



Conference on ENTERprise Information Systems / International Conference on Project
MANagement / Conference on Health and Social Care Information Systems and Technologies,
CENTERIS / ProjMAN / HCist 2016, October 5-7, 2016

Towards of a Business Intelligence Platform to Portuguese *Misericórdias*

Danilo Coelho^a, João Miranda^b, Filipe Portela^{a,c*}, José Machado^a, Manuel Filipe Santos^a,
António Abelha^a

^aAlgoritmi Research Centre, University of Minho, Braga, Portugal

^bCentro Hospitalar do Alto Ave, Guimarães., Portugal

^cESEIG, Porto Polytechnic, Porto., Portugal

Abstract

In the healthcare industry it is imperative the need to increase the efficiency of resource management and services. The increasing of Business Intelligence (BI) use in organizations and the demonstrated effectiveness of this type of solution, arises the desire to use BI in healthcare as in *Misericórdias*. So, in this work some concepts associated to the use of BI in *Misericórdias* were addressed and a BI architecture was designed. Furthermore, a survey was made in order to understand what are the tools used by *Misericórdias* every day and which ones have the BI components. Finally, a BI architecture was developed based on the organization's mission and their stakeholders. Through this work it was possible to identify the critical processes and designing the Entity Relationship Diagram as well as a set of indicators to meet the needs of a sustainable decision-making in Portuguese *Misericórdias*.

© 2016 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Peer-review under responsibility of the organizing committee of CENTERIS 2016

Keywords: Business Intelligence; Data Warehouse; *Misericórdia*; HealthCare;

1. Introduction

Currently, the national health system is one of the main pillars of society. It is mandatory to increase the efficiency of resource management and services. The use of Business Intelligence (BI) in health organizations in particular in

* Corresponding author. Tel.: +0-000-000-0000 ; fax: +0-000-000-0000 .

E-mail address: cfp@dsi.uminho.pt

the non-profit organizations can help to increase the efficiency. Non-profit organizations have always been present in society, playing a critical role on it. These organizations defined in 1982, as "Private Institutions of Social Solidarity" (PISS) are organizations that established non-profit goals by private initiative, in order to give organized expression to the moral responsibility of solidarity and justice [1]. In other words, PISS are an answer of civil society to a set of social problems, developing an economic activity based on the principles of solidarity, cooperation and equity [2]. From all of the PISS, the oldest of this group and the most recognized by the Portuguese society is *Misericórdias* [3].

In health organizations, the volume of data has been growing sharply. This situation instead of facilitating the decision-making process makes it an extremely complex process with a high degree of uncertainty [4]. Consequently, recognizing the importance of decision making in healthcare and the existence of Business Intelligence (BI) solutions which facilitate the work of health professionals it is an improvement for the organization. The implementation of a BI system becomes an asset in a health organization because it provides evidences and updated information to a best decision. This work meets the need of *Misericórdias* in solving problems and identifying possible improvements through the data analysis. In sequence it improves the efficiency of the decision-making process. During this work the surgical process was chosen to be represented and implemented. The main goal of this paper is presenting 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*. This work used real data provided from a Portuguese institution in the north of the country aiming a sustainable decision-making process in health care.

Section 2 presents a brief description of the key concepts related with the topic and a set of tools used by *Misericórdias*. Then, in Section 3 is presented the processes architecture. Section 4 displays the BI architecture. In Section 5 the main results and SWOT analysis are exposed. Section 6 address a short discussion of the results, the final conclusions and future work.

2. Background

According to the Decree-Law 172-A / 2014 of 14 November the Ministry of Solidarity, Employment and Social Security, *Misericórdias* are "associations recognized in canon law, in order to meet social needs and acts of Catholic worship, in accordance with its traditional spirit, informed by the principles of doctrine and Christian morality". In spite of they have performing different roles in society, they have always been associated with the provision of health care [5]. 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.

Williams & Williams (2010) defines BI as an environment where the business users can get consistent data, reliable, perceptible and manipulated in a simple and intuitive way in order to help managers in the search for knowledge about the organization in the past, present and future. According to Negash & Gray [7], the use of BI allows the conversion of data into useful information and then converting this information into knowledge. The last conversion is performed by a human analysis. In addition, BI systems combine the collection and data storage and knowledge management with analytic tools. Business Intelligence (BI) is being increasingly used by organizations [8], in the private sector allowing managers to improve the decision-making processes. In terms of application areas, the BI is primarily used in sales analysis, general reporting, planning and forecasting, performance reporting and budgeting and profitability analysis [9]. In accordance with Santos & Ramos [10], "Business Intelligence integrates exploration activity of Data Warehouse (DW), including predefined queries, ad-hoc queries and reporting, which usually allow monitoring of developments in the main indicators business over the organization". For Inmon [11] "A DW is a data set oriented subject, integrated, cataloged and temporally non-volatile, which supports managers in the decision making process".

Tanaka & Tamaki [12] reaffirm the complexity and subjectivity associated to decision-making process in healthcare. There is a greater responsibility on the part of decision makers (health professionals) since making decisions directly affect the health of patients. The BI system implementation becomes an asset in a health institution because it provides conditions for decisions to be made based on reliable information. For Vogt [13] a BI system allows to analyze operational data management and statistical data on the clinical picture of a patient in a clear and detailed way allowing an identification of risk situations and a more quickly and effectively response. The same author [13] assumes that more safety and quality of care improve the patient health care. Health Care institutions use information system tools to facilitate their operations and management. As initially mentioned a list of tools used by

Misericórdias was made. It is important to emphasize that most of the solutions were designed to be used in hospitals and they are not prepared to be adopted by the *Misericórdias* at the moment. From the tools identified only AIDA [14], [15] and GlobalCare [16] have a BI component.

3. Process Architecture

In this section the process architecture is presented. The MLearn methodology was used to identify all the Stakeholders related with the organization. All the identities, that may affect the *Misericórdias* performance or can be affected by it, were considered as stakeholder. After the Stakeholders are identified the macro processes of the organization were identified according to Michael Porter's value chain. The processes that support the main or primary activities are the ones that are directly related to the provision of health services, satisfying each one of the patient specific needs by responding to their requests. The main objectives are: Provide continuous care; Provide urgent care; Provide conventional surgical care; Provide surgical outpatient care; Provide inpatient care; Provide consultation care; Perform supplementary means of diagnostic and therapeutic. The backup or support processes are not directly related with the productive organization component, serving essentially as support to the primary processes. They have as main objectives: Manage human resources; Manage financial resources; Manage Clinical and General Resources; Ensure continuous improvement and manage facilities and equipment. After conclude the architecture of processes an analysis was made with the management department in order to select one of the processes to be an object of development of Business Intelligence system. This process should be able to evaluate and monitor the performance of itself. The selected processes were: "Provide conventional surgical care" and "Provide surgical outpatient care". These processes were then aggregate in a main process namely "Surgical Process". After conclude the analysis of the problems and the concerns existing in the process, the relationships (proceeds and stakeholders) were identified. This task has as main goal define one set of indicators of performance able to monitoring the concerns, the existing problems and evaluate the process' performance. For each indicator was mentioned the dimension corresponding to Balanced Scorecard, the goal to achieve and the analysis periodicity. The indicators related to the processes: Managing financial resources and managing the human resources cover all the organization. A origem da referência não foi encontrada..

Dimension	Process	Concerns/ Issues	Goals	Indicators	Unit
Financial	Manage financial resources	Lack of profitability of the surgical process	Maintain the profitability of the surgical process within the defined limits	Total amount of spending	€
				Total income Value	€
				Value operating result	€
				Operating Profitability	%
Financial	Manage financial resources	Billing unacknowledged	Identify value billing unrecognized	Total amount of spending	€
Financial	Manage human resources	Result exercise off budget	Maintain the result within defined limits	Value of net income	€
				Income before taxes and depreciation / amortization	€
Internal processes	Ensure continuous improvement	Production surgery outside the agreed	Ensure the production operations as agreed	Total number of surgeries	Un
Users	Patient; Continuous improvement	High waiting time for surgery	Reduce the waiting time for surgery	Number of days waiting for Surgery	Day
Employees	Employees	Absenteeism of employees	Reduce absenteeism of employees	Number of Hours of Work	Hour
				Number absenteeism hours	Hour

Table 1 Performance indicators of surgical process

They are going beyond the scope of the surgical process. It was considered useful the inclusion of these indicators to ensure the use of the balanced Scorecard's principals. The indicators will be available in Dashboard allowing a simple and embracing visualization of the processes' performance. To allow a more detailed level of analysis and the creation of multidimensional analysis, mainly for operational and intermediate managers, a Data Mart is available. This Data Mart allows a more detailed analysis of the facts and dimensions defined in the BI Architecture.

4. Business Intelligence Solution

The BI architecture was designed with the goal to support the Key Performance Indicators (KPI) previously defined. The BI architecture is divided into 3 environments: Data sources, Data warehouse and Business Analytics. Data Sources Environment presents the data source that show the operational databases and / or external files. These data sources are the ERP Primavera and SONHO. Date Warehouse Environment corresponds to the stage where the data resulting from the previous stage are loaded into a single database. Then the data are sent to the data mart surgical process. By using the staging area, the performance of operational databases is not called into question. Finally, in Business Analytics Environment a cube is prepared and the dashboards and multi-dimensional reports are presented. It should be noted that the data mart updating process is done through the staging area when the impact on operational databases is reduced.

Misericórdias uses several tools to store data provided by diverse data sources. The data warehouse model includes characteristics like *granularity*, *dimension tables*, *fact tables* and the *constellation scheme*. The interface will be composed by two ways of presentation: *dashboards* and *multidimensional reporting*. Dashboard is a data visualization tool that displays the current status of metrics and key performance indicators for an organization.

The surgical process was the process chosen. In this process all the support activities were considered. The importance of the surgical process for the organization’s strategy puts it as owner in the creation of systems that evaluate and monitor their performance. Consequently, a Data Mart which guarantees the information availability to support the decision making process at the different levels of management was created. Data Mart is a repository of data smaller than a DW referring to a specific area. Regarding to the granularity, four types of different granularities were defined: episode (patient id), hour, request and day. With this granularity it is possible to support analyzes at the four levels. In terms of dimensions, ten dimensions and the respective attributes were defined: hour, month, specialty, doctor, process, diagnosis, (nature of expenses), type of intervention, financial identity responsible and patient. In this architecture three fact tables are used. The facts are used to measure the surgical performance, through the use of dimensions aforementioned: profitability of the surgical process, production surgeries and waiting time in days.

The fact table “profitability of the surgical process” has as main goal maintaining the profitability of the surgical process within defined limits. The measures used are: spent value, income value, result (spent profitability) and invoiced amount not recognized. The fact table “production of surgeries” has as main goal ensuring the production of surgeries as agreed with the financial identities responsible and with the doctors. The measure used are the number of surgeries and the fact table is loaded and used through the operational systems. The fact table “days of waiting till surgery” has as main goal monetize and reducing the waiting time until the surgery according to the agreed targets. Finally, the fact/ measure used is the number of days waiting until the surgery and the table is loaded and updated through the operational systems. Therefore, the Data Mart of the surgical process is constituted for three fact tables: Profitability of the surgical process (Fig. 1), Waiting days till surgery (Fig. 2) and Production of surgeries (Fig. 3). Consequently, the data mart is based in the constellation scheme. Given the complexity of the scheme and to a better perception in the article, the scheme was divided into 3 diagrams. The Data Mart is already deployed and it is prepared to be used.

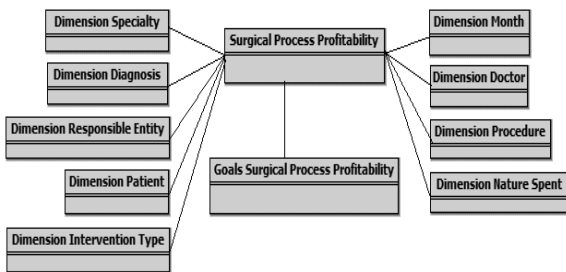


Fig. 1. Star schema of the profitability of the surgical process

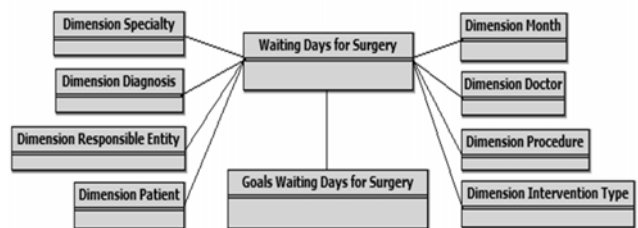


Fig. 2. Star schema for waiting days for surgery

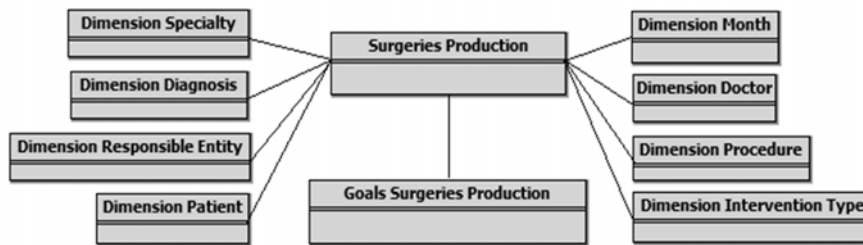


Fig. 3. Star schema for surgeries production

5. Results Business Indicators

After an analysis of the surgical process, a set of performance indicators to monitoring the concerns, problems and evaluate the performance of the process were identified. Associated with each concern / problem is a set of KPIs: Lack of profitability of the surgical process: The total spending value; The total income value; Value operating results and the operating profitability; Invoicing not recognized by the responsible entities: The total amount of spending; Result of the year out of the budget: Value of net profit; The result before taxes and depreciation/ amortization; Surgeries production outside the agreed: The total number of surgeries; High waiting time for surgery: The number of days of waiting for surgery; Absenteeism of employees: The number of working hours; The number of hours of absenteeism. Absenteeism rate.

5.1. Strengths, Weaknesses, Opportunities and Threats

The SWOT analysis is used to identify the strengths and weaknesses of the organization and the opportunities and threats in the environment [17]. It is one of the most popular management tools regarding the strategic review of the organization, as it provides information relevant to the decision-making process, allowing a starting point to check the business strategic alignment of the organization [18]. Then the SWOT analysis of the implementation of this solution in the health area of *Misericórdias* is presented having in consideration the business process. **Strengths:** Increases efficiency and quality of health services; Reduce costs of information analysis; Increases quality in decision-making; Faster access to data; Multidimensional reports and dashboards; Storage Data from multiple operating systems in one place and Intuitive platform with easy access. **Weaknesses:** Multiple data sources; Resistance to change the organization caused by the use of dashboards and multidimensional reports by the team management; Reduced knowledge of tools used to contain the dashboards and multidimensional reports; Complexity of dashboards and multidimensional reports and employees' absenteeism. **Opportunities:** Needs of reducing the organization cost; Improve the quality of decision making; Improve efficiency in health service delivery; Improved patient satisfaction; Improve the profitability of the surgical process and Ensure production operations as agreed. **Threats:** Changing the tools used by the *Misericórdia* in health area; Management Suspicions concerning to the information processing task; Patients with high waiting times for surgery. Poor management of materials; Lack of profitability of the surgical process and Surgeries production outside the agreed.

6. Discussion, Conclusions and future work

The SWOT analysis of the project indicates that the benefits from the use of BI in the health of *Misericórdia* overcome the disadvantages. The number of tools used by *Misericórdias* incorporating BI component is very low, so their use still reduced. Furthermore, it is important to emphasizes the fact that the *Misericórdias* sometimes use several tools in one health unit to perform their tasks. It means that there is a higher degree of difficulty when it is needed to analyze data provided from multiple sources. BI shown to be an important tool to help solving this problem. The surgical procedure was chosen from the process architecture through the use of various methodologies focused in the processes. Then, it was possible to define a set of performance indicators to meet the required needs in the surgical

procedure. Therefore, the implemented model promotes the interoperability because it allows the information generated by the tools used to be stored and handled from one place which allows to obtaining real-time information which in turn leads to a well-supported decision-making process. It promotes a more accurate decision making process based on evidence. In addition to the information query based on the model in question, this solution can lead to the identification of possible improvement actions.

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 in order 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 making 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 a BI architecture and their KPIs which can be reused in others *Misericórdias*, in order to improve the quality of health care and patient satisfaction. As future work some challenges are being considered: propose improvements to ensure the success and usefulness of BI systems, management function, responsible for assessing and monitoring organizational performance; disseminate the project to other organizational processes, starting from the identified organizational process architecture. Explore other tools in order to verify what is indicated for the development and presentation of dashboards, multidimensional reports, according to the organization needs.

Acknowledgments

This work has been supported by FCT - Fundação para a Ciência e Tecnologia within the Project Scope UID/CEC/00319/2013.

References

- [1] S. A. da C. Andrade, “Inovação nos serviços de saúde das Misericórdias da região norte de Portugal,” 2014.
- [2] C. M. C. Enes, “Análise de custos e estudo de economias de escala na Santa Casa da Misericórdia de Barcelos,” 2013.
- [3] *Decreto-Lei n.º 138/2013 de 9 de Outubro do Ministério da Saúde*, vol. 2. Portugal, 2014, pp. 6068–6071.
- [4] H. Vuori, “Primary health care in Europe—problems and solutions,” *J. Public Heal.*, vol. 6, no. 3, pp. 221–231, Aug. 1984.
- [5] *Decreto-Lei n.º.172-A/2014 de 14 de Novembro do Ministério da Solidariedade, Emprego e Segurança Social*, no. 2. Portugal, 2014, pp. 2–26.
- [6] S. Williams and N. Williams, *The Profit Impact of Business Intelligence*. Elsevier Science, 2010.
- [7] S. Negash and P. Gray, “Business Intelligence,” *AMCIS 2003 Proc.*, p. 423, 2004.
- [8] S. Chaudhuri, U. Dayal, and V. Narasayya, “An overview of business intelligence technology,” *Commun. ACM*, vol. 54, no. 8, p. 88, 2011.
- [9] R. Jacobson and S. Misner, *Microsoft SQL Server(TM) 2005 Analysis Services Step by Step*. Microsoft Press, 2006.
- [10] M. Y. Santos and I. Ramos, *Business Intelligence: Tecnologias da informação na gestão de conhecimento*. FCA-Editora de Informática, 2006.
- [11] W. H. Inmon, *Building the data warehouse*. John wiley & sons, 2005.
- [12] O. Y. Tanaka and E. M. Tamaki, “The role of evaluation in decision-making in the management of health services,” *Ciência Saúde Colect.*, vol. 17, pp. 821–828, 2012.
- [13] F. Vogt, “Os benefícios das ferramentas de Business Intelligence na área da Saúde.” 2013.
- [14] L. Cardoso, F. Marins, F. Portela, M. Santos, A. Abelha, and J. Machado, “The Next Generation of Interoperability Agents in Healthcare,” *Int. J. Environ. Res. Public Health*, vol. 11, no. 5, pp. 5349–5371, May 2014.
- [15] A. Brandão and F. Portela, “Step towards Improving the Voluntary Interruption of Pregnancy by Means of Business Intelligence,” in *Applying Business Intelligence to Clinical and Healthcare Organizations*, IGI Global, 2016, pp. 43–63.
- [16] “As Tecnologias de Informação e Comunicação e os Sistemas de Informação nos Hospitais Business Intelligence na Saúde Perspetivas e Desafios Agenda,” p. 27.
- [17] R. G. Dyson, “Strategic development and SWOT analysis at the University of Warwick,” *Eur. J. Oper. Res.*, vol. 152, no. 3, pp. 631–640, 2004.
- [18] M. Kajanus, J. Kangas, and M. Kurttila, “The use of value focused thinking and the A’WOT hybrid method in tourism management,” *Tour. Manag.*, vol. 25, no. 4, pp. 499–506, 2004.