



Department of Information Science and Technology

## **A Productivity Dashboard for Hospitals: An Empirical Study**

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## **Resumo**

As unidades de saúde são instituições que requerem informações atualizadas e precisas para apoiar as decisões de gestão a fim de prosperarem numa indústria tão crítica. Assim, os sistemas de informação de saúde foram desenvolvidos para ajudar os gestores hospitalares a dirigir as operações diárias. Esses sistemas não fornecem só suporte operacional, mas também indicadores de desempenho chave (KPI's) para monitorizar áreas relevantes numa base agregada no tempo.

A tese concentra-se em dois problemas: As organizações hospitalares precisam de informações sobre produção e produtividade para melhorar o acesso aos serviços. Os gestores precisam de informações de produção e produtividade para otimizar a alocação de recursos.

A importância da resolução destas questões prende-se com o facto de que ao monitorizar a informação de produção e produtividade é possível melhorar a alocação de recursos.

A pesquisa consiste no desenvolvimento de painel de controlo para monitorar as informações obtidas numa organização hospitalar ao nível da produção e produtividade, com a missão de apoiar os decisores no processo de decisão.

Para desenvolver adequadamente o painel de controlo de produtividade, adotou-se a metodologia Design Science Research (DSR) para construir e avaliar o artefato.

Verificou-se que o segmento de produção e produtividade necessita de mais estudo e que o painel de controlo sobre estas temáticas é uma mais-valia ao nível da monitorização e análise e posterior processo de tomada de decisão.

O contributo esperado é melhorar o processo de tomada de decisão nas Organizações de saúde, podendo ser útil para alertar de factos que a própria organização possa ainda desconhecer relativamente à sua operacionalidade.

**Palavras-Chave:** Sistemas de informação em saúde; Inteligência empresarial; Painel de control; Gestão hospitalar; Indicadores chaves de desempenho.



## **Abstract**

Health units are institutions which require accurate, updated information to support managerial decisions for thriving in such a critical industry. Thus, health information systems have been developed to help hospital managers steer daily operations. These systems provide not only operational support, but also key performance indicators (KPI's) to monitor relevant areas at a time-aggregated basis.

Despite the recognized value of dashboards in helping decision-makers, the literature shows a lack of proposals of productivity dashboards to assist Hospitals stakeholders.

The thesis focuses on two problems: Hospital organizations need access to production and productivity information to improve access to services. Managers need production and productivity information to optimize resource allocation.

The importance of addressing these issues lies in the fact that to monitor production and productivity information, is it possible to improve resource allocation.

This dissertation consists of the development of dashboards to monitor information obtained from a hospital organization at the level of production and productivity, with the mission of supporting decision makers in the decision process.

To properly develop the productivity dashboard, the Design Science Research (DSR) methodology was adopted to build and evaluate the artefact.

It was ascertained that the production and productivity segment need more study and that the dashboards on these themes is an asset at the level of monitoring and analysis and subsequent decision-making process.

The expected contribution of this research is to develop a dashboard recognized by health stakeholders as capable of better assisting them during their management duties.

**Keywords:** Health information systems; Business Intelligence; dashboard; hospital management; KPI's.



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## List of Abbreviations and Acronyms

APPT	–	Appointment
BI	–	Business Intelligence
BSC	–	Balanced Scorecard
BPMN	–	Business Process Modeling Notation
CalNOC	–	California Nursing Outcomes Coalition
COPD	–	Chronic Obstructive Pulmonary Disease
CONSUL.	–	Consultations
CON.	–	Conventional
CPI	–	Continuous Process Improvement
DSR	–	Design Science Research
DSAA	–	Data Science and Advanced Analytics
DFID	–	Design Feature Implementation Dashboard
DPM	–	Design Performance Matrix
ED	–	Emergency Department
ETL	–	Extract Transform Load
HIS	–	Hospital Information System
ICT's	–	Information and Communications Technology
ICU	–	Intensive Care Unit
INT.	–	Interventions
IS	–	Information Systems
KPI's	–	Key Performance Indicator
LR	–	Literature Review
NHS	–	National Health Services
NQF	–	National Quality Forum
OECD–	–	Organization for Economic Co-operation and Development
O/P	–	Outpatient
RADEF	–	Relatório Analítico do Desempenho Económico e Financeiro
VA	–	Visual Analytics
VAD	–	Visual Analytics Dashboard



## **Chapter 1 – Introduction**

Health is a sector that is constantly evolving and growing, making it one of the largest industries in the world. Its impact on the economy of the countries is enormous, and in developed countries, this area receives high budgetary resources from the state (Rahimi et al., 2016).

However, like all other institutions, hospitals are at the mercy of the unstable environment of external factors such as technological advances, demographic changes, and changes in the average lifespan of people. For these reasons and due to the impact on the healthcare system at the level of effectiveness it is necessary that hospitals continuously improve their performance (Koumpouros, 2013).

To improve performance, it is necessary to measure and evaluate it and act, so that it is possible to allow hospital organizations to define strategies for the future. To achieve the respective goals, it is necessary to collaborate with the various hospital stakeholders. The strategic objectives of healthcare are always challenging because of the complexity of healthcare organizations (Rahimi et al., 2016); (Engla, 2006).

The increasing volume of data is due to the emergence of more than 20 years of electronic storage of patients' data, with the Hospital Information System (HIS) being able to store and subsequently provide useful information throughout the hospital's medical history: from financial information, laboratory data and patients' electronic records (Kawamura et al., 2014).

The impact of the introduction of information and communications technology (ICT's) in the multifaceted health sector is well known and recognized (Berler et al., 2005).

There is an essential relationship between the level of ICT's adoption, the level of financial well-being and the level of productivity of healthcare organizations (Mettler & Rohner, 2009).

Business Intelligence (BI) is essential in ICT's and has a direct impact on the following aspects: providing data visualization tools, improving organizational decisions, supporting analysis of breaking corporate information barriers, influencing strategic business decisions, and helping to give meaning to organizational data (Safwan et al., 2016).

When designed to measure performance and backed by a business-oriented BI infrastructure, it will enable healthcare managers to measure performance, monitor KPI's

by preventing deviations, understand undesirable behaviors and redefine the trajectory of the set objectives (Ghazisaeidi et al., 2015).

BI provides the essential tools which enable efficient analysis of crucial information from the organization. One of these tools is the dashboards that must be developed to allow access of any healthcare stakeholders to the information contained herein. The dashboards information presented graphically or textually is based on KPI's that are chosen due to their importance in the organization's strategy. The visualization of the data is a crucial factor so that stakeholders can obtain the information to make the necessary decisions. Due to the complexity of the decision process it is necessary to make available techniques such as drill down which, when necessary, allow a more detailed analysis of the information and thus provide data to justify the decision (Baskett et al., 2008); (Ryan et al., 2017).

The measurement of production has always presented enormous complexity because healthcare is not tradable. This fact hinders the observation of prices and results. Technological advances also increase the complexity of price analysis and results (Sharpe et al., 2007).

### 1.1. Problem and Motivation

The research focuses on the development of a dashboard for healthcare organizations productivity. The two problems that we attempt to solve are shown in Table 1.

*Table 1 – The key problems of the study*

<b>ID</b>	<b>Description</b>	<b>Authors</b>
P1	Hospital organizations have difficulty in improving the services provided when they do not have access to production and productivity information which allows real time information analysis.	(Sharpe et al., 2007)
	Managers find it difficult to identify trends and patterns as well as to mitigate deviations and negative trends, which makes it impossible to make decisions that are fundamental for improving the productivity and motivation of hospital organizations.	(Nogueira et al., 2017)
P2	Hospitals do not have tools that assist in the analysis, evaluation and monitoring of productivity to manage the allocation of resource optimization.	(Black, Browne, & Cairns, 2006)
	Hospital organizations can not evaluate the performance of their resources due to the lack of tools that can help in the decision-making phase.	(Ramos & Miyake, 2010)

One of the motivations of the research is the increasing need for healthcare institutions to have dashboards to provide assessed information about the quality of services provided to patients (Daley et al., 2013). To this end, healthcare managers must have adequate information available to facilitate productivity measurement, hospitals' performance as a whole, the services it provides and the healthcare professionals (Gordon & Richardson, 2013).

Another motivational point for this research is that measuring productivity overcomes the barriers of organizations reaching international institutions, which demonstrates the importance of the subject. In 2000, the Organization for Economic Co-operation and Development (OECD) launched the first document to help simplify this measurement and other entities followed suit (Sharpe et al., 2007).

## **1.2. Objective**

In this dissertation the main objective is to develop a dashboard which can provide information that allows the stakeholders of the hospital organizations to be able to perform an analysis, evaluation and monitoring of production and productivity KPIs to support the decision-making process in which the allocation of human resources, techno-technical financiers is concerned.

## **1.3. Dissertation Structure**

This remaining document is organized as follows: in the second chapter State of the Art is presented introducing Theoretical background and Relational Work. The Research Methodology is in the third chapter where the methodology used in the research is explained. The fourth chapter is reserved for presentation of the proposal, where the results of the interactions are presented. Finally, in chapter fifth conclusion serves to present the main findings of the research, research limitations, lessons and future work.



## **Chapter 2 – State of the Art**

After the previous process, it is necessary to present in greater detail the themes which are the foundation of this research. This chapter will present a review of the literature on the subject. The consultation /research done in the literature focused on the following topics:

### **2.1. Health Industry**

The primary objective of the healthcare industry is the constant improvement of the service provided and a constant concern for the safety of its users (Henkel et al., 2007). However, it is one of the most complex sectors, due to the high number of stakeholders and their high number of conflicting interests; an example is the characterization of healthcare: it must be equal, it must offer high quality and be efficient at the same time. This need for efficiency entails greater complexity due to the appearance of different stakeholders (Henkel et al., 2007). The complexity is not only due to a large number of stakeholders, but also to the amount of data that is produced and that healthcare managers are generally unaware of its existence (Escrivão Junior, 2007).

### **2.2. The Importance of Health Information**

The provision of quality healthcare requires the accomplishment of the interconnection of patient information which is found in several different sources and makes it available to all healthcare professionals and the patients (Ashrafi et al., 2014).

The increase in data is due to the emergence of more than 20 years of electronic storage of patient data, with HIS being able to store and subsequently provide information throughout the hospital's medical history: financial information, laboratory data, and electronic records of patients, provided that the data obtained are of good quality, which is dependent on how the data is entered into the system. (Kawamura et al., 2014).

Healthcare executives are provided with a significant amount of information to improve the well-being and the future of organizations, but this information underload leads healthcare professionals to do everything they can simplify the obtaining data (Ashrafi et al., 2014).

The medical community is known for pioneering in several areas and the technological area is one of them, but concerning improving patient care at a therapeutic level, and the computer systems at the management level of hospital organizations do not receive the same attention (Berler et al., 2005).

### **2.3. The Role of Information Technology in Health**

The primary challenge of ICT's in the healthcare industry is how this sector is organized because it is very people-centered, ICT's are still subject to some resistance from some healthcare professionals. Another obstacle that ICT's faces is that it is usually introduced into hospitals organizations as pilot projects and has not been tailor-made for doctors, and this is the main argument that doctors use to avoid implementation (Berler et al., 2005). Finally, because of the previous points, mapping the data is complex, because the data is distributed in several places, there are repetitions, and sometimes it is not possible to obtain a match. However this situation is gradually changing since ICT's are drawn towards providing service-oriented solutions (Berler et al., 2005).

The organizations have to invest in HIS, diagnostic technology and preventive care programs, with the aim of achieving healthcare quality goals (Ashrafi et al., 2014). Hospitals that use HIS can take advantage of the vast amount of data produced in it, as well as technological development which ensures the possibility of taking advantage of the information to offer better care (Kawamura et al., 2014). The impact of HIS on the health sector is increasing in areas with financial and human resources, in the other areas the role of HIS has increased, but in the absence of HIS, organizations do not fail to play their role. In order not to lose traceability of information, so that they are not deprived of the improvement in the quality of the service and finally do not want to lose the advances in the service, they rely on software that supports the clinical decision (Kawamura et al., 2014).

ICT's in healthcare are now seen as an asset to achieve not only the effectiveness, efficiency and quality of healthcare services, but can also offer transparency of economic activities and provide real-time information to support the decision (Mettler & Rohner, 2009).

### **2.4. The Strategic Importance of BI and The Role of Dashboards**

Nowadays, organizations need to get the most up-to-date operational and financial data to make decisions which have an enormous impact on the company, so they need to bet on BI.

Dashboards, when designed to measure performance and backed by a business-oriented BI infrastructure, will enable healthcare managers to measure performance, monitor KPI



by preventing deviations, understand undesirable behaviors and redefine the trajectory of the set objectives (Ghazisaeidi et al., 2015).

Dashboards have become more prominent in both the health sector and the research community which addresses this topic (Table 1).

### **2.5. Production and Productivity**

Productivity growth in health organizations is generally lower than the growth of the economy as a whole, which is attributed by experts to measurement problems. Productivity is a critical aspect for the performance of health systems, which can be defined by the physical inputs used (labor, capital, and supplies) to achieve a certain level of health outcomes in the treatment of a specific disease (Hill, 2012) ; (Black et al., 2006). Measuring production and productivity is essential to achieve a more efficient allocation of resources in a hospital organization (Sharpe et al., 2007). By measuring productivity, it will be possible to make improvements in the service of organizations, which will not imply an increase in expenses, but the optimization of resources (Black et al., 2006).

Health organizations need to improve the mechanisms for measuring and analyzing estimates to measure productivity, which will improve the performances of the same organizations (Sharpe et al., 2007).

The role of the Dashboard has been increasing in both the health sector and the research community which addresses this topic. For Dashboards to be valuable in decision support they need to strike a balance between the visual aspects and the information they contain. This equilibrium is intended to avoid the excess of information that is not relevant, providing access only to the crucial information for decision-makers (Zhang, Gallagher, & Goh, 2011).

Dashboards allow reduced time in a manual analysis and facilitate the obtaining of information by a higher number of people, due to the appeal in presenting the data. Moreover, the visual design of a dashboard is a determinant factor for its success or failure. The decision makers need dashboards to help organizations in the decision support phase. The significant challenge is to make use of the visualization to facilitate the extraction of the information contained in the dashboard (Eckerson, 2012); (Stadler et al., 2016).

### **2.6. Dashboards**

The role of dashboards is quite broad, spans from helping to measure, monitor and plan in a multidimensional analysis (Ghazisaeidi et al., 2015). For the dashboard to succeed it

should provide more visibility into the critical areas of an organization, to help decision-makers take the necessary steps to keep the organization on track (Alexander, 2007). The development of the dashboard should be based on solid foundations of measurement performance, helping managers focusing their attention on problem areas, corrective actions, analyze poor performance, identify patterns and trends and conduct comparative analyzes between organizations (Ghazisaeidi et al., 2015). The dashboards can be divided into several windows that deal with more detailed issues and feature specific features and capabilities which allow data exploration and analysis (Al-Hajj et al., 2013).

#### 2.6.1. Visualization

The idealization of the visual design of a dashboard is a determinant factor for its success or failure. The decision makers need dashboards to help in the decision support phase in organizations. The important challenge is to make use of the visualization to facilitate extracting the information contained in the dashboard (Eckerson, 2012).

When one develops a dashboard grounded on visual techniques, it should provide unambiguous information. The visualizations should not be prone to misinterpretations, the information should be consumer-ready to the decision makers, only so dashboards can be an added value (Martin et al., 2017).

Dashboards based on visualization techniques allow stakeholders to an answer to their questions about indicators in a given area and trigger new research which helps to increase the knowledge base, improve existing indicators and also contribute to the emergence of new indicators (Al-Hajj et al., 2013); (McLeod et al., 2010).

Visualization techniques enable the creation of new data-driven perspectives to obtain new views of information. The information which is obtained by these techniques allows the creation of a situation point of a particular disease both at a local and regional level (Al-Hajj et al., 2013).

A developed dashboard based on such techniques should provide unambiguous information, the visualizations should not be prone to misinterpretations, the information should be consumer- ready to the decision makers only so dashboards can be an added value (Martin et al., 2017).

#### 2.6.2. Drill Down

Some authors defend that detailing is a feature of extreme importance which adds more value to dashboards. Even when we use the dashboard technology correctly, “A single page is rarely sufficient to present all the relevant performance metrics and therefore the

dashboard must have a drill down capability” (Baskett et al., 2008) (p.18). Furthermore, Park et al. (2010) also refer that “The drill down may follow the organizational hierarchy from the health system to a business unit hospital, a service, a department and a division, all the way down to individual practitioners”(p.295) (Park et al., 2010).

The drill down technique, when implemented in dashboards, provides stakeholders with intelligent analysis because of the level of detail they can ensure. They can even produce a granular level of information through various techniques such as filtering and zooming (Ghazisaeidi et al., 2015). Additionally the drill down technique enables the capacity to analyze indicators, to present answers to the decision makers questions and to support the creation of multiple types of perspectives with more or less detail, which enables the materialization of the big picture for that information (Gordon & Richardson, 2013) ; (Santos, 2015) ; (Silva et al., 2012).

### 2.6.3. Benefits & Disadvantages of Dashboards

Other articles analysis obtained information of the advantages and benefits that are pointed out in the articles on the use of dashboards in the hospital organizations. Tables 2 and 3 were developed following Webster's concept centrics (Webster & Watson, 2002). The first column indicates the concept of profit and the second column presents the statement and reference that support such concept.

The benefits found in the literature were the following: Process Optimization, Information, Performance and Technological. These are the areas where the implementation of dashboards will have greater impact.

Table 2 – Benefits of Dashboard

Benefits	References	Number
Process Optimization	(Stadler et al., 2016); (Ghazisaeidi et al., 2015); (Al-Hajj et al., 2013); (Providers & Nelson, 2010); (Park et al., 2010); (Prevedello et al., 2010); (Mahendrawathi et al., 2010);(Stadler et al., 2016)	8
Improve Access Information	(Stadler et al., 2016); (Ghazisaeidi et al., 2015); (Al-Hajj et al., 2012); (Martin et al., 2017); (Ward et al., 2014); (Park et al., 2010)	6
Increased Performance	(Shailamet al., 2018); (Gordon & Richardson, 2013); (Mahendrawathi et al., 2010); (Ward, Marsolo, & Froehle, 2014)	4
Improve Knowledge Data	(Al-Hajj et al., 2013)	1

The most relevant drawbacks that were found in the State-of-the-Art chapter form the following Formation Needs, Barriers to Technology, Ununiform Infrastructure and Present Essential Information.

Table 3 – Disadvantages of Dashboard

Disadvantages	References	Number
Formation Needs	(Al-Hajj et al., 2013); (Shailam et al., 2018); (Park et al., 2010)	3
Barriers to Technology	(Gordon & Richardson, 2013); (Mahendrawathi et al., 2010); (Shailam et al., 2018)	3
Ununiform Infrastructure	(Franklin et al., 2017)	1
Present Essential Information	(Zhang et al., 2011)	1

## 2.7. Related Work

A survey of libraries and databases was conducted, resulting in a total of 191 articles and books examined. From this first list a first selection was made, where 101 documents were excluded. The motivation for such removal was because 45 documents addressed the issue of health but did not contain the Dashboard shed, 6 were about Dashboards but in areas other than health, 20 were duplicates, and finally, 30 articles focused only on KPI's and Balanced Scorecard (BSC).

After this selection, there were 91 documents classified as potential articles to be included in the literature review (LR). In a second analysis 41 articles were excluded, since articles speak of dashboards, but the main focus is the KPIs (23) and BSC (18) and not in the panels. The second selection left out 41 articles that were the targets of the last selection process, which resulted in the exclusion of 12 articles. In them, a prototype is not presented or, when a prototype of the tool is presented, the process of its implementation is not addressed. That leaves 38 articles remaining to analyze and set out State of the Art can be seen in Figure 1.

The process described above was performed using the following IEEE digital libraries: ACM digital library, SpringerLink, ResearchGate, and ScienceDirect, the keywords used for external searches: "Healthcare Dashboards", "Health Performance Dashboards", "Healthcare and Dashboards", "Performance health panels ". The articles are mainly primary sources (such as 37) and secondary sources (such as 1). The selection of articles was based on the fact that they contained a proposal for panels to assist decision making in the health sector.

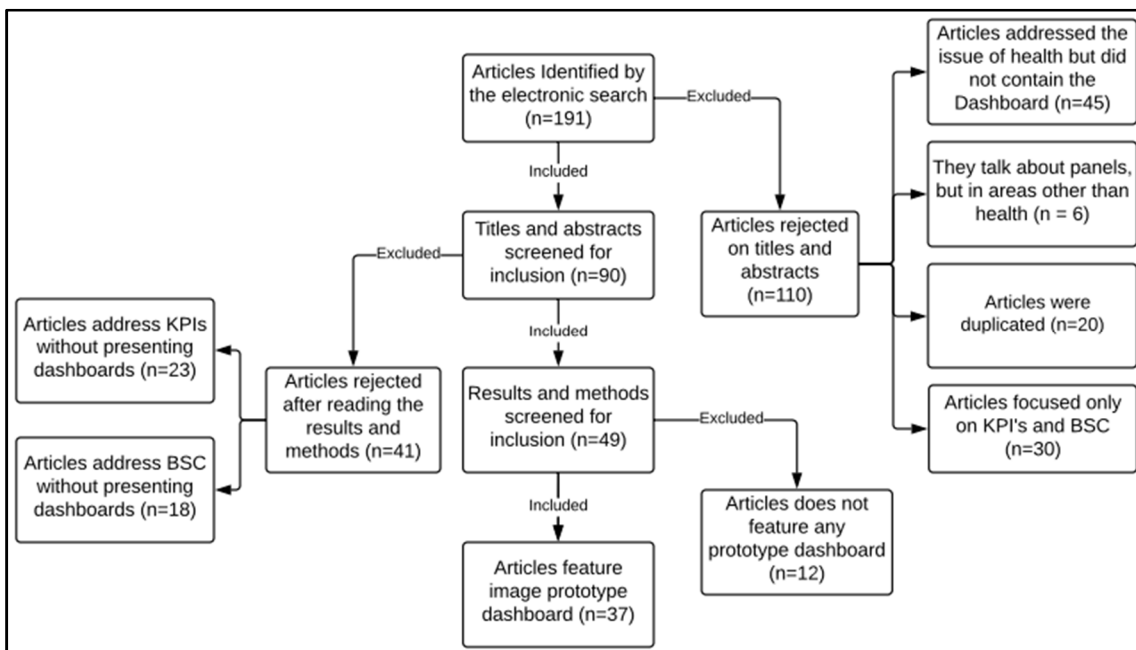


Figure 1 – State of Art selection diagram

After a careful and rigorous LR, 38 articles were selected, all of them related to dashboards in healthcare. Appendix A identifies all the analyzed articles where only 3 authors wrote more than one article. The authors in question are: Jim Ryan (Ryan et al.,

2013, 2017) and Manuel Barrento (Barrento, 2016); (Barrento et al., 1997) with 2 articles each and Samar Al-Hajj (Al-HAJJ et al., 2012); (Al-Hajj et al., 2013); (Al-Hajj, et al., 2013) with 3 articles. Both Jim Ryan and Manuel Barrento articles have some temporal detachment, while in the case of Samar Al-Hajj, his 3 articles are complementary and inserted in his research.

In Table 4 it is possible to check the most used keywords that appear in articles, the criterion of inclusion in the table was to appear in 4 or more articles. Due to the number of articles in this review, a total of 132 distinct keywords were obtained.

Table 4 – List of keywords per article

Keywords	Articles	No. of Articles
Dashboards	(Al-HAJJ et al., 2012); (Al-Hajj et al.,2013); (Franklin et al., 2017); (Ghazisaeidi, et al., 2015); (Gordon & Richardson, 2013); (Martin et al., 2017); (Presthus & Bergum, 2015); (Shailam et al., 2018); (Zhang et al., 2011); (Daley et al., 2013); (Mahendrawathi et.al, 2010); (Barrento, 2016); (Santos, 2015); (Hain et al., 2012); (Park et al., 2010); (Barrento et al., 1997); (Ryan et al., 2017)	17
Healthcare /Health care	(Ghazisaeidi et al., 2015); (Presthus & Bergum, 2015); (Providers & Nelson, 2010); (Stadler et al., 2016); (Ward et al., 2014); (Zhang et al., 2011); (Daley et al.,2013); (Donaldson et al., 2005); (Miniati et al., 2014)	9
Hospitals /Hospital Units	(Daley et al., 2013); (Donaldson et al.,2005); (Hain et al., 2012); (Mahendrawathi et al., 2010); (Mallak, 2009); (McLeod et al., 2010); (Miniati et al., 2014); (Park et al., 2010); (Ryan et al., 2013)	9
Decision Making	(Al-HAJJ et al., 2012); (Al-Hajj et al., 2013); (Franklin et al., 2017); (Mallak, 2009); (Park et al., 2010); (Providers & Nelson, 2010)	7
Business intelligence	(Barrento et al., 2013); (McGlothlin et al., 2016); (Presthus & Bergum, 2015); (Providers & Nelson, 2010); (Ryan et al., 2013); (Stadler et al., 2016); (Zhang et al., 2011)	7
Data visualization	(Arinze, 2014); (Franklin et al., 2017); (Mahendrawathi et al., 2010); (Mattingly et al., 2015); (Providers & Nelson, 2010); (Zhang et al., 2011)	6
Data	(Egan, 2006); (McGlothlin et al., 2016); (Park et al., 2010); (Providers & Nelson, 2010)	4
Quality	(Gordon & Richardson, 2013); (Jha & Epstein, 2010); (Koronios & Gao, 2010); (Perron et al., 2017)	4

The table in Appendix B shows the distribution of articles by the various newspapers and Conferences and Proceedings. You can check out the diversity of newspapers and Conferences and Proceedings which publish articles focusing on healthcare dashboards. In this table, we can verify that there are two Conferences and Proceedings that have more than one article. Being Iberian Conference on Information Systems and Technologies and Hawaii International Conference on System Sciences with 2 and 3 respectively. Still on the Journal and Conferences and Proceedings, Appendix C we can draw other conclusions from 38 articles selected. We find that these were published in 18 newspapers and 17 Conferences and Proceedings, which makes a total of 35 publications.

In the Journal distribution and Conferences and Proceedings by country we also find that the USA is to no surprise the country with the most Journal and Conferences and Proceedings and the only one that has both Journal and Conferences and Proceedings.

Another point analyzed was the distribution of articles by the research period stipulated for this review, which was between 1997 and 2017, which appears in the table in Appendix D. We can conclude that in 1997 (Barrento et al., 2013), there was already a concern in the comparative analysis between hospitals organizations, more specifically between the emergency departments. The research was conducted in Portugal and focused on BI and the creation of a dashboard to compare hospital emergencies. Another item to keep in this table is the growing evolution of articles on the subject from 2010 to 2017, with the exception of 2011 with an article (Zhang et al., 2011).

Also, in Appendix D, there is a column of citations where the relevance of the articles is highlighted and the pertinency of the dashboards theme in healthcare is shown. The Focus column lists the information and also lists the information area for which the dashboards were developed. It should be noted that of the 38 articles, one of the articles deals with productivity and 4 with performance. However, this evaluation does not have the same scope as we intended to give in our research.

From Appendix D one can verify that only 33 articles from the total amount of thirty-seven describe in which country the research was carried out. From those twenty-six are from outside of Europe, and only seven are from the European continent. We should note that the overwhelming majority of studies are from the USA (20 articles) and that Portugal has four articles.

In Table 5 the concept-centric of the LR of the research is presented, where the survey of the areas where the proposals of dashboard are made is conducted, the articles presenting images of the prototype of the proposed dashboards, the articles that present and are based in the development of dashboards in the Balanced Scorecard, which articles address the possibility of performing information drilldown and which articles implement visualization techniques.

In the first vector, it is pointed out that the thirty-seven articles present the dashboards for fourteen different areas. The majority were developed in a global perspective of the hospital organization. It should be noted that radiology, emergency and surgery are the departments where there is an investigation of performance improvement and analysis of quality of service.



In the vector of the display of a dashboard, for example, it is possible to verify that only 4 articles do not present an image of the proposed dashboard. The remaining 33 articles present images of the proposals of dashboards. It should be noted that in these 4 articles, the article of the literary review is included, which is easily understandable that there is no image of the dashboard (Ghazisaeidi et al., 2015).

In the vector of the BSC it is possible to verify that only five articles develop the dashboard following the BSC defined strategy, being that the indicators which are presented are divided in the four perspectives of this one. However, it cannot be said that the other articles presenting dashboard proposals are not based on a balanced scorecard, only this information is not presented in the article. One of the articles that addresses the subject of the BSC is a LR article, which is due not to the use of BSC in the body of the article, but there are primary articles present in the LR that are based on the development of the dashboard in the BSC strategy (Ghazisaeidi et al., 2015).

The articles reviewed only thirteen articles that feature or talk about this functionality in their dashboard. According to Park et al. (Park et al., 2010), the drill down is a feature of extreme importance which adds more value to the dashboard:

Baskett asserts in her article Using the dashboard technology properly that “A single page is rarely sufficient to present all the relevant performance metrics and therefore the dashboard must have a drilldown capability” (as cited in Park et al., 2010). “The drill-down may follow the organizational hierarchy from the health system to a business unit hospital, a service, a department and a division, all the way down to individual practitioners” (p.295) (Baskett et al., 2008).

To finalize, the last vector to be analyzed is the visualization, which is another element that helps to assign value to the dashboards with reference (Garcia, 2014) to address this problem: “Information visualization, which is a manifestation of the Information Design field, means a process in which the goal is to facilitate the understanding of a large amount of data, revealing similarity, order and proportionality relationships underlying it”(p.1). Of the present, 90 articles deal with data visualization, which demonstrates the validity of this vector.

Table 5 – Concept Centric - Dashboard Healthcare

Healthcare Area	Articles	Displays dashboard	BSC	Drill down	Visualization
Clinical	(Daley et al., 2013)	•		•	
	(Dixon et al., 2014)	•			
	(Mattingly et al., 2015)	•			•
Emergency Department	(Koronios & Gao, 2010)	•			
	(Martin et al., 2017)	•			•
	(Franklin et al., 2017)	•		•	•
	(Ward et al., 2014)	•			•
	(McLeod et al., 2010)	•			
	(Barrento et al., 1997)	•		•	
Management & Logistics	(Ghazisaeidi et al., 2015)		•	•	
	(Nelson , 2010)	•	•		•
	(Mahendrawathi et al., 2010)	•		•	
	(Stadler et al., 2016)	•			•
	(Presthus & Bergum, 2015)	•		•	•
	(Perron et al., 2017)				•
	(Zhang et al., 2011)	•		•	•
	(Arinze, 2014)	•			•
	(Jha & Epstein, 2010)	•			
	(McGlothlin et al., 2016)	•		•	•
(Mallak, 2009)	•				
Information system	(Silva et al., 2012)	•			
Pneumology Department	(Alharbey, 2016)	•			
	(Santos, 2015)	•			•
Nursing Department	( Gordon & Richardson, 2013)	•			
	(Donaldson et al., 2005)	•		•	
Surgery Department	(Egan, 2006)	•			
	(Miniati et al., 2014)	•			
	(Park et al., 2010)	•		•	
	(Ryan et al., 2013)	•	•		•
	(Ryan et al., 2017)		•	•	•
Pediatric Department	(Hain et al., 2012)				
Public healthcare	(Al-Hajj et al., 2013)	•		•	•
	(Al-Hajj et al., 2012)	•			•
	(Al-Hajj et al., 2013)	•		•	•
	(Barrento, 2016)	•			
Radiology Department	(Shailam et al., 2018)	•			
	(Georgiana et al., 2017)	•			
	(Prevedello et al., 2010)	•	•		•

The article by Hain (2012) that addresses the subject of the Pediatric Department is only a state-of-the-art article but has neither dashboard presentation nor BSC nor visualization techniques and drill down, however it focuses on productivity.

In Appendix E, the result of the analysis of the articles that compose the state of the art is presented. The vectors that are analyzed in this table are the macro objectives of each article and the results obtained. As it is evident, the macros objective of the articles is to increase the availability of useful information to stakeholders so that they can make decisions as safely and quickly as possible. This is accomplished using the dashboard that is developed based on the most relevant KPIs and taking advantage of visualization techniques and drill down will allow obtaining higher efficiency results, better information sharing, shorter analysis time and performance improvement of hospital organizations.

Appendix F presents the limitations, contributions and future work proposal of the analyzed articles. At the level of limitations, a large part is related to the fact that the articles were only about fictitious scenarios, the size of the sample of the information that the dashboards received, the difficulty in generalizing the results obtained, data quality issues and the fact that studies are carried out in a department or only in a hospital organization. These are the main limitations indicated in the study. The limitations listed up surge future proposals which call for the continuation of studies which will help improve and analyze the role of dashboards in hospital organizations. It demonstrates that the scientific community longs for further studies on the benefits of dashboards. At the level of contributions, they are in a general way a demonstration of the benefits of dashboards and their role in hospital organizations.

## **2.8. Literature Review Synthesis**

The state of the art demonstrates that the health industry is complex to the level of the dynamics existing within and form of this, and this complexity gives rise to barriers that often triggers difficulties in obtaining information from the high number of data. Such data, when treated and analyzed, is of value for hospital organizations, helping to raise awareness for these organization's needs. As it is clear, the role of HIS in hospital organizations is increasingly influential and unpredictable for improving decisions. The dashboard is a tool that can be useful to provide the information in a transparent and easy to analyze form and accelerates the phase of the decision process. In the economy as well as in hospital organizations the concern with the production and productivity areas is to

have a greater prominence. The use of dashboards to help meet this growing need is an even better bet supported by visualization and drill down techniques that provide an ability to both optimize analysis and the possibility of deepening the information needed. After the State of the Art presented, two deficiencies were identified: the literature lacks panel proposals that allow a production and productivity analysis per hospital and there are no production and productivity panels which include detailing and visualization techniques.

Based on these findings, this research intends to add a valuable panel to the body of knowledge to be discussed and analyzed by the scientific community, as shown in Table 6.

*Table 6 – Contribution of the current dissertation*

<b>Healthcare Area</b>	<b>Articles</b>	<b>Displays dashboard example</b>	<b>BSC</b>	<b>Drill down</b>	<b>Visualization</b>
Management & Logistics	(Pestana et al, 2018)	•		•	•

When analyzing the literature, there is an area that is not so detailed and needs a contribution, which is the measurement of hospital production and productivity.

### Chapter 3 – Research Methodology

The Research Methodology adopted in the research was Design Science Research (DSR). This methodology premise is to design, build and evaluate the dashboard we intend to develop. When the research aims to expand the limits of human capacities and organizations, to create new artefacts invoking the Design Science Research Methodology (DSRM) it is the right choice (Hevner et al., 2004). In contrast to other paradigms of research, this one stands out as it tries to develop and obtain artefacts which make it possible to buy the effectiveness of this in the real world (Peppers et al., 2007). The approach (DSR) would include three elements: conceptual principles that help define the DSR, practical rules for DSR impersonation and procedures to perform and conduct research (Peppers et al., 2007). The application of DSR process in this research can be seen in Figure 2.

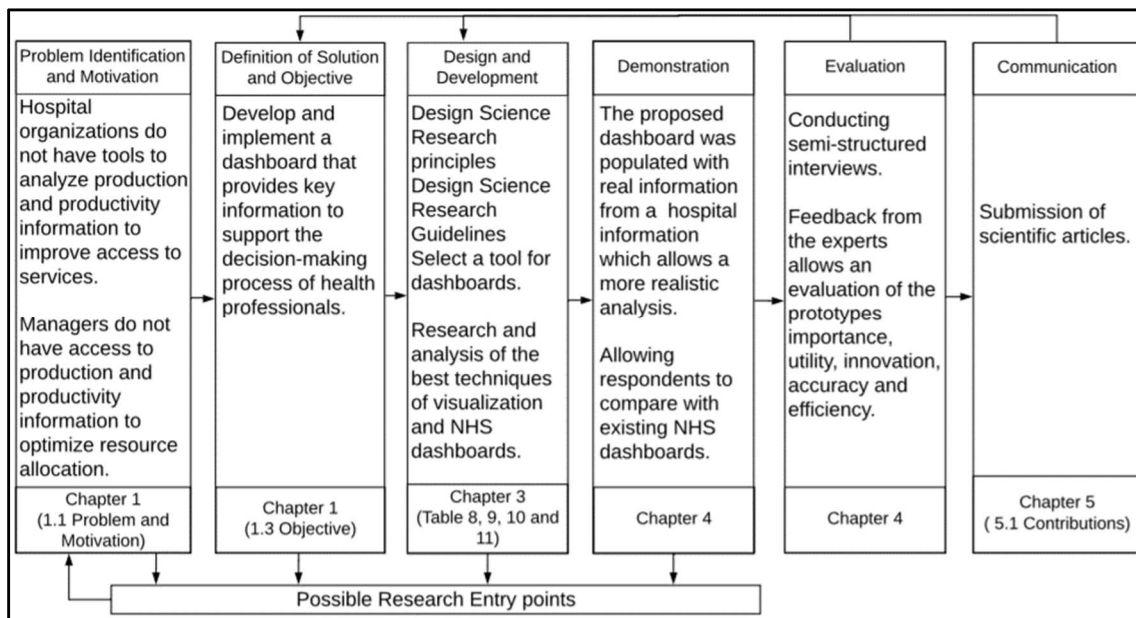


Figure 2 – DSRM Process Model Followed

The principles of DSR are grounded in the engineering of artificial things, and information systems (IS) are a perfect example of artificial systems when implementing the goal is to increase the efficiency of the organization (De Sordi et al., 2013). For this reason, the authors follow the principles present in Table 7.

The principles alone are not sufficient to justify the added value and consequent applicability that is useful in design science, so we also follow the DSR guidelines proposed by Hevner (Hevner et al., 2004). Table 8 shows how this research matches the seven DSR guidelines.

*Table 7 – Design Science Research principles*

<b>DSR Principles</b>	<b>Explanation</b>
<b>Abstraction</b>	The research consists of the development of dashboards to monitor the information obtained from the operation of a hospital unit with the mission of being able to support the various stakeholders in the decision phase. Thus, the authors follow indicators from the National Health Service (NHS), which is the entity by which the Portuguese Government regulates health in Portugal. The dashboard was validated in a large Portuguese hospital.
<b>Originality</b>	The proposed artifact with a macro perspective of hospital organizations that is not in the body of knowledge (BoK).
<b>Justification</b>	The justification for the panel is based on the methods proposed for its evaluation. Qualitative interviews were conducted with health specialists and with some of the main stakeholders of the proposed artefact. With this contribution it was possible to improve several aspects and add value to the artefact.
<b>Benefit</b>	The development of dashboards which allow obtaining in a single location the macro production and productivity information of a hospital organization that allows decision makers to obtain useful information so that they can make the right decisions in a timely manner. This added value can help improve the performance of organizations.

The use of colors in a dashboard can be a plus, but for this to happen it is necessary to know the rules, to understand what helps to transmit the information that harms, in that sense there are 9 rules that must be used and are listed in Table 9.

Table 8 – Design Science Research Guidelines (Santos, 2015)

<b>Guideline 1: Design as an Artefact</b>
The artefact proposed by the research is production dashboard and productivity.
<b>Guideline 2: Problem Relevance</b>
Need to have a dashboard on production and productivity that allows an analysis of each hospital organization.
<b>Guideline 3: Design Evaluation</b>
Semi-structured interviews. The evaluation made by health professionals who should be able to extract the information useful for decision making, which allows to carry out the evolution of the artifact and to attribute credibility and importance to it.
<b>Guideline 4: Research Contributions</b>
Development of an artifact (dashboard) that allows a macro analysis of a hospital organization that is not yet present in the body of knowledge.
<b>Guideline 5: Research Rigor</b>
The main principles, practices, and procedures of DSR were adopted, to increase the credibility of the artefact and the consequent contribution of the research. Stephen Few guidelines practical Rules for Using Colour in Charts. Gestalt theory and forming principles of visual perception.
<b>Guideline 6: Design as a Search Process</b>
The result obtained is the departure from unknown. Combination of good visualization practices and other relevant guidelines for prototype development.
<b>Guideline 7: Communication of Research</b>
Plus, the submission of the article to a journal/conference with high credibility and respect in the scientific community.

The principles of Gestalt's visual perception help to understand which elements are crucial and which are not for the transmission of information and which elements are pollution and / or accessories (Knafllic, 2015). Next, the 6 principles of Gestalt Theory of visual perception coaches are listed in Table 10.

In the evaluation phase of the proposals a questionnaire was to be carried out, the questions that are in Table 11 do the same, and with them it was possible to obtain the positive aspects, the negative and the proposed improvements.

The information we collected from these issues is presented in Tables 15, 17 and 19. Table 12 demonstrates the structure of the table. This is made up of 4 columns and 3 rows which are the pros, cons and Proposed Improvements sections. The first column identifies the three sections indicated above. In the Pros the positive aspects of the dashboards are presented, in the perspective of the interviewees. In the Cons, the negative aspects of the dashboard are presented according to the interviewees and finally, the section Proposed Improvements is where the enumeration of the proposals is made, and these can be done by the interviewees or even by the author. The second column is ID where you identify each aspect of the sections. The third column serves to present the aspects of the synthesis

of what was obtained from the interviews. The fourth column is where the idea that the interviewee has of each point in this table is presented.

In each evaluation of the iteration a table is presented with the proposed improvements made by both Stakeholder and Author.

*Table 9 – Rules for Using Color in Charts (Stephen Few2006)*

<b>Rule</b>	<b>Description of rules</b>
Rule 1	If you want different objects of the same color in a table or graph to look the same, make sure that the background—the color that surrounds them—is consistent.
Rule 2	If you want objects in a table or graph to be easily seen, use a background color that contrasts sufficiently with the object.
Rule 3	Use color only when needed to serve a specific communication goal.
Rule 4	Use different colors only when they correspond to differences of meaning in the data.
Rule 5	Use soft, natural colors to display most information and bright and/or dark colors to highlight information that requires greater attention.
Rule 6	When using color to encode a sequential range of quantitative values, stick with a single hue (or a small set of closely related hues) and vary intensity from pale colors for lower values to increasingly darker and brighter colors for higher values.
Rule 7	Non-data components of tables and graphs should be displayed just visibly enough to perform their role, but no more so, for excessive salience could cause them to distract attention from the data.
Rule 8	To guarantee that most people who are colorblind can distinguish groups of data that are color coded, avoid using a combination of red and green in the same display.
Rule 9	Avoid using visual effects in graphs.

*Table 10 – The Gestalt principles of visual perception*

<b>Principles</b>	<b>Description of the principles</b>
Proximity	Objects that are physically close are perceived as a group due to their closeness (Few, 2006).
Similarity	Objects that have any of the following characteristics such as color, shape, size, or orientation are presumed to be realigned or belong to a group (Knafllic, 2015).
Enclosure	Objects that have any of the following characteristics, such as color, shape, size, or orientation, are considered to be related or part of the same group (Few, 2006).
Closure	Graphs without borders, without shaded background are also perceived as complete Nussbaumer Knafllic guidelines visualization (Knafllic, 2015).
Continuity	This principle is very similar to that of the Closure when an object is analyzed, the human eye seeks the smoothest and most natural way, creating continuity as far as this continuity can exist (Knafllic, 2015).
Connection	When objects are interconnected they create an idea of a group (Few, 2006).



Table 11 – Key Evaluation Questions

Questions
What are the negative aspects of the proposed dashboard?
What are the positive aspects of the proposed dashboard?
What improvement proposals do you intend to make regarding the proposed dashboard?

Table 12 – The Prototype Evaluation table structure

	ID	Interviewee synthesis	Interviewee Opinions
<b>Pros</b>	–	–	–
<b>Cons</b>	–	–	–
<b>Proposed Improvements</b>	–	–	–

Table 13 presents the structure of Tables 16, 18 and 20, which is composed of 6 columns: the first column is the ID that serves to identify each improvement; the second column is where a summary of the interviewee appears. The third column is used to classify the type of improvement. It can be classified as visualization, information and navigation.

These three types are essential elements in any dashboard, the visualization is one of the most important elements in the dissertation. The visualization techniques allow stakeholders to answer their questions about indicators in a given area and trigger new research that helps to increase the knowledge base, improve existing indicators and also contribute to the emergence of new indicators (Al-Hajj et al., 2013); (McLeod et al., 2010).

Another very important element is the information where the stakeholders are information consumers, this element is of extreme importance since they make decisions and change the strategies based on the presented information (Nogueira, Paulo; Martins, José; Rita, Francisco; Fatela, 2017).

Finally, the element is navigability which has to be treated very carefully so as not to create an exaggerated overload of components, contents and tabs to dashboards, they should only provide and be used to facilitate the necessary navigation to the dashboards without making it too confusing (Karami et al., 2017).

Table 13 – Improvements table structure

<b>Iteration</b>					
<b>PI</b>	<b>Proposed improvement</b>	<b>Type improvement</b>	<b>Implemented?</b>	<b>Who suggested</b>	<b>Figure</b>
–	–	–	–	–	–

## **Chapter 4 – Proposal and Evaluation**

The proposed dashboard was the subject of an iterative DSR process, using four semi-structured interviews with health professionals. Each interview resulted in a DSR iteration that helped validate, consolidate, and improve the dashboard. Table 14 aims to present the interviewees who contributed in this process. All the interviewees have more than 20 years of experience in the health area. In addition, this experience is not restricted to a hospital organization or just to one sector, the interviewees, for the most part, have experience in both sectors.

In average the interviews lasted 1:30, these were divided in two phases being the first part dashboard presentation and navigation and the second part the phase of response to the questionnaire. This questionnaire consists of the dissertation and three questions are presented throughout this section Table 11 and the rest are in Appendix H.

### **4.1. First DSR Iteration**

By following the DSR methodology I performed 4 iterations to improve the prototype. This was filled with information from the hospital where the interviews were conducted. In this section, I provide the main information about the three phases of each iteration: the proposal, demonstration and evaluation.

Using real information from the hospital organization allows respondents to be more familiar with the data and to be able to assist in building a useful dashboard to improve decision support.

#### **4.1.1. Proposed Dashboard**

To develop the panel, it was necessary to perform several steps that are distributed in three phases. The first phase consisted of a research and analysis, followed by the processes of extraction of load of transformation (ETL) and finally development of the dashboard was done, as can be seen in figure 3.

Table 14 – Data of the interviewees

DSR Iteration	Gender	Age	Department	Role	Years of experience in health	Years experience in the hospital unit	Number of institutions	Public	Private	Graduation	Post-Graduate Habilitations
1	Female	44	Planning, Studies, Analysis and Management Control Service	Superior technique	23	10	3	2	1	- Human Resources Management	- Labor Law
2	Female	41	Surgery Area	Administrative Hospital	20	11	3	3	0	- Human Resources Management	- Hospital Administration
3	Female	51	Planning, Studies, Analysis and Management Control Service	Service Director	30	8	7	6	1	- Nurse - Computer Science and Business Management	- Management of Health Services - Business Administration
4	Male	54	Information Systems Management Service	IT Director	36	8	4	4	0	-Computer Science	-Bachelor of Engineering in Computer Science
Total					109	37	17	15	2	N/A	
Average					27,25	9,25	4,25	3,75	0,5		

#### 4.1.1.1. Research and Analysis

The research and analysis phase were divided into two parts. The first part was devoted to researching and analyzing the existing supply of dashboards for health organizations, and make sure that information was public. That allowed the creation of dashboards without any dependence on a permission to use the data which could provoke delay in the development of proposals. By creating a dashboard proposal for the public data allows the development and demonstration of a dashboard thus allowing to demonstrate the value of the same which, in turn, will allow for a greater opening of hospital organizations in the process of access to data that are not public in a future work of evolution of the proposed dashboard.

Then a survey on visualization techniques was done to validate what best practices in this area and to verify if these techniques are already being used in health organizations. After validating the question of the data level of availability, a more exhaustive analysis was made to the NHS site to see which KPIs are related to production and productivity. The Portuguese State has tried to make health data as transparent as possible, both for the average user and for the healthcare professional. On the site there was a page named Transparency, where you can find all the data and KPIs that are contained in the pages of monthly monitoring and benchmarking, as well as explanations about them.

Information on the NHS website is provided by public hospitals on a quarterly basis. This information is used both in monthly monitoring and in many data implemented almost directly, without great recourse to ETL. Monitoring information, in turn, is used in benchmarking, that is, the current KPIs are created based on the indicators in the monthly monitoring.

The data present in the proposed dashboard were extracted from the monthly monitoring. On this page there are 4 more segments, but as was previously justified in the State of the Art, the segment that shows a gap in analysis and study and that organizations need a tool that helps in the analysis of production and productivity.

#### 4.1.1.2. ETL process

In the ETL process phase the data of production and productivity of the site NHS was extracted. The data used to construct the proposed dashboard were obtained directly from the NHS website on the Transparency page, where it is possible to download the data in several formats, the format chosen was xls.

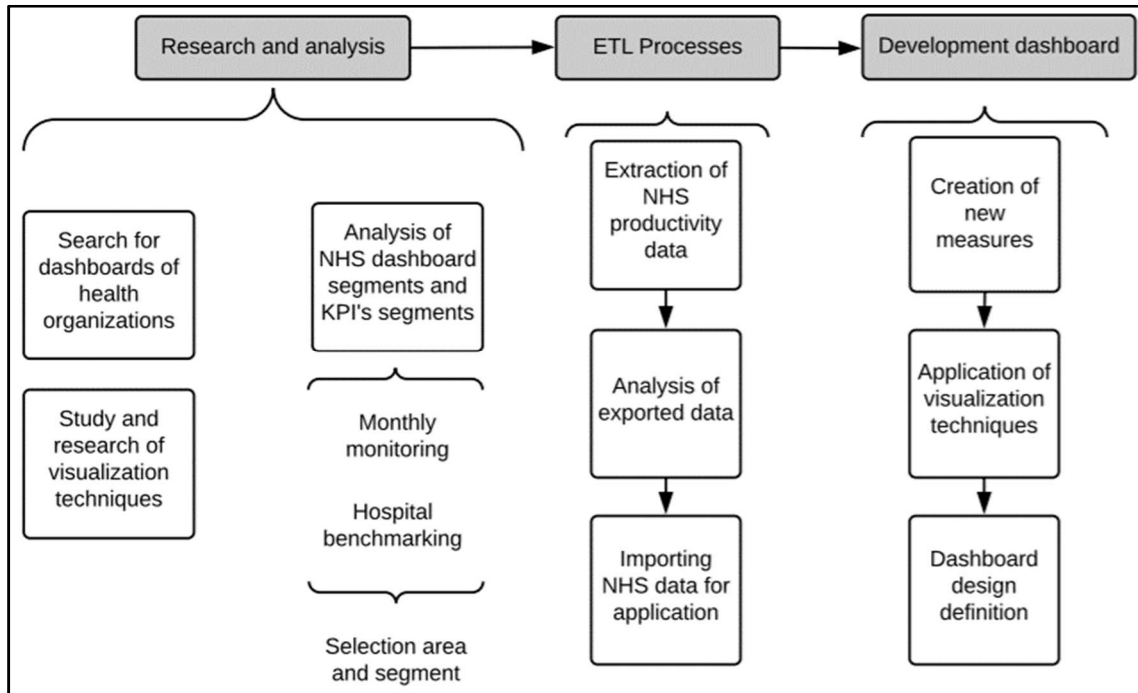


Figure 3 – Proposal Development Workflow

An analysis was made of the xls files obtained to validate their structure and verify what data exists and their connection. The files have a key composed of date, institution, area, and location, and sometimes there is a special additional field. It was necessary to make some adjustments to the data to standardize it, so that the process of developing the dashboard would be as automated a process as possible.

#### 4.1.1.3. Development Dashboard

The In the development phase of the panel, new measures were created based on the indicators included in the exported files on the SNS website. Then, graphic choices and other aspects related to visualization techniques were made and according to the

following guidelines in section 4.1 Guidelines. Finally, the layout of the graphics and information on the panel was done.

#### 4.1.1.4. Guidelines

The use of colors in a dashboard can be a plus, but for that, you need to know the issues related to color perception and follow rules that help you convey the information. To achieve a dashboard according to good color practice, some rules must be used and followed in the proposed panel, and these rules are presented and explained in books (Few, 2006); (Wexler et al., 2017).

Gestalt's principles of visual perception help to understand which elements of training are crucial to the transmission of information and which elements are pollutants and / or enhancements. Several authors approach these principles which can be studied in more detail in one of the following works (Few, 2006) ; (Wexler et al., 2017) ; (Knafllic, 2015). For the first iteration, a panel was created in the production and productivity segment of the following areas of surgery, internally, external consultations and emergencies. The segments present in the dashboard are defined in a decree-law by the Portuguese State and are used by the NHS in the benchmarking and in the monthly monitoring that this entity provides to hospital organizations. The data contained in the dashboards are referring to the hospital organization where we were to carry out interviews. It allows a premature familiarization of the interviewees with the data and get faster evaluation of the value of the proposed dashboards.

#### 4.1.2. Demonstration

To demonstrate that the artefact developed can be applied in a hospital organization, it was populated with the information of a real hospital organization so that the interviewees could provide a more accurate evaluation. The presentation of the panel serves to present the artefact both in terms of navigability, presentation of information, types of graphics and functionalities that allows a more detailed analysis of KPIs. In Table 11 it presents the main issues that contributed to the evaluation and improvement of the artefact. The remaining questions answered by respondents can be seen in Appendix G.

At the level of the dashboard structure, it is divided into three types of principal and applied views whenever the data foresee, annual, monthly and target. These perspectives are presented whenever the data allow. In the monthly perspective Figure 4 it is possible to verify that it is divided into two headers and detail areas, being that in the header is where the title of the segment that is being viewed return button and filtering per year is. The detail area is divided in two, and on the left side we have the KPI's with annual values and compared with the homologous year, and on the right side we have the graphs with the monthly distribution of KPI's and other analysis that can be used by the decision-makers. Also, in these graphs is the comparison of current year with the homologous.

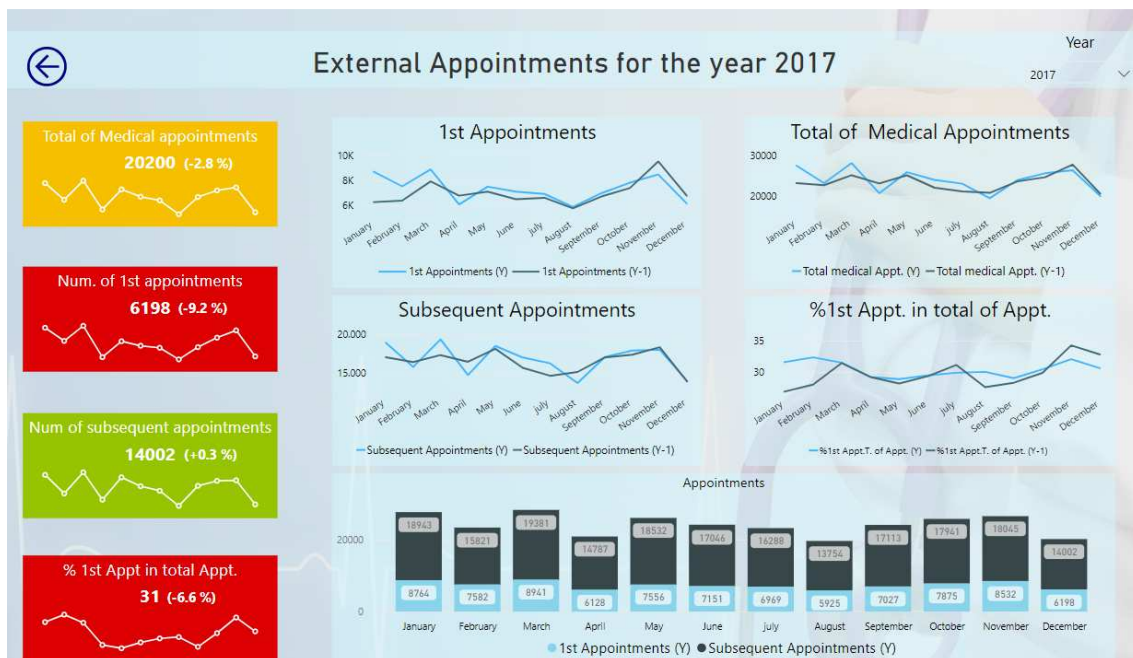


Figure 4 – The monthly perspective of external appointments – 1<sup>st</sup> Iteration

In Figure 4, it is noticeable that the authors followed the subsequent principles of Gestalt: Proximity, Similarity, Closing, and Connection. These forms are also followed in the views (Annual and Target). Throughout the dashboard the guidelines of the colors rule, being that rules 4 and 5 are the ones that stand out more whereas the colors only change for different subjects and the use of more attractive colors for the KPI's. In Figure 5 when referring to the annual information, the color guidelines are also visible.



Finally, the separated from the target Figure 6 shows only those indicators that have a defined goal in the contract program (annual agreements between the Portuguese State and the hospitals where the levels of economic and financial assistance that are assured by each hospital are defined).

The dashboards are idealized in the light of the guidelines we mentioned before at the level of organization and distribution of information, as well as at the choice of graphics and color choices. Its primary objective is to provide ready to use information for decision-makers.

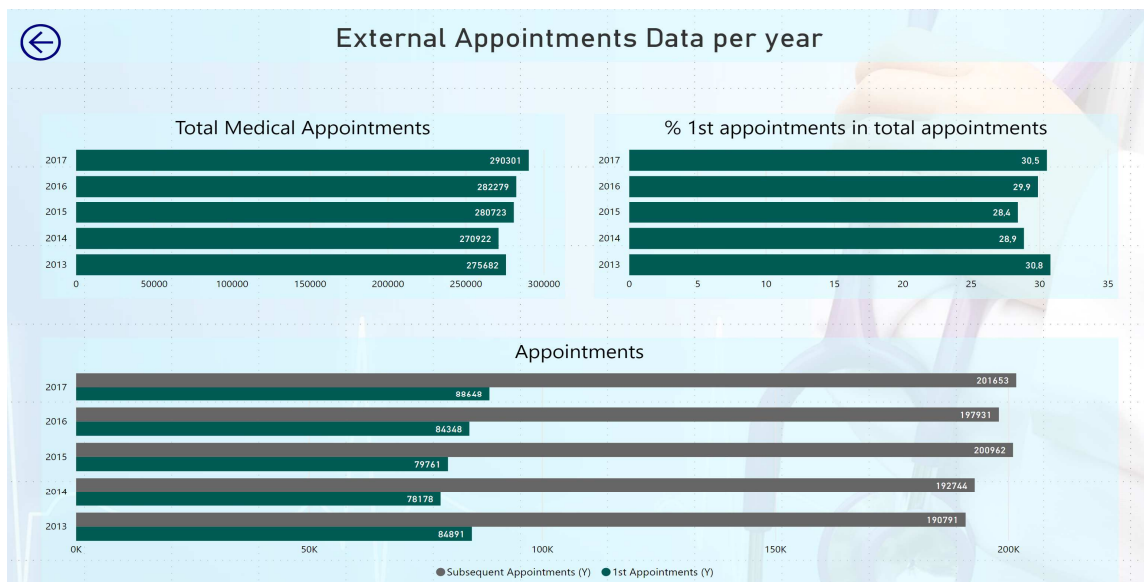


Figure 5 – The annual perspective of external appointments – 1<sup>st</sup> Iteration

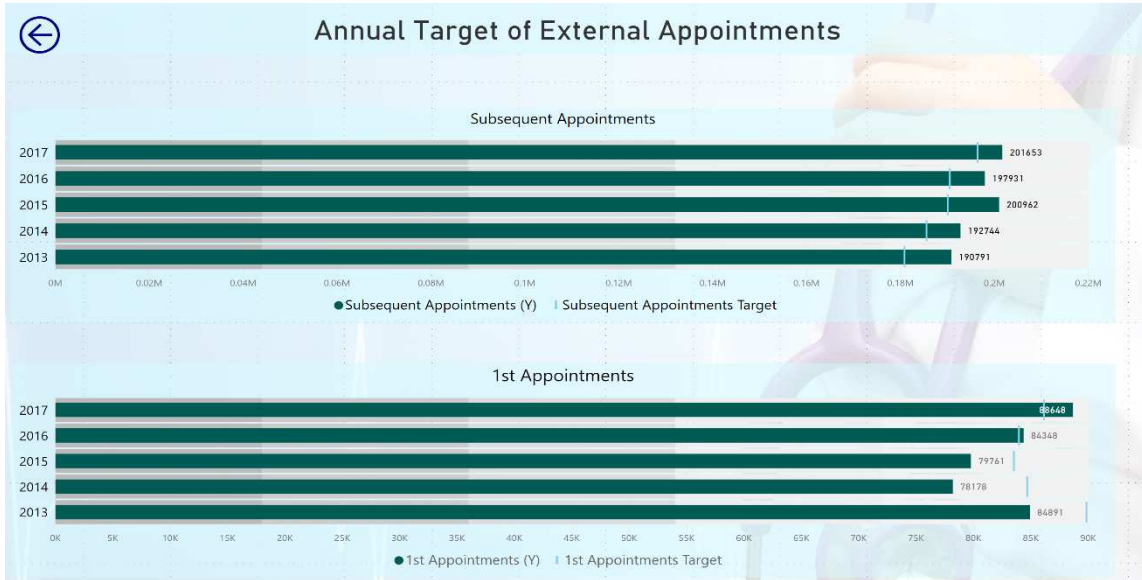


Figure 6 – The Annual Target of External Appointments – 1<sup>st</sup> Iteration

#### 4.1.3. Evaluation

After the first presentation / interview, the following feedback was obtained: 3 positive aspects, 2 negative ones and 4 improvement proposals, as shown in Table 16. The positive aspects are related to the easy analysis and consultation of dashboards due to the way of presenting the information, the choice of graphics also helped make dashboards easy to read. Another point praised is that the dashboards proposed only to present data of the hospital organization which allows to have a clearer idea and focus of the organization. The negative aspects are related, on the one hand, to the organization of the information that was not in agreement with the logical distribution of KPI's and on the other hand with the choice of background colors that sometimes makes it difficult to analyze the graphs' information.

At the level of the improvement proposals these are essentially of the information type, and of visualization, all these improvements are quite pertinent to be able to present a more user-friendly dashboard.

#### 4.2. Second DSR Iteration

After carrying out the analysis of the feedback of the first interviewee, all the aspects indicated by the interviewee present in table 16 were weighed and along these sections a presentation and explanation were made.

#### 4.2.1. Proposal

In the second interaction, the data was updated so that the interviewees could validate the dashboard with the actual and updated data, the improvement proposals made by the first interviewee were implemented. The improvement proposals are presented in Table 15, which helps to have a synthesized view of the improvements. As it is possible to verify the 4 improvement proposals that were implemented over of point 4.2.2 Evaluation, see more in detail.

*Table 15 – Proposed improvement prototype – 1<sup>st</sup> Iteration*

<b>PI</b>	<b>Proposed improvement</b>	<b>Type improvement</b>	<b>Implemented?</b>	<b>Who suggested?</b>	<b>Figure</b>
PI1.1	“Creation of KPI's graph that allows the comparison of the current year with the homologous.”	Information	Yes	Interviewee	7
PI1.2	“Improvement in the organization of the information of KPI's plus macro for the more micro.”	Information	Yes	Interviewee	7,8,9
PI1.3	“Changing the graphics background color.”	Visualization	Yes	Interviewee	7,8,9
PI1.4	Big Picture Building	Information	Yes	Author	10

Table 16 – Evaluation of the prototype – 1<sup>st</sup> Iteration

	ID	Stakeholder synthesis	Stakeholder Opinions
Pros	P1.1	“The dashboard is useful and easy to read as it allows an overview of the data of each segment.”	The proposed dashboard has the advantage of being able to present data from the various segments. This advantage is very useful for analyzing information and making decisions.
	P1.2	“The choice of graphics components is well achieved.”	The choice of graphics is beneficial because they help reading the information, provide a quick analysis of the information, there is no pollution or unnecessary elements.
	P1.3	“The information on the dashboard only concerns the hospital.”	The fact that the dashboard presents information from one hospital organization was praised since it allows a more focused analysis to the organization.
Cons	C1.1	“The data present in the dashboard should be organized from the more general to the more specific.”	The organization of the information is not very user friendly, the information present in the dashboard should be presented from the most general to the most specific, from the most to the less comprehensive, with this organization the user can optimize the reading and obtaining of information.
	C1.2	“The background color of the graphics should be changed to improve the reading.”	An aspect that causes some difficulty when analyzing and reading the data is the chosen background color, since in some cases the color is slightly similar.
Proposed Improvements	PI1.1	“Creation of a graphical component of KPIs that allows the comparison of the current year with the homologous, as well as the current year and the target.”	Create a graphical component of KPIs that allow the comparison between the current year and the corresponding year, as well as the current year and Target showing the values of both and the difference between them. This would allow a comparative analysis to give useful information and improve the perception of the situation of these KPIs.
	PI1.2	“Improvement in the organization of the information of KPI’s plus macro for the more micro.”	To organize the KPIs in order to facilitate reading, there are KPIs that are composed of more than a KPI's, which are more comprehensive, and the KPIs that make up the KPI must be presented in this way, and the reading will be more fluid.
	PI1.3	“Changing the graphics background color.”	One improvement that I suggest implementing is changing the background color of the graphs so that there is no difficulty in analyzing the information and also some confusion at the time of analysis.
	PI1.4	Big Picture Building	The Big Picture is a feature that helps to give an overall picture of the state of an organization. The big picture allows you to get a global picture of production and productivity and in case you need the drill down on the dashboards for more detail (Zhang et al., 2011).

#### 4.2.2. Demonstration

In Figure 7 we can check the changes made to implement PI1.1 To implement the requested enhancement, it was necessary to install a new graphic component that would allow this analysis. It was necessary to implement the Gestalt closure principle in the KPI column, as shown in the figure, to perform a separation between the components and KPIs that present the comparison between year N and year N-1 and the component that presents the comparison between the year N and target. To perform the comparison of how we were, we can refer to Figure 4, where you can see that there is a graphic element that presented information of each KPI. This component was considered interesting, but an improvement was asked for. In the graphic component of KPI's that are located on the left side of Figure 7, you can see three Gestalt principles of visual perception which are Proximity, Similarity, and Enclosure.

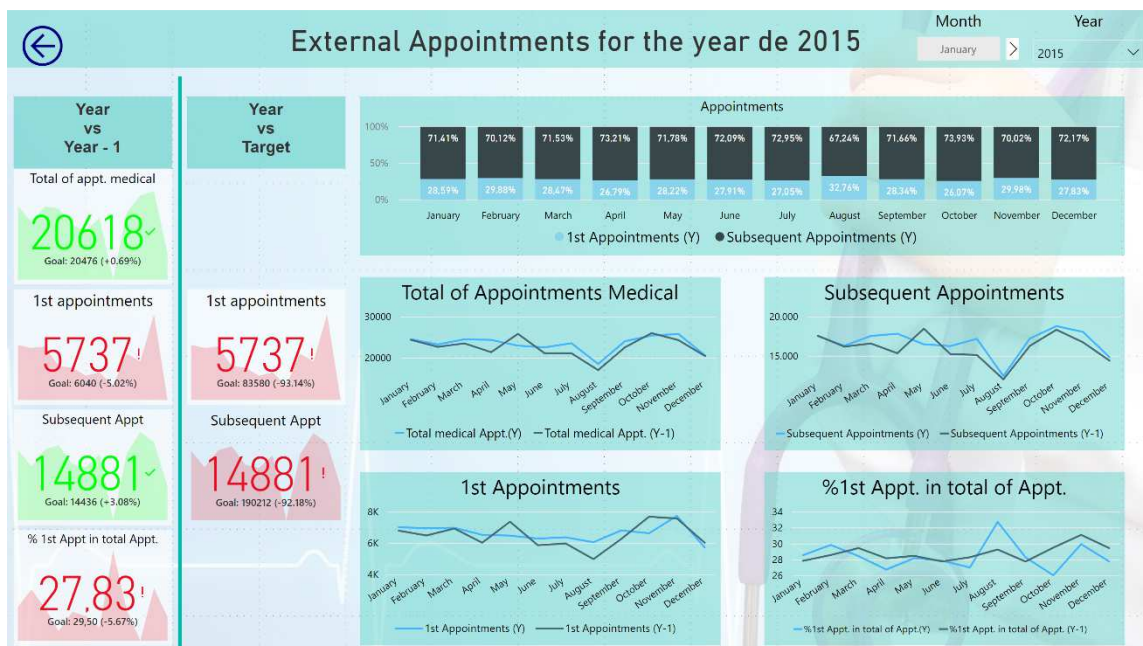


Figure 7 – The monthly perspective of external appointments – 2<sup>nd</sup> Iteration

The implementation of PI1.2 deals with the logical reorganization of the information of the KPIs, this organization aims to make the KPI more comprehensive for less. To see an example of this change we can see in Figure 7 the result and see Figure 4 from First DSR Iteration to have a greater perception of this change.

PI1.3 is related to background color adjustments, in Figures 7, 8 and 9 we can see the implementation of this improvement. The background color is darker. To achieve this color only a change was made in the percentage of transparency. As can be seen in comparison with Figures 4, 5 and 6 from First DSR Iteration, it did not cause visual loss, quite the contrary, this adjustment made it possible to improve the visualization and increase the focus on the data. It is in line with good practice, namely rule 2 of Rules for Using Color in Charts (Stephen Few2006), which is shown in Table 9.

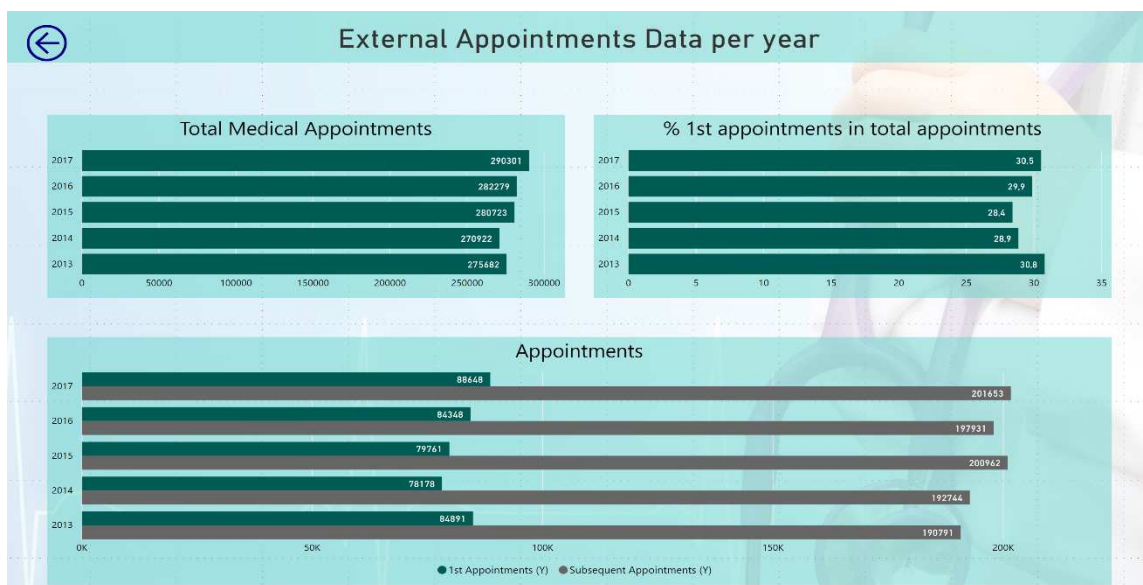


Figure 8 – The annual perspective of external appointments – 2<sup>nd</sup> Iteration

The PI1.4 refers to the Big Picture and it is a suggestion of improvement related to the possibility of giving a general perspective of the four segments that appear in the panel. The Big Picture contributes for the stakeholders to have a sense of the alignment and commitment that their goals should have for the improvement of the hospital organization (Voelker et al., 2001). Figure 10 presents the first proposal with the strategic KPIs of each segment.



Figure 9 – The Annual Target of External Appointments – 2<sup>nd</sup> Iteration

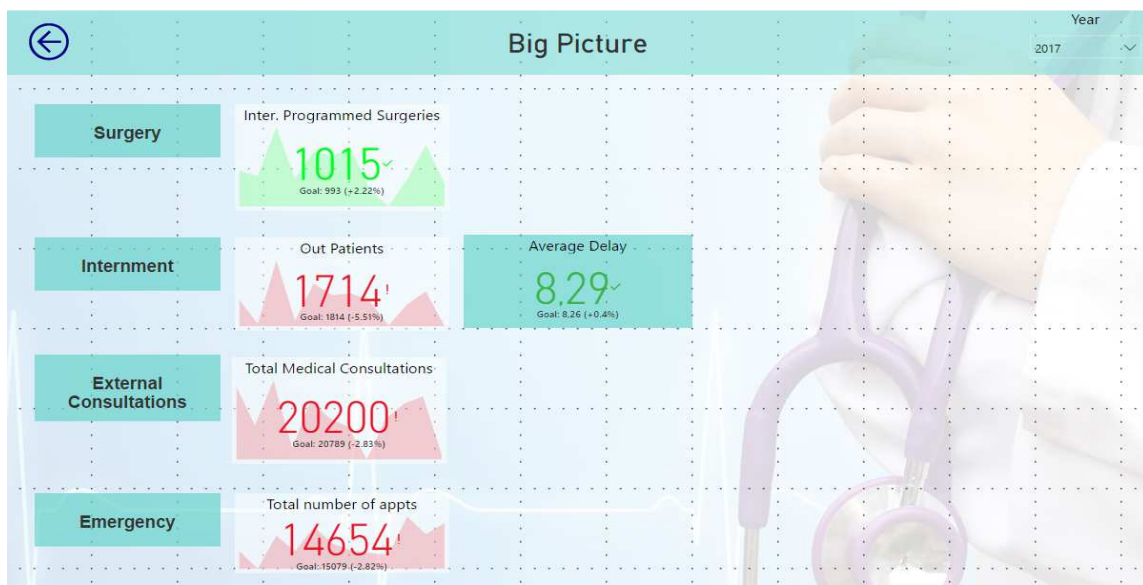


Figure 10 – Big Picture – 2<sup>nd</sup> Iteration

#### 4.2.3. Evaluation

After the second interview the result was 3 positive aspects, 2 negative aspects and 4 suggestions for improvement, as shown in Table 18. The praised aspects are related to information visualization issues which are a plus compared to NHS dashboards.

The negative aspects are related to information, so in the second interview feedback what was pointed out is that the macro information was important, but there should be the

possibility of having access to a more micro vision, to obtain detailed information at the department level, service and health professional.

The proposed improvement to meet the negative aspects pointed out and only implemented the proposals for more emergency information and the question of navigability.

### 4.3. Third DSR Iteration

With the feedback analysis of the second interviewee, a weighting of the improvement proposals was made with a view to their implementation. Throughout this section explanations and images of the improvement proposals implemented will be made.

#### 4.3.1. Proposal

In the third iteration, the data contained in the panel were updated so that the interviewee could perform an analysis with real data. The proposal presented in this third iteration implemented only 2/4 improvements suggested by the interviewee. In Table 17 it is possible to check which proposals were not implemented, but the explanation will be made in section 4.3.2 Evaluation.

*Table 17 – Proposed improvement prototype – 2<sup>nd</sup> Iteration*

PI	Proposed improvement	Type	Implemented?	Who suggested?	Figure
PI2.1	“Obtain data at the contractual level.”	Information	No	Interviewee	–
PI2.2	“Allow for a more detailed analysis of the information, allowing an analysis by department, service and health stakeholders.”	Visualization	No	Interviewee	–
PI2.3	“Add more emergency information.”	Information	Yes	Interviewee	11
PI2.4	Navigation buttons	Navigation	Yes	Author	12,13



Table 18 – Evaluation of the prototype - 2<sup>nd</sup> Iteration

	ID	Stakeholder synthesis	Stakeholder Opinions
Pros	P2.1	“The dashboard allows immediate analysis and monitoring of production data and hospital productivity”	The proposed dashboard allows fast access to the 4-segment information and the KPIs that are contained in each. In this way, the analysis and monitoring of the information are swifter.
	P2.2	“Good colour pallet helps with information readings”	Choosing the colors present in the dashboards, both at the level of the background color of the data colors and the colors of the KPIs helps to read the data.
	P2.3	“The dashboard displays only hospital information unlike the NHS”	The proposed dashboard is a plus because it only provides information from the hospital organization and thus analysis at the organizational level is more facilitated compared to the dashboards provided in the NHS.
Cons	C2.1	“It is a macro view of production and productivity”	The data presented in the dashboard are macro data, which makes it impossible to analyze at the level of departments, service and health professional. For a macro analysis the data present are useful, but if it is necessary to perform a less macro analysis it is difficult to perform the same in this dashboard.
	C2.2	“It was an advantage if the panel allowed for detailed analysis by specialty, services and stakeholders.”	The analysis that was interesting for my position was an analysis that allowed the realization of the drill down of the information in several levels by specialty, by service and by professional of health.
	C2.3	“Lack of emergency target data”	The absence of information about the goals of the emergency department is something that appears in the program contracts and could be present in this dashboard.
Proposed Improvements	PI2.1	“Obtain data at the contractual level.”	Obtain contractual data information from both the contract program and other contracts, allowing an analysis of information from acts that have been contracted between hospital organizations and other organizations.
	PI2.2	“Allow for a more detailed analysis of the information, allowing an analysis by specialty, service and health stakeholders.”	What was very interesting was getting more detailed information from these macro data, getting macro data information to levels of detail at the level of specialty, service and health professional.
	PI2.3	“Add more emergency information.”	In emergencies there are data that are in the contract program that can help to present target values.
	PI2.4	Navigation buttons	The implementation of buttons in the monthly detail screens will improve the navigability between these screens that until then had to go to the main panel to make that navigability.

#### 4.3.2. Demonstration

In the first place we will explain the points that are suggested and were not implemented, next we will present the improvement proposals that were implemented.

The PI2.1 was quite interesting, and in part there is already data that appear in the dashboard and that were obtained by consulting the contracts program and this is the data used to present the tasks included in the dashboard. But what is requested is more than just this consultation and to implement this suggestion a more thorough query would have to be made and turn the data into digital format for further treatment. One issue that is relevant and the main obstacle to the implementation of this data in the dashboard is that only the annual data in the contract are included, not the monthly data. It could be presented with hypothetical values, but it would not bring any added value to the dashboard and would always be a prominent limitation for those interviewed, since most of them have a great deal of knowledge of the data present on the dashboard.

The suggestion PI2.2 was quite interesting and provided a boost both for the proposal of dashboard and for the healthcare professional, for some of these the macro data are not enough nor allow to make the decisions that they need at the level of the specialty, the service and the healthcare professional. Even more, to make a PI2.2 suggestion phase, it was necessary to obtain data that are not public. This made it difficult to create a control panel with more information than it exists on the NHS website. It raises some questions about the relevance that some KPIs present in the dashboard that without the context of more indicators their value for decision making is greatly reduced. The decision not to create a dashboard with hypothetical data is due to the goal of improving dashboard visualization and later implementing drill down that will present more context to the KPIs present in the dashboard.

Suggestion PI2.3 deals with the implementation of the emergency department's annual objectives. This is a segment that was already in the control panel which only needed to create an emergency separator and use the graphic components that were already used for separate ones for the same goal. As you can see in Figure 11, there are 4 KPIs that have

their defined objectives, which makes an analysis possible with the aim to verify if the objectives are reached or not.

The suggestion PI2.4 was a suggestion that has the purpose to attribute a significant improvement in the navigability between the monthly data and annual data as you can see in the blue button in Figure 12 and 13. This necessity was verified after the first two interviews ended and it was found that there was some way of navigating between these two views of the data. To implement it you only needed to use a standard software functionality.

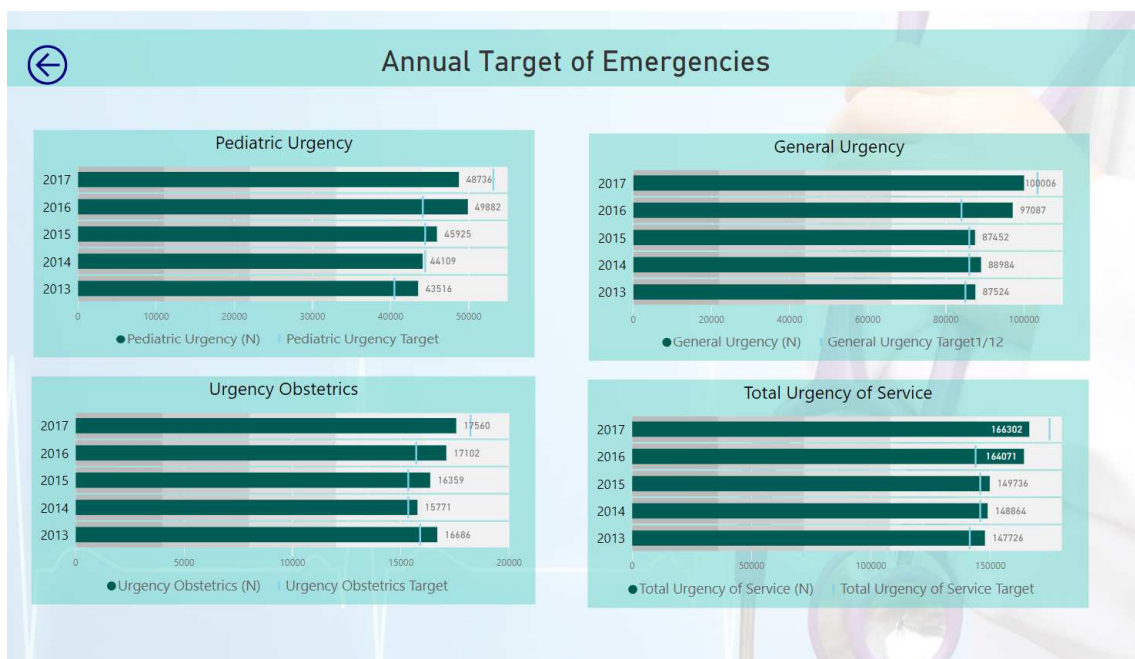


Figure 11 – The Annual Target of Emergencies – 3<sup>rd</sup> Iteration

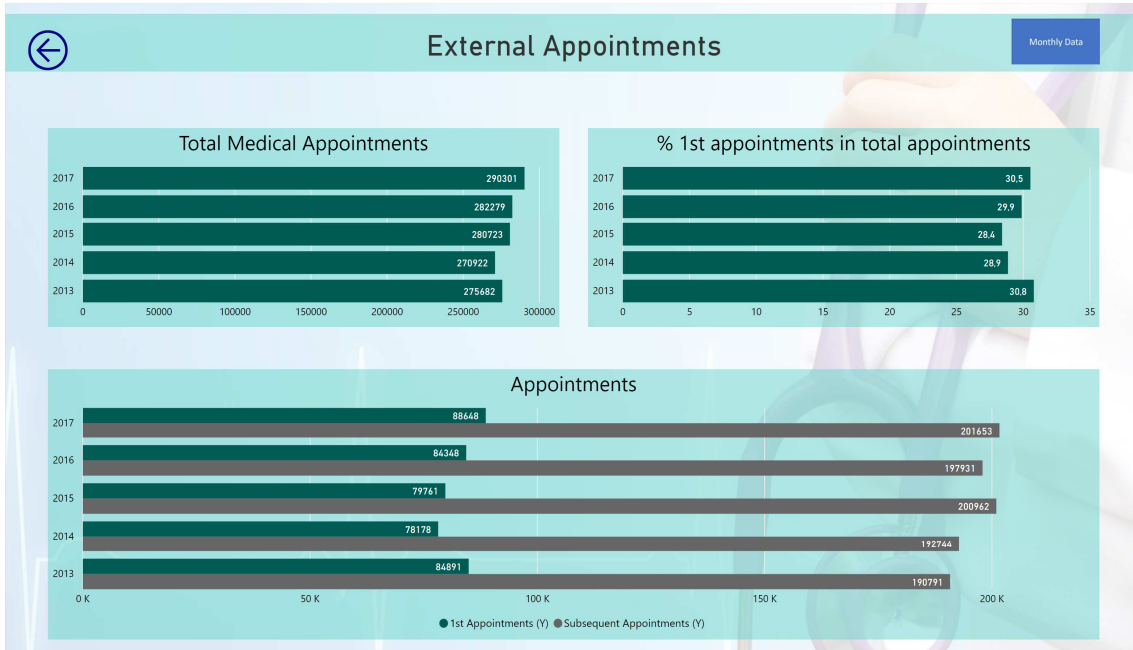


Figure 12 – The annual perspective of external appointments – 3<sup>rd</sup> Iteration

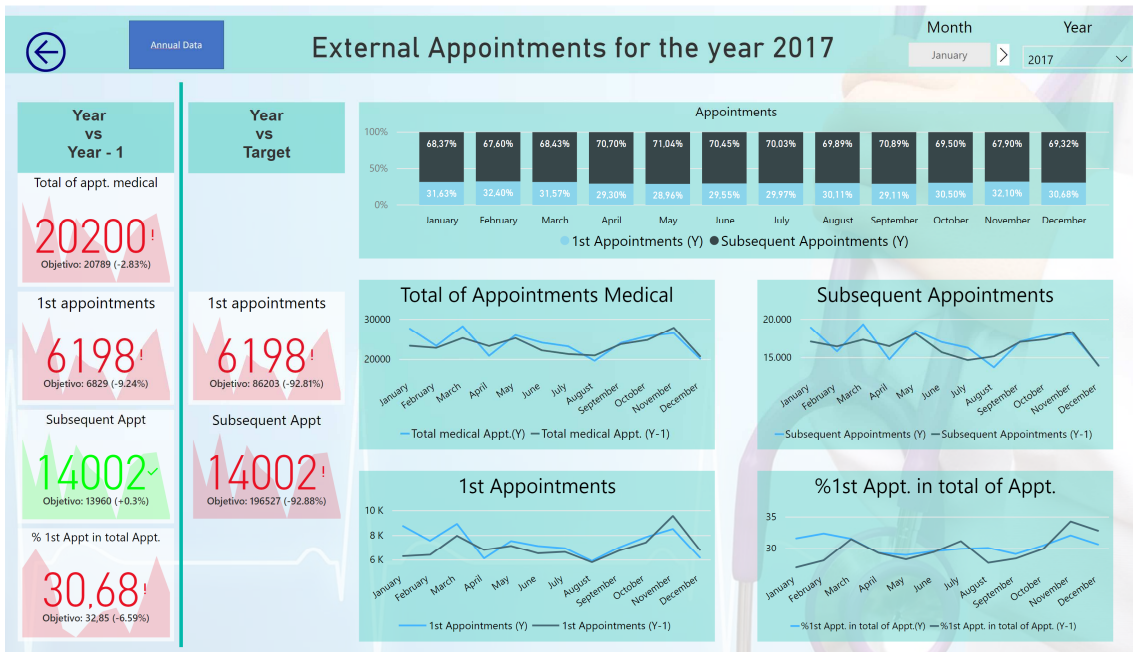


Figure 13 – The monthly perspective of external appointments – 3<sup>rd</sup> Iteration

#### 4.3.3. Evaluation

After the third interview, the result was 3 positive aspects, 4 negative aspects and 12 suggestions for improvement, according to Table 19.

In the third interview the positive aspects are related to data visualization and information disposal issues that present the KPIs of each segment in a single window. Negative aspects are related with issues of obtaining information and presenting non-published information.

In the third interview, 12 improvement proposals were made, and section 4.4.2 will explain the implementation and non-implementation.

Table 19 – Evaluation of the prototype – 3rd Iteration

	ID	Stakeholder synthesis	Stakeholder Opinions
Pros	P3.1	“The dashboard allows immediate analysis and monitoring of production data and hospital productivity.”	The fact that the proposed dashboard presents the production and productivity information of a single hospital in a more user-friendly way helps in the data analysis and motorization.
	P3.2	“Good colour pallet helps with information readings.”	The colors used do not hinder the analysis of the dashboard and allow analysis to be done without any kind of mistake due to the use of colors.
	P3.3	“The dashboard displays only hospital information unlike the NHS.”	Dashboard presents only information from the hospital which allows an analysis with greater focus on the institution and allows an overview of the aspects of production and productivity of the hospital organization.
Cons	C3.1	“It is a macro view of production and productivity.”	One of the positive aspects of the proposed dashboard is that it only has macro data on production productivity even if it is the dashboard data of production and productivity from the NHS. However, for a more rigorous analysis and detail of the hospital organization it was necessary to have more detailed information and not so much macro.
	C3.2	“It was a plus if the dashboard allowed for a detailed analysis by department, services and stakeholders.”	The fact that the proposed dashboard only presents macro data and does not provide detailed information by service department and health professional is a point against and that could be improved. For this one would have to have access to the specific database of the hospital organization and to know some KPIs relevant to this type of analysis.
	C3.3	“Implement information of the day hospital.”	Another point against is the fact of not having information about the day hospital, although the information of this KPI's are not identified in the NHS portal, this information was more of a contribution to help measure productivity and production.
Proposed Improvements	PI3.1	“Obtain data at the contractual level.”	The contractual data are important because they allow for more detailed and comprehensive analysis of production and productivity, so it was quite interesting to be able to add this information to the proposed dashboard.
	PI3.2	“Placing button in the Big Picture to access the Main Panel.”	The Big Picture being the first view of the dashboard it should have a mechanism that allows navigation to the main panel. The idea was to create a button in case the user wanted to go back and access the main panel. It was accomplished by creating a link.
	PI3.3	“Modify the presentation form of Big Picture data.”	When rearranging the big picutre at the level of the layout of the KPI's it will bring improvement in the presentation, as it is not bad but as we will not have more data it is possible to dispose the information in another way, instead of being all on one side of the screen.

Proposed Improvements	PI3.4	“Modify the location of the Big Picture button and increase its size to give more prominence.”	The Big Picture button on the main panel needs to be highlighted in both size and location.
	PI3.5	“Place links on the label of the segments that lead to the main panel.”	In the big picture place links in the segments' labels; these links will help increase navigability in the dashboard.
	PI3.6	“Change the background of the graphs so that there is a coherence between the segments and information that appears in both the monthly data separator and the annual data also, target.”	The background of the graphics makes it easy to read, the color was well chosen, however it was convenient to choose a background color per segment which allowed a stakeholder who was using the dashboards to know in which segment is the core background graphical components present on the tab.
	PI3.7	“Change the text that appears on the monthly button.”	Changing the text in the button to access the monthly data allows an improved reading of the action that will be performed after clicking the monthly detail button.
	PI3.8	“Put two years in the Big Picture (Try to put two years in the big picture (2017 and 2018)).”	In Big Picture put two years to make a comparison between the years at the level of the KPI's present in the Big Picture. This makes it possible to perform an analysis of their evolution.
	PI3.9	“Putting all hospitals on the database and filtering information by hospital.”	Place all hospitals listed in the NHS database in the tables that appear in the proposed dashboard. Thus, a hospital analysis will be possible, when entering the user should select the hospital they want to analyze and then the data will only refer to that hospital.
	PI3.10	“Put two hospitals in the big picture.”	The big picture could be able to present information from two hospitals, that is to compare the KPIs between hospitals.
	PI3.11	“Obtain information using “Relatório Analítico do Desempenho Económico e Financeiro” (RADEF).”	To obtain the data present in RADEF and consequently to put more data that are not available now by reason of these not being public. This proposal would allow to make more information available for analysis and make the dashboard more robust in terms of production and productivity information, allowing even the possibility of a more micro analysis.
	PI3.12	“Send an MSM to stakeholders with the main data.”	To allow the sending of information via MSM to stakeholders, this functionality had the objective of sending the Big Picture to the various stakeholders or at a specific periodicity or in case of a more relevant change in the Big Picture data and that this change would be important to notify the same to certain stakeholders.

#### **4.4. Fourth DSR Iteration**

In the fourth iteration, the interviewee from the third iteration made several improvement proposals. As was done in the previous interactions, an analysis and weighting were performed on the applicability of the improvement proposals. The result of this weighting is given in section 4.4.2.

##### **4.4.1. Proposal**

In the fourth iteration, the data contained in the panel were again updated so that the interviewee could perform an analysis with real data. The proposal presented in this third iteration implemented only 6/12 improvements suggested by the interviewee. In Table 20 it is possible to verify which proposals were not implemented, but the explanation will be made in section 4.4.2. Evaluation.

##### **4.4.2. Demonstration**

In the first place the explanation of the points that are suggested and were not implemented will be made and next the presentation of the improvement proposals that were implemented.

Proposal PI3.1 is the same as proposal PI2.1 made in the second iteration and its non-implementation has already been duly justified in section 4.3.2, in the paragraph referring to PI2.1 However, it reinforces the idea that these implementations were enough and would bring added value to the dashboards, however it was necessary more data for its implementation and to obtain this impact.

The PI3.2 improvement proposal aims to improve the navigability of the dashboard, so we have implemented links that lead us to the main dashboard, to accomplish this functionality the segments have associated links. For that it is enough to look at Figure 14 and where the names of the segments are, when loading the stakeholders will be conducted to the main panel.

The proposal PI3.3 deals with the question of presenting the information in the Big Picture if we analyse Figure 10 referring to the second iteration we verify that the data are all on one side, which was a better use of the existing space in the Big Picture as we can see in Figure 14.



Table 20 – Proposed improvement prototype -3<sup>rd</sup> Iteration

PI	Proposed improvement	Type	Implemented?	Who Suggested?	Figure
PI3.1	“Obtain data at the contractual level.”	Layout	No	Interviewee	–
PI3.2	“Placing Button in the Big Picture to access the Main Panel.”	Navigation	Yes	Interviewee	14
PI3.3	“Modify the presentation form of Big Picture data.”	Visualization	Yes	Interviewee	14
PI3.4	“Modify the location of the Big Picture button and increase its size to give more prominence.”	Visualization	Yes	Interviewee	15
PI3.5	“Put links on the label of the segments that lead to the main panel.”	Navigation	Yes	Interviewee	15
PI3.6	“Change the background of the graphs so that there is a coherence between the segments and information that appears in both the monthly data separator and the annual data also, target.”	Visualization	Yes	Interviewee	14,15, 16,17, 18
PI3.7	“Change the text that appears on the monthly button.”	Visualization	Yes	Interviewee	17
PI3.8	“Put two years in the Big Picture (Try to put two years in the big picture (2017 and 2018)).”	Visualization	No	Interviewee	–
PI3.9	“Put two hospitals in the big picture.”	Visualization	No	Interviewee	–
PI3.10	“Putting all hospitals on the database and filtering information by hospital.”	Information	No	Interviewee	–
PI3.11	“Obtain information using RADEF.”	Information	No	Interviewee	–
PI3.12	“Send an MSM to stakeholders with the main data.”	Information	No	Interviewee	–

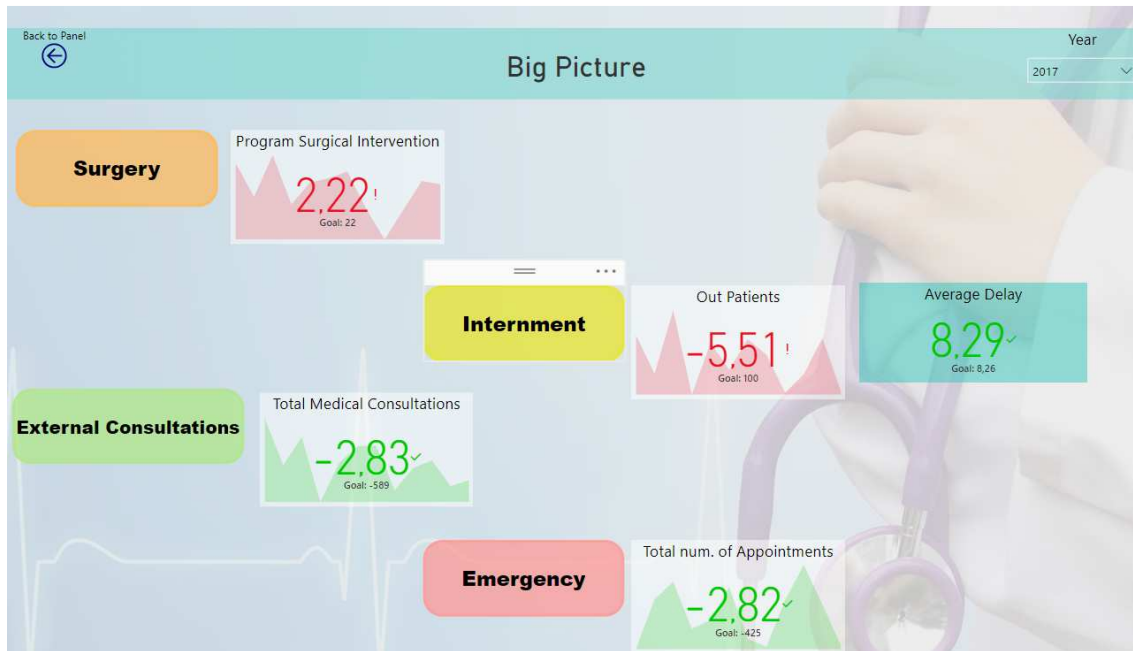


Figure 14 – Big Picture – 4<sup>th</sup> Iteration

The PI3.4 proposal deals with the need to highlight the Big Picture button. As you can see in Figure 19 of Appendix G, the Big Picture button was not included; in the second iteration, it already exists since the first iteration, but in a place with little emphasis since it was still under construction, but in the third iteration it can be placed in a place of greater prominence, as was suggested, as you can see in Figure 15 Big Picture this highlight was made.

The suggestion PI3.5 is a reinforcement to the suggestion PI3.2, in this case in addition to the button added in this suggestion, it was also implemented in the labels where the segments were added, links which lead to the main panel and other improvements that link the question of navigability of the dashboard, as shown in Figure 14.

Proposals PI3.6. have the purpose of defining one color per segment and use that color in the background of all the graphic components of that segment. This change helps create logical coherence between the graphic components and the segments. This change is based on the first rule in Table 9. To validate the implementation, it is possible to verify in Figures 14 and 15 that the segments have different colors, these colors are used in the backgrounds of the graphic components present in Figures 16, 17 and 18.

In proposal PI3.7 it was suggested to change the text of the button that gives access to the monthly detail information, and can be seen in Figure 12 of the 3-iteration button in the upper right corner the text of the button was "Monthly data" what was suggested as

"Monthly details" as shown in Figure 17. This change allows a better understanding of what the user will get by pressing that button, which in this case is monthly internment data.

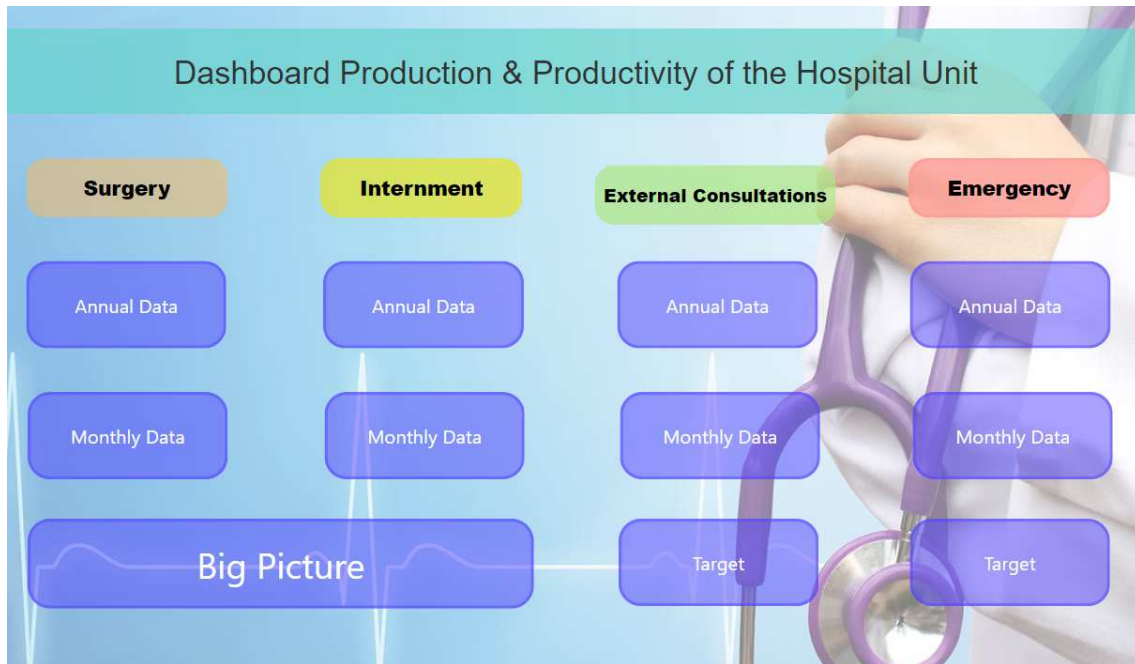


Figure 15 – Main panel – 4<sup>th</sup> Iteration

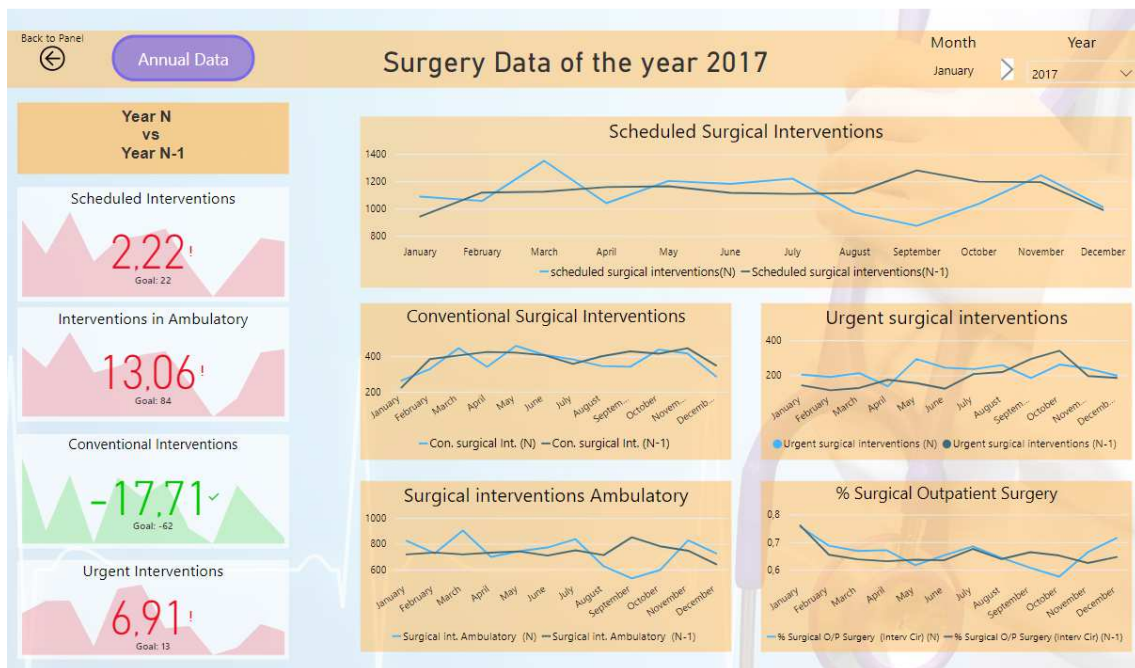


Figure 16 – Surgery data per year – 4<sup>th</sup> Iteration

The suggestion PI3.8 was one of the suggestions that were not implemented due to the technological and data structure question. At the technological level, it takes more time to get to know the functionality of the application where the dashboard was developed and to verify the possibility of implementing the presentation of two years. At the data structure level, it was necessary to perform data treatment to be able to execute these suggestions, in this way I am considering it as a proposal for future improvement.

In PI3.9 it was suggested that in the Big Picture it was possible to make a comparison between two different hospital organizations This suggestion was not implemented by the same types of reasons of technological PI3.8 and data structure. At the technological level it was necessary to carry out some research and tests to validate its applicability. At the data structure level, it was necessary to take a less focused approach to the hospital organization, and to have data from all the hospital units that are part of the NHS.

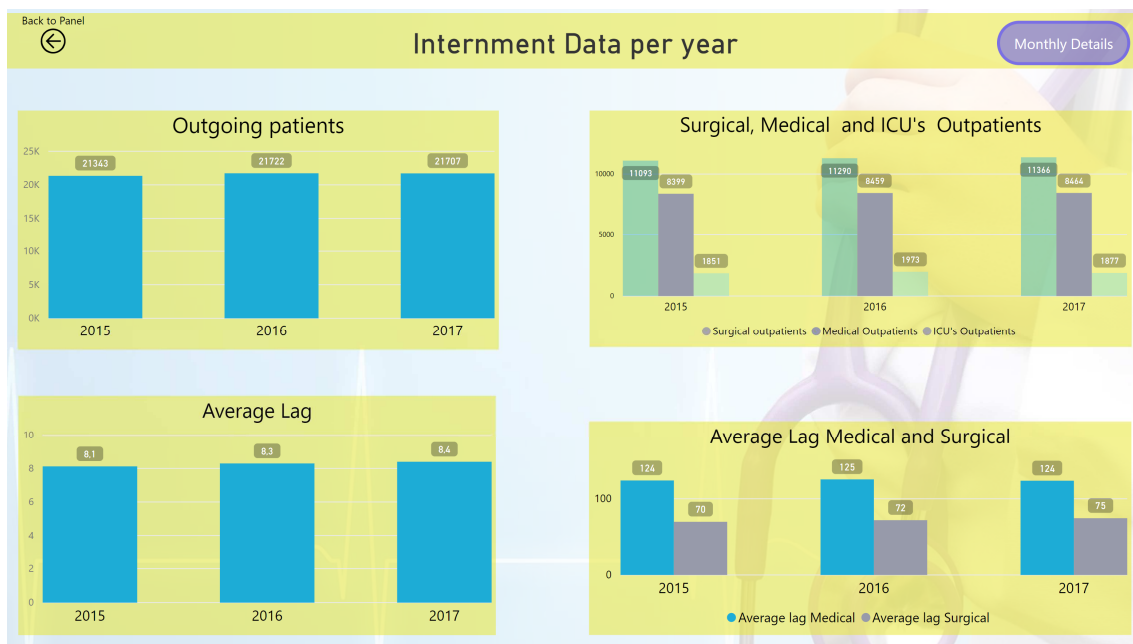


Figure 17 – Internment data per year – 4<sup>th</sup> Iteration

The suggestion PI3.10 had as its main objective the implementation of more than the hospital in the database that is being used to popularize the information on the dashboard. This new functionality implied a change in the access to the dashboard, since only some type of information was presented if the hospital was previously selected, because it is necessary to carry out the filtering of the information to present the correct data of each

institution. This suggestion was not implemented at this stage but was noted as a future improvement.

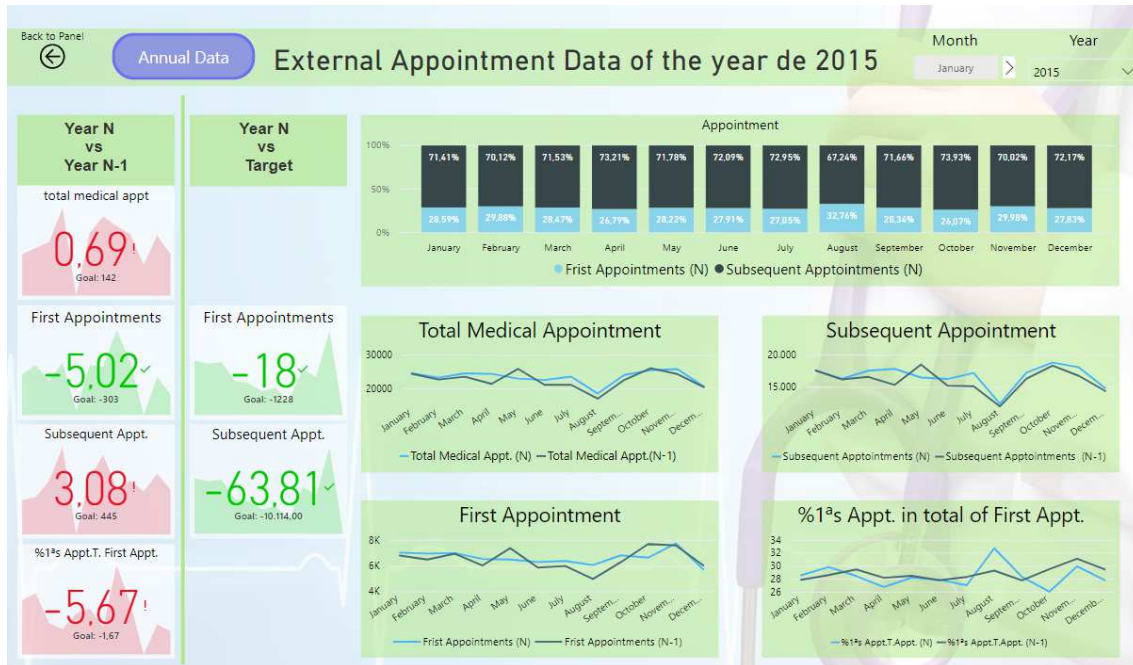


Figure 18 – External Appointment Data – 4<sup>th</sup> Iteration

In suggestion PI3.11 what is suggested is that the dashboard presents data that are in the RADEF and thus enrich the dashboard with more KPI's of production and productivity. However, with the database not being public it has not been implemented. It is true that public hospitals publish RADEF annually, only the annual data are included, and the monthly data are not presented to be able to show a detailed monthly analysis only with access to the RADEF database. These suggestions will be noted for a future improvement. Proposal PI.3.12 suggests the implementation of sending the Big Picture or specific KPI's by SMS to healthcare professionals of the hospital organization. This functionality would allow them to have access to the information to make the necessary decisions. These suggestions will be recorded for future implementation.

#### 4.4.3. Evaluation

After the fourth interview, the result was 2 positive aspects, 2 negative aspects and 1 suggestion for improvement, according to Table 22.

Again, in the fourth interview, the positives are related to data visualization and focus issues that are addressed in the dashboard for analysis of just one hospital organization. Negative aspects relate to the lack of more information that makes it impossible to analyze more micro.

In the fourth interview, 1 improvement proposal was made, and section 4.4.2 explained the non-implementation.

The proposal PI4.1 present in Table 21 is the same as the proposal PI2.1 and PI3.1 made in the second iteration and third iteration, its non-implementation has already been duly justified in sections 4.3.2 and 4.4.2, in the paragraph referring to PI2.1 and PI3.1.

*Table 21 – Proposed improvement prototype - 4<sup>th</sup> Iteration*

<b>PI</b>	<b>Proposed improvement</b>	<b>Type</b>	<b>Implemented?</b>	<b>Who Suggested?</b>	<b>Figure</b>
PI4.1	“Obtain data at the contractual level.”	Layout	No	Interviewee	–

#### 4.5. DSR Iterations Synthesis

From the answers of the interviewees we obtained a set of improvement proposals that are included in Table 23. In a total of 21 improvement proposals 19 were made by the interviewees and 2 were made by the author. Of the 21 proposals for form improvement 12 were implemented and the remaining 9 were registered for future improvements.

Table 22 – Evaluation of the prototype – 4<sup>rd</sup> Iteration

	<b>ID</b>	<b>Stakeholder synthesis</b>	<b>Stakeholder Opinions</b>
Pros	P4.1	“The fact that it is a dashboard that enables immediate analysis of production information and productivity of the hospital.”	O dashboard apresenta as possibilidades de produção de informação e produtividade de uma organização orgânica hospitalar. The dashboard presents the possibilities of information productivity of an organic hospital organization.
	P4.2	“To be a decision support tool focused on a single hospital organization.”	The proposed Dashboard displays only information from a hospital organization. Analysis is focused on the institution, allowing a greater knowledge of the production and productivity aspects of the hospital organization.
Cons	C4.1	“It is a macro view of production and productivity”	The macro view is very important to carry out an analysis with a macro optics, however when we need to perform a more detailed analysis we need to have the information which allows this type of micro analysis. Being able to have both sides was a very interesting factor.
	C4.2	“The Dashboard should have information that would allow analysis at the departmental, service and stakeholder levels.”	The macro information is a starting point for a good analysis of the information of a hospital organization, however, it is necessary to have more data which will make a more detailed analysis and that allows an analysis at the level of the department, the service and the stakeholders.
Proposed Improvements	PI4.1	“Obtain data at the contractual level.”	Achieving contractual data will allow a broader coverage of dashboards to the issue of production and productivity.

Table 23 – Proposed improvement prototype by iterations

Iteration 1					
ID	Proposed improvement	Type	Implemented?	Who suggested	Figure
PI1.1	“Creation of KPI's graph that allows the comparison of the current year with the homologous.”	Information	Yes	Interviewee	7
PI1.2	“Improvement in the organization of the information of KPI's plus macro for the more micro.”	Information	Yes	Interviewee	7,8,9
PI1.3	“Changing the graphics background color.”	Visualization	Yes	Interviewee	7,8,9
PI1.4	Big Picture Building	Information	Yes	Author	10
Iteration 2					
PI2.1	“Obtain data at the contractual level.”	Information	No	Interviewee	–
PI2.2	“Allow for a more detailed analysis of the information, allowing an analysis by department, service and health stakeholders.”	Visualization	No	Interviewee	–
PI2.3	“Add more emergency information.”	Information	Yes	Interviewee	11
PI2.4	Navigation buttons	Navigation	Yes	Author	12,13
Iteration 3					
PI3.1	“Obtain data at the contractual level.”	Layout	No	Interviewee	–
PI3.2	“Placing Button in the Big Picture to access the Main Panel.”	Navigation	Yes	Interviewee	14
PI3.3	“Modify the presentation form of Big Picture data.”	Visualization	Yes	Interviewee	14
PI3.4	“Modify the location of the Big Picture button and increase its size to give more prominence.”	Visualization	Yes	Interviewee	15
PI3.5	“Put links on the label of the segments that lead to the main panel.”	Navigation	Yes	Interviewee	15
PI3.6	“Change the background of the graphs so that there is a coherence between the segments and information that appears in both the monthly data separator and the annual data also, target.”	Visualization	Yes	Interviewee	14,15,16,17,18
PI3.7	“Change the text that appears on the monthly button.”	Visualization	Yes	Interviewee	17
PI3.8	“Put two years in the Big Picture (Try to put two years in the big picture (2017 and 2018)).”	Visualization	No	Interviewee	–
PI3.9	“Put two hospitals in the big picture.”	Visualization	No	Interviewee	–
PI3.10	“Putting all hospitals on the database and filtering information by hospital.”	Information	No	Interviewee	–
PI3.11	“Obtain information using RADEF.”	Information	No	Interviewee	–
PI3.12	“Send an MSM to stakeholders with the main data.”	Information	No	Interviewee	–
Iteration 4					
PI4.1	“Obtain data at the contractual level.”	Layout	No	Interviewee	–



## **Chapter 5 - Conclusion and Future Work**

The NHS dashboard is not complete and since it is not up to date it should present more information on areas with human and financial resources.

The positive aspects of the NHS dashboard are that it has all the information of the public hospitals and allows the comparison between hospitals. It is the only tool that provides health information at the national level. But there are some fewer positive aspects of this solution, such as the comparison is not made between all hospitals but by groups of hospitals which prevents a more precise comparative analysis. Another less positive aspect is that graphs have up-to-date information.

The negative aspect of the dashboard is that data is not updated and not user friendly, these are some of the aspects that can be improved.

The implementation of a Big Picture is seen as being useful because it makes it possible to present the most relevant KPIs of production and productivity and allows to indicate which specimen should be analyzed in greater detail. Another relevant point is that it allows for an analysis of the real year as well as the homologous.

In general, there is no lack of information in the tabs presented, however if it were possible to put contractual information and allow more detailed information at the department, service and health professional level it would be an asset.

In the opinion of the interviewed the information present in the dashboard is clear and the navigability is good or very good.

In the comparison between the proposed dashboard and the NHS dashboard the responses were unanimous at the level of positive aspect of the proposal phase to dashboard of the NHS and that the fact that the proposed dashboard analyzes only a hospital organization allows to optimize analysis of the state of the hospital organization. Regarding the negative aspects, it was identified by one of the interviewees that absence of other areas and the possibility of benchmarking if the decision maker needs a comparative analysis. The remaining professionals interviewed do not suggest blunt negative aspects.

The possibility of implementing the proposed dashboard is well regarded by the interviewees, because it presents new functionalities with Big Picture, analysis of real year with the homologous and possibility of fast way to have access to all information of each segment.

All interviewees indicated that there is a similar tool in the hospital organization that helps to monitor multiple KPIs. The positive aspect of this tool is that it is able to aggregate all the KPIs in the NHS portal, in addition to other KPIs that have been losing their importance at the NHS level, but which are useful in the analysis of the hospital organization and as such have been retained to help decision makers also make decisions based on these KPIs. This tool was developed following the guidelines of the BSC that was defended by the hospital organization itself, allowing to obtain analysis of data by department, service fast. The application serves to define, control and monitor the objectives and goals of the organization. On the one hand and less positive aspect of these solutions is its visual limitation of the same, i.e. there are few graphic components available to the development of graphics following the good practices of visualization and on the other hand it does not allow the development of dashboards like the proposed one. It can be concluded that the proposed panel is seen as an added value for production and productivity analysis because it allows to create a more useful data visualization for decision makers.

The results obtained by the interviews show that the implementation of dashboards on production and productivity is an asset for hospital organizations. Another important aspect that can be concluded from the research is that applying the guidelines of colours and Gestalt's principles of visual allow enhancing the value of dashboards for stakeholders. It is also important to note that the prototype was populated with real hospital information which allowed stakeholders to become more familiar with the data and to gain more certainty of the information they need to obtain with dashboards. The implementation of the dashboards has all the conditions to materialize as indicated in the feedback of the stakeholders interviewed. Moreover, the dashboard allows us to respond to a need which is to be able to measure the production and productivity of the hospital organization.

To finalize the proposed dashboard allows to give a macro view of the production and productivity using the KPIs indicated by the NHS. It focuses only on a hospital organization. So far, the only solution exists in hospital organizations, it was hospital benchmarking, monthly monitoring and possible tools tailored to each hospital organization. With these solutions organizations gain a tool focused on their reality,

which also follows the good practices of visualization techniques and Drill Down and is up to date.

### 5.1. Contributions

The main contribution of this research is the creation of a dashboard which allows hospitals' stakeholders to obtain relevant information regarding productivity and production and to provide the possibility to carry out an analysis of the KPIs that allows a better knowledge of the state of the organization. By the end of this research it was possible to answer the questions listed in Table 1 Problem P1 and P2. The contribution is in line with the objective defined in sub-section 1.2, which consists of developing a panel that can provide information to enable stakeholders in hospital organizations to perform an analysis, evaluation and monitoring of production and productivity KPIs to support the decision-making. The dashboard was developed with the application of good visualization practices and drill-down techniques, thus providing a useful tool for decision support.

It should also be pointed out that the contribution made by hospital organizations and international organizations such as the OECD, which has been gaining more importance since 2000, has launched a first document which warned of the need to create KPIs and tools to measure production and productivity. To help simplify this measure, other entities followed suit (Sharpe et al., 2007).

At the scientific level, the research is in line with a proposal of future work that is part of the LR where it is proposed to do more research on the benefits of data visualization in health (Stadler et al., 2016). But the contribution goes further and as it can be seen in Table 6, in this research the proposed dashboard concentrates in itself the good practices of visualization, the techniques of drill down and we present the final result that can be seen in the Figures: 15, 16, 17 and 18. So we added to the scientific level a new research on dashboard in the health area, but with the focus on production and productivity and based on the good visualization of Drill Down. This research is the starting point for the appearance of more studies which address the same theme and improve dashboard tools in the health area. In order to show that the dissertation has relevance in the academic universe, an article was published (Pestana et al., 2018).

The contribution to health professionals is to provide a new survey of dashboards I have been developing according to good practices and resorting to real data from the hospital organization. This will allow the productivity and production data to be provided to health stakeholders, so that in the future it will be possible to apply the solution to hospital organizations.

## 5.2. Limitations

The research has some limitations. First, it was performed only in one hospital, which made it difficult to generalize the conclusions, despite interviewees' experience for in their professional career they passed through several hospital organizations, both in the private and public sectors, as evidenced by Table 14.

Second, only 4 interviews were made, which means that more improvements can be proposed in the future with more interviews. However, these 4 interviews were made to professionals who need to obtain this type of information (real stakeholders). Third, it was not possible to implement all the improvements proposed due to their periodization time, some of the proposals are already registered for future development.

## 5.3. Future Work

As a proposal for future work, it was very interesting to continue the research with more iterations in the same hospital and other hospitals. This will allow, on the one hand, to create a more complete dashboard and the possibility of obtaining conclusions that allow the generalization and consequent implementation of the artefacts in other hospital organizations. Another proposal for future work is to gain access to private data from hospitals and thus be able to present more information than just the public information. Another proposal of future work is to create a dashboard that allows for an analysis by department, services and health professional. This dashboard allowed to create a more complete dashboard that beyond the presentation of a macro vision allowed a micro vision when it was useful for the decision makers.

## References

- Al-Hajj, S., Pike, I., & Fisher, B. (2013). Interactive Dashboards: Using Visual Analytics for knowledge Transfer and Decision Support. *2013 Workshop on Visual Analytics in Healthcare*, 37–40. Retrieved from <http://www.cc.gatech.edu/gvu/ii/PublicHealthVis/Papers/Dashboards>
- Al-HAJJ, S., Pike, I., & Fisher, B. (2012). Visual Analytics to Support Medical Decision-Making Process. *XXIV Conference of the European Federation for Medical Information: Quality of Life through Quality of Information.*, 1–3.
- Al-Hajj, S., Pike, I., Riecke, B. E., & Fisher, B. (2013). Visual analytics for public health: Supporting knowledge construction and decision-making. *Proceedings of the Annual Hawaii International Conference on System Sciences*. <https://doi.org/10.1109/HICSS.2013.599>
- Alexander Berler, Sotiris Pavlopoulos, and D. K. (2005). Using Key Performance Indicators as Knowledge-Management Tools at a Regional Health-Care Authority Level. *Ieee Transactions on Information Technology in Biomedicine*, 9(2), 184–192. <https://doi.org/10.1109/TITB.2005.847196>
- Alexander, J. (2007). Performance dashboards and analysis for value creation, 301. <https://doi.org/10.1002/9781119197324>
- Alharbey, R. (2016). Predictive Analytics Dashboard for Monitoring Patients in Advanced Stages of COPD. *2016 49th Hawaii International Conference on System Sciences (HICSS)*, 3455–3461. <https://doi.org/10.1109/HICSS.2016.431>
- Arinze, B. (2014). A model for delivering smart healthcare using patient-facing dashboards, clinical DSS and electronic health records. *Canadian Conference on Electrical and Computer Engineering*, 1–4. <https://doi.org/10.1109/CCECE.2014.6900996>
- Ashrafi, N., Kelleher, L., & Kuilboer, J.-P. (2014). The Impact of Business Intelligence on Healthcare Delivery in the USA. *Interdisciplinary Journal of Information*, 9(9), 117–130. [https://doi.org/10.1016/S2212-5671\(14\)00859-4](https://doi.org/10.1016/S2212-5671(14)00859-4)
- Barrento, M. (2017). European Benchmarking in Healthcare Analysis by Country with highlight on Portugal, 1–4. <https://doi.org/10.23919/CISTI.2017.7975899>
- Barrento, M., Estudos, C. De, & Informação, D. (2013). Admissão da Business Intelligence às Urgências Hospitalares Business Intelligence admission to Hospital

- emergency. Retrieved from  
<http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6615824&isnumber=6615699>
- Baskett, L., LeRouge, C., & Tremblay, M. C. (2008). Using the dashboard technology properly. *Health Progress (Saint Louis, Mo.)*, 89(5), 16–23. Retrieved from  
<https://www.chausa.org/docs/default-source/health-progress/using-the-dashboard-technology-properly-pdf.pdf?sfvrsn=0%5Chttp://www.ncbi.nlm.nih.gov/pubmed/18814789>
- Black, N., Browne, J., & Cairns, J. (2006). Health care productivity. *BMJ*, 333(7563), 312–313. <https://doi.org/10.1136/bmj.333.7563.312>
- Daley, K., Richardson, J., James, I., Chambers, A., & Corbett, D. (2013). Clinical dashboard: use in older adult mental health wards. *The Psychiatrist*, 37(3), 85–88. <https://doi.org/10.1192/pb.bp.111.035899>
- De Sordi, José Osvaldo; Meireles, Manuel; Sanches, C. (2013). Design science aplicada às pesquisas em administração: reflexões a partir do recente histórico de publicações internacionais. *RAI - Revista de Administração e Inovação*, 8, nú, 10--36. <https://doi.org/https://doi.org/10.5773/rai.v8i1.770>
- Dixon, B. E., Jabour, A. M., Phillips, E. O. K., & Marrero, D. G. (2014). An informatics approach to medication adherence assessment and improvement using clinical, billing, and patient-entered data. *Journal of the American Medical Informatics Association*, 21(3), 517–521. <https://doi.org/10.1136/amiajnl-2013-001959>
- Donaldson, N., Brown, D. S., Aydin, C. E., Bolton, M. L. B., & Rutledge, D. N. (2005). Leveraging nurse-related dashboard benchmarks to expedite performance improvement and document excellence. *The Journal of Nursing Administration*, 35(4), 163–172. <https://doi.org/10.1097/00005110-200504000-00005>
- Eckerson, W. W. (2012). Performance Dashboards. *Performance Dashboards, 2nd Ed. - Business Book Summaries*, (November), 1. <https://doi.org/10.1002/9781119199984.ch1>
- Egan, M. (2006). Clinical Dashboards. *Critical Care Nursing Quarterly*, 29(4), 354–361. <https://doi.org/10.1097/00002727-200610000-00008>
- Engla, N. E. W. (2006). New engla nd journal. *Perspective*, 363(1), 1–3. <https://doi.org/10.1056/NEJMp1002530>

- Escrivão Junior, Á. (2007). Uso da informação na gestão de hospitais públicos. *Ciência & Saúde Coletiva*, 12, 655–666. <https://doi.org/10.1590/S1413-81232007000300015>
- Few, S. (2006). *Information Dashboard Design - The effective Visual Communication of Data*.
- Franklin, A., Gantela, S., Shifarrow, S., Johnson, T. R., Robinson, D. J., King, B. R., ... Okafor, N. G. (2017). Dashboard visualizations: Supporting real-time throughput decision-making. *Journal of Biomedical Informatics*, 71, 211–221. <https://doi.org/10.1016/j.jbi.2017.05.024>
- Garcia, L. J. (2014). A importância do design na viabilização de embalagens para uma micro e pequena empresa da maricultura, 1, 1–12. <https://doi.org/10.5151/designpro-ped-01037>
- Georgiana, V., Kartawiguna, D., & Indrajani. (2017). Evaluation of radiology data warehouse implementation on education, research, and quality assurance. *Proceedings of 2016 International Conference on Information Management and Technology, ICIMTech 2016*, (November), 277–280. <https://doi.org/10.1109/ICIMTech.2016.7930344>
- Ghazisaeidi, M., Safdari, R., Torabi, M., Mirzaee, M., Farzi, J., & Goodini, A. (2015). Development of performance dashboards in healthcare sector: Key practical issues. *Acta Informatica Medica*, 23(5), 317–321. <https://doi.org/10.5455/aim.2015.23.317-321>
- Gordon, J., & Richardson, E. (2013). Continuous Improvement in the Management of Hospital Wards: The Use of Operational Dashboards. *International Journal of Management*, 30(4), 414–417.
- Hain, P. D., Daru, J., Robbins, E., Bode, R., Brands, C., Garber, M., ... Tobey, D. (2012). A Proposed Dashboard for Pediatric Hospital Medicine Groups. *Hospital Pediatrics*, 2(2), 59–68. <https://doi.org/10.1542/hpeds.2012-0004>
- Henkel, M., Johannesson, P., & Perjons, E. (2007). Value and goal modelling in healthcare. *Management*, 1–14.
- Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design Science in Information Systems Research. *MIS Quarterly*, 28(1), 75–105. <https://doi.org/10.2307/25148625>

- Hill, H. M. (2012). Measuring productivity in bioanalysis. *Bioanalysis*, 4(19), 2317–2319. <https://doi.org/10.4155/bio.12.207>
- Jha, A., & Epstein, A. (2010). Hospital governance and the quality of care. *Health Affairs*, 29(1), 182–187. <https://doi.org/10.1377/hlthaff.2009.0297>
- Karami, M., Langarizadeh, M., & Fatehi, M. (2017). Evaluation of Effective Dashboards: Key Concepts and Criteria. *The Open Medical Informatics Journal*, 11(1), 52–57. <https://doi.org/10.2174/1874431101711010052>
- Kawamura, T., Kimura, T., & Tsumoto, S. (2014). Estimation of Service Quality of a Hospital Information System Using a Service Log. *The Review of Socionetwork Strategies*, 8(2), 53–68. <https://doi.org/10.1007/s12626-014-0044-x>
- Knaflic, C. N. (2015). *Storytelling with data: A data visualization guide for business professionals*. John Wiley & Sons. <https://doi.org/10.1002/9781119055259>
- Koronios, A., & Gao, J. (2010). Data Quality for Emergency Department BI Dashboard. *Advances in Intelligent Systems Research*, (2001), 301–309. <https://doi.org/10.2991/icebi.2010.47>
- Koumpouros, Y. (2013). Balanced scorecard: application in the General Panarcadian Hospital of Tripolis, Greece. *International Journal of Health Care Quality Assurance*, 26(4), 286–307. <https://doi.org/10.1108/09526861311319546>
- Mahendrawathi, E. R., Pranantha, D., & Utomo, J. D. (2010). Development of dashboard for hospital logistics management. *ICOS 2010 - 2010 IEEE Conference on Open Systems*, (Icos), 86–90. <https://doi.org/10.1109/ICOS.2010.5720069>
- Mallak, L. A. (2009). DPM and DFID: Interactive tools for evidence-based decision making. *PICMET: Portland International Center for Management of Engineering and Technology, Proceedings*, 642–649. <https://doi.org/10.1109/PICMET.2009.5262057>
- Martin, N., Bergs, J., Eerdeken, D., Depaire, B., & Verelst, S. (2017). Developing an emergency department crowding dashboard: A design science approach. *International Emergency Nursing*, 1–9. <https://doi.org/10.1016/j.ienj.2017.08.001>
- Mattingly, W. A., Kelley, R. R., Wiemken, T. L., Chariker, J. H., Peyrani, P., Guinn, B. E., ... Ramirez, J. (2015). Real-time enrollment dashboard for multisite clinical trials. *Contemporary Clinical Trials Communications*, 1, 17–21. <https://doi.org/10.1016/j.conctc.2015.09.001>



- McGlothlin, J. P., Vedire, S., Crawford, E., Pappas, J., Bruneau, B., & Obregon, L. (2016). Improving patient care through analytics. *2016 4th International Symposium on Computational and Business Intelligence (ISCBI)*, 94–100. <https://doi.org/10.1109/ISCBI.2016.7743265>
- McLeod, B., Zaver, F., Avery, C., Martin, D. P., Wang, D., Jessen, K., & Lang, E. S. (2010). Matching capacity to demand: A regional dashboard reduces ambulance avoidance and improves accessibility of receiving hospitals. *Academic Emergency Medicine*, *17*(12), 1383–1389. <https://doi.org/10.1111/j.1553-2712.2010.00928.x>
- Mettler, T., & Rohner, P. (2009). Performance Management in Health Care: The Past, the Present, and the Future. *Proceedings of the 9th International Conference on Business Informatics*, *2*, 699–708.
- Miniati, R., Frosini, F., Cecconi, G., Dori, F., Iadanza, E., Biffi Gentili, G., Belardinelli, a. (2014). Development of Web-Based Operating Theatre Dashboard for Activity Monitoring and Planning in Hospitals. *Proceedings IEEE-EMBS International Conference on Biomedical and Health Informatics (BHI 2014)*, 50139, IN PRESS. <https://doi.org/10.1109/BHI.2014.6864319>
- Nogueira, Paulo; Martins, José; Rita, Francisco; Fatela, L. (2017). Dashboards da Saúde: Passado, Presente e Futuro. Uma Perspetiva da Evolução em Portugal., 1–9. <https://doi.org/10.1158/0008-5472.SABCS12-S5-3>
- Park, K. W., Smaltz, D., McFadden, D., & Souba, W. (2010). The operating room dashboard. *Journal of Surgical Research*, *164*(2), 294–300. <https://doi.org/10.1016/j.jss.2009.09.011>
- Peffer, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A Design Science Research Methodology for Information Systems Research. *Journal of Management Information Systems*, *24*(3), 45–77. <https://doi.org/10.2753/MIS0742-1222240302>
- Perron, C. E., Bachur, R. G., & Stack, A. M. (2017). Development, Implementation, and Use of an Emergency Physician Performance Dashboard. *Clinical Pediatric Emergency Medicine*, *18*(2), 115–123. <https://doi.org/10.1016/j.cpem.2017.04.004>
- Pestana, M., Pereira, R., & Moro, S. (2018). A productivity dashboard for hospitals: An empirical study. *Lecture Notes in Business Information Processing*, *333*(351), 184–199. [https://doi.org/10.1007/978-3-030-00060-8\\_14](https://doi.org/10.1007/978-3-030-00060-8_14)

- Presthus, W., & Bergum, I. (2015). Business Intelligence to the People. A Case Study of Dashboard Adoption in the Health Care sector. *Norsk Konferanse for Organisasjoners Bruk Av IT*, 23(1).
- Prevedello, L. M., Andriole, K. P., Hanson, R., Kelly, P., & Khorasani, R. (2010). Business intelligence tools for radiology: Creating a prototype model using open-source tools. *Journal of Digital Imaging*, 23(2), 133–141.  
<https://doi.org/10.1007/s10278-008-9167-3>
- Providers, H., & Nelson, G. S. (2010). The Healthcare Performance Dashboard : Linking Strategy to Metrics Table of Contents SAS Global Forum 2010, 1–10.
- Rahimi, H., Kavosi, Z., Shojaei, P., & Kharazmi, E. (2016). Key performance indicators in hospital based on balanced scorecard model. *Journal of Health Management and Informatics*, 4(1), 17–24.
- Ramos, A. W., & Miyake, D. I. (2010). Desenvolvendo Indicadores de Produtividade e Qualidade em Hospitais: Uma Proposta de Método, 11, 67–84.
- Ryan, J., Doster, B., Daily, S., & Lewis, C. (2017). Key Performance Indicators across the Perioperative Process: Holistic Opportunities for Improvement via Business Process Management, 3479–3488. Retrieved from  
<https://scholarspace.manoa.hawaii.edu/bitstream/10125/41579/1/paper0430.pdf>
- Ryan, J., Doster, B., Daily, S., Lewis, C., Doster, B., Daily, S., & Lewis, C. (2013). A Balanced Perspective to Perioperative Process Management Aligned to Hospital Strategy.
- Safwan, E. R., Meredith, R., & Burstein, F. (2016). Business Intelligence (BI) system evolution: a case in a healthcare institution. *Journal of Decision Systems*, 25(November), 463–475. <https://doi.org/10.1080/12460125.2016.1187384>
- Santos, M. Y. (2015). A Data-driven Analytics Approach in the Study of Pneumonia ' s Fatalities.
- Shailam, R., Botwin, A., Stout, M., & Gee, M. S. (2018). Real-Time Electronic Dashboard Technology and Its Use to Improve Pediatric Radiology Workflow. *Current Problems in Diagnostic Radiology*, 47(1), 3–5.  
<https://doi.org/10.1067/j.cpradiol.2017.03.002>
- Sharpe, A., Bradley, C., & Messinger, H. (2007). The Measurement of Output and Productivity in the Health Care Sector in Canada : An Overview The Measurement

- of Output and Productivity in the Health Care Sector in Canada : An Overview  
Abstract Résumé, (December), 1–58.
- Silva, P., Quintas, C., Duarte, J., Santos, M., Neves, J., Abelha, A., & MacHado, J. (2012). Hospital database workload and fault forecasting. *2012 IEEE-EMBS Conference on Biomedical Engineering and Sciences, IECBES 2012*, (December), 63–68. <https://doi.org/10.1109/IECBES.2012.6498150>
- Stadler, J. G., Donlon, K., Siewert, J. D., Franken, T., & Lewis, N. E. (2016). Improving the Efficiency and Ease of Healthcare Analysis Through Use of Data Visualization Dashboards. *Big Data*, *4*(2), 129–135. <https://doi.org/10.1089/big.2015.0059>
- Voelker, K. E., Rakich, J. S., & French, G. R. (2001). The balanced scorecard in healthcare organizations: a performance measurement and strategic planning methodology. *Hospital Topics*, *79*(3), 13–24. <https://doi.org/10.1080/00185860109597908>
- Ward, M. J., Marsolo, K. A., & Froehle, C. M. (2014). Applications of business analytics in healthcare. *Business Horizons*, *57*(5), 571–582. <https://doi.org/10.1016/j.bushor.2014.06.003>
- Webster, J., & Watson, R. T. (2002). Analyzing the Past to Prepare for the Future: Writing a Literature Review. *MIS Quarterly*, *26*(2), xiii–xxiii. <https://doi.org/10.1.1.104.6570>
- Wexler, Steve, Shaffer Jeffrey, C. A. (2017). *The Big Book of Dashboards: Visualizing Your Data Using Real-World Business Scenarios*. Wiley. <https://doi.org/10.1002/9781119283089>
- Zhang, X., Gallagher, K., & Goh, S. (2011). BI application: Dashboards for healthcare. *17th Americas Conference on Information Systems 2011, AMCIS 2011*, *5*, 3898–3902. Retrieved from <http://www.scopus.com/inward/record.url?eid=2-s2.0-84870316889&partnerID=40&md5=45a4760a81149393d4daa2f7df08c207>



## Appendices

### Appendix A – List of Articles by Author

Authors	Title
(Zhang et al., 2011)	BI Application Dashboards for Healthcare
(Stadler et al., 2016)	Improving the Efficiency and Ease of Healthcare Analysis Through Use of Data Visualization Dashboards
(Presthus & Bergum, 2015)	Business Intelligence to The People. A case Research Of Dashboard Adoption in The HealthCare Sector
(Ghazisaeidi et al., 2015)	Development of Performance Dashboards in Healthcare Sector: Key Practical Issues
(Egan, 2006)	Clinical Dashboards Impact on Workflow, Care Quality, and Patient Safety
(Koronios & Gao, 2010)	Data Quality for Emergency Department BI Dashboard
(Al-Hajj et al., 2013)	Visual Analytics for Public Health: Supporting Knowledge Construction and Decision-Making
(Al-Hajj et al., 2012)	Visual Analytics to support Medical Decision-Making Process
(Al-Hajj et al., 2013)	Interactive Dashboards: Using Visual Analytics for knowledge Transfer and Decision Support
(Nelson , 2010)	The Healthcare Performance Dashboard: Linking Strategy to Metrics
(Martinet al., 2017)	Developing an emergency department crowding dashboard: A design science approach
(Franklin et al., 2017)	Dashboard visualizations: Supporting real-time throughout decision-making
(Perron et al., 2017)	Development, Implementation, and Use of an Emergency Physician Performance Dashboard
(Shailam et al., 2018)	Real-Time Electronic Dashboard Technology and Its Use to Improve
( Gordon & Richardson, 2013)	Continuous Improvement in the Management of Hospital Wards the Use of Operational Dashboards
(Ward et al., 2014)	Applications of business analytics in healthcare
(Mattingly et al., 2015)	Real-time enrollment dashboard for multisite clinical trials
(Alharbey, 2016)	Predictive Analytics Dashboard for Monitoring Patients in Advanced Stages of COPD
(Arinze, 2014)	A model for delivering smart healthcare using patient-facing dashboards, Clinical DSS and Electronic Health Records
(Daley et al., 2013)	Clinical dashboard: use in older adult mental health wards
(Donaldson et al., 2005)	Leveraging nurse-related dashboard benchmarks to expedite performance improvement and document excellence
(Jha & Epstein, 2010)	Hospital Governance and The Quality of Care
(McGlothlin et al., 2016)	Improving Patient Care Through Analytics
(Mahendrawathi et al., 2010)	Development of Dashboard for Hospital Logistics
(Barrento, 2017)	European Benchmarking in Healthcare

(Georgiana et al., 2017)	Evaluation of Radiology Data Warehouse Implementation on Education, Research, and Quality Assurance
(Silva et al., 2012)	Hospital database workload and fault forecasting
(Miniati et al., 2014)	Operating Theatre Model for Activity Monitoring and Planning in Hospitals
(Dixon et al., 2014)	An informatics approach to medication adherence assessment and improvement using clinical, billing, and...
(Prevedello et al., 2010)	Business Intelligence Tools for Radiology: Creating a Prototype Model Using Open-Source Tools
(McLeod et al., 2010)	Matching Capacity to Demand: A Regional Dashboard Reduces Ambulance Avoidance and Improves Accessibility of Receiving Hospitals
(Santos, 2015)	A Data-driven Analytics Approach in the Research of Pneumonia's Fatalities
(Hain et al., 2012)	A Proposed Dashboard for Pediatric
(Park et al., 2010)	The Operating Room Dashboard
(Barrento et al., 1997)	Admissão da Business Intelligence às Urgências Hospitalares Business Intelligence admission to Hospital emergency
(Ryan et al., 2013)	A Balanced Scorecard Approach to Perioperative Process Management: A Case Research Perspective
(Ryan et al., 2017)	Key Performance Indicators across the Perioperative Process: Holistic Opportunities for Improvement via Business Process Management
(Mallak, 2009)	DPM and DFID: Interactive Tools for Evidence-Based Decision Making

## Appendix B – Conferences, Proceedings and Journal

Conferences and Proceedings	Country	Total of pub. by country
Conference of the European Federation for Medical Information: Quality of Life through Quality of Information.	Belgium	1
Canadian Conference on Electrical and Computer Engineering	Canadian	1
Advances in Intelligent Systems Research	France	1
Proceedings from the annual NOKOBIT conference held in Oslo	Norway	1
Americas Conference on Information Systems, AMCIS	USA	13
Hawaii International Conference on System Sciences		
Healthcare Analytics Academy		
Iberian Conference on Information Systems and Technologies		
ICOS- IEEE Conference on Open Systems		
IEEE International Conference on Data Science and Advanced Analytics (DSAA)		
IEEE-EMBS Conference on Biomedical Engineering and Sciences		
IEEE-EMBS International Conference on Biomedical and Health Informatics (BHI)		
International Conference on Health Information Technology Advancement		
International Conference on Information Management and Technology (ICIMTech)		
International Symposium on Computational and Business Intelligence (ISCBI)		
PICMET: Portland International Center for Management of Engineering and Technology, Proceedings		
Workshop on Visual Analytics in Healthcare		
Total of Conferences and Proceedings		17
Journal	Country	Total of pub. by country
Acta Inform Med	Bosnia and Herzegovina	1
Journal of Digital Imaging	Germany	1
Business Horizons	Netherlands	1
Clinical Pediatric Emergency Medicine	UK	4
International Emergency Nursing		
International Journal of Management		
The Psychiatrist	USA	11
Academic Emergency Medicine		
Big Data		
Contemporary Clinical Trials Communications		

Critical Care Nursing Quarterly		
Current Problems in Diagnostic Radiology		
Health Affairs		
Hospital Pediatrics		
Journal of Biomedical Informatics		
Journal of Surgical Research		
Journal of the American Medical Informatics Association		
The Journal of nursing administration		
	Total of Journal	18
	Total of Conferences and Proceedings and Journal	38



## Appendix C – Articles by Publications

Conferences and Journals	No. of Articles	Articles
Academic Emergency Medicine	1	(McLeod et al., 2010)
Acta Inform Med		(Ghazisaeidi et al., 2015)
Advances in Intelligent Systems Research		(Koronios & Gao, 2010)
Americas Conference on Information Systems, AMCIS		(Zhang et al., 2011)
Big Data		(Stadler et al., 2016)
Business Horizons		(Ward et al., 2014)
Canadian Conference on Electrical and Computer Engineering		(Arinze, 2014)
Clinical Pediatric Emergency Medicine		(Perron et al., 2017)
Conference of the European Federation for Medical Information: Quality of Life through Quality of Information.		(Al-Hajj, et al., 2012)
Contemporary Clinical Trials Communications		(Mattingly et al., 2015)
Critical Care Nursing Quarterly		(Egan, 2006)
Current Problems in Diagnostic Radiology		(Shailam et al., 2018)
Health Affairs		(Jha & Epstein, 2010)
Healthcare Analytics Academy		(Providers & Nelson, 2010)
Hospital Pediatrics		(Hain et al., 2012)
ICOS- IEEE Conference on Open Systems		(Mahendrawathi et al., 2010)
IEEE International Conference on Data Science and Advanced Analytics (DSAA)		(Santos, 2015)
IEEE-EMBS Conference on Biomedical Engineering and Sciences		(Silva et al., 2012)
IEEE-EMBS International Conference on Biomedical and Health Informatics (BHI)		(Miniati et al., 2014)
International Conference on Health Information Technology Advancement		(Ryan et al., 2013)
International Conference on Information Management and Technology (ICIMTech)		(Georgiana et al., 2017)
International Emergency Nursing		(Martin et al., 2017)
International Journal of Management		(Gordon & Richardson, 2013)
International Symposium on Computational and Business Intelligence (ISCBI)		(McGlothlin et al., 2016)
Journal of Biomedical Informatics		(Franklin et al., 2017)
Journal of Digital Imaging		(Prevedello et al., 2010)
Journal of Surgical Research		(Park et al., 2010)
Journal of the American Medical Informatics Association		(Dixon et al., 2014)
PICMET: Portland International Center for Management of Engineering and Technology, Proceedings		(Mallak, 2009)
Proceedings from the annual NOKOBIT conference held in Oslo		(Presthuss & Bergum, 2015)

The Journal of nursing administration		(Donaldson et al., 2005)
The Psychiatrist		(Daley et al., 2013)
Workshop on Visual Analytics in Healthcare		(Al-Hajj et al., 2013)
Iberian Conference on Information Systems and Technologies	2	(Barrento, 2016)
		(Barrento et al., 1997)
Hawaii International Conference on System Sciences	3	(Al-HAJJ et al., 2012)
		(Alharbey, 2016)
		(Ryan et al., 2017)

## Appendix D – Data per Article

Articles	Year	Google Scholar Citations	Research Parents	Focus
(Zhang et al., 2011)	2011	8	----	Patients Satisfaction Heart Attack Quality Measures Analysis on Revenue
(Stadler et al., 2016)	2016	9	USA	Sepsis patient outcomes 30-day hospital readmissions
(Presthus & Bergum, 2015)	2015	0	Norway	Quality health service Volume of treatments Waiting times in somatic, mental and substance abuse health services
(Ghazisaeidi et al., 2015)	2015	9	----	General
(Egan, 2006)	2006	55	USA	Clinical Dashboards Patient Safety
(Koronios & Gao, 2010)	2010	1	Australia	Emergency Department productivity
(Al-Hajj et al., 2013)	2013	7	Canada	Mortality and Morbidity injury
(Al-Hajj et al., 2012)	2012	0	Canada	Mortality and Morbidity injury
(Al-Hajj et al., 2013)	2013	5	Canada	Analytical Injury
(Providers & Nelson, 2010)	2010	1	USA	Diabetes quality metric
(Martin et al., 2017)	2017	0	Netherlands	Patient flow Emergency Department
(Franklin et al., 2017)	2017	3	USA	Flow and the demands of the entire Emergency department
(Perron et al., 2017)	2017	0	USA	Physician Performance
(Shailam et al., 2018)	2017	1	USA	Radiology performance
(Gordon & Richardson, 2013)	2013	2	USA	Quality of Nursing Department
(Ward et al., 2014)	2014	44	USA	Emergency department performance
(Mattingly et al., 2015)	2015	3	USA	Clinical trials
(Alharbey, 2016)	2016	1	USA	Data analysis Pulmonary Disease
(Arinze, 2014)	2014	0	USA	Patient Monitoring
(Daley et al., 2013)	2013	14	UK	Clinical Dashboards
(Donaldson et al., 2005)	2005	86	USA	Quality of Nursing Department
(Jha & Epstein, 2010)	2010	135	USA	Hospital quality

(McGlothlin et al., 2016)	2016	0	USA	Patient Safety
(Mahendrawathi et.al, 2010)	2010	9	----	Logistics performance
(Barrento, 2017)	2017	0	Portugal	Benchmarking in Healthcare
(Georgiana et al., 2017)	2016	0	Indonesia	Radiology Quality
(Silva et al., 2012)	2012	4	Portugal	Monitoring database performance hospital
(Miniati et al., 2014)	2014	1	----	Measuring efficiency Operating Theatre
(Dixon et al., 2014)	2014	23	USA	Electronic health record, pharmacy claims, and personal health record
(Prevedello et al., 2010)	2010	33	USA	Radiology performance
(McLeod et al., 2010)	2010	20	Canada	Coordination regional capacity of emergency department
(Santos, 2015)	2015	1	Portugal	Data analysis Pulmonary Disease
(Hain et al., 2012)	2012	5	USA	Improvement and monitoring service of Pediatric Department
(Park et al., 2010)	2010	24	USA	Improvement and monitoring Operating room
(Barrento et al., 1997)	1997	0	Portugal	Benchmarking of hospital emergency departments
(Ryan et al., 2013)	2013	4	USA	Monitor and improve the perioperative process
(Ryan et al., 2017)	2017	0	USA	Monitor and improve the perioperative process
(Mallak, 2009)	2009	0	----	Measuring efficiency of Hospital

## Appendix E – Macro Objective and Results per Article

Articles	Macro Objective	Results
(Zhang et al., 2011)	----	----
(Stadler et al., 2016)	Efficient visualization of data in health organizations Dashboards enables complex healthcare data on sepsis and readmissions to be made more accessible, consumable, and meaningful to any healthcare stakeholder. What comes to promote the understanding and interpretation of data to customers.	It should be noted that the impact that existed regarding efficiency and gains in knowledge since this work was manual and started to have aggregated data and obtain statistical information. The process is no longer manual, which resulted in an optimization of time spent with the analysis process. Another factor contributing to such optimization was the implementation of visualization techniques. The time to analyze the data until the results was drastically reduced. The dashboard has become central to the data analysis of many customers, and this analysis has even become available to end customers. Another possibility achieved with visualization techniques and dashboards is to provide the possibility of benchmarking between hospitals since KPI's are transversal to healthcare organizations.
(Presthus & Bergum, 2015)	The characteristics of business intelligence (BI) dashboards and understand how citizens can use them, (Comparative analysis of two dashboards one based on BI and another not). The BI dashboard should be simple enough to attract users, but sophisticated enough to support decision making.	The -BI dashboard has more BI aspects than the dashboard that has three layers of BI. BI dashboard that is based on a BI architecture with three layers is more complicated to use than the dashboard that has BI aspects. It is necessary to pay attention to the development of the panels, these should be easy to use and accessible, but providing the information needed by users. Demonstrate that panels are useful for decision making and should be crafted according to best practices. Otherwise, they can be difficult to use and extract useful information for decision making and lose value.
(Ghazisaeidi et al., 2015)	Literature review to analyze which key points to develop health performance measuring panels.	It was concluded that the development of performance dashboards based on performance measurement principles and executive information system building on an appropriate back-end infrastructure would result in the creation of dynamic reports that bring increased value to health organizations, both in the analysis of past, present and future.

(Egan, 2006)	The article addresses the topic of integrating all relevant patient information into a single dashboard so that critical care nurses can get the patient's process, all the information obtained both in the perioperative period and in the surgical process.	The added value of these dashboards is the accessibility of patient information that it would have all the data in just one place and also the possibility to analyze the information that you want in more detail.
(Koronios & Gao, 2010)	Focuses on the discussion of data quality with managers at the operational and medical level, this discussion took place in the development phase of a dashboard that aims to assess the productivity of emergencies.	Guidance was provided on the types of data that should be collected and the quality requirement of the data so that dashboard is reliable in the decision phase.
(Al-Hajj et al., 2013)	The issue of the Visual Analytics (VA) to allow health professionals on the one hand to understand data on heterogeneous lesions and, on the other hand, to decide on health situations dynamics.	Peer collaborative sessions were conducted to analyze the Visual Analytics Dashboard (VAD) and demonstrate the help that health professionals can receive in the investigation of data on injuries, as well as support in the construction of knowledge and decision making.
(Al-Hajj et al., 2012)	In this case, the focus of the research is to be able to obtain the information appropriate to the needs of each user and in each moment.	VA has proven to be influential in helping medical stakeholders to reveal valuable information about massive injury data and build essential knowledge. Offering advanced techniques such as filtering and zooming in on details that help you understand information that allows you to speed up the decision-making process. Collaborative research was carried out where it was possible to validate the potentialities of VA in support of decision making.
(Al-Hajj et al., 2013)	This case objective is to create an Analytical Damage Dashboard (AID) that can be used by any health professional and can help both in the understanding of the data knowledge and in the making of decisions in a more informed way.	The importance of dashboards was demonstrated to support the analysis of injuries related issues. The integration of a dashboard as a decision support tool and on multidimensional and dynamic data.

(Providers & Nelson, 2010)	The dashboard on diabetes metrics, based on a US association.	It is argued that dashboard should focus on quality data, right metrics, and tools with control panels and balanced scorecard, among others, allowing to provide context and meaning to the data making them an added value for the organization.
(Martin et al., 2017)	An analysis is made of the added value of implementing a dashboard to be able to support flow management in emergencies.	The panel was developed with the main agglomeration indicators and with general patient flow characteristics and thus allowing real-time information on clusters in the emergency room, allowing the emergency team to take corrective measures to avoid the effects of the cluster in these services. Dashboards give useful information to improve ED management.
(Franklin et al., 2017)	Focuses on the emergencies and creation of a dashboard with information of each patient that is in the emergency room, visualization of this type of information will enable faster and more certain clinical decisions to be made, and rapid intervention to improve the flow of emergencies.	The research based on other studies where it was found that the workflow of clinicians was often based on in-the-moment rather than global perspective.
(Perron et al., 2017)	It focuses on the physician's proficient performance, dashboard proposal is made available through the web that allows measuring the performance of doctors.	The added value will be the availability of information in a fluid and balanced way, which allowed more information to doctors and groups of doctors and ensure the confidence of other stakeholders and increase the quality of patient care.
(Shailam et al., 2018)	It focuses on the development of a dashboard to measure the performance of the radiology department. The proposal is to create a real-time dashboard in the pediatric radiology reading room, presenting updated information about the state of the waiting room and the schedule of exams, so that physicians could get a sense of the workflow and clinic efficiency.	This implementation resulted in improvements from both the operational level and resource management.
( Gordon & Richardson, 2013)	It focuses on the creation of a dashboard that helps to measure the quality of the nursing department.	The nursing department needs to respond to the constant changes in the department, which ultimately has repercussions on the quality of care and influence performance.

		The dashboard will help monitor the results and evaluate the progress of the nursing department occupation, which is responsible for the outpatient and outpatient service.
(Ward et al., 2014)	The performance of emergencies. The analysis is presented as having a fundamental role in the transformation of the American health system.	The panel would obtain information on all suggested improvements and could present the essential information to measure performance in emergencies and thereby support the decision phase.
(Mattingly et al., 2015)	The topic of clinical trial screening and enrollment. A dashboard was developed to assist in the management of two observational studies of pneumonia.	The result of the observation is that 23 of the respondents to the survey, 77% feel more comfortable using the panel because there is better sharing of information among all. It is possible to use in more robust systems where the availability of information is crucial.
(Alharbey, 2016)	The analysis of chronic obstructive pulmonary disease (COPD) is a disease that has a significant impact on the public health system, which affects concerning mortality, since they are often fatal, such as through hospital admission and readmission, which affects your hospital resources.	The goal is to create a dashboard that allows remote monitoring of COPD patients and to predict the risks of exacerbation and prevent its occurrence. The control panel will allow you to understand the behavior of the patient, will provide indicators that help in the decision-making process.
(Arinze, 2014)	It focuses on patient follow-up and the need to place health, more precisely, electronic health records with greater transparency for patients.	It was proposed to create a Dashboard, which will include proactive and reactive alerts for both patient and physician consultations. Portable computing and mobile computing will be used to collect patient data on an ongoing basis and to keep the patient up-to-date with health alerts and consultations.
(Daley et al., 2013)	It was is proposed the development of a panel that provides useful information for the patient. Information that is related to aspects of the mental health of the elderly acute.	The prototype was made available, and after three months of use by the medical team, the benefits are evident, from better access to information, through increased communication and information sharing, to greater awareness and quality of data.
(Donaldson et al., 2005)	To be able to provide an overview of the aggregate trends and benchmarks obtained in the California Nursing Outcomes Coalition acute care database (CalNOC) database, focusing on two	The CalNOC benchmarks are of great importance to the nursing departments. Since many of the indicators present in them are cited by the National Quality Forum (NQF), due to their relevance to the professionals of the ward. Implementing a dashboard to support the nursing department will have a very beneficial impact. The advantages can be measured at three levels: Conduct a comparison of organizational data on national



	quality indicators related to nurses. Dashboard integration can be crucial for health professionals to formulate and share a commitment to accelerate improvement in patient safety, results, and service excellence.	and regional clinical indicators, identify performance and improvement goals, and undertake commitment improvement projects for better patient care.
(Jha & Epstein, 2010)	Implementation of measures and tools to improve the quality of healthcare in the USA. Reiterate conclusions from a sample of both profit and non-profit hospitals, smaller and larger hospitals, and there is another factor that is the experience of hospital staff.	Non-profit healthcare organizations do not have a smaller focus than was advisable for quality problems. There is a discrepancy between hospitals with poor performance and average performance. This is an excellent opportunity to implement new techniques and measures to improve these aspects.
(McGlothlin et al., 2016)	Creation of BI tools to perform a patient satisfaction analysis and to reduce KPI's related to clinical results, such as length of stay, readmissions, and mortality.	Several dashboards have been developed to present information on customer satisfaction data. The success of these was the high number of users, which gave rise to new configurations of panels, which allowed for more frequent use and to support research and the conclusions.
(Mahendrawathi et.al, 2010)	Develop a dashboard for analysis for logistics management.	The development of a dashboard that would allow an item-level analysis, as well as its usefulness and its value to hospital/department. In this way, it was possible to take measures to solve the problem of stock of articles, the need to better manage material shortages and to address issues related to the stock of hospital units.
(Barrento, 2017)	Conduct a comparative analysis of the various hospitals at European level.	It was possible to highlight the differences in the different areas of the hospitals that were analyzed at the European level. The aspects that have been analyzed form the following: Inpatients Dissections, Days of Inpatients, Inpatient length of stay, Physicians and other questions of public health.
(Georgiana et al., 2017)	To determine the effectiveness of radiology data storage in order to measure the quality of the service provided.	Dashboard value recognition at the time of presentation of information on patients and also in the radiology department. Measure the degree of interest, and the perception radiologists have on the dashboard.
(Silva et al., 2012)	Create a dashboard that could help in the characterization and evaluation of the workload of the hospital databases.	Detection of critical periods, as well as situations that need to be reviewed and alerted to a decision.

(Miniati et al., 2014)	<p>To develop a support model that, based on the specific performance of indicators, would be able to support health departments.</p> <p>The dashboard would support the analysis of performance and contribute to the analysis of the efficiency of OT activity.</p>	<p>The implementation of this type of solution will allow the hospital managers to be able to perform a detailed OT analysis.</p> <p>The idealized Dashboard is being implemented in a real hospital department.</p>
(Dixon et al., 2014)	<p>Objective: the creation of a dashboard to assist in communication between doctors and patients. Support in the stage of defining strategy and improving the phase medication/treatments. With the dashboard, the discussion of the treatment process and its suitability to the patient is improved.</p>	<p>Significant advances in the backing to the decision support is that the feedback of the health professionals and the patients was very positive. The dashboard is on the right path to being able to host crucial patient information in one place. Centralization of information that is spread in several sources.</p>
(Prevedello et al., 2010)	<p>Development of a prototype in BI to assist in the analysis of radiology department information. It relies on the various BI areas from the data warehouse to dashboard tools.</p>	<p>Improvements in the service provided to the patients, advances in the department's performance and the process of analyzing the data generated by the department.</p>
(McLeod et al., 2010)	<p>Development of a dashboard that helps in the coordination of the various emergency departments to balance the flow of patients arriving by ambulance to the various emergencies of hospitals.</p>	<p>Proactive selection of target patients, using real-time analysis of data coming from a dashboard, has enabled better coordination of capacity of emergency at the regional level and also allowed a significant reduction in the ambulance diversions.</p>
(Santos, 2015)	<p>The objective is to analyze the phenomenon of the increase in the incidence of deaths due to pneumonia in the Portuguese population. It is intended to characterize the incidence of the disease to define a strategy to combat growth.</p>	<p>Dashboards helped provide useful information for defining a patient profile. With the information collected with the aid of dashboards, it was possible for health professionals and authorities to take the necessary steps to anticipate the fight against this problem.</p>

(Hain et al., 2012)	Development of a dashboard to monitor, measure and compare the performance of pediatric departments. Also enable the creation of a transparent repository of information about the same department.	First steps were taken towards measures and significant improvements in pediatric care at the level of care received by patients, as provided by health professionals.
(Park et al., 2010)	Developing a dashboard for managing OT appears a critical feature in a hospital. A resource that is much needed, so it is necessary to create a way to manage the same efficiently.	Dashboards will enable you to better manage resource leasing, support cost management, and plan room utilization by healthcare managers.
(Barrento et al., 1997)	Development of a dashboard that will analyze the performance of the emergency department based on the data obtained by the Manchester Triage Protocol. Also perform a comparative analysis with three hospitals.	Dashboards elevate the ability to view information, increase capacity analysis of high volumes of information.
(Ryan et al., 2013)	Development of a dashboard aims to improve the perioperative process.	The results obtained are exploratory and require additional confirmations. Through a broader and broader investigation, it can be confirmed that with the implementation of dashboards, help will be enhanced by improving the preoperative process
(Ryan et al., 2017)	The dashboard to be suggested for implementation will allow verifying the impact of the qualification and quantification of the improvements in the preoperative process	The benefits of Business Process Modeling Notation (PBMN) and BSC use in management support are presented. The results obtained are exploratory and require additional confirmations and can be expanded or investigated more deeply to confirm the process improvements that the dashboards implement
(Mallak, 2009)	Promote the use of tools such as Design Performance Matrix (DPM) and Design Feature Implementation Dashboard (DFID) to create an essential dashboard to measure hospital efficiency and assist in decision making.	It allows for the possibility of a more detailed and objective analysis.



**Appendix F – Future Proposed Limitations / Contributions by Article**

Articles	Limitation	Future Proposals/Contribution
(Zhang et al., 2011)	----	----
(Stadler et al., 2016)	For a more comprehensive analysis, it is necessary to carry out research where a complete analysis is performed to validate the impact of the dashboards. Implementation of a dashboard with a focus on visibility requires a training of employees and more detailed documentation.	Future Proposals: Research on the benefits of data visualization in healthcare. Contribution: The research is only analysis in the process of obtaining and making available information, the research is not a comparative analysis of the results obtained with the manual process versus the computer processor with the help of dashboards.
(Presthus & Bergum, 2015)	Fictional scenario, citizen sampling. The group of people was very unholistic. The number of KPI's can influence the adoption of the dashboard, but this point has not been analyzed. The research was done only for healthcare.	Future Proposals: "For example, is it possible to apply research from disciplines such as User Experience and Usability to BI dashboards in order to increase adoption? Related to this, we also make a call for more research on the comparison between an organizational BI dashboard and a BI dashboard developed for citizens. Will there be any significant differences between the two?" Contribution: At the academic level, it promotes advances in the BI health area. The practical contribution, to propose a set of guidelines for the adoption of panels that facilitate the decision-making process using BI and facilitating access.
(Ghazisaeidi et al., 2015)	----	----
(Egan, 2006)	----	----
(Koronios & Gao, 2010)	----	Contribution: The Guidelines for future dashboards development according to best practices and based on quality data. for future developments of dashboards according to the best practices and based on quality data.

(Al-Hajj et al., 2013)	The data was collected in a small focus group, which limits the generalization of discovery and extrapolation to a level of public health interest. These limitations are related to information privacy issues. Another limitation is that for reasons of confidentiality it is not possible to present the patient's data.	Future Proposals: It is necessary to carry out more heuristic evaluations of the use of VA in the daily activity of the health Professionals to improve decision making. Another proposal is to extrapolate the application of the VA in other domains and areas within the healthcare industry, including data from the trauma log and data of the emergency patients. Research related to a project that helps the aspects of synthesizing and optimizing decision making. Contribution: Confirmation of strong correlation between exploring and understanding the data and also the ability to obtain information, generate knowledge and make informed decisions
(Al-Hajj et al., 2012)	----	Future Proposals: It is suggested that more work is done on collaborative VA. Contribution: Conducting research related to the VA for healthcare.
(Al-Hajj et al., 2013)	The research was done by hypothetical questions and injuries, not on actual data; The sample of the research was relatively small, which could prevent a more generic analysis. The selection of the specialist to assist in the research was made in a premeditated way based on the knowledge and experience of these. Collaborative sessions are involved because of the heterogeneity of knowledge and the professional relationships that exist between the elements of these groups. Data privacy issues are other limitations that impact the research.	Future proposals: consider the limitations indicated in the research and try to overcome them. Suggest the design of innovative cluster analysis and an additional innovative research panel, which are needed in exploring the integration of visual analysis in health informatics. Contribution: Research using VA in healthcare
(Providers & Nelson, 2010)	----	----
(Martin et al., 2017)	The panel was not tested in daily use on an ED. From the Delphi research, only Flemish doctors are listed.	Future proposals: in the future, the focus should be on improving the presentation of information, including color schemes. Make a prototype that is tested in ED's daily work. Integration of prediction and simulation DEM real-time on dashboards, to provide recommendations on other ED with fewer patients. Contribution: the information obtained with the development of the panel, will allow the decision-makers to make decisions with more solid bases. The developed panel follows the principles of Design Science Research.

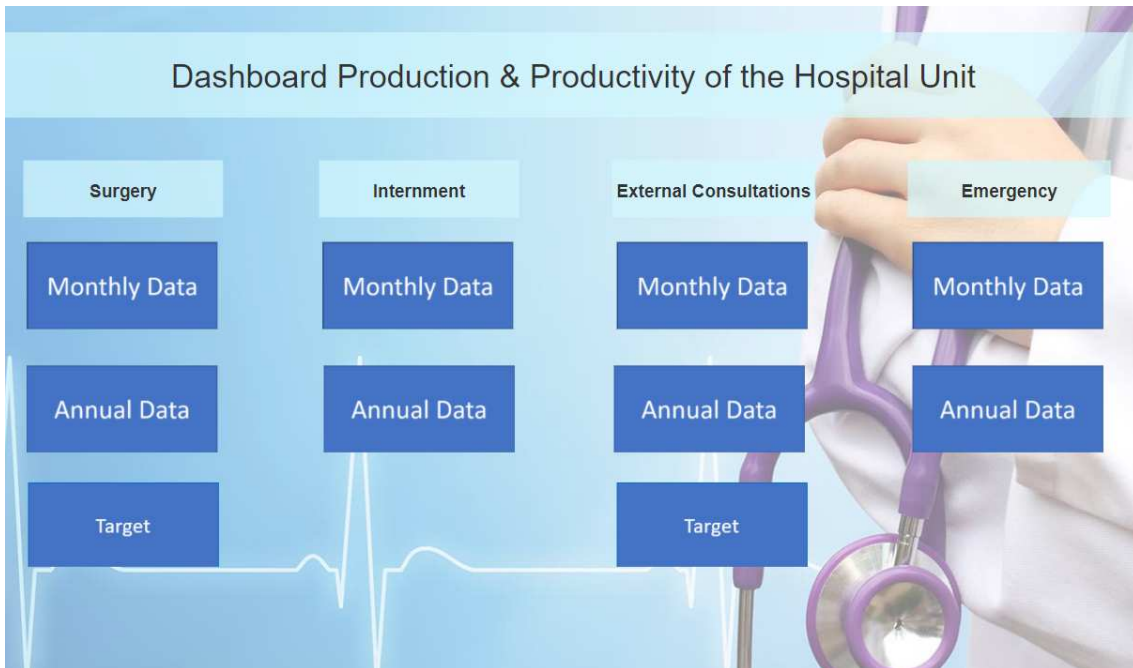
(Franklin et al., 2017)	The flow of use of the dashboard varies depending on the influx of Hospitals. Not all hospital have the most appropriate conditions to be able to make the dashboard available to take a decision.	----
(Perron et al., 2017)	----	Contribution: Detecting medical performance standards, developing a dashboard that facilitates measurement feedback.
(Shailam et al., 2018)	----	----
(Gordon & Richardson, 2013)	----	----
(Ward et al., 2014)	----	----
(Mattingly et al., 2015)	We did not develop the root of the process, from obtaining data, through data cleansing techniques. If this were done from scratch, it would add complexity and increase development time.	Contribution: The result of the observation is that 23 of the respondents to the survey, 77% feel more comfortable using the panel because there is better sharing of information among all. It is possible to use in more robust systems where the availability of information is crucial.
(Alharbey, 2016)	Lack of access to current COPD data. The type of data generated, and lack of normalization is a limitation since the algorithm only works with the data type. Lack of access to current COPD data. The type of data generated, and the lack of normalization is a limitation since the algorithm only works with the data type.	Future proposals: Carry out complementary research to what was done and add a system of warning mechanisms with the predictive system.
(Arinze, 2014)	----	----
(Daley et al., 2013)	The number of answers obtained in the questionnaire, this fact is due to the short term of the observation 6 months.	----
(Donaldson et al., 2005)	----	----
(Jha & Epstein, 2010)	Sample size and one-third of almost all non-profit US hospitals. Non-profit hospitals that represent 15% in the US are not analyzed.	Contribution: Non-profit healthcare organizations do not have a smaller focus than was advisable for quality problems, there is a discrepancy between hospitals with poor performance and average performance. This

		is an excellent opportunity to implement new techniques and measures to improve these aspects.
(McGlothlin et al., 2016)	Questions about data quality.	Contribution: Statistical analysis details clinical results with control set. Add cost information by analyzing the financial improvement obtained.
(Mahendrawathi et.al, 2010)	The fact that it is a fictional hospital and the number of KPI's are reduced is impossible to perform a drill down of information.	Future proposals: More research is needed in hospital logistics to find more indicators and also to be possible to carry out a more detailed analysis to better understand the prblem and correct it.
(Barrento, 2017)	Research at European level only.	Future proposals: The future issues are three: to increase KPI's to amplify and improve the scope of analysis, to create automatisms for extracting information and ultimately to expand to other continents and countries.
(Georgiana et al., 2017)	With the KPI's present in the research it is not possible to obtain information about the patients. One improvement would be to adopt KPI's more customer-centric.	----
(Silva et al., 2012)	----	----
(Miniati et al., 2014)	----	----
(Dixon et al., 2014)	----	Future proposals: Future research should focus on therapy/treatment. Emphasizing the combination of IT tools to support the complex task definition of therapy/treatment.
(Prevedello et al., 2010)	The solution cannot be seen as the only solution, but rather with a contribution and progress in the research for the creation of dashboards for the radiology department.	Contribution: Perform analysis of other BI tools and other techniques that may bring more value. Improvements to selected KPI's
(McLeod et al., 2010)	It was not possible to apply in any ED, nor any interhospital factor. External factors are many and can easily influence the distribution analysis of flow in the emergency room. The organization of ED is crucial to the success of the research and replication of the same. The research was modeled on a particular organization, and if it does not exist in other hospitals, it calls into question the conclusions reached.	----

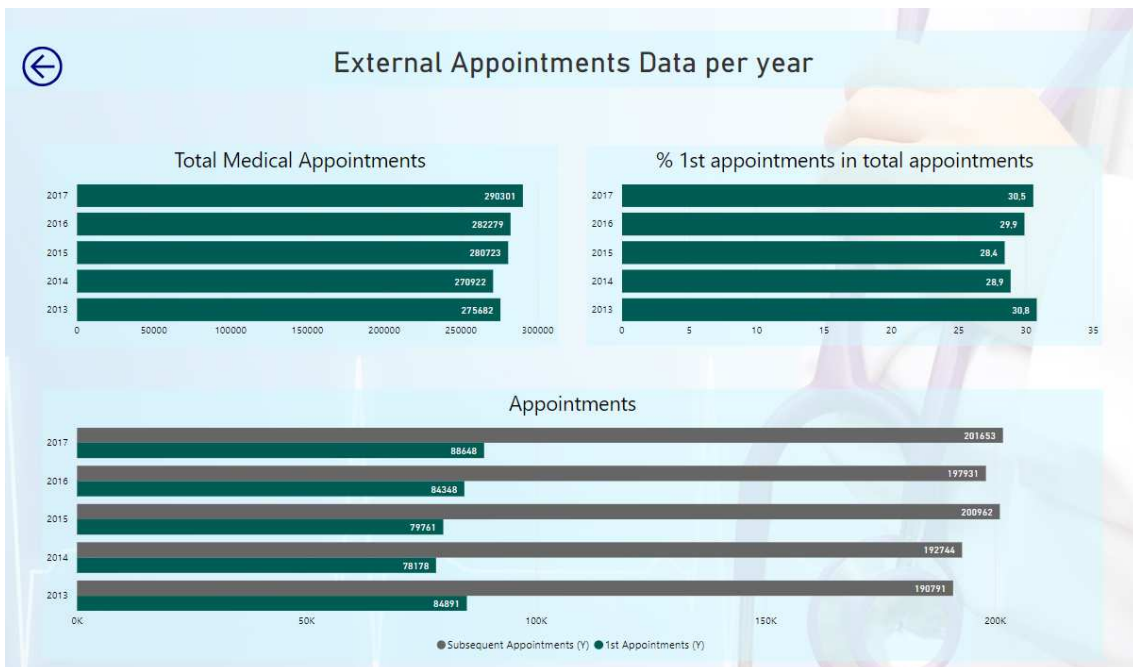


(Santos, 2015)	----	Contribution: Use a data mining algorithm to create predictive models. The aim is to help prevent the evolution of the disease and prevent the increase in the number of victims.
(Hain et al., 2012)	There are variations on the dashboard in the collection of data and variations in patient populations. Facts that limit and hinder the lessons that are to be drawn from the analysis of it.	----
(Park et al., 2010)	The complexity of the OR is because it is an arena where several interests converge to compete for limited resources, analysis of these flee from the scope of the article and are influencers to being able to make more certain decisions.	----
(Barrento et al., 1997)	----	----
(Ryan et al., 2013)	The research was done only on a single case	Future proposals: to promote enlargement and increase the focus of the research, enhancing the possibility of repeating the same tool in other areas of the hospital and in other services of other hospital units, as well as addressing aspects that may not have been inadvertently addressed by the authors. Contribution: Analyzing how the Continuous Process Improvement (CPI), the BSC, the Dashboards and the Process Management can contribute to healthcare.
(Ryan et al., 2017)	The limitation is that the research was done only on a single case	Contribution: The benefits of PBMN and BSC use in management support are presented. The results obtained are exploratory and require additional confirmations and can be expanded or investigated in a more profoundly confirm the process improvements that the dashboards implement
(Mallak, 2009)	Promote the use of tools such as Design Performance Matrix (DPM) and Design Feature Implementation Dashboard (DFID) to create an essential dashboard to measure hospital efficiency and assist in decision making.	Future proposals: to promote enlargement and increase the focus of the research, enhancing the possibility of repeating the same tool in other areas of the hospital and other services of other hospital units, as well as addressing aspects that may not have been inadvertently addressed by the authors. Contribution: Analyzing how the CPI, the BSC, the Dashboards and the Process Management can contribute to healthcare.

**Appendix G – Dashboard images proposed in 1 Iteration**



*Figure 19 – Main panel – 1<sup>st</sup> Iteration*



*Figure 20 – The annual perspective of external appointments – 1<sup>st</sup> Iteration*

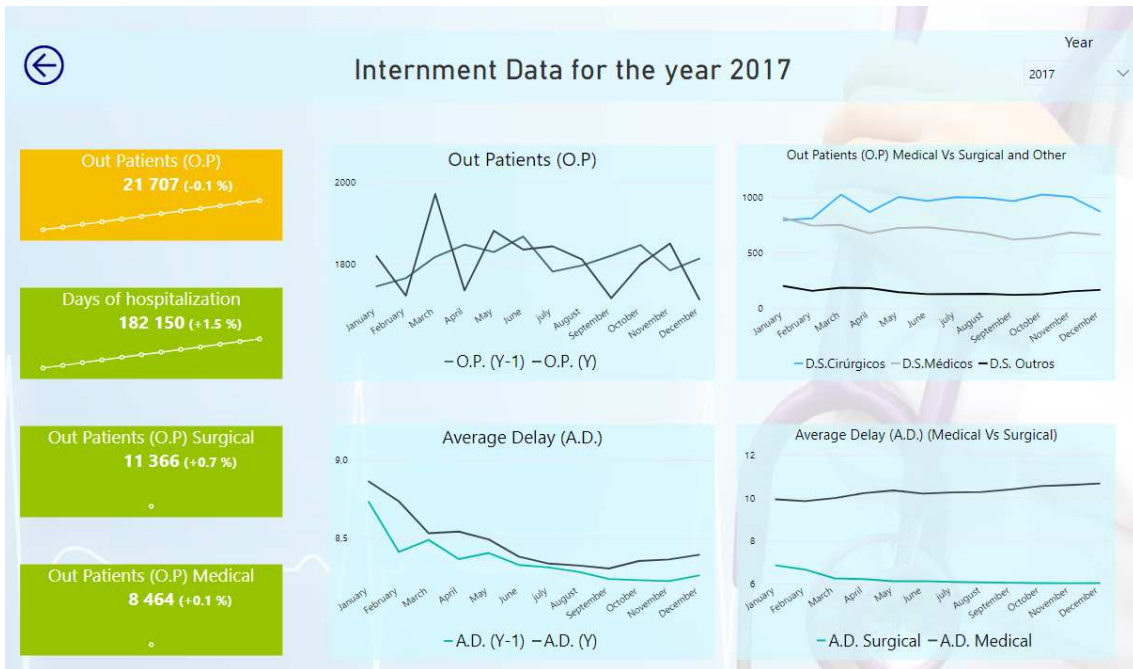


Figure 21 – The monthly perspective of external appointments – 1<sup>st</sup> Iteration

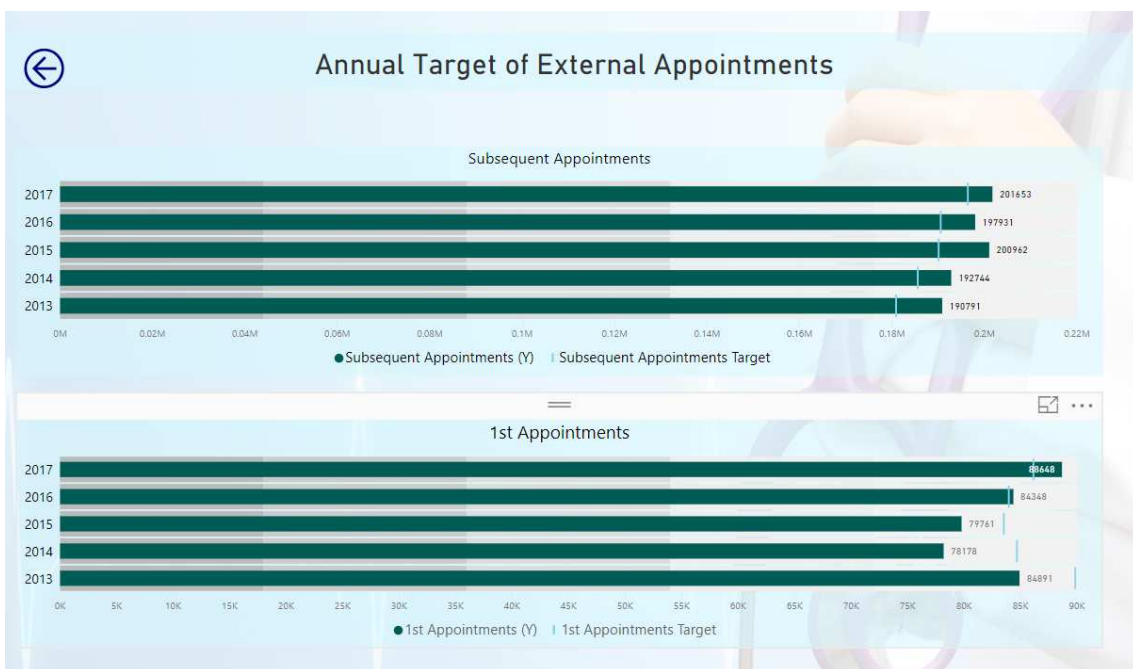


Figure 22 – The Annual Target of External Appointments – 1<sup>st</sup> Iteration

## Appendix H – Questionnaire answered by the interviewees

Question	Do you consider the dashboard important in the Productivity theme (Yes / No)?
1	Yes
2	Yes
3	Yes
4	Yes
Question	If you answered yes, why do you consider the dashboard important in this matter?
1	I think it is useful to have a dashboard that presents us with a first view of the production data in the sense that at the first visualization we perceive what is happening in the institution.
2	It allows immediate monitoring, analysis and monitoring of existing indicators on the production and productivity of a hospital.
3	It allows a multidimensional analysis of the data in an easy way.
4	The type of visualization chosen (DashBoard) seems to me the most correct, as it allows us an immediate and comprehensive view of the indicators.
DSR Iteration	Question about the NHS dashboard
Question	In your opinion, is the NHS dashboard complete (Yes / No)?
1	Yes
2	No
3	No
4	No
Question	If you answered no, what do you think is missing from the SNS dashboard?
1	----
2	It is not a question of not being complete, but we do not have up-to-date information (at the date the information on the site is November 2017) and the way of visualizing the information is not very user friendly or immediate. In terms of navigability this is also not user friendly.
3	There should be more detail at the financial and HR level. Development of health KPIs at the population level.
4	Absence of indicators related to HR and Financial areas
Question	Identify what are the positive aspects of the NHS dashboard?
1	The positive aspects in my opinion are the overall data at national level, the power to verify whether the institution compared to other institutions and to be able to follow in some specific areas
2	To date it is the only tool that provides the information contained in a dashboard.
3	It allows for easy benchmarking with other health institutions.
4	Possibility of benchmarking with other Health Units.
Question	Identify the negative aspects of the NHS dashboard?
1	I do not see any negative aspect, but some points that could be improved.
2	The way information is viewed is not very user friendly or immediate. In terms of navigability this is also not user friendly.

3	The fact that the information contained in the portal is not properly updated, the information dates from October 2017 and we are in June 2018.
4	The dashboard not updated.
<b>Questions with the proposed dashboard</b>	
Question	In your opinion should the dashboard have a Big Picture with the main KPIs (Yes / No)?
1	Yes
2	Yes
3	Yes
4	Yes
<b>Questions with the proposed dashboard</b>	
Question	If yes, what indicators should be in the Big pictures of a production dashboard and productivity?
1	It should always indicate the comparison with the homologous year and also at the same time the position with the defined goal for the year under analysis.
2	The indicators that appear in this, but with the possibility of performing drill down at the specialty level.
3	With information that is published at the moment these KPI's present in the Big Picture are complete. It allows a milestone analysis of the data and allows a later one to carry out a more detailed analysis of the data.
4	Improve annual comparisons. Allow to deepen / detail the level of analysis (drill down).
<b>Questions with the proposed dashboard</b>	
Question	Is there missing information on any of the tabs (Yes / No)?
1	No
2	Yes
3	No
4	No
<b>Questions with the proposed dashboard</b>	
Question	If so, which one?
1	----
2	Add contractual indicators; Add information at the level of the specialty;
3	----
4	----
<b>Questions with the proposed dashboard</b>	
Question	Is the information on the dashboard clear (Yes / No)?
1	Yes
2	Yes
3	Yes
4	Yes
<b>Questions with the proposed dashboard</b>	
Question	How do you rate the navigability of the dashboard? Possible Values (Poor, Satisfactory, Good, Very Good)
1	Very Good
2	Very Good
3	Good
4	Good
<b>Comparison between dashboards</b>	
Question	Compared to the dashboards of the Monthly Monitoring of NHS what are the positive aspects of the proposed dashboard?

1	We visually have all the indicators on the same "sheet" without having to click on each indicator.
2	In each segment the user can immediately glimpse all the indicators and their situation. Better navigability.
3	The dashboard is more institutional allowing an analysis of the institution
4	I consider the most relevant aspect to be the fact that we can see data from our institution.
Question	Compared to the NHS Monthly Monitoring dashboards what are the negative aspects of the proposed dashboard?
1	There are no negative aspects.
2	There are no negative aspects.
3	The NHS dashboard has other types of safety indicators and other areas. Comparative analysis of several institutions
4	There are no negative aspects.
<b>Finishing Questions</b>	
Question	Do you consider that the implementation of the dashboard in this hospital is an added value (Yes / No)?
1	Yes
2	Yes
3	Yes
4	Yes
Question	Could you justify your answer?
1	By the pressure of having a reading in terms of maps with homologous periods and with visualization of defined goals. Although some information we already have with other applications.
2	In each segment the user can immediately glimpse all the indicators and their situation. Better navigability.
3	They have a Big Picutre, easy to use.
4	Effective and visually pleasing access to relevant indicators.
Question	Is there a dashboard that addresses the productivity issue (Yes / No)?
1	Yes
2	Yes
3	Yes
4	Yes
Question	If yes, is there any aspect of the proposed dashboard that can be implemented in the existing dashboard (Yes / No)? If yes, please indicate which aspects
1	By the pressure of having a reading in terms of maps with homologous periods and with visualization of defined goals. Although some information we already have with other applications.
2	There is a BI and FT system in hospital organization that monitors contracting, allowing you to infer various information from the indicators.
3	There are two BI systems from First Target Sina BI datawarehouse Sinai and FT BSC solution and dashboard.
4	There are two BI systems from Frist Target Sina BI datawhehouse Sinai and FT BSC solution and dashboard.

Question	Do you consider that the proposed dashboard has applicability in other hospitals?
1	Yes
2	Yes
3	Yes
4	Yes