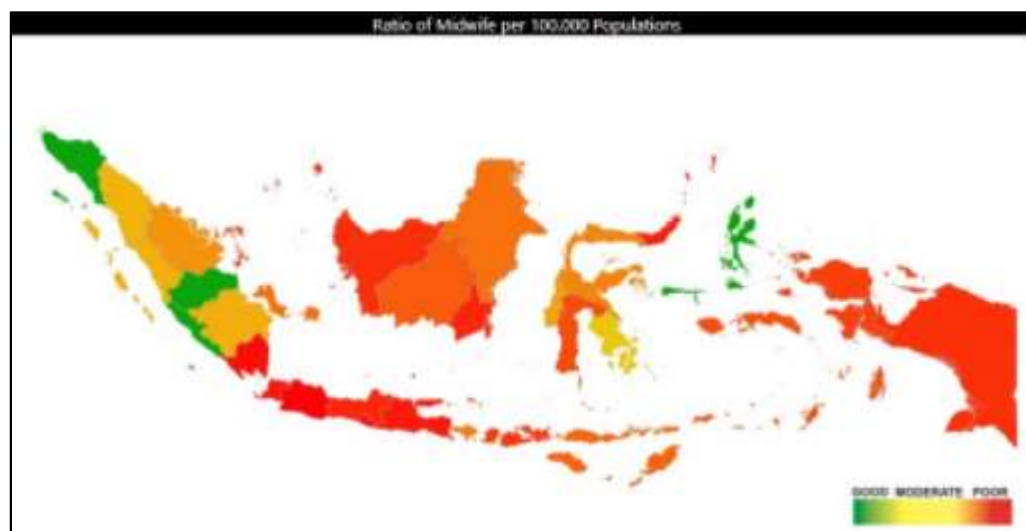
Figure 6. Summary of health supporting performance

Figure 7. Distribution of midwives ratio as graded map

5. Conclusions

Based on the implementation of maternal and children health profile dashboard, there are several conclusions that can be drawn as follows:

- The research shows that the implementation of data warehouse and business intelligence as a dashboard application able to integrate and extract a number of fragmented data sets into an easy and quickly inferred information about the current situation of mother and child health care service.

- By applying an online analysis technology and several visualization techniques, our system has been able to recognize parameters and provincial entities that need performance improvement to conform the national standards of maternal and child health care services. We identify that child health services in Indonesia have seen a better performance than the maternal ones. Particularly in the provincial analysis level, we found that most provinces in eastern part of Indonesia have health service performances under the national standard.

- This research has applied a common data analysis method which have some limitations to extract new insight in the data set. Hence for the future studies, we recommend an expansion and deeper analysis of maternal and children health data set by applying some data mining techniques, such as associations to identify the rules for combining a number of health

parameters, clustering algorithm to understand the health condition in the past, and classification method to predict the future health events.

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