Development of an Active Health Dashboard for Heart Failure Patient

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Abstract

The techniques utilized for the creation and deployment of an active dashboard for an Electronic Health Record System, especially for heart failure patients, are presented in this paper. The active dashboard, which is built on a set of ELK Stack software, enables the visual examination of patient information through interactive visuals, improving the process of data interpretation by health professionals and promoting a data-driven decision approach. The authors divide the development process into three steps in this paper: configuring the database for Logstash, then indexing data with Elasticsearch, and creating indexed data views with Kibana. The authors also present the most recent version of the active dashboard, which displays graphs based on the users' gender, pulse, NYHA cardiac function classification, weight, height, diabetes, urea, liver disease, age, type of heart failure, Temperature, BMI, and emergency, as well as the number of healed and dead patients. Finally, the authors explain the insights gained throughout the interactive dashboard's development.

Keywords *Electronic Health Record (EHR), interactive / active Dashboard, KPIS.*

1. Introduction

Recent growth in the use of new technologies (computers and smartphones) coupled with a steady increase in internet access [1] have significantly increased access to and application of technical and scientific information across many different fields. Information systems, which are primarily responsible for storing, managing, and distributing data, are also concerned with converting data to provide business value. This includes education, health, culture, and many others.

Globally, the health sector is a critical one, as highlighted by the World Health Organization [1], for example, the uncontrolled growth in patient expenditures. There have been significant efforts made to implement information systems in several countries. As a result, electronic health records (EHRs) and health information systems have been developed [2]-[7]. The research to date indicates that, despite the extensive understanding of electronic health records by diverse healthcare professionals, and despite a noticeable increase in the adoption of EHR by various health-care organizations, the process of adoption remains slower than anticipated, especially in rural and small clinics and to achieve complete paperless EHR within the planned time-frame, they will have to accelerate beyond their current pace[8].

Reference [9] shows the level and depth of EHR implementation in Saudi governmental hospitals. Only seven institutions (46.6 percent) had a fully functional HER system and were in the process of implementing it. Four hospitals (26.6 percent) are making progress in the installation of EHR systems, three hospitals (20 percent) finished the implementation but their systems are not yet operational, and one hospital has not yet begun the implementation of EHR (the survey included 15 hospitals). With the EHR, it is possible to keep an accurate record throughout a person's lifetime, allowing for integration of services, timely access to information for stakeholders, potentially reducing damage and, hopefully, lowering costs associated with healthcare; but, most importantly, to resolve information breakdowns and avoid losses, thereby making professional, patient, and family life better. In this article, Patient's EHR becomes an attractive model for the treatment of health information, presenting itself as an auxiliary instrument in the decision that health professionals make, independent of the specialization of our dataset, the mechanism can be applied to all types of electronic health records, regardless of their specializations.

There have been a number of studies published about various aspects of EHRs. Researchers have mostly focused their attention on the use of the new system in this or that circumstance [10], but a new line of research work has recently gone deeper into exploiting the benefits of using EHRs in diagnosing and analyzing medical causes and phenomena. Using EHRs to control quality is a common topic in many articles [11], while others explore the use of built-in features such as alerts to improve documentation and counseling [12], or alerts to predict mortality among patients.

In this article, we will describe the tactics utilized for the creation and deployment of a health dashboard for an Electronic Health Record System, particularly for heart failure patients, which will allow for the analysis of administrative data from health services. Developing the dashboard with ELK stack software with KPIs. Improving the dashboard by using interactive features to make the decision-making process easier. The remainder of the article

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is organized as follows: Section II discusses the background; Section III discusses the technology utilized in the dashboard's creation; and Section IV discusses the dashboard itself. Section V contains the discussion, while Section VI contains the conclusion and future work.

2. Background and Related work

Dashboards are essentially interactive performance management tools, operating as a tiered information delivery system that delivers critical information about strategic target achievement on a single screen, allowing managers to more effectively assess, monitor, and manage performance [13].

Dashboards used tables, graphs, alarms, and other formats to visually represent values extracted from important data. A dashboard helps decision-makers to keep track of numerous performance indicators at once, making the decision-making process more efficient and effective [14].

The usage of a dashboard is not new in the health care field, where studies reveal a relation between dashboard application and improved quality in the delivery of health care services [15]. A well-designed dashboard might raise awareness of areas where the health care institution is underperforming or that are off the executives' radar.

Dashboards are currently seen by health professionals as a useful tool for accountability, as the public frequently scrutinizes health institutions due to the societal value of their services [16].

As a result, health organizations are under pressure not only to invest in programs targeted at increasing the quality of their internal activities but also to publicize their efforts [15]. As a result, healthcare institutions are increasingly implementing dashboards as a means of assessing and enhancing the quality of treatment they provide [17].

However, the dashboard must be designed to serve its intended audience, specific data domains, and the actions that experts will undertake to interpret the data [18].

In the case of the heart failure patients, the audience ´ includes medical practitioners, clinics managers, and department headers. We anticipate the sharing of information and data with public health organizations that are responsible for public policy in the healthcare industry.

The use of dashboards to improve operational efficiency and the ability to oversee operations in health service providers is well documented in the many pieces of literature [19], [20] that mentioned uses of the dashboard in different fields in health department such as emergency, nursing, maternal care, operating room, laboratory, radiology control, and hospital infection control panel

Another important consideration is the huge amount of data generated in the health sector, which must be monitored in real time to maintain the quality of the service offered. To deal with all of this data, many people now use a dashboard with business intelligence (BI) as a solution [25], [26] that allows them to work with massive amounts of data and extract sophisticated data that is critical for planning and management operations. BI is all about generating value for businesses using data, or more accurately, facts [30]– [33].

3. Solutions architecture and technology

In this article, we have followed the work steps in the study mentioned in [34] in addition to taking additional steps to achieve the objectives of this scientific article. We started by using PhysioNet patient datasets to create the dashboard. Using Logstash, it was easy to extract the most essential values from the dataset with the assistance of contacting medical specialists. We indexed this data in Elasticsearch so that we could execute efficient searches. Following that, we elicited key performance indicators (KPI) with the assistance of health experts and created graphs to display these indicators on the Kibana interface. More information can be found in the sections that follow.

We created a health interactive dashboard to help clinic administrators make decisions by facilitating access to and visualization of information about patients with heart failure, as well as to allow officially authorized health experts to access data and conduct specific research using the control panel. We utilized ELK Stack [35] technologies to create the dashboard since they are consolidated tools used by firms such as Adobe, Cisco, and Airbus [35], as well as being totally open source. The letters "ELK" stand for the initials of the three tools that comprise the solution: Elasticsearch, Logstash, and Kibana.

Logstash [36] is a piece of software that allows you to combine several data sources, such as databases and log files (files that record system events), into a single location while standardizing the data format. Several filters, which may be defined in Logstach, are used to unify the data. Following standardization, this data may be inserted into other applications, such as Elasticsearch, or output files in a variety of formats.

Elasticsearch is a data indexing technology that allows for efficient and scalable information consultation via HTTP (Hypertext Transfer Protocol) protocol queries using an Application Programming Interface (API) based on Representational State Transfer (REST) [37]. The technology generates a unique identity for each piece of information in the database, such as gender, age, marital status, and ethnicity, among others, and uses it to locate the data wherever it occurs. Rather of searching through each set of values separately, the tool retrieves all instances of the word in the existing sets.

Kibana is a visualization tool that allows you to build representations from Elasticsearch data. It allows the operator to readily link information, aiding in the understanding of patterns or relationships between variables and allowing data to be exported to various formats such as PDF, PNG, or CSV. In the available views, you can also specify the degree of access for users [38]. We may also add interactive features to our dashboard, such as controls for

applying dashboard-level filters and drilldowns for navigating to Discover, other dashboards, as well as other websites. Fig 1 presents the structure of the solution among the ELKStack software. The health dashboard was created in four phases, as shown in Fig 2:

Fig. 1. Solution based on ELK Stack.

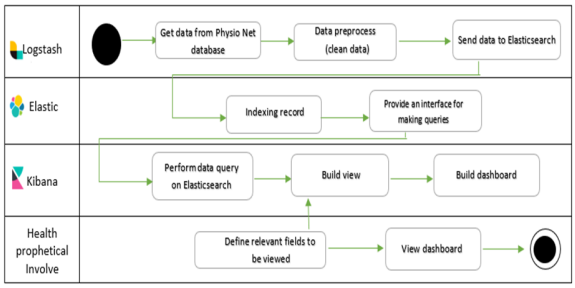

Fig. 2. Activity diagram of steps to build the dashboard.

Step 1: Installing and configuring Logstash to retrieve relevant data from a dataset.

Step 2: Indexing the data with Elasticsearch Index data is data that has been structured in a way that allows the program to conduct its operations. Elasticsearch indexes records by assigning a unique identifier to each one, hence enhancing database searches.

Step 3: The specification of the data to be made available is an important step in creating a successful dashboard. As a result, at this stage, health experts identified all of the data that would be displayed on the dashboard, identifying which key performance indicators should be displayed. The key objective was to guarantee that the tool could help with decision-making and academic research appropriately.

Step 4: Last step, we designed the dashboard with Kibana. To do this, we used Kibana to query the Elasticsearch-indexed data and then generated distinct views for each field accessible. Using this method, it was straightforward to construct a wide range of information, from simple (bar or pie) graphs to more complicated graphs based on interactive features. Kibana provides all the heavy lifting in creating the visualizations by providing a library of pre-built graphs.

The dashboard applies visual analytics, which is the science of analytical reasoning helped by interactive visual interfaces, to improve the interpretation of EHR data sets in healthcare areas. It is compatible with the health information analytics dashboard, which contains a wealth of clinical data from multiple sources. The future of healthcare analytics will include an increasing demand for and use of sophisticated analytics methods and tools (e.g., visual analytics dashboards) to explore and analyze data with improving patient care, boosting efficiency, optimizing resource use and allocation, and improving decision-making at the clinical and enterprise levels [39].

By delivering knowledge that enhances decision making and increases the efficiency and effectiveness of activities, monitoring and evaluation have become critical elements of the administration of health services. Decision making in health management is complex, laden with subjectivity and ambiguity. In health, the potential to enhance decision-making is challenged by the process' complexity, which is defined by the various factors of the health-care process [40]. In the process, the dashboard will provide epidemiological, statistical, and research reports as well as security control, auditing, and reporting indicators. These indicators will enhance privacy for all health care professionals.

4. The Heart Failure Patient Dashboard

We used information on gender, pulse, blood pressure, NYHA cardiac function classification, weight, height, diabetes, urea, liver disease, Age, type of heart failure, temperature, BMI, and emergency, as well as the number of healed and dead patients, to assemble the display with the graphics on the Heart Failure patients dashboard. The data was chosen after a review by health specialists involved in the process because it is wide enough to create a KPIs of vital values that used by health professionals.

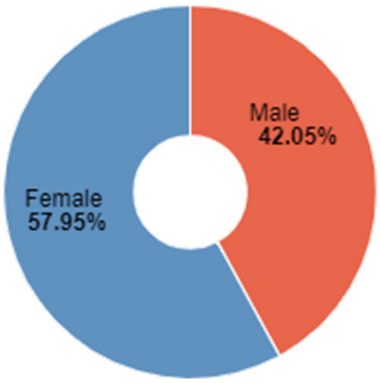

Fig. 3. Graph of the segmentation by patients' gender.

Fig 3 presents the graph in the dashboard that shows the segmentation of the patients by Gender. This graph shows the percentage of the male, female records in the dataset (the patient's gender). According to the graph, the female represents the proportion of patients with heart failure.

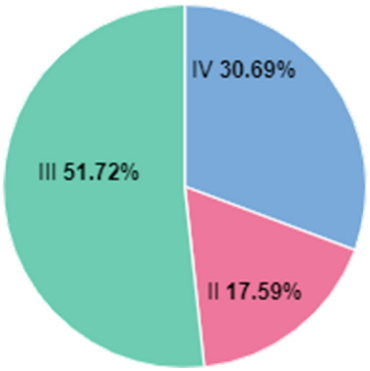

Fig .4. Graph of the segmentation patient by NYHA.

Fig 4 presents the graph in the dashboard that shows the segmentation of the patients by (NYHA) New York Heart Association is the most frequently used classification system, as seen in the graph. It categorizes patients into one of three groups based on how restricted they are during physical exercise. This type of information is used by physicians to monitor the effectiveness of treatment interventions in heart failure patients. According to the graph, most patients are classified into the III NYHA category, which means marked limitation of physical activity.

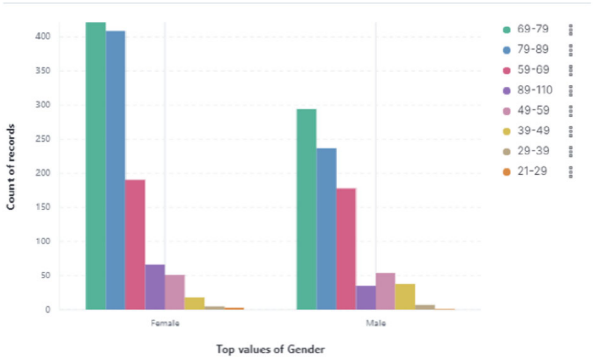

Fig .5. Graph of the segmentation patient by Age and Gender.

Graph, as shown in Fig 5, represents the segmentation of the patients of the dataset by patients' age and gender. This type of information is used by physicians and health researchers to know which age group has heart failure.

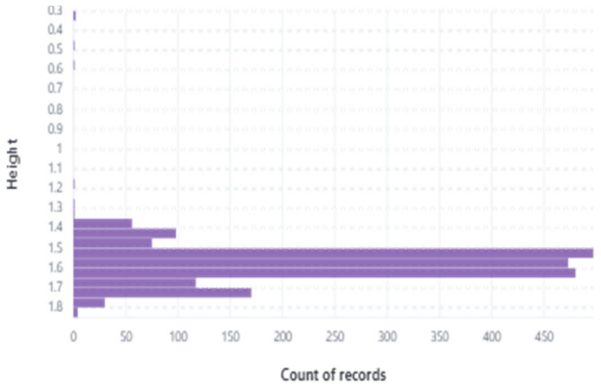

Fig .6. Graph of the segmentation patient by patients' Height.

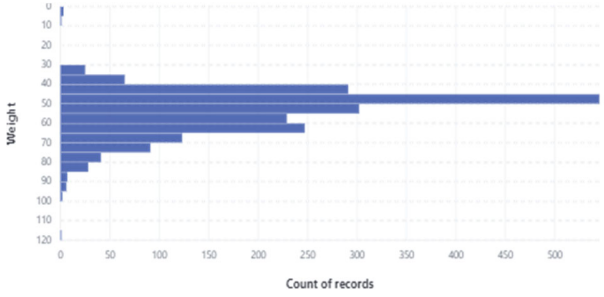

Fig .7. Graph of the segmentation patient by patients' Weight.

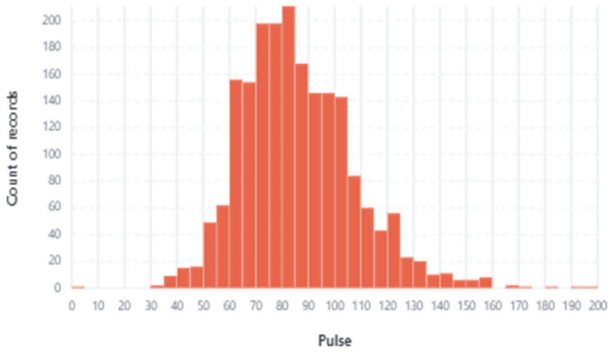

Fig .8. Graph of the segmentation patient by patients' Pulse.

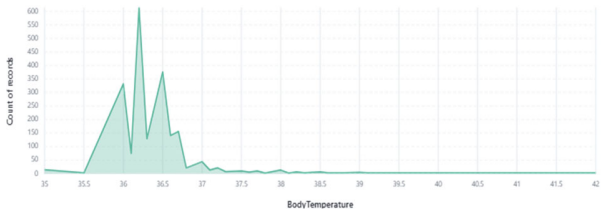

Fig .9. Graph of the patients' temperature.

Also, the dashboard represents information of patient's weight, height, Pulse, and body temperature as shown in Fig 6, Fig 7, Fig 8, and Fig 9. This information can be used with health data to better understand patients' cases.

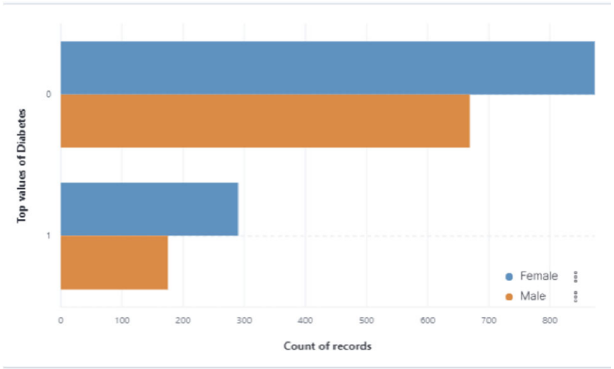

Fig .10. Graph of the segmentation patients by Diabetes and gender.

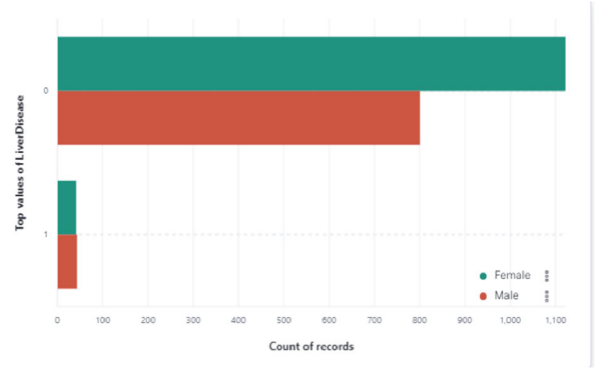

Fig .11. Graph of the segmentation patients by Liver Diseases and gender.

Another information shown in Fig 10 the relationship between Diabetes and gender of heart patients. In Fig 11 the graph represents the relationship between Liver Diseases and gender of heart patients.

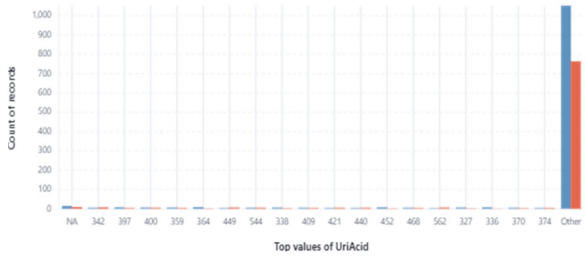

Fig .12. Graph of the segmentation patients by Liver Diseases and gender.

In Fig 12 shown the relationship between patients' UriAcid values and gender of heart patients.

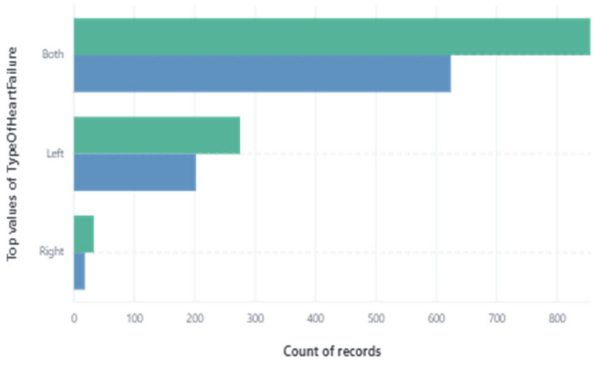

Fig .13. Graph of the segmentation patients by types of heart failure.

In Fig 13 represents the segmentation of patients' heart failure side and patient gender. The heart failure usually affects only one side of the heart, although it can affect both. According to doctors, there are three forms of heart failure, according to doctors. Another piece of information shown in the data panel is the relationship between heart failure types and gender. The dashboard shows each type of failure with gender.

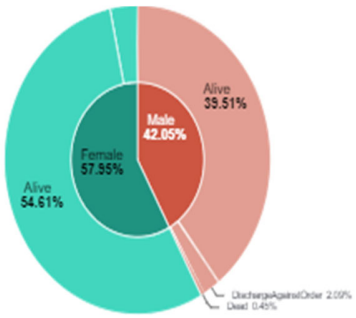

Fig .14. Graph of the segmentation of patients healed and dead.

The interactive dashboard also shows the number of patients healed and discharged from the hospital and the number of patients that are dead. This information, as in Fig 14 is useful for preparing for the needs of human resources.

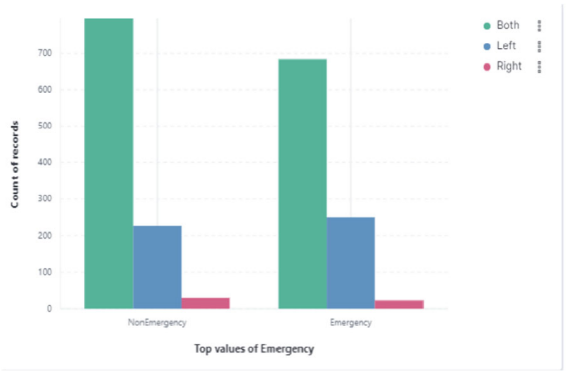

Fig .15. Graph of the segmentation of patients healed and dead.

Fig .16. Dashboard of Heart Failure Patients.

Through this information, the quality of services provided can be seen. The number of emergency patients per time unit can be used to see the trend of the highest number of patients, for example, which type of failure was an emergency as shown in Fig 15,The complete dashboard are show in the Fig 16.

I. DISCUSSION

As previously stated, the phases of research [34] are followed in this work. [34]'s dashboard was simple in design. On their dashboard, they provide information such as blood type, patients' geographic locations, gender, marital status, ethnicity, and age. The ELK stack was utilized to represent the data and display it on the health dashboard. In this article, we have other goals, such as the dashboard must create various reports suites for certain specific conditions that health experts demand, are discussed in this article. Our interactive dashboard displays heart failure patients' vital values to assist healthcare providers in making decisions that improve the quality of health care provided.

In this article, the interactive dashboard display visualizes the values of gender, pulse, NYHA cardiac function classification, weight, height, diabetes, urea, liver disease, Age, type of heart failure, temperature, BMI, and emergency, as well as the number of healed and dead patients. The output of a previous study on health dashboards focused on displaying the data for patients. In this study, we developed an interactive dashboard that can display data under some conditions that health professionals deem relevant by the control panel. In Fig 17, the values of weight and height (the BMI) can be managed by control panel, these considered as interactive features that allow health professionals to determine the wanted values to be represented in graph.

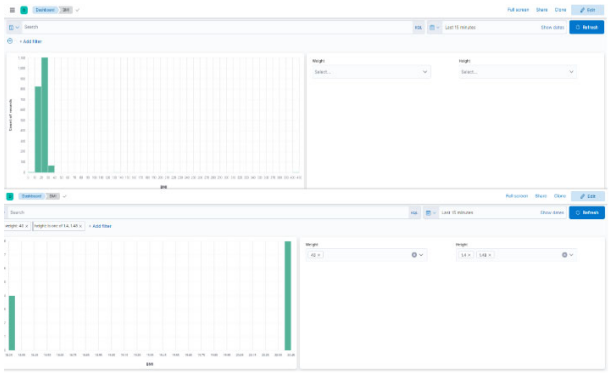

Fig .17. Dashboard of patients' BMI with control panel.

In this health interactive dashboard, there is a variety of information about heart failure patients, we mentioned above, like if they have another disease, or the stage of the heart failure. The interactive dashboard allows us to filter out some unwanted values to perform a specific search based on certain values. There is an "add filter" icon to filter the data patients. In Fig 18, the number of female patients with their data that are represented on the dashboard after the health specialist adds a filter to show the female values with all graphs in the dashboard. Filtering feature can extract patients or values that do not have a health specialist interest in some research.

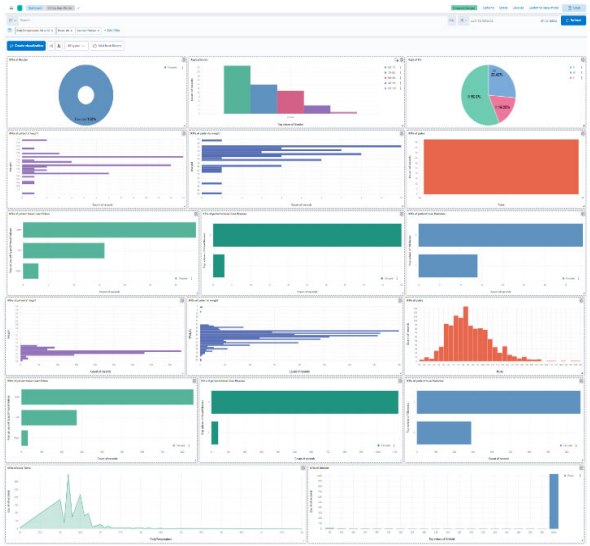

Fig .18. Dashboard of female patients by filter feature.

Our interactive dashboard presents some values on many dashboards that are linked to the main one. These interactive features deliver precise values based on a certain requirement determined by medical professionals. The other dashboard visualizes the KPIs Based on gender and age, to clarify that, look at Fig 19, which shows all the female values in the additional dashboard. We can select a certain age and present all KPIs associated with that age. We can also do the filter feature for some values and control via the control panel to

insert or extract some values from the data and link them in the other dashboard to display these values.

The existence of this health interactive dashboard can reduce the existence of human error so as to facilitate the decision-making process appropriately. Therefore, health service facilities and stakeholders can find out more quickly and respond appropriately.

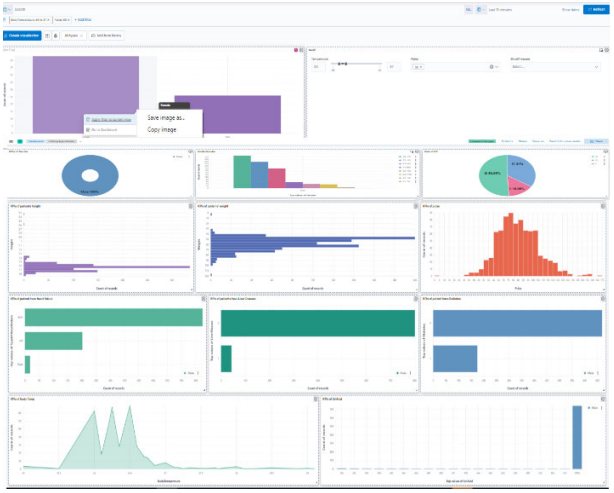

Fig .19. Interactive Dashboard link with gender dashboard.

II. Conclusion and Future Work

A dashboard provides a visual representation of health information in a faster and more efficient manner, as well as bringing key performance indicators (KPIs) that are crucial to determining how to plan, monitor, execute, and evaluate health actions at an individual or collective level. Since we used heart failure patient data in this study, the proposed dashboard can be applied by any EHR. Thus, we hope to strengthen the public health system by providing health professionals with faster and easier access to a set of clinical information for subsidiary research. For the technological solution, the ELK Stack provided all the tools to organize, classify, and visualize the relevant data of interest.

Based on this experience, the learning lesson for the development of the health interactive dashboard is to elicit the KPIs that are important to the audience and to organize the data to make it easily readable using graphs and numbers. When we're immersed in development, trying to provide as many features as possible, it seems as if eliciting KPIs is not an issue, but we must keep in mind that the main objective of an interactive dashboard is to present valuable information in a swift, user-friendly manner.

This tool was designed at the beginning of the EHR system to make it useful to health professionals as it evolves. Future versions of the EHR system will include many additional factors. Moreover, with the continuous expansion of its use, the dashboard will soon include more diverse information, such as the international classification of diseases (ICD) and the use of medicine by gender, allowing us to contribute to the planned health and prevention campaigns and provide useful data for research. We have designed our dashboard not to be real-time but instead to provide a retrospective evaluation of clinic performance, allowing to extract valuable insights about data trends.

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