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DW RHSB: A Framework for Optimal Allocation of Health Care Resources.

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***Abstract*— In emerging countries, governments must satisfy increasing requirement for care, they face constant worsening health inequalities, as well a need to build health centres, hospitals, staff training and the acquisition of medical equipment. The health needs assessment at the local level must be very precise to allow practitioners, managers and policy makers to identify the highest priority needs. Moreover, A medical decision-support system can provide the clinicians with useful information and knowledge needed to overcome different situations, to improve the quality of care and health of patients. In this context, an implementation of the medical data warehouse is presented in this paper, The purpose of DW RHSB (Data Warehouse of Regional Health Sector of Bejaia) is to provide decision makers with a clear vision of health sector data, It allows to manage different orientations during the planning stages, to provide better distribution of healthcare, and ensure that the allocation of health care resources has optimal effects on improving the health.**

Keywords-Medical DW; Decision-support; Health Sector; OLAP.

I. INTRODUCTION

This paper reports on a DW (data warehouse) for the RHSB (Regional Health Sector of Bejaia). Indeed, this Healthcare institution is in constant growth. To supervise and monitor this evolution, we focused on the design and implementation of a DW, which is used to provide an information overview to analysts and policy makers. Construction and implementation of a DW is a complex task which consists of several steps, such as data sources analysis, identification of user needs, data organization in warehouse, establishing various query tools (analysis, data mining or queries).

More specifically, in the medical field, the DW consists to improve the analysis, monitoring and control of health expenditure, activities of doctors and consumer and patients' behaviour. The purpose of our DW is to provide decision makers with a clear view of the health sector data in the Bejaia region. DW RHSB will help decision makers to take the right decisions and to answer many questions such as, where we should build health centres and what is their specialty? How to improve medical staff recruitment plan? What is the equipment needed to operate a hospital? How to improve the efficiency of drug delivery devices? Also, our warehouse gives information that will help medical research.

This paper is organized as follows; Section 2 presents some concepts about data warehousing. Related work on medical DW is described in Section 3. The Section 4 presents the health sector of Bejaia region and the objective of this work on this institution. Section 4 details steps of the DW RHSB design and implementation. Conclusion and results close the paper.

II. DATA WAREHOUSING

A DW is a collection of data, organized to be used as a decision support [1], where data are organized by themes or subjects (Example: Production, Sales, Marketing etc ...), this organization allows to gather all the information related to a specific topic in order to facilitate decision making. Data in a warehouse are mainly used in consultation mode, and are less frequently modified or deleted by users; this keeps the traceability of information in order to perform analysis over a long period. Data integration in a DW eliminates all conflicts of representation, names and context, to get a uniform and consistent representation of data when data are loaded at the DW [2].

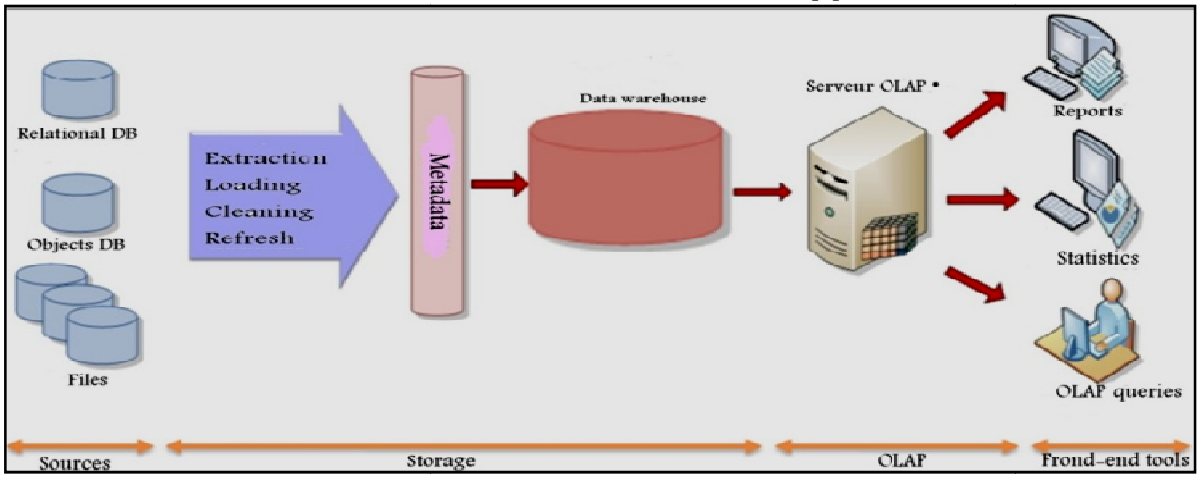

Figure 1: General architecture of a data warehouse [1]

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Figure 1 illustrates the general architecture of a DW. It stores data from various sources of heterogeneous and distributed information. These sources may include databases, data files, external sources, etc. Before being stored, data sources must first be cleaned. The cleaning process is to select and purify the data to eliminate problems and reconcile the semantic differences between these data. Once cleaned, the data will be integrated into the warehouse. The ETL (extract, transform, and load) process is used to integrate data from multiple sources, it is necessary to perform the loading of data sources at the logical warehouse schema transformations [4]. This is done in three steps: (1) Extraction, which is to retrieve data from several sources. This step requires managing the synchronization of extraction processes to ensure data integrity loaded. (2) Transformation is a set of rules for formatting extracted data according to the target warehouse schema, such as assigning semantics to data sources and combine source fields to target fields. (3) Loading data is loaded into a target database, DW or a data mart to be analyzed. Information about a creation, management, and use of the warehouse is stored in a separate directory in the warehouse, this information is called "Metadata". Metadata may contain information of sources and their contents, the warehouse schema, refresh rules, profiles and user groups, etc [5]. A DW may include several data marts; they are excerpts from the warehouse dedicated to one type of users and meet a specific need. They are dedicated to decision analysis OLAP-style, it provides access to the warehouse, it converts client requests in requests for access to the DW and provides multidimensional views of data to support tools decision [6].

III. Medical Data Warehouses

The medical sector has been slow to adopt data warehousing, this is unfortunate since integrated and historical data is especially needed in the medical field [7]. Several studies and projects that activates on medical data warehouses, among the first projects describing an accomplished clinical DW, it is that presented in [3], where the need for a DW in health sector is demonstrated. A self-medication system illustrated in [8], which proposes to patients, information and services on mild clinical signs and associated treatments, where ontology is used to infer the right treatment proposal out of the self-medication knowledge base. The warehouse outlined in [9] has the patient in the focus of its interest, authors show the main differences between conventional, business oriented data warehouses and clinical data warehouses, also they identified key research issues in clinical data warehousing. In France the PMSI project [11] is introduced, the context is a medical program of information systems. A bioinformatics project called Gedaw [12], which involves the DW construction on hepatic transcriptome, this project aims to bring together within a single knowledge base, complex data, varied and many of the genes of the liver, for analysis, its objective is to provide researchers with a comprehensive tool and integrated transcriptome and provide decision support, to guide biological research. DWs of different health insurance organizations in Austria are merged in an evidence-based medicine collaboration project [13], called HEWAF (Healthcare Warehouse Federation), in conceptual design of the proposed tool, they use ontology of the DW domain, as well as of the healthcare and pharmacy domains, to provide schema matching between the federation and the component warehouses.

IV. Regional Health Sector of Bejaia

A. RHSB Presentation

Bejaia Health sector includes several health structures; it has an operating budget and management autonomy. It has the following structures:

- A hospital,
- Two annexe hospitals,
- Two maternity clinics,
- Three polyclinics,
- A Laboratory of Hygiene
- Four health centres with maternity,
- A dental clinic,
- A diabetic centre,
- A sanitary control centre at borders,
- A testing unit and monitoring,
- A blood transfusion centre,
- Thirty care units nearby,
- A paramedical school,

The hospital's mission is to support an integrated and hierarchical manner, the health needs of the population

B. Objectives of the decision support system

The Director Health scheme of Algeria for the 2009-2025 period, will invest 20 billion Euros for the construction of new health facilities and modernization of existing hospitals. As such reforms have been initiated for the infrastructure maintenance, hospital equipment and training of health body function [10]. The outline of this program project achieving 172 hospitals 45 specialized health complexes, 377 polyclinics, 1000 health centres, 17 paramedical training schools, and more than 70 specialized institutions for persons with disabilities. Bejaia Health sector is part of this scheme.

Main objectives of our decision support system are to reply to several problems, which cover several aspects, political, Financial, economical and Public health. The purpose of our DW is to provide decision makers with a clear view of data in the health sector of Bejaia region and navigate through them. it allows to manage different orientations during the planning stages, to have a complete predictive vision, and this by a better repartition of care offerings (hospitals specialization, number of health centres by region, hospital equipment allocation, number of specialist per hospital, number of beds by specialty) these offers have to regularly be adapted with changing of demand (changing health techniques, diseases, health structures, population age and geographical location of the population). Our warehouse will orient leaders toward making objective

decisions, which will lead to significant cost reduction, more efficient method for accurate health management as soon as possible, improves the availability of material and human resources, increases the quality of services and patient safety. So we give answers to questions like:
Where we should build health centres and what is their specialty?
How to improve medical staff recruitment plan?
What is the equipment needed to operate a hospital?
How to improve the efficiency of drug delivery devices?
Also, our warehouse gives information that will help medical research.

V. DW RHSB DESIGN AND IMPLEMENTATION

The DW will allow providing multidimensional views for data of the Regional Health Sector of Bejaia in order to take good decisions for its future extension and news construction of its structures. For the design and implementation of RHSB DW, we followed steps shown in Figure 2. We start with the requirements gathering and data extraction, then multidimensional model design, afterwards data transformation, and then OLAP cube building and in the end achieving graphic interface and representation tool.

A. Requirement gathering and sources extraction

Identified requirements of our projects are of two types, functional needs, meaning to look for decisional information about sickness and others relate to the patients, such as name and type of each disease, disease patterns in time, or in location and regions, age categories of patients and directions or services concerned. And non-functional requirements that ensure the processing speed, performance and security.

B. Multi-dimensional design

To create dimensional model, we started with the creation of the warehouse database, this by created and populated fact table firstly and the same for dimension tables, our model architecture must be easily expandable to meet future needs.

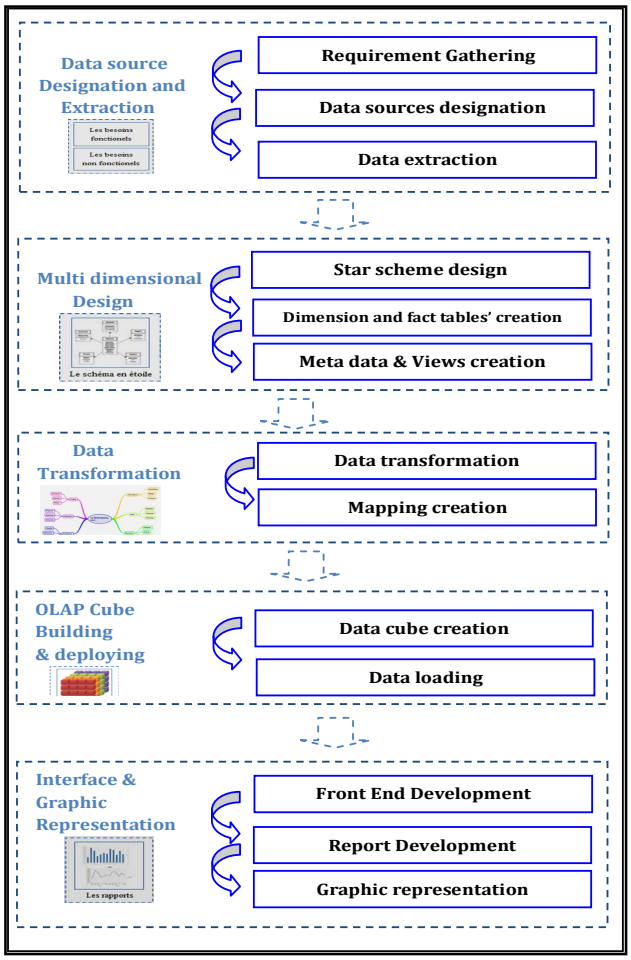

Figure 2: DW RHSB building Steps

This model supports the design of OLAP cubes to provide instant results of a query for analysts. We give some examples of the dimensions used in our multidimensional model; Figure 3 shows an example of five (05) dimensions used.

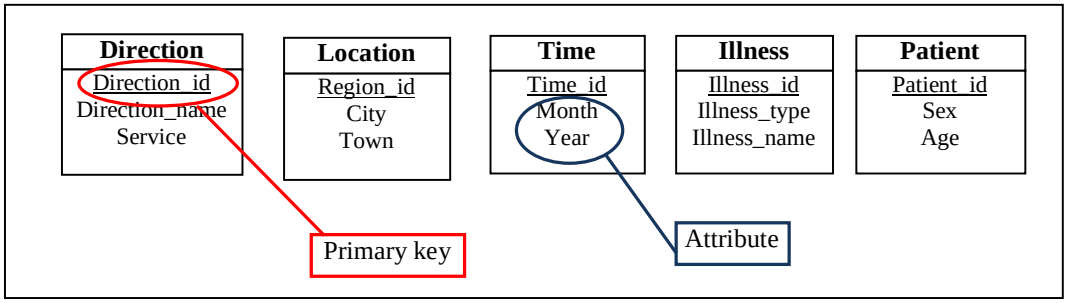

Figure 3: Dimension tables.

Fact table contains mainly three (03) essential information: primary key ”Yard Id”, foreign keys ”Illness id, Patient id, Region id, Time id, Direction id” and measure ”the number of patients,” as illustrated in Figure 4.

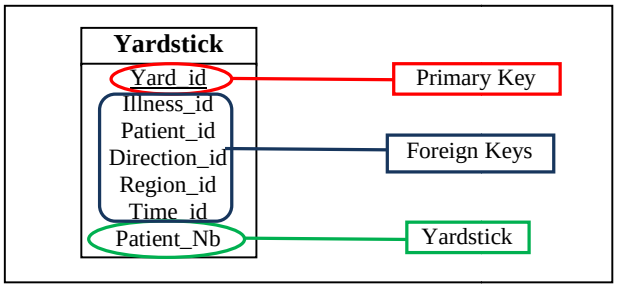

Figure 4: Fact table.

The following Figure 5 shows the star schema used for the data presented previously. The centre of the star consists of fact table "yardstick" and the points of the star are the dimension tables "Illness, Time, localization, patient and direction".

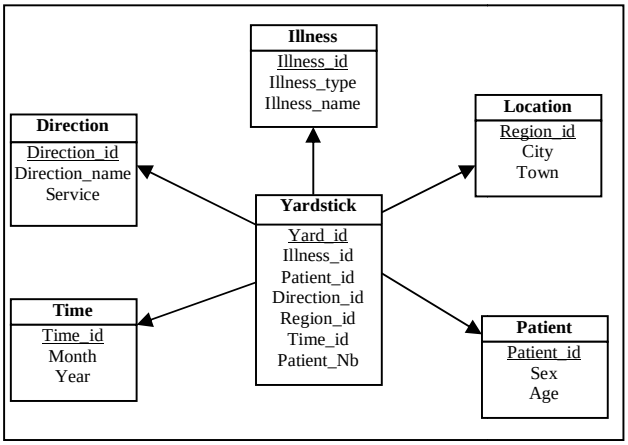

Figure 5: The star schema

C. Data transformation

Data transformation is the process of converting data from one format (e.g., database file, XML document, or Excel sheet) to another. So transformation is to map the incoming data from different DSs to be in a format of DW RHSB repository. We have used some technical, such as, combining multiple name fields into one field, breaking down fields. Creation of mapping, which is determining the relationship between the data elements of two applications and establishes instructions for how the data from the source application is transformed before it is loaded into the target application. Also we transform some column name to other name and convert columns from one data type to another.

D. OLAP Cube building and deploying

To facilitate data analysis, it is necessary to use multidimensional data modelling. With OLAP concept, we can transform the medical data stored in relational databases to relevant medical information and easy to operate, through creating a data cube. It is the objective of this step, i.e. the design of our multidimensional database for OLAP cubes. We have used in this modelling MOLAP (Multidimensional OLAP) and T-SQL. A data cube is identified by 03 dimensions or attribute of a dimension. Since we have 05 dimensions and each dimension has at least two attributes, then there may be several cubes depending on the dimensions. The following Figure 6 shows a representation of a data cube by using the dimensions: Illness, Time and Location.

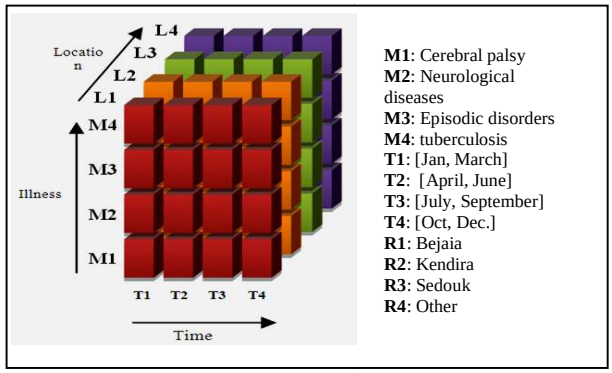

Figure 6: Data cube.

Then, we have achieved a tool for graphic presentation of data, which are very useful in the process of decision making, this tool is rich with graphics capabilities, and easy to make a connection between our data cube.

E. Interface and graphic representation

In this step, we have created graphical interface tool and we have made a connection between our data cube and graphical tool. Our application contains several interfaces, the main interface shown in Figure 7, with which we can reach other specific functions and interfaces.

Figure 7: Main interface.

We can see reports enter several medical parameters that we want to analyze as illustrated in Figure 8. So, RHSBW has the possibility to achieve high quality graphics. The usual graphics are easily obtained using predefined functions and have numerous parameters.

VI. CONCLUSION

The DW RHSB will be the support for data analyses for decision taking for health sector emergence in Algeria and especially in the Bejaia region. The implementation of this warehouse represented in the same time a technical and political progress and challenge. Our paper presents an interesting solution at many levels (economical, social, technical...), is intended to ease the decision-making process in management, coordination, finances, treatment and care resource allocation. With the initial results, we were able to establish health framework to Bejaia region, which gives us very important information about various diseases, their concentration and repartition in Bejaia. It shows periods affected by a specific disease. And age classes of sick in our region, etc.

Moreover, and due to the sensitive nature of medical data, it is important to take into account their own privacy policies problems. Currently, we are implementing solutions, such as user authentication, specifying their rights access, encryption or deletion of personal information relating to patients for transmission over the network. This work is the core of a decision support tool for the Algerian national health system.

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