Continuous Ambulatory Peritoneal Dialysis: Business Intelligence applied to patient monitoring

CAPD study and statistics

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***Abstract*—Continuous Ambulatory Peritoneal Dialysis (CAPD) is one of the many treatments for patients with advanced kidney disease. It is a treatment that needs regular monitoring and understanding of all the factors of blood and urine samples of each patient to understand if the treatment is going well. This article will explore data information from patients undergoing CAPD procedure. This data information helps to comprehend how interoperability acts in a Health Information System since this data contains patients' personal information but also patients' blood and urine samples' results, meaning all the services must be connected. In this work, it is used Business Intelligence process to prove that all the information available can be useful to understand the treatment above-mentioned and also how can several factors influence or not the number of patients going through kidney failure and CAPD by the study of indicators.**

Keywords— Kidney, Continuous Ambulatory Peritoneal Dialysis, Business Intelligence, Health Information Systems

I. INTRODUCTION

The kidney is a very sensitive organ once it is susceptible to several diseases. These diseases treatments go from simple medication to dialysis when the disease develops to kidney failure [1]. Chronic Kidney Disease (CKD) affects 8\% to 16\% of the worldwide population and it is expected to grow in the developing countries [2].

In Portugal, CKD is commonly treated with Haemodialysis and Peritoneal Dialysis. The number of people on treatment has passed the ten thousand mark, reaching in this moment 11372 people, according to *Ministério da Saúde*, a government entity [1].

Dialysis has been used for many years now, however it still has disadvantages such as blood infections (Haemodialysis) or even catheter infections (Continuous Ambulatory Peritoneal Dialysis). None of these treatments are used to cure but to help the patient to survive in opposing to transplantation.

The Peritoneal Dialysis diverges from Haemodialysis since it does not filtrate the blood directly, not causing blood infections but also since it can be made at home, work or while travelling. This process is done by using a cleansing fluid which flows through a catheter and that fluid filters the waste products present in blood, then, these waste products, by gravity, flow to the bag attached to the abdomen [3].

Continuous Ambulatory Peritoneal Dialysis (CAPD) is, then, a method to treat end stage renal disease patients. This treatment has been used in short to mid-term period since CAPD does not show long-term success [4].

Although this treatment does not bring the cure to CKD it helps the patients to keep the blood and urine tests' values between some reference values. And these values must be registered in every patients' database.

Health databases aren't common databases, all the environment in which they are inserted must have some aspects to maintain patient confidentiality yet they must be accessible by the competent entities. These issues are responded by Health Information Systems (HIS) where interoperability, usability and security are fundamentals to create a good and functional system. These systems must also contain a good connection to the Hospital database where all the information is located.

This article will focus not on the HIS implemented in the Hospital but in the results of patient samples going through CAPD treatment. And how they may enlighten people about the CKD and CAPD. Focusing in statistics it was needed to create a Data Warehouse with the help of SQLWorkbench where, after implementing a multidimensional model, was created tables to insert data information previously requested to the Hospital. After this process, this information was analysed in a new tool so-called Power BI.

Power BI helped to understand data information and analysing the statistics resulting. With this tool, it was possible to understand how sex and age may influence the number of patients undergoing CAPD and even influence the procedure duration.

This study helped to understand that sometimes there's not a pattern to a certain disease, not an age pattern neither a gender pattern, which means it cannot be predicted if a patient

978-1-5386-3281-9/17 $31.00 © 2017 IEEE
DOI 10.1109/FiCloudW.2017.91

is more susceptible to undergo CAPD treatment when CKD develops to kidney failure. This approach must be settle by the doctor or the caregiver if that seemed the most suitable treatment. Clinical Decision Support Systems based on patients' samples would be a substantial step to help doctors know which treatment to choose in these critical conditions, also helping this health professionals to keep track of patients and monitoring their health close by.

II. STATE OF ART

A. *Health information systems*

Many years ago, informatics were introduced to health sciences, many fields began to be explored by informatics such as genetic, biology and medicine. This new way to see the world brought us several opportunities to change what was wrong and to improve the services offered.

Throughout the years, massive data information was being gathered which made people think in some way to save and analyse this data easily, without going through hours and hours of data analysis made by a large amount of people. The solution was to create a simple and sustainable system and not too costly in terms of people and machines [5]. Information systems may have the key to lessen healthcare costs' and amend the expected outcomes [6].

To this end, new systems were created known as *Health Information Systems* (HIS). With a rapidly growing literature on these systems is expected for it to thrive even further and to become the foundation of all monitoring systems in healthcare. Therefore, these systems have a basic principle which is to capture, store, manage or transmit information to decision makers [5] [6]. Considering this, these systems can be implemented in several fields in a medical facility [7]. Such as:

- Administration (Human Resources);
- Financial Accounting;
- Storage;
- Clinical.

All this fields have high demands, especially on the clinical field where health providers have a huge need for information to help in patient care, the core functions of all *HIS* are based in interoperability, usability, quality of information and even data security and data confidentiality [8]. *Healthcare Information Systems* tend to share similar characteristics with most organizations yet they evince special characteristics, which are connected to the intricacy and variety of healthcare information that may contain all the distinct ways a procedure is done [6].

HIS should support several functions besides it core functions. These functions go from the first time the patient is admitted in the hospital to the moment of their discharge. Going from medical admission the execution of diagnostics, therapeutics and nursing procedures till patient discharge or transfer to other institution. All of this just on the clinical side of the system [9]. The figure shown above [Figure 1] highlights some of the functions mentioned before.

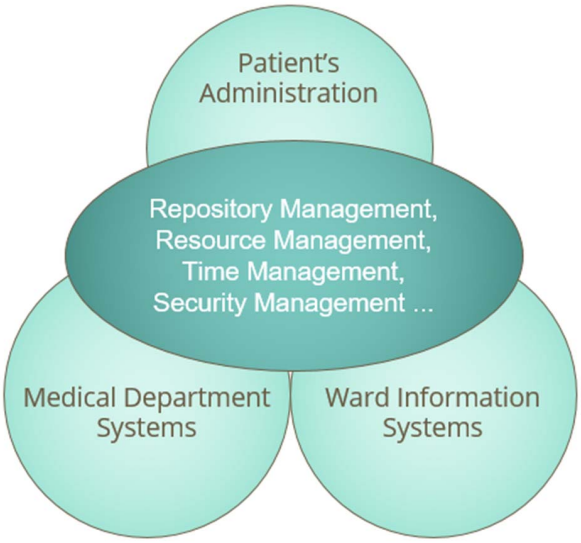

Figure 1. Functions and Information Systems [10].

These systems are commonly described as distributed and heterogeneous and the most prominent features in these systems rely on the interoperability and usability of the system, both aspects affect the way users handle the software. Interoperability is the ability of two or more systems interact between them, where the systems understand each other languages, process and data exchange [11][12].

As seen, though HIS are of major importance in Hospitals there is a long road ahead to evolve these systems. One of the biggest steps is applying Business Intelligence in these systems, improving the quality of medical care and patient quality of life, and it can also be applied in the other fields of HIS [13].

B. *ETL Process - Extract, Transform, Load*

Data warehouse is a system for gathering, storing, processing, and providing huge amount of data with analytic tools to present complex and meaningful information for decision makers. However, the Data Warehouse system is dependent on the ETL processes to provide the data.

The ETL process is used to extract data from a Data Base System, processing and modifying in order to add it to another Data Base. This is the most critical phase in the Data warehouse construction because it has big amount of data being processed [14].

The ETL process has three main phases [14][15]:

- Extraction – Firstly the data is extracted from the source systems and it is converted into a Data Warehouse format which is ready for transformation processing. The data can be in text form (heterogeneous). At this phase data is called

"Source". In this particular case of study, the data was in excel form.

- Transformation - Transforming the data evolves the process of cleaning (for example Male is "0" and Female is "1"), filtering (selecting certain columns), normalization, calculation new columns, etc. The data source was transformed in "Data Staging Area" (DSA).
- Load - After the Extraction and Transformation, the data will be finally ready, organised and cleaned to be inserted in the data repository in SQL. The tables will be populated after their construction in SQL.

Unfortunately there's a massive amount of unstructured relevant and important information data. Because of the growth and importance of unstructured data to decision making, ETL solutions are beginning to offer standardized approaches to transforming unstructured data so that it can be more easy to integrate with operational structured data (separate information in columns and rows to an easier approach) [16].

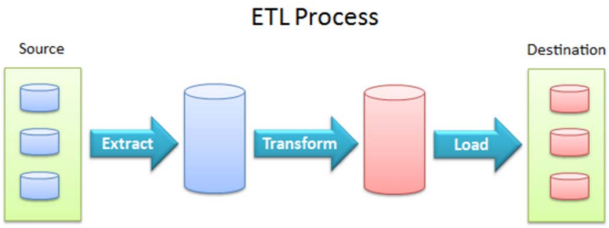

Figure 2. ETL - Extract, Transform and Load [17].

C. *Power BI*

Power BI was built by the Microsoft Corporation and started being available to the public in 2013. The main purpose of this application is to help the user to analyse the data, instead of spending hours or perhaps days preparing our data, with this tool treating data will be much easier [18].

Power BI aggregates tools that allows the transformation of collected data into valuable information for the decision makers in order to have something useful in place of columns and lines without any meaning [19]. It provides the chance of creating intuitive reports that will make finding answers easier, like detecting some patterns and indicators on data [18].

Combining data from distinct databases, files and web services with visual tools that allows to understand and fix data or formatting issues automatically in order to create stunning reports that communicate effectively the desired message [18].

This application gives the chance of unify all of an organization's data and by using Power BI gateways it's possible to connect a dashboard with SQL Server databases, Analyses Services models and with many other data sources. The dashboard is where we have the visual summaries of data that were created by simple clicks or drag-and-drops [20].

Power BI offers basic data wrangling capabilities similar to the Excel's Power Query [20] however it allows sharing reports and data (perhaps row based security), filtering capabilities are much more intuitive, easier focusing on what the users really need and want to see, more capable of dealing with large data sets and lots of other advantages [21]. It works with dozens of data types like Excel, Access, CSV files, GitHub, MailChimp and dozens of others [20].

It has got a desktop application (only runnable on Windows) and a cloud service. The desktop application is designed for authoring, which means the data modelling is done here. The cloud service is used for sharing and creating dashboards. So, for things like combine data sources, add or delete columns or reshape tables is the desktop application the chosen one. To visual summaries of data from one or more sources as well as to share your analysis with others its need the cloud service [20].

Power BI also offers a mobile service, allowing the user to access the data and reports from anywhere and at real time because it updates automatically with any changes on data [18].

In that way Power BI dashboards gives to the users a very embracing view with most important metrics, updated in real time and also available on all of their devices, as it shown on the illustration below.

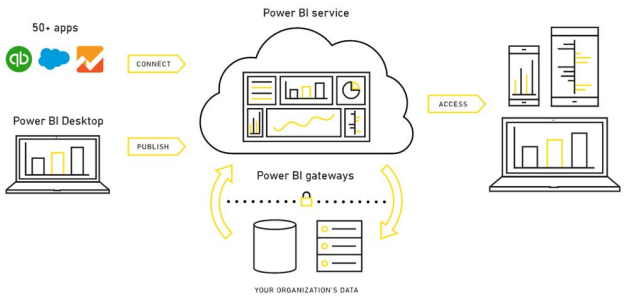

Figure 3. How Power BI works [20].

III. Related Work

Interoperability has many relevant features to the medical field, improving its qualities each year. However, there is a need to understand how interoperability in HIS (Health Information Systems) really helps. Going from connecting different systems to create a global system able to help in patients' diagnosis. Interoperability should also improve easiness to work with HIS, to facilitate the works of health professionals who do not have enough time to learn how to use a complex system.

Numerous papers define HIS as an aggregation of distributed and heterogeneous systems that communicate

using different methods, integrate medical equipment and is developed by different people aimed at different goals [22].

The paper *Semantic Interoperability and Health Records* is another example of the importance of Systems Interoperability in healthcare. It had the main purpose to show how semantic web could enforce the use of electronic documents in order of visualising free-paper hospitals. In that way, it is another case that proves how healthcare is improved by informatics software, as well as reinforce the importance of interoperability, which enhances the communication into different systems. The interoperability was necessary for allowing communication between HIS and Electronic Health Record (EHR) system and that was accomplished by the development of an Agency for the Integration, Diffusion, and Archive (AIDA). Also, this study increases the quality of information and decision support [23].

A *Multi-Agent Platform of Hospital Interoperability* is another paper that proves the necessity of interoperability in healthcare. It's presented the Biomedical Multi-Agent Platform for Interoperability (BMaPI) integrated into AIDA and it's used by each hospital service that communicates with AIDA. In this case, it was improved the usability and functionality of two systems: AIDA and INTCare System [11].

Another paper, *Intelligence in Interoperability with AIDA*, aims to explain how interoperability can be achieved using the above-mentioned platform AIDA, which was developed by researchers from University of Minho. This paper remarks the massive data present in HIS and all the difficulties entailed [24].

Focusing in Semantic Interoperability, the standards used in EHR and in Ambient Intelligence, this paper represents an innovative intelligent framework for interoperability in HIS. Although the satisfactory results showed, the heterogeneous information of clinical, medical and administrative systems are still an obstacle to greater results [24].

Other paper focusing in Multi-agent technologies is *Interoperability in Health Care*. The several methodologies to implement interoperability in HIS are based in common communication architectures and standards. However, there is still faults in this process of communication standards and some concerns about the distribution. So, interoperability is being addressed by multi-agent technologies which are becoming a problem solver for many issues. These technologies exhibit some essentials properties which promotes its autonomy, dynamic and problem solving capability [22].

The paper *Intelligent Systems for Monitoring and Prevention in Healthcare Information Systems* presents monitoring and prevention systems implemented in the *Centro Hospitalar do Porto*, with the main purpose of improving the system integrity and high availability to overcome problems with AIDA, an interoperability healthcare platform [25].

IV. Methodology

At first step, it was necessary to analyse carefully the data, which was organized by columns in an excel file with 9954 lines. To be able to understand easily the relations between such columns it was needed to build a relation model, which made possible the study of the primary and foreign keys, meaning knowing for sure how the identities were linked.

The following sections will describe all steps required to achieve the reports with the indicators that have been chosen. The illustration bellow presents a scheme of the phases that should be followed.

A. *ETL process*

This phase consisted on the treatment of the data. At first sign, it was evident some inconsistencies and lack of some information on data. In that way, it was appealed at the tools and capabilities of the Excel. For example, it was necessary to convert all the data times at the same form. Also, it was created IDs (identification numbers) for the columns gender, subsystem code, module and exam date, that was vital for the next phase.

Also, it was used the excel capabilities to create attributes like *FREQ_S_EP* and *AGE_APOI*, that will be described in the next section.

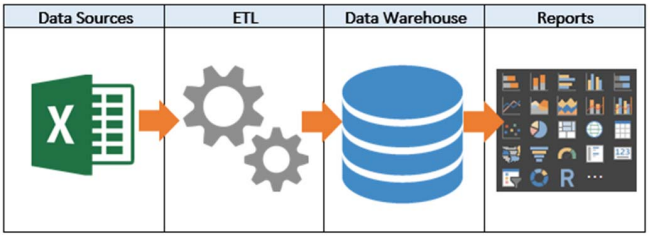

Figure 4. Scheme of the required phases.

B. *SQL – Data Warehouse*

Then, it was required the creation of a dimensional modelling that will design the Data Warehouse. As said before, a dimensional modelling uses concepts of facts and dimensions, which facts are typically numeric values that can be aggregated and dimensions are groups of hierarchies and descriptors that define the facts. For this case, it was built five tables:

- *fact_sample*
- *dim_exam_date*
- *dim_gender*
- *dim_performer*
- *dim_subsystemcode*

In that way, the dimensional modelling had one fact (first table) and four dimensions, as shown in the illustration below.

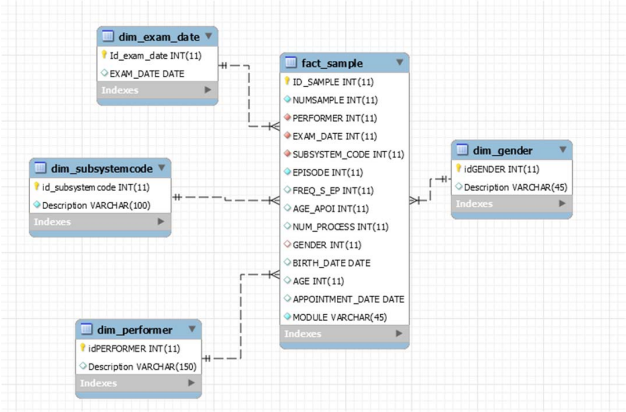

Figure 5. Dimensional modeling.

1) Dimensions:

The dimensions created are relatively to the following columns: gender, exam date, performer, and subsystem code. Those dimensions allows the achievement of the intended indicators.

The table *dim_gender* is composed by an ID ("0" refers to male gender and "1" refers to female gender) and respective description. Next, there's the table *dim_exam_date* where which date has an ID. For the table *dim_performer* there was an ID for each performer name. For the *dim_subsystemcode* it has an ID and respective description.

2) Fact Table:

This table, *fact_sample*, has got the following attributes:

- ID_SAMPLE
- NUMSAMPLE
- PERFORMER
- EXAM_DATE
- SUBSYSTEM_CODE
- EPISODE
- FREQ_S_EP
- AGE_APOI
- NUM_PROCESS
- GENDER
- BIRTH_DATE
- AGE

Therefore, it was created an auto incremental number *ID_SAMPLE*, which represents the ID of each table's line, having a unique number for each sample uploaded.

The attributes *PERFORMER*, *EXAM_DATE*, *SUBSYSTEM_CODE*, and *GENDER* are all foreign keys that allow the connection of the fact table with the dimensions.

The *FREQ_S_EP* describes the frequency of samples per episode and such information was obtained by using excel tools. As well as, it was used excel to calculate the age of each patient at the time of its appointment, *AGE_APOI*. Those attributes were obtained in the first phase (ETL process).

In that way, it existed all the necessaries conditions to the phase of loading the data into SQL (data from Excel). After succeeding this phase, the data warehouse was available for analysing and studying.

C. Power BI

The next phase was loading the data warehouse into Power BI, where it will be created the reports. The Power BI allowed the achievement of the intended indicators. For that, it was used tools like filters, graphics and other kinds of visualizations. For example, the visualization by card was used to easily know the number of samples, patients, and episodes of the data. That was one of the situations that proved how the software Power BI can be useful and practical to analyse such large data.

Also, it was possible to obtain the indicators, which are influenced by number of samples, episodes, and patients, as well as by gender, exam date, and appointment age. For the attribute exam date, it was created a filter that made possible the selection of an interval date to only have information restricted to such interval. Also, in the report created is possible to select by gender and age at appointment, confining the indicators to those selections. It was made four indicators: number of episodes per performer, number of processes per age, female/male ratio and number of samples per subsystem code. For those, it was used tools of visualization such as circular graphics and bar charts. The illustration below presents a report that was obtained.

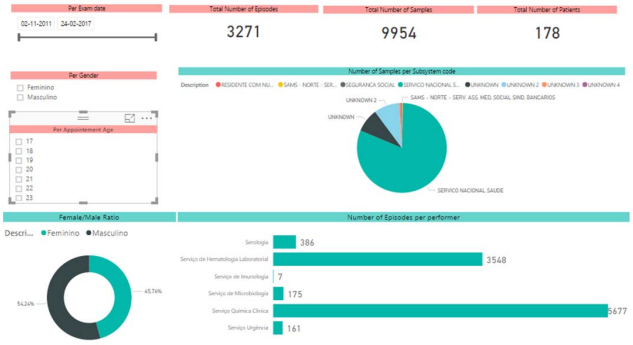

Figure 6. Report from Power BI.

V. RESULTS

The main purpose of this study was to analyse data provided by a Hospital. The data contains information about patients undergoing CAPD treatment and suffered the ETL process to statistically understand this treatment.

Therefore, with the help of the tool previously explained, Power BI, it was possible to create indicators which will provide the study a way to analyse how age, sex, timeline and

other factors may influence the number of CAPD treatments and the number of patients undergoing this procedure. Considering this, there are 3 indicators that prevail above all the rest:

- Number of episodes per performer
- Number of processes per age
- Female/Male Ratio

A. Number of episodes per performer

How the performer influences the number of episodes?

Each episode is made by a performer, and they're six different ones. With this indicator is intended to discover a correlation between the number of episodes and the performer, analysing how many episodes has each performer. For that, it was chosen for visualization a bar chart. In that way, it was possible to see clearly how the episodes were distributed by the performers. Also, it could be analyse how attributes like gender, appointment age and the interval of exam date influences this indicator. For example, when changing the appointment age from 27 years old into 28 years it's verified an increase of the number of episodes on the performer *Serviço de Urgência.*

In that way, it's evident that the performer *Serviço Química Clínica* is the most usual, which means that the patients usually do the exams in this kind of service. This is a vital information for a later study of analysing clinical results.

The illustration below represents this indicator without any restriction of gender or another filter.

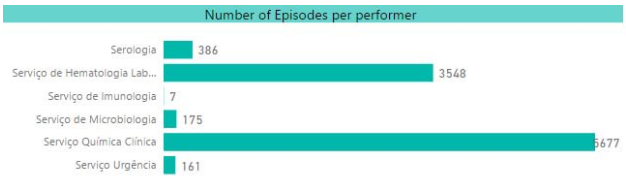

Figure 7. Number of episodes per performer.

B. Number of processes by age

How age influences the number of processes?

To each patient, it is given a Process Number, this number is distinct, which means that there cannot be two patients with the same process number.

This indicator tries to demonstrate a correlation between age and number of patients undergoing CAPD treatment. The first observation has shown 6 people in 5 predominant ages, showing, above all, that there is not a correlation in terms of younger or older ages since it goes from 30 years to 59 years.

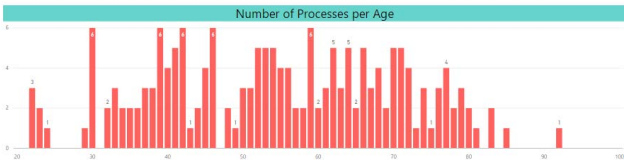

Figure 8. Number of processes by age.

This treatment may also be influenced by patients' gender, having the possibility to observe if there is an age that has more female [Figure 9] or male [Figure 10] patients, trying to determine if there is a critical age for this procedure.

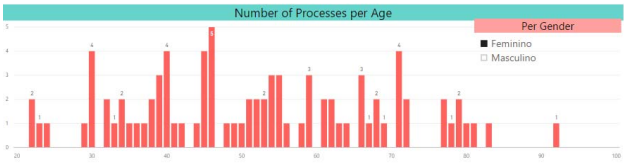

Figure 9. Number of processes by age (Female).

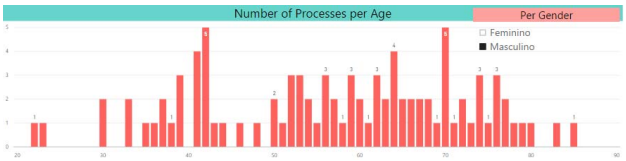

Figure 10. Number of processes by age (Male).

As seen above, the highest number of patients from a certain age, in both genders, is 5. The Male gender seems to have to critical ages at 42 years old and 70 years old, however, 4 patients belong to the 41 years old and 65 years old scale. On the other hand, the female side shows at 46 years old a certain predominance, although at 30, 40, 45 and 71 years old it can be observed 4 patients in each.

According to the data information analysed it was not possible to have a disclosure in terms of timeline since this data went from January of 2013 to February of 2017 (last date of patients' samples).

C. Female/Male Ratio

How does gender influences data?

The last indicator helps to understand the gender statistics. As it can be seen, the number of female and male patients are almost the same (50-50). That is clearly an evidence that gender doesn't influence the probability of going under a treatment like CAPD. It's also interesting to analyse how gender statistics can change if the date is changed.

In this particular case, there are more female patients than male.

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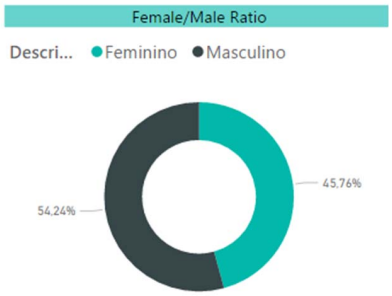

Figure 11. Gender indicator.

VI. Conclusion

The work done with a dataset may enlighten the knowledge about a certain population. Although this brought some difficulties, all of them were overcome by the advantages shown by this type of study.

The main difficulty found was that the ETL process took a lot of time because of data's size. The data chosen to work at this phase was statistical data. It was decided to keep attributes such as sex, age, episode's date, patients' id, performer, etc. Many changes were done at this phase. Columns were added, edited and deleted in order to keep the information clean and readable for SQL. The ETL process was the phase that took more time.

At this point it was evident how interoperability is needed, this dataset had, for example, information relatively to lab analyses and also relatively to patients' register. So, there's clearly more than one system involved.

Relatively to the construction of the dimensional modelling, it was clear that organising data into table's structures helps the user to visualize the relations and the attributes of each entity. As well as, allow us to achieve easily the indicators that have been chosen, by having a fact table with measures linked to dimensions. In that way, the determination of the dimensions that should exist was very important for the achievement of the indicators.

Later, Power BI was a big advantage and proved to be a helpful tool, intuitive and easy to use. It works faster if the ETL process is well done. With this tool, it was possible to create indicators and filters with different graphics and statistics such as the number of processes per performer. In that way, it helped to analyse the dataset in a visual, easier and faster way than looking at the database excel itself.

This study helped to understand that a treatment like CAPD is not influenced by attributes like age or gender, for example, a female patient is not more susceptible to undergo CAPD treatment when CKD develops to kidney failure. This approach must be settle by the doctor or the caregiver if that seemed the most suitable treatment. It's evident how systems like this can help the doctor on analysing and track possible patterns in such large information.

All of these tools can be used in non-Healthcare fields, which proves that this study is versatile and can be used in different ways applying tools such as Power BI, MySQL etc.

As conclusion, interoperability should be a critical feature in HIS, where all systems must be connected in order to make the different information technology systems and software applications to communicate and exchange data. In that way, the professionals of healthcare have access to all information relatively to the patients.

For a future work, it would be interesting to add the initial data that was put aside related with the blood analysis in order to use it has indicators, or even monitoring each patients' health.

Acknowledgment

This work has been supported by Compete: POCI-01-0145-FEDER-007043 and FCT within the Project Scope UID/CEC/00319/2013.

References

[1] GID - Gestão Integrada da Doença: Doença Renal Crónica - Estatísticas, http://gid.min-saude.pt/estatisticas/index.php

[2] Wearne, N., Kilonzo, K., Effa, E., Davidson, B., Nourse, P., Ekrikpo, U., and Okpechi, I.: Continuous ambulatory peritoneal dialysis: perspectives on patient selection in low- to middle-income countries. International Journal of Nephrology and Renovascular Disease, Volume 10, 1{9. (2017).

[3] Mayo Clinic: Peritoneal Dialysis, http://www.mayoclinic.org/testsprocedures/peritonealdialysis/home/ovc-20202856?p=1
Acessed 20th April, 2017

[4] Canaud B(1), Mion C.: Role of continuous ambulatory peritoneal dialysis (CAPD) in a program for the treatment of chronic renal insufficiency. Problems posed by transfer of CAPD to transplantation or hemodialysis Nephrologie. 1995;16(1):129-35.

[5] Pacific Health Information Network: Health Information Systems (HIS), http://phinnetwork.org/resources/health-information-systems-his/ Accessed April 10, 2017.

[6] Fredericks, E., Schneider, D. R., Koutsouris, DiDonLazakidou, A. A. ysios-Dimitrios : Annals of Information Systems (Vol. 5) - Concept and Trends in Healthcare Information Systems.(2009).

[7] Faculdade de Medicina da Universidade do Porto: Sistemas de Informação em Saúde, http://im.med.up.pt/si saude/si saude.html Accessed April 10, 2017.

[8] Ammenwerth, Elske and Winter, Alfred: Strategic Information Management in Hospitals: An Introduction to Hospital Information Systems. Springer 302 pages, 2004.

[9] Winter, A., Ammenwerth, Elske, Hellrund, N.: Health Information Systems – Architectures and Strategies. Springer 2011.

[10] Blodel, B.: Analysis, design and implementation of secure and interoperable distributed health information systems. (2002). Studies in Health Technology and Informatics, 89, 1-352.

[11] Cardoso, L., Marins, F., Portela, F., Santos, M., Abelha, A., and Machado, J.: A multi-agent platform for hospital interoperability. Advances in Intelligent Systems and Computing, 291, 127-134. 2014

[12] Pereira, A., Portela, F., Santos, M. F., Machado, J., Abelha, A., & Rua, F. (2017). Pervasive Business Intelligence in Intensive Medicine An overview of clinical solution, (c), 37–41.

[13] Machado, J., Abelha, A. (2016). Applying business intelligence to clinical and healthcare organizations (Advances in Bioinformatics and Biomedical Engineering). IGI Global; 1 edition. 347 pages.

[14] Ferreira, J., Miranda, M., Abelha, A., Machado, J.: O Processo ETL em Sistemas Data Warehouse.

[15] DataWareHouse4U: ETL Process, http://datawarehouse4u.info/ETLprocess.html Acessed April 13, 2017.

[16] Hurwitz, J., Nugent, A., Halper, F., Kaufman, M.: THE ROLE OF TRADITIONAL ETL IN BIG DATA

[17] Quora: Which is the best BI ETL tool in existence? (2016) https://www.quora.com/Which-is-the-best-BI-ETL-tool-in-existence Accessed April 13, 2017.

[18] Microsoft Corporation: Power BI, (2017). https://powerbi.microsoft.com/pt-br/ Accessed April 12, 2017.

[19] TechRepublic: Microsoft Power BI - The smart person's guide, (2016). http://www.techrepublic.com/article/microsoft-power-bi-a-smart-persons-guide/ Accessed April 11, 2017.

[20] ComputerWorld: Free data visualization with Microsoft Power BI – Your step-by-step guide, (2016). http://www.computerworld.com/article/3088958/dataanalytics/free-data-visualization-with-microsoft-power-bi-your-step-by-step-guidewith-video.html Accessed April 11.

[21] Microsoft Corporation: Power BI User Group Norway - Excel 2016 vs PowerBI, https://community.powerbi.com/t5/Power-BI-User-Group-Norway/Excel-2016-vs-PowerBI/gpm-p/80889 Accessed April 12, 2017.

[22] Cardoso, L., Marins, F., Portela, F., Santos, M., Abelha, A., Machado, J.: *Interoperability in Health Care*. Universidade do Minho, Braga, Portugal.

[23] Peixoto, H., Machado J., Neves, J. and Abelha, A.: Semantic Interoperability and Health Records. Universidade do Minho, Braga, Portugal.

[24] Peixoto, H., Santos, M., Abelha, A., Machado, J.: Intelligence in Interoperability with AIDA (2012).

[25] Marins, F., Cardoso, L, Portela, F., Abelha, A., Machado, J. (2014). Intelligent Systems for Monitoring and Prevention in Healthcare Information Systems, B. Murgante et al. (Eds.): ICCSA 2014, Part VI, Springer Lecture Notes in Computer Science, Volume 8584, 197-211.