

Clinical Dashboard for Hospital Quality Indicator Assessing

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Declaration

I declare that this document is an original work of my own authorship and that it fulfills all the requirements of the Code of Conduct and Good Practices of the Universidade de Lisboa.

Preface

The work presented in this thesis was performed at the Centre Hospitalier Universitaire Grenoble Alpes (CHUGA), a university hospital in Grenoble (France) during the period January-July 2020, under the supervision of Dr.Sylvain Kotzki. The thesis was co-supervised at Instituto Superior Técnico by Prof. Mário Jorge Costa Gaspar da Silva.

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I would like to thank Prof. Sylvain Kotzi who trusted me to carry out this project at CHUGA (university hospital in Grenoble, France) and from the beginning accompanied me and helped in its realization. A big *Merci Beaucoup* for all the useful information and knowledge that were crucial for the development of this dissertation. I will never forget the way I was received and welcomed by all in CHUGA, especially Mrs. Brigitte Cohard, who had a concern for me beyond work, knowing that I was alone in another country, and Ms. Angelina Diker, who always helped me whenever I needed. *Un grand merci beaucoup à Grenoble et à la ville de la neige.*

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This dissertation is dedicated to all my family. In special to my father *José Mário* and mother *Maria Goreti*, my brothers *Fernando and Bernardo*, my grandmother *Avó Paixão*, my grandfather *Avô Farias* and my aunt *Angelina*. With them this journey is complete.

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Abstract

This dissertation presents the development of a dashboard for the generation of health quality indicators related to a discharge note. The dashboard's intuitive interface displays the different percentages related to the mandatory Quality Criteria presented in the *Lettre de Liaison* (discharge letter), as required by the Haute Autorité de Santé (HAS), the French national authority for the assessment of health quality indicators. The Centre Hospitalier Universitaire Grenoble Alpes (CHUGA), where the dashboard was developed, is a healthcare institution in France that aims to improve and automate the calculation of the percentages of the mandatory Quality Criteria in the discharge letter, related to internal medicine, surgery and obstetrics activities (Médecine Chirurgie Obstétrique (MCO) activities). The developed dashboard provides the general panorama on the quality of the discharge note. An evaluation of the usability showed good results, with CHUGA demonstrating an interest in integrating it in its information quality system.

Keywords

Health Quality Indicators, Information Dashboards, Data Analytic, Clinical Engineering

Resumo

Esta dissertação apresenta o desenvolvimento de um quadro de visualização para a geração de indicadores de qualidade em saúde, relacionados com a nota de alta. Este quadro permite uma interação intuitiva, sendo possível visualizar as diferentes percentagens relacionadas com os critérios obrigatórios das *Lettres de Liaison* (notas de alta) pela *Haute Autorité de Santé* (HAS), a autoridade nacional francesa, responsável pelo desempenho dos indicadores de qualidade em saúde. O Centre Hospitalier Universitaire Grenoble Alpes CHUGA, onde foi desenvolvida a aplicação de visualização apresentada nesta dissertação, é uma instituição de saúde em França que pretende melhorar e automatizar o cálculo das percentagens dos critérios obrigatórios nas notas de alta do paciente, relacionados com as atividades de medicina interna, cirurgia e ainda obstetrícia (MCO). Com este quadro de visualização desenvolvido é agora possível ter uma perceção do panorama geral sobre a qualidade das notas de alta. Uma avaliação à usabilidade mostrou bons resultados, tendo o CHUGA mostrado interesse em integra-lo a curto prazo na sua atividade oficial.

Palavras Chave

Indicadores de Qualidade em Saúde, Análise de Dados, Engenharia Clínica, Quadro de Visualização

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Acronyms

| | |
|--------------|------------------------------------------------------|
| BI | Business Intelligence |
| CAGR | Compound Annual Growth Rate |
| CHUGA | Centre Hospitalier Universitaire Grenoble Alpes |
| DAX | Data Analysis Expressions |
| DBMS | Database Management System |
| DGOS | Direction Générale de l'Offre de Soins |
| EHR | Electronic Health Record |
| ETL | Extract, Transform, Load |
| HAD | Hospitalisation à domicile |
| HAS | Haute Autorité de Santé |
| IFAQ | Incitation Financière à l'Amélioration de la Qualité |
| IQSS | Indicateurs de Qualité et Sécurité des Soins |
| IS | Information System |
| IST | Instituto Superior Técnico |
| KPI | Key Performance Indicator |
| MCO | Médecine Chirurgie Obstétrique |
| PCD | Evaluation et Prise en charge de la douleur |
| PSY | Santé Mentale |
| QLS | Qualité de la Lettre de Liaison à la Sortie |
| SQL | Structured Query Language |
| SSMS | SQL Server Management Studio |
| SSR | Soins de Suivi et Réadaptation |

| | |
|------------|----------------------------|
| SUS | System Usability Scale |
| UF | Unité Fonctionnelle |
| URL | Uniform Resource Locator |
| VPN | Virtual private network |
| XML | Extensible Markup Language |
| WHO | World Health Organization |

1

Introduction

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Hospitals are under an increasing pressure to share performance information based on indicators. The purpose of these indicators is to promote quality improvement and increase the hospital's performance (Botje et al., 2016).

Several countries in Europe have national policies and programs that require hospitals to use quality and safety healthcare indicators (Greer and Greer, 2009). Sweden was the first, in the 1970s, to set up a system for collecting quality indicators, which is very comprehensive and transparent. This system responds to the founding principle of the *Swedish Healthcare Act* according to which "the Swedish healthcare system must ensure access to quality healthcare for all its population". In some countries, quality control is a mandatory activity that results from legislation (France). Other countries have developed quality assessment activities in response to a mandate provided for a strategy at the national level (Portugal) or as initially decentralized procedures (Finland, Sweden) (Health Systems Performance Assessment, 2016).

The quality and safety of care are one of the priorities included in the national health strategy 2017-22 in France. Accordingly, the partial evolution of the method of hospital financing has been identified as a lever for continuous improvement of patient care in health establishments, both public and private.

In France, some of the indicators are mandatory. They are assessed and inspected by Haute Autorité de Santé (HAS). Acting as an independent, public and scientific authority with legal and financial self-government, the HAS aims to develop quality in the health, social and medico-social fields, for the benefit of patients.¹ It maintains an Internet Website <https://www.has-sante.fr/>, to provide active support for its missions. In particular, the three big assignments are assessment/evaluation, recommendation and certification/accreditation, as depicted in Figure 1.1 (Golse, 2013).

The focus of the evaluation differs from national to more regional or local level related to healthcare indicators. In France, some health quality indicators are used to reward hospitals. Therefore, a research program on a financial incentive for improvement of quality and safety of care (Incitation à l'amélioration de la qualité et de la sécurité des soins –IFAQ) was launched in 2012, by the Ministry of Health and the HAS (Ferrua et al., 2015). The objective of Incitation Financière à l'Amélioration de la Qualité (IFAQ) indicators is to build a model adapted to the French context to rank healthcare establishments and remunerate the best according to not only to their results but also their progress. The model is based on the assessment of the health quality indicators. (Ferrua et al., 2015).

The General Directorate of Healthcare Provision (Direction Générale de l'Offre de Soins (DGOS)) also co-pilot the financial incentive system for quality improvement in French healthcare establishments.²

¹https://www.has-sante.fr/jcms/c_452559/fr/la-has-en-bref

²https://www.has-sante.fr/jcms/c_493937/fr/l-incidentation-financiere-pour-l-amelioration-de-la-qualite-ifaq#:~:text=Le%20mod%C3%A8le%20IFAQ%201%20a,du%20dernier%20recueil%20et%20

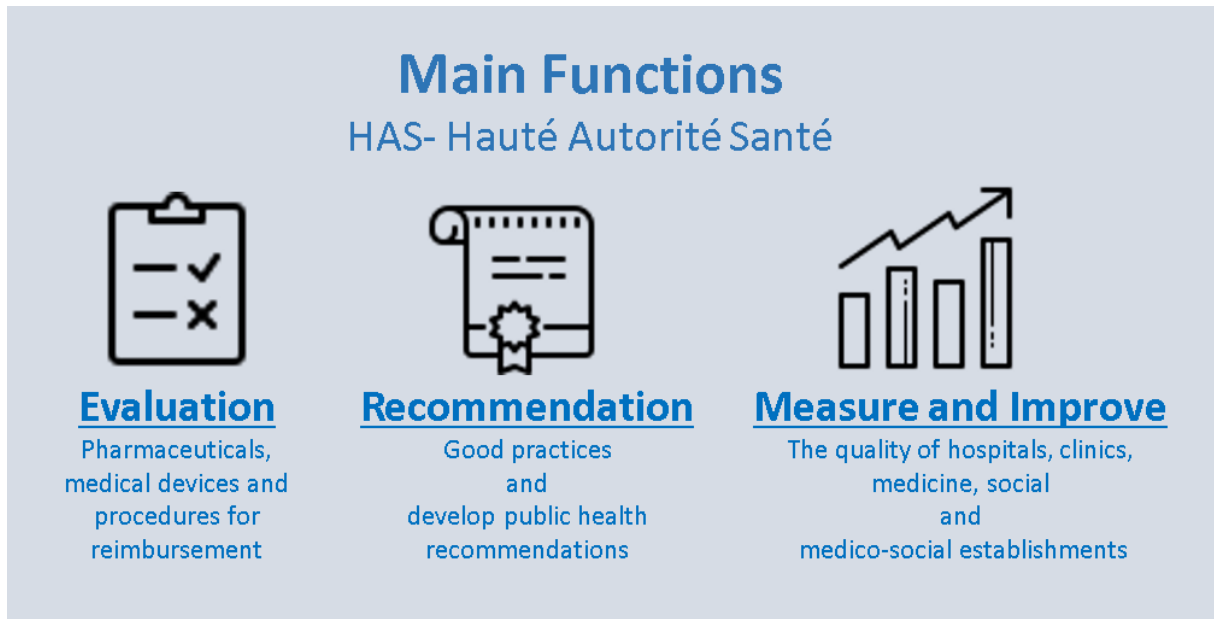


Figure 1.1: The Three Main Functions of HAS.

The main principles of the IFAQ program are:

1. a merely incentive-based approach, with no penalties for the lowest-ranked establishments;
2. the use of all or part of the results from national quality measurement procedures without additional collection;
3. remuneration based on the quality score and pay-for-performance (tarification à l'activité), activity-based pricing revenue.

Therefore, the financial incentive is positive only for health establishments with a score greater than or equal to the median are remunerated.

In France, health establishments need to produce indicators of all types to assess the quality of care as well as to support the management of activities. The health quality indicators are:

- used during the accreditation process by HAS;
- included in contracts with the Regional Health Agency, and;
- the basis on which the financial incentives for quality improvement have been built (Health Systems Performance Assessment, 2016).

The focus of development of this dissertation work was on the Qualité de la Lettre de Liaison à la Sortie (QLS) Indicator. This indicator measures the quality of the *Lettre de Liaison*, a specific letter that all hospitalized patients receive in the moment of discharge. The assessment of this indicator is

mandatory by HAS and is also one of the indicators included in the pay-for-performance model of the French national health authority. This means that a better classification is higher revenue.

The Centre Hospitalier Universitaire Grenoble Alpes (CHUGA) aims to increase national classification and financial investment. To achieve it, a more sophisticated process for computing the QLS indicator is a priority.

Nowadays, the analysis of the *Lettre de Liaison* data is manual, and it does not include all the collected data. In addition, to have a better perception and interpretation of the data, it is necessary to provide means intuitive visualization methods.

1.1 Objectives

The main goal of this master's thesis was to propose, develop and validate a dashboard integrated into the CHUGA hospital Information System (IS), with data collection, data analysis and data reporting.

The indicators in the dashboard extract information from the analysis of *Lettre de liaison à la sortie d'une hospitalisation* in the Médecine Chirurgie Obstétrique (MCO) (Medicine, Surgery and Obstetric) activity.

The dashboard addressed the following requirements:

1. an intuitive and suitable system to the end-user;
2. automated and with real-time information;
3. cross-tabulation of data, mainly by medical services and interval of time;
4. visualizations exportable, for external analysis and building reports;
5. visualization of trends over time.

The central activity of this work was the development of a dashboard system for CHUGA, for analysis and visualization of all the data related to the QLS Indicator.

This dashboard must be accessible to healthcare executives, department heads, as well as support departments such as the quality department, medical assessment or even financial services.

1.2 Methodology

Initially, I was allowed to understand the topic and the details of the QLS Indicator and how it is important both nationally and for CHUGA.

I was integrated into the Pole of *Finance et Systemes D'Information* (Finance and Information Systems) of the Service of *Direction des Services Numériques*, under the supervision of Mr. Kotzki Sylvain. Some meetings were held with him and Mrs. Marie-Reine Mallaret, from Pole *Santé Publique* and who is responsible for providing the QLS Indicator.

The methodology steps were:

1. Understand the problem and identification of the main motivations to implement a dashboard that considers all the available data;
2. Definition of the objectives of a value solution;
3. Identification of the needs of end-users;
4. Some specific requirements about the proposed solution were determined, analysed and defined, including the metrics and the proposed functionalities to incorporate the dashboard prototype;
5. Definition of the technologies and tools to be used;
6. Definition of the procedure for the Extract, Transform, Load (ETL) process to be developed;
7. Development and design of the dashboards;
8. Conduct a satisfaction survey to obtain some feedback on the developed work, and;
9. Draw conclusions on the accomplishments and re-iterate steps above when required.

1.3 Contributions and results achieved

This thesis work has the following contributions:

- Computed indicators for CHUGA;
- New information visualization and presentation techniques at CHUGA;
- New knowledge how to analyse the data and report quality information;
- Encouragement of management practices advocates the development of self-awareness within healthcare organizations and recommendation for filling the *Lettre de Liaison* correctly, having based on data collected in the databases.

1.4 Thesis Outline

This dissertation is organized in five chapters (see Figure 1.2).

Chapter 2 introduces the background and state-of-the-art concerning dashboards and Business Intelligence (BI) tools.

Chapter 3 identifies the objectives of the solution, justifies the choice of Power BI and explains the method for presenting quality indicators at CHUGA.

Chapter 4 presents the evaluation and validation of the developed dashboard.

Finally, Chapter 5 discusses the contributions and limitations of the work and outlines possible future work opportunities.

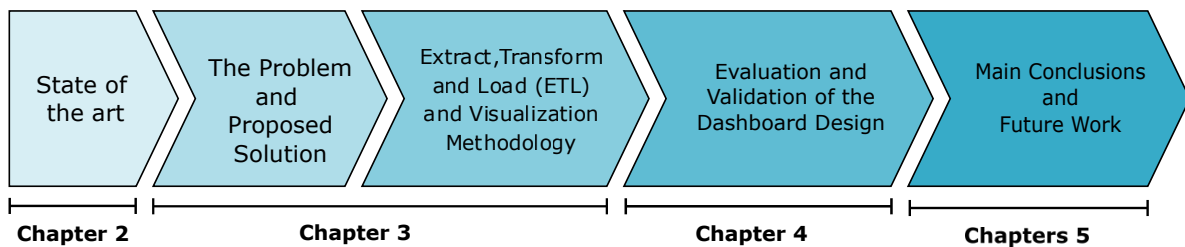


Figure 1.2: Outline of the thesis work, with the content of each chapter.

2

State of the art

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Every single day the amount of data produced in hospitals worldwide by scientists, doctors, nurses and other health professionals has been increasing at a high rate and with a Compound Annual Growth Rate (CAGR) of 36% through 2025.¹ Due the growth and amount of data over the last few decades, its management is increasingly difficult. However, data do not generate knowledge by themselves. Hence, it is necessary to exploit and manipulate the collected data, to obtain valuable information. Information dashboards are very important in transforming and visualizing data. In essence, these dashboards display information, provide insights and help making informed decisions, according to Vázquez-Ingelmo et al. (2018).

This chapter presents an overview of the crucial concepts of information Dashboards, along with a revision of the related work and problem in the field. It describes the context of the quality indicator for the *Lettre de Liaison à la Sortie* in Centre Hospitalier Universitaire Grenoble Alpes (CHUGA). This chapter also surveys the state of the art on information visualization and dashboard presentation technologies.

2.1 Public Health Indicators

"Public Health refers to all organized measures (whether public or private) to prevent disease, promote health, and prolong life among the population as a whole." - World Health Organization (WHO)

According to Acheson et al. (1988), the definition of Public Health is defined as *"the art and science of preventing disease, prolonging life and promoting health through the organized efforts of society"*. Consequently, there is a need from the healthcare institutions in the improvement of treatments, deleting the non value-added tasks reducing the expenses and implement new technological services (Christensen et al., 2010).

According to a report by WHO, titled *Monitoring, evaluation and review of national health strategies* in 2011 refers that there are thousands of health quality indicators and large amount of global indicator guides for particular health programs. These indicators are responsible for the information needed for monitoring progress and performance towards the principle goals (WHO, 2011).

Indicators should include all necessary data descriptors: a clear description of their definition, the method to collect and analyse the data, and the regularity of measurement.²

The success of an organization is evaluated through the measurement of Key Performance Indicator (KPI)s. KPIs are the quantitative information of an institution that demonstrate the direction of the activities and structures (Badawy et al., 2016). To assess the efficiency of healthcare organization, significant indicators are required. These are important for monitoring, assessing and managing health

¹Big Data in Healthcare: <https://www.fingent.com/blog/5-ways-big-data-is-changing-the-healthcare-industry/>

²Eventually, every country should maintain an indicator and metadata registry, linked to the country observatory of health statistics, within which core and supplemented indicators would be identified and defined along with data sources, analytic methods and the statistical values for the indicators (see: <https://www.who.int/data/gho/indicator-metadata-registry>).

systems to improve efficiency and quality (Arah et al., 2003).

2.1.1 CHUGA and Problem Statement

Since 1990 France embarked on the development of a system of indicators for the quality of hospital care, according to Moisdon (2014). In France, and at CHUGA, some of the indicators are national and mandatory. The certification of healthcare establishments is led by the Haute Autorité de Santé (HAS), which concerns all healthcare establishments, public or private, regardless of their size and activity.

As in many other countries, the public authorities are looking into incorporating of taking quality in the funding model of health establishments. Towards this, healthcare systems are moving forward with new payment models for hospitals. The *Direction Générale de l'Offre de Soins (DGOS)* (General Directorate of Healthcare Provision) and the HAS co-pilot the financial incentive system for quality improvement, the Incitation Financière à l'Amélioration de la Qualité (IFAQ) (Financial Incentive to Quality Improvement) in French healthcare establishments. IFAQ is an experiment aimed at anticipating the effects of compensation for French healthcare hospitals based on their performance assessment using indicators. Among them, pay-for-performance (P4P) programs proposed a improving in quality of healthcare have been under high review (Lalloué et al., 2017).

Healthcare certification by HAS is an external, independent and mandatory evaluation system and it takes place every two years. The certification relates to:

- the level of services and care provided to patients and;
- the dynamics of improving the quality and safety of care implemented by the establishments.
- to supply an independent assessment of the quality of care in hospitals and clinics in France.

The IFAQ program was generalized to all, 1300 acute care hospitals in 2016. The objective of IFAQs is to build a model appropriate to the French context for ranking healthcare establishments and remunerate the best of them according to their results, but also to stimulate their progress (Ferrua et al., 2015).

The description of each of the mandatory national indicators and observed results are made available to the public, on the website of the HAS. The construction and calculation methods of those indicators are defined according to the sector of activity concerned: *Médecine Chirurgie Obstétrique (MCO)*, *Hospitalisation à domicile (HAD)*, *Soins de Suivi et Réadaptation (SSR)* and *Santé Mentale (PSY)*.³

In Table 2.1 is explained the meaning of the four fields of activity in french hospitals.

³Rapport de certification CHUGA: https://www.has-sante.fr/upload/docs/application/pdf/2019-10/30088_rac1_vd.pdf

| Activity Field | Description |
|--------------------------------------|------------------------------------------------------------|
| MCO - Médecine Chirurgie Obstétrique | Medicine, Surgery, Obstetrics and Odontology |
| HAD - Hospitalisation à domicile | Home Hospitalization |
| SSR - Soins de Suivi et Réadaptation | Follow-up care or rehabilitation |
| PSY - Santé Mentale | Psychiatry-collection of medical information in psychiatry |

Table 2.1: The four fields of activity in CHUGA and the respective description.

Since the law of 31 July 1991⁴, healthcare institutions, whether public or private, must pass on information about their activities to the State and Medicare.

The HAS collects and evaluates the national *Indicateurs de Qualité et Sécurité des Soins (IQSS)* indicators, among others.

The IQSS Indicators are tools that measure the state of health of a patient, a professional practice or the occurrence of an event to be investigated, to reliably assess the quality of patient care and safety, in all French healthcare hospitals and clinics.⁵ IQSS indicators give an image of the level of quality of care within each of the structures concerned⁶.

CHUGA is engaged in continuous process improvement of its quality management system and safety of care. Like all health establishments, CHUGA is subjected to an external procedure evaluation and Certification by HAS. Following the April 2018 assessment, the CHUGA is certified at level C, considering the Qualité de la Lettre de Liaison à la Sortie (QLS) Indicator evaluation, observed in Figure 2.1.

The higher result of this indicator represents a better *Lettre de Liaison à la Sortie*, and higher chances that continuity of healthcare will be ensured. The results are reported in the form of a performance class (rating from A to D). These classes indicate the quality level assessed for an establishment compared to the expected. It is expected that 80% (National Objective) of patients receive the *Lettre de Liaison à la Sortie*, if they were hospitalized for more than 48 hours.

Establishments in Class A have exceeded this expected value, Class B establishments have reached it, and Class C establishments have not yet reached it, see Table 2.2. The fourth category D is used when the hospital did not comply with the reporting obligation. The results are publicly reported on-

⁴Les effets de l'accréditation et des mesures d'amélioration sur la qualité des soins: <https://drees.solidarites-sante.gouv.fr/IMG/pdf/serieetud48.pdf>

⁵Haute Autorité de Santé (HAS): https://www.has-sante.fr/jcms/c_452559/fr/la-has-en-bref

⁶IQSS and QLS in MCO Report: https://www.has-sante.fr/upload/docs/application/pdf/2019-12/iqss_rapport_mco_qls_2019.pdf

| Class A | Class B | Class C |
|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| more than 8 out of 10 patients received the Letter with the expected Quality Criteria. | 8 out of 10 patients received the Letter with the expected Quality Criteria. | less than 8 out of 10 patients received the Letter with the expected Quality Criteria. |

Table 2.2: Classification of the Healthcare Establishments Performance in France.

Lettre de liaison à la sortie d'une hospitalisation en Médecine Chirurgie Obstétrique ?

Date des données : 2018

Position de l'établissement dans la répartition nationale des hôpitaux et cliniques :

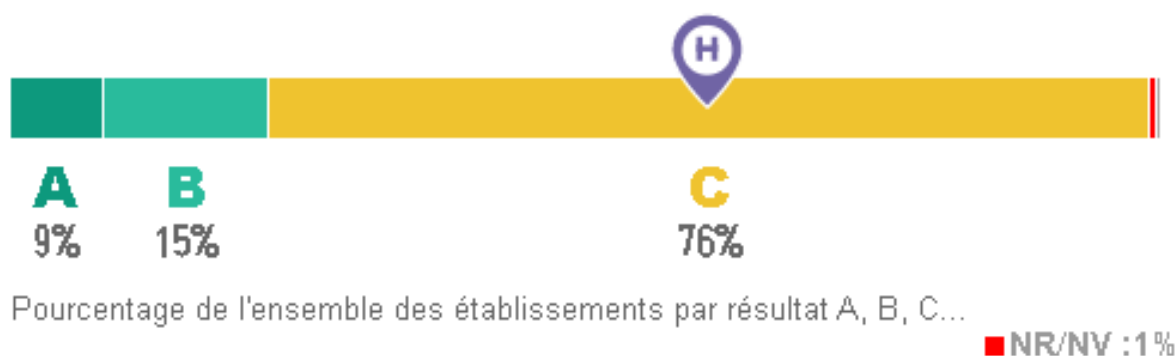


Figure 2.1: Comparative Position of CHUGA related to QLS Indicator in 2018. CHUGA was classified in the C Class, as well as 76% of the National French Hospitals. (<https://www.has-sante.fr/>).

line, and hospitals have the legal obligation to inform their patients about their results (Health Systems Performance Assessment, 2016).

In Grenoble there is only one hospital, CHUGA, with multiple Establishments: *C.H.U. Hopital Nord*, *C.H.U. Hopital Sud*, *C.H. de Voiron*, among others. Figure 2.2 represents the internal organization and structure of CHUGA. Each establishment is divide in Poles such as *Pole Anesth Reanimation*, *Pole Tete Chir Repara* and *Pole Urgences Medicine Aigue*, among others. The sector corresponds to the concerned activity, such as MCO. The *Unité Médicale*, medicale unit, it represents a specific area, for example, cardiology or neurology. By the other hand, the *Unité Fonctionnelle (UF)* (Functional Unit) is circumscribed to a specific medical activity. In the case of *Unité Médicale* related cardiology, a possible UF is myocardial infarction, for example. Also, UFs are placed under the responsibility of a doctor with clearly identified means and an administrative function. A UF is the smallest unit of production identified in a health facility.

Figure 2.3 shows how the information from the *Lettre de Liaison à la Sortie* is shared between patient and healthcare professionals. At the time of discharge, all relevant documentation must be delivered to the patient or family member. This document ensures continuity of care after hospital discharge.

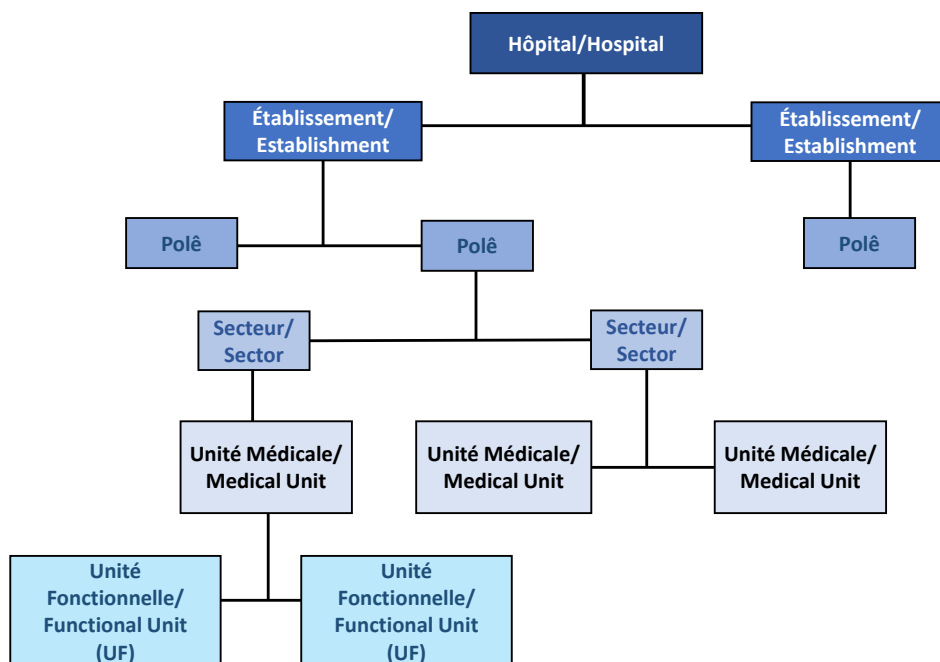


Figure 2.2: CHUGA Internal Organization and Structure.

Public Health Indicators in Portugal

Notas de Altas - (Discharge Letters) in Portugal, that are very similar to the *Lettre de Liaison à la Sortie* in France, were also created with the intention of being used at the hospital level and become an important indicator of quality in healthcare, in Portugal too (Varela and Rola, 2000).

Regardless of whether patients are discharged to another hospital or home, they must receive a discharge letter (Direção-Geral de Saúde, 2016).⁷

The information that should appear on the discharge note has already been established in Portugal (Ministry of Health, Diário da República, 2013)⁸.

Thus, in the services integrated into the National Health Service (SNS), in Portugal, the discharge notes include the following data: ⁷ ⁹

1. User identification (full name, date of birth, sex, nationality and country of habitual residence);
2. Date of admission, date of medical discharge, date of administrative discharge;
3. Name of the physician responsible for medical discharge (professional email address and profes-

⁷https://www.dgs.pt/departamento-da-qualidade-na-saude/ficheiros-anexos/manual_de_standards_hospitais_versao_2_me-02-1_051.aspx

⁸MINISTÉRIO DA SAÚDE. Aprova os registos eletrónicos relativos às notas de alta médica integrados no Serviço Nacional de Saúde. Diário da República, 20 fev 2013; https://static.sancoeassociados.com/DireitoMedicina/0mlegisum/legislacao2013/Fevereiro/Desp_2784_2013.pdf

⁹Altas Hospitalares: <https://www.msmanuals.com/pt/casa/assuntos-especiais/cuidados-hospitalares/a-alta-do-hospital>

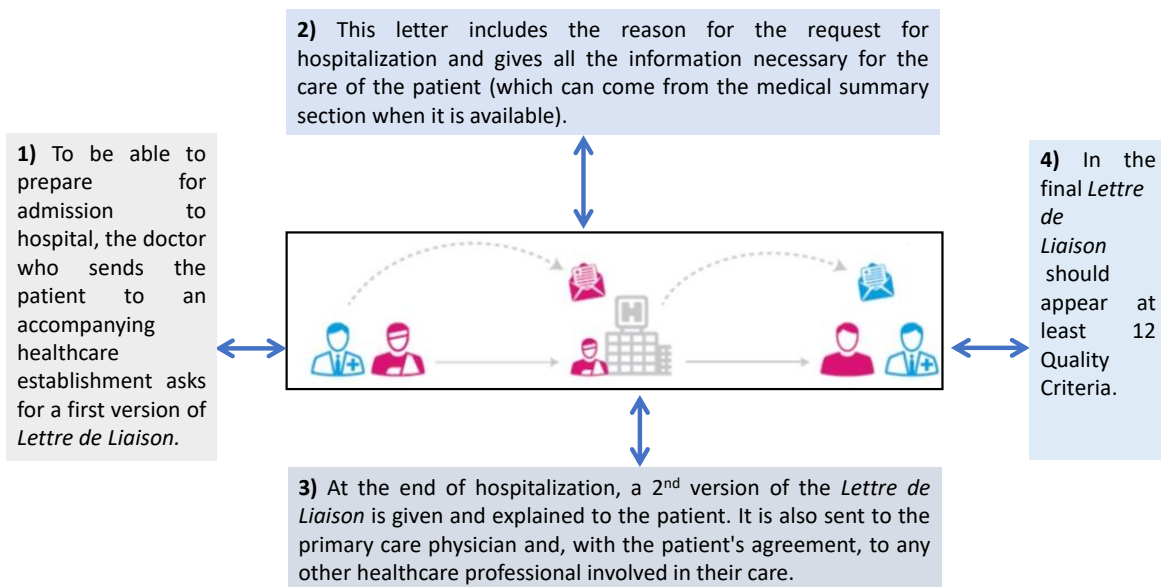


Figure 2.3: *Lettre de Liaison* and Information Sharing.

sional ID number);

4. Name of the doctor of general and primary care doctor;
5. Cause of hospitalization (at the time of hospital admission);
6. Brief description of the hospitalization episode;
7. Indication of therapy performed during hospitalization;
8. Indication of the post-discharge care continuity plan;
9. List of medical or surgical procedures with clinical description, among others.

We note that many of these elements are very similar to the 12 Quality Criteria, for the french *Lettre de Liaison* detailed in the next chapter. This information, since July 1, 2013, must be in conditions to be accessed, in digital format, by health professionals qualified for this purpose, through the Plataforma de Dados de Saúde (PDS), a Health Data Platform⁷.

Integrated into the National Strategy for Health Quality in Portugal, the National Plan for Patient Safety 2015-2020, created on February 10, 2015, is coordinated by the Department of Quality in Health of Directorate-General for Health. Following closely the recommendations of the Council of the European Union of 9 June 2009 on patient safety, the National Plan is part of a public policy for the prevention of safety incidents associated with the provision of healthcare within the scope of the National Health Service (SNS)¹⁰.

¹⁰Direção-Geral da Saúde: <https://www.dgs.pt/qualidade-e-seguranca/seguranca-dos-doentes.aspx>

At the end of 2020 with the objective of increasing Communication Security, intended in the national plan to carry out internal audits on the transfer of information on patient transitions, transfers and discharges. In this plan, it is also an objective that 90% of the Health Center Groups have access to discharge notes from reference hospital entities ⁹.

2.2 Quality on measurement in Healthcare

The measurement of quality in healthcare is at least 250 years old (Loeb, 2004). The main issue in performance measurement remaining today is the absence of agreement on what should be measured, considering that not everything in health care can or should be measured (McIntyre, 2001).

With recent advancements, healthcare associations made an extremely and efficient improvement in information technology at collecting and using electronic data, such as Electronic Health Record (EHR). (Rahman et al., 2019).

The main challenge that almost all hospitals are facing is perhaps how information knowledge from the collected data. The problem is that nowadays of health data are introduced and stored in natural language (free text). EHR have been implemented in diverse places in the world with a great success and brought large of improvements to the health care, in the last two decades.

According to Loeb (2004) performance measurement is increasingly becoming an integral part of the health structure. Also, there are an increase requests for data and information for various purposes, including improving performance, accountability and decision-making.

2.2.1 Electronic Health Records (EHR)

EHRs are defined by Menachemi and Collum (2011) as *“a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting”*.

EHRs, include information related to the patient demographics, vital signs, progress notes, immunizations, medications, laboratory data, and radiology reports, past medical history, among others (Menachemi and Collum, 2011). Further, the creation of the EHRs handle the medical information essential for patient care and improve the efficiency and accessibility of that information, from the healthcare professionals.

Table 2.3 shows the main advantages and disadvantages in the use of the EHR. The potential benefits of EHRs include: reducing the medical errors, improve the quality clinical outcomes (organizational outcomes) and improve and reduce the searching time, improved population health and reduce the costs (societal outcomes). There are also some drawbacks related to the EHRs, such as (Menachemi and Collum, 2011) the maintenance and the investment costs.

Some of the EHRs usability and benefits are explained in Figure 2.4.

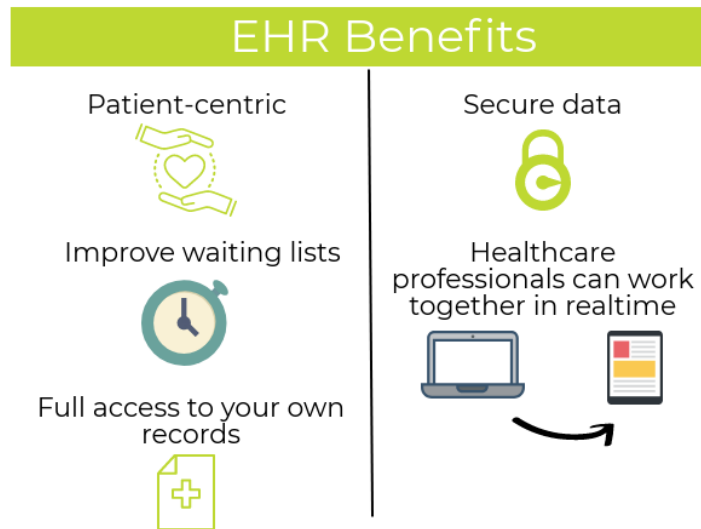


Figure 2.4: Electronic Health Records (EHR) Benefits.
 (<https://www.ehealthireland.ie/Strategic-Programmes/Electronic-Health-Record-EHR-/>)

2.3 Business Intelligence (BI) Concept

As described by Negash and Gray (2008), Business Intelligence (Business Intelligence (BI)) means the "process of extracting, transforming, executing and analyzing a large variety of data, to boost the mechanism of decision making". BI has two stages, data sourcing and data analysis. The first refers to the capacity to extract data from multiple data sources and the second converts data into information or knowledge using different data analysis techniques, such as reporting and data visualization. Figure 2.5 summarizes the benefits and advantages of using BI tools.

Resuming, BI tools are defined as systems that combine (Bonney, 2013) (Negash and Gray, 2008):

1. Data gathering and collecting;
2. Data storage, manipulating, analyzing and;
3. Knowledge Management, providing access to data that helps organizations make better decisions.

| Advantages | Disadvantages |
|------------------------------------------------|-------------------------------------------------------------|
| Access computerized records | Temporary loss of productivity associated with EHR adoption |
| Reducing costs at the health care system level | Privacy and security concerns |
| Health Information Exchange | Increasing medical errors and over dependence on technology |

Table 2.3: Advantages and Disadvantages of EHR (Winslow et al., 1997).

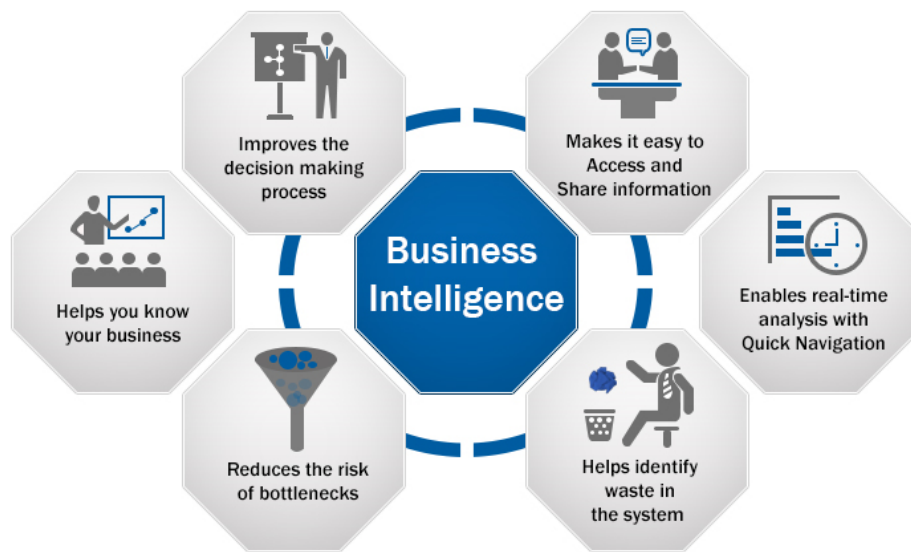


Figure 2.5: Business Intelligence Advantages and Benefits.
 (<http://www.accelintlinc.com/services/business-intelligence-analytics-data-mining/>).

The BI process consists of two primary activities, getting data in and getting data out. In essence, this kind of tools collects, cleans and present the data. BI works very well with both structured and unstructured datasets. The BI technology includes several software applications for Extract, Transform, Load (ETL), database query and reporting, and data visualization (Bonney, 2013).

According to Luís (Silva, 2017) from Instituto Superior Técnico (IST) and considering that the amount of data that exists nowadays is increasing faster, this makes necessary to have tools which are able to handle large volume of data. Table 2.4 describes how ETL works.

Further, BI can be seen as a tool to make proactive and preventive, instead of reactive decisions (Negash and Gray, 2008).

To finally and according to Pirttimaki (2007), the central idea in BI is the identification and processing the data gathered, transforming it into useful knowledge and intelligence. For that these tools are used to produce visual dashboards, and mainly these dashboards are not static. In general, the dashboards in the BI applications are interact and dynamic.

2.3.1 Business Intelligence in Healthcare

In 2009 Mettler and Vimarlund (2009) describe the use of BI in healthcare as becoming increasingly relevant and the need for real time information to improve healthcare performances.

Currently, according to Ferranti et al. (2010), BI tools are used more in other industries than in healthcare, despite the amount of data generated by healthcare organizations.

| | |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Extract | This action consists in extracting data from homogeneous or heterogeneous sources for later work in a target system. Extracting data in a correct way can condition the success of subsequent actions. The extraction process is often one of the tasks that consume the most time. |
| 2. Transform | Data Transforming is the phase that applies a set of methods to transform the extracted data to load them into destination storage. Data transformation is not a simple operation with columns and tables, it is also sometimes essential and necessary to change some content or create new columns (conditional ones for example) or pivot or unpivot the data. It is necessary change the data to analyse our data in a correct way. |
| 3. Load | This step is after performing all the task related the transformation phase. Now the data is ready to be analysed and visualized, so data can be loaded in the destination system target. |

Table 2.4: Extract, Transform and Load ETL Process Stages.

Above all, the quality of the operational data in the healthcare field is a decisive part of the success in the use of the BI tools. Hence, in contrast to other industries, the obtained information in healthcare influences a range of stakeholders such as specialists, patients, government, insurance companies, hospital administrators, among others. Together with the large amount of different processes, this makes the use of BI tools in healthcare more difficult than in other industries (Ashrafi et al., 2014).

Also, according to Ashrafi et al. (2014) another reason for the small amount of research on BI tools in healthcare is the acceptance beyond the organization. Another concern with BI tools in healthcare is the privacy and security of the data, as it contains very sensitive data about patients.

BI has the capability to develop healthcare quality, safety and performance. Also, the fact that the EHR include large clinical datasets about patients makes it a useful repository for employing BI technology (Bonney, 2013).

2.4 Dashboards

Dashboards are tools that stand out in the data visualization area, as a result of their graphic characteristics and the possibilities they offer in terms of exploration and analysis of information. This section presents the most relevant concepts for dashboard understanding, including the concept and history, some functionalities and finally the design.

2.4.1 Dashboard Concept and Brief History

A dashboard can boost a user's alertness towards their activities, by not only providing an examination of the task, but also allowing a more clear view to let users determine the origin causes of problems and take action on them.

| Categories of Dashboards | |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Operational Dashboard | Monitoring real-time performance. These dashboards monitor constantly changing activities, and reply quickly to events that might require attention. |
| Tactical Dashboard | Identifying opportunities or investigating problems by analysing historical data. Managers and business analysts use tactical dashboards to compare actual performance to expected efficiency. |
| Strategic Dashboard | Setting goals and tracking progress. Focused on long-term strategies and gather on high-level measures of performance and forecasts. |

Table 2.5: The Description of the Three Categories of Dashboard referred by Few (2004).

Historically, dashboards have been around since the end of last century (Rasmussen et al., 2009) where they were first created and used in cars, which we still use today. These consisted of various indicators to monitor and display the car's most important information (speedometer, mileage indicator, fuel gauge). A Tableau de Bord is a dashboard such as those found in airplanes or automobiles, this term was created in France in the last century (Marr and Schiuma, 2003). Nowadays, dashboards are well-known, utilized in Business Intelligence (BI), in many fields of study.

Although many different definitions exist, the two most important ones are listed below:

- *"A dashboard is a visual display of the most important information needed to achieve one or more objectives; consolidated and arranged on a single screen so the information can be monitored at a glance"* (Few, 2004).
- *"A visual and interactive performance management tool that displays on a single screen the most important information needed to achieve one or several individual and/or organizational goals, allowing the user to identify, explore, and communicate problem areas that need corrective action"* (Yigitbasioglu and Velcu, 2012).

Dashboards are multi-layered applications built on BI tools and data integration infrastructure that allow organizations to measure, audit, and manage the activity (Eckerson, 2006). Also, BI Dashboards diverge from basic dashboards in terms of interactivity and real-time. These dashboards allow an exhaustive search as well as filtering and ordering by interacting with their visual components and elements.

Additionally, Stephen Few (2006b) in his book "Information Dashboard Design" divided the dashboards into three categories, depending on your horizon the periodicity of the information, the recipients and the objectives. That are operational, tactical and strategic dashboards. The respective description is presented in the Table 2.5.

2.4.2 Dashboard Advantages and Functionalities

A Dashboard is vital for information presentation and visualization, they have been referred as one of the most essential analytical tools in BI by Negash and Gray (2008).

According to Wilbanks and Langford (2014), some of the most mentioned benefits of dashboards are:

- the capability to evaluate large amounts of data;
- demonstrate results in an easy-to-interpret layout;
- to provide notifications of metrics that diverge from predefined acceptable levels to reduce adverse adverts;
- to provide decision assistance to improve efficiency and quality;
- build up data-driven decision making to executive-level management.

Currently, most dashboards are more than just graphics compilations, they are extremely interactive and have features that revolutionized information analysis. Among the most important features that have been developed and improved over the past few years, the following stand out:

- Filters;
- Timelines;
- The possibility to change the graphic representation of the information in real time;
- Navigation operations on the data and;
- Updating data according our desire.

Filters were a huge step forward, in terms of dashboard functionality. These make it possible to eliminate, or at least reduce, the unnecessary information found in the elements of a dashboard, making it more focused on the problem under analysis.

This simple action potentially has a major impact in reducing the time spent by the user in using the dashboard, as well as improving analysis and interpretation of the data presented. The possibility to change the graphic representation of the information we are viewing in real time allows the user to adapt the dashboard to his needs and preferences without the need to recreate the dashboard.

Some of the potential uses of the dashboards listed by Pauwels et al. (2009) are presented in Table 2.6.

| Potential Uses of the Dashboards |
|----------------------------------------------------------------------------------------------|
| 1. Advice administrative department to connect this data information every time. |
| 2. Aid management departments define crucial tasks and data. |
| 3. Teach people in the organization about the most essential elements. |
| 4. Set objectives and expectations for peculiar group or institution. |
| 5. Highlight and specify alerts when problems appear. |
| 6. Communicate advancement and success. |
| 7. Provide a common interface for interacting with and analyzing important information data. |

Table 2.6: Potential Uses of the Dashboards (Pauwels et al., 2009).

2.4.3 Dashboard Components and Design

Dashboard styles can include stacked column graphs, scatter plots, pie graphs, column graphs, radar chart area graphs, radar graphs, among others (Wilbanks and Langford, 2014). Figure 2.6 it is possible to observe some of the main visualizations references used in BI tools, such as Power BI and Tableau. Charts categories included comparison (compare the magnitude of measures), change over time (display the changing trend of measures), part-to-whole (identify the parts making up a measure total), flow (display a flow or dynamic relations), ranking (rank measures in an order), spatial (display measures over spatial maps), distribution (display the distribution of values), correlation (show correlations between measures) and single (present single values).

There are numerous types of graphs available, with some of the most used below:

1. Bar chart: chart that uses bars to represent values. The dimension of the bars is equivalent to the values they represent. The bars are horizontal or vertical;
2. Pie chart: pie chart divided into slices or sectors. The curve dimension sector is proportional to the amount it's percentage/number;
3. Histogram: graph that represents the prevalence distribution of different classes, commonly represented using vertical bars.
4. Line graph: graph where the diverse values of a given measure, or metric, through time are represented by points, with a line being drawn that connects all points. There can be several lines on the same chart, making it possible to analysis of variations in the value of a particular metric, such as comparative analysis of the values of various metrics over time.

2.4.4 Dashboards in Healthcare Field

As referred by Wilbanks and Langford (2014) the aim of a dashboard is to provide a succinct overview of a huge amount of data. Dashboards can in general enable healthcare professionals to compare

COMPARISON

Use these visuals when you want to display measures compared by its magnitude.



CHANGE OVER TIME

Use these visuals when you want to display the changing trend of measures.



PART-TO-WHOLE

Use these visuals when you want to display parts that compose measures.



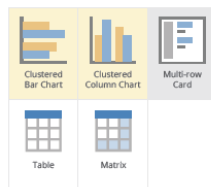
FLOW

Use these visuals when you want to display a flow or dynamic relations between measures.



RANKING

Use these visuals when you want to display measures by its rank order.



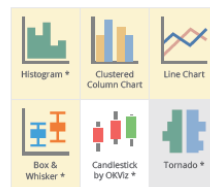
SPATIAL

Use these visuals when you want to display measures over spatial maps.



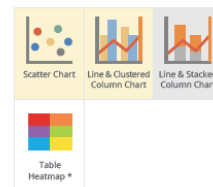
DISTRIBUTION

Use these visuals when you want to display the distribution of a measure.



CORRELATION

Use these visuals when you want to display relations between measures.



SINGLE

Use these visuals when you want to display a single value.

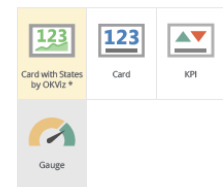


Figure 2.6: Power BI Visual References and Components (<https://www.sqlbi.com/ref/power-bi-visuals-reference/>).

information from diverse formats and origins to do some improvements. One of the ways to improve the quality healthcare is to measure value, making it transparent and reward providers based on value improvement. Hospitals' conduct and communication between professionals can improve by the use of dashboards (Mona Isazad Mashinchi, 2020).

With BI tools it is possible to create dashboards, in which way hospitals can use them to gather data from various sources, in order to present a simple information visualization. With this hospitals could improve their achievements and productivity, promoting proactive and preventive decisions. A quality dashboard shall be able to perceive and eliminate the causes of mediocre performance.

Along these lines, dashboards can gain space to improve the quality system of the hospitals, and make some advances in saving time and attainment of decision-making likewise the procedure and techniques, hence it procedure present all the information.

2.5 Dashboard Platforms

Visualization becomes crucial when data are vast, comprehensive, and originate from numerous sources and in a diverse formats. Also, visualization has a lot of potential to become an integral part of medical

healthcare. For that, the visualization of patient histories from EHR data is one of the central subjects of interest, and can support medical research, clinical treatment, financial and evaluation of hospitals, and communication between medical experts and patients.

According to Engelbrecht et al. (2015) some guidelines to build an information visualization solution:

- apply techniques to enhance mapping of data elements to visual objects;
- reduce user actions to achieve a goal;
- support flexibility in the ways to achieve a identical goal;
- support functionality to represent additional information spatially organize the visual layout;
- consistently apply design choices;
- support the user with information on alternatives when numerous actions are available;
- remove extraneous or distracting information and;
- consider means to minimize the dataset.

The BI applications explored during this work were Tableau and Power BI. This choice was influenced by CHUGA since are the most used tools in healthcare and Power BI is also nowadays used in CHUGA.

2.5.1 Power BI

Power BI is a BI tool that aims to provide interactive visualizations. It is a tool with an interface simple for create dashboard and reports and also publish them, sharing with others. In Figure 2.7 it is possible to observe two Power BI Dashboards, both of them related with Healthcare. Figure 2.7(a) shows a template to track the COVID-19 Pandemic. The Second, Figure 2.7(b) is a template format for the analysis of the division in hospitals. These two dashboards are interactive and dynamic.

Power BI comes in various versions, such as Power BI Desktop, Power BI Service, Power BI Mobile, and Power BI Report Server. Power BI desktop is the free version, and it is possible to build our dashboard connecting Power BI with various data sources (examples: Excel, Extensible Markup Language (XML), CSV, JSON, SQL Server, MySQL, Oracle, many more others). Power BI Desktop offers a lot of space in the storage cloud. Also, Power BI Desktop gives a complete access to Power BI's library of visualization templates and components. Additionally, Power BI Desktop presents the Power Query and the Power Pivot. With Power Query users can extract data from different sources, manipulate the specified data into a form that matches our needs, and then load it, ready for the visualization part. Power Pivot is also known as Data Analysis Expressions (DAX), which is a repository of functions and operators that when used together build formulas and expressions.

Business Intelligence (BI) tools like Power BI can be used for a enormous of purposes. Power BI is a BI tool that aims to provide interactive visualizations. It is a tool with a simple interface to create dashboard and reports and also publish them, sharing with others. Some of the crucial benefits of using Power BI:

1. Input large amounts of data;
2. Including machine learning characteristics, data can be analyzed and help users create patterns and predictions;
3. Information can be visualized using persuasive templates, making a better sense of their data;
4. Power BI is cloud-based, which allows update the data regularly;
5. Alerts can be establish on indicators, provide important metrics and measures up to date;
6. Use a intuitive interface, making it user-friendly and easy to navigate comparing with complex spreadsheets, for example.

Power BI has also some machine learning capabilities, that could find some patterns and trends in data and use them to do predictions.¹¹

2.5.2 Tableau

Tableau is a BI application for data discovery and data visualisation. Figure 2.8 presents two examples of dashboard built using Tableau. In one of them, Figure 2.8(a) it is possible to observe the Readmission in a hospital after a discharge of a patient. The other one, Figure 2.8(b) is related to the COVID-19 Pandemic, in which it is possible to choose the country for example, and in this case it is chosen Europe. With Tableau software, it is easy to analyse, visualise and share data, with well-designed dashboards that are very accessible to take benefit of. Likewise, Tableau provides various data sources such as MS Excel, Oracle, SalesForce, MS SQL and Google Analytics. With Tableau, it is simple to transform raw data into a very clear form. The analysis of the data with Tableau is very quick. Tableau is free for personal use, but if more features are needed, the price can increase very quickly. Furthermore, Tableau also offers three different products: Tableau Desktop (everyone) and Tableau Server (analytic for organisations) and Tableau Online. One drawback of Tableau is the fact do not support automatic refreshing of the reports. In Tableau it is also impossible to import external visual elements, unlike other software such as Power BI.

Tableau is dedicated in helping healthcare organizations with understanding their data. An example of that is the Michigan Medicine Organization. This organization is one of the biggest healthcare centers

¹¹Power BI Microsoft: <https://powerbi.microsoft.com/en-us/desktop/>

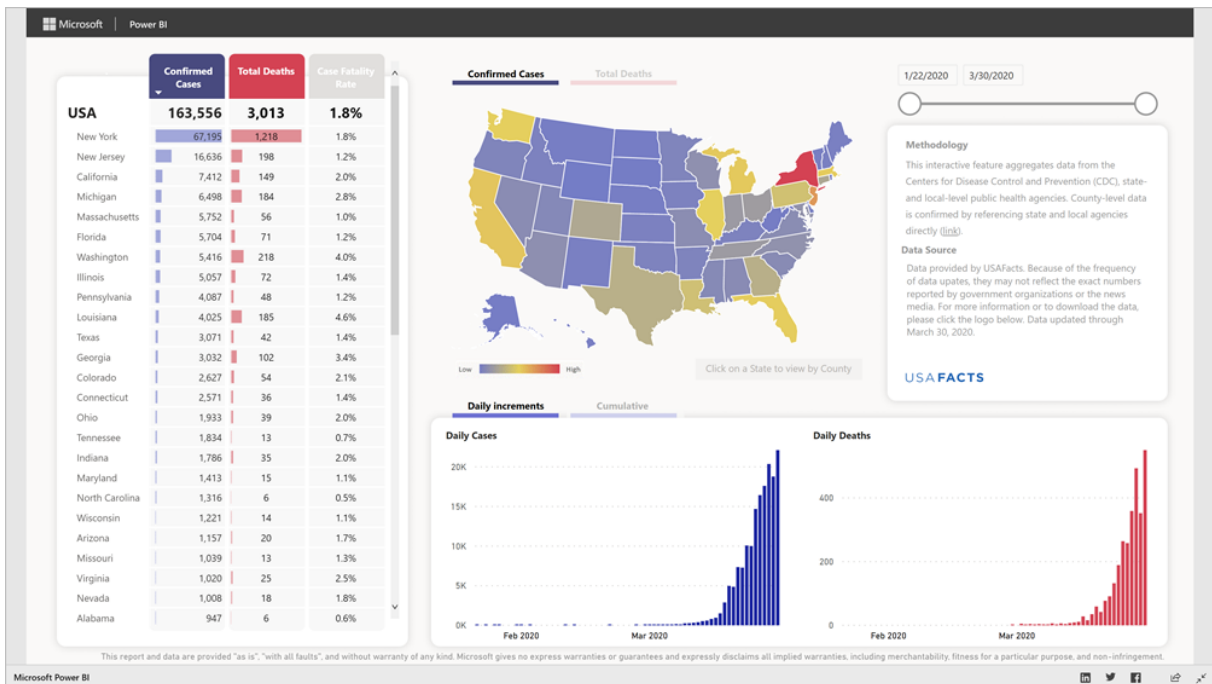
in the world. Michigan Medicine has three different hospitals, 40 outpatient centers and almost 150 clinics. With the implementation of Tableau Michigan Medicine in just one year with the automated reporting saved more than 5 000 hours of work in the healthcare system, covering four different projects. Nowadays, the stored information is easier accessible by the teams, driving too quick decisions. With these saved time, Michigan Medicine could concentrate their human's resources in strategic projects.¹²

2.6 Summary

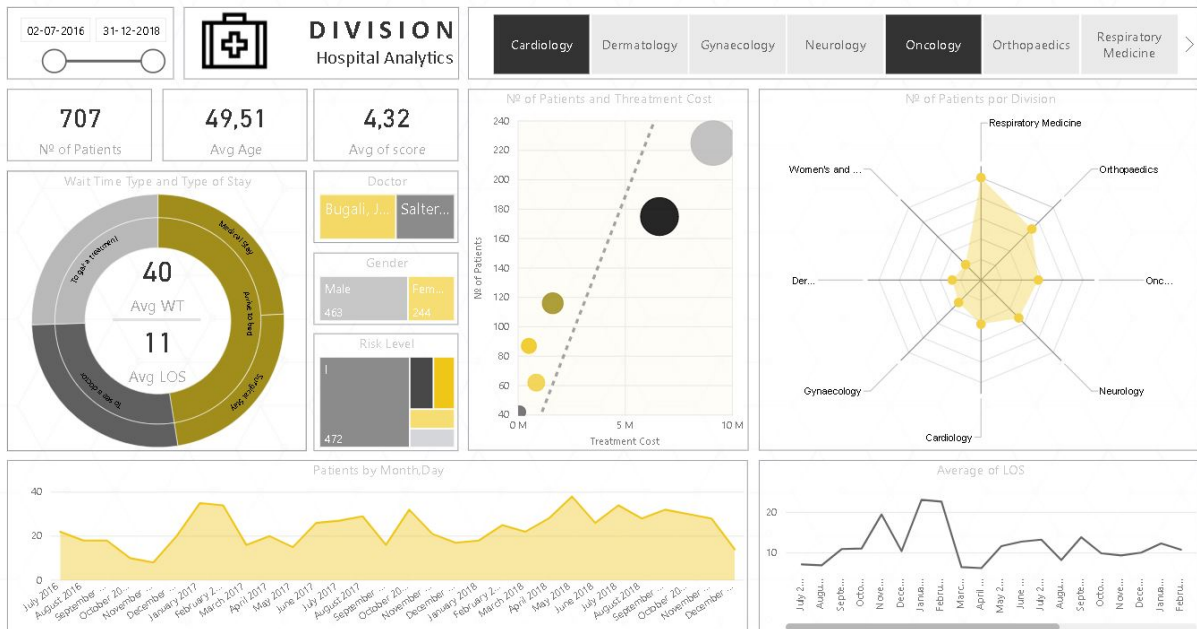
This chapter begins by conceptualizing the actual situation related to the QLS Indicator. Following it describes how dashboards are used as a support tool for effective and efficient decision-making. Then, it is presented the two main BI tools used nowadays in the context of healthcare, Power BI and Tableau. In the next chapter, it is explained why Power BI was used instead of Tableau and also the steps taken to have the final solution, a dashboard showing the Quality Criteria about QLS Indicator at CHUGA.

There exists a consensus about the importance of public health and the fact that Healthcare is now a sector with exponential growth, making it one of the largest industries in the world with enormous impact on countries' economy. In this context, hospitals must constantly try to improve their performance and efficiency. Hence, to improve performance, it is necessary to measure and evaluate it, then some health quality indicators were created by national authorities and sometimes by the hospitals individual. For the analysis of these health quality indicators and taking into account that data alone do not generate knowledge, it is necessary to exploit the collected data. Thus, the role of the Dashboard has been increasing in the healthcare field. Since, one of the best ways to analyse a huge amount of data it is through visualising it, dashboard play a crucial role in visualizing the outcomes through data processing using graphical visual elements.

¹²<https://www.tableau.com/solutions/customer/university-michigan-health-center-processes-literally-thousands-hours-seconds>



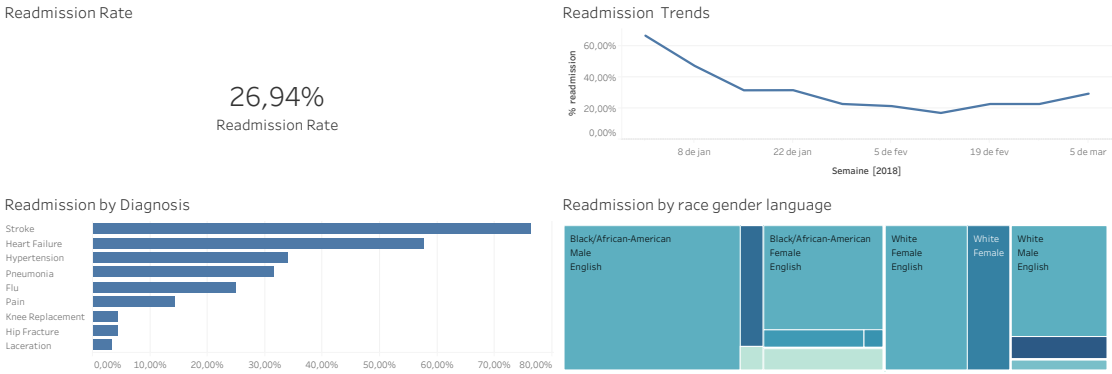
(a) Power BI Dashboard COVID-19 tracking sample for US state and local governments. Features spatial (Bar and Line Charts, Card Numbers and Shape Map) and tabular information. (<https://docs.microsoft.com/en-us/power-bi/create-reports/sample-covid-19-us>)



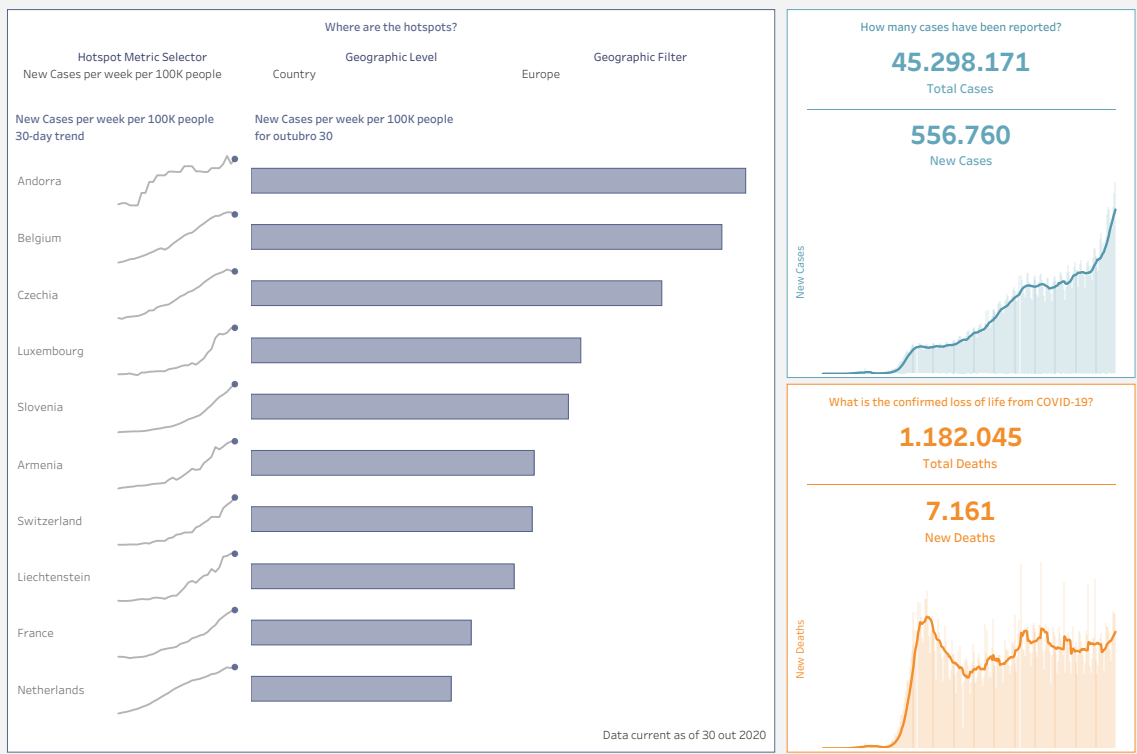
(b) Power BI Dashboard Division Hospital Analysis. Features spatial (Dot plot, Donut, Line and Radar Charts and Card Numbers). (<https://bit.ly/powerbiDashboard>)

Figure 2.7: Examples of Power BI Healthcare Dashboards.

Readmission Analysis



(a) Healthcare Readmission Analysis Dashboard. Features spatial (bar, line, treemap and single card). https://public.tableau.com/profile/drumare6248#!/vizhome/Readmissions_2_15967909370820/Readmissiondashboard



(b) Global COVID19 Tracker Dashboard. Features spatial (bar, line and card numbers) with the possibility of choosing between Hotspot Selector and Geographic level and Filter. <https://www.tableau.com/covid-19-coronavirus-data-resources>

Figure 2.8: Examples of Tableau Healthcare Dashboards.

3

Dashboard

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3.1 The Problem and Proposed Solution

This section presents the problem awareness and the quality criteria definitions, which defines the specific and actual problem and justifies the value of the developed solution, followed by the description of the Solution Software Architecture.

One of the requirements of the project was that it would be carried out using tools already used, leveraging previous investment and promoting uniformity of computing resources at the hospital.

This work focused on the implementation of the Indicateurs de Qualité et Sécurité des Soins (IQSS) on the Médecine Chirurgie Obstétrique (MCO) activity, at Centre Hospitalier Universitaire Grenoble Alpes (CHUGA). There are two mandatory classes of IQSS indicators related the MCO activity:

1. *Qualité de la Lettre de Liaison à la Sortie (QLS)-[Quality of the patient discharge letter]*
2. *Evaluation et Prise en charge de la douleur (PCD)-[Pain assessment and management]*

The QLS Indicator assesses the quality of the *Lettre de Liaison* upon discharge from hospital. If the *Lettre de Liaison* is missing, it creates a break in the care process for people returning home. On the other hand, the PCD Indicator, presented in the form of a compliance rate, provides an assessment of pain. For patients with pain of at least moderate intensity, the implementation of a pain management strategy and pain reassessment.

This work addresses the implementation of the QLS Indicator. The QLS Indicator assesses the quality of the *Lettre de Liaison* after discharge from a hospital stay longer than 48 hours. The *Lettre de Liaison* is a key element in the continuity of care. It must be signed by a doctor of the healthcare unit (Unité Fonctionnelle (UF)) and addressed to the primary care doctor, and also given to the patient on the day of discharge. The *Lettre de Liaison* summarises the conclusions of the hospitalisation and establishes recommendations for care to ensure good coordination in the healthcare structure system. This letter includes 12 different elements called quality criteria with very useful information, which can contribute to ensuring continued healthcare.¹

Has a *Lettre de Liaison* included the essential elements for continuity of care been given to the patient? This is the question that QLS Indicator answer.

To summarize the quality and safety of care are one of the priorities included in the French national health strategy 2018-22.²

The partial evolution of the method of hospital financing has been identified as a lever for continuous improvement of patient care in health establishments, both public and private. With this perspective, and as CHUGA is also a hospital that participates in a programme related to the Incitation Financière à

¹HAS: https://www.has-sante.fr/jcms/c_452559/fr/la-has-en-bref

²National Health Strategy 2018-2022: https://solidarites-sante.gouv.fr/IMG/pdf/dossier_sns_2017_synthesev6-10p_anglaisv2.pdf

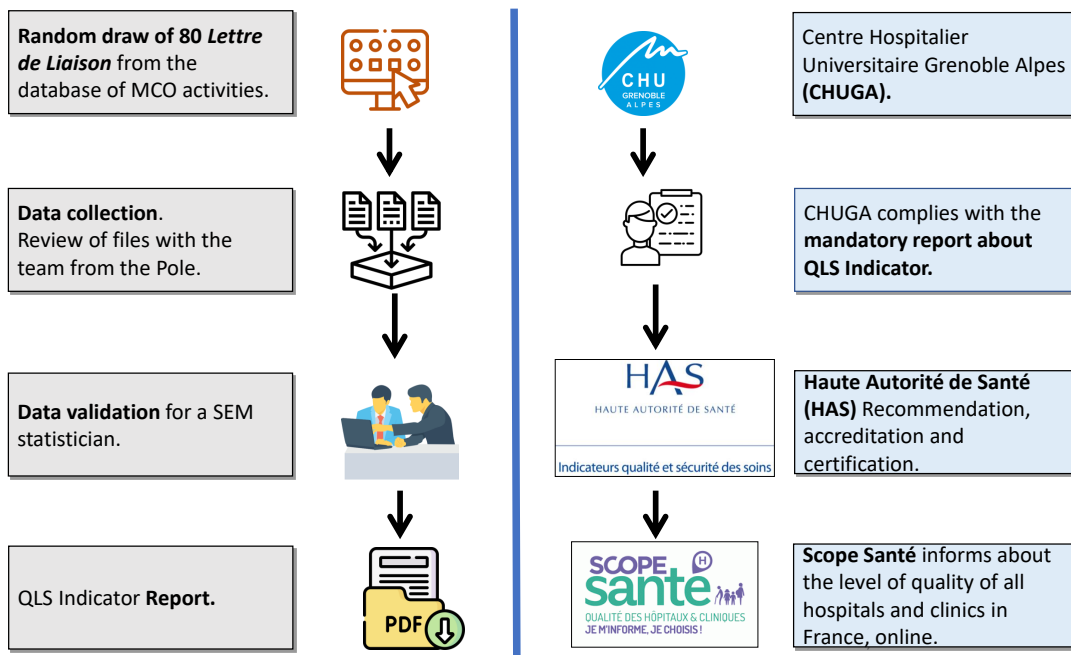


Figure 3.1: Existing/Actual Method of the generate of the QLS Indicator. In the right side of the figure it is represented the identities responsible for the process. The left side illustrates some specifications of the current method.

l'Amélioration de la Qualité (IFAQ), it intends to improve the classification of these indicators over time and thus also be financed and recognized in this way.

3.1.1 *Lettre de Liaison* and QLS Indicator

The *Lettre de Liaison* is a crucial element in the continuity of care. It must be signed by a doctor of the hospital and addressed to the primary care Doctor or the transfer structure, and handed to the patient or sent by email on the day of discharge. Figure 3.1 represents the current method used at CHUGA to analyse and generate the QLS Indicator Report.

The *Lettre de Liaison* summarizes the conclusions of hospitalization and establishes recommendations for care after discharge to ensure good coordination hospital/home or hospital/hospital of transfer.³

In summary *Lettre de Liaison* ensures:

1. The guarantee of continuity of care;
2. Information sharing between healthcare professionals and;
3. Secure healthcare for patients.

³*Fiche Descriptive:* https://www.has-sante.fr/upload/docs/application/pdf/2015-12/fiche_descriptive_qds_mco_9.12.2015.pdf

| QLS Indicator - Quality Criteria | |
|-------------------------------------------------|--------------------------------------------------|
| 1. Lettre de liaison à la sortie retrouvée | 1. Letter of discharge found in the database |
| 2. Lettre de liaison datée du jour de la sortie | 2. Liaison Letter dated in the discharge day |
| 3. Remise au patient à la sortie | 3. Letter delivery at discharge |
| 4. Identification du patient | 4. Patient identification |
| 5. Date entrée et sortie | 5. Date of entry and discharge |
| 6. Identification du signataire | 6. Identification of the signatory |
| 7. Motif hospitalisation | 7. Cause for hospitalization |
| 8. Synthèse médicale du séjour | 8. Medical summary of the hospitalization |
| 9. Actes techniques et examens Complémentaires | 9. Technical acts and Complementary examinations |
| 10. Traitements médicamenteux | 10. Drug treatments |
| 11. Planification des soins | 11. Care planning |
| 12. Identification du médecin traitant | 12. Identification of the responsible physician |

Table 3.1: 12 Quality Criteria in *Lettre de Liaison* by Haute Autorité de Santé (HAS) and translations.

This monitoring of quality and safety of care IQSS indicators producing comparative data is used to internal steering, regional and national regulation, and transparency towards patients.

QLS Indicator Description

The QLS Indicator assesses the quality of the *Lettre de Liaison* from the hospital. It is presented as a quality percentage between 0% and 100%.⁴

The QLS Indicator is calculated from 12 Quality Criteria (Maxime, 2018). Two from these 12 Quality Criteria are essential, five are medico-administrative and five medical. The 12 Quality Criteria of the *Lettre de Liaison* are listed in Table 3.1.

The two essential quality criteria are:

1. *Lettre de Liaison à la sortie retrouvée*

The criterion is satisfied if the *Lettre de Liaison* is found in the database of medical files. In this case, it counts as one *Lettre de Liaison* found. Only one document is required to be located. If several documents are located and are intended for the continuity of care, counts the one given to the patient first. The criterion is not satisfied if the *Lettre de Liaison* is not located in the patient record.

2. *Lettre de Liaison à la sortie datée du jour de la sortie*

The criterion is satisfied if the date of validation on the *Lettre de Liaison* is similar (one to three days) to the date of discharge from administrative hospitalization of the patient. The criterion is not satisfied if the *Lettre de Liaison* on leaving is not dated, or if the date of validation is later than the patient's discharge date.

⁴https://www.has-sante.fr/upload/docs/application/pdf/2019-01/fiche_descriptive_qls_mco_2019.pdf

In the absence of conformity of one of these two above criteria, the next 10 criteria are count as not satisfied, since if it is not possible to find the *Lettre de Liaison*, it is not possible to have access to the information inside the Letter. Hence, these two first indicators are essential.

Next, these 10 Quality Criteria could be divided in two categories. Five belong to Medico-Administrative information, for example, the Identification of the Patient, and the other 5 are part of the Medical Criteria.

Five Medico-Administrative Quality Criteria:

3. Remise au patient de la Lettre de Liaison à la sortie

The criterion is satisfied if a mention of the delivery of the *Lettre de Liaison* to the patient is found, hand to hand or sent by email OR if there is a trace of the justification for not delivery it.

4. Identification du Médecin Traitant

The criterion is satisfied if we find on the *Lettre de Liaison* the identity of the physician/doctor (name, contact and address) or if it is mentioned that the patient refuses having the *Lettre de Liaison* sent to the primary care physician or the patient has no declared primary care physician.

5. Identification du Patient

The criterion is satisfied if we find, the correct identification of the patient: birth name, date of birth and gender.

6. Date d'entrée et date de sortie

The criterion is satisfied if we find a reference to the dates of the stay (entry date and exit date).

7. Identification du Signataire de la Lettre de Liaison

The criterion is satisfied if we find the identity of the signatory of the document (name, department and hospital) and its contact details (email address or telephone).

Five Medical Quality Criteria:

8. Motif de l'hospitalisation

The criterion is satisfied if the reason for hospitalization is found on the *Lettre de Liaison*.

9. Synthèse Médicale du Séjour

The criterion is satisfied if one of the following elements are found on the *Lettre de Liaison*:

- a summary of patient care during the stay or,
- a summary of the patient's clinical situation on discharge.

10. *Actes Techniques et Examens Complémentaires*

The criterion is satisfied if one of the following conditions are granted:

- Conclusion or information concerning the additional techniques or examinations during the hospitalization is found;
- No technical additional examination has been performed during hospitalization, or;
- Pending results.

11. *Traitements Médicamenteux à la Sortie*

The criterion is satisfied if we find on the *Lettre de Liaison* the list of drugs on discharge from the patient, including for each prescription of the drug: its common name, its dosage (unit dosage and the rate of administration), route of administration and duration of the prescription, or the mention of the absence of treatment at the exit.

12. *Planification de Soins*

The criterion is satisfied if there is information on care planning on the *Lettre de Liaison* that it is planned after hospitalization (for example additional exams to do, nursing or rehabilitation), OR if there is mention that the patient does not require immediate care.

3.1.2 Solution Architecture Overview

The solution developed in this dissertation entailed the reformulation of the existing method for generating the QLS Indicator, making it better optimised and more robust application with data analysis, visualisation and possible reporting features. The QLS Indicator monitoring system consists of three components:

1. the database, in which the data to be used are stored;
2. the Extract, Transform, Load (ETL), the layer responsible for accessing the data and analysing it, and;
3. finally the visualization (front-end), the layer responsible for the graphic presentation of the data to end-user.

To simplify the development process my own database (*Indicateurs-QLS*) was created with tables imported from the databases in the information related to the QLS Indicator. To access the database it was necessary to be connected to the CHUGA network or via Virtual private network (VPN), that connects two or more computers, encrypting the connections.

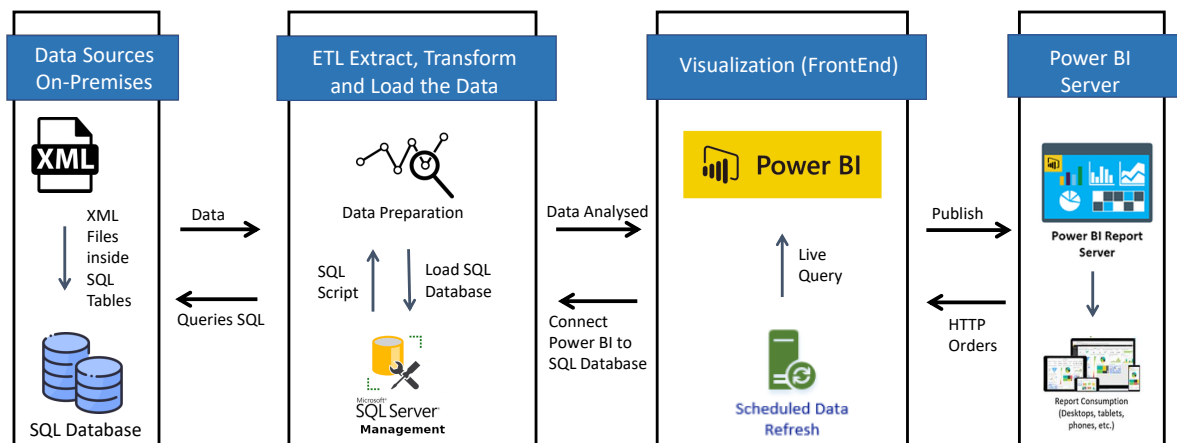


Figure 3.2: A simple schema of the solution and the method used to build the dashboard. The tools used (Power BI and SQL databases) and the respective interaction are illustrated.

Figure 3.2 illustrates a simple schema of the solution and the method used to build the dashboard. The main tools available for the development of this thesis work were Power BI and an SQL database. Some CHUGA workers have the knowledge in these tools and it will facilitate the future maintenance of the dashboard system and also to expand and build up others dashboards related to another indicators and information.

The Server that was made available to me was called PROBACK82, which contained many copies of real data for pilot projects and experiments. The PROBACK82 Server has databases and tables. The data sources of this work were in this Server. Some of the data were stored in the tables in Extensible Markup Language (XML) format.

The *Indicateurs-QLS* database was created with the Database Management System (DBMS) in Microsoft SQL Server. A DBMS is a program that allows the creation and manipulation of databases, maintaining the independence between the way data is stored and its structure, and the way they are used in a program or application that manipulates them. The data is accessed with SQL. Structured Query Language (SQL) is a language that allows queries to be made to a database and to modify or delete elements from a database. Through Microsoft SQL Server Management Studio, it was possible to access the databases, manipulating the data and to connect it to Power BI.

In the second phase, an ETL procedure was developed. The data is extracted before being transformed. When transforming data, several operations are performed, because of that some intermediate tables were created. At the end of this phase, the data are in a coherent and consistent format, allowing the creation of visualizations. Power BI and SQL databases connect and the transformed data is loaded. In the Power BI Desktop is developed the dashboard and the data can be updated currently.

Lastly, the dashboard system is available from a browser, connected to the Power BI Server.

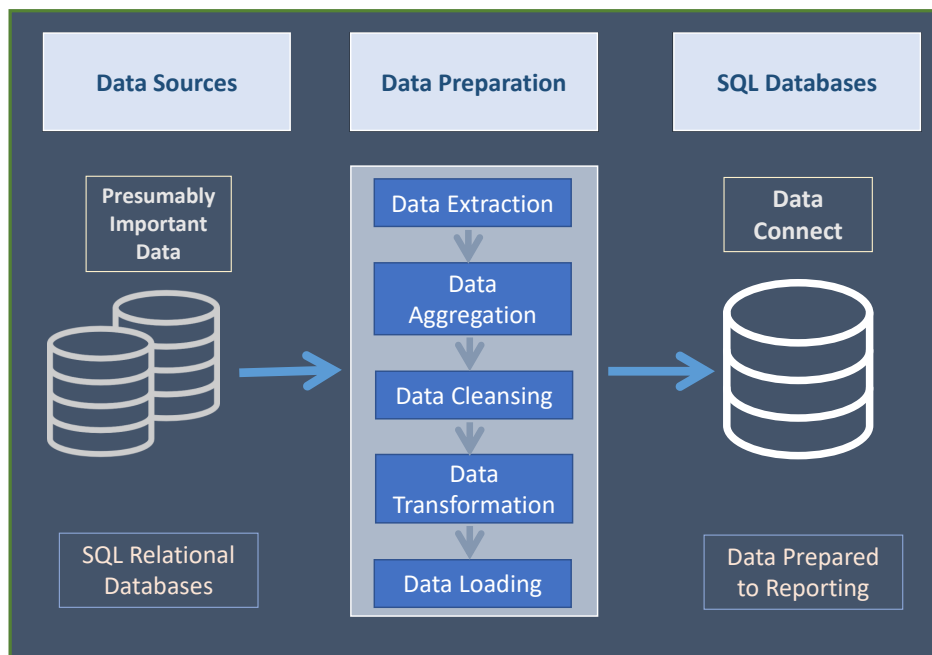


Figure 3.3: Data flow for the QLS Indicator production.

3.2 Extract, transform, load (ETL)

In this section, the method of extracting the data and its transformation will be presented before visualization was possible. Therefore, before starting to view any information from the QLS Indicator, it was necessary to have access to the databases provided by the Department *des Services Numériques* at CHUGA to understand what information should be used. The structure of the data and the way it was organized is also presented. Figure 3.3 depicts the main steps during the ETL process.

Extract Transform and Load (ETL) is a process responsible for running the extract, transform and load data from one or more source data systems to a target data system. The main ETL layers in this work are:

- Identification of relevant information about QLS Indicator, at the source side;
- Extraction of the information from the SQL Databases;
- Customization and integration of the information into a common format;
- Cleaning of the resulting data sets based on database and Quality Criteria rules.

3.2.1 Data access

Initially, data was available from an SQL Server through the SQL Server Management Studio (SSMS). SSMS is an integrated environment and graphical interface used to access, set up, manage and develop all components of SQL Server. The management studio provides the necessary tools to create a new database and new database tables. This PROBACK82 Server has several Databases that have been defined for different purposes and offered the development environment used for developing this dissertation. Several tables from various databases were used to create the final analysis table with the Quality Criteria information from the *Lettre de Liaison*.

To condense all the data in the PROBACK82 Server, a specific database was created named *Indicateur-QLS*, with two raw tables containing all the data from other databases/tables. These two tables contain all the essential data and were used to fill in the table to be load in the Business Intelligence (BI) stage, in our context the Power BI Desktop.

3.2.1.A Data Extraction

The first step must be extract the data, before data can be analyzed or used. Data extraction is a method of collecting data from different data sources. The data sources formats used in this dissertation include relational databases and XML format.

Some of relational databases tables used are related to a document called *Fiche d'hospitalisation*, and example of this kind of Fiche it is detailed in Appendix A. In this appendix, some details are not visible, in order to protect the patient's identity and some other details and fields are false.

Lettre de Liaison constitute almost all of the *Fiche d'hospitalisation*, that is an internal hospitalisation report. On behalf of, we use the tables related to *Fiche d'hospitalisation* to develop the percentages about QLS Indicator, as if the data about the mandatory Quality Criteria are in the *Fiche d'hospitalisation* it is also in the *Lettre de Liaison*, once the first one document automatically generated almost all the parts from the second one.

It is possible through the Appendix A (where it is an example of *Fiche d'hospitalisation J0*) and Appendix B (where it is an example of *Lettre de Liaison à la Sortie*) observe that the same information is in both of them, instead of a different format and sequence. The *Lettre de Liaison* it is automatically generated from the *Fiche d'hospitalisation* and this information it is in the *Fiche d'hospitalisation* in the last page where it can be read "*Lettre de liaison valant CRH*" and in front the date when it was generated. Also, other details such as the identification of the patient, identification of the physician, the dates of stay, reason for hospitalization and the other Quality Criteria are presented in both documents. Initial, some of these two documents were compared to check if they are in concordance.

This approach becomes relatively important since the *Lettre de Liaison* is in Word Format, and the possibilities to automate the analysis of these data are much more difficult.

Listing 3.1: Example of an XML document related to the *Fiche d'hospitalisation*.

```
1 <Fiche_dhospitalisation_J0_CHUGA model_id="0000000000">
2 <diagnostic_detaille>text</diagnostic_detaille>
3 <entree>2030-01-01T00:00:00</entree>
4 <sortie>2030-01-08T00:00:00</sortie>
5 <Remis_en_main_propre_V2>text</Remis_en_main_propre_V2>
6 <Medecin_Traitant>text</Medecin_Traitant>
7 <motif_entree>text</motif_entree>
8 ...
9 <trait_habituel_perso_entree>text</trait_habituel_perso_entree>
10 <diag_sortie>text</diag_sortie>
11 <evt_complication_maladie_chronique>text</evt_complication_maladie_chronique>
12 <evt_acte_tech_bio_imag_marquant_txt>text</evt_acte_tech_bio_imag_marquant_txt>
13 <autres_prescriptions>text</autres_prescriptions>
14 </Fiche_dhospitalisation_J0_CHUGA>
```

XML Data Extraction from SQL

The *Fiche d'hospitalisation J0* is in an XML format in the database. XML is a "hierarchical data format for information exchange". An XML document consists of aligned element structures, beginning with a root component. The element data contain attributes or sub-elements and the document is composed of units named entities (Anders et al., 2009).

In Listing 3.1, it is presented as an example of a XML document related to the *Fiche d'hospitalisation J0*.

To query the XML files and store them in relational tables was used a sample of information from a medical activity (*CR0201 = rhumatologie- rheumatology*) and from a surgery category (*CR232= Oto-rhino-laryngologie ORL- Otorhinolaryngology* and *Chirurgie plastique Maxillo Faciale CMF- Maxillofacial surgery*) during the period of 09/30/19 and 12/31/19. The period declared in the SQL query it is presented in the Listing 3.2.

These parameters could be modified and more information could be analysed. Among all the data collected, only hospital stay reports (with the category of "CRH" or "lettre de liaison valant CRH") were analyzed and considered as a *Lettre de Liaison*. From this analysis resulted in 631 *Lettre de Liaison*.

Querying XML data is very distinct from querying relational data. An XML document is by nature hierarchical, it can be represented easily in a tree diagram.

It is possible to manipulate most queries on XML documents applying a relational database and con-

Listing 3.2: Period of time queried.

```
1 DECLARE @debut_periode datetime2(2), @fin_periode datetime2(2)
2
3 SET @debut_periode = '2019-09-30 23:59:59.999999'
4 SET @fin_periode = '2019-12-31 23:59:59.999999'
```

Listing 3.3: XML Query Path.

```
1 SELECT patient_id, formulaire, CRH, fiche_id, CR, UF, num_venue,
2 date_admission, date_sortie, date_creation_doc, date_validation_doc,
3 fiche_JO_associee, envoi_zeptra, impression, medecin_responsable,
4 t.contenu_JO_XML.value(
5     '/Fiche_dhospitalisation_JO_CHUGA/Remis_en_main_propre_V2)[1]', 'nvarchar(max)')
6 AS remise_patient_main_propre,
7 t.contenu_JO_XML.value(
8     '/Fiche_dhospitalisation_JO_CHUGA/Medecin_Traitant)[1]', 'nvarchar(max)')
9 AS medecin_traitant,
10 t.contenu_JO_XML.value(
11     '/Fiche_dhospitalisation_JO_CHUGA/motif_entree)[1]', 'nvarchar(max)')
12 AS motif_d_hospitalisation,
13 t.contenu_JO_XML.value(
14     '/Fiche_dhospitalisation_JO_CHUGA/trait_habituel_perso_entree)[1]', 'nvarchar(max)')
15 AS traitement_personnel,
16 t.contenu_JO_XML.value(
17     '/Fiche_dhospitalisation_JO_CHUGA/diag_sortie)[1]', 'nvarchar(max)')
18 AS diagnostc_sorti,
19 t.contenu_JO_XML.value(
20     '/Fiche_dhospitalisation_JO_CHUGA/evt_complication_maladie_chronique)[1]', 'nvarchar(max)')
21 AS synthese_medicale_sejour,
22 t.contenu_JO_XML.value(
23     '/Fiche_dhospitalisation_JO_CHUGA/evt_acte_tech_bio_imag_marquant_txt)[1]', 'nvarchar(max)')
24 AS actes_complementaires,
25 t.contenu_JO_XML.value(
26     '/Fiche_dhospitalisation_JO_CHUGA/autres_prescriptions)[1]', 'nvarchar(max)')
27 AS prescripion_sortie
```

verts XML documents to relational tuples/columns, translates semi-structured queries over XML documents to SQL queries over tables. The XML documents are in relational tables and a column has a hyperlink to access to the XML files.

With the existing of XML path, it is feasible to query the elements of the data stored in XML documents, and it is presented Listing 3.3.

3.2.2 Data Analysis

After the extraction part, two raw data tables were built and saved in the *Indicateurs-QLS* database. The columns, description and the data type of this two tables are presented in Table 3.2 and Table 3.3, in which it is possible to analyse which kind of information it is needed to calculate the QLS Indicator.

Before loading the data into the stored database, it should be transformed and cleaned. The extracted data from diverse sources can contain meaningless data with duplicates, wrong values and contradictory data. These data are unnecessary and must be removed from the dataset. In general, data cleansing will not just consist of a clean dataset, but also provide data consistency to diverse sets of data that have collected from different data sources/databases.

Normally, we find data in a variety of ways, sometimes some data is missing and unstructured, or data that doesn't have a regular format. In such a way, we need some methods to clean up and transform the data before processing it to improve its quality and reporting.

The main difference between data cleansing and data transformation is that the data cleaning is the

| Column | Description | Data Type |
|---------------------|--------------------------------------------------------------------|--------------|
| fiche J0 associee | Primary Key - Number of the correspondent <i>Lettre de Liaison</i> | int |
| patient id | Identification of the Patient | int |
| fiche id | Number of Fiche Identification | int |
| CR | Code responsibility hospital center | int |
| UF | <i>Unités Fonctionnelles</i> - Functional Units in the Hospital | int |
| date creation doc | Date of the document creation | date |
| date validation doc | Date of the document validation | date |
| envoi zepa | Electronic / email sending of the <i>Lettre de Liaison</i> | Boolean |
| impression | Paper/Hand delivery of the <i>Lettre de Liaison</i> | Boolean |
| medecin responsable | Identification of the responsible physician | varchar(MAX) |

Table 3.2: Database table *Compte Rendu* and description of its fields.

process that removes and eliminate meaningless data in the data set, while data transformation is the process of altering data from one structure or format into another.

3.2.2.A Data Cleaning

Data cleaning accounts for 50% to 80% of the development time and budget in projects (Fan, 2008). But this step is very important and here we decide which data we need or not and which data we will transform too.

First of all, a manual and visual analysis regarding the two tables from the Database "Indicateurs-QLS" were realized. After understanding the main content in each column, some columns were deleted and modified, due to some of the information weren't necessary to build the 12 Quality Criteria from QLS Indicator.

Using the *Fiche ID*, once this column has the primary key and for faster identification, it was possible to eliminate the duplicates files related to *Lettre de Liaison*. To do that some SQL Queries were useful and developed.

3.2.2.B Data Transformation

The transformation phase applies a set of rules to transform the extracted meaningful data in order to load them into the BI application. The data transformation is not just a basic mapping of columns and tables to the appropriate location. It is repeatedly necessary to change the data format in order to match the target system and corresponding to Quality Criteria restrictions.

A relational database has effective tools for accessing and transforming data. In such a way, with relational database management systems, it is viable to access powerful query capabilities that let easily transform and retrieve data, decreasing one of the dominant bottlenecks in data analysis. In such a way, developing a SQL Script that transforms the data, it was fundamental and advantageous.

| Column | Description | Data type |
|--------------------------|---------------------------------------------------------|---------------|
| Fiche id | Number of the <i>Lettre de Liaison</i> | int |
| patient id | Identification of the Patient | int |
| Formulaire | Identification of the Hospital's Service | nvarchar(250) |
| num venue | Number of the stay | int |
| date entree | Date of the hospitalization | date |
| date sortie | Date of the last day in hospitalization | date |
| medecin responsable | Responsible physician | nvarchar(100) |
| remise au patient | Delivery of the <i>Lettre de Liaison</i> to the Patient | Boolean |
| medecin traitant | Physician responsible for the treatment | nvarchar(100) |
| motif hospitalisation | Reason of hospitalization | varchar(MAX) |
| traitement personnel | Medical treatment | nvarchar(250) |
| diagnostic sorti | Diagnostic of the patient | nvarchar(100) |
| synthese medicale sejour | Resume of the stay | varchar(MAX) |
| actes complementaires | Complementary treatment and Exams | varchar(MAX) |
| prescription sortie | Prescription in the last day of stay | varchar(MAX) |

Table 3.3: Database table *Fiches hospitalisation J0* and description of its fields.

Brief Method Calculation

The demonstration of the method for assessing compliance and percentage calculation with the Quality Criteria of the QLS Indicator is in the following Equation 3.1.

$$\text{Percentage of Quality Criteria} = \frac{\text{Number of Quality Criteria satisfied}}{\text{Number of Total } \textit{Lettre de Liaison} \textit{ Retrouvée}} \times 100\% \quad (3.1)$$

The Quality Criteria are Boolean, and their objective is to verify whether or not they exist in each *Lettre de Liaison*. Hence, it was decided to create a final table with 0 and 1 in the database table created for the analysis of the QLS Indicator. This way greatly facilitates the final analysis of the data, since it can be converted into percentages of 0% and 100% and then average the same column, giving a percentage of the occurrence of that same Quality Criteria. For this reason, a table using 0, when the quality criteria are not satisfied and 1 when it is satisfied. After that and the loading of the table in Power BI, the data type is converted to a percentage and then the average formula (depict in the Equation 3.2) to calculate the percentage of each individual Quality Criteria was applied. In this format, data can be used in a proper way in the visualization part.

The concept of average is presented in the 3.2 Equation Formula.

Let $x_1, x_2, x_3, \dots, x_n$ be a set of numbers.

$$\text{Average} = \frac{(x_1 + x_2 + x_3 + x_4 + \dots + x_n)}{n} \quad (3.2)$$

The average is calculate through the sum of all the numbers in the set following by the division of the

| SQL Clauses and Commands | Usage |
|--------------------------|--------------------------------------------------------------------------------------------------|
| SELECT | Selects which information will be written in the output file, and in which order. |
| INNER JOIN | An inner join combines rows from different tables if the join condition is true. |
| FULL OUTER JOIN | Returns all records when there is similar data in left (table1) or right (table2) table records. |
| UPDATE | Statements enable to edit rows in a table. |
| DELETE | This command deletes data from a database. |
| ALTER DATABASE | Modifies a database. |
| CASE | Used to create different output based on conditions. |

Table 3.4: SQL Clauses and Commands and the respective description

numbers of parcels in the same set of numbers.

Hence, calculate average percentage requires a distinct set of steps than calculating the average of two or more regular numbers, but once we are talking about percentages of 100% and 0% only. The average percentage it will be the same as the average between 0 and 1 multiplied by 100%.

In conclusion, the main advantage to clean and transform the data before the analysis is the performance of the data visualisation tools, as follows reports are built in an easy and flexible form.

3.2.3 SQL Queries - Transforming Data

SQL Databases are powerful and present a lot of commands that can be used to clean and transform almost of the data. It was possible to develop a single SQL Script as a Stored Procedure. A stored procedure is a prepared SQL code and when saved it can be reused over and over again. When a stored procedure is created it generates a single point of reference and the same stored procedure can be called multiple times without replication of the SQL code. Hence, and when data is refresh data transformation can be also refreshed only call this stored procedure.

With SQL queries, it is possible to generate and create other tables from other tables and keep them update. This was the strategy used. With access to the *Indicateurs-QLS* database, intermediate tables with useful were created. In Table 3.4 it is found a brief resume of the SQL Commands used and the respective description.

In the implementation of the ETL process, Quality Criteria are obtained by running SQL queries. In this sense, the data that share the same "where" clause are calculated in the same transformation.

In the script and before each query a *DROP TABLE* command is useful, once it eliminates the need to keep multiple versions of data files and gives a possibility to run the queries using the same table

Listing 3.4: INNER JOIN Syntax.

```
1 SELECT * INTO DonneesEnsemble
2 FROM Fiches_hospitalisation_J0 AS Fiche
3 INNER JOIN compte_rendu_copy AS Compte
4 ON Fiche.fiche_id = Compte.CR_FICHE_J0_ASSOCIE
```

name.

The join operation is one of the crucial query commands. The *INNER JOIN* Syntax presented in Listing 3.4, it selects records that have matching values in both tables selected. The *Fiche id* it is the primary key of the *Fiche d'hospitalisation J0* and the *Fiche J0 associee* it is the foreign key of the *Compte Rendu*. In this case, the primary key represents the identification of the fiche and the foreign key represents the same number in another table that serves as an association identification. When the two numbers are similar all the columns from both tables are saved.

The *SELECT INTO* command replicates data from one table and introduces it into a new table, in our case an intermediate table.

In the data analysis were found a lot of *NULL* values that count as 0 in the final intermediate table, once this value means that the Quality Criteria it is not satisfied. Therefore, an *ISNULL* function, presented in Listing 3.5, returns an alternative value when an expression is *NULL*, in our case 0. If the expression it is not *null* the function returns this expression.

The data in the columns sometimes have rows with wrong characters or text, and this is due to intensive fields to fill, that health professional need to complete every day with useful information. What really happens, it that sometimes they do not have time to complete it and think that no one needs the data, hence these fields are complete with wrong characters, thousands of times.

The *UPDATE* statement, presented in Listing 3.6, is used to change the existing records and text in a table.

With this command, it is possible to build a list of expressions that we consider not valid information in order to substitute them by 0. Thus, the valid information could be analysed by Power BI without problems. For example, in this script the *motif hospitalisation* will be update to '0' in the *DonnéesEnsemble1* table when the cells are part of the following list ('*',',','hg','-',',','Null','null','?').

The *CASE* command is used to create different output based on conditions. An example of a query using this command is in Listing 3.7. The *CASE* command is very beneficial to generate conditional tables. And after transforming all the unacceptable data in 0 statement, it is very useful to convert the rest data in 1 statement, the satisfied cells.

This command goes through diverse conditions and returns a value when the detailed condition is satisfied. Hence, once a condition is true this value is returned and if there are no true conditions, it returns the value in the *ELSE* clause.

Listing 3.5: *ISNULL* and *SELECT* from the Table *DonnéesEnsemble*.

```

1 SELECT ISNULL(patient_id,0) AS patient_id,
2    ISNULL(formulaire,0) AS formulaire,
3    CRH,
4    fiche_id,
5    CR,
6    ISNULL(UF,0) AS UF,
7    date_creation_doc,
8    date_validation_doc,
9    ISNULL(medecin_responsable,0) AS medecin_responsable,
10   date_entree,
11   date_sortie,
12   remise_patient_main_propre,
13   ISNULL(medecin_traitment,0) AS medecin_traitment,
14   ISNULL(motif_d_hospitalisation,0) AS motif_hospitalisation,
15   ISNULL(traitement_personnel,0) AS traitement_personnel,
16   ISNULL(diagnostic_sortie,0) AS diagnostic_sortie,
17   ISNULL(synthese_medicale_sejour,0) AS synthese_medicale_sejour,
18   ISNULL(actes_complementaires,0) AS actes_complementaires,
19   ISNULL(prescription_sortie,0) AS prescription_sortie,
20   CR_PATIENT_ID,
21   CR_FORMULAIRE,
22   CR_FICHE_ID,
23   CR_CR,
24   ISNULL(CR_UF,0) AS CR_UF,
25   CR_NUM_VENUE,
26   CR_DATE_CREATION_DOC,
27   cr_date_validation_doc,
28   CR_FICHE_JO_ASSOCIEE,
29   CR_ENVOI_ZEPRA,
30   CR_IMPRESSION,
31   ISNULL(CR_IdentificationDuSignataire,0) AS CR_IdentificationDuSignataire,
32 INTO ready1
33 FROM [Indicateur_QLS].[dbo].[ready]

```

The *UNPIVOT* relational operator command is used to convert table columns into rows, rotates a table by transforming columns into rows. After the *IN* clause, all the columns desired to convert into row are referred. The *UNPIVOT* function for the Quality Criteria are presented in Listing 3.8.

In Figure 3.4 is represented as an intermediate table, in which the names of the column corresponds to the 12 Quality Criteria. Cells with '1' correspond when Quality Criteria is satisfied and '0' when not satisfied.

After applying the *UNPIVOT* function the final intermediate table looks like Figure 3.5, where the

Listing 3.6: *UPDATE* data from the Table.

```

1 UPDATE DonneesEnsemble1
2 SET medecin_traitant = 0
3 WHERE medecin_traitant IN ('*', '.', 'hg', '-', '/', 'Null', 'null', '?');
4
5 UPDATE DonneesEnsemble1
6 SET motif_hospitalisation = 0
7 WHERE motif_hospitalisation IN ('*', '.', 'hg', '-', '/', 'Null', 'null', '?');
8
9 UPDATE DonneesEnsemble1
10 SET traitement_personnel = 0
11 WHERE traitement_personnel IN ('*', '.', 'hg', '-', '/', 'Null', 'null', '?');
12
13 UPDATE DonneesEnsemble1
14 SET diagnostic_sortie = 0
15 WHERE diagnostic_sortie IN ('*', '.', 'hg', '-', '/', 'Null', 'null', '?');

```

Listing 3.7: CASE SQL Command.

```

1 CASE
2 WHEN synthese_medicale_sejour='0' THEN 0
3 WHEN diagnostic_sortie='0' THEN 0
4 ELSE 1
5 END AS 'DS- Diagnostic Sortie et Synthese Medical',
6
7 CASE
8 WHEN actes_complementaires='0' THEN 0
9 ELSE 1
10 END AS 'Actes Complementaires',
11
12 CASE
13 WHEN prescription_sortie='0' THEN 0
14 ELSE 1
15 END AS 'Traitement Medicamentaux',
16
17 CASE
18 WHEN CR_IdentificationDuSignataire='0' THEN 0
19 ELSE 1
20 END AS 'Identification Signataire',
21
22 CASE
23 WHEN remise_patient_main_propre='oui' THEN 1
24 WHEN CR_ENVOI_ZEPRA=1 THEN 1
25 WHEN CR_IMPRESSION= 1 THEN 1
26 ELSE 0
27 END AS 'remise du patient',

```

numbers of rows were multiplied by the number of Quality Criteria, affecting 6 941 rows.

To resume, after performing all the tasks that make up the transformation phase, the data is ready to be loaded to the destination data-store (Power BI) and then create the visualizations.

3.2.4 ETL Using Power BI

With Power BI it is also possible to treat and transform the data before creating visualizations from the data. A tool that can make ETL process much easier and faster: Power Query using Power BI Desktop. During this dissertation and before finally the ETL using SQL, Power BI was used to try to transform the data and understand how the final data should look like in order to extract meaningful data and visualization. Nowadays, in CHUGA and to produce the reports for Haute Autorité de Santé (HAS) it is normal to use a radar chart, in this way this type of visualization was chosen.

All of these transformations are made possible by choosing the transformation option in the menu of Power Query and then applying the options required for that transformation. Some of the data transfor-

| cr_date_validation_doc | Patient ID | Date entree et sortie | Medecin Traitant | Motif Hospitalisation | Traitement personnel | Diagnostic Sortie | Synthese Medicale Sejour | DS- Diagnostic Sortie et Synthese Medical | Actes Complementaires |
|-----------------------------|------------|-----------------------|------------------|-----------------------|----------------------|-------------------|--------------------------|-------------------------------------------|-----------------------|
| 2019-10-11 17:00:31.4350000 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 2019-10-08 10:28:07.6000000 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| 2019-11-25 11:10:35.3740000 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 2019-11-04 16:36:11.0110000 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 2019-11-21 10:31:15.8140000 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| 2019-12-04 12:27:57.3620000 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 2019-11-21 09:13:29.1470000 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 2019-11-20 19:03:15.7570000 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| 2019-11-22 19:21:13.2060000 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 2019-12-04 12:27:34.5650000 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |

Figure 3.4: Structure of a table with data transformed before *UNPIVOT* Function.

Listing 3.8: UNPIVOT SQL Relational Operator.

```

1  SELECT [formulaire],
2         [fiche_id],
3         [CR],
4         [date_creation_doc],
5         [date_validation_doc],
6         [date_entree],
7         [date_sortie],
8         [CR_UF],
9         [Objective National],
10        Atributo,
11        Valor
12    INTO DonneesEnsemble12
13
14 FROM [Indicateur_QLS].[dbo].[DonneesEnsemble11]
15 UNPIVOT (
16     Valor
17     FOR atributo IN (
18         [Patient ID]
19         [Datee entree et sortie],
20         [Medecin Traitant],
21         [Motif Hospitalisation],
22         [Diagnostic Sortie],
23         [Synthese Medicale Sejour],
24         [DS- Diagnostic Sortie et Synthese Medical],
25         [Actes Complementaires],
26         [Traitement Medicamentaux],
27         [Identification Signataire],
28         [remise du patient])
29 ) AS tableready

```

mation tasks available in the transform tab are:

- Adding or removing columns;
- Changing data types (percentage, int, text, etc...);
- Conditional columns;
- Pivot columns and unpivot rows;
- Replace values with another in the selected columns;
- Filtering rows based on condition.

| formulaire | fiche_id | CR | date_creation_doc | date_validation_doc | date_entree | date_sortie | CR_UF | Objective National | Atributo | Valor |
|------------|-----------------------------------------|-----|-----------------------------|-----------------------------|-------------|-------------|-------|--------------------|-------------------------------------------|-------|
| 40 | OMF- Fiche d'hospitalisation JO CHIL... | 232 | 2019-11-21 11:08:34.3960000 | 2019-11-21 11:08:34.3960000 | 2011/2019 | 2211/2019 | 2462 | 0,0 | DS- Diagnostic Sortie et Synthese Medical | 0 |
| 41 | OMF- Fiche d'hospitalisation JO CHIL... | 232 | 2019-11-21 11:08:34.3960000 | 2019-11-21 11:08:34.3960000 | 2011/2019 | 2211/2019 | 2462 | 0,0 | Actes Complementaires | 0 |
| 42 | OMF- Fiche d'hospitalisation JO CHIL... | 232 | 2019-11-21 11:08:34.3960000 | 2019-11-21 11:08:34.3960000 | 2011/2019 | 2211/2019 | 2462 | 0,0 | Traitement Medicamentaux | 0 |
| 43 | OMF- Fiche d'hospitalisation JO CHIL... | 232 | 2019-11-21 11:08:34.3960000 | 2019-11-21 11:08:34.3960000 | 2011/2019 | 2211/2019 | 2462 | 0,0 | Identification Signataire | 1 |
| 44 | OMF- Fiche d'hospitalisation JO CHIL... | 232 | 2019-11-21 11:08:34.3960000 | 2019-11-21 11:08:34.3960000 | 2011/2019 | 2211/2019 | 2462 | 0,0 | remise du patient | 1 |
| 45 | ORL- Fiche d'hospitalisation JO CHIR | 232 | 2019-12-12 14:56:16.9790000 | 2019-12-12 14:56:16.9790000 | 12/12/2019 | 13/12/2019 | 3951 | 0,0 | Patient ID | 1 |
| 46 | ORL- Fiche d'hospitalisation JO CHIR | 232 | 2019-12-12 14:56:16.9790000 | 2019-12-12 14:56:16.9790000 | 12/12/2019 | 13/12/2019 | 3951 | 0,0 | Date entree et sortie | 1 |
| 47 | ORL- Fiche d'hospitalisation JO CHIR | 232 | 2019-12-12 14:56:16.9790000 | 2019-12-12 14:56:16.9790000 | 12/12/2019 | 13/12/2019 | 3951 | 0,0 | Medecin Traitant | 0 |
| 48 | ORL- Fiche d'hospitalisation JO CHIR | 232 | 2019-12-12 14:56:16.9790000 | 2019-12-12 14:56:16.9790000 | 12/12/2019 | 13/12/2019 | 3951 | 0,0 | Motif Hospitalisation | 1 |
| 49 | ORL- Fiche d'hospitalisation JO CHIR | 232 | 2019-12-12 14:56:16.9790000 | 2019-12-12 14:56:16.9790000 | 12/12/2019 | 13/12/2019 | 3951 | 0,0 | Diagnostic Sortie | 1 |
| 50 | ORL- Fiche d'hospitalisation JO CHIR | 232 | 2019-12-12 14:56:16.9790000 | 2019-12-12 14:56:16.9790000 | 12/12/2019 | 13/12/2019 | 3951 | 0,0 | Synthese Medicale Sejour | 0 |
| 51 | ORL- Fiche d'hospitalisation JO CHIR | 232 | 2019-12-12 14:56:16.9790000 | 2019-12-12 14:56:16.9790000 | 12/12/2019 | 13/12/2019 | 3951 | 0,0 | DS- Diagnostic Sortie et Synthese Medical | 0 |
| 52 | ORL- Fiche d'hospitalisation JO CHIR | 232 | 2019-12-12 14:56:16.9790000 | 2019-12-12 14:56:16.9790000 | 12/12/2019 | 13/12/2019 | 3951 | 0,0 | Actes Complementaires | 0 |
| 53 | ORL- Fiche d'hospitalisation JO CHIR | 232 | 2019-12-12 14:56:16.9790000 | 2019-12-12 14:56:16.9790000 | 12/12/2019 | 13/12/2019 | 3951 | 0,0 | Traitement Medicamentaux | 1 |
| 54 | ORL- Fiche d'hospitalisation JO CHIR | 232 | 2019-12-12 14:56:16.9790000 | 2019-12-12 14:56:16.9790000 | 12/12/2019 | 13/12/2019 | 3951 | 0,0 | Identification Signataire | 1 |
| 55 | ORL- Fiche d'hospitalisation JO CHIR | 232 | 2019-12-12 14:56:16.9790000 | 2019-12-12 14:56:16.9790000 | 12/12/2019 | 13/12/2019 | 3951 | 0,0 | remise du patient | 1 |
| 56 | ORL- Fiche d'hospitalisation JO CHIR | 232 | 2019-10-14 08:29:09.4340000 | 2019-10-14 08:29:09.4340000 | 13/10/2019 | 14/10/2019 | 2461 | 0,0 | Patient ID | 1 |

Figure 3.5: Table from the Database prepared to load in Power BI.

The advantage of the Power Query is that can be scheduled refresh. Every time this query connects to the source of the data, those steps are executed, so that the data is always shaped the way we specified and all Power BI visualizations are refreshed too.

The way you transform data will greatly influence the layout of the dashboard. This is why it was useful to try the ETL in Power BI to make sure that in the end, we can have the right data set analysed.

The ETL process that we did use mainly SQL to extract, transform and afterload, but it is possible nowadays do all these tasks in a lot of different BI applications.

To conclude in this section, it is possible to gather that Power Query is a helpful tool that may be used to get data from different sources and how to cleansing and transforming data with an intuitive interface without to use code.

Next section will present and figure out the visualization part, discussing some design features and shows the final solution of the QLS Indicator dashboards.

3.3 Visualization (FrontEnd)

This section illustrates and describes the major design decisions and requirements that shaped the dashboard system. It also presents figures of the dashboard developed during this thesis. The development was structured in a way that would involve a user's evaluation and feedback at the end of each iteration. This section also outlines the main concepts and features of the prototype dashboard from a user's perspective.

3.3.1 Presentation and Visualization Design - Relationship with Actual Report for HAS

The system developed to display information about the Quality Criteria of the *Lettre de Liaison* aims to answer the mandatory reporting required by the HAS, indicating the percentages of the QLS Indicator. According to the existing method, an example of how information is considered and presented about the QLS Indicator is illustrated in Figure 3.6, highlighting the existing 12 Quality Criteria. This image was taken from the last report to HAS, dated of 2018. The visualization chosen for these indicators was a radar chart, also known as spider charts, which is an adequate approach for visualizing multivariate data.

Figure 3.6 also shows that the number of *Lettre de Liaison* analyzed in 2018 was $n=80$. These 80 *Lettre de Liaison* were chosen randomly from the database. Consequently, the first essential Quality Criteria, *Lettre de Liaison à la sortie Retrouvée*, which is the percentage of the letters found, is always 100%, as only this small random sample is considered the found letters.

Qualité de la lettre de liaison à la sortie (QLS) – hôpital Nord – Détail par critère (%)

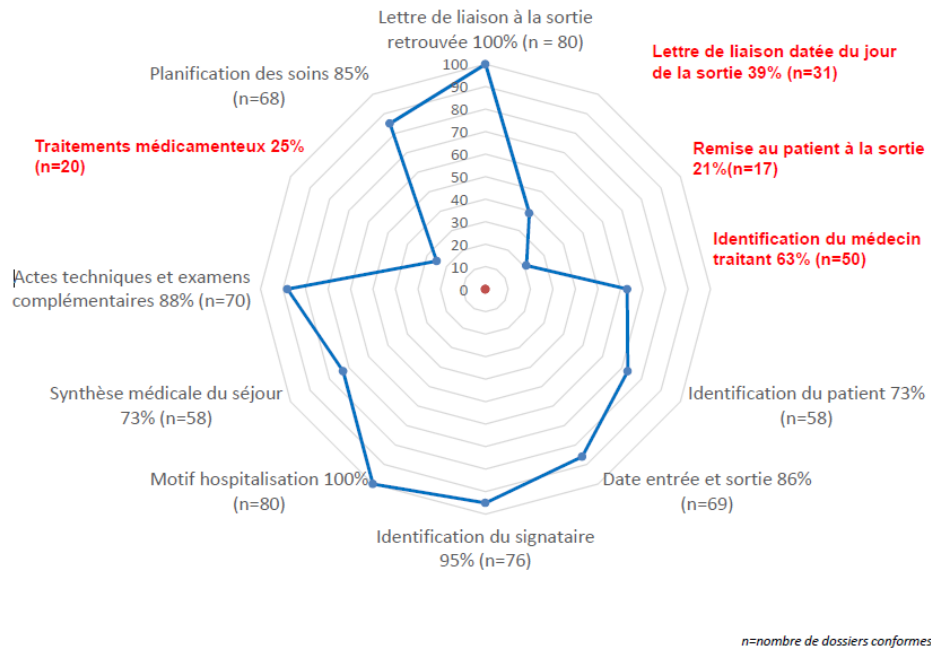


Figure 3.6: Example of QLS Indicator analysis using a radar chart.

This approach has several limitations, the main one being that this number of *Lettre de Liaison* is not significant and is not representative of the whole period analyzed. The national objective is to be above 80% for all the 12 Quality Criteria. Also, 4 out of 12 Quality Criteria are lower than 80% and are written in red.

It is important that the functional features of the dashboard fit with its purposes and engage the end-user work with pleasure and comfort. Thus, using a radar chart, whenever possible in the dashboards prototype, was a requirement of the visualization part. Hence and according to the description of Hanna Nowicki and Carter Merenstein, radar charts are considered a useful way to display diverse observations with an arbitrary number of variables.⁵

In this kind of charts, each variable has an axis and these axes are organized radially around a central point and spaced uniformly, thus depending on the number of the variables different shapes appear. Also, it is very common to have grid lines, that connect the axes and are used as a guideline to create the chart more clear and easily readable. With a radar chart, it is also easy to compare the variables with high or low scores.

This type of chart also presents some problems, such as the importance that viewers could potentially give to the area of the polygons. In Table 3.5 some pros and cons of this type of visualization are

⁵https://www.cs.middlebury.edu/~candrews/showcase/infovis_techniques_s16/radar_chart/

| Advantages | Disadvantages |
|--------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| Very useful for multivariate analysis and finding extremes values | High amount of axes will make the chart unreadable and hard to work with |
| A quick general overview when certain factors are more prevalent than others | If there are many variables comparison of observations can become confusing |
| Analyse all variables at once making it easy to compare all values in one look | Overestimate of the area of displayed polygons |
| Creates a polygon that is more memorable for human mind than a single line | Changing the variables order it may produce a different polygons for the same data, which may or may not confuse users |

Table 3.5: Radar Chart - Advantages and Disadvantages. https://www.cs.middlebury.edu/~candrews/showcase/infovis_techniques_s16/radar_chart/

mentioned.

3.3.2 QLS Indicator Dashboard

This section aims to present the final aspect of the dashboard solution for QLS Indicator. To accomplish the final goal data visualization techniques were used and data was visualized using Power BI Desktop. Visualization data is a reachable way to understand results, identify trends, recognize patterns in data and support reports development. The idea of this dashboard is to take benefits and simplify the task of analyzing healthcare QLS Indicator and even give the possibility of discovering new opportunities for improvements and changes.

It is recommended that the relevant information display in the report should be possible visualize in an average of 5 seconds and contain no more than 6 or 7 visualizations elements. By that reason and in order not to sample too much information on each Tab, it was decided to divide it into three Tabs, being possible to expand them in the menu located in the lower-left corner.

Each dashboard was developed on a control page (.pbix) for presentation to the user. The dashboard is structured in this way:

1. Essential 2 Quality Criteria Tab - This page contains the information related to the first two Quality Criteria that are essential to calculate the next ones as depicted in Figure 3.7 (*Lettre de Liaison a lá Sortie Retrouvée* and *Daté du jour de lá Sortie*).
2. Radar Chart 11 Quality Criteria Tab - The Figure 3.8 illustrates a Radar Chart that incorporates an overall view of the rest of Quality Criteria Calculated (9 of these Quality Criteria are mandatory by HAS and the other two ones were asked by CHUGA). This chart allows time filtering, UF and Quality Criteria filtering too, to have the desired display.
3. Quality Criteria in Information Table Tab - Figure 3.9 shows the raw data that it's found in the *Fiche d'hospitalisation* and also a graphic that shows the number of hospitalisations through time with

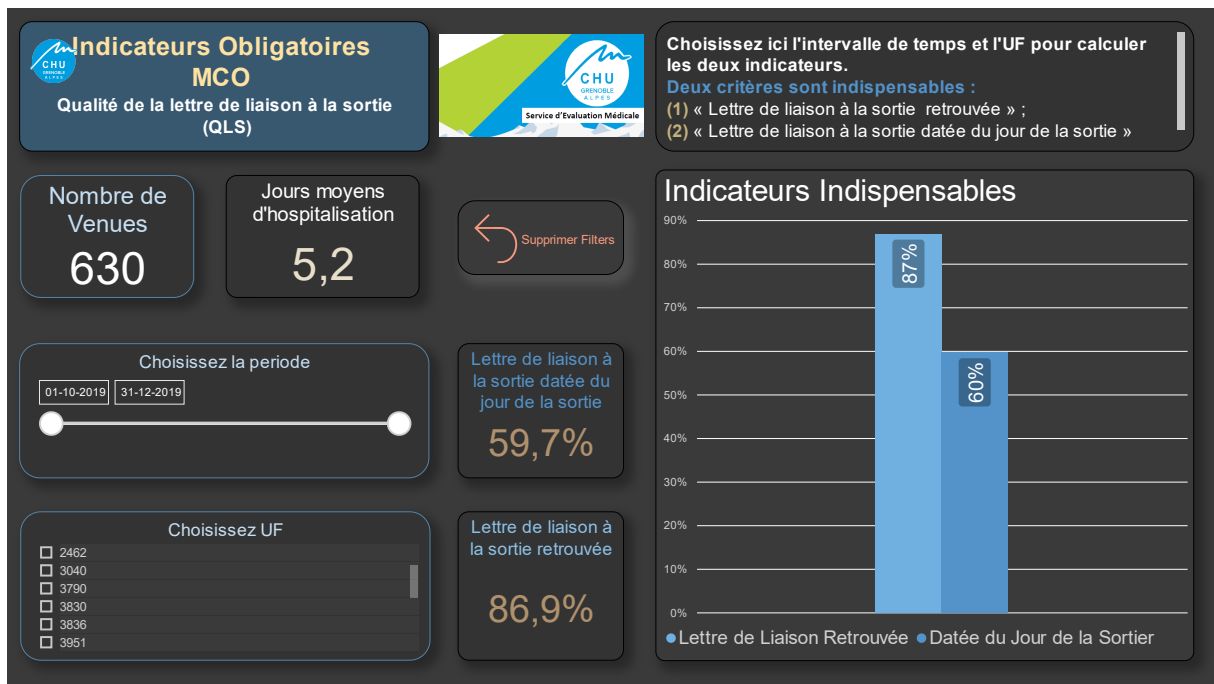


Figure 3.7: Essential 2 Quality Criteria Tab Dashboard.

filtering options, either through time or UF. This raw data is visualized in a table where the columns name it's the Quality Criteria correspondent.

This dashboard is currently unavailable in CHUGA for the official use for analysis and supports the HAS mandatory report. However, the dashboard to be implemented will facilitate CHUGA users' understanding of data and assist their decision-making process through improved information presentation and visualization.

Each dashboard tabs, even if different because of the defined metrics and information displayed, each of them have a very similar design and colours, in order to maintain consistency. This way as time goes by and users interact more with the platform, it is easy to find the needed information in each dashboard.

3.3.2.A Design Features of the Dashboard

As a whole, and according to Ghazisaeidi et al. (2015), developing high-quality performance dashboards in the context of the healthcare sector with their environment and with the intrinsic use of certain technologies, needs to address several issues about data sources, data quality, dashboards integration to source systems, and data presentation to a user.

All of the dashboards developed during this work followed the same organization principle and the same layout and colours, to facilitate the identification and user interaction. Hence, with consistency in

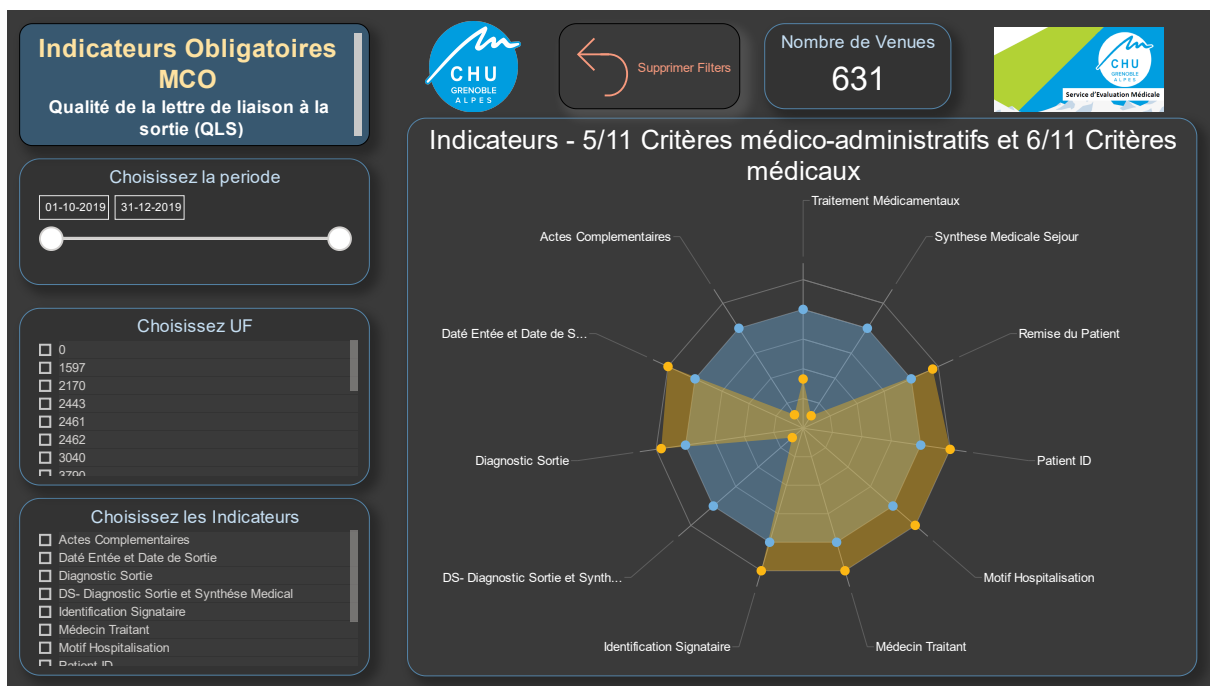


Figure 3.8: Radar Chart 11 Quality Criteria Tab Dashboard.

using the same visualization and layouts between groups will be far easier to read.

Afterwards, many evaluation meetings were held throughout the dissertation and were essentially used to assess the state of development of the dashboard, clarifying doubts regarding the data and discussing visualization techniques to be used as well as the necessary buttons.

Subsequently, the dashboards presented are the last iteration.

Different font types and sizes should not be mixed, thence and despite different sizes, using the biggest ones in the most important titles and captions, only Arial type font was used.

One essential button, *Supprimer Filters* which means remove all filters, it's presented in all the tab dashboards. This button was added after understanding the necessity too change the filters and start over and over again, to display the information desired choosing different periods of time or UF. Also, all of them present the same structure and colours in order the end-user feels familiar with these buttons, every time the tab is changed.

Other aspects related to information visualization, such the graphical elements, textures, orientation of line or object, volume of shape, colours low and use of grid lines graphs described, should be considered in the information visualization design.

In conclusion, a good balance between visual complexity and information utility is necessary and fundamental.

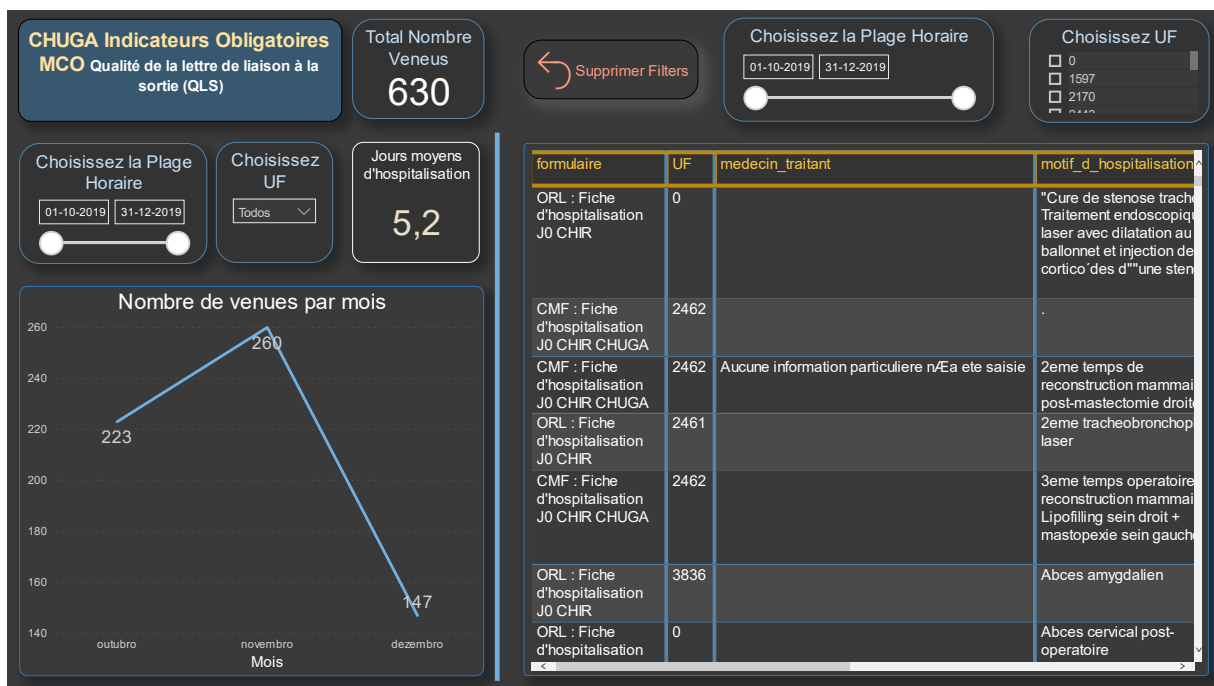


Figure 3.9: Quality Criteria in Information Table Tab Dashboard.

Essential 2 Quality Criteria Tab Dashboard - Figure 3.7

In this first Dashboard Tab, as illustrated in Figure 3.7, only information related to the two indispensable Quality Criteria are displayed. It was decided to illustrate these two first indicators separately to the other ones for the following reasons:

1. In the absence of one of these two Quality Criteria the percentage of these two and the other 10 Quality Criteria are 0. Considering that the *Lettre de Liaison* it is not found the others elements are automatically not found too;
2. To calculate this two Quality Criteria another table that matches with the table of *Fiche d'hospitalisation J0* is demanded, in order to have the number of hospitalisation and the number of *Lettre de Liaison*, to calculate the percentage of which *Lettre de Liaison* found;
3. To calculate the difference between the day of the hospitalisation and the day of discharge, to have the average days of hospitalization and;
4. Lastly, the percentage of the other Quality Criteria only referred to the *Lettre de Liaison* found in the database and it could be confusing have in the same graph and tab. Nowadays, it is not confusing and it could be observed in Figure 3.6 (related to the actual radar chart) because the first essential Quality Criteria is always 100% since the process is manual.

Radar Chart 11 Quality Criteria Tab Dashboard - Figure 3.8

Choosing the right visualization elements is key to making sure your end-users understand what they're looking at. With this perspective and counting on the fact that the actual report for QLS Indicator uses a radar chart, it was used a radar chart to present the information related to the rest of Quality Criteria. Also, in this dashboard tab, it is possible to filter the data choosing the period of time desired, the Quality Criteria and the UF. A rectangular element displaying the number of hospitalisation depending on the chosen filters is further part of this tab dashboard, called *Nombre de Venues*.

In this radar chart 11 Quality Criteria are displayed, in which 9 of them are mandatory in the report by HAS and 2 of them (*DS- Diagnostic Sortie et Synthèse Medical de Séjour* and *Diagnostic de Sortie*) were asked by the end-user to have more information about the *Lettre de Liaison*.

Observing the Radar Chart, it is possible to observe that each variable/attribute is provided with an axis that starts from the centre, in which all axes are arranged radially, with equal distances between each other, keeping the same scale. Radar charts have the peculiarity for visualizing similarities of quality data, as in this case study. Also, some grid grey lines that connect from axis-to-axis are seen. These grid lines are used as a guideline and in this case, where percentages between 0% and 100% are used, these gridlines are spaced by 20% between each other, which facilitate the interpretation of the different variables percentages.

Taking into account that the national minimum percentage objective for each Quality Criteria is 80% and in the sense to facilitate the interpretation, an area builds from points at the same distance from the centre indicating 80% was placed. Herein, this area is blue and the regular polygons formed has his lines in the fourth grid line counting from the centre, once each grid line represents 20% of the total.

Each Quality Criteria value percentage is plotted along its axis and all these points connected to form a polygon. The Quality Criteria can be easily correlated each along their axis, and in general differences are understandable by the size and shape of the two polygons, the orange one (with the 11 Quality Criteria) and the blue one (representing the national minimum objective). Hence, this radar chart compares the average percentage in each attribute making it easy to compare all the Quality Criteria in one look, also offers a good way to find extremes.

Quality Criteria in Information Table Tab Dashboard - Figure 3.9

Graphs are more powerful for tasks that demand identifying relationships and number values (i.e. comparing and pattern recognition) although tables are greater for tasks that need extracting particular text and connecting them into an overall judgment (Read Aaron, 2009).

The dashboard tab presented in Figure 3.9 it is not the most important one, once it not display the percentage regarding the Quality Criteria of the QLS Indicator. Although, this tab was asked with the intuit of analysing the raw data in the cases that the end-user finds some percentage strange and so

he/she could understand what is happening in the most diverse Quality Criteria. Again, in this dashboard tab, it is possible to filter the data choosing the period of time desired, the Quality Criteria and the UF.

In the left side, it could be observed also the number of hospitalisations distributed by the month of the year, in our case only data related to the October, November and December were analysed.

In the right side, it could observe the information table, in which the columns name are the Quality Criteria name. At the bottom of the table, it is possible to scroll from right to left side and vice-versa with the cursor through the rest of the columns/Quality Criteria. This figure doesn't show a lot of information purposely, to protect the patient and healthcare professionals information.

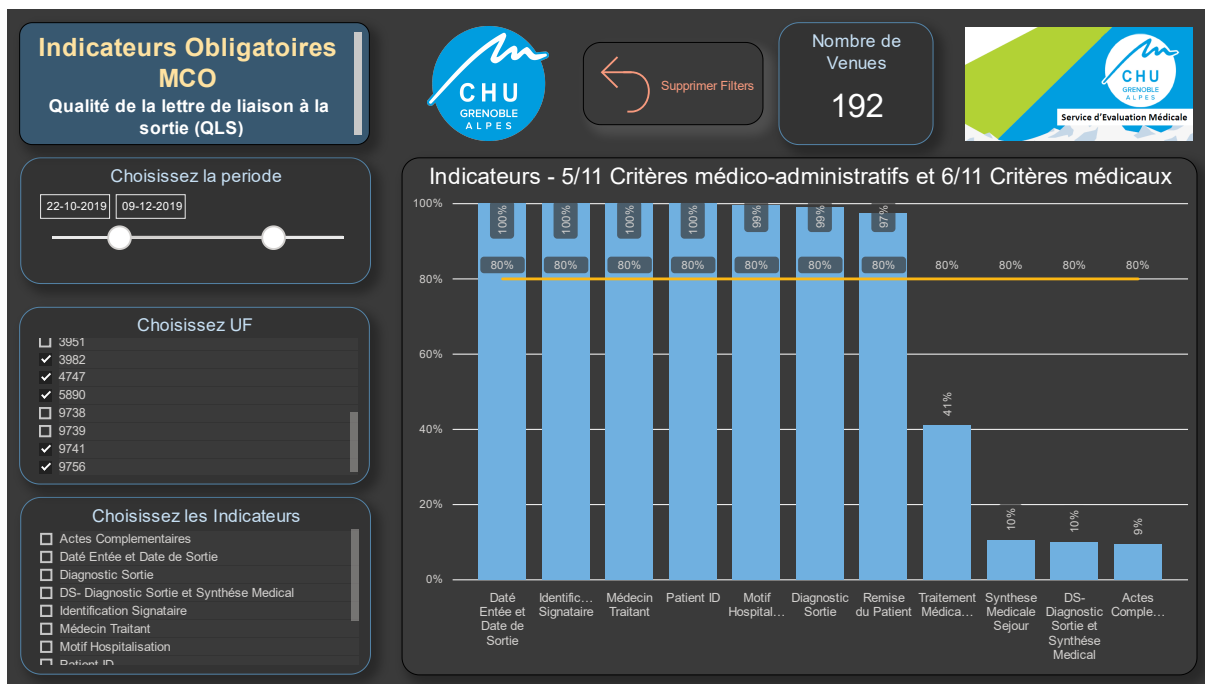
3.3.2.B Others Dashboard Reports Developed

Information can be displayed in various different forms, such as numbers, graphs, tables and bars. Figures 3.10(a) and 3.10(b) illustrate other different ways to present the same dataset that use a similar design to keep harmony. This dashboard was requested to show end-users other ways to present the information and to choose which ones fit better their requirements.

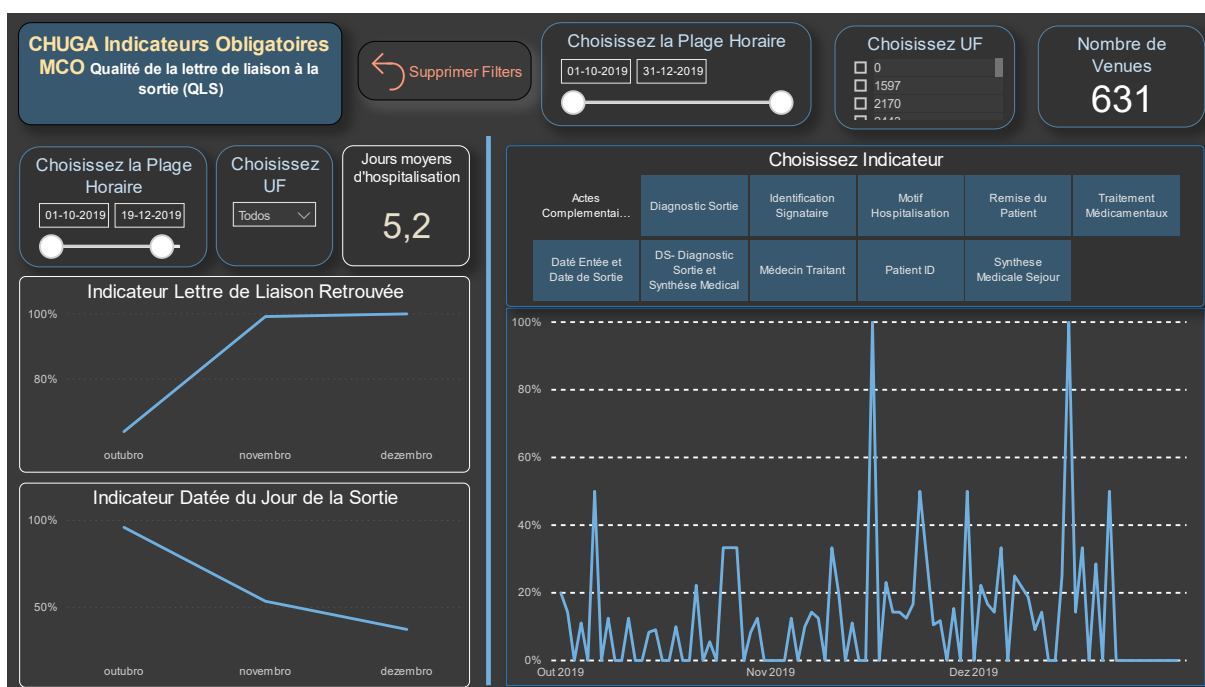
Figure 3.10(a) shows the data analysis in a line and clustered column chart. We can observe the 11 percentages of the Quality Criteria displayed in the columns and the minimum objective national of the 80% in the orange line. Further it is possible to notice that data, which are filtered by a period of time and UF, exhibit the information related to 192 hospitalisations.

Figure 3.10(b) presents each Quality Criteria detail at a time using a timeline chart. To display the desired Quality Criteria, a rectangular card just above the timeline chart allows you to choose one at a time. In this Figure the Quality Criteria selected is the *Actes techniques et Examens Complementaires*. Thus, it is possible, for example, to know immediately which day had the lowest or highest percentage in a chosen Quality Criteria, merely by hovering the cursor over the data.

Multiple interesting ideas and recommendations for implementing the presentation and visualization of information on a dashboard were held. In such a way, it is consider important to evaluate the display of information.



(a) Line and Clustered Column Chart 11 Quality Criteria Tab Dashboard



(b) Time Line Chart 11 Quality Criteria Tab Dashboard

Figure 3.10: Examples of other Dashboards.

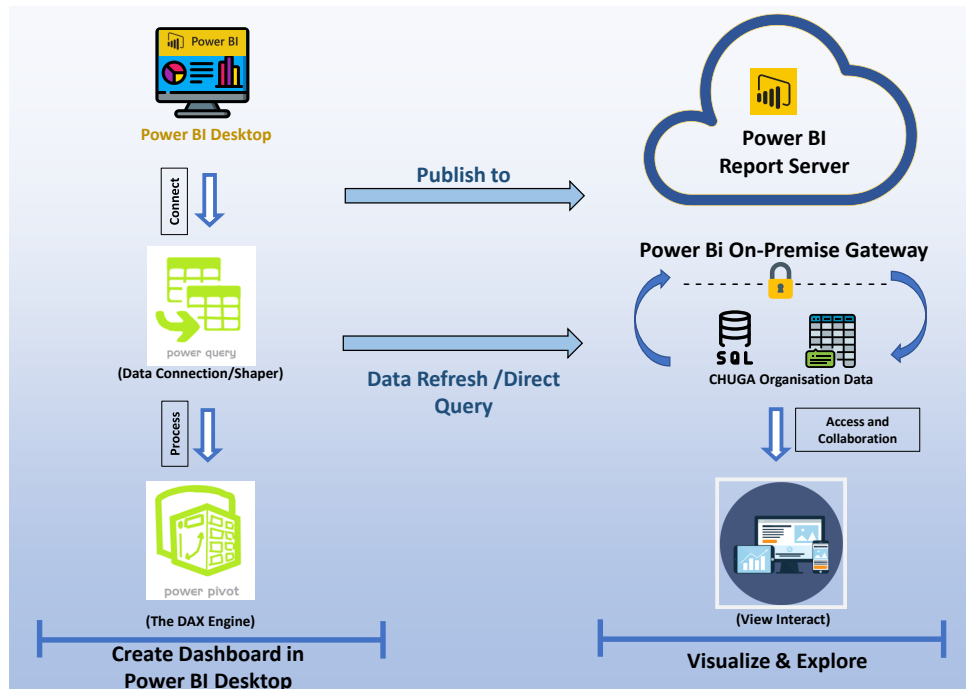


Figure 3.11: Process Flow in Power BI. This Figure is divide in two main parts, on the left side it is related to Power BI Desktop functionalities, and the right part related to the Power BI Report Server, both are components of the Power BI Microsoft. Power BI Desktop incorporates two essential tools, the Power Query and Power Pivot.

3.3.3 Power BI Dashboard Report Development

This section aims to discuss how dashboard reports in Power BI were developed and also shared with others.

In Figure 3.11 it's presented a simple scheme about how Power BI was used to create the dashboard and visualize and explore it with others. All the dashboards reports presented in the last section were developed in Power BI Desktop and shared with the collaborates through Power BI Report Server.

The data tables needed for visualization is already stored in the CHUGA SQL Server Database. The two database tables presented in the section about ETL are the ones used to feed the dashboards reports. Currently, interoperability that is the capability of software making and exchanging the use of information. Hence, SQL tables were connected with Power BI using just a few clicks, in the *Get Data Menu*, with the possibility of updating this data with time intervals defined.

It was possible to store and manage the information of Power BI dashboard in the Power BI Report Server web portal. This was possible, because CHUGA purchased Power BI Server via Power BI Premium, allowing all the CHUGA collaborates publish and share their dashboard through the organization. With Power BI Report Server it is possible to display and manage dashboard via a web portal accessing from the cloud.

| DAX Function | Description |
|--------------|---------------------------------------------------------------------------------------------|
| AVERAGE | Returns the average (arithmetic mean) of all the numbers in a column. |
| COUNT | Counts the number of cells in a column that include text/numbers. |
| COUNTA | Returns the total number of cells in a column that present a not empty value. |
| COUNTAX | Counts nonblank results when assessing the result of an expression over a table. |
| COUNTBLANK | Returns the number of blank cells presented in a column. |
| COUNTROWS | Returns the number of rows in the particular table, or in a table defined by an expression. |
| DATEDIFF | Returns a table that represent the difference between two tables (tables with dates). |
| FILTER | Returns a table with the filter condition desired. |
| DIVIDE | Calculate the requested division between two numbers or returns BLANK() on division by 0. |

Table 3.6: Power Pivot - DAX Functions Description. <https://docs.microsoft.com/en-us/dax/datediff-function-dax>

With on-premises data gateway, it is able to support a fast and secure data transfer. In this way SQL databases connect with Power BI Report Server, keeping the data updated.

Subsequently, when we give access to a specific dashboard report to the target coworkers, it is only needed to send the direct link by copying the Uniform Resource Locator (URL). Users only can view and interact with the dashboard and don't have the permission to edit it. Also, it's possible to control how much time each different people spend using the dashboard.

Lastly, and thinking in one of the goals related to the mandatory report by HAS, all dashboards contain an export option, in order to generate a PDF report containing all visualization elements that are important for analysis.

Power Query and Power Pivot (DAX)

While Power Query is used to getting, clean and transform the data (able to do the ETL process), Power Pivot explore the data, offering the possibility to create measures, model data and create news additional columns in our dataset. These two tools complement each other.

As some of the values were needed (like the number of hospitalisations, the average days of stay in the hospital or the percentage of the *Lettre de Liaison* found between others) the functionalities of Power Pivot were significantly useful, to explore the data. Power Pivot uses a Data Analysis Expressions (DAX) language, that represents a formula language very similar with functions in *Excel* formulas.

Using DAX language some measures and an extra column were calculated, and in Table 3.6 the DAX Functions are described, the ones used to develop the dashboard. Another advantage is when the user changes the filters all the values are recalculated too. The DAX functions presented in the table are

from text, date and time, statistical, math and informational functions category.

For example, the *DATEDIFF* operation was used to build an extra column calculating the difference in days between the first day of hospitalization (*Daté de Entrée*) and the day of discharge (*Date de Sortie*). Afterwards, using an *AVERAGE* Function in this column, the average of the hospitalization days was calculated, changing when the user changes the filter, for example, the period of time.

3.4 Summary and Conclusions

The *Lettre de Liaison* is essential for all French National Hospitals since its quality assess the Hospital through a mandatory report by Haute Autorité de Santé (HAS).

The *Lettre de Liaison* needs to have at least 12 Quality Criteria, and depending on their existing this letter has high or low quality. The *Lettre de Liaison* is a good healthcare indicator because represents a higher chance in the continuity of healthcare ensured.

This dissertation work on extracting and making available the QLS Indicator. This indicator measures the quality of the *Lettre de Liaison*.

Nowadays, the process to analyse data related the QLS Indicator is manual, and it only includes 80 *Lettres de Liaisons* and this number it is not significant during a year.

Hence, to have a better perception and automated the interpretation and analyses of the data, dashboards were developed. These dashboards were built using Power BI Desktop and shared with the end-user through the Power BI Server, via a URL link and where data can be refreshed/updated.

All dashboards share a common purpose, that is to present the right information quickly. The dashboard solution needs to be accessible and user friendly.

Information visualization is an important component and information can be presented in many various ways, such as numbers, graphs, tables and bars. The section about Visualization presents the dashboard reports using the same dataset in different ways (e.g.radar chart, bar charts and tables).

4

Evaluation

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| 4.2 Evaluation of 2019 data related to Medicine and Surgery activities in CHUGA | 65 |
| 4.3 Summary | 69 |

The evaluation activities for assessment of the developed dashboard took place across two dimensions:

- A survey of the users' subjective satisfaction about the dashboards and;
- Presentation of the performance of the prototype dashboard including data from *Lettre de Liaison* during the entire year of 2019.

4.1 User Satisfaction Survey

This section describes the user satisfaction survey at Centre Hospitalier Universitaire Grenoble Alpes (CHUGA) respondents gave their feedback on the developed prototype clinical dashboard concerning the Qualité de la Lettre de Liaison à la Sortie (QLS) Indicator. As such, an important aspect of assessment is the satisfaction of the target users of the dashboard.

Users Participants

A total of 10 participants who tested the dashboard are workers at CHUGA, coming from three age groups: 30% of participants between 18 and 35 years old, 40% between 35 and 50 years old and the remaining 30% between 50 and 65 years old. Half of them are female and half are male (see Table 4.1). Participants come from two different departments in CHUGA, seven participants (70%) belong to the Digital Systems Department (*Direction des Systèmes Numériques*), and three (30%) belong to the Risk and Quality Management Department (*Direction Qualité Gestion des Risques*). Some of the seven participants from the Digital Systems Department had little or no familiarity with the QLS Indicator. Two of the participants work regularly with Power BI, developing other dashboards. The remaining, work in pilot projects related to the development of Information System (IS) tools for the hospital similar to this dissertation work. One of the participants, from the Risk and Quality Management Department, works on data extraction from various activities for the reorganization of some departments at CHUGA, another respondent is the responsible for quality management for drug treatment. Finally, one participant works in the coordination of the pilot projects in the risk management of the various indicators, including the QLS Indicator.

| Gender n (%) | | Age (years) (Between) | | | Department | |
|-----------------|------|--------------------------|-------|-------|--------------------------------------|------------------------------------------|
| Female | Male | 18-35 | 35-50 | 50-65 | Direction des Systèmes Numériques | Direction Qualité Gestion des Risques |
| 5 | 5 | 3 | 4 | 3 | 7 | 3 |
| 50% | 50% | 30% | 40% | 30% | 70% | 30% |

Table 4.1: Feedback Participants Characterization.

The satisfaction survey evaluation had four sections:

1. Usability questionnaire (section 4.1.1);
2. Dashboard specific usability and aesthetics questions (section 4.1.2);
3. Open questions about its potential and future deployment (section 4.1.3), and;
4. Dashboards coloring evaluation (section 4.1.4).

4.1.1 Usability questionnaire

This questionnaire had the objective of evaluating the dashboard in terms of interactivity, potential and usability. Participants received a link by email to access the dashboard as well as the link to the online satisfaction survey form. A description of the dashboard was also included in the link as well as the specific origin of the data.

For the usability questionnaire, the System Usability Scale (SUS) questionnaire was used. The SUS questionnaire was originally developed by John Brooke in 1986. It permits the evaluation and assesses a wide variety of products and services, including hardware, software and applications (Martins et al., 2015). These 10 questions enable to a quickly and inexpensively evaluate the usability of the dashboard, develops in this dissertation.

This questionnaire consisted of 10 multiple choice questions, being the possible answers given on a scale of 1 to 5, where 1 corresponds to *Strongly Disagree* and 5 corresponds to *Strongly Agree*. The 10 questions from the original SUS are presented in Table 4.2.

The original SUS questionnaire has items that alternate between positive (odd-numbered questions) and negative wording (even-numbered questions). This was created with the intuit of reducing biases. One of the disadvantages is the misinterpretation of the questions. To get around this, all the questions

| SUS Odd-Numbered Questions | SUS Even-Numbered Questions |
|----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| 1. I think that I would like to use this system frequently. | 2. I found the system unnecessarily complex. |
| 3. I thought the system was easy to use. | 4. I think that I would need the support of a technical person to be able to use this system. |
| 5. I found the various functions in this system were well integrated. | 6. I thought there was too much inconsistency in this system. |
| 7. I would imagine that most people would learn to use this system very quickly. | 8. I found the system very cumbersome to use. |
| 9. I felt very confident using the system. | 10. I needed to learn a lot of things before I could get going with this system. |

Table 4.2: The Original 10 Item Questionnaire from System Usability Scale (SUS). Odd-numbered questions are positively worded and the Even-numbered are negatively worded.

| User | SUS Questions | | | | | | | | | | Total | Total x 2.5 |
|----------------|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|-------------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | |
| 1 | 3 | 4 | 3 | 4 | 2 | 3 | 3 | 4 | 4 | 3 | 33 | 82.5 |
| 2 | 4 | 3 | 3 | 4 | 3 | 2 | 2 | 3 | 4 | 3 | 31 | 77.5 |
| 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 39 | 97.5 |
| 4 | 3 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 3 | 4 | 37 | 92.5 |
| 5 | 3 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 3 | 3 | 36 | 90 |
| 6 | 1 | 2 | 3 | 4 | 3 | 3 | 4 | 3 | 3 | 4 | 30 | 75 |
| 7 | 0 | 3 | 3 | 4 | 3 | 2 | 3 | 3 | 3 | 3 | 27 | 67.5 |
| 8 | 0 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 35 | 87.5 |
| 9 | 2 | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 4 | 33 | 82.5 |
| 10 | 2 | 2 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | 3 | 25 | 62.5 |
| Average | 2.2 | 3.3 | 3.5 | 3.7 | 3.1 | 3.2 | 3.4 | 3.4 | 3.4 | 3.4 | 32.6 | 81.5 |

Table 4.3: SUS scores for the 10 questions and respective averages, using 10 participants from CHUGA.

were formulated with positive wording, for this dissertation evaluation. A SUS version with all positively worded questions has been tested and similar results, having both positive and negative worded questions were achieved.¹ It was thus decided to use all the SUS positively worded questions, altering the negative words for their positive synonyms.

SUS Score

The responses to the SUS questionnaire could be subsequently converted into a SUS score, using the following criteria:

- For odd-numbered questions (or positive wording questions): subtract one from the user response;
- For even-numbered questions (or negative wording questions): subtract the user responses from 5;
- Sum the converted responses of each user and multiply by 2.5;
- Lastly, calculate the average SUS score.

Table 4.3 presents the evaluation of the dashboard by the participants (already in SUS scores). The average SUS score regarding the evaluation of the QLS Indicator Dashboard is 81.5 points.

The obtained SUS average score, can be compared with a baseline score of 68 points, which is the considered standard score of a good system in terms of usability. Systems evaluated with SUS average score below 68 points can be considered as needing to be strongly improved on usability. Otherwise, systems with SUS score above 68 points are considered to have good usability.

¹<https://measuringu.com/positive-negative/>

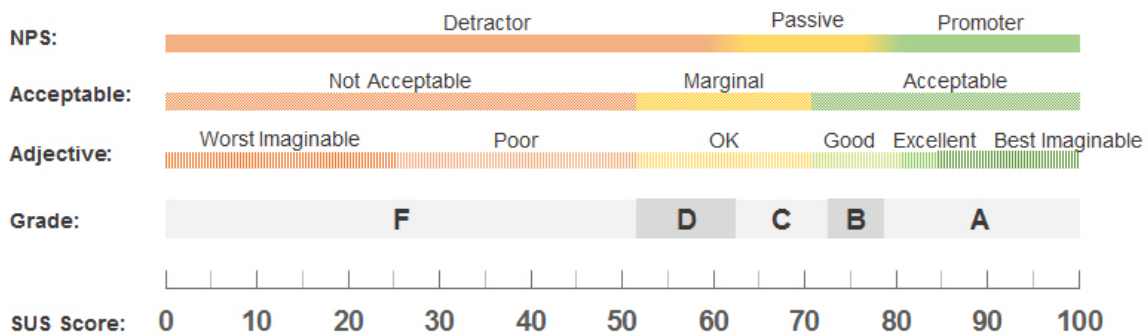


Figure 4.1: A comparison of the adjective ratings, acceptability scores, and grading scales, in relation to the average SUS score (Bangor et al., 2008).

The standard reference score can be more accurate (as Figure 4.1 shows) considering that systems with average scores above 74 points have very good usability and are pleasurable for participants. Average scores above 80 points are considered to be very usable systems.

The average SUS score for the dashboard developed in this dissertation is 81.5 points, above 80 points, a value from which excellent usability (adjective rating scale in Figure 4.1) is considered.

Concerning the score of some of the individual SUS responses scores (see Table 4.3), in the first SUS question the average score is below 3, this is expected as the majority of participants were not exactly future end-users of the dashboard, while the question asked if they would use this system frequently. The questions that obtained the lowest score were questions 5 and 6. These two questions are related since both are associated with the integrity and consistency of the dashboard. One possible explanation could be for the fact that the 12 Quality Criteria of the QLS Indicator were not all presented in the same tab (Figures 3.8 and 3.9 from the visualization section).

The two answers with the highest score were given to questions 3 and 4. These two questions are also related, as one considers the ease of use of the dashboard and the other one the need for technical support. It is possible to conclude from the responses that the participants find the dashboard easy to use without prior technical support.

4.1.2 Dashboard specific usability and aesthetics questions

Table 4.4 presents the answers to the questions related to the dashboard usability, aesthetics, subjective satisfaction and future deployment of the dashboard in daily work. As in the SUS questionnaire, these answers were rated in the same scale between 1 and 5, where 1 corresponds to *Strongly Disagree* and 5 corresponds to *Strongly Agree*. Overall, answers had an average score above 3.5, which is very good and could show that the dashboard is a not so complicated system to be used and interpreted.

| Questions | Average Score of the 10 Participants |
|----------------------------------------------------------------------------------------------------------------|--------------------------------------|
| 1. It is relatively easy to understand which buttons to choose the Time, UF and indicator you want to analyze. | 4.7 |
| 2. The indicators and graphs are presented in a great way. | 4.0 |
| 3. The dashboard uses beautiful and "harmonious" colors. | 3.7 |
| 4. The "Clean Filters" button is useful. | 4.5 |
| 5. The text font as well as the position of the titles are appropriated. | 4.0 |
| 6. It is easy to read the letters and words written on the screen. | 3.9 |
| 7. The radar chart meets expectations. | 4.7 |
| 8. I think it will be easy to use it to produce reports for the HAS certification. | 3.7 |
| 9. The dashboard will help identify areas for improvement in the QLS Indicator. | 4.0 |
| 10. These scorecards will help make decisions to improve QLS percentage (towards the national target of 80%). | 4.2 |
| Total Average | 4.2 |

Table 4.4: Questions about dashboard simplicity, aesthetics and subjective satisfaction and also suggestions for a future deployment of the dashboard in daily work.

Questions 3, 6 and 8 scored below 4 on average. One of them is related to the used colours system, another one concerning readability and the last is related to the production of the mandatory report for Haute Autorité de Santé (HAS). As the design features play an important role, it is crucial to think about how the information should be visualized and presented. Since these features are mainly subjective, one possibility it is to give the possibility of choosing the desired presentation format. For example, to pick the favourite text font. The average score of answers to questions 9 and 10 shows that participants believe that the dashboard will improve the analysis of the QLS Indicator and will also help in the decision-making process. That could help to improve the average percentage of the Quality Criteria of the *Lettre de Liaison*.

Concerning the functional part of the dashboard, questions 1, 4 and 7 obtained an average score above 4.5. In a general sense, the buttons to filter the data (like an interval of time and Unité Fonctionnelle (Unité Fonctionnelle (UF)) were easy to use and understand.

Similarly, the button that clears all the filters and resets the initial data was considered very useful, keeping the dashboard stable dynamically. Plus, it was considered that the radar charts met the expectations and are a great way to compare multivariate variables.

4.1.3 Open questions about potential and future deployment

The questionnaire included open questions asking participants to share their opinions about their daily work and suggest improvements in specific characteristics (See Table 4.5 presents the questions).

| Open Questions |
|---------------------------------------------------------------------------------------------------------------|
| 1. What did you improve in this dashboard? |
| 2. Which characteristics should be presented differently? |
| 3. Do you think this dashboard and similar ones will help your work, in the health quality indicators? |
| 4. How do you think is the future of healthcare in CHUGA? |
| 5. What is the most inconvenient thing you need to do in your daily work, regarding this indicator? |

Table 4.5: Open questions about its potential and future deployment.

Participants provided the following suggestions:

- Develop a button with a link to detailed documentation and help about the system;
- Put the filters list in the left side instead of the right side of the dashboard and put more contrast on the shadows;
- Add labels to Unité Fonctionnelle UFs, instead only providing the numbers (for example the UF numbered 201, is the Unit for *Rhumatologie* - Rheumatology);
- Change the orientation of some percentages in the bar charts, displaying them horizontally instead of vertically;
- Add the Pole division level above the UF (related to the structure of the hospital.)

One of the participants also referred that it could be interesting to display the numbers of re-hospitalisations for the same cause or in a short period. Such changes and implementations are all possible and for some of them the information it is ready. One other suggestion, for the deployment of the final dashboard, was to ask the final user more features should be added.

Regarding the importance of using a dashboard in the context of healthcare indicators, all 10 CHUGA participants agreed that will be possible with a similar dashboard to have almost real-time indicators in others areas, which could be used on one hand to raise some practices and on the other hand, to follow up the actions implemented.

Two of the participants believe that in the future the institution could rely on preventive medicine instead of reactive medicine.

Lastly, the evaluation questionnaire asked what was the most inconvenient and bothersome thing respondents need to do in their work related to the production of indicators. Four in ten (40% of participants) responses to this question referred that it is the manual collection of data and the time-consuming search for data in the medical records. They also mentioned that this work should be done automatically and this is one of the activities in more need for improvement in information management.

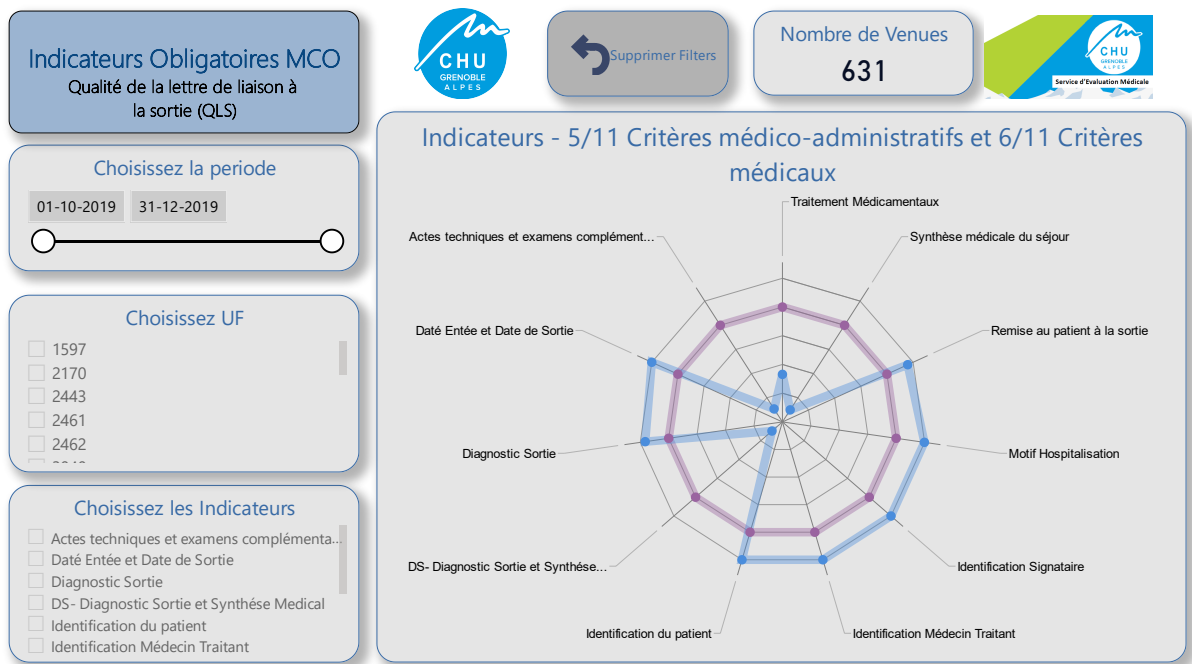


Figure 4.2: MCO Dashboard prototype with different colours and white background.

To conclude, in general participants find that the implementation of more tools like the developed dashboard is very important in several departments soon (some of the indicators and data are also analysed using Power Bi at CHUGA currently).

4.1.4 Dashboards Coloring Evaluation

Figure 4.2 illustrates the dashboard prototype with the same information, but with light colours and white background.

The appropriate use and choice of the colour scheme may help to avoid distraction while improving and facilitating the comprehension of given information displayed on a dashboard. Figure 4.3 summarizes the analysis and percentages of feedback to each of the 6 questions on different dashboards configurations.

Regarding the question about the preferred dashboard background 60% of participants chose the white background. These participants agree that this format is preferable while recommending some changes, mainly the contrast of the colours.

Two of the participants mention that they prefer the radar chart with all the area below the line covered, like in the one presented in the back background dashboard.

Also, the same percentage of participants prefer to use a white background when using the dashboard for long periods.

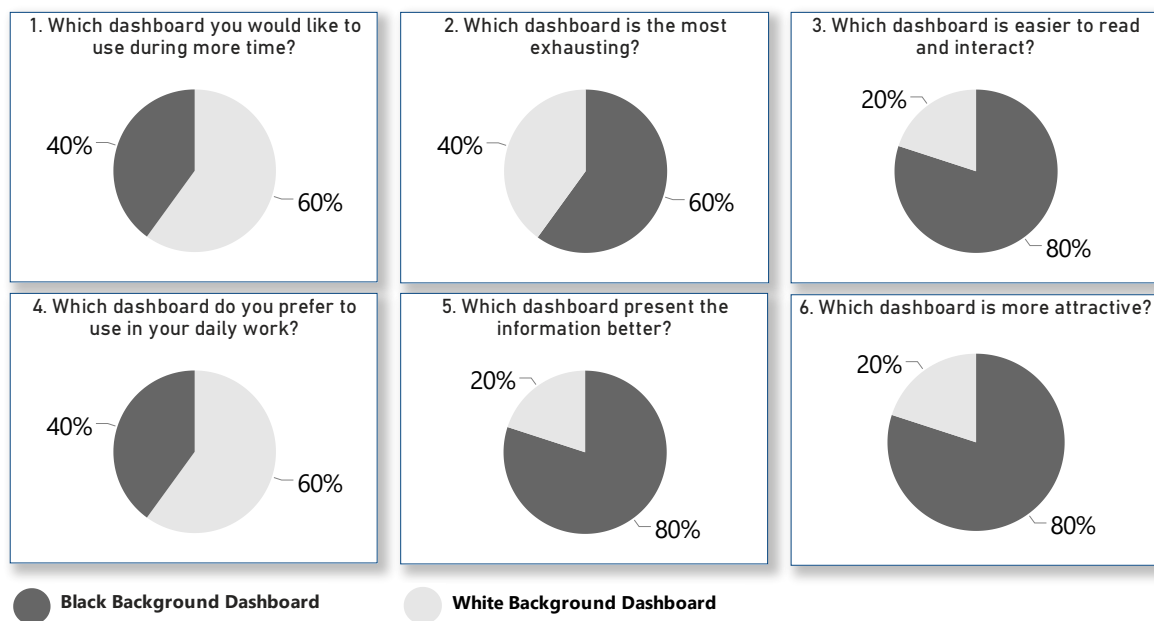


Figure 4.3: Feedback Percentages of the Questions related with the comparison between the Dashboard with a Black Background (Figure 3.8 Visualization Section) and the Dashboard Prototype with a White Background (Figure 4.2 above).

Related to the reading part and the way the information is presented, 80% of the participants prefer the black background dashboards.

An open question about the importance of the colours in this type of tools was included, and all of the participants agree that the choice of the colours and details, like some lines and the disposition of the information, helps reading, highlighting the targeting information.

One recommendation for the implementation of this and other dashboards is to ask end-users directly about what colours they prefer.

4.2 Evaluation of 2019 data related to Medicine and Surgery activities in CHUGA

The Risk and Quality Management Department at CHUGA requested for the analysis of all the *Lettres de Liaison* in the databases in the year of 2019, use the developed dashboard.

Figure 4.4 depicts the analysis of all the *Lettres de Liaison* from of 2019, covering the Medicine and Surgery activities with the dashboard I developed. The Obstetric activity was not evaluated and displayed in the dashboard of the figure, but this was a test to the dashboard I developed. Altogether the analysis of these data resulted in almost 27 thousand *Lettre de Liaison*.

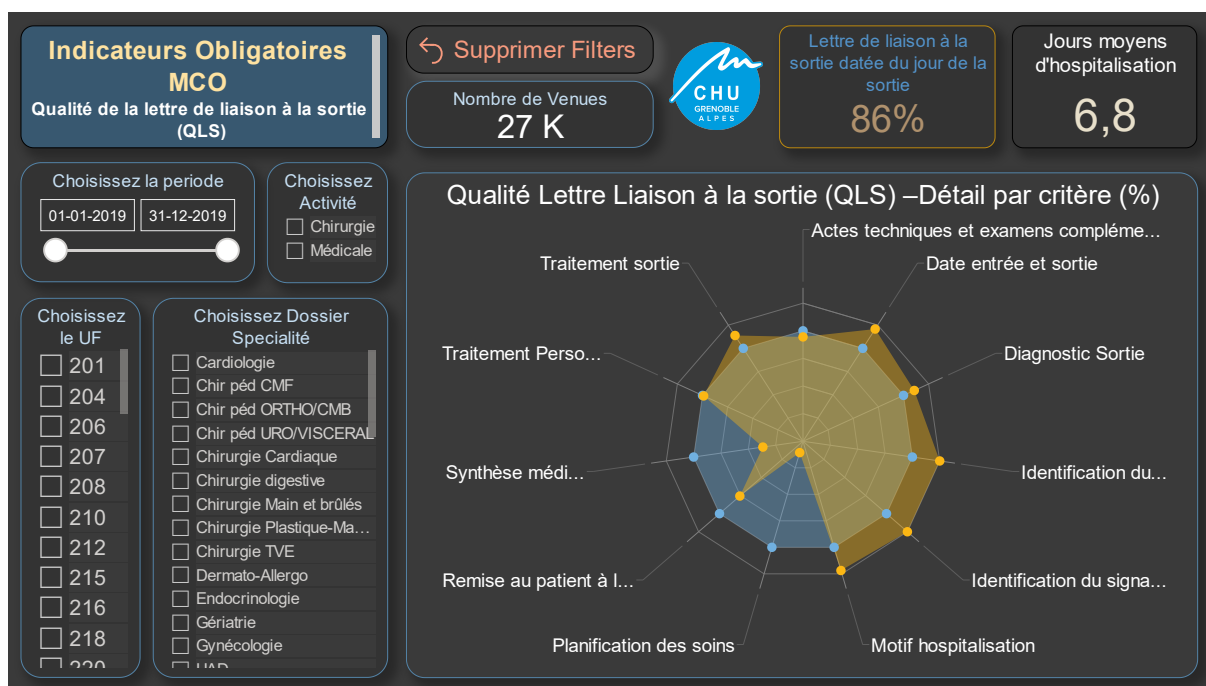


Figure 4.4: Dashboard with the analysis of almost 27K different *Lettre de Liaison* related about all the year of 2019. This information covered Medicine and Surgery activities at CHUGA.

In the the Medicine and Surgery activities dashboard it is not possible to observe the following Quality Criteria:

- *Lettre de Liaison à la Sortie Retrouvée;*
- *Identification du Médecin Traitant* and;
- *Traitements Médicamenteux.*

Instead, the following Quality Criteria were requested by CHUGA for the Medical and Surgery activities:

- *Diagnostic Sortie;*
- *Traitement Personnel Entrée* and;
- *Traitement Sortie.*

The dashboard in this case had to produce 12 Quality Criteria, where 9 of them are mandatory by the HAS.

| Some Future Improvements |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Add the analysis of the Obstetric activity, in order to include all the activities of the Médecine Chirurgie Obstétrique (MCO). |
| 2. Include the two first essential Quality Criteria in the radar chart and make sure the filters work properly for these two criteria. |
| 3. Automate the collection and storage of some data in the database tables. |
| 4. Clarify some of the questions in the <i>Lettre de Liaison</i> from to encourage and facilitate filling it out. |
| 5. Change some of the open questions to multiple choice questions to homogenize the responses and reduce false positives (for example <i>Planification des soins</i> and <i>Traitements médicamenteux</i> thereby reducing <i>null</i> fields). |
| 6. Realize how many patients need re-hospitalization after discharge for the same reason, in order to improve care planning outside the hospital and reduce the number of re-hospitalizations. |

Table 4.6: Some future actions and improvements to take in consideration, to develop a better dashboard and increase the Quality Criteria percentages.

As seen in Chapter 3 (visualization section) the two first and essential Quality Criteria could not be included in the radar chart, mainly due to the filters applied and the way they are calculated, since two different columns are necessary.

Considering the minimal objective national of 80%, 4 in 12 Quality Criteria are under this value (representing 33% of the Quality Criteria). One of these Quality Criteria, the *Actes techniques et examens complémentaires*, when no filter it is applied it is almost 75%. The *Synthèse médicale du séjour* and *Planification des soins* are the ones with the lowest percentage, 29% and 8% respectively.

One possible cause for a low percentage obtained on the Quality Criterion *Synthèse médicale du séjour*, is the fact that the collected data is voice recorded by the responsible physician and then filled directly in the word document of the *Lettre de Liaison*, by an assistant secretary. This means that the data for this criterion are in the Word document and not in the database tables related to the *Fiche d'hospitalisation*.

Regarding the Quality Criterion *Actes techniques et examens complémentaires*, the obtained percentage is below 80% (almost 75%), as expected, because the form question is not clear enough, leading to blanks or answers containing dots or question marks, for example.

In the case of the *Remise au patient à la sortie* this time it is lower compared to the analysis of the 631 *Lettres de Liaison*. This criterion indicates if the *Lettre de Liaison* was sent by email, given by hand, or both of them. This percentage is lower because it is calculated with a conditional function between 3 columns, and during the data analysis only one column was accessible to me.

Some of possible future actions and improvements in the analysis of the *Lettre de Liaison* are described in Table 4.6.

| Acronym | Description | Translation |
|---------|------------------------------------------------------|-------------------------------------------------------------------------------|
| AIT | Accident Ischémique Transitoire | Transient Ischemic Attack (TIA) |
| AVC | Accident Vasculaire Cérébral | CerebroVascular Accident (CVA) |
| BAV | Bloc Atrio-Ventriculaire | AtrioVentricular block (AV) |
| BPCO | BronchoPneumopathie Chronique Obstructive | Chronic Obstructive Pulmonary Disease (COPD) |
| CEE | Cardioversion Électrique | Electrical Cardioversion |
| CHC | Carcinome HépatoCellulaire | HepatoCellular Carcinoma (HCC) |
| CIA | Communication InterAuriculaire | Interauricular Communication |
| CPRE | CholangioPancréatographie Rétrograde Endoscopique | Endoscopic Retrograde CholangioPancreatography (ERCP) |
| DAI | Défibrillateur Automatique Implantable | Implantable Automatic Defibrillator |
| DC | Décompensation Cardiaque | Decompensated Heart Failure (DHF) |
| EEP | Examen ÉlectroPhysiologique | Electro Physiological Examination (EP) |
| FOP | Foramen Ovale Perméable | Patent Foramen Ovale (PFO) |
| IRM | Résonance Magnétique Cardiaque | Cardiovascular Magnetic Resonance Imaging (CMR, also known as cardiac MRI) |
| MAAD | Maladie d'Alzheimer ou Autre Démence | Alzheimer's Disease or Other Dementia |
| OAP | Oedème Aigu Pulmonaire | Acute Pulmonary Edema |
| TAVI | Transcatheter Aortic Valve Implantation | Transcatheter Aortic Valve Implantation (TAVI) |

Table 4.7: Acronyms in the *Lettre de Liaison* and detected in the dashboard databases. Some of them are related with the diagnostic, treatment or cause of hospitalisation.

4.2.1 Detailed quality analysis of a sample of *Lettres de Liaisons*

In another study, a sample with 631 *Lettres de Liaison* was evaluated to understand if the table's contents were correctly filled (data used in the first iteration of the dashboard between September and November of the year 2019).

Specific data in text fields (for example "aaa") are difficult to clean. However, they are accounted for when computing the Quality Criteria and can be considered false-positives. False-positives occur when a value indicates that it presents the conditions sought when in reality they do not meet the expected requirements.

After an examination of such in the data, I observed that sometimes in some fields there are two, three or four random characters. In the columns for the Quality Criteria: *Motif hospitalisation*, *Traitements médicamenteux* and *Planification des soins*, I have counted between 13 and 16 false-positives. In a sample of 631 documents, this represents an average percentage of 4% of false-positives in the data. In other quality criteria like *Identification du signataire* I found no false-positives.

Initially, I considered developing a program to clean this type of data, by deleting or set to 0 the fields with less than 5 or 6 characters. However, I observed for example in the Quality Criteria related to the cause of the hospitalization (where a phrase it is expected in the majority of cells), that sometimes acronyms with two, three or four characters should represent a valid filling. Some of the acronyms

sometimes appear with the french initials and sometimes with English initials, which makes them hard to identify. Considering that the analysis of these data is not only performed by healthcare professionals but also information annalists.

I have created a list of some of the found acronyms (see Table 4.7). There are many more acronyms presented in the tables of the database and most of them are related to the diagnostic, treatment or cause of hospitalisation. A complete list of acronyms will be a start point for the development of a program, for cleaning the incorrect by filled entries and count entries with acronyms correctly filled.

In future work, it is possible to improve the accuracy of the Quality Criteria display in the dashboard, by minimizing the false-positives a homogenizing the acronyms used by healthcare professionals (only French or only English). One suggestion is to replace the open questions by multiple-choice questions using the acronyms as options for this effect.

4.3 Summary

The dashboard displaying the QLS Indicator was evaluated for user satisfaction. For that purpose, I have adapted SUS (all positive wording questions) for measuring user satisfaction. The feedback form also included other questions related to the usability of the dashboard, and about the design and colours chosen.

The main objectives of the usability evaluation were:

- To assess the accessibility of the system's functionality;
- Evaluate the users' experience in interacting with the system, and;
- Identify specific problems with the system.

The survey enabled the identification of some areas that can be improved in terms of the user interface. Users agree that the design of the dashboard helps to avoid distraction and could help them feel more comfortable, improving comprehension of the visualised information on the dashboard. Thus, the quality of work-life of the users could be improved.

Considering the results of the feedback, it can be concluded that the established objectives were achieved. The results show that the dashboard allows a quick perception and that the interaction is very intuitive. This also means that users will perform better as they become more familiar with it.

It was also possible to conclude that the dashboard system has good usability on the SUS questionnaire. The dashboard was evaluated with an average of 81.5 points in the SUS Score, above the average of 80 points, for systems considered as having excellent usability.

Further, an analysis of almost 27 thousand *Lettres de Liaison* between January and December of 2019, including the activities of Medicine and Surgery demonstrated the capacity to scalable processing to massive collections of documents like the *Lettres de Liaison*. This result was presented to the management of the Risk and Management Quality Department at CHUGA, who was pleased and satisfied with the developed solution.

5

Conclusions and Future Work

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5.1 Conclusions

The main goal of this master's thesis was to propose, develop and validate a dashboard integrated into the Centre Hospitalier Universitaire Grenoble Alpes (CHUGA) hospital Information System (IS), with data collection, data analysis and data reporting. The dashboard aims to display the Quality Criteria related to the Qualité de la Lettre de Liaison à la Sortie (QLS) Indicator.

The main objective has been achieved. It is now possible to visualize a large amount of data on the dashboard and to filter/aggregate the data in several dimensions. A method for extracting and transforming the data for analysis in the dashboard is also available. Furthermore, special attention was given to the user interface of the dashboard for an intuitive display of information. The proposed requirements have all been met since it is possible to visualize the information filtered by various factors such as time and *Unité Fonctionnelle* (Unité Fonctionnelle (UF)).

The evaluation of the dashboard with users showed that the system has good usability, ensuring a good interaction by future users. Besides that, some usability issues could be and should be addressed in future design. The development of updates and new versions is, in the future, of the responsibility of the CHUGA.

One of the central contributions appreciated by the CHUGA workers was having an automatically method to collect and analyze large amount of data, replacing exhaustive routines of manually data analysis. Another contribution is the possibility of outlining strategies for improving the QLS Indicator and in this way increase the payment for performance to CHUGA.

5.2 Future Work

The developed dashboard it is not yet in production, but I am confident that the dashboard will help its end-users in their professional work.

The QLS Indicator dashboard is only the first version. Hence, there are some ways in which I believe the dashboard can be improved in the future, such as:

1. Finding a way to integrate the two first essential indicators in the radar chart;
2. Improve the calculation of the percentage of some Quality Criteria;
3. Improve the automatic detection of invalid fields in the *Lettre de Liaison*.

One example could be the *Synthèse Médical de Séjour*, once some of the information it is not taking in consideration once it is presented in a Word format. Thus, some improvements in the way this information is collected and stored will be crucial in my opinion.

Another improvement related to the Extract, Transform, Load (ETL) process, could be related to minimizing the percentage of false-positives, with Natural Language Processing (NLP) methods using machine learning algorithms. Also, to decrease the amount of time cleaning the data, it will be important to raise awareness of healthcare professionals to the importance of providing high-quality data. Moreover, it would be interesting to change some of the questions in the *Lettre de Liaison* form, replacing some of the free text fields by multiple choice options, to minimize errors when filling the form.

In the context of the evaluation by the Haute Autorité de Santé (HAS), CHUGA was classified in the QLS Indicator in the C class (classification between A and D, where A it is considering an excellent percentage). CHUGA has the goal to achieve a B or A classification, which means that it has to reach the minimal national objective of scoring 80% in the QLS Indicator. Some information that could be added in future versions of the dashboard to help this goal are;

- External factors that lead to the hospitalization in certain cases;
- Number of re-hospitalisation for the same cause;
- Geographic location of the patients residence and the respective cause of the hospitalisation, in order to correlate both;
- Numbers related to the humans resources available by UF.

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Fiche d'Hospitalisation

Fiche d'hospitalisation J0 CHUGA

Service: RHUMATOLOGIE

Patient: FARIAS SARA , née le 01/01/1990 , IPP 00000000



Entrée 01/01/2030

Sortie 08/01/2030

Unité

Responsable Charles, Marie

CONTEXTE Dernière modification faite le 10/01/2030.

Contexte de vie

Mode de vie :

...

Médecin traitant : Dr. Gustav

Antécédents (Atcd déjà renseignés : Med. All.)

Facteurs de risque

Médicaux

| Date | Libellé |
|------|---------|
| | |

Ajout antécédents médicaux

Date Libellé :

Chirurgicaux

| Date | Libellé |
|------|---------|
| | |

Ajout antécédents chirurgicaux

Date Libellé :

Obstétricaux

| Date | Libellé |
|------|---------|
| | |

Ajout antécédents obstétriques

Date Libellé :

Allergies

| Date | Type | Libellé |
|------|------|---------|
| | | |

Ajout antécédents allergies

Date Typ Libellé :

Contexte maladie chronique

Diagnostic détaillé

Traitement et suivi de la maladie chronique

SEJOUR

Examen médical d'entrée

Saisie le 09/01/2030 par

Motif entrée

Anamnèse

Conclusion de l'examen clinique initial

Poids : Kg Taille : cm IMC : kg/m2

Variation poids pré-hospit. :

Traitement à l'entrée :

VOLTARENE
PARACETAMOL

Evolution au cours du séjour

Filtres

Intervenant

Type d'observation

Synthèse de séjour

Synthèse de séjour :

Complications/Maladie chronique prise en charge pendant le séjour/Affections intercurrentes

SORTIE

Sortie

Diagnostic de sortie

Destination du patient à la sortie

Evolution du traitement médicamenteux (entrée/sortie)

Prescription de sortie

Aucune ordonnance

Ajouter :

Suite à donner

Continuité des soins

- RDV à prendre par le patient

- RDV pris pour le patient

- Autre

Prise en charge sociale

Conseil, recommandation ou surveillance particulière

Patient en ALD

Evènements marquants au cours du séjour

- Patient porteur/contact de BMR ou BHR

- Transfusion

- Allergies au cours du séjour

- Actes techniques, biologiques ou imageries marquants

- Vigilance

Lettre de liaison valant CRH

- Lettre de liaison valant CRH

génééré le 05/01/2030

- Remis en main propre

B

Lettre de Liaison à la Sortie



**CENTRE HOSPITALIER UNIVERSITAIRE
GRENOBLE ALPES**

Hôpital Sud – CS 90338 – 38434 Echirolles Cedex – Standard : 04 76 76 75 75
www.chu-grenoble.fr – N° SIREN : 263 800 302 – N°FINESS : 38 07827 22

**PÔLE APPAREIL
LOCOMOTEUR CHIRURGIE
REPARATRICE ET ORGANES
DES SENS**

DR. GUSTAV
1111 AVENUE RIBEIRO
33333 PRADOS

CLINIQUE UNIVERSITAIRE DE
RHUMATOLOGIE
www.rhumatologie-grenoble.com

Echirolles, le mercredi 30 janvier 2030

**Compte-rendu d'hospitalisation de Mme FARIAS SARA , née
COLOMBET le 01/01/1990, Sexe : F, hospitalisée du 01/01/2030 au
08/01/2030**

Secrétariat :
Tél : 04 76 76 54 58
Fax : 04 76 76 50 39

Consultations
Niveau 2
Tél : 04 76 76 54 58
Fax : 04 76 76 50 39
secretariatrhumatologie@chu-grenoble.fr

Hospitalisation
Niveau 6
A. Naessens-Lagраста
Cadre de Santé
Tél : 04 76 76 57 23
Fax : 04 76 76 52 67

Hôpital de Jour
Niveau 1
Infirmière Coordinatrice :
Tél : 04 76 76 95 82
Fax : 04 76 76 95 57
Secrétariat Tél. : 04 76 76 56 14

Rhumatologie Interventionnelle
Niveau 1

Hôpital de Jour Rééducation
Institut de Rééducation RDJ
Tél : 04 76 76 70 59 / 04 76 76 54 58
Fax : 04 76 76 50 39
KinesRhumatoReeduc@chu-grenoble.fr

MEDECIN TRAITANT :
Dr. GUSTAV

MOTIF D'HOSPITALISATION :

ANTECEDENTS :

1°/ Antécédents médicaux :

2°/ Antécédents chirurgicaux :

3°/ Antécédents d'allergies :

4°/ Antécédents familiaux :

MODE DE VIE :

HISTOIRE DE LA MALADIE :

EXAMEN CLINIQUE :

- Poids :
- Taille :
- IMC :
- T° :
- Amaigrissement :
- Obésité :
- Dénutrition :
- Variation de poids :
- EVA à l'entrée :
- EVA à la sortie :
- TA :
- Fréquence cardiaque :
- Saturation :

Sur le plan rhumatologique :

Sur le plan neurologique :

Sur le plan cardiopulmonaire :

Sur le plan abdominal :

EXAMENS PARACLINIQUES :

1°/ Examens biologiques :

2°/ Examens morphologiques :

TRAITEMENT ET EVOLUTION DANS LE SERVICE :
Sur le plan rhumatologique :

EVENEMENTS INDESIRABLES/INTERCURENTS :

- Allergies :
-
- Patient porteur/contact SAMR :
- Transfusion :
- Autres évènements marquants/indésirables :
- Pose d'un dispositif médical implantable :

AU TOTAL :

Sortie autorisée ce jour pour : Retour à domicile

HISTORIQUE DES TRAITEMENTS :

| Médicaments à l'entrée | Médicaments à la sortie <i>QSP 1 mois sauf si précisé dans commentaire</i> | Commentaires |
|-------------------------------|------------------------------------------------------------------------------------------|---------------------|
| VOLTARENE | | |
| PARACETAMOL | | |
| | | |

SUIVI APRES L'HOSPITALISATION :

L'ordonnance a été remise au patient en mains propres, relue en sa présence et expliquée quant aux effets secondaires indésirables des médicaments.

Nom du patient : FARIAS
Prénom du patient : SARA
IPP : 00000000

Edité par : @Easily
Pages :4/4

En vous remerciant de ce que vous ferez pour cette patiente, nous vous adressons l'assurance de nos meilleures salutations.

Bien confraternellement.

Dr
PH

Dr
ACC

Dr
ACC

[nom du médecin responsable],
Interne

Document validé par Dr [Identification du signataire]

Oui, remis en main propre

Copie à :
Mme FARIAS SARA

Diagnostic principal :
Diagnostics associés
Gestes effectués :