Clinical Dashboard for Hospital Quality Indicator Assessing

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Abstract—**This work 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 dimensions 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]

1. Introduction

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].

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].

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]

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

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].

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

The focus of development of this 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.

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, analysis and 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.

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 :

A	B	C
9%	15%	76%

Pourcentage de l'ensemble des établissements par résultat A, B, C...
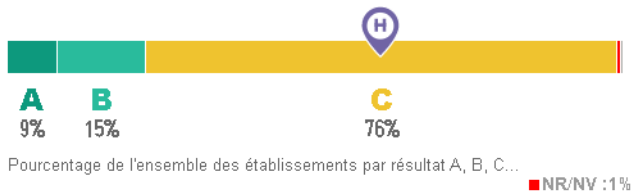
■ NR/NV :1%

Figure 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.*

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.

In conformity, the main contributions of this work are:

- 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.

2. Related Work

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.[2] Due to the growth and amount of data over the last few decades, its management is increasingly difficult. Hence, it is necessary to exploit and manipulate the collected data, to obtain valuable information. Information dashboards play a key role in transforming and visualizing data about a specific domain. In essence, these dashboards display

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

information, provide insights and help to make informed decisions [Vázquez-Ingelmo et al., 2018].

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 QLS Indicator evaluation (see Figure 1). Establishments in Class A have exceeded this expected value, Class B establishments have reached it, and Class C establishments have not yet reached it.

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.

The two most important definitions 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 individuals and/or organizational goals, allowing the user to identify, explore, and communicate problem areas that need corrective action"* [Yigitbasioglu and Velcu, 2012].

A dashboard is vital for information presentation and visualization, they have been referred to as one of the most essential analytical tools in Business Intelligence (BI) [Negash and Gray, 2008].

Some of the most mentioned benefits of dashboards [Wilbanks and Langford, 2014]:

- 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 advents;
- to provide decision assistance to improve efficiency and quality;
- build up data-driven decision making to executive-level management.

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].

Business Intelligence (BI) means the "process of extracting, transforming, executing and analyzing a large variety of data, to boost the mechanism of decision making" [Negash and Gray, 2008].

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.
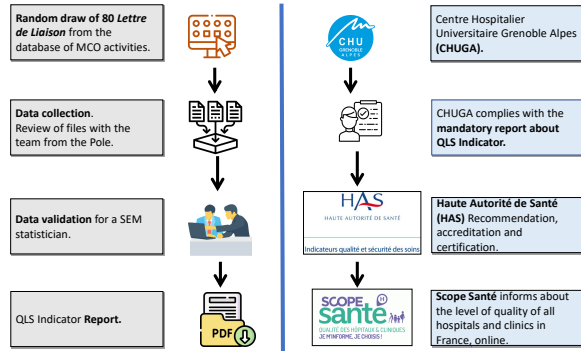
Figure 2. Existing/Actual Method of the generate of the QLS Indicator. In the right side of the figure it is rep-resented the identities responsible for the process. The left side illustrates some specifications of the current method.

Power BI is a BI tool aiming 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 are:

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.

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 multiple 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.

3. Clinical Dashboard

3.1. Problem

Figure 2 represents the current method used at CHUGA to analyse and generate the QLS Indicator Report. 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.

The QLS Indicator assesses the quality of the *Lettre de Liaison* in a hospital. It is presented as a quality percentage

TABLE 1. 12 QUALITY CRITERIA IN *Lettre de Liaison* BY HAUTE AUTORITÉ DE SANTÉ (HAS) AND TRANSLATIONS.

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

between 0% and 100%.[3] 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.

The *Lettre de Liaison* needs to have at least 12 Quality Criteria, and depending on their existing this letter has high or low quality [Maxime, 2018]. Two from these 12 Quality Criteria are essential, five are medico-administrative and five medical. The quality of the *Lettre de Liaison* is a good healthcare indicator, because it represents a higher chance in the continuity of healthcare ensured. The 12 Quality Criteria of the *Lettre de Liaison* are described following and listed in Table 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.
   In the absence of conformity of one of these two essential criteria, the next 10 criteria are count as not satisfied, since it is not possible to find a valid *Lettre de Liaison*.

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

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.

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).

Five Medical Quality Criteria:

8) *Motif de l'Hospitalisation*
The criterion is satisfied if the cause for hospitalization is found on the *Lettre de Liaison*.

9) *Synthèse Médicale du Séjour*
The criterion is satisfied if one of the following elements is 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.

3.2. Solution Architecture Overview

The solution developed in this work entailed the reformulation of the existing method for generating the QLS Indicator, developing a clinical dashboard.

Figure 3 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. This choice it was because some CHUGA workers have knowledge in these tools and it will facilitate future maintenance of the dashboard system.

The data is accessed with SQL. The most important files are stored inside Structured Query Language (SQL) tables in a Extensible Markup Language (XML) format.

In the second phase, an Extract, Transform, Load (ETL) procedure was developed.

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.

3.3. Extract, Transform, Load (ETL)

Before data can be analyzed or used, it must first be extracted. Data extraction is the process of retrieving data from different data sources.

The data should be cleaned and transformed before loading into the stored database. A relational database has powerful tools for accessing and transforming data. Queries can both transform and retrieve data, handling most of the data transformation processes. With this in mind, developing an SQL Script that transforms the data is fundamental and advantageous.

Equation 1 below represents the method used to calculate the percentage of the Quality Criteria (P_QC).

$$P_{QC} = \frac{Number\ of\ Quality\ Criteria\ Satisfied}{Number\ of\ Total\ Lettre\ de\ Liasion\ Retrouvée} \times 100\% \quad (1)$$

The Quality Criteria are Boolean, and their objective is to verify whether or not they exist in each *Lettre de Liaison*.

3.4. Visualization

Nowadays, at CHUGA and to produce the reports for HAS it is normal to use a radar chart, and this type of visualization was also chosen to display the QLS Indicator data. The idea of this dashboard is to take benefits and simplify the task of analyzing healthcare QLS Indicator.

To accomplish the final goal, a dashboard using Power BI was developed (see Figure 6).

Radar charts are considered a useful way to display multivariate observations with an arbitrary number of variables. [4]

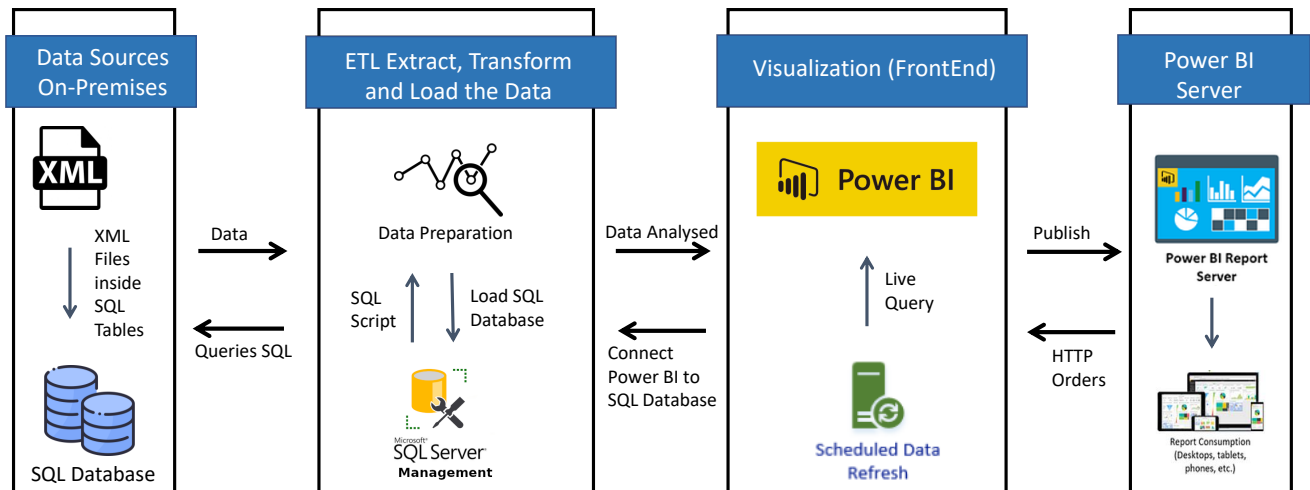4. https://www.cs.middlebury.edu/~candrews/showcase/infovis_techniques_s16/radar_chart/

Figure 3. 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.
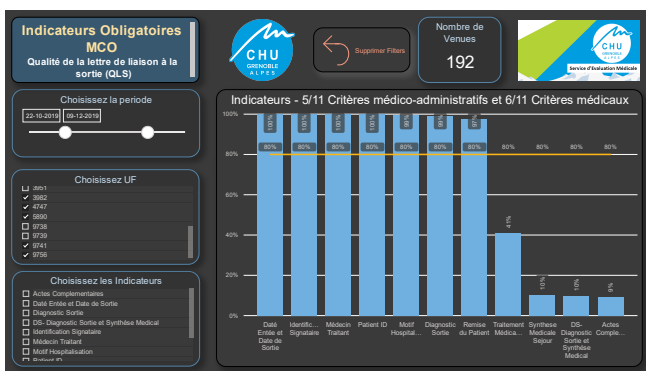

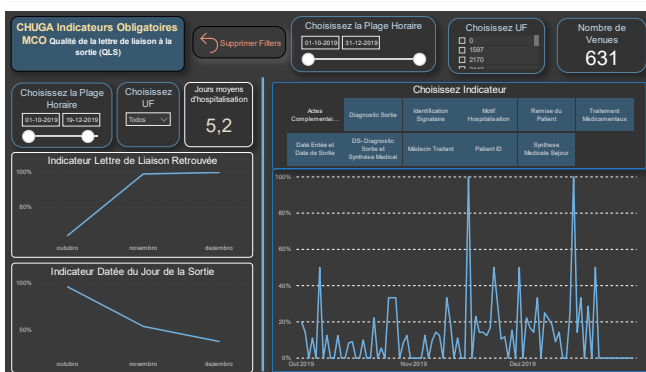Figure 4. Line and Clustered Column Chart Quality Criteria - Dashboard.

Figure 5. Time Line Chart Quality Criteria Tab - Dashboard.

In radar charts, each variable has an axis and these axes are arranged radially around a central point and spaced equally, thus depending on the number of the variables different shapes appear. Each Quality Criteria value percentage is plotted along its individual axis and all these points connected to form a polygon. Also, it is very common to have grid lines, that connect the axes and are used as a guideline to make the chart more clear and easily readable. This type of chart also presents some problems, such as the importance that viewers could potentially give to the area of the polygons.

The radar chart of the Figure 6 displays eleven Quality Criteria. It presents 9 Quality Criteria mandatory in the report by HAS and 2 requested by CHUGA (*DS- Diagnostic Sortie et Synthése Medical de Sejour* and *Diagnostic de Sortie*). Another tab dashboard with the first two essential Quality Criteria was also developed, and it is described in my master's thesis.

A rectangular element displaying the number of hospitalisation depending on the chosen filters is further part of this dashboard, called *Nombre de Venues*.

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%.

Information can be presented in several different forms, such as numbers, graphs, tables and bars. Figures 4 and 5 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 4 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
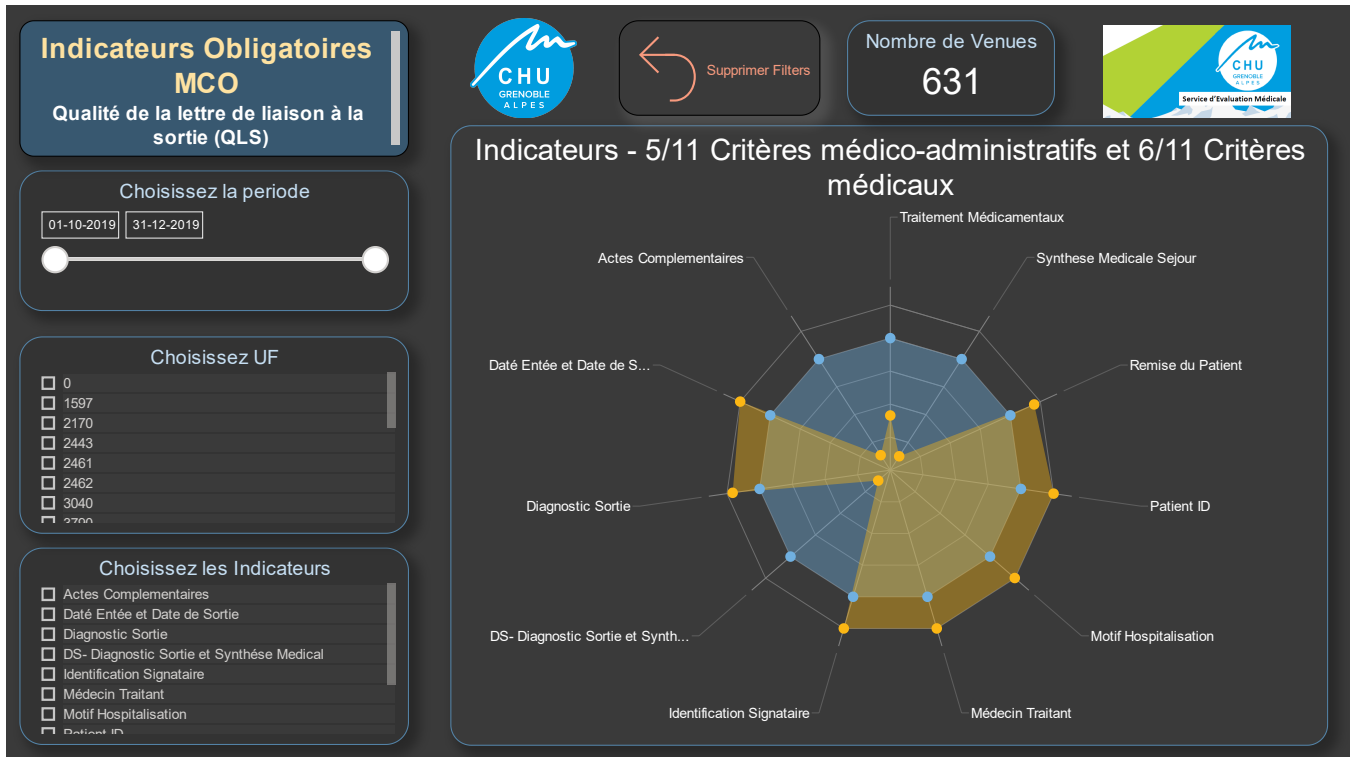
Figure 6. Radar Chart Quality Criteria of the *Lettre de Liaison*.

of time and Unité Fonctionnelle (UF) (unit functional of the hospital structure), exhibit the information related to 192 hospitalisations.

Figure 5 presents each Quality Criteria detail at a time using a timeline chart. 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.

4. Evaluation

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 developed dashboard including data from *Lettre de Liaison* during the entire year of 2019.

4.1. User Satisfaction Survey and Participants

A total of 10 participants who tested the dashboard are workers at CHUGA (in Table 2 participants' age, gender and department are explicit).

The satisfaction survey evaluation had four sections:

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

4.2. 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.

A System Usability Scale (SUS) questionnaire was used and was originally developed by John Brooke in 1986. It per-

TABLE 2. FEEDBACK PARTICIPANTS CHARACTERIZATION.

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 3. THE ORIGINAL 10 ITEM QUESTIONNAIRE FROM SYSTEM USABILITY SCALE (SUS). ODD-NUMBERED QUESTIONS ARE POSITIVELY WORDED AND THE EVEN-NUMBERED ARE NEGATIVELY WORDED.

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. SUS SCORES FOR THE 10 QUESTIONS AND RESPECTIVES AVERAGES, USING 10 PARTICIPANTS FROM CHUGA.

| 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

mits 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.

This questionnaire consisted of 10 multiple choice questions (see Table 3), being the possible answers given on a scale of 1 to 5, where 1 corresponds to *Strongly Disagree* and 5 corresponds to *Strongly Agree*.

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 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.

The standard reference score can be more accurate 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.

Concerning the score of some of the individual SUS responses scores (see Table 4), 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.

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.

Questions	Average Score
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**

4.3. Dashboard specific usability and aesthetics questions

Table 5 presents the answers to the questions related to the dashboard specific usability, aesthetics and future deployment of the dashboard in daily work. These answers were rated on 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 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 HAS. 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.

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 Fonctonnelle (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.

4.4. Open questions about potential and future deployment

The questionnaire included 5 open questions asking participants to share their opinions about their daily work and suggest improvements in specific characteristics.

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?

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 more contrast;
- Add labels to Unité Fonctionnalle UFs, instead only providing the numbers (for example the UF numbered 201, is the Unit for *Rhumatologie*);
- 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.)

Lastly, the evaluation questionnaire asked what was the most inconvenient and bothersome thing they need to do in their work, related to the production of indicators, and Four in ten (40% of participants) responses 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.

4.5. Dashboards Coloring Evaluation

Figure 7 illustrates the dashboard prototype with the same information, but with light colours and white background.

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 back background dashboard.

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.

4.6. 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 Liaisons* in the databases in the year of 2019, using the developed dashboard.
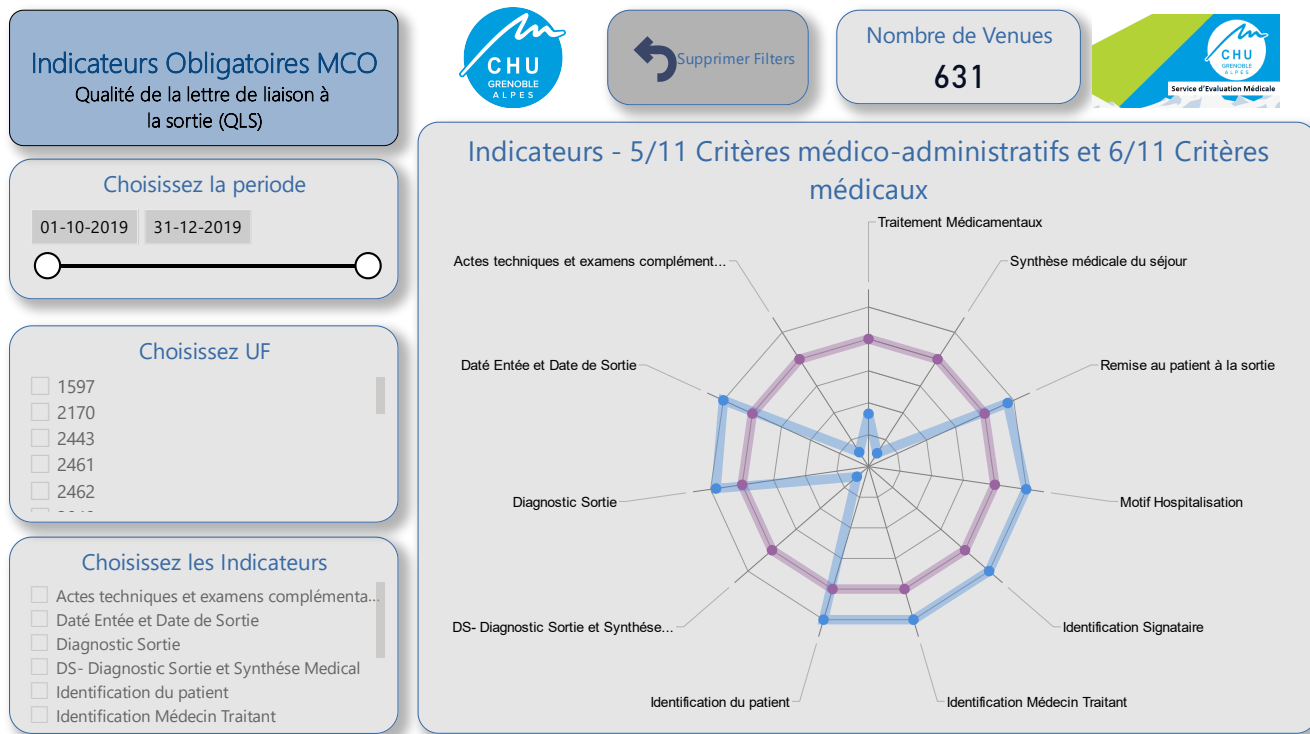
Figure 7. MCO Dashboard prototype with different colours and white background.

Figure 8 depicts the analysis of all the *Lettres de Liaisons* from of 2019, covering the Medicine and Surgery activities with the dashboard I developed. Altogether the analysis of these data resulted in almost 27 thousand *Lettres de Liaisons*.

In 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:

- *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.

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 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.

The Quality Criteria *Remise au patient à la sortie* 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.

5. Conclusions

The main goal of this master's thesis was to propose, develop and validate a dashboard integrated into the CHUGA hospital IS, with data collection, data analysis and data reporting. The dashboard aims to display the Quality Criteria related to the 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
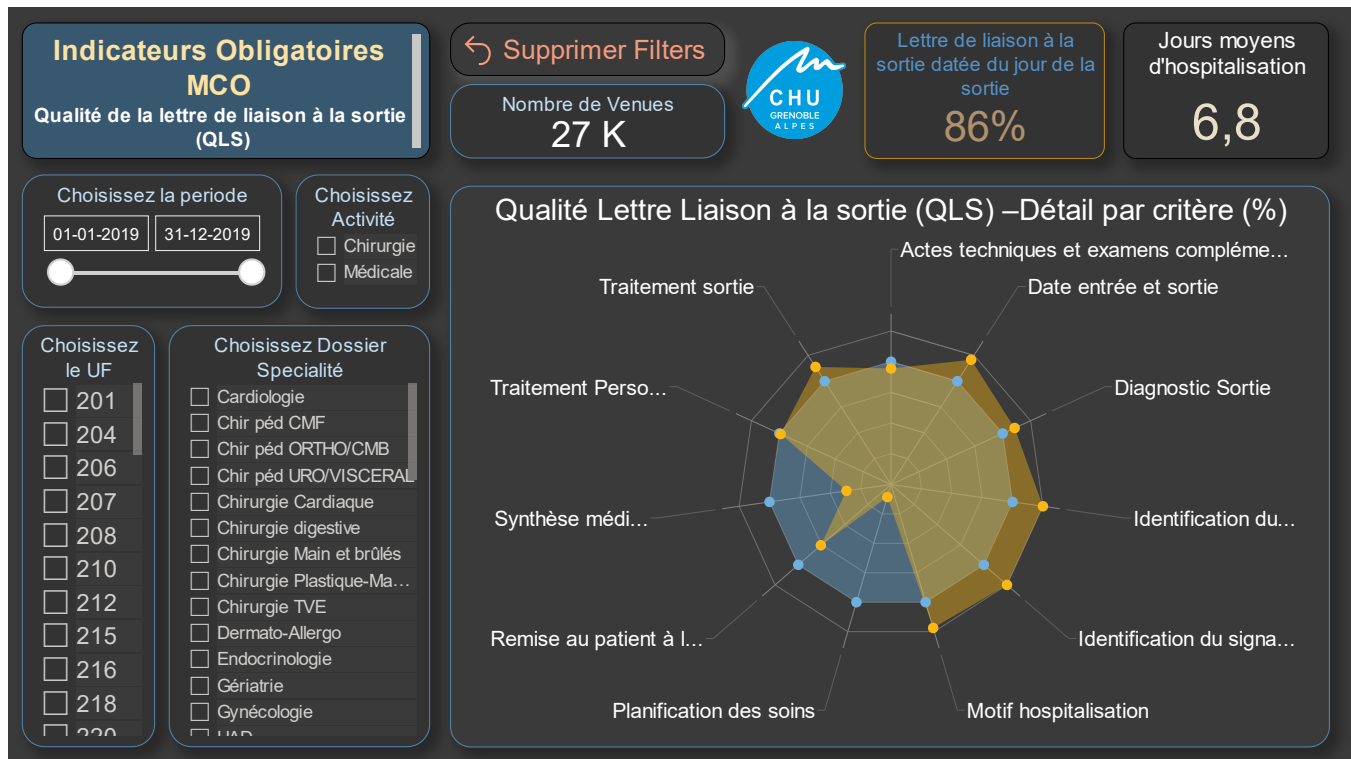
Figure 8. Dashboard with the analysis of almost 27K different *Lettre de Liaison* related about all the year of 2019. This information covered Medicine and Surgery activities at CHUGA.

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 *Unite 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.

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