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Enhancing Clinical Management of Bariatric Surgery Using Business Intelligence

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Abstract

There is a problem with collecting information in healthcare services as it is scattered among various sources. This leads to potential impact on patient care focus. To address this issue, a Business Intelligence platform was developed and implemented at the Centre for Surgical Treatment of Obesity at Centro Hospitalar do Tâmega e Sousa. The platform developed enables knowledge extraction and aids healthcare professionals to easily access helpful information and perform better decisions, specifically in regards to the growing global concern of obesity and the increasing prevalence of bariatric surgery.

Keywords: Business Intelligence, Knowledge Extraction, Obesity, Bariatric Surgery;

1. Introduction

Currently, the collection of information is one of the problems present in health services, since this same information is scattered among unconsolidated sources [1]. In addition, the lack of human resources means that it is the health professionals themselves who collect the information. There are several potential problems that can arise in this situation. Inefficient collection and management of hospital information can be compromised, as well as limiting the availability of human resources in other areas of action [2]. Consequently, there will be a potential impact on patient care. Furthermore, there is a risk of inconsistencies or errors due to human error, which can compromise the accuracy and reliability of the data. Automated information systems and databases can often provide a more efficient and reliable way to collect, manage, and analyse hospital data. It is to fulfil this function that Business Intelligence (BI) systems emerge, capable of integrating huge amounts of data from various heterogeneous sources and providing analytical tools for data analysis [1]. This way, there will be an improvement in the decision-making process performed

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by health care professionals, through the use of targeted information from real data, resulting in the improvement of the patient's clinical condition through a more efficient diagnosis and the identification and application of best practice treatment protocols [3, 4]. First, data is collected and stored in a database. Then, the collected data is processed by BI systems that extract information, and knowledge is extracted from that information. This knowledge is essential to identify, analyse, and monitor all the processes and activities that take place within a healthcare institution to ensure that all the information is available when it is needed and that a correct interpretation of it is made without putting a person's life at risk [3].

A growing global public health concern is obesity. Patients who are obese run a significant risk of contracting a number of comorbid diseases [5]. As obesity has become a major concern, bariatric surgery has become more and more widespread. These therapies have been associated with significant and long-lasting weight loss, treatment and prevention of obesity-related diseases, as well as significant improvements in quality of life and longevity [6]. However, bariatric surgery is a prolonged process that begins with a careful initial clinical assessment and continues beyond the operative procedure through ongoing patient follow-up [7, 8]. In order to allow an objective assessment of risks and benefits across the community, careful management of the data associated with the entire surgical procedure is essential.

Due to the numerous advantages that Business Intelligence has associated with it, increasingly, the health sector seeks computer applications to support the daily practice of health professionals, and the area of Bariatric Surgery is no exception. The BI technology uses historical and current data in order to visualise them through reports, graphs and Key Performance Indicators (KPIs), using analytical processing tools [3, 9]. Thus, the great motivation for this investigation is the creation and implementation of a BI platform in the Centre for Surgical Treatment of Obesity (CTCO) in Centro Hospitalar do Tâmega e Sousa (CHTS). CTCO is typically staffed by a team of specialised surgeons, nurses, and other healthcare professionals who are trained in the latest techniques for treating obesity. With this, it is intended to explore the role of BI in supporting healthcare innovation in the bariatric surgery area and provide performance indicators for this unit to improve control over the entire surgical and post-surgical process. Moreover, the ability to quickly access data related to the entire surgical procedure is one of the incentives of the project in order to enable an objective assessment of the various clinical affairs and aid in the decision-making process. In addition, the implementation of this project aims to simplify the work that the medical team of the CTCO performs in the design of reports and indicators. Thus, the usefulness and interest that this platform provides for health professionals became another of the work's primary motives. To this end, the main objective of this study is to build and implement a BI system and Business Analytic (BA), able to support the decision-making process in Bariatric Surgery.

2. Background

The goal of Hospital Information Systems (HIS) was to create a paperless workplace that could accommodate all aspects of hospital operations, including the clinical, administrative, and financial systems [2]. In order to respond to the growing need to make administrative work in Portuguese hospitals more efficient, the SONHO system was developed in the 1990s by IGIF - Instituto de Gestão Informática e Financeira da Saúde. The system, which has its own database, manages the personal data of the users/patients, such as the patient's unique identification and the reason for their visit to the hospital, as well as the respective examinations. This system not only allows the registration of this information, but also its sharing and consequent quick access to the patient's history [10, 11]. The support given to hospital administrative services allows production and invoicing control to be ensured, enabling the exportation of data, the statistical treatment of the information collected and also the calculation of indicators which assist the decision-making processes in the organisational area of hospitals [11, 1].

2.1. BI in the Healthcare Context

Most research in BI focuses mainly on the Industrial Sector. In order to adapt the knowledge already existing in that sector to the healthcare sector, Mettler and Vimarlund [12] conducted a review where a comparison between BI focused on the healthcare sector and focused on other sectors is presented. Most sectors have a defined group of customers with some variation of products, while healthcare involves a huge variety of stakeholders with different needs. Another difference mentioned, is that industrial systems have strict metrics, while in healthcare, people's feelings and choices are also relevant. But while there are differences, there are also similarities between the sectors. The demand

for improving quality and the value of associated costs through integrated processes, essential for collecting, processing, and distributing data and information, is the one that stands out the most. The fact that healthcare organisations must meet legal requirements requires them to systematically collect information about their own performance. Consequently, healthcare organisations will need to acquire knowledge and technology for BI so as not to overburden healthcare professionals. Thus, the authors believe that in healthcare, BI should help management, both clinical and administrative, understand the capabilities available in the healthcare institution and facilitate decision making by integrating all kinds of metrics on a variety of internal and external stakeholders from a wide range of processes. Further, at the future level, they believe that the potential of BI applied to healthcare will not only be related to the simplification of communication and information delivery that it enables, but also by allowing for the integration of information and organisations and the measurement of outcomes in real time [12].

In a study developed by Abreu et al. [13], the major goal was to employ BI and BA approaches to extract knowledge from obstetric data that was targeted at therapeutic decisions. The information was taken from the obstetric service of the Centro Hospitalar e Universitário do Porto (CHUP). Initially, a search was carried out for all the indicators required for the obstetrics service of the CHUP, including the total number of deliveries and the total number of twin deliveries. All of the indications needed for the CHUP's obstetrics service, including the overall number of births and the overall number of twin births, were initially searched for. The information that was taken from the CHUP's obstetrics service was then translated and imported into the (Data Warehouse) DW's fact and dimension tables. For this, the Oracle SQL Developer tool was used, which allows the extraction of information from large databases and the implementation of (Extract, Transform, Load) ETL processes. Next, the processed information was made intuitively available to the final user by means of a visualisation tool, in this case, the tool chosen was Power BI. The authors justify choosing this tool with its ease of use and versatility in creating dashboards, reports, and indicators, making it a tool with relevance in the BI, BA, and data visualisation markets. With the work completed, it was feasible to use the CHUP databases' data more effectively, resulting in the quality assurance of the knowledge that was made available to health professionals. Through the indicators they noticed, they were able to gather scientific evidence that aided in their clinical decision-making.

3. Bariatric Surgery Support Platform

The CTCO medical team is in charge of creating annual reports that include unit's performance metrics and delivering them to the Direção Geral da Saúde (DGS). The primary goal of this project is to automate information gathering and visualisation. Thus, in this stage, tasks were realised such as: requirements definition, architecture definition and setting up the ETL process.

3.1. Requirements

During the requirements collection phase, it is important to understand the needs of the organisation. Currently, in the particular case of the CTCO unit of the CHTS, data regarding the surgeries performed as well as the Assessment Consultations for the Surgical Treatment of Obesity (AMTCO) performed are collected manually by the medical team of the unit, as mentioned above. There is a constant need to organise, analyse, and control this data, so it is necessary to optimise the whole process in order to improve the efficiency of the reports prepared with this information and to ensure compliance with all the steps defined in the Obesity Surgical Treatment Programme (PTCO). The PTCO includes a mandatory minimum of consultations per speciality that must be carried out in the respective follow-up year after surgery. In the first phase, it was a priority to build a table with all the data related to the mandatory queries that make up the PTCO. The requirements initially defined were the number of consultations registered by speciality and the respective year of follow-up, and the number of consultations scheduled by speciality and the respective year of follow-up. In this way, it would be possible to control the different situations associated with each patient:

1. The patient already attended the minimum number of mandatory consultation(s) in the respective follow-up year.
2. The patient attended less than the minimum number of mandatory consultation(s) in the respective follow-up year, but completes with scheduled consultation(s)

3. The patient does not attend any mandatory consultation(s) in the respective follow-up year, but has the minimum number of mandatory consultation(s) scheduled.
4. The patient has attended less than the minimum number of mandatory consultation(s) in the respective follow-up year but has no further consultation(s) scheduled. In this situation it is necessary to analyse how much time is left until the end of the respective follow-up year (1st, 2nd and 3rd) to understand if the consultation should be made with some urgency or not.
5. The patient has not attended any of the mandatory consultation(s) in the respective follow-up year and has less than the minimum number of mandatory consultation(s) scheduled. In this situation it is necessary to analyse how much time is left until the end of the respective follow-up year (1st, 2nd and 3rd) to understand whether or not the appointment should be made with some urgency.
6. The patient has not attended any of the mandatory consultation(s) in the respective follow-up year, but also has no appointment scheduled. In this situation it is necessary to analyse how much time is left until the end of the respective follow-up year (1st, 2nd and 3rd) to understand whether or not consultation(s) should be made with some urgency.
7. The patient did not attend any mandatory consultation(s) in the respective follow-up year or attended fewer than the mandatory consultation(s), but the follow-up year has passed. Therefore, it is concluded that he did not comply with the requirements set out in the PTCO.

3.2. Architecture

Thus, in Figure 1, the architecture and flow of the entire development up to the intended solution is presented. The process can be summarised by the occurrence, in a first phase, of the analysis of the data present in the SONHO database. Afterwards, these data were submitted to the ETL process, where the cleaning and extraction of the data from the original database was performed and the treatment of these same data so that they become uniform. Finally, it is necessary to perform the loading to the DW. In a final step, the information is obtained and visualised in the chosen open source tool.

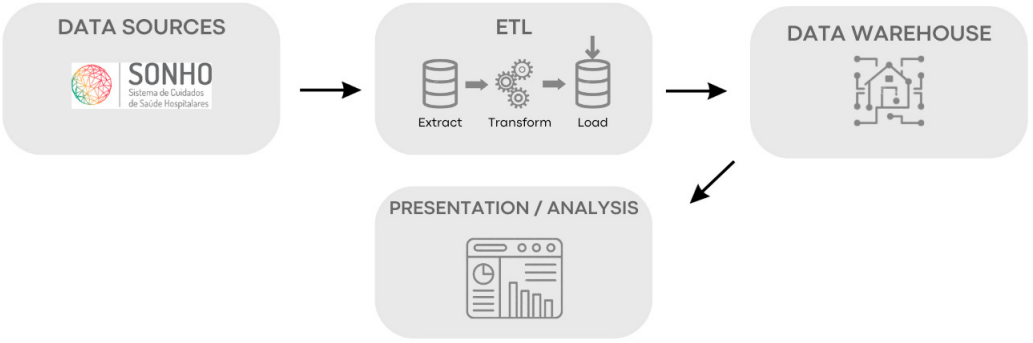

Fig. 1. BI platform architecture.

3.3. ETL Process

The ETL process is fundamental to process the data and improve the performance of the solution to be developed. In this phase, the columns in the SONHO database that did not add any interest to the defined indicators were eliminated, giving rise to table with only the attributes necessary. Table 1 shows the obtained attributes from ETL process with their descriptions and formats. It should be noted that some of the attributes presented in Table 1, such as C1CIRURGIA, C1ENDOCRINOLOGIA, C1NUTRICAO, C1PSIQUIATRIA, are the result of calculations carried out for the construction of consultations control table to comply with the requirements of the PTCO.

Table 1. Data Analysis.

Attributes	Description	Format
NSEQ	Patient ID number	Integer
PROCESSO	Identifying number of the case	Integer
DATAPRIMEIRO	Starting date of the first year of follow-up	Date
DATAFIMPRIMEIRO	End date of the first year of follow-up	Date
C#CIRURGIA*	Nº of consultations of the surgical speciality carried out in the respective follow-up year	Integer
C#ENDOCRINOLOGIA*	Nº of consultations of the endocrinology speciality carried out in the respective follow-up year	Integer
C#NUTRICAO*	Nº of consultations of the nutrition speciality carried out in the respective follow-up year	Integer
C#PSIQUIATRIA*	Nº of consultations of the psychiatry speciality carried out in the respective follow-up year	Integer

* $\# \in \{1, 2, 3\}$

4. Results and Discussion

After an analysis of the agreed requirements, a dashboard was elaborated, as can be seen in Figure 2, whose function is to ensure compliance with the minimums established by the PTCO.

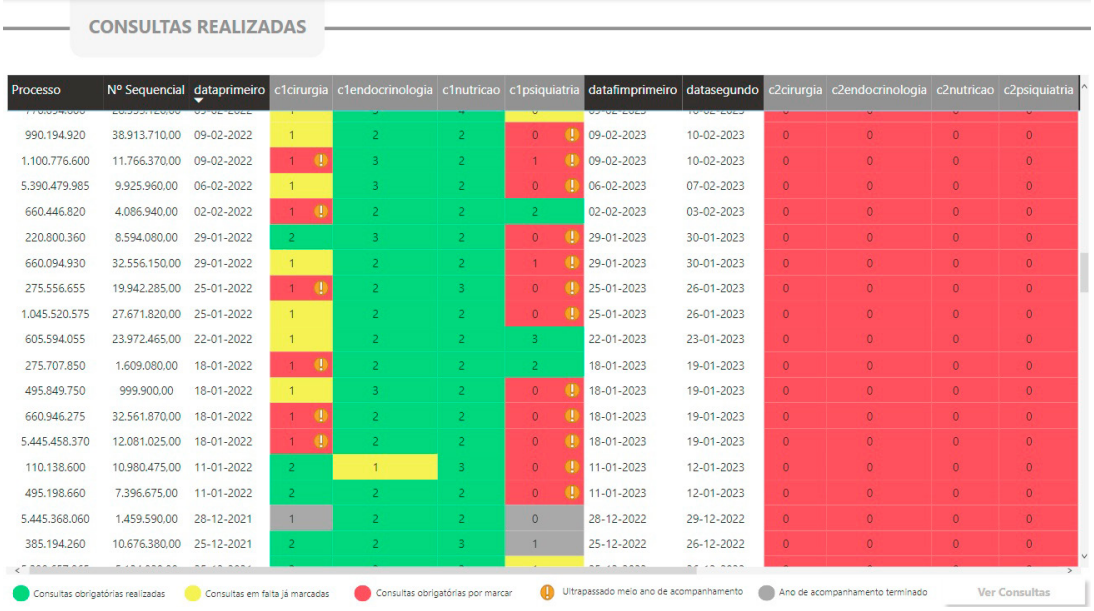

Fig. 2. AMTCOs Control Panel.

The BI tool chosen to build the dashboard was Microsoft Power BI® since it is more user-friendly, intuitive, and easier to integrate with other APIs. With the help of this tool, in order to facilitate the visualisation, in an efficient manner, of the different situations in which the patients may find themselves during the follow-up period, an intuitive colour code was attributed to them. Green indicates patients who have already attended all the obligatory consultations in the respective follow-up year. Yellow indicates cases numbered 2 and 3 in section 3.1. Red indicates cases numbered 4, 5 and 6 (section 3.1), and gray represents the situation described in the last point (7). In the cases listed as 5 and 7 in the previously mentioned section, it is necessary to understand whether half a year of follow-up has passed. If this is the case, the missing appointments need to be scheduled urgently, so these situations are marked in Table 2 with an exclamation mark. The results obtained from the construction of the dashboard presented above were as intended, as it fulfils its intended functionality. Through its analysis, it is possible to conclude that the information is properly organised, updated, and distributed, allowing early detection of risks that occasionally go unnoticed, such as, for example, forgetting to schedule missing AMTCOs. The CTCO of CHTS will gain a lot from using the BI platform

since it will enable sustainable decision-making throughout the process. So answering the research question: Yes, it is possible to implement a BI platform in the CTCO of the CHTS able to improve the decision-making process.

5. Conclusions and Future work

This project produced a prototype that enables knowledge extraction from already-existing hospital data, making it easier for CTCO's medical professionals at CHTS to acquire helpful information and support them in their decision-making. Previously, these data were gathered manually, over an extended period of time, using time-consuming, inefficient methods and tools. With the dashboard in place, medical staff will be able to ensure compliance with PTCO requirements much more efficiently. This is intended to ensure that the entire process is completed successfully and on time, without errors or oversights. In conclusion, in this way, better and more efficient healthcare for patients is ensured. The following challenges are being considered for future work: automate the ETL process; allow the visualisation of detailed information about the registered and scheduled appointments of a particular patient; build more KPIs that assist the medical team with complementary and organised information; and analysis of its contribution in a real-world setting.

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References

[1] J. Machado, A. Abelha, J. Neves, M. Santos, Ambient intelligence in medicine, in: 2006 IEEE Biomedical Circuits and Systems Conference, IEEE, 2006, pp. 94–97. doi:10.1109/BIOCAS.2006.4600316.

[2] P.-T. Chen, C.-L. Lin, W.-N. Wu, Big data management in healthcare: Adoption challenges and implications, International Journal of Information Management 53 (2020) 102078. doi:https://doi.org/10.1016/j.ijinfomgt.2020.102078.

[3] H. Peixoto, A. Domingues, B. Fernandes, Steps towards interoperability in healthcare environment, in: Virtual and Mobile Healthcare: Breakthroughs in Research and Practice, IGI Global, 2020. doi:https://doi.org/10.4018/978-1-5225-9863-3.ch023.

[4] I. Muraina, A. Ahmad, Healthcare business intelligence: The case of university's health center, in: International Conference on E-CASE E-TECH, 2012.

[5] S. M. Fruh, Obesity: Risk factors, complications, and strategies for sustainable long-term weight management., Journal of the American Association of Nurse Practitioners (2017).

[6] S. I. Khalid, P. A. Omotosho, A. Spagnoli, A. Torquati, Association of bariatric surgery with risk of fracture in patients with severe obesity, JAMA Netw Open 3(6) (2020) 1358–1365. doi:https://doi.org/10.1001/jamanetworkopen.2020.7419.

[7] P. E. O'Brien, Bariatric surgery: mechanisms, indications and outcomes, Journal of gastroenterology and hepatology 25 (2010) 1358–1365. doi:https://doi.org/10.1111/j.1440-1746.2010.06391.x.

[8] A. Afonso, C. Alvaréz, D. Ferreira, D. Oliveira, H. Peixoto, A. Abelha, J. Machado, Openehr based bariatric surgery follow-up, Procedia Computer Science 210 (2022) 271–276.

[9] A. Brandão, E. Pereira, M. Esteves, F. Portela, M. F. Santos, A. Abelha, J. Machado, A benchmarking analysis of open-source business intelligence tools in healthcare environments, Information 7 (4) (2016). doi:10.3390/info7040057.
URL https://www.mdpi.com/2078-2489/7/4/57

[10] SONHO, Sonho hospitalar — sistema integrado de informação hospitalar – spms, https://www.spms.min-saude.pt/2019/01/product-sclinicohospitalar/, accessed: 2022-10-10 (2022).

[11] A. A. C. Teixeira, A. M. Brochado, Quando o sonho se torna realidade...: avaliação estatística do impacto das tecnologias de informação nos serviços de consulta externa hospitalar, Revista Portuguesa de Saúde Pública 23 (1) (2005) 43–55.

[12] T. Mettler, V. Vimarlund, Understanding business intelligence in the context of healthcare, Health informatics journal 15 (3) (2009) 254–264.

[13] J. Abreu, T. Guimarães, A. Abelha, M. F. Santos, Business analytics components for public health institution-clinical decision area, Procedia Computer Science 198 (2022) 335–340. doi:10.1016/j.procs.2021.12.250.