

A Pervasive Business Intelligence Solution to Manage Portuguese Misericórdia

Danilo Coelho, Filipe Portela, Manuel Filipe Santos, José Machado and António Abelha
Algoritmi Research Centre, University of Minho, Guimarães, Braga, Portugal

Keywords: Business Intelligence, Misericórdia, Data Mart, Pervasive HealthCare, Dashboards.

Abstract: Currently, the healthcare system is one of the main pillars of any society. Given the economic crisis in Portugal and poor healthcare system in need of profound improvements, the need to increase the efficiency of resource management and services is imperative. With the increasing use of Business Intelligence (BI) in organisations and the proven effectiveness of this, comes the desire to use BI in healthcare, specifically in the healthcare of Misericórdia. One of the purposes of this article is to present the results obtained through the development of the dissertation whose theme is "Prototyping of Business Intelligence component to support the management in the health area of a Misericórdia". So, in this work, some concepts associated with the use of BI in Misericórdias were addressed, and the Pervasive BI architecture of the developed solution was designed. It is also important to emphasise that the solution presented is pervasive, available anywhere at any time. Furthermore, a set of metrics were developed and the data presented in the form of dashboards, for later use by the users. Through this work, it was possible to gather all the data into a single structure (Data Mart), to identify a set of aspects that can be improved and to have a generalised view of the state of operation of the organisation, as far as health care is concerned.

1 INTRODUCTION

Currently, the national health system is one of the main pillars of any society. It is almost mandatory to increase the efficiency of the management of resources and services in the provision of health care. In this way, the present article aims to present the results obtained through the dissertation "Prototyping of Business Intelligence component to support the management in the health area of a *Misericórdia*" whose objective is to develop a pervasive functional prototype of Business Intelligence (BI) in the health area of a *Misericórdia*. The use of BI in health organisations, particularly not-for-profit organisations, increases efficiency and effectiveness in care delivery. Nonprofits have always been present in society, playing a critical role in it. These organisations, defined in 1982 as "Private Institutions of Social Solidarity" (PISS), are organisations that have established non-profit goals by private initiative, to give organised expression to the moral responsibility of solidarity and justice. In other words, the PISS is a response of civil society to a set of social problems, developing an economic

activity based on the principles of solidarity, cooperation and equity (Decreto-Lei n.º 172-A/2014).

In a health organisation, the volume of data is high and complex. Most of the time the data is stored in several sources which make it difficult to analyse it for later decision making. This situation instead of facilitating the decision-making process makes it an extremely complex process with a high degree of uncertainty (Vuori, 1984). Consequently, recognising the importance of decision making in healthcare and the existence of BI solutions that facilitate the work of health professionals is an improvement for the organisation. One of the purposes of this paper is to present the results obtained and consequent advantages and disadvantages of applying a BI platform in the health area of an organisation, to understand the extent to which a sustained decision-making process is important in an organisation.

This work is divided into several sections. A brief introduction is initially exposed. Next, in section 2 a background is presented to present the background in which the article is found. Then in Section 3 is stated the methodologies used to develop the Pervasive BI platform. In Section 4 is

presented the BI architecture and in Section 5 the main results of the dissertation development. Section 6 address a short discussion of the results and final, in Section 7 the future work.

2 BACKGROUND

Today, health is one of the pillars of any society. Since health is an area that affects every citizen, the quality of health care delivery is important. In this way, the need for a more sustainable decision-making process arises, as well as the need to identify possible aspects to be improved. Therefore, the optimisation of healthcare delivery involves the computerization of clinical procedures, with a transition from paper-based processes to electronic processes, using Information Systems (IS) or reorganising the IS. The health professionals are based on the analysis and monitoring of the clinical information of each user to obtain and sustain a correct clinical diagnosis. Nowadays, with the technological and economic advances, all this clinical information is available and distributed by different SIs. According to Marins (Marins, 2013), hospital information systems (SIH) are "systems responsible for acquiring, processing and presenting all information about all the participants (patients, doctors, nurses, among others) and all services, among others)".

In the current context, due to the pressure exerted on organisations, given the current economic crisis, their management focuses on the decision-making process through the Business Intelligence (BI) component. They need to make quick and effective decisions in any of the areas of the organisation, be they tactical, strategic or operational, and this is one of the critical success factors. However, a correct decision-making from the organisational point of view is based on a large amount of data that allows us to perceive the best option.

This article addresses health issues using BI in the health area of a *Misericórdia*. This presents the results obtained through the development of a BI functional prototype. On *Misericórdias*, these are characterised as non-profit institutions, whose purpose is to express the moral duty of solidarity and justice (Andrade, 2014). Also, they play a considerable role in Portuguese society, characterised by the wide range of areas in which they work, with special emphasis on health. Therefore, since the *Misericórdias* are not-for-profit institutions and given the need for more and more organisations to require sustained and effective

decision-making, it is concluded that the need for a well-defined basis for decision-making is imperative.

On the article, this one presents the results obtained through the development of a functional BI prototype developed through the dissertation which theme is "Prototyping of a Business Intelligence component to support the management in the health area of a *Misericórdia*". This work also can help to answer the research question "How can the use of Business Intelligence contribute to decision making in a *Misericórdia*?".

Thus, the solution developed throughout the dissertation and presented in the article meets the needs of organisations because it allows for sustained decision making and as it is hosted in the cloud then allows remote access on any device. During this process, open-source tools also were explored (Brandão, et al., 2016).

2.1 Portuguese *Misericórdias*

The *Misericórdias* have always played a very important role in Portuguese society.

According to the Decree-Law 172-A / 2014 of 14 November the Ministry of Solidarity, Employment and Social Security, *Misericórdias* are "associations recognised in canon law, to meet social needs and acts of Catholic worship, by its traditional spirit, informed by the principles of doctrine and Christian morality". In spite of they have performed different roles in society, they have always been associated with the provision of health care (Decreto-Lei nº.172-A/2014). According to the Decree-Law 172-A/2014, *Misericórdias* may provide goods and develop social intervention activities, which includes the area of health. *Misericórdias* can promote health, disease prevention and care in curative perspective, rehabilitation and reintegration. Also, Penteadó (Penteadó, 2004) defines *Misericórdias* as associations of believers who, according to the country's legislation, have the status of IPSS, which was granted to them in 1979. The same author, Penteadó (Penteadó, 2004), states that *Misericórdias* are non-profit institutions, whose purpose is to express the moral duty of solidarity and justice between individuals and the provision of services in the field of social security.

In Decree-Law no. 138/13 of October 9 of the Ministry of Health, these institutions play an important role in the health system, being increasingly recognised in Portuguese society. The same decree (Decree-Law no. 138/13 of October 9 of the Ministry of Health, 2013) states that the

Misericórdias have been associated with the provision of health care, although they have different roles in society (Decreto-Lei n.º 138/2013).

2.2 Pervasive Business Intelligence

In health, the access and presentation of medical information are identified as a major concern for health professionals. This concern is because caregivers need to make sustained decisions because the patient's health is at stake. Currently, one of the main problems in health facilities is that all medical information is dispersed by several data sources, the result of the use of various tools. In this way, accessing, crossing and querying the data when necessary becomes a complicated task to perform promptly, which may lead to less correct decisions on the part of the professionals. To solve this problem, the need to use a pervasive system arises.

The main objective of a pervasive system in health is to achieve a quality care service, to anyone and at any time, regardless of their location or position (Pereira et al., 2016).

A pervasive health system is characterised by a set of heterogeneous information, a set of stakeholders, and ubiquitous computing that connects digital infrastructures to our daily lives. It gathers, processes and distributes "any kind" of personal information and contextual data anywhere (Pereira et al., 2016).

Pervasive Healthcare is considered a key factor in the reduction of expenses and is known for allowing improvements in disease management and advances in communication technologies and wireless networks providing the acquisition, transmission and treatment of critical medical information in real time (Pereira et al., 2016).

For Larburu et al. (Larburu et al., 2015), the Pervasive Healthcare systems apply information and communication technologies to allow the use of omnipresent clinical data by authorised medical personnel.

Pervasive Business Intelligence (BI) systems are a future area whose goal is to support decision-making by health professionals.

2.3 Related Work

As a related work, we continue the work presented in the dissertation "Use of process-oriented methodologies in the implementation of Business Intelligence systems - application in the health area" (Miranda, 2015). This work arose from the need of exploring the process-oriented potentialities, such as

Business Process Management (BPM), Mlearn, and Balanced Scorecard, to clearly and objectively identify the information needed to support decision making. The objective, according to the author João Miranda (Miranda, 2013), was to "develop a Business Intelligence System (BI) that guarantees its alignment with the organisation's mission and strategy, using process-oriented methodologies and supporting the function of analysing and Organisational performance, enhancing the continuous improvement of its processes".

After the work mentioned above was completed, the dissertation discussed in the introductory chapter was developed and serves as the basis for this article. This work is divided into several phases, according to the methodologies used. In an initial phase (information research) a survey of concepts associated with the theme and of the tools used by the *Misericórdias* in their daily life was carried out with the objective of perceiving the characteristics of these, at a later stage, to develop a differentiating solution capable of interacting with Existing information systems. Throughout the development of the dissertation and with the intention to present the work developed an article whose was written about "Towards a Business Intelligence Platform to Portuguese *Misericórdias*" (Coelho et al., 2016). Its purpose is to show the surgical process dimensional model, the BI architecture and the Strengths, Weaknesses, Opportunities, Threats (SWOT) analysis of the solution proposed to health area of Portuguese *Misericórdias*.

In addition, the same article presents the key concepts, tools used by *Misericórdias* and process architecture.

3 METHODOLOGIES

The present chapter describes the characteristics of each of the methodologies used throughout the development of the dissertation and consequently the development of the functional prototype as well as its different phases, interconnecting each one of the phases to what was being done in the course of the work. The methodology used for research is the Design Science Research (DSR), and for the practical component, the Kimball methodology was used. The DSR methodology consists of a set of principles, practices and procedures for conducting research, through the design of artefacts and the analysis of their use/performance, in order to solve problems (Peffer et al., 2007).

The main tasks of DSR are the identification of the problem and motivation; Definition of the objectives of the solution; Design and development; Demonstration and finally evaluation and communication (Peffer et al., 2007).

Briefly, the use of this methodology allowed the entire development of the project to be oriented correctly and rigorously. Through the Several phases of the DSR, we are able to identify and describe the problem, showing the importance of this in order to clarify any doubts about the importance of the project development. This methodology served to assist in all project planning and development. As in any type of project, there is a need for the stakeholders to have a theoretical basis to fill potential knowledge gaps in the area of the project and, therefore, it is necessary to use a methodology that guides the entire research process and Concept documentation.

Regarding Kimball's methodology, also known as the business dimensional life cycle, it was conceived in the mid-1980s by members of the Kimball group. This methodology has been used in projects related to Data Warehouse and Business Intelligence (DW / BI) in the various organisational areas (Kimball, 1998).

The main phases of this methodology are project planning; Analysis of business requirements; Dimensional modelling and design of the technical architecture; Selection of tools; Design and development of the Staging Area and finally installation and start-up and maintenance and evolution. It should be noted that throughout the development of all these phases of the project, a project management is carried out simultaneously, aiming at monitoring the entire development of the solution, deadlines, duration and so on (Kimball, 1998). Through the use of these methodologies, it was possible to develop the solution always in a phased and rigorous way, without forgetting any phase.

4 PERVASIVE BUSINESS INTELLIGENCE ARCHITECTURE

The development of the Pervasive Business Intelligence (BI) prototyping component was based on an architecture composed of 3 levels, data sources, Data Mart and finally Dashboards and Reports. As can be seen in Figure 1, two operational data sources and a set of tools were used to support

the development of the whole process. The Misericordia defined this architecture and all the features associated with it.

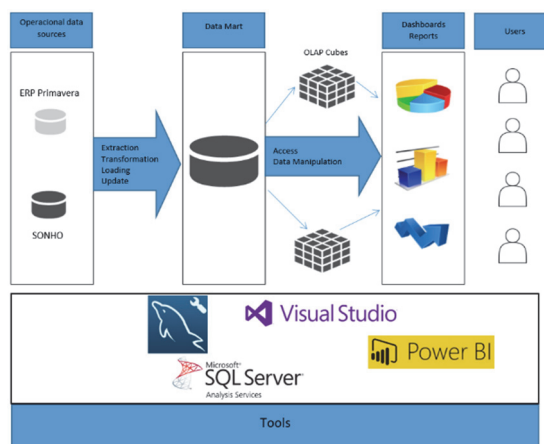


Figure 1: Pervasive BI Architecture.

In an initial phase data were extracted, transformed, loaded, and updated to Data Mart. Next, OLAP cubes were developed through access and manipulation of data and metrics created to meet the needs of users. Finally, panels with dashboards and reports were developed to present the data to the final user(s).

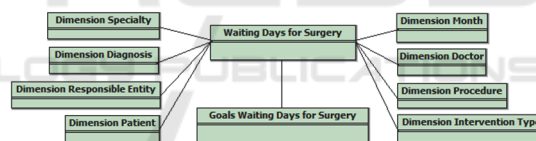


Figure 2: Star schema for waiting days for surgery.

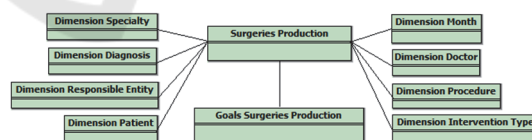


Figure 3: Star schema for surgeries production.

The entire process was developed using the tools shown in the architecture: MySQL

Workbench where Data Mart, Microsoft Visual Studio and Microsoft SQL Server Analysis Services are located where the metrics and OLAP cubes were developed and finally the Microsoft Power BI Desktop where the panels were developed and therefore presented the data. The fact that the data can be accessed in both the desktop and cloud tools indicates that it is a pervasive platform because the

data can be queried and the panels changed if necessary anytime, anywhere.

The development of Data Mart was based on a constellation scheme designed per data type of the operational sources. This consists of two tables of facts, waiting days for surgery and surgeries production and eight dimensions in common (date, speciality, doctor, intervention, diagnosis, intervention type, users and responsible financial entities). Given the complexity of the scheme and to a better perception in the article, the scheme was divided into 2 diagrams: Waiting days till surgery (Figure 2) and Production of surgeries (Figure 3).

The Data Mart is already deployed, and it is prepared to be used.

5 RESULTS

The multidimensional analysis using facts and dimensions of Data Mart allows a set of functionalities available to the user, among which:

- Ad-hoc creation and access to queries;
- Registration of queries for future use, which may be provided to one or more users;
- Performing Roll-up actions to aggregate the data from a more detailed perspective on a more generalised one;
- Selection detail level in the query, that is, allow the data to be explored for a more detailed perspective, performing drill-down;
- Definition the criteria of the data query;
- Show results of data analysis through graphs, tables and maps.

Table 1: Metrics, types in each table.

Name	Type	Used table
Total surgeries	Record count	
Maximum number of waiting days for surgery	Maximum	Fact table: Waiting days for surgery
Minimum number of waiting days for surgeries	Minimum	
Total surgeries production	Record count	Fact table: surgeries production
Quantity of patients	Record count	Dimension: Patients
Quantity of interventions	Record count	Dimension: Interventions
Quantity of doctors	Record count	Dimension: Doctors

Over OLAP cube development were defined a set of metrics to allow greater analysis capacity in data presentation. Table 1 presents the developed

metrics, where it is possible to verify which type of metric and what dimension or table of facts each metric is based on it.

The presentation of the data was done using panels in the PowerBI Desktop tool. Each panel consists of a set of dashboards.

Figure 4 is one of the several examples of the use of the cube. As you can see in figure 4, it is possible to analyse the data with different levels of detail. In this case, it is possible to analyse the production of surgeries by month (*mês*), a quarter (*trimester*), semester (*semester*) and year (*ano*), which allows obtaining knowledge regarding which periods of time the production of surgeries is more and less. In addition, it is possible to select only one or more specialities (*especialidades*) as well as the type of surgery (*tipo de cirúrgias*) that is intended, Ambulatory (*ambulatório*) and Normal (normal). This type of information helps the manager to make decisions regarding, for example, what times of the year a larger / smaller amount of hospital material and a larger / smaller amount of health professionals are required. In this way, it is possible to tailor resources to hospital needs based on sustained decision making.

6 DISCUSSIONS AND CONCLUSIONS

Throughout the article, the central theme is health. This theme is very important since it directly influences the quality of life of each citizen. This leads to the need to contribute to significant improvements in this area, for example, in the decision-making by professionals. It is known that one of the main problems that a manager of a health organisation is facing is the difficulty in perceiving which aspects can be improved. What has been verified is that the high variety of tools used leads to the stored data are dispersed, which makes it difficult to access the data. With this, the use of the data stored by the different tools becomes quite complicated. In this way, one of the possible contributions to health would be to help those in charge of managing the organisation in their decision-making, through Business Intelligence (BI) applications.

Based on the BI functional prototype developed throughout the dissertation, the data stored in the various sources are extracted, processed and stored in one place and then easily manipulated according to the needs of *Misericórdia*. As shown in the

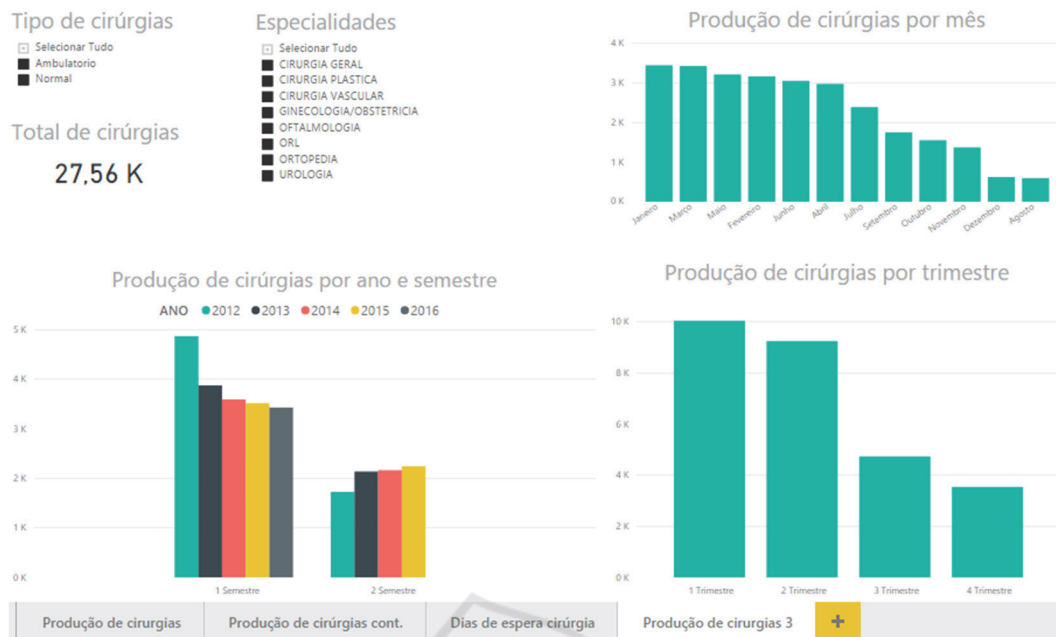


Figure 4: Surgeries Production panel example.

Results section, the displayed pane is just an example of data presentation. Having said this, the end user can easily access the dashboard in real time and make sustained decisions, which until then was a complex process.

In summary, the use of BI in the *Misericórdia* healthcare sector brings many benefits. In this article, the solution proposed by the BI architecture allows a *Misericórdia* sustainable decision-making in the surgical procedure. This architecture requires a complete process of data storing and processing tasks to the data being converted into information/knowledge later. When the user makes queries, the system can help the decision-makers in their task by providing them new insight able to help to make the right choices leading it to a positive impact on their patients. In brief, this BI solution can provide concrete information regarding the trends and needs of the *Misericórdia*.

The main contribution of this paper is to show a BI architecture of functional prototype which can be reused in others *Misericórdias*, to improve the quality of healthcare and patient satisfaction. This architecture is a new approach and the first architecture to this market segment. During this phase, *Misericórdia* participated actively in the process, namely in requirements elicitation.

7 FUTURE WORK

As a future work and according to Kimball's methodology, the phase of installation and start-up of the solution would be a possible phase to be developed in the future, and in an initial phase, it would be important to proceed with the survey of the requirements of the solution according to the needs of the organisation. After the implementation of the solution it is important to study the Maintenance of the platform without leaving aside possible adjustments to the platform as new features arise and/or new tools.

In addition, other challenges could be considered: to provide improvements to ensure the success and usefulness of BI systems, management function, responsible for organisational performance assessment and monitoring; Disseminate the project to other organisational processes, starting from the identified organisational process architecture. Explore other tools to verify what is indicated for the development and presentation of dashboards, multidimensional reports, according to the organisation needs.

ACKNOWLEDGEMENTS

This work has been supported by COMPETE: POCI-01-0145-FEDER-007043 and FCT –

Fundação para a Ciência e Tecnologia within the
Project Scope: UID/CEC/00319/2013

REFERENCES

- Decreto-Lei n.º172-A/2014 de 14 de Novembro do Ministério da Solidariedade, Emprego e Segurança Social, Portugal (2014).
- Vuori, H.: Primary health care in Europe—problems and solutions. *J. Public Heal.* 6, 221–231 (1984).
- Marins, F. de A.: Monitorização e prevenção em plataformas de interoperabilidade hospitalar. (2013).
- Andrade, S.A. da C.: Inovação nos serviços de saúde das Misericórdias da região norte de Portugal. (2014).
- Penteado, P.: A Investigação em sistemas de arquivo organizacionais: algumas reflexões sobre o caso das Misericórdias de Portugal. *Actas do Colóquio “Do Doc. à informação” e das Jornadas sobre Sist. Informação Munic.* 141–163 (2004).
- Decreto-Lei n.º 138/2013 de 9 de Outubro do Ministério da Saúde, Portugal (2014).
- Pereira, A., Portela, F., Santos, M.F., Machado, J., Abelha, A.: Pervasive Business Intelligence: A New Trend in Critical Healthcare. *Procedia Comput. Sci.* 98, 362–367 (2016).
- Larburu, N., Bults, R.G.A., Van Sinderen, M.J., Hermens, H.J.: An ontology for telemedicine systems resiliency to technological context variations in pervasive healthcare. *IEEE J. Transl. Eng. Heal. Med.* 3, 1–10 (2015).
- Miranda, J.: Utilização de metodologias orientadas a processos na implementação de sistemas de Business Intelligence – aplicação na saúde, (2013).
- Peffer, Ken, Tuunanen, T., Rothenberger, M., Chatterjee, S.: A Design Science Research Methodology for Information Systems Research. *J. Manag. Inf. Syst.* (2007).
- Kimball, R.: *The Data Warehouse Lifecycle Toolkit: Expert Methods for Designing, Developing, and Deploying Data Warehouses.* Wiley (1998).
- Miranda, João "BI nas Misericórdias", Mestrado em Sistemas de Informação. 2015
- Brandão, A., Pereira, E., Esteves, E., Portela, F., Santos, M.F., Abelha, A., and Machado, J. A Benchmarking Analysis of Open-Source Business Intelligence Tools in Healthcare Environments. *Information. Volume 7, Issue 4. ISSN: 2078-2489. MDPI.* 2016.
- Coelho, D., Miranda, J., Portela, F., Santos, M., Machado, J., Abelha, A. Towards of a Business Intelligence Platform to Portuguese Misericórdias. *Procedia Computer Science - HCIST 2016 - Healthy and Secure People. Volume 100, pp 762-767. ISSN: 1877-0509. Elsevier- 2016.*