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A Business Intelligence Platform for Portuguese *Misericórdias*

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Abstract

Health systems are a constant concern in today's society. The health sector, like any others, collects a large amount of information necessary to make decisions on a daily basis. Therefore, a quick and effective response is needed in order to increase its efficiency, focusing in the implementation of Information Systems. The main objective of this project is to understand the value of Business Intelligence systems being implemented in health care institutions. Through to this work it was possible to create a visualization environment capable of helping health professionals in the data organization and understanding, allowing them to make decisions in a more sustainable and efficient way and responding to the institution necessities. In conclusion, BI is an extremely important tool in the present and future of healthcare, being necessary a more in depth expansion of this system and training of users.

Keywords: Business Intelligence, *Misericórdia*, Healthcare;

1. Introduction

There are several non-profit organizations that differ from both the public and private sectors, providing public services and operating in a spirit of sharing and solidarity. *Misericórdias* are one of these organizations that stand out in the health area [1]. These have always played a significant role in Portuguese society and, due to political decisions, their number is increasing. Existing information systems are heterogeneous, developed in isolation and not prepared for this type of institution and, therefore, a solution is needed [2][3]. The recognition of the implementation of Business

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Intelligence (BI) solutions is imperative for this type of institution [4]. For this reason, a case study was created to develop a BI solution capable of responding to the needs of *Misericórdias*. The solution aims to increase the institution effectiveness and efficiency in the management of its performance indicators. One of the objectives of this article is to present the results obtained and monitor the advantages and disadvantages that the implementation of the BI solution has in order to realize how important it is the decision-making process.

The present work is divided into several sections, initiating with a brief introduction. Next, is presented the context in which the article is inserted and then presented the methodologies used to develop the BI solution and the study itself. Finally, it's presented a brief discussion of the results obtained and the final conclusions.

2. Background

Misericórdias have always played a significant role in Portuguese society. According to Decree-Law 172-A / 2014, of November 14, the Ministry of Solidarity, Employment and Social Security [5], Misericórdias are recognized associations in canon law in order to respond to social needs and acts of Catholic worship, according to their traditional spirit, informed by the principles of Christian doctrine and morality. As stated by Decree-Law 172-A / 2014, Misericórdias can promote health, disease prevention and protection and medical care in a curative perspective, rehabilitation and reintegration, assuming an extremely important role in the healthcare system [6].

The access and presentation of medical information are pointed out by health professionals as a major concern. There is a continuing need to improve the quality of patient care and clinical performance [7]. Currently, one of the biggest problems in health units is that all medical information is dispersed across various data sources, result of using several tools. Ideally all information should be on a single combined structure of all services, incorporating all the information available, indispensable for the good management and development of health services. The analyzed data create more relevant and better quality information, capable of identifying patients' problems and increasing the quality of health services [8][9][10]. According to Azvine [11], BI is the ability to collect, access, analyze, perceive and convert one of the main, and most precious, assets of an organization, represented by raw data into active and useful information in order to improve organizational business. BI provides information and tools necessary for statistical and trend analysis, using the main performance indicators to assess the current state of the organization, with the purpose of developing a course of action for the organization [12][13]. BI is being increasingly used by organizations in order to improve their performance in the competitive market [14]. For the creation of BI projects, it is necessary to have a central data repository, a Data Warehouse (DW). According to Inmon [15] a DW is oriented to a set of data, integrated, non-volatile and time-varying, which assists managers in decision-making processes.

In conclusion, it is imperative for a health institution to implement Business Intelligence solutions to support health professionals in decision-making processes that play a vital role on how fast and effective the care provided to a patient is [16].

Taking into consideration the nature of *Misericórdias* and the need to improve citizens' service, a research question was formulated: "How does the use of Business Intelligence contribute to the improvement of the management process of performance indicators within a *Misericórdia*?". To answer this question, a BI prototype was developed after exploring open source tools.

3. Methodology

For the development of the final solution, two methodologies were followed, the Design Science Research (DSR) and the Kimball methodology. The first one was the research methodology and the second one was the practical component of the solution. Throughout this chapter, the two referred methodologies are described. The DSR methodology aims to address existing problems or needs in different sectors, through the creation of innovative, useful and valuable artifacts, in order to efficiently solve these detected problems or needs [17]. The Ralph Kimball's methodological approach focuses on guiding the realization and development of projects where a DW is created, where they must be focused on the needs of the business and the data presented to users must be dimensional. It should be noted that although it is a continuous process, each implementation project must have a finite cycle with a specific beginning and end. A project management is carried out simultaneously, in order to follow the entire evolution of the solution, deadlines, duration and so on [18].

4. Business Intelligence Solution

4.1. Project Planning

Initially, the necessary tasks were identified and programmed, from the study of the available data to the design of the final solution. This was obtained by the study of the organization, definition of business requirements, understanding the data, data processing, ETL process and the construction of the Business Intelligence solution. Finally, the solution was tested and the results obtained were interpreted.

4.2. Business Requirements

It was defined the business requirements in order to identify the current needs that *Misericórdia* has on the process of managing performance indicators. In this sense, a study was carried in order to determine and understand what kinds of requirements are necessary to answer their needs, being divided into functional and non-functional. **Functional requirements**: Understand the influx of performance indicators in the different sub-areas, departments and services that make up the institution. **Non-functional requirements**: Readable, intuitive and easy to use solution, being of easy access and automation.

4.3. Definition of Technological Architecture

The technological architecture defined for the design of the final solution is shown in Fig. 1. The image illustrates all the technologies used and the process flow, beginning with the collection of information from different data sources of the *Misericórdia*, proceeding to the ETL process, where the data will be processed and loaded into a DW. When the data is connected with the analysis tool, a visualization environment is created, which will be made available to the end user in the form of relevant information.
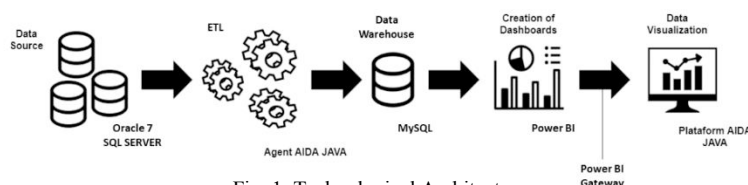

Fig. 1. Technological Architecture

4.4. Dimensional Modeling

Initially, to perform the dimensional modeling an intensive study of the data provided by *Misericórdia* was carried out in order to understand its usefulness. Upon realizing the usefulness of each attribute, the relevant tables were selected, which highlight three dimensions and a fact table. The three dimensions consist in the storage of all performance indicators existing in the different sub-areas, all departments and services and all the dates between the first and the last registered event. The fact table has as main objective to manage the number of events that each indicator presents within the institutional framework. Before being uploaded to the DW the tables need to go through the data processing process due to some inconsistencies detected in the study of attributes.

4.5. Physical Model

The physical model contains the necessary physical structures to support the dimensional scheme, being divided into 3 components: data source, repositories and analysis structure. Associated with data sources are the tables exported from the Misericórdia database, based on the Oracle 7 and SQL Server database format. In the repositories there is the DW created in the MySql format where information about the dimensions and fact tables created is stored. Finally, Power BI Desktop was used in the analysis structures to develop the entire visualization environment necessary to meet the needs presented by Misericórdia.

4.6. Data ETL Design and Development

At this point, all the corrections necessary to improve the data, for them to be loaded into the DW, were made. When performing the analysis of the attributes that make up the different selected tables, some inconsistencies were identified, such as null values, excessive spacing between characters and spelling errors. The way to solve these problems consist in replacing the values by 0, removing the unnecessary spaces and replacing the errors for the correct nomenclature, respectively.

Finally, the data is ready to be loaded into the DW. Fig. 2. represents the dimensional scheme created, being a star scheme composed of a fact table and three dimensions associated with it.
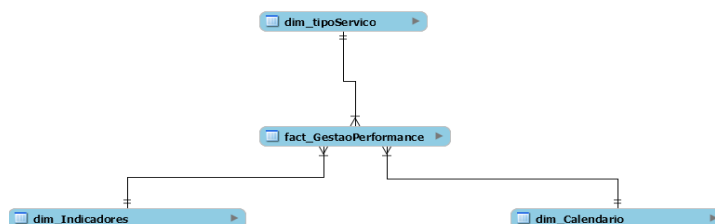

Fig. 2. Dimensional Model

4.7. Analytical Application Development

The data presentation was performed through panels in the Power BI Desktop tool. The connection between DW and Power BI Desktop enabled the access to data necessary for the creation of visualization and analysis environments, as shown in Fig. 3. In order to maintain data condifentiality the panels presented contain fictional data. Within the Power BI Desktop some additional columns and tables, metrics and filters were developed in order to make data analysis more robust and, consequently, more intuitive. It is important to note that each of the interfaces developed has similar analysis structures, making a study aiming to the same direction as the performance indicators, differing only in the filtered ones.

Fig. 3. Viewing Environment

It is important to note that due to the heterogeneity presented, the responsible team should not compare the performance indicators with each other as they have different values and meanings. As shown in Fig. 3., it is possible to analyze the data with different levels of detail. In this case, it is possible to analyze the variation in the number of events for each indicator over time, which allows us to know in which periods of time the number of events for each indicator is higher or lower. In addition, it is possible to select only one or more indicators in order to see their variation in the different departments and services, as well as to select in which department and service you want to see the variation in the number of events for each indicator.

In order to help the team responsible for *Misericórdia*, two detailed analyzes were created, as shown in Fig .4., the calendar view and the table view. In order to maintain data condifentiality the panels presented contain fictional data. The first one allowed the analyses of the evolution in the number of events that a given indicator presents in a daily

basis and the second one the analyses of the variation in the number of events of an indicator in the present and past years in order to understand its evolution.
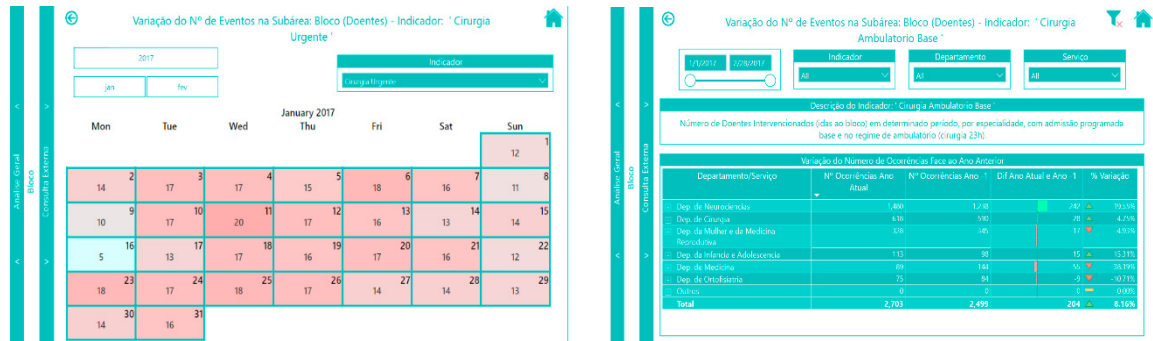

Fig. 4. Viewing Environment - Detail

This type of information assists the responsible team in making decisions about at what time of the year more or less hospital supplies and health professionals are needed, allowing the adaptation of the resources needed.

4.8. Implementation and Growth

The implementation part of the final solution is divided into three phases. **Phase 1:** testing of the prototype in order to guarantee the proper functioning, quality of the data and integrity between the different connections, being the entire integrity of the system guaranteed. **Phase 2:** implementation of the final solution. **Phase 3:** assurance of health professionals training, allowing them to learn how to use the program and understand the mechanics inherent to the entire process.

It is necessary to guarantee the continuous growth of the developed solution with the appearing of new data and processes in the heart of *Misericórdia*.

5. Discussion

This work showed the importance of Business Intelligence in *Misericórdias*. With the use of a BI solution, it is possible to directly influence the quality of life of each citizen. The information provided by the solution helps to manage the most correct and efficient decision making. However, it is essential to follow a development roadmap in order to know the business and the stakeholders that act on it, defining on a set of metrics relevant to the process.

The work developed helps the team responsible making better and more informed decisions, guided by data, with regard to the variation in the number of events that each performance indicator presents. They evaluate the individual impact of each indicator in the different areas, sub-areas, departments and services that make up *Misericórdia*. It is possible to understand which indicators have a greater record of events, verify the variation with the present and past years, as well as in the different departments and services. However, it is important to keep attention on all indicators and not just those with the highest number of events, because, as mentioned above, the performance indicators are heterogeneous with each other, so the number of events that a given indicator presents defines whether it is negative or positive.

In general, through the developed solution it is possible to: monitor the evolution of the number of events for each indicator; Manage performance indicators throughout the institutional environment; Manage human resources; Manage *Misericórdia* in general, in a more efficient way, by improving its performance as a whole.

6. Conclusions and Future Work

The developed solution allows for the extraction, storage and proper processing of data. The visualization interface presents a set of reports with dashboards, which have metrics capable of responding to the objectives and needs of the institution, being the knowledge provided in real time.

The answer to the research question "How does the use of Business Intelligence contribute to the improvement of the management process of performance indicators within a *Misericórdia*?" is that BI can support the management of small processes carried out in the institution. It is an excellent tool because allows the improvement of decision-making by the better control of its resources.

The main contribution of the work developed in this project is the manufacturing of a functional solution and the implementation of the solution itself. This solution can also be optimized and adapted to other health units in order to improve health care quality and user satisfaction, being extremely versatile.

In the future, the developed solution will be implemented and new panels in other areas will be developed. Predictive analyzes will also be focus point, since this analysis can anticipate possible scenarios in the medium and long term.

Acknowledgements

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