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USING DATA WAREHOUSE TO MANAGE HEALTH FACILITY DATA

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Abstract:

Managing a complete master list of public health facility data is deemed important in coordinating and planning of health services and achieving better service delivery. The master lists allow stakeholders to share a uniform operational health services data and ensuring availability and reliable data. This will able to support and manage patients clinical data and other health management services such as disease monitoring, facility management and monitoring service performance. However, most health facilities do not have accurate and informed data, this can affect monitoring of infrastructure and services provided. Various facilities have multiple and redundant lists of health data, the lists differ not only in the information they contain but also in the way they are named and identified. Existing studies state that the development of health facility registries store information mostly using conventional two-dimensional table methods or relational databases as in the case at the Health Informatics Center (HIC), Ministry of Health Malaysia. Hence, they faces the challenges in managing the data since it contains diverse data sources, the absence of uniform data standards and the dependence on manual processes and human intervention. To overcome the current problems, a dimensional modeling technique has been developed in an effort to design a Health Facility Data Warehouse. The proposed design of the data warehouse has been verified by the expert and they agrees that it is suitable for HIC to manage information related to health facilities due to its ability to deal with data sources, able to generate strategic information, as well as the ability to obtain a historical view of facility data. This study shows dimensional modeling techniques are effective in analyzing and designing data warehouse and can be a possible method in managing the master list of health facilities in Malaysia as well as other countries.

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Master List of Health Facility, Data Warehouse Design, Dimensional Modeling

Introduction

A health facility is a place that provides health care services. These facilities include hospitals, clinics, out-patient care centers and others. Health facilities are physical entities where health services are delivered to the general public, making them an important data collection point. These physical entities represent a standard list of health facilities or often called a Master List of Health Facilities (MLHF). This list is a complete listing of both public and private health facilities information in the country. The World Health Organization (USAID & WHO, 2018) defines the MLHF as "a complete, up-to-date and authoritative list of health facilities for a country". The list normally provides

- Information on health facilities based on location, the level of facilities, the ownership, the status of functionality and services provided
- The unique identification code of health facilities and administrative units that can be used as a single reference to the stakeholders and users
- To guide effective planning for equitable distribution of resources (services, staffing, rational distribution of medicines and supplies, and access to the facilities)

In Malaysia, various health information systems have been developed to meet the needs of health management information (Mohamad, 2022). The diversity of these systems requires a consistent MLHF in order to guarantee interoperability between the information systems in the Ministry of Health (MOH) Malaysia. USAID and WHO (2018) said that this MLHF is seen as one of the basic layers in the Health Information Exchange that enables the interoperability of health information systems. However, many countries do not have accurate and informed data on their health facilities. The facilities differ not only in the information they contain but also in the way they are named and identified. Therefore, the need to uniquely identify health facilities in the country is of paramount importance for better health service delivery (Mishran & Sahay, 2020). This can facilitate effective monitoring of infrastructure development and services provided to the increasing population.

At the MOH Malaysia, the preparation of a MLHF relies heavily on manual processes in terms of providing data sources as well as data collection at the central level. However, conventional solutions for creating MLHF tend to use two-dimensional tables or relational databases that are difficult to meet the complexity of the information requirements and dealing with complex data sources. The information commonly included in the MLHF is available in different data sources, where some are stored in databases while others are in the form of flat files. In the context of the diversity of data sources and formats, the data warehousing techniques should be adapted and considered for better decision making. Hence, a study of the implementation of data warehousing techniques should be done considering the increased accessibility of information from various sources and the ability to collect historical data are among the advantages offered by data warehouse techniques (Jameel et al., 2022). However, the challenges are in designing the data warehouse process for the MLHF.

Previous studies on the development of the MLHF generally produce a database in the form of a flat file or relational database as an output that may lead to various problems such as data

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redundancy, data inconsistency, query processing and others. Finding solutions to overcome these problems become the motivation of this paper. Therefore the aim of this paper is to develop the design of the Health Facility Data Warehouse for the MOH Malaysia.

The Importance of Master List Health Facilities

The existence of a MLHF in a country can bring many benefits to various parties involved in the entire healthcare industry. This includes health authorities, insurance service providers, researchers, and also the members of the public who need to access health services at these facilities. This list allows the health workers to identify the appropriate referral destination for the patient, while from the patient's perspective; this list allows them to identify the appropriate location to obtain the necessary health services. Among the benefits that can be gained through sharing this list with the public are as follows (USAID & WHO, 2018):

- Increased efficiency, with joint efforts among healthcare industries in updating a single list instead of interested parties managing their respective lists.
- Increased interoperability between health information systems, with the use of unique identifiers for each individual facility. This allows different information systems to exchange information in a meaningful way, with a consistent reference which is a unique facility.
- Enrich the content of information contained in health information systems, with attributes supplied along with the unique identification of each individual facility.
- Increased efficiency in terms of health service planning and coordination of assets and manpower, by enabling policy makers to identify and obtain basic information related to each facility immediately. This includes in disaster situations, where aid coordination may be required at the national level (Rose-Wood et al., 2014).
- Allowing continuous care at the level of individual health care. The ability to identify individual facilities in different health information systems allows episodes of care to be followed from one facility to another.

On the part of the health workers, this list allows them to identify the appropriate referral destination for the patient, while on the patient's side; a list like this allows them to identify the appropriate location to obtain the necessary health services. Although this list provides many benefits, however producing a complete and usable list by all parties involved is a challenge. This is probably due to the lack of technical and organizational capabilities in producing a standard mechanism in collecting and storing health information in one platform (Mishran & Sahay, 2020). Therefore, an initiative needs to be started in managing MLHF and this has becomes the motivation of this study.

The World Health Organization (WHO, 2014) has put an additional criterion to the MLHF. This criterion is that the list should be shared openly through software known as the Health Facility Registry (USAID & WHO, 2018). Therefore, apart from health administrators, this list should be shared with the public to ensure the coordination of service offerings, research, interoperability of information systems and aid coordination (Rose-Wood et al., 2014). In Malaysia, the list of health facilities is under the supervision of different departments responsible for different types of facilities in the MOH Malaysia (Health Informatics Center, 2020). Therefore, any effort to develop a single master list that is complete and able to meet the information requirements as listed by the World Health Organization needs to take into account the consistency and availability of data sourced from various health information systems (Mohd Nawawi, 2000).

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The Review on the Master List of Health Facilities

Different kinds of information generated from health management information systems have led to duplication and multiplicity of health data. However the usability in sharing of these data with other systems is limited (Wan Puteh & Taib, 2015). Therefore to achieve interoperability among these multiple systems needs an effective standard list of health facilities. Constructing a MLHF is deemed important as it is a list of health facilities in a country, and comprises of three main aspects, namely:

- location of health facilities and types of services offered
- system used to store data
- governance structure to support continuous updating and maintenance

These three aspects are essential to maintain the accuracy of the MLHF. In order to review the initiatives on outlining MLHF, publications from 1999 - 2023 are referred. The reviews discovered that even though initiatives of MLHF are established in the developed countries however, the development process of the MLHF began to attract the attention of several low-rate developing countries such as in Nigeria (Makinde et al., 2014), in Uganda (Mpango & Nabukenya, 2019), in Haiti (Rose-Wood et al., 2014) and the African continent (South et al., 2021). While Indian Ministry of Health and Family Welfare also initiated a programme to build a master facility list (MFL) known as National Identification Number to Health Facilities to improve the ability to share clinical data with other systems (Mishra & Sahay, 2020). Makinde et al. (2014) produced a master list of health facilities with a numbering convention that ensures unique identification for each health facility. Rose-Wood et al. (2014) provided a master list based on disaster management operations in Haiti. Mpango and Nabukenya (2019) study issues that arise in the effort to maintain a master list of health facilities. Among the issues identified include the absence of data standards, incomplete lists, poor governance and difficulty accessing existing lists. In fact, studies report the difficulty of creating a complete list with complete information content. Although there are studies involving private health facilities such as Makinde et al. (2014) and Rose-Wood et al. (2014), the information is usually limited and only includes domain signatures and not service domains. At the same time, there are also studies that only involve public facilities without the involvement of private facilities, such as Maina et al. (2019). The development and improvement of existing MLHF requires an innovative approach to leverage facility data from various health information systems, therefore a more structured ecosystem needs to be developed to support this innovation.

Managing Health Facility Data Using Data Warehouse

MLHF guides the Planning Department in MOH to make appropriate decisions to support the actual health facilities accordingly while ensuring equity in resource distribution (Arifin et al., 2011). The existence of this list allows all users to share a uniform operational overview of the provision of health services in a country. This list allows coordination and planning of health services to be made. In fact, decision making can be made accurately based on the latest information by ensuring the resources can be distributed quickly. With a lot of data and located in various storages, the use of data warehouses is very promising. A data warehouse as defined by Jameel et al. (2022) is described as a data collection technique that is subject-oriented, integrated, timely and stable, which is used in making strategic decisions of the organization. While Kimball and Ross (2013) describe a data warehouse as a copy of transaction data that is specifically structured for the purpose of query, analysis and decision making.

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Based on previous studies, data warehouse is widely used in patient care and clinical research. Bocquet et.al (2022) developed an application using a data warehouse to store medical data where these data is described as very heterogeneous, unstructured, and produced at different scales. In fact Farooqui and Mehra (2018) found that the dimensional modeling method used by most industries is not very suitable for the healthcare field. This is because the business processes of most industries are linear, while healthcare is more appropriately described in the form of a value chain with patient care at the center of the chain, surrounded by other business processes.

Methodology

Based on the data warehouse's ability to manage clinical data, this study developed a data warehouse design that shall be proposed to the Malaysian Ministry of Health. To design this application, a qualitative approach was used. The methodology has identified three main activities in order to construct the data warehouse designs, which are:

- analyze documents and interviews with custodian data related to health facilities
- data collection from the Ministry of Health Malaysia
- design entity relationship diagrams and star schemas for a data warehouse

Figure 1 describes the methodology which divided into four phases in the development of the Health Facility Data Warehouse design. This design is verified by three domain experts consisting of experts in Health Facility.

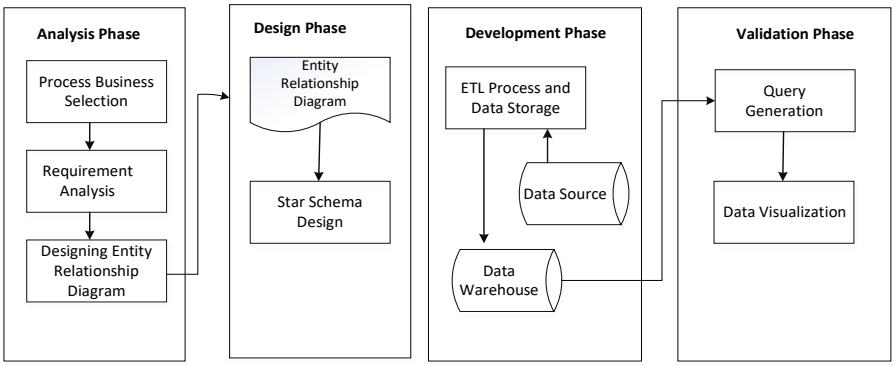

Figure 1: Four Phases of Research Methodology

As stated in the diagram, during the design phase, entity relationship diagram and star schema are used as a tool to design the process and the dimension involved in the Malaysian Ministry of Health's facility services.

Designing Health Facility Data Warehouse

To design a data warehouse, important facts and dimensions related to health facilities need to be identified, hence, Health Indicators report published by Health Informatics Center (HIC) is referred. This report provides information on the achievement in Malaysia's health sector. The information that is often found in this report normally is related to patient care and facilities that are available at the health facilities. Table 1 displays some of the health facility information found in the report.

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Table 1: Information on Health Facilities in Health Indicator Report

Facility Name	Number of Facility	Sector
• Hospital Distribution and • Number of Official Beds in The Government Sector	• Absolute number of facilities • Number of official beds	• By State • By Hospital
• Number of Public Health Facilities and, • Ratio of Public Facilities to Population	• Absolute number of facilities • Ratio of facilities to population	• By state
• Death Rate in Hospital	• Death Rate	• By hospital
• Number of visiting patient	• Number of patients admission to hospital	• By sector • By State
• Number of Outpatient	• Number of attendance • outpatients to the hospital	• By sector • By State

Information about important entities that play a role in health care and work processes in each table is identified. The relationship of each entity and business process is also extracted to allow an entity relationship diagram to be constructed. The understanding and summary from the Health Indicators report is collected and concluded. The findings from the report are verified through interviews with three domain experts from the Health Informatics Center (HIC), Ministry of Health Malaysia. The informant profile is stated as in Table 2.

Table 2: Informant Profile

Informant	Designation	Responsibility	Working Experience
A	Information Technology Officer	Managing Health Information Systems in HIC	13 years in Health Information Technology sector
B	Statistics Officer	Manage applications and production of health information for internal and external users	10 years in managing health data
C	Health Medical Specialist	The head of the section responsible for the administration of HIC	19 years in system planning and management health information

Samples data related to health facilities were obtained from HIC. These data are used to identify business entities that are suitable to be as dimensions and facts in designing a data warehouse. Based on the received data sample files and the results of interviews with domain experts, an Entity Relationship Diagram is constructed, as shown in Figure 2.

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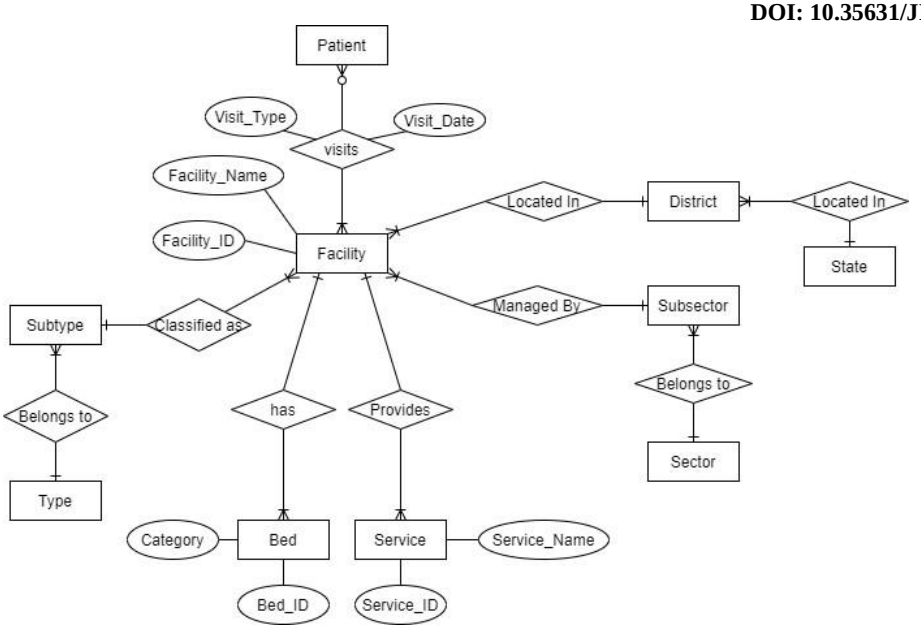

Figure 2: Entity Relationship Diagram for Health Facility

There are four important entities as appeared in the Entity Relationship Diagram which are patient, facilities, services and administrative level. The entities are identified based on the information obtained through document analysis, interviews and organizational data profiling. This entity is used as a guide in designing the star schema, which is a dimensional model for the data warehouse. A star schema is a logical representation of a data warehouse consisting of a fact and a dimension table and the relationship between these two tables. Figure 3 shows the proposed star schema of the data warehouse for the Malaysian Ministry of Health's facility services built based on the details contained in the ERD. Five dimensional tables are proposed, namely time, service, administrative level and facility, where these dimensions are interconnected with the facility management fact table. Through this fact table, queries about the number of facilities, the number of outpatients, the admission of inpatients and the number of beds can be made.

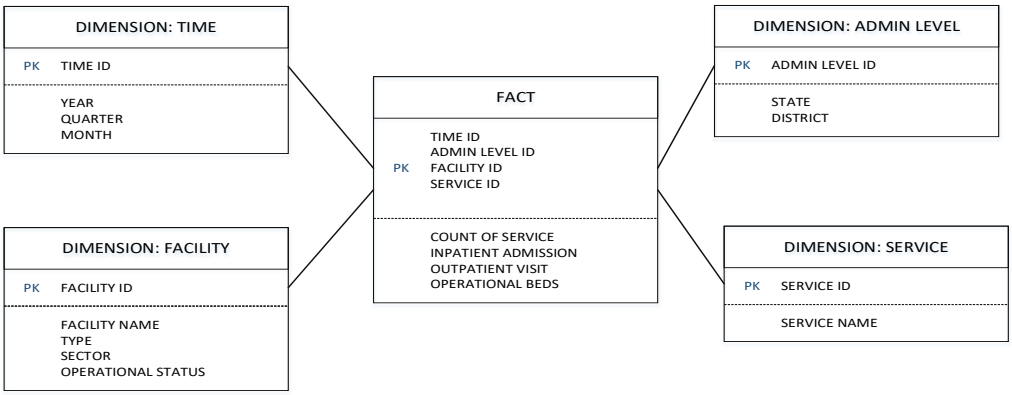

Figure 3: The Proposed Star Schema

The design of a data warehouse also needs to take into account the interaction between users and the data warehouse system. For this purpose, a use case diagram as a visual representation

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of the interaction between the data warehouse systems and other system users is proposed. This is shown as in Figure 4.

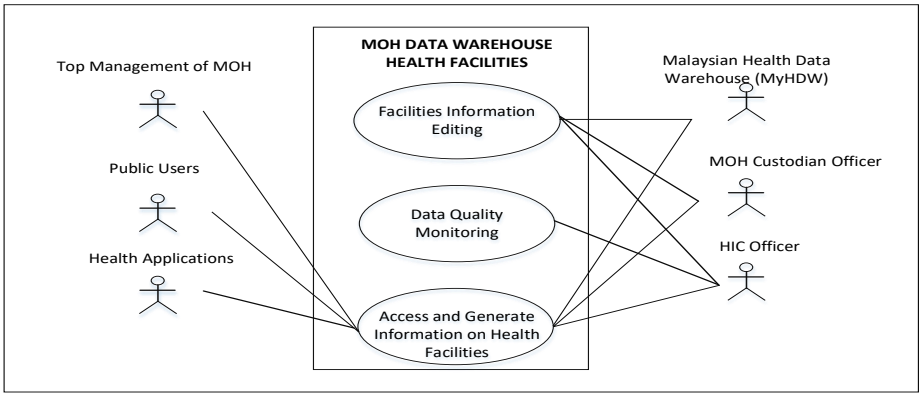

Figure 4: Use Case Diagram for Health Facilities Data Warehouse

Discussion

The usability and the design of entity research diagram (ERD), the star schema and the use case diagram produced in this study is verified by the three experts as stated in Table 2. The experts agree that the diagrams produced are suitable to be used since it fits the data profile, data environment and information system environment used by PIK. The design of the data warehouse and its use were found to be in line with PIK's business needs and able to increase the effectiveness of information sharing. The business needs of one health care center differ from another, so the design of the data warehouse produced is unique. This design is constructed based on the information extracted from the current MLHF. Therefore, the resulting design cannot be compared with the existing design, however the proposed Health Facilities data warehouse is accepted by the experts and is usable to improve decision making.

Conclusion

MLHF (Master List of Health Facilities) needs to be constantly updated to allow stakeholders and health service providers to plan and coordinate available resources. Therefore designing and developing applications using a data warehouse approach is essential so that all sources of information about health facilities can be collected and stored. In fact, decision making can be made more accurately and comprehensively since the data collected in the data warehouse is quality and comprehensive data. This paper has proposed a data warehouse design based on the specifications of Malaysian Ministry of Health. Based on related entities of health facilities, the dimensions and facts of the Health Facility Data Warehouse have been proposed, and dimensional modeling techniques have been used by constructing the star schema. This star schema design has been verified by the domain experts and can be used as a reference for any initiative to develop a health facility data warehouse in the future.

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