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Dashboards for Visualization of Individual Activity of Health Professionals in Obstetrics

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Abstract

In 2022, there was an increase in the number of births in Portugal. However, during the same year, there were also several closures of hospitals and maternity units. This disparity resulted in significant constraints on the quality of the national obstetric service, leading to an overload of obstetric healthcare professionals. This strain was not only related to extended working hours but also to the existence of a stressful work environment, resultant from the need to ensure the service's response to patients.

Daily, an obstetric healthcare professional encounters diverse situations where their professional expertise comes into play. They must discern which technique to use and the appropriate timing for its application, as exceptional performance is demanded in such cases. The use of management tools, like dashboards, can prove to be useful in monitoring events that occur in hospitals, as they allow tracking multiple aspects of the service.

In this dissertation, a dashboard for the visualization of the individual activity of obstetric healthcare professionals who use ObsCare application for recording obstetric service-related data is presented, product developed by VirtualCare, the company where this dissertation was conducted. The primary objective in constructing the dashboard was centered around the selection of essential indicators, the analysis of which would lead to improvements in healthcare professionals' performance. The analysis of a well-structured dashboard leads to enhancements in the quality of treatment and medical service by optimizing performance and enabling effective service management.

The applied methodology consisted in four stages (analysis and selection of indicators, design of visual presentation, construction of the dashboard and its evaluation), which enabled the development of a monthly performance dashboard comprising nine modules, encompassing a total of eighty-three performance indicators. The analysis of these indicators provides a comprehensive overview of the state of the service, as well as the evaluation of the performance and professional experience of obstetric healthcare professionals.

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Resumo

Em 2022, registou-se um aumento no número de nascimentos em Portugal, contudo nesse ano, também foram constantes os fechos de hospitais e maternidades. Este desequilíbrio provocou grandes constrangimentos na qualidade do serviço obstétrico nacional, levando a uma sobrecarga dos profissionais de saúde de obstetrícia, não só relativamente à sobrecarga horária, mas como a existência de um ambiente de trabalho stressante para garantir a resposta do serviço aos pacientes.

Diariamente, um profissional de saúde de obstetrícia depara-se com situações diferentes, onde tem de usar a sua experiência profissional, de modo a discernir qual técnica deverá ser utilizada e qual o momento adequado da sua aplicação, sendo que um bom desempenho é exigido. A aplicação de ferramentas de gestão, como *dashboards*, pode se revelar útil na monitorização dos eventos ocorridos nos hospitais, uma vez que permitem monitorizar de forma simples diferentes aspetos do serviço.

Nesta dissertação, é apresentada uma *dashboard* para a visualização da atividade individual de profissionais de saúde de obstetrícia que utilizem a aplicação Obscare para o registo de dados relativos ao serviço obstétrico, produto desenvolvido pela VirtualCare, empresa onde foi realizada esta dissertação. O principal objetivo na construção da dashboard consistiu na seleção dos indicadores essenciais, cuja análise provoque melhoria no desempenho dos profissionais de saúde. Efetivamente, a análise de uma dashboard bem estruturada permite melhorias na qualidade do tratamento e do serviço médico, através da otimização da performance e da gestão eficaz do serviço.

A metodologia aplicada na dissertação consistiu em quatro etapas (análise e seleção dos indicadores, design da apresentação visual, a construção da dashboard e avaliação), que permitiram a concepção de uma *dashboard* de performance mensal constituída por nove módulos que compreendem um total de oitenta e três indicadores de performance. A análise destes indicadores permite uma visão abrangente do estado do serviço, bem como a avaliação do desempenho e experiência profissional dos profissionais de saúde em obstetrícia.

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Abbreviations, acronyms and symbols

BMI	Body Mass Index
IUGR	Intrauterine Growth Restriction
KPI	Key Performance Indicator

Chapter 1: Introduction

1.1. Context

According to data collected by the National Institute of Statistics, in 2018, in Portugal there was a total of 1,437,441 obstetric consultations, 89,110 major surgeries, and 85,604 births. To meet these demands, it is estimated that 1,065 specialists in Gynecology-Obstetrics, working 40 hours per week, are required. As represented in Table 1, over the past 5 years, the number of births decreased in result of COVID-19 pandemic. However, in 2022, there was registered an increase in the number of births by approximately 5% compared to 2021. Also, in the first half of the current year, 41,153 births were recorded, approximately 5% more than those registered in the first half of 2022 (39,123), as shown in Table 2. This increase indicates that the number of births will also continue to rise, underscoring the need for a response from national obstetric services [1].

Lately, the state of obstetric services in Portugal has faced significant challenges, including the closure of some obstetric units. These closures have raised concerns about access to maternal healthcare in certain regions of the country, from small-scale hospitals to large ones in densely populated cities. Also, the concentration of obstetric services in larger hospitals, while beneficial in terms of resources and specialization, can also result in long distances for many expectant mothers, making effective management of these changes essential to ensure that all women have adequate access to healthcare during pregnancy and childbirth. It is a challenge that requires careful attention from health authorities to ensure the quality and accessibility of obstetric services nationwide. Currently, a significant number of specialists are aged 55 or above, and there is a shortage of obstetric professionals in several healthcare organizations. Therefore, it is necessary to train new healthcare professionals to ensure the quality of obstetric services [2].

Table 1 - Total of Births Registered in the Last Five Years in Portugal [1].

Year	2018	2019	2020	2021	2022
Total of births	87020	86579	84530	79582	83671

Table 2 - Total of Births Registered in the First Semesters of 2022 and 2023 in Portugal [1].

Year	2022	2023
Total of births	39123	41153

Skilled health professionals who are trained in emergency obstetric and newborn care services play a vital role in ensuring positive outcomes for mothers and babies. Some clinical interventions are crucial, like the prevention and treatment of conditions like postpartum haemorrhage and pre-eclampsia/eclampsia, as well as the management of birth asphyxia [3].

Indeed, ensuring quality care in obstetrics is crucial for the well-being and safety of both mothers and their babies. High-quality obstetric care involves comprehensive management throughout the entire pregnancy journey, from prenatal care to postnatal follow-up. Quality care means having skilled healthcare professionals who follow the best practices and guidelines, such as closely monitoring the health of both the mother and baby, addressing any issues promptly and taking necessary actions as required. By striving for excellence in obstetric care, we can promote positive birth outcomes, reduce maternal and infant morbidity and mortality rates, and empower women to have a safe and fulfilling childbirth experience [4].

Advances in technology have revolutionized healthcare, enabling a more effective and personalized treatment. Nowadays, healthcare professionals have access to powerful tools for diagnosing and treating diseases through artificial intelligence, telemedicine, and large-scale data analysis [5].

Sophisticated algorithms are capable of processing large amounts of clinical and genetic information, enabling a more precise understanding of patients' health conditions. Additionally, innovative medical devices such as wearables and sensors can continuously monitor patients' vital signs, providing real-time data that aids in treatment monitoring. With these technologies, it is possible to personalize medical interventions according to each patient's individual needs, resulting in more efficient, accurate, and clinically improved outcomes [6].

A specialized and high-quality treatment during pregnancy and childbirth is essential for the health and well-being of both mother and newborn. The obstetrician plays a fundamental role in monitoring the fetus' development, enabling the identification and management of complications while providing appropriate guidance and care [6], [7].

One of the main advantages of receiving proper obstetric care is the early detection of potential health issues, both in the mother and the fetus. Through regular examinations, such as ultrasounds and blood tests, the obstetrician can identify conditions such as preeclampsia, gestational diabetes, fetal abnormalities, and inadequate fetal growth. This early detection

enables the implementation of appropriate treatments and the adoption of preventive measures to ensure the well-being of both mother and baby [3].

Furthermore, the presence of an experienced obstetrician is also crucial during labour, as they can easily recognize and manage complications that may arise during childbirth, such as dystocia, fetal distress, and obstetric emergencies, as they are also capable of performing necessary interventions, such as caesarean sections [7].

Although several factors can impact the quality of obstetric treatment and care, such as the availability of adequate healthcare services, access to prenatal care, financial resources, and social support, several innovative approaches have been developed and applied to the healthcare sector, to enable improved monitoring and treatment, as a more accurate data recording [7].

To enhance the quality of healthcare services, several companies have been dedicated to developing new approaches that optimize the healthcare service, such as *VirtualCare*, the company where the work of this dissertation was developed.

1.1.1. VirtualCare

VirtualCare (which company's logo is represented in Figure 1) is a company dedicated to the development of innovative and high-quality clinical applications. Founded by researchers with backgrounds and experience in medicine, informatics, and management, it counts ten years of market experience, currently working with twenty-one hospitals. Throughout the years, VirtualCare has developed several applications for different clinical areas, such as obstetrics, pharmacovigilance, prescription and administration of long-acting antipsychotics, and clinical activities in breast pathology, among others. As a result of the fusion between academics and clinical practice, in addition to innovative solutions for clinical practice, *VirtualCare* also offers consultancy services and training sessions [8].

1.1.2. Obscare

To improve the quality of obstetric service in Portugal, among the several applications developed by VirtualCare, Obscare presents itself as an obstetric-specific Electronic Health Record that supports the clinical activities of obstetric services, with 18 years in the market (application's logo is represented in Figure 2). Over the years, over one hundred thousand births have been registered in 13 hospitals, documenting information from approximately 25% of the births performed in Portugal [9].

Obscare allows better monitoring of the pregnancy, enabling the recording and retrieval of the most relevant clinical data. It also allows the registration of data related to childbirth and the newborn, while it is sending and receiving information to

and from other applications throughout the process, as the application is integrated with other existing clinical and administrative information systems in hospitals [10].

The application features an intuitive interface accessed through the *VCINTEGRATOR* system, making the software accessible to users, specifically the entire team involved in the Obstetrics service: doctors, nurses, administrators, and IT professionals. The application also has security features to protect patient and healthcare professional confidentiality [9].

Regarding its clinical application, it can be used in various obstetric contexts, including appointments, hospital admissions, childbirths, surgeries, and emergencies. This application allows the recording and management of obstetric data, enabling better clinical monitoring of pregnant women, including access to medical history, examinations, tests, and relevant obstetric data. Allowing quick and organized access to information, this application assists health professionals in decision-making, improving the monitoring of maternal and fetal health by tracking specific parameters such as blood pressure, fetal heart rate, and fetal movements, among others. These data combined provide information on the health condition of both the mother and newborn.

The use of *Obscare* also offers several advantages, as this software gathers the information in one place, which was previously scattered across different software. It also allows the automatic calculation of gestational age, generates discharge notes based on the data entered throughout the process, and automatically sends birth notifications to the mother's healthcare centre. Through the application, it is even possible to know who create and update the report and check the number of existing versions.

Obscare simplifies healthcare professionals' work, as it not only retrieves the information in a single system but also automatically calculates gestational age based on the first ultrasound. Additionally, it provides access to the healthcare professional's curriculum vitae at any time and supplies data for analysis and research purposes.



Figure 1 - VirtualCare Company Logo.



Figure 2 - ObsCare Application Logo.

1.2. Motivation

Good obstetric treatment and monitoring are crucial to ensure the health and safety of the mother and the newborn. For that, the hospital must have a skilled and experienced obstetric team, to assure healthcare quality, during pregnancy and labour [6].

To enhance the quality of the service, it is also important to maintain accurate records of data throughout the entire pregnancy, delivery, and postpartum period. These data provide valuable insights, allowing a better assessment of the patient's condition, leading to improved monitoring and, consequently, an enhancement in the quality of care [11], [12].

Additionally, recording data related to the performance of healthcare professionals can be extremely useful to improve obstetric service quality, as monitoring the professionals' performance allows to evaluate the quality of obstetric care in that service [11].

However, healthcare professionals may perform several tasks, and different obstetric techniques can be applied to each patient. As a result, a significant amount of data is recorded. Therefore, a performance dashboard for healthcare professionals would be extremely valuable, as it would simplify the process of reading and analysing the data, making it more efficient and accessible. Obstetrics professionals perform several tasks and techniques that entail distinct knowledge areas. Therefore, a dashboard would enable the monitoring of performance by simplifying the complexity of data [6].

A well-organized presentation of this data would allow healthcare professionals to understand and assess their individual performance, enabling them to modify their strategies and enhance their performance. Key indicators such as success rate in normal deliveries, caesarean rates, response time to obstetric emergencies, and the quality of prenatal counselling can help identify areas for improvement. They also offer valuable feedback to healthcare professionals, assisting them in enhancing their practice and delivering better care to their patients [5].

On the other hand, a performance dashboard would serve as a management tool for those responsible for the obstetric service. It would enable them to evaluate the team's performance, support service optimization, and assist in decision-making. Consequently, this would contribute to an overall improvement in the quality of care provided. Indeed, the use of the dashboard would allow the identification of patterns and facilitate comparisons of results among different professionals, teams, or institutions. This comparative analysis can help identify best practices and effective approaches, as well to recognize areas in need of improvement through the identification of trends and systemic issues [12], [13].

The measurement and evaluation of healthcare are essential elements of the healthcare system. The development and assessment of performance metrics for healthcare are crucial and relevant, once by monitoring the performance of obstetric professionals, it becomes possible to identify areas that require improvement and implement appropriate corrective measures. These measures can include specialized training, protocol revisions,

standardization of practices, or the provision of additional support and resources. Such actions contribute to the enhancement of the quality of obstetric care, resulting in a better experience for mothers and newborns [6].

1.3. Main goals

This dissertation aims to develop a dashboard for the visualization of the individual activity of healthcare professionals in obstetrics, which implementation would allow professionals to assess their performance and hospital managers to evaluate the quality of service quickly and intuitively, enabling improvements in the quality of care. To achieve this goal, specific objectives have been set, which can be split into three phases, proposal, implementation, and evaluation. The proposal stage started with the elaboration of a literature review focused on performance dashboards used in clinical environments. Then, based on the acquired knowledge, specific parameters were established and some proposals for the dashboard structure were developed.

Then in the implementation stage, after choosing the final structure, the performance dashboard was developed (proof of concept) and installed in Obscare. Finally, in the evaluation phase a questionnaire was developed to be administered to healthcare professionals to assess their potential interest in using the Performance Dashboard as a tool for monitoring performance, to collect insights for its improvement and validation.

1.4. Structure

This document is divided into five chapters, each describing a specific stage of the dissertation's work. Firstly, in the Introduction, the theme of the dissertation was briefly introduced, and the motivation of the dissertation was presented, as its main goals.

In the second chapter, it is presented the literature review conducted, exploring the concept of performance dashboard and its applications in healthcare, examining the advantages and disadvantages of using these dashboards in this context, providing a solid foundation for the study. In the third chapter, the methodology used for the dissertation's development is presented. In the fourth chapter, the results obtained throughout the study are presented and analysed.

Finally, in the fifth chapter, the dissertation's conclusion is presented. This chapter summarizes the key points discussed throughout the work, highlights the most significant findings, and provides practical recommendations. This section is crucial for understanding the impact of performance dashboards in the healthcare environment and for identifying valuable insights that can contribute to future improvements. Additionally, it may suggest potential directions for future research in the field of performance dashboards in healthcare environments.

Chapter 2: Performance Dashboards for visualization of individual activity of health professionals

Hospitals are complex organizations with multiple objectives, from patient care to health professionals' education. They also possess multiple services, structures, and processes, carried out by different healthcare professionals with distinctive roles. All this complexity results in a vast amount of data from a wide range of sources, from which becomes difficult to identify the essential information needed for decision-making [5], [14].

Healthcare organizations are currently facing difficulties in processing and analysing data due to this overwhelming volume. The abundance of data does not necessarily contribute to informed management decisions, making it difficult to deliver services effectively and efficiently. Moreover, as the quality of life improves, patients have higher expectations regarding the quality of service, which increases the demand for better treatments and medical services, thus necessitating performance improvement [5], [12].

The increasing demand for delivering high-quality services at a reasonable cost poses a significant challenge for healthcare organizations. To achieve this objective, effective management and improved performance are crucial. However, the inadequate sharing of information and ineffective data monitoring hinder the improvement of healthcare quality [6], [13], [15].

To overcome these organizational problems, hospitals and healthcare services have been implementing different tools to better process data, that can be used in quality improvement initiatives [5].

During the decision-making process, managers must carefully consider all factors that could potentially affect the quality of service, which includes assessing the performance of healthcare professionals. To aid in this evaluation, interactive tools like performance dashboards can be employed to organize and analyse relevant information efficiently. This analysis drives improvements in the performance of healthcare professionals, thereby contributing to an overall enhancement in the quality of treatment [11], [15], [16].

2.1. Performance Dashboard

Dashboards are business intelligence reporting tools that display relevant data according to specific metrics through graphic elements, such as charts, graphs, and other visual elements, allowing a quick visualization [17], [18].

Through its analysis, it is possible to establish relations and draw conclusions, allowing the monitoring of the organization, as it improves the knowledge of its status. Dashboards assist in decision-making as they synthesize extensive data sets, displaying specific information in real or near real-time and highlighting factors that request consideration [15], [19]. The utilization of dashboards facilitates the attainment of organizations' goals by enabling thoughtful and well-informed strategic decision-making. Moreover, it enhances the monitoring of daily organizational activities [18], [20].

The utilization of dashboards facilitates the attainment of organizations' goals by enabling thoughtful and well-informed strategic decision-making. Moreover, it enhances the monitoring of daily organizational activities [18], [20]. [17], [19].

Dashboards have been widely used in clinical settings for patient monitoring, clinical decision support, and management purposes. Among these types, performance dashboards are increasingly being used, as they provide valuable insights into key performance indicators, facilitating data-driven decision-making related to healthcare professionals' delivery and the service outcome [21].

Performance refers to the way a professional carry out their tasks and fulfils their responsibilities at work. It is the measure of their effectiveness, efficiency, and the quality of work. Management control plays a crucial role in improving professional performance. Through measurement, comparison, and analysis of indicators and goals, it is possible to identify professionals' strengths and improvement opportunities. By establishing performance parameters and monitoring results, corrective actions can be taken, improvement strategies can be implemented, and professionals can achieve their best outcomes. Management control provides an objective basis for evaluating performance, identifying gaps, and fostering a more productive and efficient work environment [22].

A performance dashboard is a visual tool that displays relevant performance information and metrics of a professional or organization. It provides a quick and clear overview of current and past performance, facilitating effective analysis and monitoring to make informed decisions and drive continuous improvement in professionals' performance [15].

Performance dashboards are designed with three primary objectives: monitoring, analysing, and managing. Indeed, through the visual organization of the information, this tool allows monitoring performance on time using specific metrics, simplifying the analysis. Professionals can assess their work, but also supervisors and managers can recognize and analyse the professional's performance intuitively and clearly, leading to improved management [5], [23].

According to Eckerson, dashboards should structure information into three layers, so that the information can be read in a logical and natural sequence, facilitating comprehension. This sequence starts with monitoring key metrics searching for exceptions, then analysing that information and finally drilling into detailed reports before acting [23].

The outer layer displays graphical and metric data, used to monitor performance through graphs, charts, and tables. As the first layer to be displayed, is responsible for monitoring, it is crucial to ensure a quick data visualization. Traffic lights can be employed for simplified visual representation. Alarms can be associated with notifications when certain thresholds are reached, which can include messages or emails. The middle layer represents the dimensional data, which allows users to analyse the information to determine the root cause of an exceptional condition highlighted in the monitoring layer. The inner layer consists of the detailed data displayed in reports and lists. This layer allows to fully understand the root cause of the problem, through a more in-depth analysis. This information can be displayed in a separated window, to avoid overwhelming the dashboard with excessive data, ensuring a clear representation [5], [23].

Although the structure is usually based on these three layers, performance dashboards may exhibit certain variations and specific details, such as incorporating assumption models, where the user can predict and anticipate the outcomes if one of the metrics values varied and assess the impact of that difference [23].

Performance dashboards can assume different structures depending on the key performance indicators displayed. According to their final objective, performance dashboards can be divided into three types: strategic, tactical, and operational [5], [22], [24]. Strategic dashboards are designed to track and monitor progress toward achieving strategic objectives. They serve as a communication tool for sharing the strategy, as well as monitoring the execution of objectives and evaluating strategic performance. Strategic dashboards emphasize management more than monitoring and analysis and are usually designed to support executive meetings that review strategies and operations. These dashboards focus on performance management, ensuring effective goal attainment within the deadline [5], [22], [23].

Tactical dashboards measure and analyse the performance and their use is destined for departmental managers, as they enable them to investigate data across many dimensions, allowing them to find the cause of the problem, leading to an improvement of processes. By focusing on metrics analysis, tactical dashboards allow users to monitor performance and track progress against specific goals. These dashboards are regularly updated, usually on a daily or weekly basis [5], [22], [23].

Operational dashboards focus on monitoring the performance and processes in real time, delivering relevant information and timely data. In healthcare this type of dashboard is known as clinical dashboards, as these are used by clinicians, to assist in decision-making, improving the quality of patient care [11], [25].

Given that each type of performance dashboard serves a distinct purpose, the three types should not be seen as separate tools. Strategic dashboards should have a cascading effect on tactical and operational dashboards. Although different departments within a company may have their dashboards, these should be structured using the same key performance indicators to attain alignment toward the organizational goals [5], [23].

Using Eckerson classification, performance dashboards, can be easily divided using a 333 rule, as schematized in Figure 3. Performance dashboards can assume three different primary objectives, can adopt three types of structure depending on the goal, and should be organized into three layers, each with a distinct function.

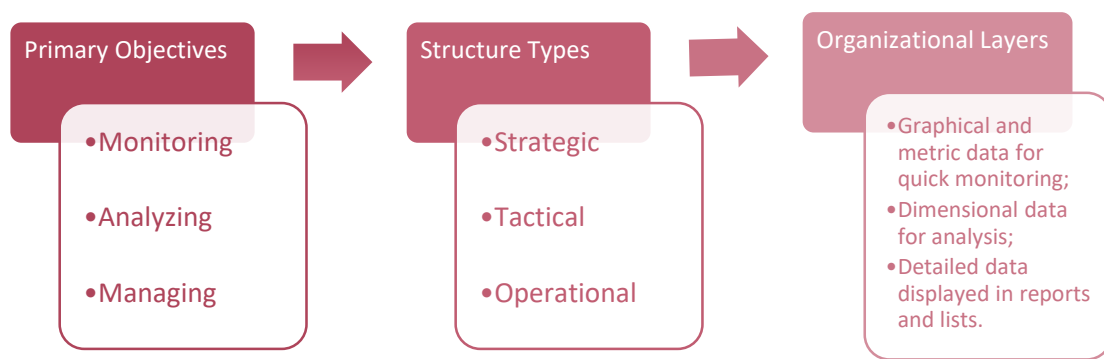


Figure 3 -333 classification of Performance Dashboards according on their primary objectives, structure types and organizational layers defended by Eckerson.

Effective metrics result in terms of defining significant action and improvement rather than simply monitoring the performance. Performance metrics are the tools used by organizations to assess and track the effectiveness of their strategies in meeting the demands and expectations of key stakeholders [5], [23].

Key Performance Indicator (KPI) refers to a measurable value or metric that helps evaluate the performance and progress of an organization, team, or individual towards achieving specific goals. They help track progress against predefined targets or benchmarks, enabling organizations to allocate time effectively, compare performance, and identify areas for improvement. However, selecting and developing KPIs require careful consideration. It is important to avoid focusing on only a few measures, as this may neglect other important performance areas and functional factors. Indeed, it is important to consider that only a limited number of indicators are sustainable for regular analysis, as an excessive set of KPIs leads to excessive consumption of time and resources. Additionally, using isolated measures does not provide a comprehensive, consistent, and fair assessment of performance. During the structuring of the dashboard, it is crucial to establish a well-categorized set of KPIs, considering several performance dimensions [5], [15], [17], [22].

KPIs used in healthcare can be classified into three types: clinical, operational and financial. Financial indicators, as their name implies, offer valuable information about an organization's financial status, emphasizing areas of financial growth and areas that need improvement. These indicators are crucial for resource allocation, including both professionals and supplies. However, in the healthcare industry, profit is not always the primary objective, as the quality of treatment must always be considered. Ideally, by utilizing these resources, it would be possible to combine an increase in treatment quality with a reduction in associated costs [5].

Two key examples of financial indicators in healthcare are revenue and reimbursement by health professionals, services and organizations. Revenue provides insights into the organization's overall financial stability and growth potential, and reimbursement helps healthcare organizations evaluate their revenue. By monitoring these indicators, healthcare providers can gain valuable insights into their financial standing, make informed decisions, and ensure the sustainability of their operations while delivering quality patient care [26].

In a performance dashboard, operational indicators are essential in order to improve operational effectiveness and efficiency. In healthcare, the visualization of clinical quality allied with operation KPIs assures the improvement of healthcare quality. Operational indicators have a high impact on productivity, employee morale and patient satisfaction. Some examples of these indicators are patient wait time, medication error and average length of stay [5], [26].

Clinical indicators, according to Mainz, can be divided into structural, process and outcome indicators. Structural indicators refer to the type and quantity of resources within a health system or organization that are utilized to provide care. This includes factors such as staffing levels, patient volumes, bed capacity, and availability of supplies. Process indicators, on the other hand, measure the specific activities and tasks involved in patient care episodes, such as timely physician assessments and adherence to clinical guidelines. Outcome indicators focus on the resulting health states or events that occur because of healthcare interventions and can be influenced by the quality of care delivered [5], [27].

A well-structured dashboard should include all types of indicators in order to represent the reality of the healthcare organization in a more comprehensive and understandable manner. During the construction of the dashboard, the selection of indicators to include should be carefully considered, as an excessive quantity of indicators can make the information too extensive, making it difficult to comprehend, as it does not focus on the established objectives. Indeed, the number of KPIs should be limited and they must be interconnected, so that the information extracted from the dashboard already allows for an immersive analysis of the reality [5], [17], [19].

Since indicators represent numerical values, it is important to establish concrete target values to achieve. When defining those targets, it is important to find benchmark points

according to past results, or even benchmark against other healthcare organizations with similar dimensions and functions [5].

After benchmarking, specific targets should be established for each KPI, as they represent performance standards in a measurable way. These targets can be fixed or variable. Furthermore, thresholds must be established to account for potential fluctuations in KPI values within a specific range. Threshold values are defined as a percentage of the target and include both the upper and lower threshold limits [5].

Kerzner outlined a 6-step process for developing a dashboard. It begins with defining the purpose of the dashboard, and then identify the organization's data sources to understand what information can be obtained. Next, it is essential to select the Key Performance Indicators (KPIs) based on the required information and determine the most relevant metrics to achieve the dashboard's objectives [22], [28].

Once these parameters are defined, it is important to design the dashboard focusing on the design and structure. A customized and well-structured dashboard enables users to access information more efficiently, so it is crucial to filter and prioritize the most relevant information when selecting KPIs to ensure that the dashboard presents valuable insights rather than overwhelming users with excessive data [26], [28].

After the development stages, the next step is to share the dashboard with users, enabling them to interact with the data and make use of the tool. Finally, it is crucial to ensure the dashboard's maintenance, as well as keep the information within it up to date [28].

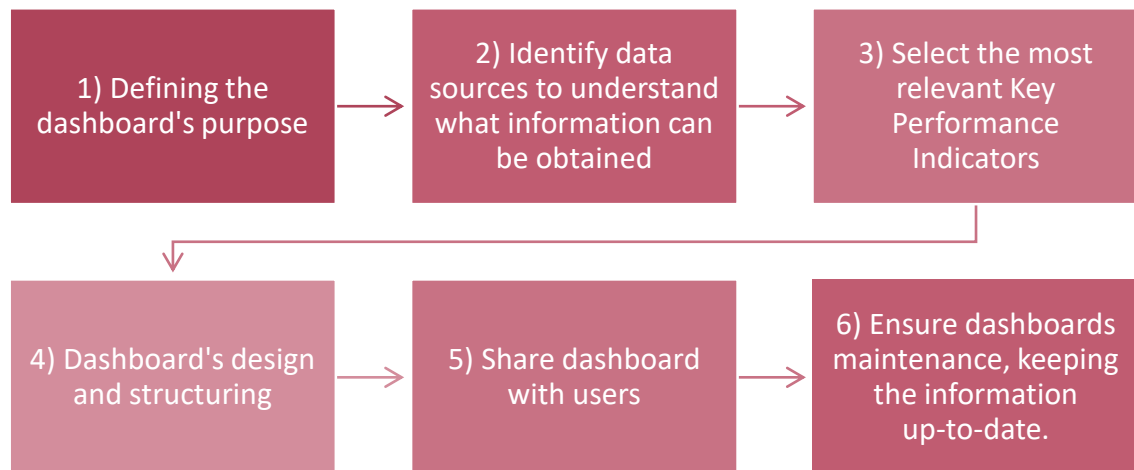


Figure 4 - 6-step Process Defined by Kerzner for the Development of a Dashboard.

A well-structured dashboard is a powerful and efficient management tool. However, designing an effective dashboard is a challenging task because there is no correct way to represent it [16], [22].

The design of the dashboard should be clear and customized to the user, enabling them to quickly access the necessary information. It should be goal-oriented, presenting the data through interactive graphical elements that empower the user to draw conclusions and make more effective decisions [12], [17].

The presentation of KPIs is essential for data interpretation, and different graphical elements can be used, such as tables, lists, bar charts, line charts, among other possibilities. In the review conducted by *Bucalon et al.*, it was concluded that the most used visual elements in the dashboards were bar charts, tables, and line charts. Interestingly, these three elements were found to be present together in 50% of the reviewed examples [21].

To enhance comprehension, colour systems like traffic light colours can be employed, as they quickly allow the identification and classification of the KPI's status. Nevertheless, an excessive use of colours can impede visualization and negatively impact decision-making. Having several indicators and different ways to represent them can make the visualization process challenging. However, it can be simplified implementing consistent patterns and carefully selecting the most significant KPIs [22].

A well-organized and goal-oriented performance dashboard provides a clear representation of information and quick readability. As a result, it boosts productivity and enhances the performance quality of healthcare professionals, leading to improved patient care quality [26].

2.2. Current applications of performance dashboards in healthcare

Performance dashboards have been widely used in healthcare organizations, as they allow profiling health professional's work, and support decision making by the hospital administration. By presenting the data in a simple and intuitive way, it allows the hospital and service managers to quickly monitor the performance of the health professional throughout the days, which is crucial to steer the service, improving the quality of care [12].

Next, examples of performance dashboard examples applied in the healthcare field are reviewed. During the analysis of the examples, specific information was obtained, namely the purpose of the dashboard, the clinical indicators used, and the graphical elements employed. The studies also provided insight into the methods employed to evaluate the dashboard usage and the success of the tool [21]. All the information is summarized in

Table 3.

Ehrenfeld *et al.* developed a dashboard to capture, assess and report anaesthesiology trainee performance. Interns received a score based on each completed anaesthesia case, according to specific quality metrics. The KPIs used for this purpose were antibiotic administration, glucose monitoring (for patients who needed intraoperative insulin uptake), central line insertion, pain management and temperature management. These KPIs were chosen based on national standards, practice guidelines, process protocols and outcome measures. The visual elements chosen for the dashboard design were tables and line charts [29].

During the dashboard's testing phase, it was observed that the developed tool successfully reported the performance of each trainee, enabling the program director to evaluate the performance of everyone in the class. To evaluate the success of the dashboard's utilization, a survey was conducted among the 60 interns who were involved in the dashboard testing. Overall, 80% of the participants strongly agreed that they desire frequent updates on their clinical performance on defined quality metrics, preferring a monthly frequency for the review, and they also desired to have access to a comparison between members of the class [29].

Within the survey, participants were given the opportunity to suggest additional KPIs, resulting in a variety of suggestions, such as post-operative events, patient satisfaction, and timing of procedures. The majority of the residents noted that they would like to receive the report by email, or through the utilization of a website or mobile app. However, some limitations were identified, as it became impossible to continue reporting the interns' performance throughout the internship, which prevented an effective assessment of the dashboard's usefulness in reporting performance. It was also observed that performance is not consistent, as it varies depending on the type of case, suggesting the need to incorporate additional indicators to better represent the reality [29].

A few years later, Laurent *et al.* also developed a dashboard to report the performance of anaesthesiology trainees. In comparison to the dashboard developed by Ehrenfeld *et al.*, this dashboard included information on 39 KPIs, in addition to tracking the number of cases and procedures performed. For analysis purposes, it featured a customized data filter, allowing each KPI to be examined within specific time intervals (weekly, monthly, or annually). Furthermore, it provided the capability to analyse KPIs within each anaesthesia unit (such as cardiac and lung surgery, obstetrics, paediatrics, etc.). The dashboard was sent to users via email and had the ability to switch the KPIs representation from numerical to percentage. The information was displayed using tables and bar charts [29].

The usability of the dashboard was also evaluated through a survey, which revealed a usability rate of 82.6%. However, some limitations were identified, once users desired a more attractive home page and better explanation of some KPIs. Some interviewees also expressed interest in having a specific dashboard for each unit [29].

The interns also reported that their use of the dashboard would likely prompt them to come up with more inputs for dashboards development and structure. This highlights that dashboards are indeed useful tools, not only allow for performance monitoring but they also enhance the productivity and engagement of professionals in their roles [29].

Clark *et al.* developed a clinical dashboard to represent relevant hospital information to support daily clinical decision making. The information was displayed in a single screen, using bar charts, line charts and histograms, facilitating the information reading. The KPIs used facilitated the control of patient flow, enabling the recognition of issues and the formulation of solutions accordingly [30].

The success of the dashboard's utilization can be attributed to the inclusion of timely and relevant clinical data as well as strong clinician engagement and acceptance. The use of the dashboard promoted a reduction in paper-based reports and a reduction in the time taken to create and sign off discharge summaries. The implementation of the dashboard also led to an increase in healthcare professionals' productivity, as it identified areas where performance needed improvement and raised awareness among the clinical team about delays in processes affecting discharge dates [30].

The implementation of clinical dashboards to monitor health professionals' performance is increasing. This study reaffirmed that this tool enhances healthcare professionals' efficiency, improves decision-making, aids in process monitoring, and reduces incidents in clinical practice [30].

Khanna *et al.* developed a clinical dashboard for practice analysis in clinics, specifically to assess performance in relation to organization costs associated with clinical practices. The dashboard displayed patient counts categorized by disease, along with the associated costs. A survey was conducted with 48 primary and specialty care clinics, revealing that 96% of the surveyed clinics were already reporting cost-related data. Regarding the presented dashboard, 72% considered its utilization beneficial, and 48% found the data represented on the dashboard interesting for monitoring clinic practice [31].

Patel *et al.* demonstrated the applicability of a performance dashboard in an obstetric context by developing a maternity dashboard to enhance the quality of treatment. This dashboard was tested for Nizwa Hospital in Oman with high-risk pregnancy patients. This hospital faced certain limitations, such as being overbooked, having insufficient staff, and a lack of healthcare professionals' experience [32].

A high-risk pregnancy can arise from pre-existing medical conditions in the mother prior to pregnancy, such as high blood pressure, polycystic ovary syndrome, lung kidney or heart problems, obesity, diabetes, autoimmune diseases, and sexually transmitted diseases. On the other hand, several factors can develop during pregnancy, such as preeclampsia, gestational diabetes, premature labour, haemorrhages, and the mother's age during pregnancy [32].

During the development of the dashboard, quality indicators were defined. In addition to clinical activities that directly monitor the healthcare professional's performance, other indicators such as maternal measures (induction of labour, workforce, eclampsia, among others) and neonatal measures (low five-minute Apgar score, perinatal asphyxia, early neonatal death, among others) were included. These indicators were initially displayed in a table using an Excel spreadsheet, which did not allow for constant updating of the information [32].

The study revealed that the Maternity Dashboard had a positive impact, contributing to improved functioning of the healthcare system in that hospital by streamlining the decision-making process. By enabling quick recognition of adverse performance situations, it was concluded that there was a significant burden on healthcare professionals, leading to a request made to higher authorities to hire fifteen midwives. Through the dashboard, it was possible to confirm that the constant overcrowding of patients in the hospital resulted in a decrease in treatment quality. By increasing the workforce, the number of scheduled deliveries per healthcare professional could be reduced. Additionally, by inducing labour, better patient flow management was achieved [32].

Overall, the implementation of the Maternity Dashboard provided valuable insights and facilitated more informed decision-making, ultimately leading to improvements in the healthcare system and the quality of care provided [32].

However, it was found that the lack of standardization of quality indicators prevented comparisons with other hospitals, which would enable a better evaluation of the service. The adoption of standardized quality indicators in obstetrics would not only facilitate benchmarking and performance evaluation across different healthcare facilities but also promote a more comprehensive understanding of the quality of care provided. By aligning with international standards, hospitals would have a common framework to assess their performance and identify areas for improvement [32].

In their study, Sprague *et al.* sought to determine the main KPIs for assessing the quality of obstetric treatment. They conducted a comprehensive review of the existing literature and identified six specific indicators. Furthermore, they established benchmarks for each of these indicators, providing a clear framework for evaluating and monitoring the quality of obstetric care [4].

In the developed dashboard, the information was displayed in a table, using the traffic light colour system, to quickly classify the indicators status. The six indicators used were the proportion of newborn screening samples that are unsatisfactory for testing, rate of episiotomy in women having a spontaneous vaginal birth, rate of formula supplementation at discharge in term infants whose mothers intended to breastfeed, proportion of women with a Caesarean section performed prior to 39 weeks' gestation among low-risk women having a repeat Caesarean section at term, proportion of women delivering at term who had Group B

Streptococcus screening at 35-37 weeks' gestation and proportion of women induced with an indication of post-dates who are less than 41 weeks' gestation at delivery [4].

Although, certain limitations were noted, once small volume hospitals will require more time than larger volume hospitals to connect sufficient data on outcomes to obtain reliable estimates of their practice patterns. To reduce misinterpretation, it would help having appropriate comparator groups, with same level of care and size, enabling better conclusions [4].

While the chosen indicators allow for the evaluation of maternal and infant treatment quality, it is expected that both the indicators and benchmarks will evolve over the years, requiring a constant system update. To obtain more detailed and specialized information, it would be advantageous to include hospital-specific indicators that align with the hospital's own objectives. By doing so, a more comprehensive assessment of the hospital's performance can be attained. Indeed, one of the major challenges in measuring obstetric quality is the standardization of indicators and benchmark values [4].

Simms *et al.* developed a study for assessing the development of clinical dashboards in 12 maternities of the Southwest of the United Kingdom. The results were obtained through an electronic survey about the methods employed to monitor outcomes such as maternity dashboards, followed by interviews with lead obstetricians and risk management midwives of each maternity [33].

The analysis of the results revealed an overwhelming number of indicators, totalling 352 across 37 different categories. Interestingly, it was discovered that 39 of these indicators represented redundant or similar information. This high number of indicators significantly increased the complexity of the dashboard, making it challenging to interpret and extract meaningful insights from the data. There is an urgent need for a standardized set of maternity quality indicators. Establishing these indicators, along with guidance for alert thresholds for adverse outcomes, would facilitate accurate comparisons of quality of care between different maternity units and healthcare providers [33].

Standardization is crucial for meaningful assessments and improvements in healthcare quality. In the USA, the Society for Maternal-Fetal Medicine suggested specific obstetric metrics to measure the quality of obstetric care. In obstetrics, unlike other areas of medicine, it is essential to consider the outcomes of two patients, namely the mother and the child, as their outcomes may involve trade-offs with each other. This unique aspect of obstetrics requires a comprehensive and holistic approach to care, considering the interdependent nature of the mother and fetus throughout the entire pregnancy journey [6].

The indicators to assess the quality of obstetric care can be divided into different groups. Structure metrics are designed to assess the capacity to perform a service or function by healthcare professionals. Process metrics assess the patient flow and outcomes metrics. Outcome metrics help assess the impact of treatments or interventions on patient health. On

the other hand, access measures focus on evaluating the ability of patients to obtain timely and appropriate care. They assess factors such as waiting times, delays in receiving care, and barriers that may hinder patients' access to healthcare services. Patient satisfaction metrics evaluate the overall experience of healthcare delivery from the patient's point of view. These measures assess various aspects of care, including communication with healthcare providers, coordination of services, responsiveness of staff, access to information, and overall satisfaction with the healthcare experience. They help identify areas of strength and areas that may need improvement in healthcare organizations, and they also play a crucial role in shaping patient-centred care [6].

The proposed quality metrics were birth trauma, obstetric trauma (vaginal with instrument, vaginal without instrument and caesarean delivery), neonatal mortality, incidence of episiotomy, caesarean delivery rate, nonmedically indicated delivery <39 week, appropriate use of antenatal corticosteroids, newborn readmission, and severe maternal morbidity. However, many more indicators can be applied to better report the quality of care in different stages of pregnancy, childbirth, and newborn treatment [6].

The application and effectiveness of obstetrical quality measures in driving clinical improvements depend on their proper implementation and utilization. Although certain aspects of quality can be measured, it is crucial to ensure that these measures are effectively applied to achieve meaningful clinical enhancements. In summary, healthcare measurement and evaluation, along with the utilization of dashboards, are integral pieces of the healthcare system as they facilitate the monitoring of performance [6]

Table 3 - Applications of Performance Dashboards in Healthcare.

DASHBOARD'S PURPOSE	KPIs	VISUAL ELEMENTS	CONCLUSIONS	Ref.
<p>Dashboard to capture, assess and report the performance of anaesthesiology trainees</p>	<ul style="list-style-type: none"> ▪ Execution of anaesthesiology tasks; ▪ Execution of central line process stage; 	<p>Table Line chart</p>	<ul style="list-style-type: none"> ▪ 80% of the trainees were inquired (48 out of 60) and they agreed that they desire frequent updates on their clinical performance. ▪ They also desire to be compared with the rest of the trainees. ▪ All of them agreed that before the dashboard implementation they were not receiving performance feedback promptly. 	<p>[29]</p>
<p>Dashboard to anaesthesia unit management and quality assessment</p>	<ul style="list-style-type: none"> ▪ Unit's overall activity; ▪ Compliance with guidelines on intraoperative hemodynamic, ventilation and monitoring; ▪ Documentation of the anaesthesia procedure; 	<p>Table Bar chart</p>	<ul style="list-style-type: none"> ▪ Dashboards' usability was evaluated with a score of 82,6% which correspond to excellent usability. 	<p>[34]</p>

<p>Maternity dashboard to improve the quality of healthcare with patients with high-risk pregnancies</p>	<ul style="list-style-type: none"> ▪ Clinical activities: deliveries, admission to the antenatal ward, outpatient department appointment, instrumental deliveries, caesarean section rate. ▪ Maternal measures: induction of labour, workforce, eclampsia, intensive care unit admission, severe postpartum haemorrhage, third-degree perineal tear, shoulder dystocia, hematomas, postpartum hysterectomy, mortality. ▪ Neonatal outcomes: low five-minute Apgar score, perinatal asphyxia, meconium aspiration syndrome, stillbirth, stillbirth with diabetes, early neonatal death. 	<p>Table</p>	<ul style="list-style-type: none"> ▪ The implementation of the dashboard was successful, leading to its increased utilization in other hospitals in Oman; ▪ It was also suggested comparing values among hospitals after the dashboard's expansion. 	<p>[32]</p>
<p>Measure quality within the maternal-newborn system</p>	<ul style="list-style-type: none"> ▪ Proportion of newborn screening samples that are unsatisfactory for testing; ▪ Rate of episiotomy in spontaneous vaginal births; ▪ Rate of formula supplementation in term infants whose mothers intended to breastfeed; 	<p>Table</p>	<ul style="list-style-type: none"> ▪ Use of traffic light colour system aided in information analysis; ▪ Successful implementation of the dashboard, although some limitations were noted, once it was a small volume hospital and some indicators were not quite 	<p>[4]</p>

	<ul style="list-style-type: none"> ▪ Rate of repeat Caesarean section in low-risk women not in labour at term, with no medical or obstetrical complications, prior to 39 week's gestation. ▪ Proportion of women induced with an indication of post-dates who are at less than 41 weeks' gestation at delivery. 		<p>represented in the numbers obtained;</p> <ul style="list-style-type: none"> ▪ Some constraints were encountered in dashboard construction due to limited benchmark information in obstetric and neonatal care.
<p>Clinical dashboard that displays relevant hospital information to support daily clinical decision making</p>	<ul style="list-style-type: none"> ▪ Patients that have been accepted for admission, length of time waiting for a bed and patients who are awaiting notification of discharge; ▪ Bed availability, location and number of patients; ▪ Percentage of patient that are at risk of falls and/or pressure injuries. 	<p>Bar chart Line chart Histogram</p>	<ul style="list-style-type: none"> ▪ Visually accessible information supporting improved local decision making, reduction in paper-based reports; ▪ Raised awareness within the clinical multidisciplinary team of process delays to achieve expected dates of discharge and reduction in the time taken to create discharge summaries; ▪ Identification of potential areas where clinical process can be improved; ▪ Popular mechanism for engaging and interacting with clinical staff. <p>[30]</p>

2.3. Advantages, limitations, and challenges of Performance Dashboards' applications

The use of performance dashboards in healthcare systems offers several benefits, in addition to improved data visualization. Performance dashboards assist in real-time monitoring by displaying up-to-date data, allowing timely interventions, and facilitating proactive management of healthcare services.

By providing a comprehensive overview of several metrics and indicators, such as patient satisfaction scores, readmission rates, and average length of stay or infection rates, dashboards enhance performance measurement, allowing the identification of areas that need improvement and the setting of performance targets, assisting in quality improvement initiatives. Indeed, performance dashboards provide insights into the effectiveness of quality improvement initiatives by measuring the impact of interventions in real-time and monitoring the progress and effectiveness of those initiatives, driving to continuous enhancement of healthcare services. An ongoing update of the dashboard also promotes increased productivity among healthcare professionals as it encourages them to exceed specific objectives.

Dashboards play a crucial role in promoting transparency within healthcare organizations by making key performance metrics easily accessible to relevant stakeholders. Additionally, when results and metrics are publicly displayed, it enhances transparency and builds trust with patients and the community (resident dashboard). By tracking and analysing key performance indicators and fostering the sharing of this performance data among professionals, managers, and executives, the health service cultivates a culture of accountability and actively encourages individual and team-level performance improvement.

Dashboards can integrate data from multiple sources, offering a holistic view of the organization's performance, and supporting decision-making at different levels, from frontline clinicians to management. Dashboards provide valuable insights to drive strategic planning, operational improvements and efficient resource allocation, as this data-drive approach enables to identify areas where resources may be underutilized or misallocated. Metrics such as patient flow, bed occupancy rates, and staff productivity enable administrators to make informed decisions to optimize resource allocation, streamline processes, and improve overall efficiency. As a result, these efforts lead to cost savings, improved resource utilization, and better patient outcomes.

All these advantages allied to the goal-centred structure of dashboards, contribute to substantial improvements in healthcare organizations, as they effectively boost operational efficiency and quality of care, leading to better overall outcomes that positively influence both patients and the healthcare system. Figure 5 synthesized performance dashboards' advantages.

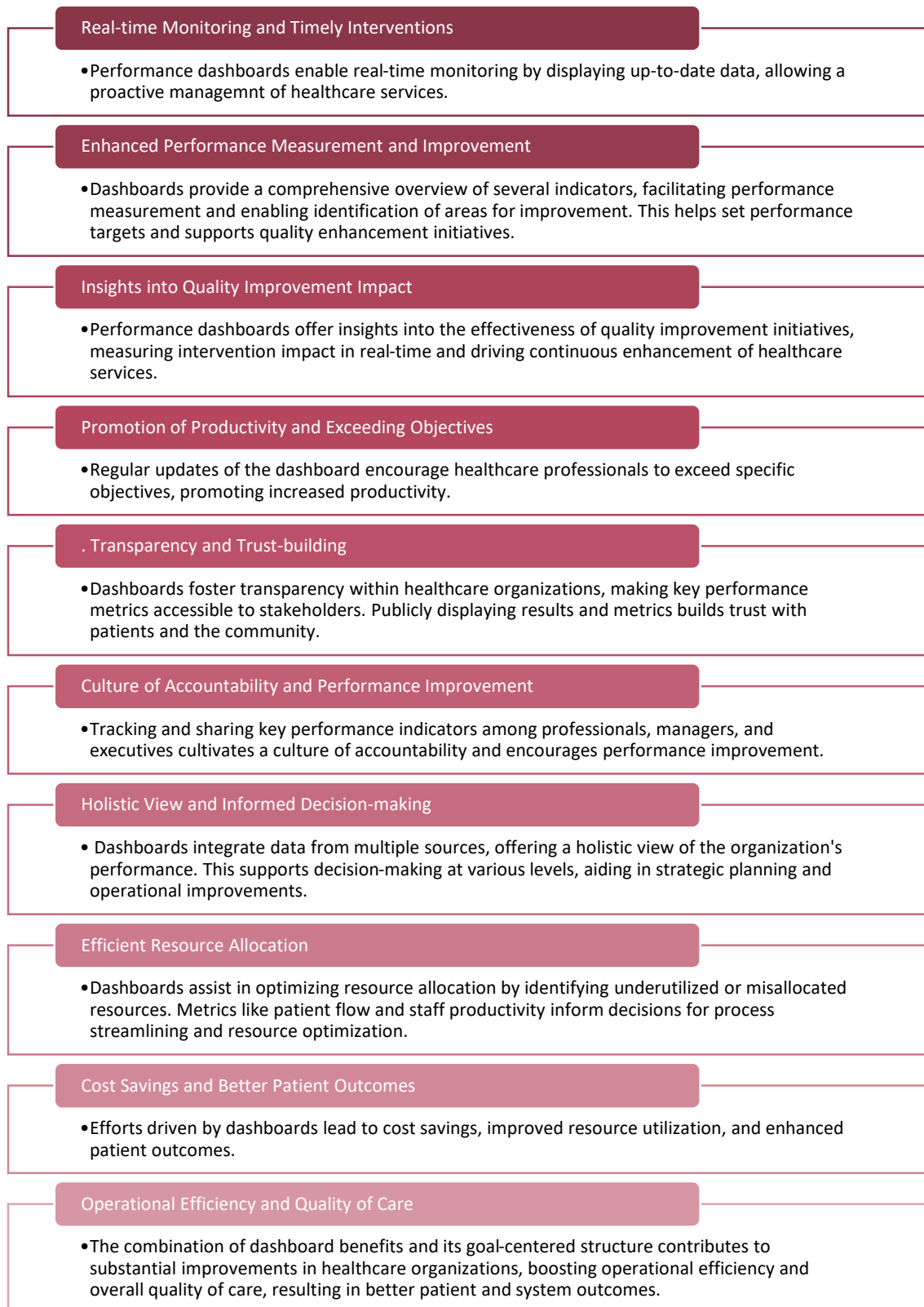


Figure 5 - Advantages of Performance Dashboards in Healthcare Systems.

On the other hand, performance dashboards present some disadvantages and limitations. In hospitals with small volumes of patients, the need for a longer time interval to obtain a significant set of results for analysis can restrain the applicability of certain data collection frequencies, such as daily or monthly. Furthermore, challenges in implementing performance dashboards may arise due to professionals' lack of familiarity with this tool, leading to a delay in performance improvements resultant from dashboard analysis.

A great limitation of performance dashboard is the lack of consensus on KPIs in clinical and obstetric contexts and, additionally, the limited information available regarding well-defined benchmarks for these indicators. Standardizing KPIs and their benchmarks would be beneficial for wider adoption of performance dashboards.

Also, once every hospital possesses a unique organizational structure, incorporating specific indicators tailored to individual needs may be necessary, yet this approach could hinder the standardization of performance dashboards and their KPIs. Another concern of the lack of consensus upon KPIs, is the difficulty in comparing results swiftly between hospitals of similar size and treatment levels. This comparison could provide relevant insights into each healthcare unit.

In the absence of standardized KPIs, the ability to draw comprehensive conclusions about each healthcare facility's performance is compromised. As the healthcare landscape evolves, efforts to address these limitations will be crucial to achieving the full potential of performance dashboards in healthcare decision-making and improvement. Figure 6 synthesized performance dashboards' disadvantages and limitations.

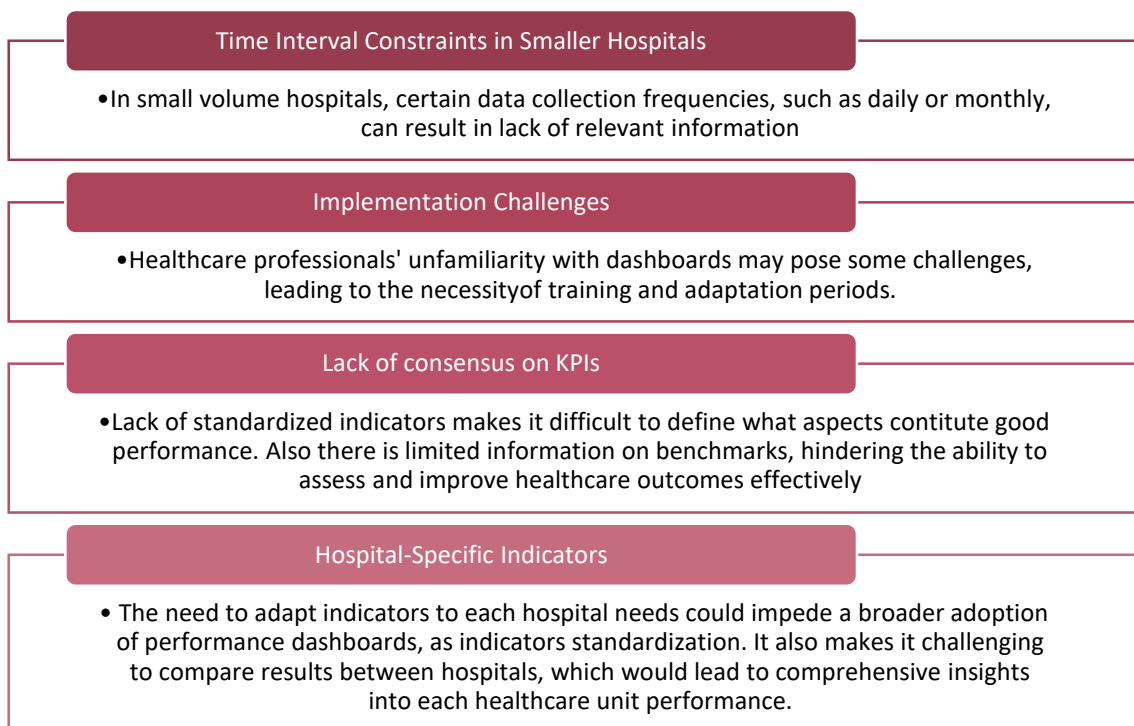


Figure 6 - Disadvantages and Limitations of Performance Dashboards in Healthcare Systems.

Chapter 3: Methodology

In this chapter, it is presented the methodology used during the execution of the dissertation, from April to August of 2023. Figure 7 outlines the four fundamental stages employed, which will be presented in detail next, enabling a comprehensive understanding of the decisions and steps taken throughout the dissertation.



Figure 7 - Applied Methodology Stages.

3.1. Analysis and selection of indicators

The initial stage involved the analysis and selection of indicators that better represent the individual activity of obstetric health professionals. An in-depth literature review was conducted to understand performance dashboards and study their relevance in a clinical context.

As shown in the previous chapter, examples were collected from obstetric services and maternity units in order to identify the most used obstetric indicators and which were more representative of the performance of healthcare professionals in obstetrics. Other examples from different clinical contexts were also used as inspiration for the visual representation of indicators. Additionally, these examples played a crucial role in determining the most appropriate type of performance dashboard for the objective, as well as the most effective strategies for data representation.

Simultaneously, a comprehensive study of the Obscare application and its database structure was also conducted, to identify the existing indicators within the collected data and how they are interconnected. This process was fundamental for the selection of potential indicators for visual representation of obstetric healthcare professionals' performance. This

analysis also streamlined the dashboard construction process, enabling a clear understanding of the indicators' locations within the database.

3.2. Design of visual presentation

In the second stage, it was selected the most suitable dashboard type to effectively represent the performance of obstetric professionals and it was also evaluated the most adequate frequency at which dashboard values should be presented. Using the indicators chosen in the previous stage, it was carefully assessed the optimal organization by grouping them into distinct categories to ensure a quick analysis and easy comprehension of the information.

The visual and schematic arrangement was achieved through the strategic use of colours and the selection of appropriate visual elements, to enhance comprehensibility. These decisions were guided by the three hierarchical levels: high-level actions representing analysis, mid-level actions pertaining to research, and low-level actions focusing on specific inquiries. This approach ensured that the dashboard displayed data effectively and facilitated prompt and meaningful interpretation.

3.3. Construction of the dashboard

During the construction of the dashboard, a multi-step approach was employed. The data, stored in an Oracle SQL database, was accessed through a series of queries contained in a PHP file. Subsequently, these queries were used to extract the necessary data, which was then formatted into JSON. This structured data was transmitted to a JavaScript file where predefined variables and graphical elements were incorporated. These elements were then integrated into the final HTML dashboard file. The dashboard file was integrated into the Obscare application, presenting the dashboard within the application. Moreover, CSS was applied to establish the visual style of the webpage, ensuring an engaging user experience.

The combination of technologies and methodologies, schematized in Figure 8, facilitated the creation of an interactive and informative dashboard. During this stage, the collaboration and support from VirtualCare team greatly contributed to the success of the project execution. Indeed, their familiarity with the application and the standardization of files played a crucial role in achieving the dashboards construction goals.

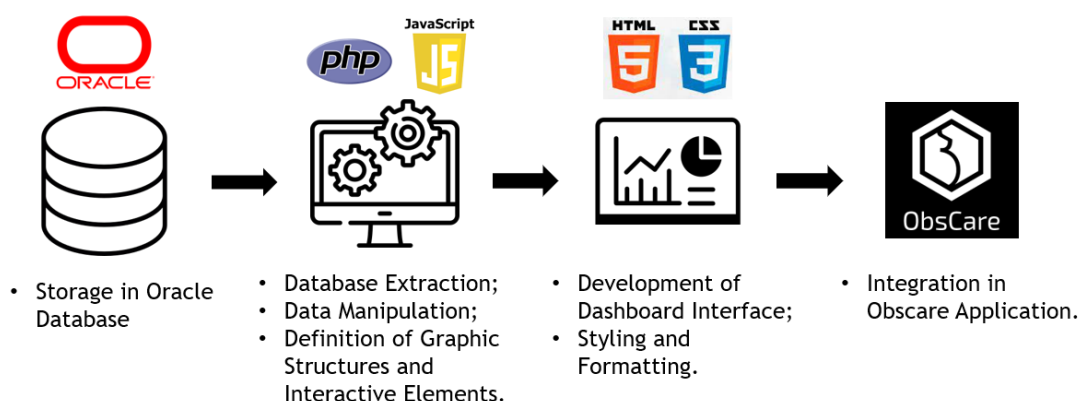


Figure 8 - Methodology and Technologies Used for Dashboard Conception.

3.4. Evaluation of usability

In the evaluation phase of the dashboard, our aim was to assess the potential use of the dashboard. The questionnaire's primary purpose was to assess the interest of the professionals in using a tool like the performance dashboard to monitor performance. This evaluation process, would give valuable insights regarding the acceptance and perceived utility of the dashboard among healthcare professionals, enabling us to modify the dashboard to better meet their needs and expectations. This evaluation step plays a crucial role in the validation and ongoing refinement of the dashboard, ensuring that it becomes an effective tool for monitoring and improving the performance of healthcare professionals.

The questionnaire used is constituted by fifteen questions and it is presented below in Table 4.

Table 4 - Questionnaire.

Question 1	Do you believe there is any current issue with the quality of obstetric care provided in the service? If yes, please specify.
Question 2	Do you think any of these issues are related to performance? If yes, please specify.
Question 3	What factors do you believe impact your performance?
Question 4	Do you currently feel that you can effectively monitor your long-term performance?
Question 5	Would you like to receive information regarding your performance?
Question 6	Would you like to have access to a dashboard that consolidates several information regarding your performance?
Question 7	Which visual representation of statistical data methods do you consider most easy to read? Options: List, Table, Bar Chart, Pie Chart, Line Chart, Scatter Plot, Stacker Are Chart, Histogram, Tree Map, Radar Chart.

Question 8	Would you like to access information regarding the distribution of your service in the last 30 days?
Question 9	Would you like to access information regarding the deliveries performed in the last 30 days?
Question 10	Would you like to access information regarding the performance of cesarean sections?
Question 11	Would you like to access information regarding the performance of other procedures during childbirth and other techniques?
Question 12	If you answered "No." to any question from 8 to 11, could you please explain the reason?
Question 13	Would you like to receive a different type of information related to performance? If yes, please, specify.
Question 14	Do you believe that using a performance dashboard would help you monitor your performance more effectively?
Question 15	Do you think that analysing the information contained in it would help you improve your performance?

Chapter 4: Results

In this chapter, the results of the dissertation work are documented. Firstly, it is presented the dashboard and its features, explaining how it could enhance the analysis of obstetric performance, leading to service quality improvement and resource allocation.

4.1. Performance Dashboard

High volumes of information and great complexity of data, lead to constraint when designing a dashboard, once more information does not always lead to better outcomes. The literature review, presented in Chapter 2, gave crucial insights into clinical dashboard design, indicators selection and visual organization. Indeed, it was noted that simple designs lead to better outcomes and facilitate the familiarization with the dashboard. For that reason, only four visual elements were used: lists, tables, pie charts and bar charts. Obscare's colour palette was used to maintain a visual harmony, and important information was highlighted using bold fonts.

During the indicator's selection process, a conscious effort was made to only select important information, without excessively limiting data, so the dashboard would reflect the performance of obstetric health professionals. Dashboards developed by Sprague *et al.* and Patel *et al.* were used as an inspiration for the selection, effectively complementing the analysis of the Obscare database. This analysis was crucial as it helped identifying the feasible information to be extracted.

Currently, Obscare provides a total of eight reports presenting several indicators, where the analysis period is selected by the user. The developed dashboard gathers only some of these indicators, the ones that were considered most representative of professionals' performance. However, this set of indicators served as significant inspiration, aiding in the selection process. The dashboard stands out from this list by allowing a quicker visualization of data, also allows a constant use and data analysis, leading to continuous improvement. The use of dashboard is not supposed to replace these documents analysis, but to complement the monitoring, analysis, and management of obstetric services.

After the indicator selection, a monthly frequency was chosen for data presentation as a daily or weekly frequency would not allow for in-depth analysis. Also, an annual or semestral frequency would result in an overwhelming amount of information, making it challenging to draw meaningful conclusions about the events encompassed within such an extended period. The developed dashboard was named “*Desempenho Mensal*” (Monthly Performance), as it displays the values of the selected indicators over the past 30 days, relative to the day of the consultation. The developed dashboard comprises eighty-three indicators distributed between nine modules and is located at the end of the document, in the annex section.

A well-structured performance dashboard simplifies the analysis, leading to effective performance improvements among professionals, so during the dashboard construction it was a goal to maintain the different components of the dashboard clean and simple, to enhance dashboard’s readability and comprehensibility. In the structuring of the dashboard, we employed the three-layer division defined by Kerzner, when the outer layer features dimensional data through different counts related to service distribution, deliveries conducted and newborns. In the top layer, visual elements as graphs and different font sizes are present, to simplify the lecture, enabling swift performance monitoring. Progressing downward the reading of the dashboard, more detailed indicators are presented below the first layer, offering insights into performance and potential constraints.

Through all the structuring phase, it was pursued a dashboard that would combine both comprehensibility and analytical efficacy, ensuring that each element had high visual impact, remaining simple and minimalist. Next, each component of the dashboard will be presented in detail, explaining why the indicator was included and considered indispensable and reflective of the performance. It will also be explained how these indicator’s analysis can drive to improvements in healthcare professional’s performance, while also helping the service director in management.

4.1.1. Service Distribution for the Past 30 days

At the top of the dashboard, is displayed the service distribution over the past 30 days, as shown in Figure 9. There are three types of events that can occur in an obstetric professional day: consultations, hospitalizations, and emergencies. Accordingly, the count of the number of episodes that took place in the last 30 days is shown, alongside a horizontal stacked bar chart. This chart, that adds up to 100%, allows to visualize the percentage of time dedicated to each service. This visual representation allows for a quick understanding of which services are spending more and less time, providing insights into the service’s operation. Accumulating this information over a few months, it also could aid in resources reallocation, assisting in service management.

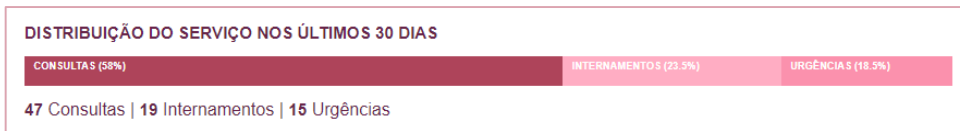


Figure 9 - Service Distribution for the Past 30 Days.

4.1.2. Statistics of Deliveries as Performer

An obstetric professional can play two distinct roles in a delivery, whether as the primary performer or as an assistant. This differentiation has been incorporated into the dashboard to count the number of deliveries conducted in the past month, not only providing an indication of the professional's experience level, but also on their involvement over the last preceding 30 days.

In each section, it is shown the total number of deliveries, distinct between vaginal and caesarean deliveries. This distinction is essential as these two delivery methods involve different knowledge and techniques, so this information offer insights into the prevalence of each type of delivery, which is significant in the assessment of the medical practices, as it is expected to perform natural deliveries, only performing caesarean sections when the situations' constraint make it necessary.

In this component, a pie chart is also presented, where deliveries are divided into four categories: eutocic delivery (unassisted vaginal delivery), instrument-assisted deliveries using vacuum extraction and using forceps, and caesarean sections. This division allows not only the count of deliveries performed by type, enabling the gathering of information about instrument-assisted deliveries carried out, but also facilitates an assessment of the application of instrument-assisted deliveries by comparing this number with the caesarean rate. To complement this analysis, counts of unsuccessful attempts of instrument-assisted deliveries are also provided, both involving vacuum extraction and forceps.

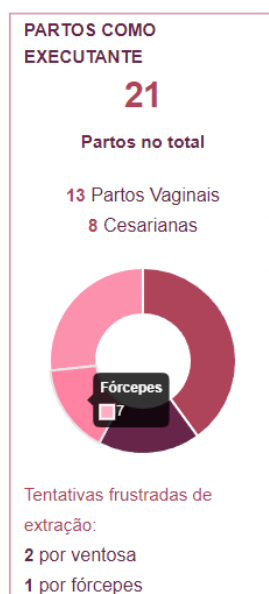


Figure 10 - Number of Deliveries as Performer by Type of Delivery.

4.1.3. Labors statistics

In this component, a visual element is once again used to easily compare the number of spontaneous deliveries with the number of induced deliveries. The comparison between the bar sizes, along with the count of the number of induced deliveries, is of extremely importance, as induction of delivery can sometimes bring problems for the newborn, in ways that monitoring the incidence of inductions would allow improvements in service quality.

4.1.4. Newborns statistics

In the newborn statistics, the total number of newborns is presented, divided into live births and stillbirths, also categorized by gender. While the gender of the children does not indicate anything regarding the quality of the service, it has been included for statistical purposes. However, the number of stillborn newborns can indicate deficiencies in the quality of care, serving as a significant indicator when combined with other information.

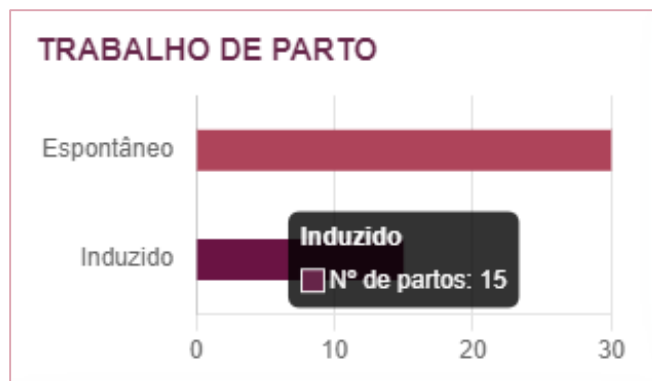


Figure 11 - Number of Spontaneous and Induced Labors.



Figure 12 - Newborn statistics, Number of Live Births and Number of Stillbirths, Differentiated by Gender.

4.1.5. High-risk Maternal Statistics

The analysis of data regarding high-risk parturient with body mass index (BMI) exceeding 30 and older than 35 holds great relevance for the quality of the obstetric service. This subset of data provides valuable insights into the intersection of multiple risk factors, shedding light on the potential complexities and challenges associated with pregnancies in older women and women with elevated BMI.

These high-risk deliveries are displayed in a table and divided into vaginal deliveries and caesarean sections, and three high-risk parturient possibilities: BMI>30, age>35 and both. By examining this specific demographic, healthcare professionals and analysts can better understand the correlation between age, weight, and pregnancy complications. Such analysis aids in tailoring targeted interventions, improving pre-natal care protocols, and enhancing the overall management of high-risk pregnancies, ultimately contributing to better maternal and neonatal outcomes.

4.1.6. Caesarean Section Statistics

In this statistics component, caesarean sections performed in the past 30 days are categorized into scheduled, urgent, and emergent cases, and further divided by the type of anaesthesia administered and the techniques employed during the procedure.

This detailed breakdown offers a comprehensive view of the varying circumstances under which caesarean deliveries are performed, highlighting the complexity of decision-making processes in obstetric care. By analysing these statistics, healthcare professionals gain a deeper understanding of the trends associated with different types of caesareans, enabling them to identify patterns, assess the effectiveness of clinical protocols, and refine their approach to delivery procedures.

The analysis comparing caesarean sections performed with locoregional anaesthesia to those conducted under general anaesthesia holds great significance. Given that both types of anaesthesia have their own advantages and disadvantages and should be applied based on the situation and the condition of the parturient, a higher number of cases in either category leads to greater experience. This, in turn, fosters improved adaptation and technique when faced with new situations in the future. Thus, this indicator serves as a measure of the service quality, for instance, the analysis might reveal whether emergency caesareans have a higher risk profile or if specific anaesthesia choices lead to better postoperative recovery rates. By carefully analysing the distribution and outcomes of caesarean sections performed with regional and general anaesthesia, healthcare institutions can assess their proficiency in providing personalized care for expectant mothers undergoing caesarean deliveries, responding to their individual needs.

Furthermore, the classification by technique allows for an assessment of the expertise of the obstetric professional in question. This data offers valuable insights into the range of

skills possessed by the obstetric team, highlighting their ability to adapt to diverse clinical scenarios and apply a variety of surgical approaches. This aspect of analysis contributes not only to enhancing the overall quality of care but also to fostering a culture of continuous learning and skill development within the field of obstetrics.

By examining the statistics of caesarean procedures, obstetric services can easily assess the proficiency and specialization of their medical staff.

PARTURIENTES DE ALTO RISCO			
	IMC>=30	Idade>=35	Ambos
Parturientes	1	2	0
Cesarianas	4	1	1

Figure 13 - High-risk Maternal Statistics.

ESTATÍSTICAS DE CESARIANAS		
6	5	7
Programadas	Urgentes	Emergentes
4 com anestesia loco-regional		
14 com anestesia geral		
3 programadas com anestesia loco-regional		
1 urgentes com anestesia loco-regional		
0 emergentes com anestesia loco-regional		
5 usando a técnica de Misgav-ladach modificada		
6 usando a técnica de Pfannenstiel Kerr		
4 usando a técnica mediana infraumbilical-Kerr		
4 usando outra técnica		

Figure 14 - Caesarean Section Statistics.

4.1.7. Newborns Hospitalizations, Preterm Births and Other Delivery-Related Information

Newborn hospitalizations are present along with preterm births numbers, once correlating preterm births with neonatal hospitalizations can offer relevant insights into the healthcare system's effectiveness. The preterm births are presented categorized by gestational weeks and identifying which infants survived. This analysis allows healthcare providers to understand the link between premature births and subsequent healthcare needs, ensuring that resources and specialized care are readily available for the vulnerable preterm population.

This analysis not only could improve neonatal care but also emphasizes the obstetric service's dedication to ensuring the well-being of newborns, assessing the service's qualities, not only at the level of professionals but also through equipment-related observations.

The indicator for twin and higher-order multiple pregnancies is crucial for understanding their prevalence, the professional's experience in the delivery and the associated care complexities. This data aids in resource allocation, specialized support, and ensuring the healthcare system's readiness to address the unique challenges of managing these cases effectively.

Stillbirths due to intrauterine growth restriction (IUGR) result in potential complications in fetal development and maternal health. Monitoring these cases can aid in early detection of issues, enabling timely interventions to mitigate risks, enhance obstetric monitoring, and improve overall quality of prenatal care.

Monitoring the occurrence of metabolic acidosis is of paramount importance in evaluating the quality of service provided. Metabolic acidosis is a critical indicator of potential complications during childbirth, reflecting disturbances in fetal oxygenation and acid-base balance. By closely tracking these occurrences, healthcare providers can assess the effectiveness of their interventions, refine protocols, and enhance overall patient safety. This monitoring ensures timely responses to prevent adverse outcomes, contributes to informed decision-making, and underscores the commitment of the healthcare system to delivering the highest standard of care to both mothers and newborns.

Monitoring the occurrence of Apgar scores below 7 at the fifth minute after birth is essential to assess neonatal health and the quality of obstetric care. Indeed, these scores indicate the newborn's vitality and the effectiveness of immediate interventions. Tracking these occurrences allows for identifying areas that require improvement, optimizing neonatal resuscitation protocols, and ensuring the provision of high-quality care to ensure the well-being of newborns.

Figure 15 shows the dashboard module focused on neonatal hospitalizations, preterm births, and other mentioned indicators.

INTERNAMENTOS DE RNs				
	UCIN	NEO		
<33 semanas	3	0		
<37 semanas	5	0		
RNs de termo	2	0		
	10	0		
Nascimentos pré-termo:				
Semanas	< 37	< 35	< 33	< 28
Total	5	3	3	0
Vivos	5	3	2	0
2 partos gemelares				
1 parto com 3 ou mais fetos				
0 nados-mortos devido a IMG				
0 acidoses metabólicas				
2 índices de Apgar < 7 ao 5º minuto				

Figure 15 - Newborn Hospitalizations, Preterm Births, and Other Delivery-Related Information.

4.1.8. Other Delivery Procedures

The final module of the dashboard combines data related to other procedures that occur during childbirth. First, it is presented the number of labour accelerations' occurrences. Monitoring labour accelerations is crucial for assessing maternal and fetal well-being during childbirth. By tracking these events, healthcare professionals can make informed decisions about labour management, ensuring the safety of both the mother and the baby, and contributing to a positive childbirth experience.

Recording the number of epidurals administered by a healthcare professional is vital to assess their expertise and competence in epidural anaesthesia. This data tracks experience and evaluates intervention effectiveness in pain relief during labour. Moreover, it contributes to ongoing clinical improvement, enhancing safety and comfort for pregnant women.

Monitoring the occurrence of artificial placenta deliveries in the operating room and delivery room is crucial for evaluating clinical practice and procedure safety. The analysis of the frequency and circumstances under which these procedures are performed, enables the identification of patterns and trends, leading to continuously improving techniques, contributing to safer and more effective childbirth care.

Comparing the occurrence of episiotomies to the incidence of 1st to 4th-degree perineal lacerations during childbirth is essential for evaluating obstetric practices and ensuring optimal maternal care. This comparison sheds light on the decision-making process between controlled

surgical incisions (episiotomies) and natural tears (lacerations) in the perineal area. Episiotomy refers to a surgical incision made in the perineum (the area between the vagina and anus) during childbirth to enlarge the vaginal opening and facilitate delivery. This procedure is sometimes performed to prevent extensive tearing of the perineal tissue, which can occur with laceration of the perineal area.

Trachelorrhaphy is the surgery to repair cervical tears following childbirth, and its monitoring allows for an extensive evaluation of the safety and effectiveness of obstetric procedures. It also provides valuable insights into the incidence of complications during labour, aiding healthcare professionals in identifying areas for improvement in maternal care. This analysis could lead obstetric services to implement preventive measures, additional training, and care protocols to reduce the need for this procedure and enhance the birthing experience for mothers, promoting safer and higher-quality obstetric care.

Monitoring the occurrence of shoulder dystocia is crucial for evaluating the experience of a healthcare professional and the quality of obstetric services. Shoulder dystocia is a complication during childbirth where the baby's shoulders become stuck, requiring specific techniques. Tracking and analysing these cases help identify areas for improvement in training, ensure a safer birthing environment, and allow for protocol adjustments to enhance overall obstetric care quality.

Postpartum hemorrhage is a serious complication that can occur after childbirth and result in excessive blood loss. Monitoring these cases is essential for ensuring maternal safety during childbirth, as through this analysis is possible to assess obstetric service quality. Indeed, this evaluation could promote medical education, driving to continuous improvement in obstetric care, leading to reductions in healthcare costs.

OUTROS PROCEDIMENTOS DO PARTO
4 acelerações de trabalhos de parto
18 analgesias epidurais em partos vaginais
24 episiotomias em partos vaginais
8 dequitação artificial na sala de partos
2 dequitação artificial no bloco operatório
2 lacerações vaginais
0 lacer. perineais 2º grau / 0 3º grau / 0 4º grau
4 traquelorrafia
2 distócias de ombros
3 hemorragias pós-parto

Figure 16 - Other Delivery Procedures.

4.2. Questionnaire results

In the final evaluation phase, it's worth mentioning that we are still in the process of gathering responses from healthcare professionals through the questionnaire. The questionnaire was carefully designed to evaluate their potential interest in adopting the Performance Dashboard as a tool for monitoring performance. These responses will play a crucial role into dashboard's applicability evaluation.

Chapter 5: Conclusions

In this chapter, the conclusions drawn from this dissertation work are presented, summarizing the efforts made, the results obtained and their potential for monitoring the individual activity of health professionals in obstetrics. Additionally, there are presented some possibilities for future work in the development and improvement of Performance Dashboards.

An effectively structuring of a performance dashboard is crucial, as it simplifies the display of multiple performance indicators. A good organization of the KPIs lead to quicker analyses, as it enables the derivation of comprehensive insights into the obstetric service quality. Indeed, the meticulous selection of performance indicators enhances the numerous benefits provided using a dashboard for monitoring the performance, from the ability to track progress, identify areas for improvement and make informed decisions. For instance, the careful selection of KPIs can lead to a more profound understanding of healthcare service efficiency, the efficacy of specific medical procedures and the level of specialization of a health professional. Throughout this dissertation, it has been possible to demonstrate the effectiveness of the performance dashboard in monitoring the performance of obstetric healthcare professionals, standing as a valuable tool for obstetric service's management.

5.1. Objectives, contributions and limitations

The main objective of this dissertation has been successfully achieved, as the developed dashboard enables the visualization of individual healthcare professionals' activity in obstetrics. The presented KPIs facilitate the assessment of obstetric healthcare professional's performance, assisting hospital managers evaluating service quality, leading to enhancements in patient care, through a quick and intuitive analysis.

The extensive literature review conducted revealed that there is still limited application of performance dashboards in obstetric services, and even within clinical contexts, they are not a widely adopted tool, as there was even some difficulty in finding articles. However, the literature review significantly aided in structuring the dashboard and selecting clinical indicators. The dashboard's structuring was a crucial step once the visual aspect

influences the readability and comprehension, as a well-structured dashboard enables the extraction of performance-related insights.

During the construction of the dashboard, several challenges were encountered, as the use of several knowledge domains and the acquisition of new skills were needed. These factors resulted in an extension of this phase; nonetheless, the performance dashboard was successfully constructed and implemented in Obscare. The evaluation stage would be of great importance for drawing results related to the applicability of this tool, which have not been possible to conclude thus far.

The collaboration and support from VirtualCare greatly contributed to the successful execution of the project. The expertise and cooperation provided by VirtualCare team were crucial in achieving dashboard's construction goals.

This dissertation's work contributes to the field of developing dashboards for visualizing individual healthcare professionals' activity, once, as previously mentioned, performance dashboards are not a widely applied tool. Therefore, it underscores the advantages of using this tool for performance monitoring, leading to improvements in service quality. Once providing top-quality healthcare is the primary goal of health organizations, performance dashboards are a valuable tool. Concerning applications in obstetric services, the developed dashboard stands out by presenting a broader range of indicators, enhancing the understanding of healthcare professionals' specialization and treatment quality. The developed dashboard can serve as a stepping stone for further applications of dashboards within clinical contexts, displaying different types of information and helping in the management of other internal aspects of the service.

The developed dashboard presents some practical implications, once the represented data is relative to the 30 days preceding the consultation. By not allowing for a broader range of results beyond one month, it hinders the monitoring and assessment of healthcare professionals' performance. Therefore, a next step in refining this dashboard would involve enabling the user to choose the research interval, thereby enhancing the data analysis.

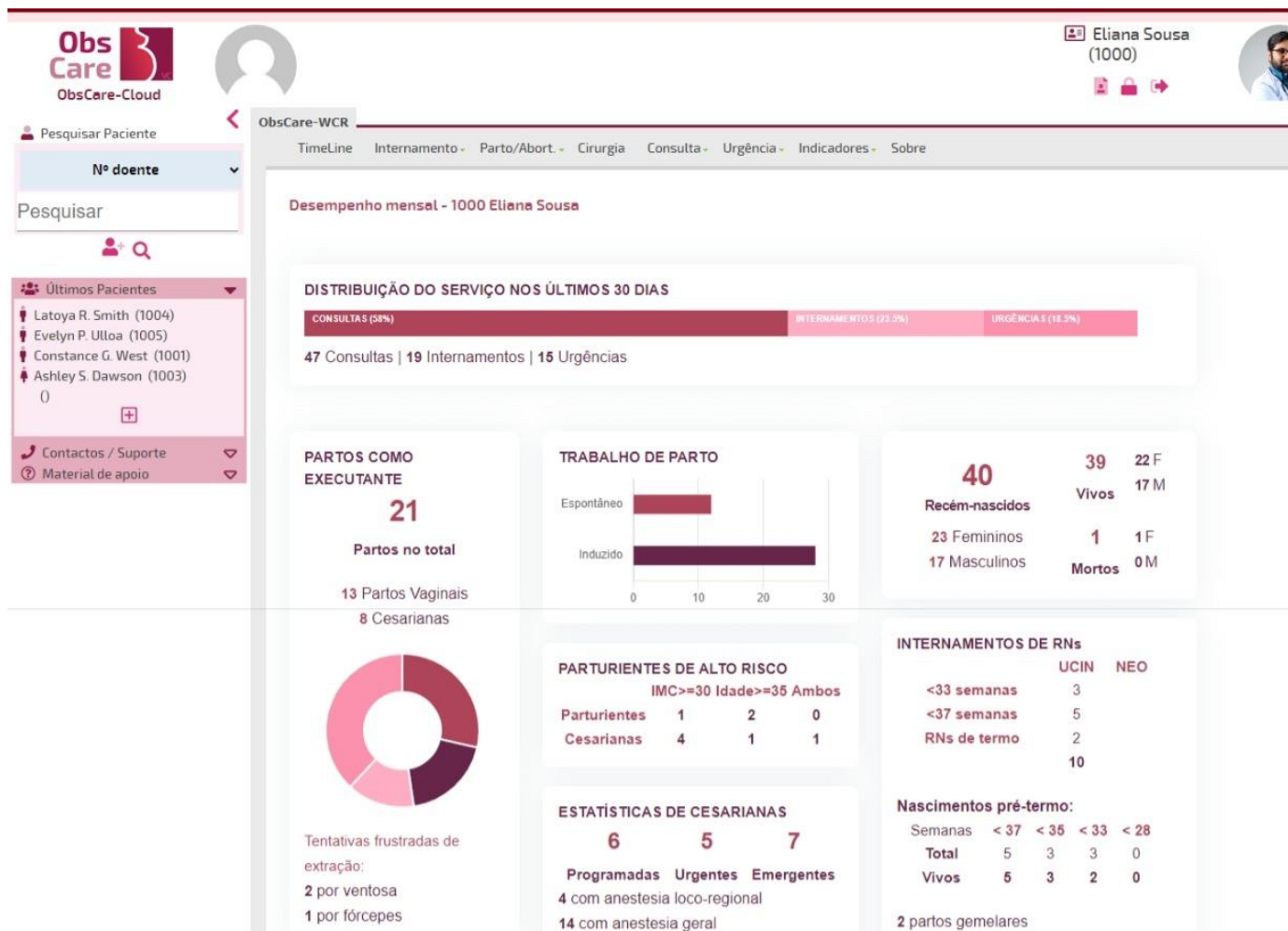
5.2. Future work

In the context of future work related to the developed dashboard in this dissertation, it would be valuable to consider modifications that grant users the flexibility to determine the data collection time interval. This adjustment would enable a more specialized analysis of the problem.

It would also be interesting to develop a dashboard that combines information related to multiple healthcare professionals within an obstetrics service. By aggregating data, it would provide an overview of the current state of the service, functioning as a management tool for service directors. This dashboard could be compared across hospitals and obstetric services, enabling a more comprehensive overview.

During the development of the dashboard, a daily performance dashboard was also designed but was not implemented, since it was made the decision to focus on a single dashboard. This dashboard, showed in Annexes, would have allowed for real-time access to service-related information, such as the total number of patients categorized by pregnant, postpartum, and others (count and percentage). In addition to the total number of pregnant patients, it specifically presented the total number of patients in the last month of pregnancy. It also displayed the total number of patients admitted and identified those admitted for induced labour. This dashboard also allows the visualization of scheduled appointments for the date and the patients admitted, that already exist in Obscare, but the objective was to consolidate these functions into one panel with the rest of the information. Additionally, there was a module planned to indicate expected deliveries for the current date and the following day. This functionality would have been innovative, as the algorithm would combine information from scheduled induced labours in the program with expected deliveries calculated based on the possible gestation date. This information would have allowed healthcare professionals to be aware of the workload they would have throughout the day, and it would have enabled service managers to allocate resources effectively. As it proves to be a useful tool, it would serve as a solid starting point for future work in the development of dashboards within clinical contexts.

Annexes



“Desempenho Mensal” Dashboard Top



Tentativas frustradas de extração:
 2 por ventosa
 1 por fórcepes

PARTOS COMO AJUDANTE

19

Partos no total

8 Partos Vaginais
 11 Cesarianas



PARTURIENTES DE ALTO RISCO

IMC>=30 Idade>=35 Ambos

Parturientes	1	2	0
Cesarianas	4	1	1

ESTATÍSTICAS DE CESARIANAS

6 5 7

- Programadas**
- 4 com anestesia loco-regional
- 14 com anestesia geral
- 3 programadas com anestesia loco-regional
- 1 urgentes com anestesia loco-regional
- 0 emergentes com anestesia loco-regional
- 5 usando a técnica de Misgav-ladach modificada
- 6 usando a técnica de Pfannenstiel Kerr
- 4 usando a técnica mediana infraumbilical-Kerr
- 4 usando outra técnica

INTERNAMENTOS DE RNs

	UCIN	NEO
<33 semanas	3	
<37 semanas	5	
RNs de termo	2	
	10	

Nascimentos pré-termo:

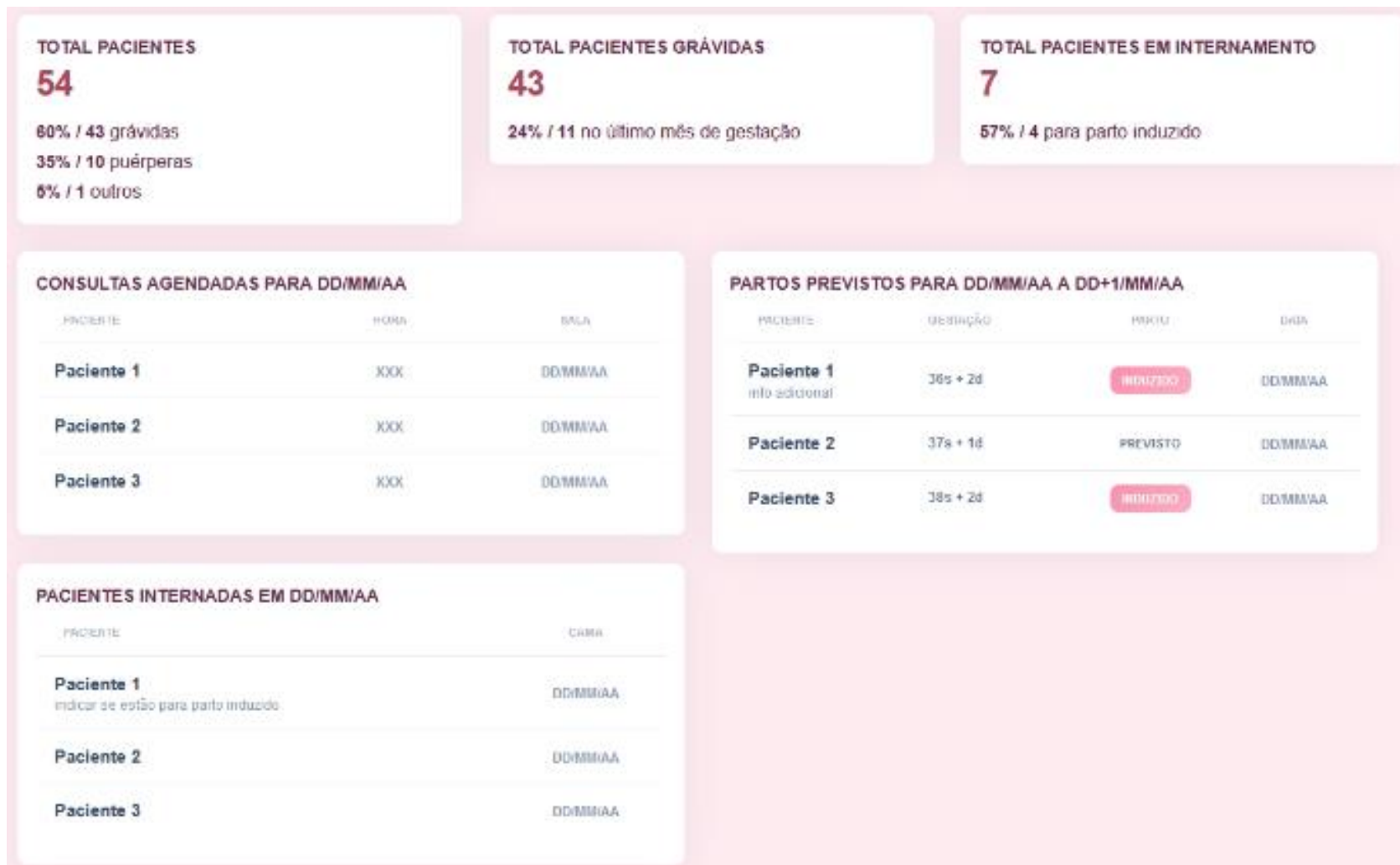
Semanas	< 37	< 35	< 33	< 28
Total	5	3	3	0
Vivos	5	3	2	0

- 2 partos gemelares
- 1 parto com 3 ou mais fetos
- 0 nados-mortos devido a IMG
- 0 acidoses metabólicas
- 2 índices de Apgar < 7 ao 5º minuto

OUTROS PROCEDIMENTOS DO PARTO

- 4 acelerações de trabalhos de parto
- 18 analgesias epidurais em partos vaginais
- 24 episiotomias em partos vaginais
- 8 dequitação artificial na sala de partos
- 2 dequitação artificial no bloco operatório
- 2 lacerações vaginais
- 0 lacer. perineais 2º grau / 0 3ºgrau / 0 4ºgrau
- 4 traquelorrafia
- 2 distócias de ombros
- 3 hemorragias pós-parto

“Desempenho Mensal” Dashboard Bottom



Prototype of the daily performance dashboard.

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