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Improvement of the Portuguese Breast Cancer Screening through Process Modelling (BPM)

Inês Filipa Terras Marques

Dissertation presented as partial requirement for obtaining the Master's degree in Information Management

NOVA Information Management School
Instituto Superior de Estatística e Gestão de Informação
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IMPROVEMENT OF THE PORTUGUESE BREAST CANCER SCREENING THROUGH PROCESS MODELLING (BPM)

by

Inês Filipa Terras Marques

Dissertation presented as partial requirement for obtaining the Master's degree in Information Management, with a specialization in Knowledge Management and Business Intelligence

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ABSTRACT

Breast cancer is a malignant epithelial neoplasm with high incidence and mortality in women. Focusing the clinical performance on screening processes has proven to be the way to improve morbidity and mortality statistics of this recognized public health problem. Business process management (BPM) is a management field that improves and analyzes business processes according to organizations' strategies. BPM may help manage patient and information flow, improving waiting time in healthcare delivery while integrating healthcare processes with IT. The early diagnosis of breast cancer is of great importance since it will enable more conservative treatments and a longer disease-free survival. Organized oncology screenings programs, with all elements properly prepared, revealed to be more efficient than the opportunistic screenings. The aim of this study is to identify and model BPM processes for the healthcare sector, namely, for the breast cancer screening in Portugal. To achieve this goal, the main processes were identified and new frameworks were proposed and validated through individual interviews with experts. In this study was concluded that BPM techniques can be applied to the healthcare. Through the application of these techniques it was possible to identify the main issues within the organized breast cancer screening and suggest changes to it. These changes focus on reducing the time of the process, improving its efficiency and offering greater support to the health user.

KEYWORDS

Business Process Management; Diagrams; Oncology; Technology

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LIST OF ABBREVIATIONS AND ACRONYMS

ABPMP	Association of Business Process Management Professionals
ACES	Primary Health Care Units
AI	Artificial Intelligence
BPM	Business Process Management
BPMN	Business Process Model and Notation
CAD	Computer-Aided Detection
EHR	Electronic Health Record
IARC	International Agency for Research on Cancer
IT	Information Technology
k-NN	k-nearest Neighbor
LPCC	Portuguese League Against Cancer
MRI	Magnetic Resonance Imaging
OMG	Object Management Group
RGPD	General Regulation on Data Protection
SVM	Support Vector Machine
TNM	Tumor-node-metastasis

PUBLICATIONS RESULTING FROM THIS DISSERTATION

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1. INTRODUCTION

Breast cancer is a public health problem since it's the most frequent cancer among women and one of the principal causes of cancer related death in women worldwide (IARC, 2016; Mathioudakis et al., 2019; Obaidullah, Ahmed, Gonçalves, & Rato, 2019). According to the International Agency for Research on Cancer (IARC), 2016, "before age of 75 years, 1 in 22 women will be diagnosed with breast cancer and 1 in 73 women will die from breast cancer, worldwide". In Portugal, in 2012, more than 6000 new cases appear and around 1600 women, per year, died with this disease (Lacerda et al., 2019). Breast cancer is a malignant epithelial neoplasm, characterized by an uncontrolled growth of the abnormal breast cells with metastasis capacity (Cardoso, 2017). It is classified in different subtypes according to histological type, differentiation and the tumor-node-metastasis staging system (Cardoso, 2017). The early diagnosis of breast cancer is of great importance since the detection of small tumors, which are only detectable in ultrasound and mammography, or tumors in evolutionary phase non-invasive, will enable treatments less mutilating, with more conservative surgeries and a longer disease-free survival (Cardoso, 2017). Oncology screening allow earlier diagnosis of the disease, in subclinical stages, and aims the reduction of cancers' mortality (Miranda, 2016). Any screening program is dependent of a sequence of interventions, beginning in the identification of the target population until the post treatment (Miranda, 2016).

Business process management (BPM) is a management field characterized for being a well-designed, implemented, executed, integrated, monitored and controlled approach, that improves and analyzes business processes according to organizations' strategies (Buttigieg, Dey, & Gauci, 2016; Lopez-Sanchez, Campos, & Musavi, 2009). A business process is composed by structured and interconnected activities, which produce a service or product focused in the client's needs (Lopez-Sanchez et al., 2009). BPM has six core elements that are needed for a proper implementation, namely: Strategic alignment, Governance, Methods, Information technology (IT), People and Culture (Buttigieg et al., 2016).

Targeting optimal patient outcomes is the aim of health service delivery. Additionally, focusing the clinical performance on processes has been proving to be the way to improve morbidity and mortality disease statistics (Buttigieg et al., 2016).

BPM in healthcare may support the development of standardized processes, minimizing the variation in quality of healthcare delivery and errors, and selecting the right enablers in information management and technology to manage these processes (Buttigieg et al., 2016). Furthermore, BPM can also help manage patient and information flows, improving waiting time in healthcare delivery while integrating healthcare processes with IT (Buttigieg et al., 2016).

The application of BPM techniques has been increasing in public health, although there are still some failures due to improper adoption of BPM and because of content and structural issues present in the health care sector (Buttigieg et al., 2016). Due to the highly complex and multidisciplinary processes existing in healthcare systems, the application of BPM becomes a challenge (Buttigieg et al., 2016). BPM principles may be applied in hospitals but also in other settings like primary care and rehabilitation units (Buttigieg et al., 2016).

In order to properly implement BPM in organized breast cancer screening programs, two research questions should be answered: (1) What are the processes involved in the breast cancer screening in Portugal? (2) What are the constraints of the breast cancer screening programs?

The current widespread of technology and its importance in several different areas, including diagnosis and treatment of oncology diseases, makes it an important feature to improve the quality and the implementation of preventive and screening actions. Technology and healthcare professionals must be connected, allowing the development of multidisciplinary teams responsible for the patients tracking since the detection and preventive stage. Organized screening programs, with all elements properly prepared, revealed to be more efficient than the opportunistic screenings (non-organized and unmonitored) (Miranda, 2016). BPM gets its role on optimizing and managing all processes from the screening until the diagnosis and treatment.

The goal of this dissertation is the optimization, identification and modelling of BPM processes for the Portuguese breast cancer screening, by:

- Identification of the "AS-IS" model for the processes of the screening of breast cancer, according to a major player (Portuguese League Against Cancer);
- Description of each activity present in the process and the role of each stakeholder;
- Identification of bottlenecks and problems;
- Process improvements proposal considering the available information and "AS-IS" model analysis.
- Development and validation of the "TO-BE" models.

2. LITERATURE REVIEW

2.1. BREAST CANCER

The human body is composed of several millions of cells which coordinate between themselves to constitute tissues and organs (Devarriya, Gulati, Mansharamani, Sakalle, & Bhardwaj, 2019). Normal cells grow and divide for a period of time and then stop growing and dividing until its needed again to replace defective or dying cells (Bhardwaj & Tiwari, 2015; Devarriya et al., 2019). When this cell' reproduction become out of control and the cells lose their ability to stop dividing and spreading, a mass called tumor is formed and the cancer appears (Bhardwaj & Tiwari, 2015; Devarriya et al., 2019; Mušić & Gabeljić, 2019). The tumor can be classified as benign or malign according to its features (Bhardwaj & Tiwari, 2015; Devarriya et al., 2019; Mušić & Gabeljić, 2019).

Breast cancer is a malignant cell growth in the breast tissue which has the capacity to spread to other areas of the body when left untreated (Bhardwaj & Tiwari, 2015; Devarriya et al., 2019). It is classified according to stages which describe the size of the tumor and if it has spread to lymph nodes or metastasized to distant organs. The staging system normally used for breast cancer is the tumor-node-metastasis (TNM) classification. In the TNM classification, stage I and II are for localized disease, stage III is for regional disease and stage IV is for distant disease. Accurate staging provides key prognostic information (IARC, 2016).

The estimated global incidence of breast cancer in 2012, was of 1.68 million new diagnosis of breast cancer (43.3 per 100 000) and the estimated mortality was of 0.52 million deaths (12.9 per 100 000), as seen in Figure 2.1 (IARC, 2016). Its incidence was three times that the cancer of colorectal (0.61 million new cases, 14.3 per 100 000), lung (0.58 million new cases, 13.6 per 100 000) and cervix (0.53 million new cases, 14.0 per 100 000), the next most frequent types of cancer in women (Figure 2.2). While its mortality was similar to that from lung cancer (0.49 million deaths, 11.1 per 100 000) and significantly greater than that from the colorectal (0.32 million deaths, 6.9 per 100 000) and cervix (0.27 million deaths, 6.8 per 100 000) (Figure 2.2) (IARC, 2016).

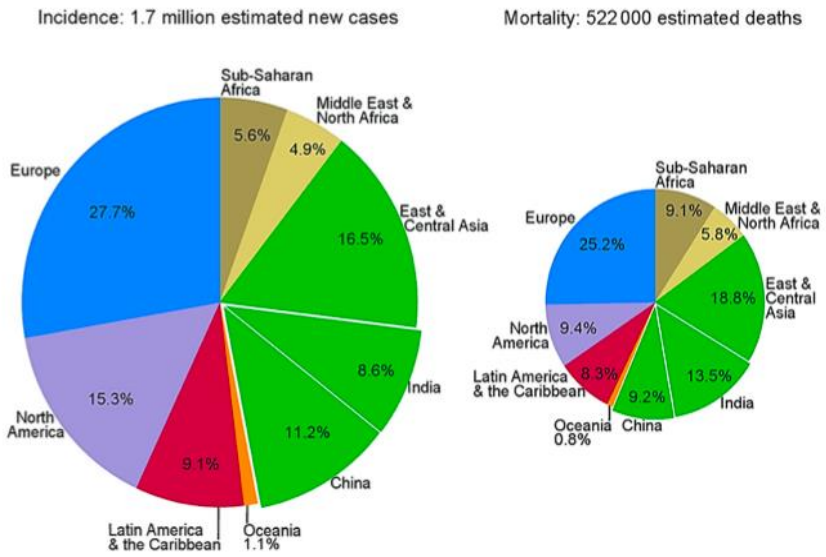

Figure 2.1 – Estimated global number of new cases and deaths for breast cancer in women, 2012. Retrieved from (IARC, 2016)

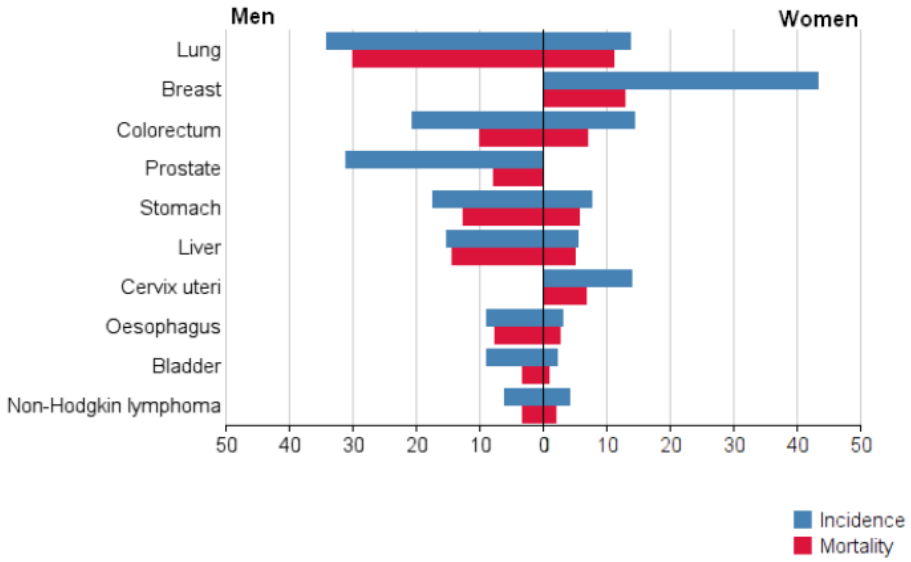

Figure 2.2 – Cancer incidence and mortality rates (estimated age-standardized) worldwide, per 100 000 in men and women in 2012. Retrieved from (IARC, 2016)

The risk of a woman develops breast cancer increase with the age, the majority of the cases appear in women older than 50 years, and the way to reduce its mortality is with an early detection and effective treatment (Bhardwaj & Tiwari, 2015; IARC, 2016). Breast cancer is one of the most treatable types of cancer when early detected (Obaidullah et al., 2019).

2.2. SCREENING

Prevention of cancer can be reached through primary prevention, intended to prevent the occurrence of cancer, or through secondary prevention, which has the purpose of an earlier diagnosis of the cancer in order to reduce related mortality and distress (IARC, 2016). The principal elements of secondary prevention are screening and early clinical diagnosis and they are essential components of any cancer control program (IARC, 2016).

Screening programs promote the detection of cancer at earlier stages, enabling the prescription of timely and suitable treatment, making the cure and the reduction of mortality associated with the disease realistic possibilities (IARC, 2016). The implementation of these programs aims to impact on disease mortality rates, however, the effective outcomes highly depend on the participation of the population, which relies on a set of factors such as people's knowledge and beliefs and on organizational aspects of the screening procedures and its availability (Deandrea et al., 2016). Thus, the acceptance and use of screening services differ between populations, making a given screening organized program not universally cost-effective (IARC, 2016).

The screening programs can be classified as organized or population-based, and opportunistic. Organized screening programs are settled at national or regional level, have a team responsible for organization and provision of healthcare, a structure for quality assurance and an explicit policy while the opportunistic screenings result from a recommendation from a routine medical consultation, for an unrelated problem, based on a possibly increased risk of developing breast cancer (due to family history or other risk factors) (IARC, 2016). Population-based screenings reach women who haven't participated in opportunistic screening. These programs enable more equity in access, creating conditions for women to obtain adequate diagnosis and treatment, including low users of healthcare services and the ones from lower socioeconomic groups (IARC, 2016; WHO, 2014). With universal access to rapid and effective diagnosis and treatment, the potential impact of early detection of cancer boosts (Anttila et al., 2015).

Opportunistic screening is less susceptible to quality assurance compared to the organized programs considering its lack of administrative and organization infrastructure (IARC, 2016). As mentioned by IARC, 2016, the organized programs include "centralized screening invitations to a well-defined target population, systematic call and recall for screening, delivery of test results, investigations, treatment and follow-up care and a program database with linkages to other information systems" and an administrative structure responsible for service delivery like follow-up of lesions, quality assurance and evaluation (IARC, 2016).

Table 2.1 presents both the advantages and disadvantages of opportunistic and population-based screening.

	Advantages	**Disadvantages**
Breast Cancer Opportunistic Screening	All women (both the ones that are invited to organized screenings and the ones that are not included) can participate;	Dependent on the initiative of individual healthcare providers to offer screening; The number of follow-up examinations or

	Enable the access to screenings in areas where organized screenings don't exist.	histopathological evaluations is probably higher; Overdiagnosis and overtreatment; Risk of causing more harm than good.
Breast Cancer Organized Screening	Attract women of lower socioeconomic status who would not usually undergo mammography screening; Equitable access to screening; Uses resources more efficiently; Best balance between benefits and harms; Organized mammography screening, biennially, is cost-effective; Can shorten the interval between diagnosis and start of treatment through prompt referral to hospital units.	Overdiagnosis (detection of breast cancer by screening that otherwise would never have presented clinically during the woman's lifetime) and consequently overtreatment; Resource costs in finding more illness and the subsequent management of what is discovered; Anxiety felt by all individuals tested between undergoing the screening test and the final diagnosis.

Table 2.1 – Comparison between Breast Cancer Opportunistic and Organized Screenings. (Anttila et al., 2015; Holland, 2006; IARC, 2016; WHO, 2014)

2.2.1. Breast Cancer Organized Screening

Since the late 1980s, good evidence emerging from trials on the effectiveness of breast cancer screening has become available, so screening programs have been in place in Europe (Deandrea et al., 2016). In the subsequent years was described a gradual implementation of breast cancer screening programs, however, with some heterogeneity and different policies (Deandrea et al., 2016). With this, the council recommendation of December 2nd, 2003, at European Union level, stablished a list of requirements to implement organized, population-based breast cancer screening programs (Deandrea et al., 2016).

Currently, the breast cancer screening with mammography alone is the population-based method used in the majority of the European countries for the early detection of this cancer (Mathioudakis et al., 2019). Screening asymptomatic women includes the execution of mammography screening, at specified intervals, and referring those women with positive results for additional diagnostic investigations and possibly treatment (IARC, 2016). A decrease on the breast cancer mortality in women aged 50 to 74 years has been shown (Mathioudakis et al., 2019). Within all of the European

countries, only France added a clinical breast examination to the mammography (Deandrea et al., 2016). The screening programs are offered to normal-risk women beginning with ages comprised between 40 to 50 years old and ending with ages between 69 to 74 years old and usually in intervals of two years (IARC, 2016).

Mammography can be used to check for breast cancer in women without signs or symptoms of the disease and is characterized for being an imaging modality specifically for breast tissue, which uses low energy X-ray (Mušić & Gabeljić, 2019). From all the breast cancers detected by mammography screening, less than one third would also be detectable by clinical examination (IARC, 2016). Normally, in the screening programs, the mammography involves two views (X-ray images) of each breast and double reading (Mušić & Gabeljić, 2019). With this technique it is possible the early detection of malignant tumors before the tumor spreads (Mušić & Gabeljić, 2019).

However, mammography screening has also some limitations and undesirable effects associated. As for example, it is not effective in detecting lesions in women with radiologically dense breasts, the radiation exposure and the false-negative or false-positive mammography results (Mathioudakis et al., 2019; Mušić & Gabeljić, 2019; Sadeghi et al., 2019). The reported rate of false-negative results in mammography is of at least 10% and false-positive results can lead to anxiety and psychological distress (Mušić & Gabeljić, 2019). There isn't yet a completely consensus on the harm-benefit balance of breast cancer screening thus, women need to receive balanced and adequate information to make informed decisions related to their participation in screening programs (Mathioudakis et al., 2019). It's essential an efficient communication in order to help women make an informed decision concerning their participation in the screening (IARC, 2016).

Although clinical breast examination and breast self-examination don't make part of the screening program, they can complement it. The first technique involves systematic palpation of both breasts and nipples and visual inspection by a trained health-care provider. While the second, is an examination done by the women herself of her breasts (IARC, 2016). These techniques are only useful for detecting suspicious breast lesions, once it doesn't determine malignancy with assurance (Jaglan, Dass, & Duhan, 2019).

2.2.2. Challenges for Breast Cancer Organized Screening

Although mammography continues to be the gold standard of the screening methods (Sadeghi et al., 2019), it has some limitations as previously mentioned. As so, it's essential to find a way to solve these limitations. Nowadays, research and discussions moved on to the use of digital breast tomosynthesis as routine for screening programs. But, until now no single screening program has changed to routine use of digital breast tomosynthesis (IARC, 2016).

Digital breast tomosynthesis derives from digital mammography and produces quasi three-dimensional images, reducing the effect of tissue superimposition, which allows better visualization and localization of potential lesions, improving mammography interpretation (IARC, 2016). It improves the rate of cancer detection and reduce the proportion of patients' recall for additional imaging studies (Ikejimba et al., 2019). Although the radiation dose of digital mammography with tomosynthesis is around twice of the dose of mammography alone, it is considerably reduced by reconstruction of two-dimensional images from the three-dimensional images (IARC, 2016).

Other imaging techniques available are: breast ultrasonography, magnetic resonance imaging (MRI), electrical impedance technology for breast imaging, scintimammography, and positron emission mammography. In non-randomized studies, for ultrasonography and digital breast tomosynthesis, there were evidence of incremental cancer detection when used as complement screening to mammography (IARC, 2016). Other studies have shown that breast ultrasonography and breast MRI are the best alternatives for mammography and may improve the breast cancer prognosis (Jaglan et al., 2019).

Breast ultrasonography screening have frequently focused on populations with mammographic density since dense breast tissue is a risk factor for breast cancer and reduces the sensitivity of mammography, consequently it is associated with greater probability of an interval cancer in mammography screening. Ultrasonography-only detected cancers were usually early-stage cancers, comparable or even in earlier stages than cancers detected through mammography (IARC, 2016).

Breast MRI have been proving to be a good alternative to mammography since it doesn't involve radiation exposure however, its specificity is too low and the interpretation is complex and not standardized, being recommended only for screening of high-risk women (Jaglan et al., 2019).

Molecular diagnostics are revolutionizing human oncology in order to enable early detection, target therapies or monitoring treatment (Wiley, Wise, & Breen, 2019). Liquid biopsies, through the identification of genetic signatures associated with cancers, allow the detection of tumors in preclinical stages (Gerratana et al., 2019; Wiley et al., 2019). This is a recent technique but efforts are being done to use them in early stage breast cancer, with respect to early disease detection and minimal residual disease, offering new opportunities for improving cancer screening (Gerratana et al., 2019; Wiley et al., 2019).

In order to early and accurately identify the breast cancer it's important to ensure the extraction of information from previous diagnosis data (Bhardwaj & Tiwari, 2015; Devarriya et al., 2019). Since machine learning techniques enable computers to learn from past data and patterns its usage in medical diagnosis is gradually increasing (Bhardwaj & Tiwari, 2015). Computer-aided diagnosis systems are being proposed since it helps reducing the number of unnecessary breast biopsies (Mušić & Gabeljić, 2019). As concluded by Mušić et Gabeljić, 2019, the use of neural network to classify mammographic tumors is benefic and should be used by physicians to improve quality, accuracy and potentially the speed of digital mammography.

2.3. PORTUGUESE LEAGUE AGAINST CANCER

The Portuguese league Against Cancer (LPCC) was founded in April 4th, 1941, proposed by Francisco Gentil. The league is based in two principles: the humanization and the solidarity (LPCC, 2019). It is a national entity of reference in the support for oncology patients and their family, in promoting health, in cancer prevention and in promoting research and training in oncology. It is composed by five regional nuclei: Azores, Centre, Madeira, North and South (LPCC, 2019).

The increasing focus of resources on patient' care and on the early detection of the disease led to the creation of one of the most important initiatives of the league: National Breast Cancer Screening Program. Currently, the LPCC is responsible for the majority of the breast cancer population-based screenings in Portugal. The population program covers completely the region of the center (78 municipalities), the districts of Beja, Braga, Bragança, Évora, Portalegre, Santarém, Viana do Castelo and Vila Real, the majority of the municipalities of the district of Porto, the municipality of Azambuja (Lisbon) and the municipalities of Alcácer do Sal, Sines, Grândola and Santiago do Cacém (Setúbal) (LPCC, 2019).

In this research project the breast cancer screening process followed by the LPCC nuclei of the south will be used as the case study (Figure 2.3).

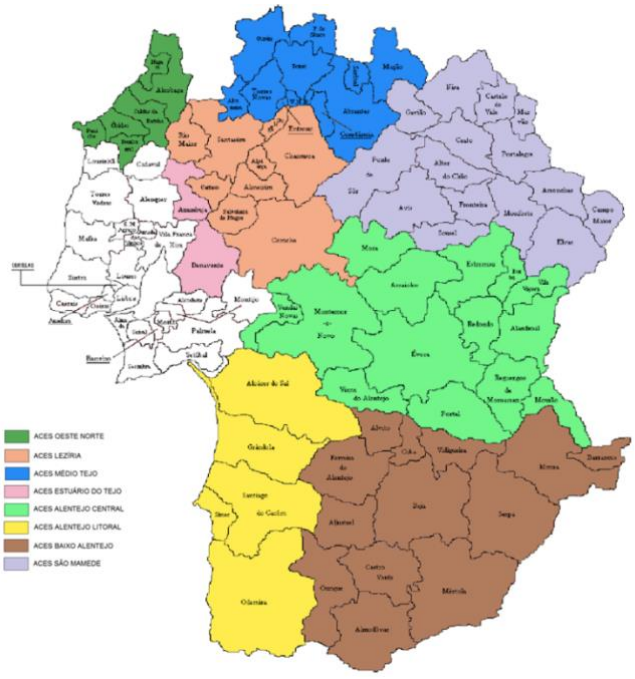

Figure 2.3 – Regions covered by the nuclei of the south of the Portuguese League Against Cancer. Provided by the LPCC

Two mobile units are used to perform the screening and every two years go to municipalities and fixed units. Inviting letters are sent to women with ages between 50 to 69 years old that are enrolled in the Health Units, in order to perform a mammogram (free exam). This exam is evaluated by two radiologists that in case of doubt call the woman to a clinic consultation and if this doubt persist she's referred to hospital facilities where a final diagnostic will be done. If suspicions are confirmed the woman goes to treatment (LPCC, 2019).

2.4. BUSINESS PROCESS MANAGEMENT

Business Process Management (BPM) has gain power and interest to organizations due to its capacity to help achieve operational excellence, increase productivity and save costs (Recker & Mendling, 2016). It is considered to be a management discipline which associates knowledge from information technology with management sciences and applies that to business processes (ABPMP, 2013; van der Aalst, 2013).

BPM is a term used since 2002, which represents a body of knowledge comprised by principles and best practices to guide an organization through focused management of the organization's business processes, in order to continuously improve and achieve their objectives more efficiently (ABPMP, 2013; Combi, Oliboni, & Zerbato, 2019; Froger, Bénaben, Truptil, & Boissel-Dallier, 2019). Its basis is an explicit representation of the activities and execution constraints between them, involved in the business processes (Hajiheydari & Dabaghkashani, 2011).

A business process is defined as a complete and dynamically coordinated set of activities, related across time and space, that transform one or more inputs into a specific output with value to a customer, either a product or a service (ABPMP, 2013; Combi et al., 2019; Hajiheydari & Dabaghkashani, 2011). The way processes are designed and executed affect the quality of the service perceived by the customer as well as the efficiency with which services are delivered (Dumas, La Rosa, Mendling, & Reijers, 2018). BPM includes methods and tools to support tasks of modelling, managing and analyzing of these processes, helping optimize the means by which the organization delivers their output (ABPMP, 2013; Dani, Freitas, & Thom, 2019). The design, administration, configuration and enactment of business processes are also integrated as capabilities of BPM techniques (Hajiheydari & Dabaghkashani, 2011). Since business processes are becoming more complex, process modelling has becoming of greatest importance for organizations (van der Aalst, 2013).

As referred by Van der Aalst, 2013, BPM aims achieve operational business processes improvement without the use of new technology but it is also frequently associated with software to manage, control and support operational processes. BPM can be used in any organization, from for-profit to non-profit and government entities (ABPMP, 2013).

According to the ABPMP (2013), when an organization has mature BPM capabilities their processes are managed following a closed-loop cycle, which composes the Business Process Lifecycle (ABPMP, 2013). The number of phases present in this lifecycle and the labels used to describe them vary between authors, considering this, in this document the DMEMO cycle will be followed (Figure 2.4).

The DMEMO cycle results from a sequence of five stages: Define, Model, Execute, Monitor and Optimize (Szelągowski, 2018).

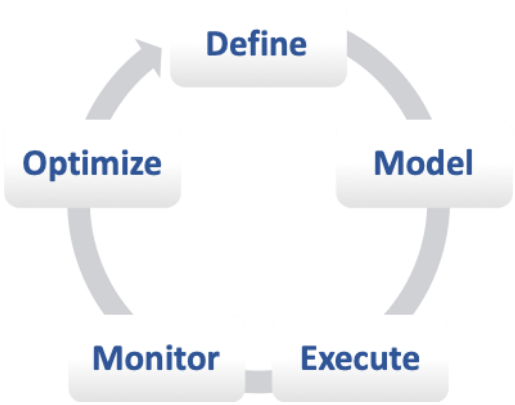

Figure 2.4 – The DMEMO process lifecycle. Adapted from (Szelągowski, 2018)

When starting a BPM initiative, the first question that needs to be clarified should be: "Which business processes do we aim to improve?" (Dumas et al., 2018). Before applying BPM, the team should have an idea of what business processes may be causing problems (Dumas et al., 2018). Considering this, it's important to start the BPM practices by describing the processes of the organization, building "AS-IS" models, and analyzing them according to the organization's data and the knowledge of its employees, which corresponds to the definition stage (Szelągowski, 2018). A critical step in BPM is understand the value delivered by a process, by measuring it. To do that it's important to determine the process performance measures that will be used to evaluate if a process is valuable or not (Dumas et al., 2018).

With the result of the previous analysis, composed by an understanding of the issues in the process and the potential solutions, an improved process model is prepared (the "TO-BE" model) which corresponds to the Model stage (Dumas et al., 2018; Szelągowski, 2018). The next phase is the Execution, where personnel's training and changes to their work is done, as well as changes to the IT systems, including process performance automation. The goal of the Monitor phase is to perform and monitor business operations in agreement with organized and implemented process descriptions.

When expectations are no longer accomplished, adjustments to the implemented business process are required which corresponds to the last stage, the Optimization (Dumas et al., 2018). At this phase, the process performance is evaluated and the process descriptions are improved with the purpose of raising efficiency and minimizing risks (Szelągowski, 2018).

2.4.1. AS-IS Model and TO-BE Model

In order to properly analyze and change a specific business process, it's necessary to start by understanding its current state, creating one or several "AS-IS" models (ABPMP, 2013). This process model should reproduce what people in the organization understands about how work is done (Dumas et al., 2018). To capture all the needed information, many different methods can be used, as for example: direct observation, one-on-one interviews, written feedback, structured workshops and web conferencing. While using these techniques, some inconsistencies, unnecessary activities and opportunities for improvement can be noticed (ABPMP, 2013). So, with these problems identified, a redesigned version of the process can be proposed, the "TO-BE" model, which is the main output of the process improvement (model phase) (Dumas et al., 2018). In this stage, analysis and redesign are

associated because several redesign options can be considered and each one of them needs to be analyzed in order to choose the preferable one (Dumas et al., 2018).

2.4.2. Process Performance Measures

Process performance management should begin with the examination of the processes that will be monitored for performance. When properly identified, it's important to understand processes effectiveness, if they deliver what is supposed to or not (ABPMP, 2013).

A process performance measure is defined by Dumas, 2018, as a quantity that can be clearly determined for a given business process. According to ABPMP (2013) and Dumas (2018) there are four fundamental measurements:

- Time – Associated with process duration. The cycle time measures the time taken from the start of a process until its completion, considering the output;
- Cost – Value associated with a process, which is typically a monetary value. There are different perspectives on cost, being possible to distinguish between fixed (almost not affected by the intensity of processing) and variable (positively correlated with some variable quantity) or it can be related to productivity, operational cost (directly related to the outputs of the business process);
- Capacity – Amount or volume of a realistic output related to a process;
- Quality – Normally expressed as a percentage of actual to optimal or maximum. It can be seen from two different angles: external quality (client's satisfaction with the product or the process) and internal quality (process participants' viewpoint).

Quality is the hardest measure to define in terms of oncology screenings, being evaluated on the basis of a set of performance indicators, like detection rates and the predictive values of the tests (Ponti et al., 2017). A screening program in order to be considered to have quality should be safe, efficient, effective and offer equity in access (National Screening Unit & Ministry of Health, 2005).

Finally, when redesigning a business process, the time required to handle a case and the cost required for executing the process should decrease, the quality of the service delivered should be improved, and the resilience of the business process to deal with variation should increase (Dumas et al., 2018).

2.4.3. Transformation Techniques

Besides BPM, many other disciplines deal with business processes, being focused in improving the operational performance of the organization (Dumas et al., 2018). Several management disciplines can be used to define improvement opportunities like:

- Lean - is an approach that has as one of the main principles the elimination of the waste or non-value-add work while focusing on continuous improvement to optimize the operations, providing higher quality, reduced cycle time and lower costs (ABPMP, 2013; Dumas et al., 2018). It focuses on the people of the organization through the creation of a culture that empowers staff at all levels to make innovative changes to improve productivity whilst reducing waste (Pearce & Pons, 2013). Nowadays, Lean is supported

by tools and statistical methods that are important for improvement projects. Normal results show reductions in time aligned with quality increase and the cost of quality decreases (ABPMP, 2013; Pearce & Pons, 2013). The application of lean is based on five steps (Amador, 2013): (1) define value from a customer's perspective; (2) identify value stream; (3) make the value flow without interruptions by eliminating when possible waste between steps of the process; (4) implement customer "pulls" service and (5) pursue perfection continuously.

- Six Sigma - is a method that improves business performance by reducing variation in work or in quality and by minimizing defects (errors) (ABPMP, 2013; Dumas et al., 2018). It has become one of the most accepted enterprise improvement methodologies for organizations chasing to identify business problems and define improvement opportunities (ABPMP, 2013). In practice, Six Sigma is not necessarily applied alone but combined with other methods as for example with Lean, being referred as Lean/Six Sigma (ABPMP, 2013; Dumas et al., 2018).

2.4.4. Process Modelling Notation - BPMN 2.0

A notation is defined as a standardized set of symbols and rules that manage how something is represented. In business process modelling notation icons and connectors are included to assist in the representation of relationships between components of a business process. There are available several modelling and notational standards and techniques (ABPMP, 2013). This research study applies Business Process Model and Notation (BPMN) 2.0, which is considered the main standard and was created by the Business Process Management Initiative, now merged with the Object Management Group (OMG) (ABPMP, 2013; Sang & Zhou, 2015). BPMN is a technique, frequently used as notation in the process modelling tasks, that uses structured analysis to diagrammatically represent business processes and aims providing, to all business users, an easy-to-understand notation (Dani et al., 2019; Georgiou et al., 2019).

BPMN 2.0 is an extremely accurate notation that indicates the beginning, intermediate and end events; activities and message flows; intra-business communications and inter-business collaboration, activity and data flows (ABPMP, 2013). According to Dani et al. (2019), Combi et al. (2019) and White (2004), there are four basic categories of BPMN elements, each other with several core elements:

1. **Flow objects:**

    - Events: representation of actions that occur during process execution and affect the sequencing or timing of process activities. Normally have a cause (trigger) or an impact (result) and are represented as circles with open centers. They can be of three types, concerning when they affect the process flow:
        - Start: initiate a process instance;
        - Intermediate: indicate where something happens somewhere between the start and end of a process;
        - End events: conclude the process.

Figure 2.5 – Symbols for start, intermediate and end events (from left to right)

- Activities: are represented by a rounded-corner rectangle and can be of two types: Task and Sub-process. It is called task when it's seen as single unit of work, it cannot be broken into a finer level of abstraction. If a process is too complex, subsets of its elements can be grouped to form sub processes within the main process, represented by a small plus sign in the bottom center of the shape.

Figure 2.6 – Symbols for tasks and sub-processes (from left to right)

- Gateways: elements in the process, that can also be called as decision points, used to control the divergence and convergence of the sequence flow. They are represented by a diamond shape and can be of three types: AND, for concurrency (two or more activities that can be executed in parallel); OR, for inclusive choices (one or more options can be true at the same time) and XOR, for exclusive choice (outcomes are mutually exclusive).

Figure 2.7 – Symbols for the different types of Gateways

2. **Connecting Objects:**

- Sequence Flow: is used to link two elements and handle the order through which a process will be executed. It is represented by a solid line with a solid arrowhead.
- Message flow: is used to demonstrate the flow of messages between two participants. It is represented by a dashed line with an open arrowhead.
- Association: is used to associate data, text and other artefacts with flow objects. It is represented by a dotted line with a line arrowhead.

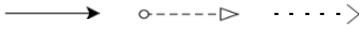

Figure 2.8 – Symbols for sequence flow, message flow and association (from left to right)

3. **Swimlanes:**

    - Pools: join elements of an organization, represents a participant in a process
    - Lanes: divide a pool into different organization's resources, being used to organize and categorize activities. It's a sub-partition within a pool.

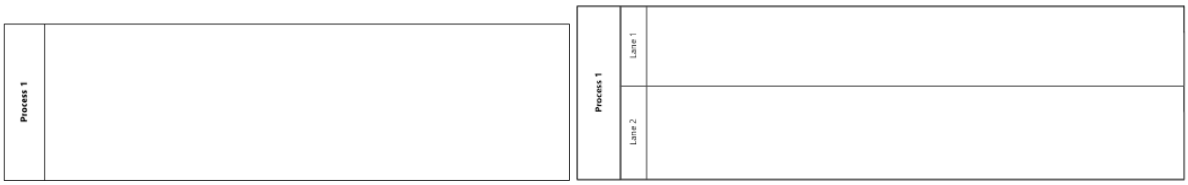

Figure 2.9 – Symbols for pools and lanes

4. **Artefacts:**

    - Data objects: present how data is required or created by activities
    - Group: is used for documentation or analysis purposes, but does not affect the sequence flow. It is represented by a rounded corner rectangle drawn with a dashed line
    - Annotation: is a mechanism to provide additional text information for the reader of a BPMN Diagram

Figure 2.10 – Symbols for data objects, groups and annotations (from left to right)

Amongst others, its advantages are widespread usage and understanding and being one of the most powerful and versatile notations for identifying process constraints (ABPMP, 2013). On the other hand, some identified disadvantages are: (1) requires training and experience to use full set of symbols correctly; (2) challenge to see relationships between multiple levels of a process; (3) doesn't support security aspects as confidentiality (ABPMP, 2013; Sang & Zhou, 2015).

2.5. ARTIFICIAL INTELLIGENCE (AI)

2.5.1. Data Cleaning

In the healthcare sector as in several other areas, the databases contain raw data that is unpreprocessed, incomplete and noisy. In this way, the databases should undergo pre-processing, through data cleaning and data transformation (Larose & Larose, 2015).

Data cleaning also called data cleansing or scrubbing refers to all types of tasks and activities to detect and repair errors and inconsistencies in the data. While collecting and acquiring data some errors are often introduced, such as missing values, typos, mixed formats and others (Ilyas & Chu, 2019; Rahm & Do, 2000). It is composed by repeated cycles of four phases: screening, diagnosis, treatment and documentation. Screening is look systematically for suspect features in assessment questionnaires, databases or analysis datasets. The diagnosis is responsible for identify the nature of the defective data and the treatment involves deleting, editing or leaving the data as it is. These two phases require a complete understanding of all sources and types of possible errors during data collection and entry processes. The documentation is related to recording modifications enabling the track of errors detected, changes, additions and error checking which allows to return to the original value if necessary (ACAPS, 2016).

2.5.2. AI in the Breast Cancer Screening

It's been for several decades that intelligent computer systems exist and impact society needs. Several different areas are interested in artificial intelligence (AI) research and development, from sectors such as technology, communication, to health and industry (Houssami, Kirkpatrick-Jones, Noguchi, & Lee, 2019).

In the healthcare sector, AI systems are being developed, explored and evaluated to help in clinical decision-making and in the detection and prognostic of diseases, as for example for oncology diseases (Houssami et al., 2019). Computer-aided detection (CAD) software was introduced in the 1990s for mammography, as an assistance for radiologists with the objective to improve human detection performance (McKinney et al., 2020; Rodríguez-Ruiz et al., 2019). However, this generation of software failed in improving readers' performance in real-world settings (McKinney et al., 2020). Unlike them, AI is capable of advanced learning and has the potential to do stand-alone interpretations in the future (Houssami, Lee, Buist, & Tao, 2017). The substantial improvements in AI, through deep convolutional neural networks (usually named as deep learning algorithms), are making closer the performances of humans and computers in several medical imaging applications, such as breast cancer detection (Rodríguez-Ruiz et al., 2019).

The screening of breast cancer requires the interpretation of digital mammograms to find suspicious abnormalities, which is subjective, and its accuracy varies widely, leaving space for improvement even in the performance of the best clinicians (Houssami et al., 2017; McKinney et al., 2020). Although the evaluation of patient data and expert judgment are the most important factors in this type of diagnosis, there are other factors affecting it, such as the visual perception capacity of the radiologist, less experience of the radiologist, the presence of noise in images, poor contrast or inadequate clarity (Sadoughi et al., 2018).

The usage of AI systems to support breast cancer screening classification could help reducing the workload involved in the double-reading process, while maintaining the standard of care (McKinney et al., 2020). As mentioned in some studies, AI represents a feasible and timely technology opportunity for exploration in breast cancer screening practice (Houssami et al., 2019, 2017).

Sadoughi et al. (2018) introduce many AI techniques in imaging processing:

- Support vector machine (SVM) – This technique is inspired by the statistical learning theory and has been recently incorporated in the machine learning set. Here, the overfitting problem in the training data is reduced and it's possible the identification of a sizeable training set with small subsets of training points.
- Cascade forward back-propagation network – In this technique each layer of neurons is linked to all previous neuron layers and it uses post propagation algorithm to update weights, like back- propagation neural network.
- Feed forward back-propagation network – This network includes input, output and hidden layers and the back-propagation learning algorithm is used for learning.
- k-nearest neighbor (k-NN) - This method selects a group of K records from a training record set that has the closest records to the test record. Deciding the class of the test record according to the highest number of records in the selected neighborhood.
- Genetic algorithm as optimizer – Since this algorithm works on its own rules, it can be used for irregular problems. It can rapidly scan a group of solutions and eliminate bad proposals and not affecting the final result.
- Naive Bayes classifier - It's estimated by the covariance matrix and it is a simple probability classifier based on the theory of Bayes. It needs only a small amount of training data to estimate the required classification parameters.
- Deep learning technology – This method contains more image processing layers than the conventional image feature-based machine learning classifiers. Each layer is a typical neural network and uses the image itself as a single input.

2.6. Past Research Using BPM in Healthcare

By searching for the words BPM, BPMN, Healthcare, Oncology Screening and Process Modelling in the platforms Scopus and Google Scholar, the authors retain important information from 7 articles, presented in the following table (Table 2.2). To the best knowledge of the author, there isn't yet a study about the implementation of BPM techniques in the process of Breast Cancer Screening.

Title	Year	Author(s)	Reference(s)	Brief Description
Introduction to BPM approach in healthcare and case study of end user interaction with EHR interface	2018	Gomes, J.; Portela, F. and Santos, M.	(Gomes, Portela, & Santos, 2018)	• Any healthcare institution needs to have a detailed and itemized management of all processes present; • Business process Management is already a solution for process management in healthcare organizations with the purpose of improve work speed and efficiency, simplifying processes and reducing the use of resources; • Healthcare organizations have very complex structures, requiring adequate process management; • Healthcare organizations have problems in process management, namely: (1) Strategic level, (2) Tactical level and (3) Operational level; • In healthcare level BPM works in parallel with hospital information systems; • The services of a health institution are not independent from each other; they are interconnected and make the organization function as a whole; • To correctly apply BPMN, its necessary to understand the steps required to execute a given process and its surroundings, in order to represent the processes detached from their level of complexity; • BPMN will have an impact in increasing the level of quality of the services, in reducing costs and in identifying losses or wastes; • BPMN is intuitive, simplifying complex processes' diagrams; • Organizations benefit with the adoption of BPMN either in organizational and economic levels.

A BPMN-based automated approach for the analysis of healthcare processes	2016	Antonacci, G.; Calabrese, A.; D'Ambrogio, A.; Giglio, A.; Intrigila, B. and Ghiron, N. Levialdi	(Antonacci et al., 2016)	• Healthcare organizations are increasingly pressed to improve the quality of care services in an unfavorable context (increasing complexity in patient treatment and reduction of available resources); • Efforts to standardized and improve healthcare quality and efficiency have been done but it still persists a variation in performance; • Researchers and practitioners promote process redesign as a valuable way to reduce practice variation and improve the quality of care while considering efficiency issues; • According to BPM frameworks, the healthcare process lifecycle includes six phases: (1) definition, (2) specification, (3) analysis, (4) implementation, (5) execution and monitoring and (6) diagnosis and improvement; • Factors that limit the adoption of simulation-based analysis techniques in the healthcare domain: (1) healthcare processes are complex, distributed and multi-disciplinary, (2) medical knowledge is often tacit and rapidly evolving, (3) the adoption of information technologies is still in its early stages and data when available is often disseminated in different information systems and (4) staff of healthcare organizations often lacks skills of modelling and analysis; • BPMN can satisfy the necessity of clinical pathway models for creating diagrams of these pathways and is able to manage the variability in a more effective way; • BPMN only works with functional characterization of processes without offering the capacity of specifying non-functional properties as performance and reliability.
Improving access to healthcare with on-line medical appointment system	2019	Leung, W. and Nøhr, C.	(Leung & Nøhr, 2019)	• Business process reengineering can be a method to find possibilities to improve the design of medical appointments systems, from “as-is” to “to-be”; • Since health care systems are composed by processes coordinated and logically sequenced, producing value to a client or costumer, they can benefit from using BPM approaches; • BPM gives importance on the use of information technology as a tool to improve business processes;

				• BPMN supports technical users and business users to manage healthcare processes by providing a notation that both understands; • Devil's quadrangle can help healthcare industry to be conscious about problems in terms of time, quality, cost and flexibility as performance indicators; • Process redesign combines incremental improvement and extension of the existing process; • Healthcare institutions should evaluate the trade-off by using “as-is” and “to-be” process model.
BPMN for healthcare processes	2011	Müller, R. and Rogge-Solti, A.	(Müller & Rogge-Solti, 2011)	• BPM has become to be considered a valuable asset in the healthcare domain; • BPMN designed to be understandable for business professionals and IT-specialists.
Driving time-dependent paths in clinical BPMN processes	2017	Combi, C.; Sala, P. and Zerbato, F.	(Combi, Sala, & Zerbato, 2017)	• Time management is important at all stages of business process design, enactment and analysis; • During process execution, different types of temporal conditions can limit how a process path is preferred; • Clinical domain it’s appropriate for business process modelling, considering its intrinsic organizational and decisional complexity; • BPMN constructs are enough to build process diagrams that succeed in specifying and enforcing temporal constraints; • BPMN process presents the main steps for the detection and treatment of Catheter-Related Bloodstream Infections in intensive care units, simplified from IDSA guideline.

A real-world case scenario in business process modelling for home healthcare processes	2016	Ilahi, L.; Ghannouchi, S. and Martinho, R.	(Ilahi, Ghannouchi, & Martinho, 2016)	• Technologies of BPM, principally the design (modelling) aspect, are recognized to normally offer collaboration support by information technologies; • BPM is a valuable asset in the healthcare area because of the competitiveness, rapid advancement and the expansion of communication techniques and new technologies in all research domains, together with the effectiveness of BPM tools to automate and better manage business processes of organizations; • Technologies of BPM didn't have a widespread adoption in the healthcare; • Process aware hospital information systems must be able to cope with exceptions, uncertainty and evolving processes; • Healthcare systems have particular modelling requirements: collaboration, understandability and flexibility.
A design methodology for medical processes	2016	Ferrante, S.; Bonacina, S.; Pozzi, G.; Pinciroli, F. and Marceglia, S.	(Ferrante, Bonacina, Pozzi, Pinciroli, & Marceglia, 2016)	• Healthcare processes are complex and need transparency of all the process elements in order to achieve their implementation; • Healthcare process modelling as solution to reduce complexity and provide transparency; • Process modelling can define cooperative work, helping surpass the information gap between different actors; • Both clinical and organizational processes introduce dynamic activities, requiring adequate modelling methodologies; • Medical decision making, the clinical problem solving, is the foundation of clinical processes, being present in all stages of care (prevention, diagnosis, treatment and rehabilitation); • Graphical modelling languages offer a shared and understandable way to represent processes, simplifying context analysis and converting experiences into models; • Modelling healthcare processes is more complex than modelling other processes since medical processes are described by uncertainties, unpredictability, evolution, variability and difficult generalization;

				• The modelled process should be predictable, repeatable, distributed, automatable and feasible; • BPMN is useful to describe the sequence of activities (normal flow of execution), the resources and the actors that are the executing units that can be related to the execution of the process; • BPMN graphs are often used to describe care pathways however, using these diagrams alone restricts the potential of process modelling on improving healthcare delivery.

Table 2.2 – Summary of related articles

3. METHODOLOGY

3.1. RESEARCH STRATEGY

To achieve the goals of this dissertation the following steps were considered (Figure 3.1):

1. Understanding the problematic of breast cancer screening;
2. Identification of the current processes for the screening of breast cancer;
3. Recognition of the Entities involved in the process;
4. Design of the "AS-IS" diagram (modelling);
5. Critical Analysis of the "AS-IS" diagram;
6. Improvement proposal through the design of the "TO-BE" diagrams;
7. Validation through interviews.

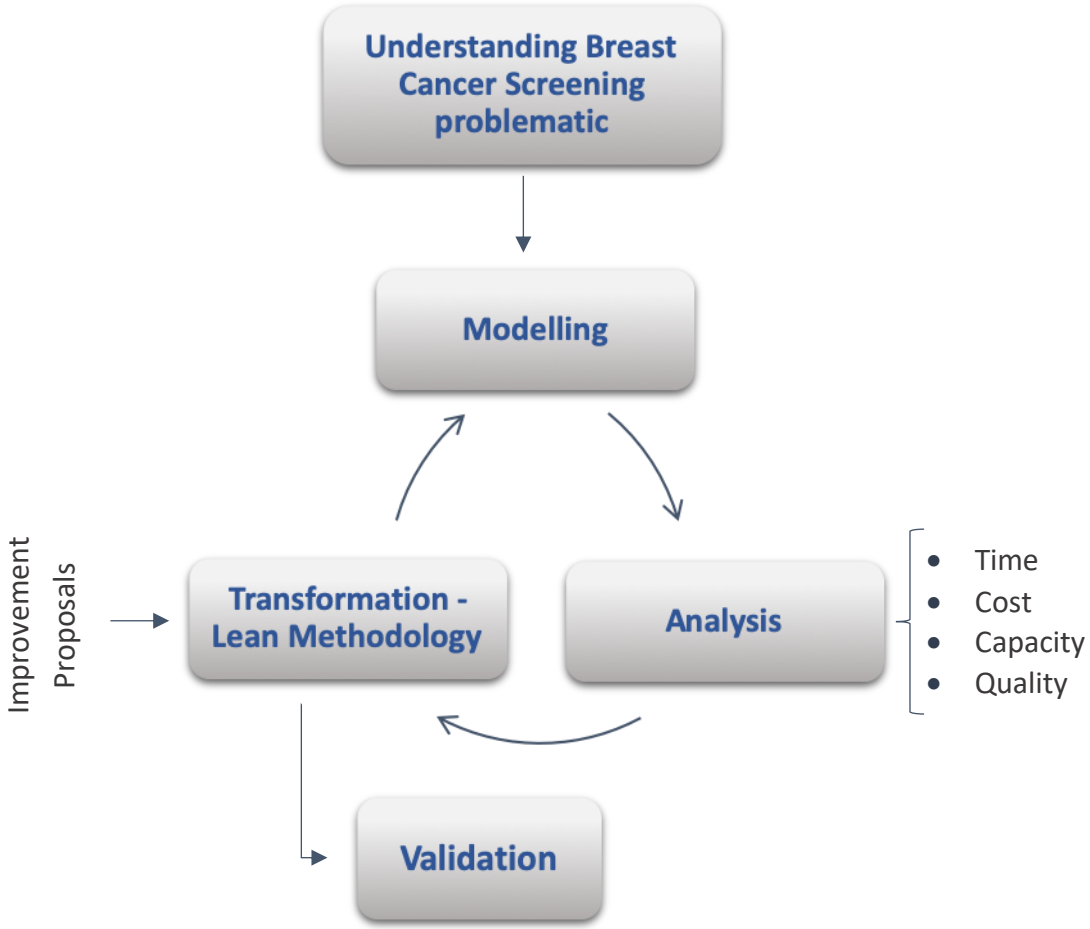

Figure 3.1 – Methodology Scheme

Through a literature review (chapter 2) the problematic of the breast cancer screening was presented, for fully understanding the process itself according to the state-of-the-art. To acquire this information, an online research through the platforms Scopus and Google Scholar was performed, which resulted in the acquisition of recent and relevant information about the topic. For the recognition of the

processes and all the entities involved, the nuclei of the south of the Portuguese League Against Cancer was used as case study and the information retrieved will be presented in the chapters 3.1.1 and 3.1.2, respectively. This enabled to modelling the current processes as "AS-IS" diagrams (chapter 4). In order to analyze the "AS-IS" diagrams and propose some improvements to the process, a reunion between the author, co-supervisors and the Regional Director of the Breast Cancer Screening from the LPCC was done. To support this, the four fundamental measurements (time, cost, capacity and quality) were used and the Lean methodology was followed (chapter 5). From here resulted the construction of the "TO-BE" diagrams for each process (chapter 6). This project ends with the validation through interviews to experts in the field (chapter 7).

3.1.1. Identification of processes

In this phase, the existing processes for the screening of breast cancer made by the LPCC were studied. To completely understand the processes and sub-processes, an interview to the Regional Director of the Breast Cancer Screening from the LPCC was required.

These processes are documented in word or PowerPoint documents and was necessary to review the existing documents and record the undocumented processes in a more comprehensible, less complex and up-to-date language, using BPMN 2.0.

The Table 3.1 has a concise explanation of the major processes identified within the breast cancer organized screening, which together form its macroprocess.

Number and Name	Type	Description
1. Health users' invitation	Process	Asymptomatic people within an age range are invited to perform the breast cancer screening
2. Screening	Process	Composed by the documents and exams required to screen the disease
3. Reading of the exam **3.1.** Sending Results **3.2.** Check-up consultation	Process Sub-process Sub-process	Evaluation of the mammograms performed by radiologists
4. Check-up consultation **4.1.** Sending Results	Process Sub-process	Consultation for health users with mammograms classified as R3, R4 or R5 to perform more exams
5. Sending Results	Process	Sending the results to the family doctor

Table 3.1 – Identified processes of the Breast Cancer Organized Screening

3.1.2. Recognition of Entities

Within a business process, there are several organizational entities that may interact with each other. To analyze and transform a process, it's necessary to understand the entities involved and their relationship.

The entities can be actors, systems or documents. The actors are the people that perform the activities in the process. The systems are the software used by the actors to perform their functions and to communicate with various stakeholders. The documents correspond to the methods used by the actors to share information between themselves, it can be digital or non-digital documents.

In the Table 3.2 the actors are presented, as well as a brief description of their roles and the screening processes in which they are involved.

Actor	Description	Processes where it arises
Administrative Technician	Person who gives administrative support for all the process. Present in all support units.	1; 2; 3; 4; 5
Radiologist Technician	Person who is responsible for the screening exam	2
Radiologist	Person who is responsible for the reading of the exam and classification of it	3; 5
Doctor	Person who evaluates the check-up exams	4
Family Doctor	Person who will receive the letter with the result to deliver to the health user	5
Health user	Person who will be submitted to the screening process	2; 4; 5

Table 3.2 – Identified actors of the Breast Cancer Organized Screening

In the Table 3.3 the systems are presented, together with a brief description of their role and the screening processes in which they are involved.

System	Description	Processes where it arises
SIRCM	Informatic system that enables monitoring every activity in the screening program	1
Post mail	System used to send the invitation letters (both for screening and for check-up consultation)	1; 2
Telephone	System used to re-invite eligible women for screening which didn't attend on the first appointment and to schedule the check-up consultation	1; 2
Microsoft Excel	Database of health users' information (family doctor, social security number, previous screenings)	1

Table 3.3 – Identified systems of the Breast Cancer Organized Screening

In the Table 3.4 all the documentation relevant for the processes already mapped, are identified, described and linked. The invitation letter and the anamnesis (both written in Portuguese) can be found in the annex I and II, respectively.

Document	Description	Processes where it arises
Invitation letter	It is a printed letter sent to the women eligible for screening to invite her for the next screening in her residence area (approximately 15 days before screening)	1
Exam	It is a digital document with the mammography exam	2; 3; 4
Letter with the result	Letter sent to the family doctor with the result of the screening	5
Anamnesis	Form filled by the health user with her personal information and answering some relevant questions for the screening	2

Table 3.4 – Identified documents of the Breast Cancer Organized Screening

3.2. SELECTION OF THE SOFTWARE TO SUPPORT THE BUSINESS PROCESS MANAGEMENT

Modelling helps to understand the business process and share this understanding with the people involved in it, while identifying and preventing issues (errors). In the market there are several software's available to support business process management. In this work, Bizagi was the selected software to develop the diagrams.

Bizagi provides leading process and workflow automation solutions to customers in industries worldwide. It supports the business process lifecycle through modelling, execution, management and continuous improvement, with minimum amount of programming (Nafie, 2016). Bizagi has 3 products: Bizagi Modeler, Bizagi studio and Bizagi Automation.

Bizagi Modeler is a free of charge desktop application which uses BPMN as modelling notation and allow business experts to design, document and evolve their process models (Gjoni, 2015). High-quality documentation can be published in formats as Word, PDF, Web (HTML) and Wiki, and it's feasible to import or export to interoperable formats such as Visio, XPDL or BPMN (Bizagi, 2019).

While working with this software, it's possible to create many diagrams and group them into models that can be stored as local files, .bpm file extension, or directly in the cloud (Bizagi, 2019).

3.3. SELECTION OF THE TRANSFORMATION TECHNIQUE - LEAN

In this project, the Lean approach was used as transformation technique since several studies evidenced that its principles and practices are being successfully used in healthcare processes (Amador, 2013; Shah, Sullivan, Gonyo, Wadhwa, & DuBois, 2013). It can be applied to improve staff productivity, standardize workflows and decrease patient waiting times while improving patient and staff satisfaction (Shah et al., 2013).

As mentioned before, the goal of this technique is the maximization of valued activities and minimization of waste. This waste can be classified as different categories (Shah et al., 2013; Teich & Faddoul, 2013):

1. Motion – movement of patients or staff members that is unnecessary
2. Transportation - movement of lab tests, supplies or equipment that is unnecessary
3. Inventory – inappropriate amount of supplies available, both too much or too little
4. Waiting – related to the time that the patient or staff waits until the next step in the process occurs
5. Defects – errors or flaws in the process which can be related to poor labelling of tests, incomplete information in patients' records and others
6. Over processing – redundancies that can be observed in the process caused by unclear definition of what needs to be done and by whom
7. Overproduction – excess work that doesn't add value to the process. Producing something in excess, faster or earlier than required
8. Under-utilizing staff – the under-use besides time-dependent it also involves deeper levels such as not sharing knowledge or not taking advantage of someone's skills

Teich and Faddoul (2013) suggest that lean implementation in healthcare should assign the patient to the center of the initiative, while time and comfort should be considered as key performance measures.

3.4. INTERVIEWS AS METHOD FOR QUALITATIVE VALIDATION

After the development of the "TO-BE" diagrams a validation is required and in this way interviews one-to-one were performed.

This is a type of semi-structured qualitative interviews which uses a single respondent, being also called in-depth interviews. They are semi-structured because a pre-determined series of questions are asked but they enable an ongoing conversation, it's an open-ended questioning (Bauer & Gaskell, 2000). This method explores the experiences of the participants and the value they give to them by encouraging the participants to talk about issues relevant to the research topic (Tong, Sainsbury, & Craig, 2007).

There are other types of qualitative interviews as for example the use of focus groups. These method is similar to the type of interview chosen but instead of being individual interviews they are semi-structured discussions composed by groups of 4 to 12 people (Tong et al., 2007). The choice of using individual interviews is due to the fact that it creates more detail, offers more insights into an interviewee's personal thoughts, beliefs and point of views and it's easier to schedule than the focus group, which usually takes more time to conduct (Guest, Namey, Taylor, Eley, & McKenna, 2017).

4. STUDY

The macroprocess of the breast cancer screening were modelled as an “AS-IS” diagram, as well as all its sub-processes. Being presented in the following chapters.

4.1. MACROPROCESS

The macroprocess is presented in Figure 4.1 where several sub-processes can be seen. Each one of these sub-processes will be presented in the following chapters. In order to understand this macroprocess it’s important to know what are the meaning of the exam’s classifications: R1 - no abnormalities, R2 - benign findings, R3 - equivocal findings, R4 - suspected cancer and R5 - strongly suspected cancer.

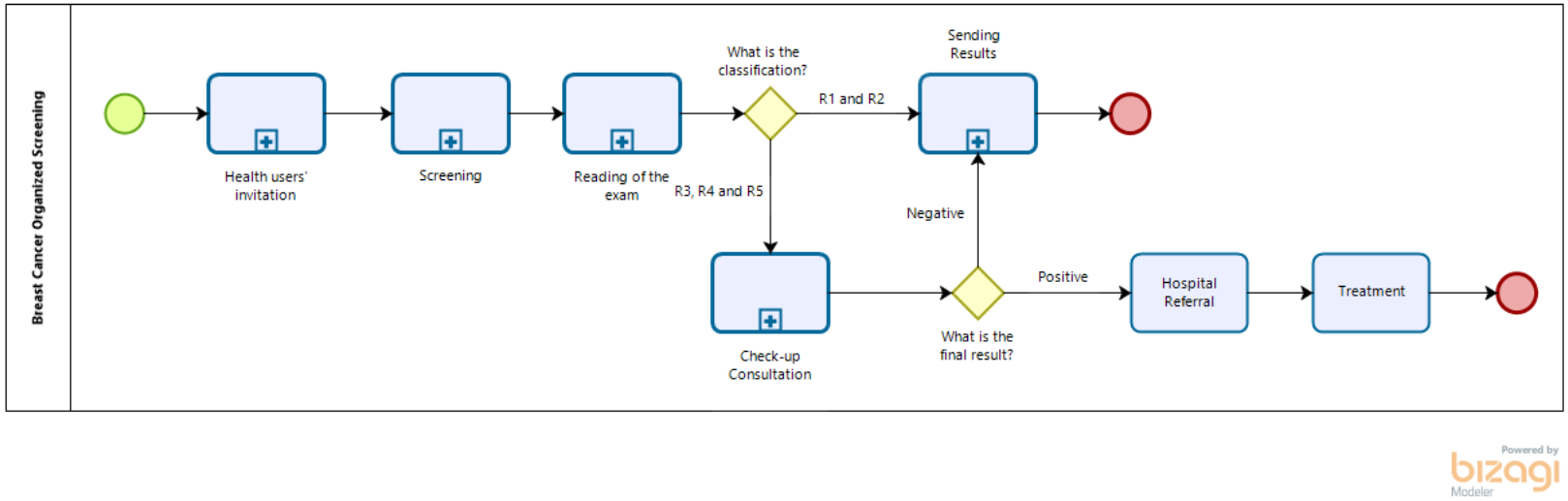

Figure 4.1 – Macroprocess for the Breast Cancer Organized Screening

4.2. PROCESS "HEALTH USERS' INVITATION" - AS-IS DIAGRAM

The process "Health users' invitation" (Figure 4.2) is performed by the administrative support unit which uses data provided by primary health care units (ACES). The health users' database is sent as a Microsoft excel sheet and all that information is imported to the server SIRCM.

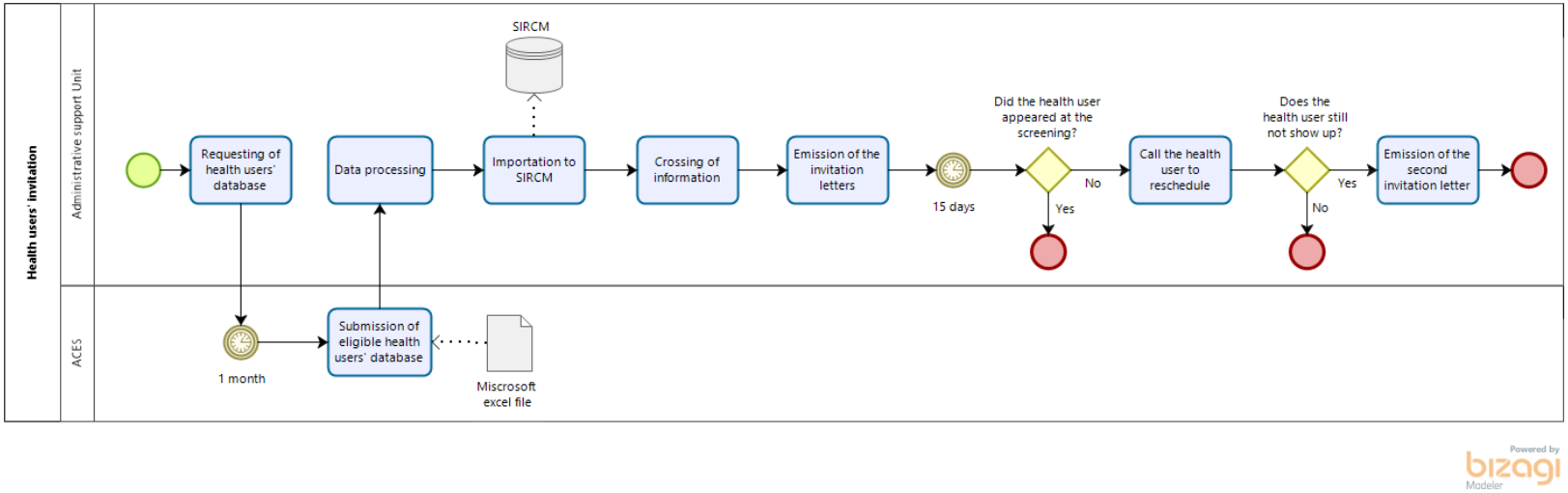

Figure 4.2 – Process "Health users' invitation" – AS-IS Diagram

4.3. PROCESS "SCREENING" - AS-IS DIAGRAM

The process "Screening" (Figure 4.3) is performed by an administrative technician and two radiologist technicians to an eligible woman which is called as health user. In this process there is one important document - the anamnesis - that must be filled out by the health user every time that is screened.

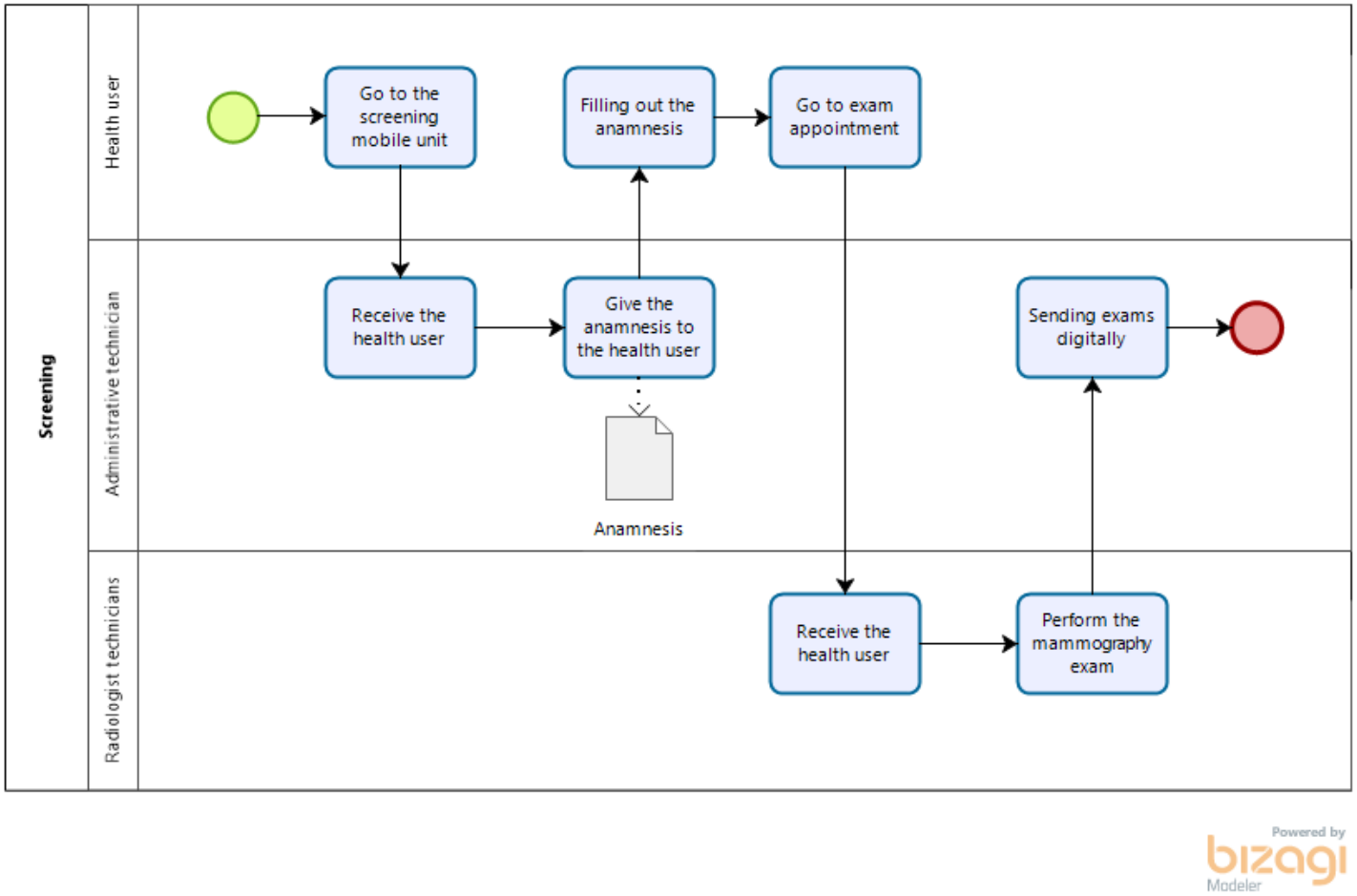

Figure 4.3 – Process "Screening" – AS-IS Diagram

4.4. PROCESS "READING OF THE EXAM" - AS-IS DIAGRAM

The process "Reading of the exam" (Figure 4.4) is performed by the radiologists but relies on the help of the reading, administrative and check-up support units. The consensus conference is done by the five radiologists of the organization. The sub-processes "Check-up consultation" and "Sending results" will be presented in the next two chapters.

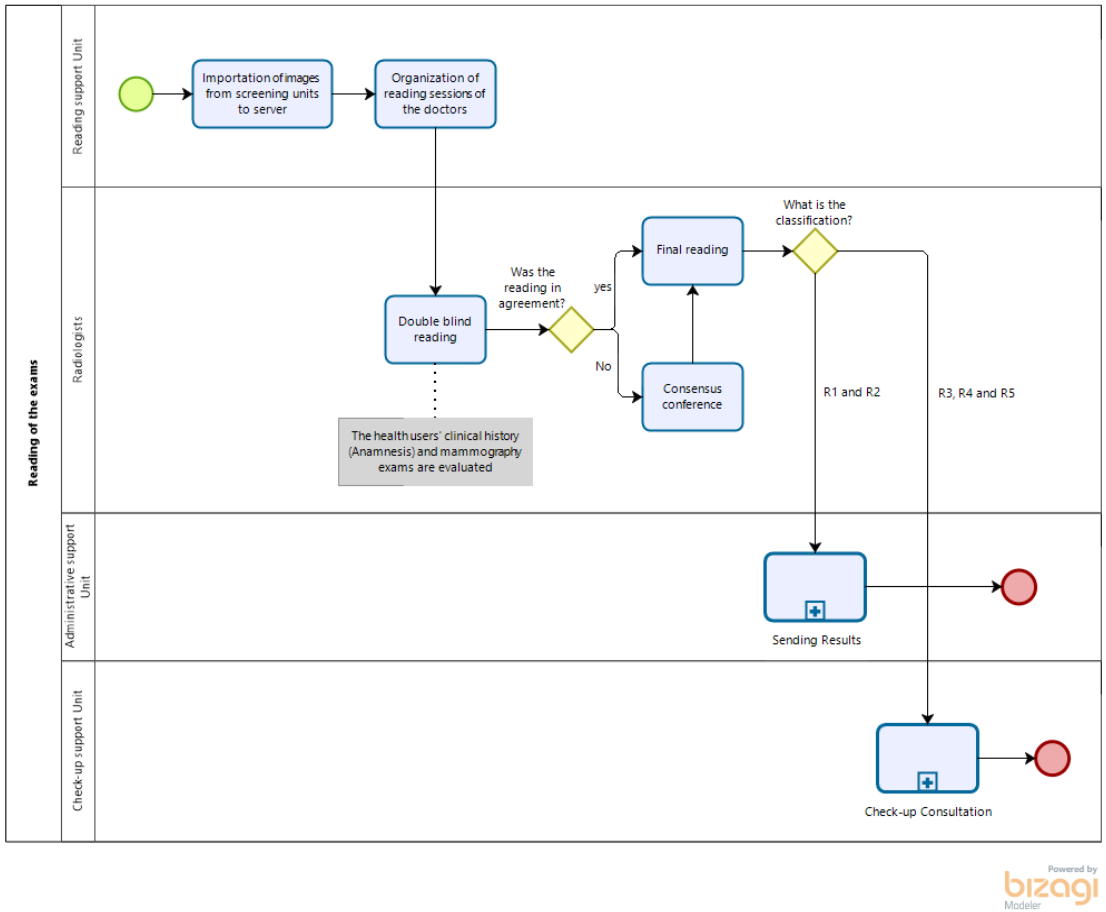

Figure 4.4 – Process "Reading of the exam" – AS-IS Diagram

4.5. PROCESS "CHECK-UP CONSULTATION" - AS-IS DIAGRAM

The process "Check-up consultation" (Figure 4.5) is performed by the check-up support unit and the doctors to the health user.

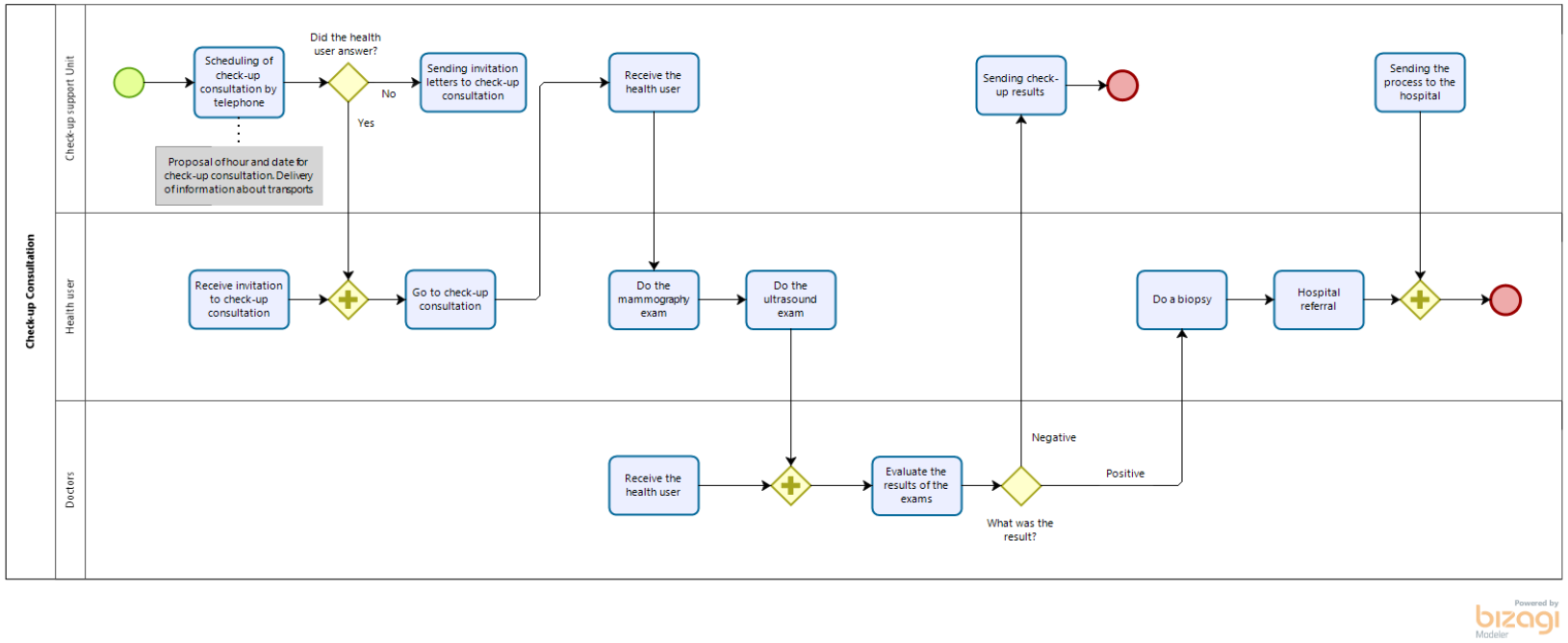

Figure 4.5 – Process "Check-up Consultation" – AS-IS Diagram

4.6. PROCESS "SENDING RESULTS" - AS-IS DIAGRAM

In the process "Sending Results" (Figure 4.6) the radiologists, the administrative support unit and the family doctor will be involved in delivering the result to the health user. The results are delivered by the family doctor due to privacy issues.

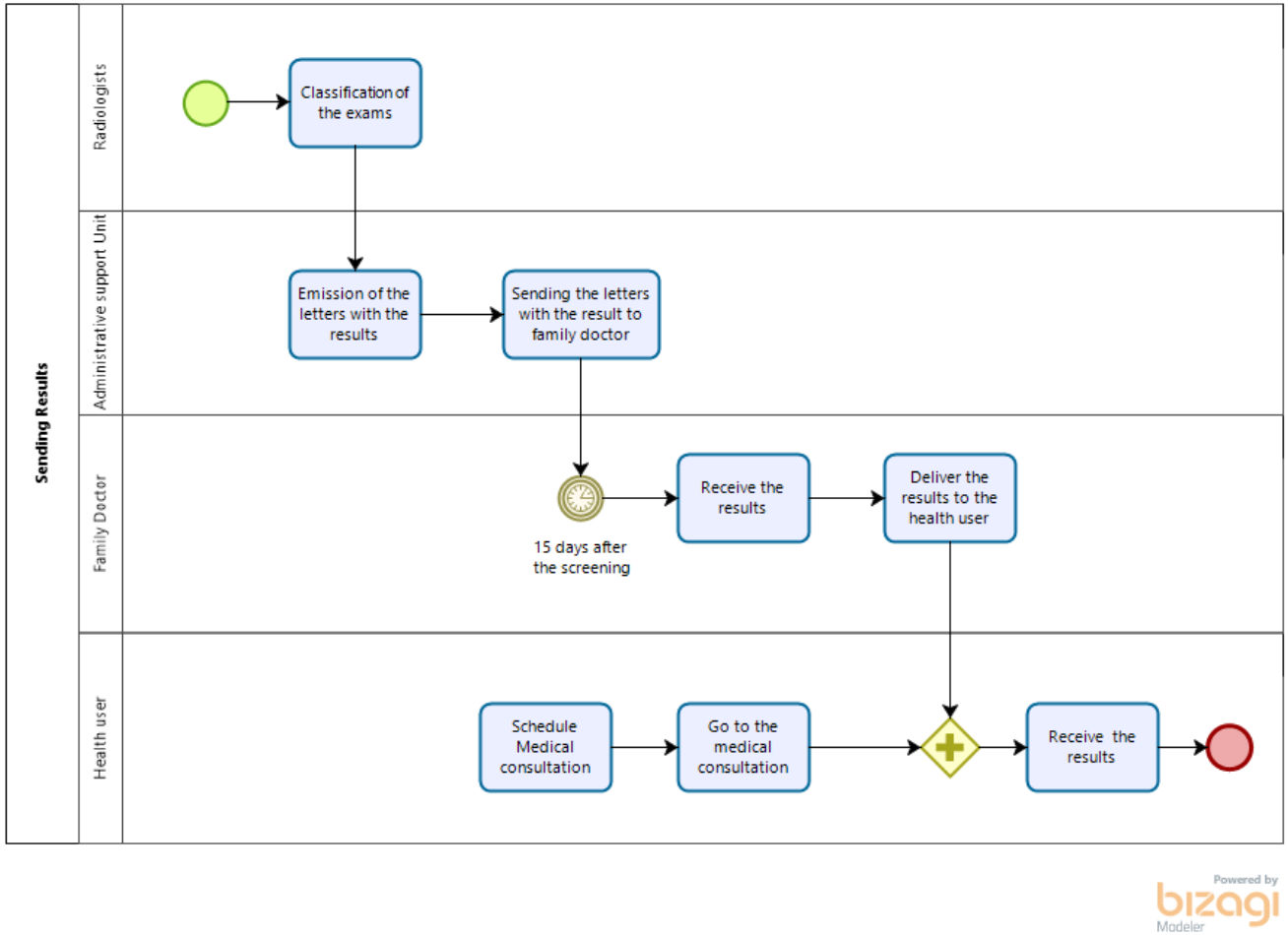

Figure 4.6 – Process "Sending Results" – AS-IS Diagram

5. CRITICAL ANALYSIS

Before updating a process is required a shared understanding of the current state of the process and finding the level of agreement with the stated organization's objectives. This is achieved by process analysis (ABPMP, 2013).

The Breast Cancer Organized Screening under study follows the macro recommendations of the European Commission, being well stablished the processes involved. However, healthcare organizations may decide on the revision of operational processes in order to best fill the goals defined and revised periodically at the European level.

Through the reunion performed between the author, co-supervisors and the Regional Director of the Breast Cancer Screening from the LPCC, and after the presentation of the "AS-IS" diagrams of the main processes, it was observed that some of the problems in the breast cancer organized screening were: (1) the participation of the health users; (2) the time the process takes; (3) the availability of the health users' information (from the available contact to filling out the anamnesis form).

After the identification of these problems, a brainstorming session was performed to propose some improvements. To complement this session, an online research was done focusing on strategies to improve the participation rate in the screenings.

The Table 5.1 presents the critical analysis to the major processes identified and some of the improvements that can be done.

Process name	Critical Analysis	Improvement proposals
Health users' invitation	1. After receiving the health users' information and before its importation to the SIRCM, it's required a manual pre-treatment where the terms are converted into the term accepted by the system. As for example, the system only accepts the name "Maria" as "M." so for each woman called Maria this conversion needs to be made what is a time-consuming process. 2. An invitation letter is sent 15 days earlier to the health user but no telephone contact is done before the screening. The health user is only contacted by telephone if she didn't appear in the day of the screening.	1. To change the manual conversion of the terms into an automatic process a data cleaning before the importation to the SIRCM would be done. 2. According to the contact that is available, the health user would be contacted every time through the same way. This means that: a. If the address it's the only available contact, the health user would always be contacted through letters.

		b. If the health user had a telephone number or an email address as contact way, this would be the method used. This would enable that a reminder message (through SMS or email, respectively) was sent in the day before the screening appointment.
	3. With the invitation letter goes information about the process itself and clarification of doubts that may exist.	3. When contacting the health user, along with the information that is already provided it would also be asked them to complete the anamnesis online form before the screening day.
	4. The invitation letter is signed by the Regional Director of the Breast Cancer Screening.	4. The reminder letter could also be signed by the Regional Director of the Breast Cancer Screening and by the health user's general practitioner in a way to improve participation in this program.
Screening	1. Anamnesis is a form filled in the day of the screening and is required in the process "Reading of the exams" where the radiologist will combine it with the mammograms and previous information.	1. The form could be filled previously to the day of the screening, online, through the creation of a site and an app. Which would reduce the time of the screening itself.
	2. The participation in the screening varies according to location and other variables. Health users that were recently examined through an opportunistic screening don't show up at the organized screening however they count as absences, decreasing the participation percentage.	2. To improve participation in the screening a reward system (like body creams, soaps, hygiene products or others) could be established through the development of agreements with renowned brands. In order to exclude the health users that didn't went to the screening because they were already screened, from the participation percentage, the anamnesis form could have a field related to this question.
	3. The exam performed is the mammography which is the golden standard but has some disadvantages.	3. Use of other imaging techniques or liquid biopsies.
Reading of the exam	1. The evaluation of the mammograms is done by a double-blind reading by two	1. Through an artificial intelligence (AI) system a sorting in the exams could be done. This would create

	radiologists but there is no order of priority within the exams, which can lead to an increase in the response time to the most severe cases.	two different paths according to the classification obtained here. Every exam would be seen and evaluated by the two radiologists but this would create a priority order. If the exam, in the AI, gets a classification of R1 or R2, it would stay in the queue. The exams classified as R3, R4 or R5 would get a priority and would be observed first. After these exams have been observed the R1 and R2 exams would get in the flow again and would be evaluated.
Check-up Consultation	1. This is a stressful process that brings concern to the woman and that can require special accompaniment.	1. The creation of an optional consultation with a psychologist, on the day of the check-up consultation would help reduce the stress associated with the process and provide a better accompaniment to the woman.
Sending Results	1. The results are sent to the family doctor approximately 15 days after the screening but the health user is not notified about the availability of the results.	1. Through the creation of an app a notification could be sent to the health user informing about the availability of the results of the exam, in the health care center with her family doctor.

Table 5.1 – Critical Analysis and improvement proposals for the identified processes.

Besides the impact that the creation of an app would have in the process "Screening" as presented before, it could also have a positive impact in the breast cancer organized screening as a whole. Because this app could have much more features like, every two years remind the woman that the following screening is almost there; or the woman could upload her previous results to the app so she can have a full picture about her health or even get some information about all the process (frequently asked questions, notices about the topic, tips to deal with the associated stress).

To reach the improvement proposals present in the previous table, was followed the principle of the Lean methodology, elimination of the waste or non-value-added work, and complemented with the four fundamental measurements (Time, cost, capacity and quality). In terms of the lean technique this improvement proposals are related to the elimination of different wasteful procedures that could be classified as waiting and defects waste.

- In the "Health users' invitation" process, using data cleaning to treat the data, the time of the process will be reduced. With the use of the appropriate type of contact, which reduce the letters sent, the cost of the process will also be reduced.
- In the "Screening" process, with the use of an online form for the anamnesis, there will be a reduction in the time of the process because the health user will only need to go to the mobile unit and perform the mammography exam and this possibly would increase

the number of women attended in the same day because it would need less time per women, increasing the process capacity. With this, we can observe a reduction of the waiting waste. With the reward system, if more women go to the screening the capacity of the process would also increase.

- In the “Reading of the exam” process, by using the AI to sort the mammograms the response time would decrease in the most severe cases, and the quality of the evaluation would increase because it would be checked by radiologists and informatic systems. Through this measure it is possible to eliminate defects waste because it is expected a reduction in the errors of the evaluation.
- In the “Check-up consultation” process, the incorporation of the psychologist consultation would increase the quality of the process as a whole because it would bring more support and accompaniment to the women, decreasing the stress associated. With the health user at the center of this analysis, this measure would improve their comfort, which is one of the suggested key performance measures to correctly implement lean.
- In the “Sending Results” process, the notification of the availability of the results to the health user would improve the process for them and, consequently, impact on satisfaction.

6. TO-BE MODELS

In the following sub-chapters, it will be presented the "TO-BE" diagrams for each process identified.

6.1. PROCESS "HEALTH USERS' INVITATION" – TO-BE DIAGRAM

With the redesigning of the "Health users' invitation" process resulted a diagram with more steps however, it is more efficient in time and cost. It is possible to observe that the administrative support unit will follow three different pathways according to the contact form available for each health user (Figure 6.1).

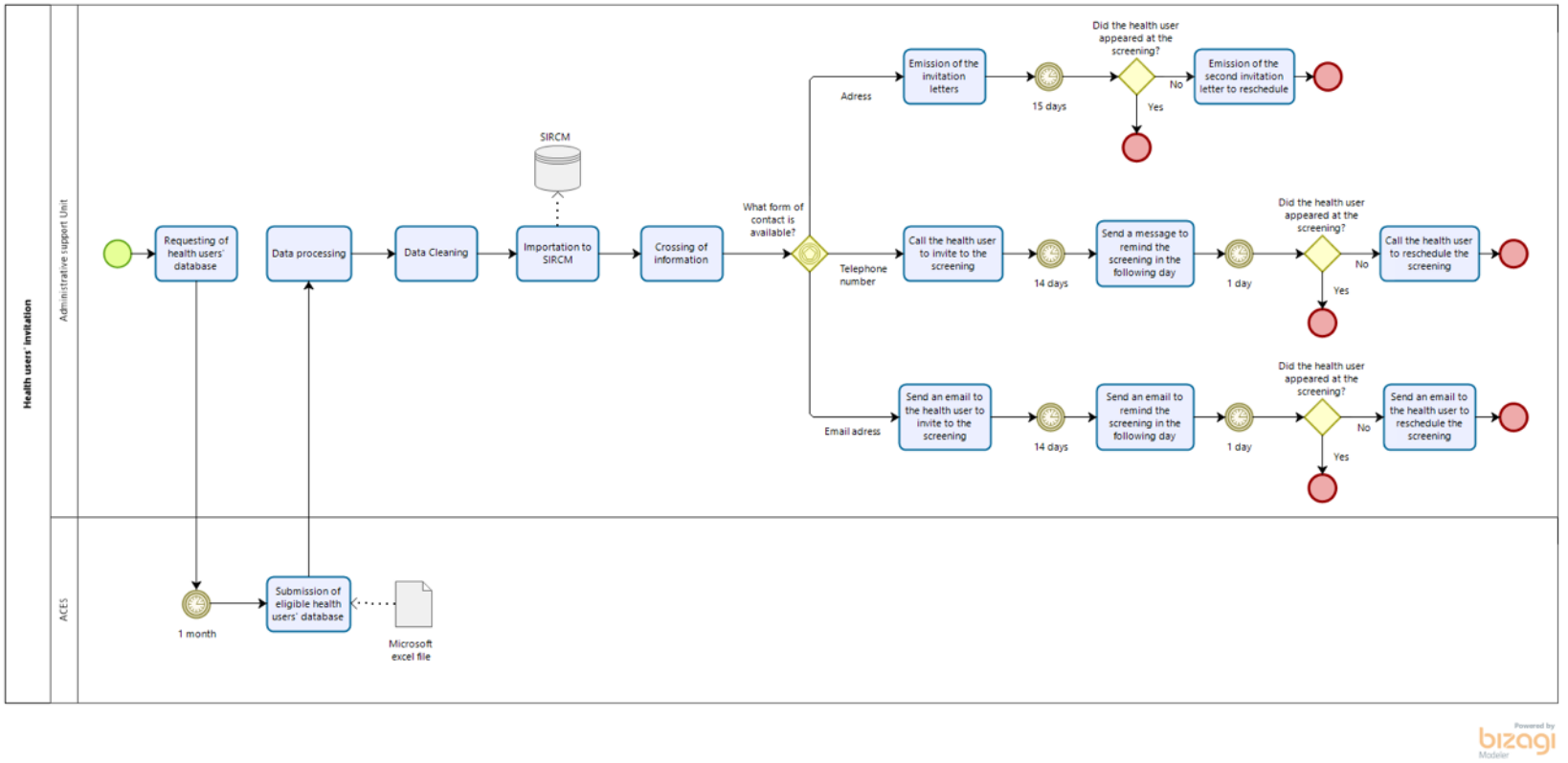

Figure 6.1 – Process "Health users' invitation" – TO-BE Diagram

6.2. PROCESS "SCREENING" - TO-BE DIAGRAM

In the "TO-BE" diagram for the process "Screening" (Figure 6.2) the administrative technician needs to confirm that the anamnesis was filled online by the health user. If it was already filled out, the health user would go directly to the exam appointment otherwise needs to fill it online before goes to the exam appointment. To be possible to assure that every health user could fill their information online a computer should be available in the mobile unit and administrative support would be offered.

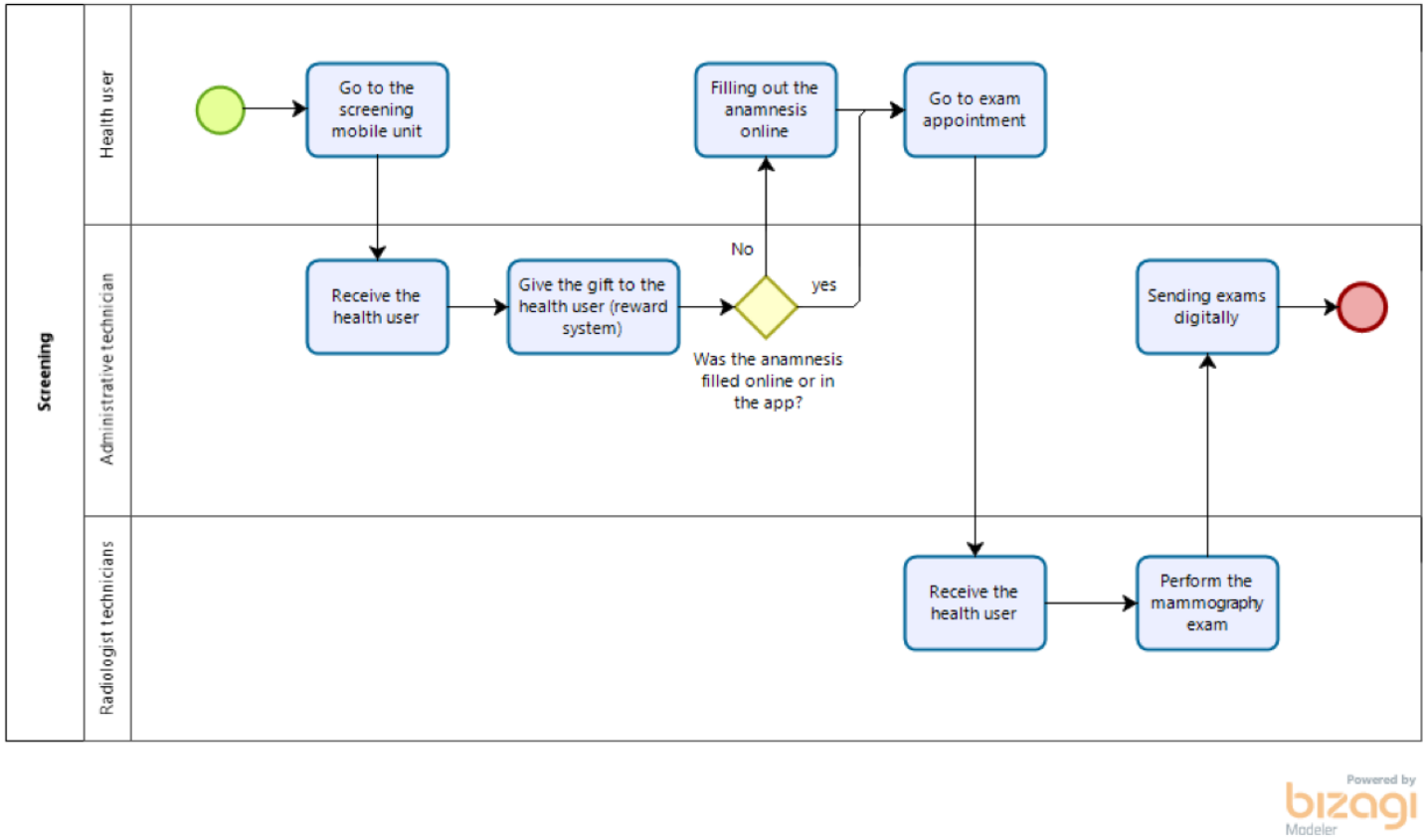

Figure 6.2 – Process "Screening" – TO-BE Diagram

6.3. PROCESS "READING OF THE EXAM" - TO-BE DIAGRAM

For this process the "TO-BE" diagram (Figure 6.3) brings two pathways according to the classification obtain in the artificial intelligence technique used. This technique could be, for example, the convolutional neural networks (CNN) because it has been referred by recent studies that it can be successful in several tasks in the healthcare sector namely in multiple applications in radiology (Geras, Mann, & Moy, 2019). Additionally, it has presented good results for image recognition problems (Ibrahim et al., 2020). These pathways would make a faster track for the most severe cases (R3, R4 and R5) and a slower one for the ones that didn't demonstrate malignancy (R1 and R2).

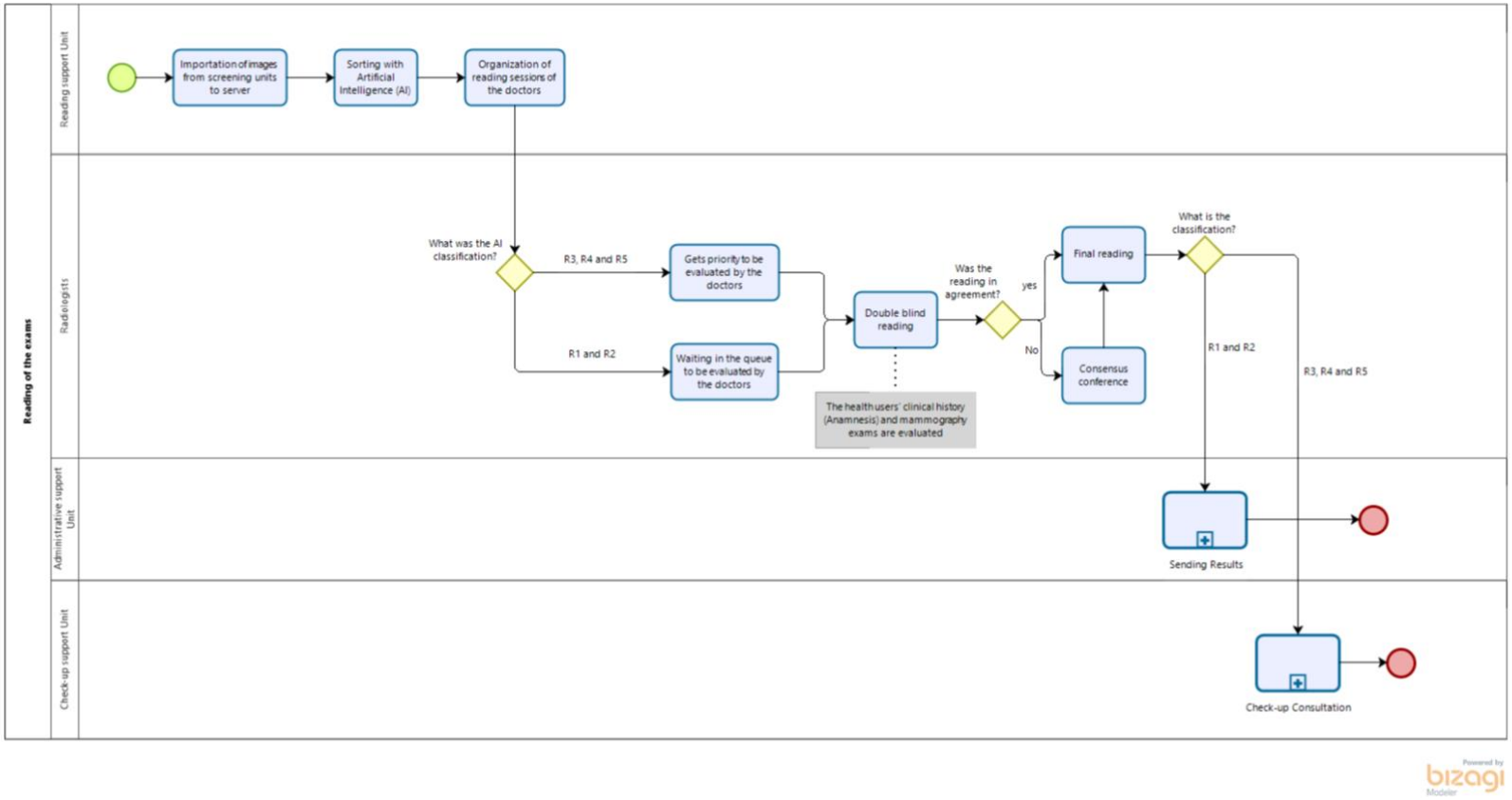

Figure 6.3 – Process "Reading of the exam" – TO-BE Diagram

6.4. Process "Check-up Consultation" - TO-BE Diagram

The "TO-BE" diagram for the "Check-up Consultation" process (Figure 6.4) brings one more step compared with the "AS-IS" diagram however it doesn't add unnecessary time since it would be an optional step for the health user, with their well-being in the center of this proposal.

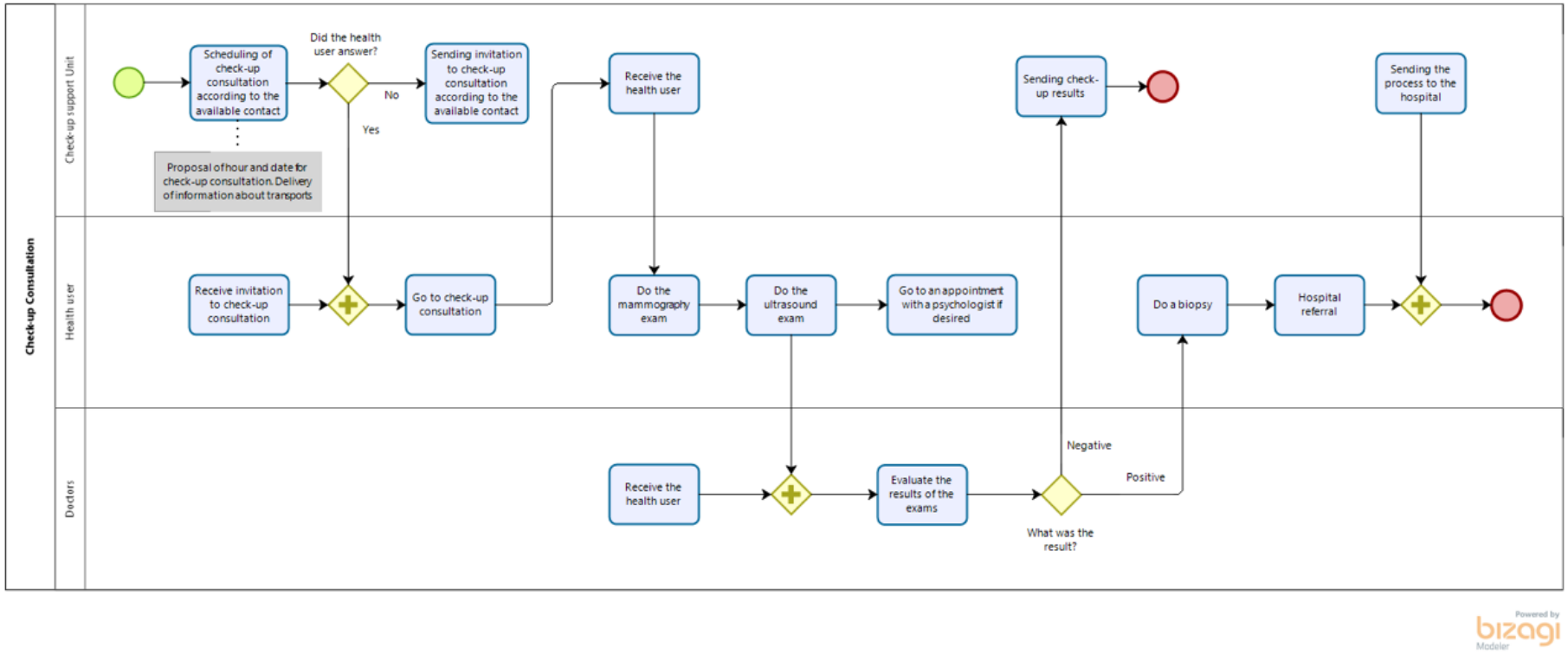

Figure 6.4 – Process "Check-up Consultation" – TO-BE Diagram

6.5. PROCESS "SENDING RESULTS" - TO-BE DIAGRAM

In the process "Sending Results" as in the previous process, the "TO-BE" diagram (Figure 6.5) carries one more step but it is a step related with the use of the app which doesn't bring any additional time to the process.

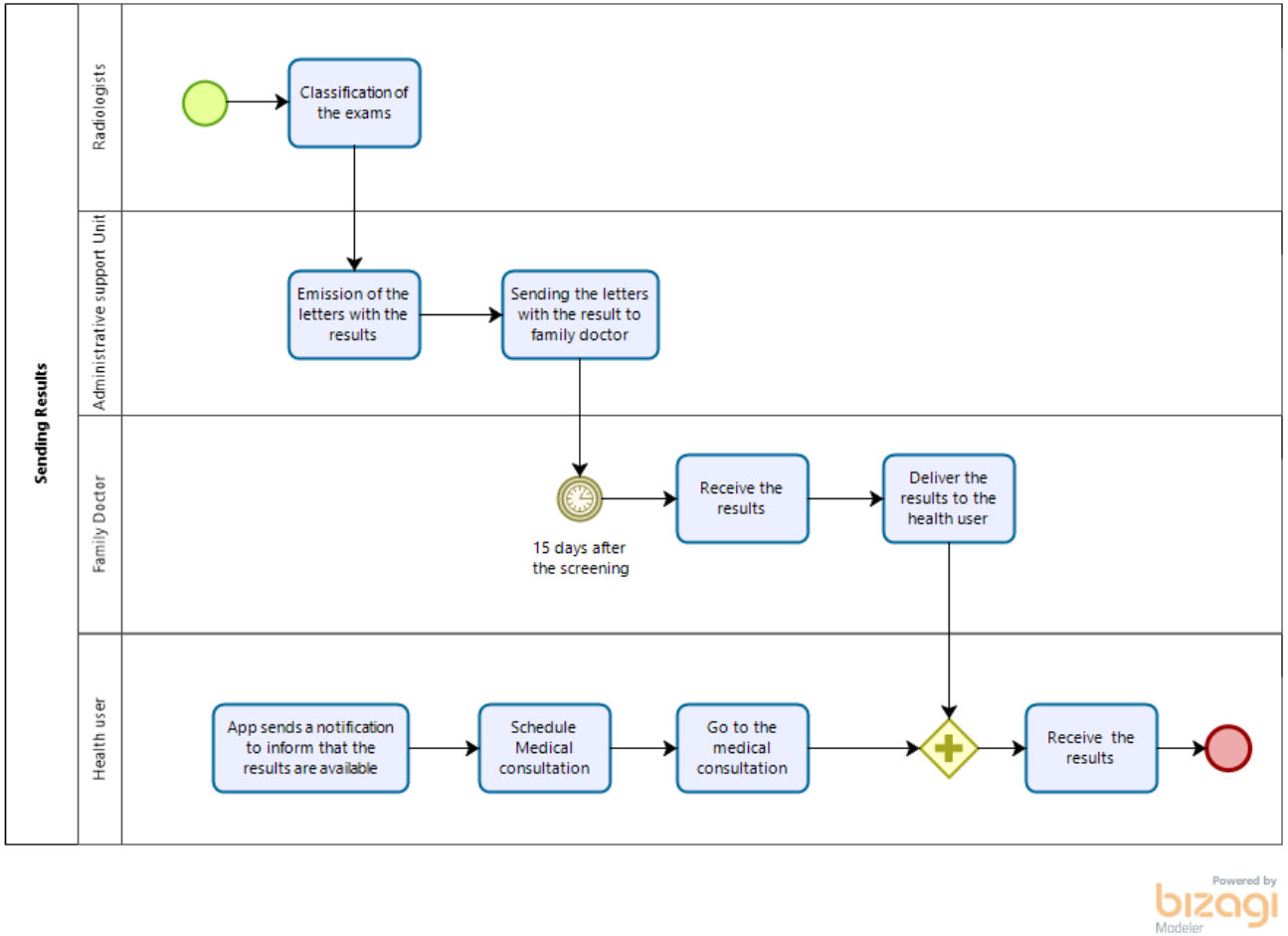

Figure 6.5 – Process "Sending Results" – TO-BE Diagram

7. VALIDATION

To validate the "TO-BE" diagrams, which included the proposed changes, four interviews were conducted with experts. These interviews included two members of the LPCC, the Dr. Fernando Lage, radiologist and technical director in the nuclei of the south of the LPCC, and Natércia Almeida, administrative technician of the check-up support unit of the LPCC. It also included a health user, Rita Teles Branco, who have participated four times in the organized screening performed by the nuclei of the south of the LPCC and Dr. Henrique Nabais, gynecologist and director of the gynecologist unit of the Champalimaud Foundation.

These experts were chosen due to their high expertise in breast cancer organized screening. Dr. Fernando and Natércia represents two different types of employees of the LPCC, bringing their explicit and tacit knowledge of the process; Rita represents the health users, the central actors of the process; and Dr. Henrique represents the doctors that follows the health users externally to the organized screening studied, bringing his experience in the area from his professional background.

These interviews were done separately and by the author through an online platform. Each interview started with an explanation of the main objective of the dissertation and the presentation of the "AS-IS" and "TO-BE" diagrams for each process identified. After this, four questions were made to the participants for them to answer according to their expertise, knowledge in public health and believes.

The four questions made were:

Q1. Do you agree with the proposed changes presented in the "TO-BE" diagrams? If not, which of the changes do you disagree with?

Q2. Do you believe that the proposed changes are sustainable/feasible? If not, which one of them do you consider unsustainable/unfeasible?

Q3. Do you have any suggestions for changes?

Q4. Would you support the implementation of these changes?

The interviews were recorded, transcribed and translated and a synthesis of the answers will be presented below.

Regarding Q1, the answers were:

Interviewee 1 (I1): I think that the psychologist should be earlier in the process. There was a time that we had a psychologist in the check-up consultation to give support to the health users but we concluded that the local support in the check-up was too late. I think it should be in the health centers. When the health users receive the information that they will need to go to the check-up consultation they get in panic. It's in that moment that the psychologist is important, not after, when they are already in front of the radiologists and they explain them what's going on, there they normally get calmer. The aspect of a previous support in the health center was sometimes important.

As for the more computerized part, it's for sure convenient to do it, whatever is possible to digitalize or computerized becomes more practical. However, there are some difficulties according to the respective health user. There are several people with more than 60 years that don't have any

informatic capacity or not even know how to write. Which would be a problem but would be solved locally with the help of the administrative technicians. In my view, that support of the administrative for the fill of the questionnaire would be important. Not necessarily the availability of the computer for the health user but the support of the administrative to fill it.

Sending an email to the health user becomes difficult because most of them don't have it.

The usage of artificial intelligence techniques is welcome but I think it won't be anytime soon.

Interviewee 2 (I2): I don't agree with the use of a data cleaning program, I think the excel does it and if someone program the excel for us to do it, it would be enough.

About the usage of the email, in Setubal and Lisbon yes but in some areas, where the network is weak it would not be possible. And in some places, such as the Alentejo where there is an elderly population with low education level and where sometimes they don't even know how to write it would not be possible. Although the age range for the screening is between 50 to 69 years old this question is still a reality. Another question that concerns me is if the invitation can be done through the email according to the general regulation on data protection (RGPD) rules. The message through the phone I think it's good because sometimes people don't answer the phone when I call them and after I send them a message they already answer.

The reminder message is interesting. A nice message/reminder in the day before of the screening is extremely interesting in the times we live. We live always running and with so much to manage and would be interesting.

The reminder message being signed by the family doctor is interesting but there is a question, some health users don't have family doctor so I would recommend that it was signed by the director of the health centers where they belong.

I agree with the arrangements with renowned brands. Very enjoyable and could be suitable with the place where the person lives as for example in Campo Maior could be offered a box with coffee. But useful things.

The artificial intelligence would benefit the health user. I think it's something to consider, it could value some issues that are not valued but it could also exacerbate in situations that automatically they see that are benign, such as calcifications. But I wonder whether the number of consensus meetings would increase.

The appointment with the psychologist, we used to have it in the past and honestly, I'm not sure if it would be better before or after. I have cases of people who tell me that they haven't slept in a week since they received our phone call and I know people who leave devastated from there. When we call to say that there is something that needs to be better evaluated, there are people who react to say that they have nothing, others to say that they are going to die and others that think that everything is fine. What I want to say is, imagine that I say "Then, if you want, you can have a consultation with a psychologist", what can this imply? That the health user questions that there is something serious after all, worse than she thought. If it is R3 we tell her that it is just doubts, if it is an R4 or R5 we already say that in fact there are changes that need to be revised. And this already makes them think that something is wrong, if I am going to talk about a consultation with a psychologist, they will think more

that something is wrong. I find it interesting because if you are nervous is good to be able to talk to the psychologist. Maybe talk about that chance only in the day of the check-up consultation.

The app would be interesting. Beneficial to the health user.

Interviewee 3 (I3): At a first sight there is nothing that I disagree with. There are things here that can be really good. Concerning the letter being signed by the family doctor, I think that the LPCC is already a very credible entity but if the reminder message it's complemented with the signature of the family doctor, it could reinforce the participation in the screenings, mostly in smaller communities where the family doctor has an increased weight because it's the doctor that we know better and we always turn to. However, I think that where it would be important that the family doctor was involved is in the invitation to the check-up consultation because the first time that the health user do the screening she doesn't know how the process is done and for example what does the classification R1 to R5 mean. I think it's important that from then on, the family doctor accompanies the process. The result must go to the family doctor and then the family doctor must accompany the health user.

Sending the remembering letter is something that I think that can be very important because I have the feeling, not only as a health user, that there are things that we forgot because of the speed that life takes nowadays and the number of things that we accumulate. I perceive in my community, which is a small community, that a considerable number of people do not go to the screening because they forget. They receive the letter some time before but doesn't remember anymore. In this way having a reminder is fantastic, great.

I think that the possibility of the R3 to R5 cases being analyzed first could be good, avoiding that the most severe cases being delayed. However, I think that I'm a little bit sceptic about these technics. I fear that there is any factor that could not be thought which transform a R3 into an R1, I don't know.

The psychology consultation, I confess that I don't know if it's too premature in the process. I think it's good it's existence but maybe not in the beginning of all of this. Let me tell you that I'm an oncology disease survivor, not from breast cancer, but I also have familiars that had breast cancer so I'm additionally a companion and I think that in this first phase we do the mammography, we get scared, but we have no time or desire to open the door for the psychologist. I think that this support is very important in the middle of the process, in the beginning or at the middle of the treatment. There yes, I think that knowing that this tool exists is good and helpful. But this soon I think no one will want it. The majority resorts to it when the cancer has returned.

The app I think is fantastic for those who are informed, but today a large part of the health users is still informatically excluded. It's good to have both options (fill the anamnesis online at home or locally). The health user who already has everything filled in goes immediately to the exam, otherwise, it's like today, it's filled in locally with the help of the administrative. Between screenings, there are situations that change, such as the question "do you have cases of breast cancer in your family?". The first time that I did the screening only my mother had it but the second time I did the screening my sister also had it. This update must always be done.

Interviewee 4 (I4): I think that these changes are very interesting. We need to think that the women that are screened are dynamic. What I mean is that the women that today are 50 years old, tomorrow are 60 years old, but the women that today are 30 years old, ten years from now are 40 and then 50

years old and will be screened, so I don't have any doubt that it should be mandatory to introduce here some facilities from the point of view of the computerization of this. So, the applications are essential because at a certain time it gets in the routine. If in a 60-year-old woman today, in the vast majority of them, it is not routine to use an application in all women aged 30, it is already part of the routine. Thus, we are preparing the way. Maybe this will not happen in the next year but we are preparing the way for five or ten years from now. This must happen. Therefore, I think it's good.

Adapting the contact medium to the health user's preference is generally more convincing. If you make a phone call inviting a woman to be screened it is usually easier to convince the person to go for screening or if it is by email, if that is the woman's preferred mean, it is usually easier if it is the way the woman prefers more. On the other hand, it is also certain that the woman received the invitation.

In terms of the psychologist I think it is fantastic. That option is the best, having the door open to the psychologist support.

The point "sending results" having an application that contains the report or at least something that says what was the result of the screening I think it would be interesting.

Considering Q2, the answers were:

I1: I think they are feasible but it's necessary that the administrative technicians of the screening have enough informatic training to align with the filling of the anamnesis to not appear with wrong information.

Concerning the execution of the reading of the exams, they are already done with a considerable speed, sometimes there are some delays but most of the times they are done 4 or 5 days after the mammography exam being performed. Nevertheless, a sustenance of the artificial intelligence not only would enable the selection of the cases and put them first in line to go to the reading and check-up consultation, but would also help us to not make errors because everything that calls our attention to any pathology that may pass without us notice it is good. Because sometimes these readings are 300 or 400 cases per session and gets a point where a person can fail and miss something. So, artificial intelligence is welcome.

I2: Data cleaning I'm not sure if it's viable in terms of cost but the rest I think that there is nothing I consider that would not be feasible. Artificial intelligence brings costs but I think that we would benefit from it. Everything that serves to improve participation of the health users I agree.

I3: I not only think they are feasible as I also think it's the way. And the proof of this is the current situation (Covid-19), which changed the world, the teleworking, tele-school and tele-consultations have started. I think that the digital and computerized part of everything is growing and we can't run from it. And we need to reinvent ourselves. I think it's feasible and recommended to do it. In rural areas, where there is an elderly population, having a phone to make calls is lucky. So, I think that it's important to always have a complement.

I4: The only question that it seems to me that would be a little bit more difficult is the availability of the psychologist. Because to have a psychologist is required an adequate space. It's something to think about. Not only to have a psychologist always available but also having a place that offers some privacy. But yes, I think that doing this consultation in the check-up consultation would be useful. Because in

the screening itself, whether we want to or not, most women don't go very anxious, they're anxious while doing the exam but it's in that moment, after she becomes calm. When she goes to the check-up consultation she already knows that something is not exactly how it was supposed to be. Therefore, I think that the invitation to the check-up causes anxiety to the women and in that way the psychologist consultation is appropriate in the moment of the check-up.

About Q3, the answers were:

I1: Regarding the process as currently is, the suggestions would be mostly technical improvement, essentially at the level of the mammography technique. Which means improving in the quality of the mammography of diagnosis and introduce the tomosynthesis because it's an advantage to correctly assess injuries and detect multicentricity and multifocality more easily than what is currently done.

Another aspect is having access to the entire panel of the hospitals in order to have feedback on what happens later with the users we refer to the hospitals to be treated. It is something that has not happened, many hospitals do not send the results.

I2: I would suggest not to only ask if the person wants to go to the psychologist consultation in the moment of the invitation to the check-up consultation. It could be talked about that possibility in the day of the screening and if the person needs to go to the check-up consultation she would already know that she had the right to it and that it is not because of the severity of its lesion.

What could be interesting in the app proposal is having a tablet in the entrance of the screening mobile unit where the health user could fill out her information's and when she got into the unit the administrative technician would confirm if it is filled or not. If it is already filled the administrative technician would only review the information with the health user otherwise she would help the health user to fill it. However, reducing the time of the administrative work would create stress to the technician team.

Another suggestion would be that the app was related with the reward system, like if the person install the app she would receive the gift. And that the app had a feedback system. Every step that the health user passes in the screening she would receive a message, smile or like. But in some automatic way that doesn't need that the professionals were always pressing a button.

I3: The suggestions that I have are that the family doctor call the health user to invite her to the check-up consultation and accompanied her since then. And that the psychologist consultation be later in the process. I think it's a waste do it in the proposed step.

I4: The suggestions that I have is related to the availability of the images of the exams through the app. Here I would discuss something with the radiologist that maybe it's not possible, I don't know, I don't know if, from an ethical point of view, it is acceptable but to have an application in which the images from the mammography exams were available. Why do I say this? Because nowadays the screening of the LPCC ranges from 50 to 69 years old. It's clear that with the increase in the average life expectancy of women (around 84 years old) many women undergo mammography after 69 years old and often do not have access to the images of previous exams. What would be important so that there is a possibility of comparison in the future. Because nowadays, despite the population-based screening that we owe to the LPCC, which is free and sometimes we don't even realize the enormous quality of this screening in Portugal, is excellent. However, what is certain is that it ends at 69 years old, it must end at some

age, but what is certain is that sometimes there is a woman aged 71/72 years old who are women who are very well with an excellent general condition and who continues to be screened because after all if a carcinoma is diagnosed it will be treated. Individually, obviously but in that way having the last images available at the end of the screening would be good. The availability of these images can also be an added value because the user may have the so-called interval cancer, the woman is screened every two years and after one year the woman may have a breast lump and needs to do an interval mammography that will not be done within the screening so if you have the images available it makes it easier.

Another suggestion would be using a tablet in the mobile unit to fill the anamnesis instead of a computer.

What we could done more is for example complement the application with more health features, like for example the national vaccination plan. An app that combines both primary and secondary prevention because it's with these types of prevention that we can reduce the mortality of severe diseases such as cancers, infections and others.

Concerning the last question, Q4, the answers were:

I1: I would support the implementation of the proposals that I mentioned that I agree with.

I2: Yes, I would support the implementation. I'm not sure about the costs but whatever is to improve I think it is good.

I3: Yes, I would support. I think it's the way. We need to rethink several things.

I4: Of course, yes. Whatever it is to innovate, innovate in this way. Especially because this innovation is interesting because it does not create a rupture. Of course, sometimes disruptions are interesting and important to happen. In this system that we currently have for screening, which works pretty well, what we want is to improve it. We already have a base structure that works relatively well, but we want to improve it. What is happening does not need a break, it just needs these changes and to think about the process and get better. I think it's very good, something that was thought out and that looks interesting. I think it can make everything a little easier, more economical, except the psychologist. That was interesting. I was thinking about volunteering but I'm afraid in this respect, do you know why? Because it is not just any psychologist who can support you at this stage, you must have some experience in the area because if not it will spoil more than help. The way to deal with this anxiety process must be well established.

8. DISCUSSION

In this section, it will be made an analysis of the improvements suggested, according to the answers obtained through the interviews performed in the validation phase and complemented with previous studies.

The validation phase focused on understanding the viability of the improvements suggested, their utility and the support that these changes in the process would have in the main actors and in public health in general.

Most of the proposed changes were accepted by the four interviewees, however some of them brought some questions, such as the proposal of the psychologist consultation. In this case, all the experts mentioned it as a good improvement, but the moment where it should happen was debatable. Being the purpose of this consultation to help and support the health users, the opinion of the health users should be considered and the interviewed one thinks that this consultation should only exist later in the process. Suggesting that it should happen only in the treatment because she fears that in the process of the screening the health users won't have the time or predisposition to open the door of the psychology support. However, according to Pineault (2007), it has been recorded demonstrations of anxiety at every steps of the screening, from the phase where the women receives the letter with the invitation to participate in the program to the waiting period, where they experience uncertainty feelings. It has been referred that offering social support by healthcare professionals reduces health users' anxiety, contributing to well-being by satisfying the person's needs for assistance and information (Pineault, 2007). When offered in an early stage, it helps preventing increased anxiety during later stages (Pineault, 2007). Knowing this, offering psychological support early in the organized screening program seems to facilitate the whole process.

The usage of the reminder message was considered a good asset by the interviewees, being this finding aligned with previous research such as those developed by Camilloni et al. (2013) and Duffy et al. (2017). As maximizing women participation is a goal of every screening program and impacts on its cost-effectiveness assessment, several studies have focused this issue. In this way, although the changes proposed in this dissertation were not implemented yet, some of them are already supported by other studies as is the case of this reminder calls which are considered as a way to improve breast cancer screening uptake and participation (Camilloni et al., 2013; Duffy, Myles, Maroni, & Mohammad, 2017).

It was mentioned that the participation of the family doctor in the invitation to the screening could reinforce the participation if it was in the reminder message. In some studies, was evidenced that the signature of the health user's general practitioner in the invitation letter is a good method to improve the participation in these programs (Camilloni et al., 2013; Duffy et al., 2017), what corroborates this idea. It was also suggested that instead of being signed by the family doctor, it could be signed by the director of the health center where the health user belongs, because some of them don't have a family doctor.

The interviewees evidenced a possible negative impact of many computerized proposals in health users, such as the introduction of an app or the use of email. This concern is because nowadays most of the health users covered by the screening still don't use applications routinely, and some of them

not even use the phone. But all the experts agreed on implementing these changes, while maintaining the traditional options for the health users with lower levels of digital literacy.

The artificial intelligence causes some doubts about the costs and if it's a closer possibility or not. But the experts mentioned that it would help and improve the process. Additionally, it was suggested that more than accelerate the process, AI could call the attention of the radiologists to lesions that could pass unnoticed, due to the number of exams to analyze in only one session. Some studies stated that, although the AI algorithm had performed worse than the highest-performing radiologists, the usage of this techniques might have an impact in the associated workload of the screening and even on the quality of the screening program (Sechopoulos & Mann, 2020). Also, it has been demonstrated that breast radiologists have higher diagnostic performances with support from AI systems compared with reading unaided (Rodríguez-Ruiz et al., 2019), confirming the experts' beliefs. In agreement with what was mentioned by the experts interviewed, Rodríguez-Ruiz et al. (2019) stated that AI systems has the potential to make radiologists' readings more efficient by improving the evaluation of equivocal cases and increasing their attention in the most suspicious examinations while reassuring them in faster readings of the least suspicious examinations. From the point of view of cost-effectiveness and considering the increased workload of the screening programs, the performance benefit of using AI support is additional higher by the fact that radiologists do not extend the reading time when using this system (Rodríguez-Ruiz et al., 2019). Previous studies refer that AI will have, in the near future, an important role in the evaluation of mammography exams, especially in the screening setting (Geras et al., 2019). All these evidences demonstrate the importance and relevance of the AI techniques in that field, supporting this suggestion and its implementation in the breast cancer organized screening program studied.

Concerning the viability of the changes suggested in this dissertation, everyone thought that they were feasible but that some need to be carefully implemented. The psychologist was indicated as possibly the most difficult to implement due to the availability of the psychologist, the required space and the experience that the professional needs to have.

Regarding the suggestions of the interviewees they were mostly related with the use of the app, having been suggested the usage of a tablet in the entrance of the mobile unit, instead of displaying a computer to fill the anamnesis form, and that this app could be complemented with other features. Another recommendation is the time that the psychologist consultation should be presented as an option and the step where it should be placed, which changed between the interviewees. Other suggestions were related with the mammography exam: (1) last mammography exam, within the breast cancer organized screening, available for example in the app, as a complement to future exams outside the organized screening; (2) tomosynthesis as complement to the mammography exam itself, to improve the detection of the lesions. This comes in agreement with what was mentioned before, in chapter 2.2.2, that the use of digital breast tomosynthesis as routine for screening programs is being discussed, however until now it's not routinely used in any screening program (IARC, 2016).

To conclude the validation phase, it was asked to all the interviewees if they would support the implementation of these proposals, to what all of them demonstrated support, confirming the relevance of this study.

9. CONCLUSION

In this work, was performed an analysis of the process of the breast cancer organized screening followed by the nuclei of the south of the LPCC and the research objectives, previously proposed, were achieved.

This study started with a research in three major subjects - breast cancer, oncology screenings and business process management - bringing support to the analysis of the breast cancer organized screening and the development of its respective “AS-IS” and “TO-BE” diagrams. These diagrams were later analyzed and validated through interviews with four experts.

This dissertation was developed with the purpose of improving the process of the detection of breast cancer, which is a disease with high incidence and mortality. The focus of this work was the breast cancer organized screening instead of the opportunistic one, considering its importance and features that the latter doesn’t demonstrate.

Both research questions were answered through an investigation in the field complemented with the available literature. RQ1: Which are the processes involved in the breast cancer screening in Portugal? This question was answered with the development of the “As-Is” diagrams, which correspond to the five principal processes of the breast cancer organized screening (1 - Health users’ invitation; 2 – Screening; 3 - Reading of the exam; 4 - Check-up consultation; 5 - Sending Results). The identification of these processes resulted from reunions with the LPCC, where the flowcharts of the process and its main documents were presented. Through the process of answering this question all the steps and actors involved were described to correctly define each process.

What brings us to the second research question. RQ2: What are the constraints of the breast cancer screening programs? The answer to this question also resulted from the meetings previously mentioned but, to properly answer it, a deep investigation in what happens in other breast cancer screening programs, both in Portugal and in the world, was required. The main constraints identified are the participation rate in this type of programs (poor information about the topic and anxiety felt in the process are some of the reasons for the health users to don’t participate), the time the process takes and its efficiency (considering the treatment of the health users’ data and the process for the mammography evaluation).

The program developed by the LPCC is a well stablished process which already proved its value, nevertheless there is a place for improvements. Through this study, and the development of the “AS-IS” diagrams, it was possible to detect some points that could be changed to reduce the time of the process, the effectiveness of it, or even to improve the comfort of the health user. The presentation of the “TO-BE” diagrams in the validation interviews mapped the value of these suggestions.

In summary, process modelling was important to clearly understand the mainly actors of breast cancer screening and review the entire process in order to correctly identify the breaking points and struggles within it.

9.1. LIMITATIONS

There are three main limitations of this study that should be considered. First, the validation group for the new diagrams was composed by a small number of experts. However, in a way to reduce this constraint it was performed individual interviews which offers more insights into an interviewee's personal thoughts, beliefs and point of views and the people interviewed were selected due to their expertise and relation to the theme, impacting in different areas of the process. This gives us a complete overview of the impact of the proposals in the whole process.

The second limitation identified is that as best as the proposals may seem, only after its implementation and an experience period, it would be possible to completely understand its feasibility and impact in the process itself, and as ultimately its impact in the screening of the breast cancer. Nevertheless, this could not be done in the scope of this master's thesis due to the short period available and may be addressed by future empirical research.

Finally, it is not possible to incorporate the change of the mammography exam to another exam since it's a decision with legal impacts, which needs to be supported by additional research. Thus, despite existing studies in the field, it was not possible to incorporate it in the "TO-BE" diagrams of this dissertation.

9.2. RECOMMENDATIONS FOR FUTURE WORKS

As future work we suggest that the diagrams should be evaluated by a bigger group, and possibly through a focus group meeting. This would promote discussion about the proposal improvements, it's strengthens and weaknesses, but it would also stimulate the proposal of new ideas and the discover of other hidden problems. Also, to completely understand the usability that the psychologist consultation would have for the health users, and in which step it should exist, more health users should be interviewed.

Secondly, as previously mentioned, and due to the lack of time associated with this master's thesis, the implementation of the new diagrams proposed was not possible. In this way, as future work we suggest to try to implement these new processes and evaluate its impact in the process and in the detection of the breast cancer.

There is one idea mentioned by Bobridge et al. (2017), which was not applied in this research, also due to time constraints and complexity, nevertheless it could be a way to improve the participation in the breast cancer organized screening, while improving the participation in other oncology organized screening programs. This consists in the use of a "one stop" screening shop, which means that different types of oncology screenings would be delivered at the same time and location (Bobridge, Price, Gill, & Taylor, 2017). In this way, we suggest as future work the use of a questionnaire to understand the impact of this idea and possibly implement it.

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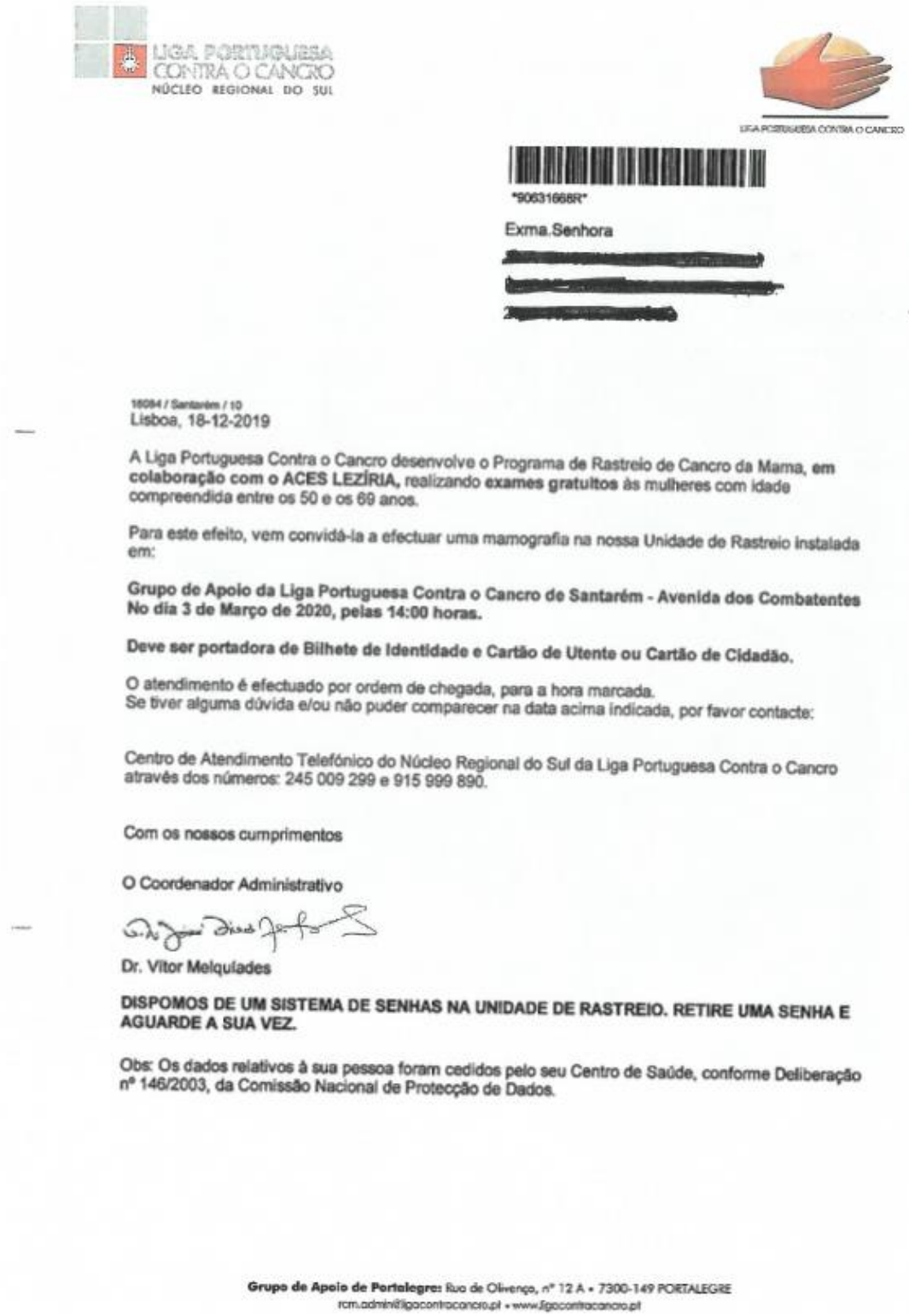
ANNEXES

Annex I – Invitation letter



LIGA PORTUGUESA CONTRA O CANCRO
NÚCLEO REGIONAL DO SUL

LIGA PORTUGUESA CONTRA O CANCRO

90631668R

Exma.Senhora
[redacted]

16084 / Santarém / 10
Lisboa, 18-12-2019

A Liga Portuguesa Contra o Cancro desenvolve o Programa de Rastreio de Cancro da Mama, **em colaboração com o ACES LEZÍRIA,** realizando **exames gratuitos** às mulheres com idade compreendida entre os 50 e os 69 anos.

Para este efeito, vem convidá-la a efectuar uma mamografia na nossa Unidade de Rastreio instalada em:

Grupo de Apoio da Liga Portuguesa Contra o Cancro de Santarém - Avenida dos Combatentes No dia 3 de Março de 2020, pelas 14:00 horas.

Deve ser portadora de Bilhete de Identidade e Cartão de Utente ou Cartão de Cidadão.

O atendimento é efectuado por ordem de chegada, para a hora marcada.
Se tiver alguma dúvida e/ou não puder comparecer na data acima indicada, por favor contacte:

Centro de Atendimento Telefónico do Núcleo Regional do Sul da Liga Portuguesa Contra o Cancro através dos números: 245 009 299 e 915 999 890.

Com os nossos cumprimentos

O Coordenador Administrativo

Dr. Vítor Melquíades

DISPOMOS DE UM SISTEMA DE SENHAS NA UNIDADE DE RASTREIO. RETIRE UMA SENHA E AGUARDE A SUA VEZ.

Obs: Os dados relativos à sua pessoa foram cedidos pelo seu Centro de Saúde, conforme Deliberação nº 146/2003, da Comissão Nacional de Protecção de Dados.

Grupo de Apoio de Portalegre: Rua de Olivença, nº 12 A • 7300-149 PORTALEGRE
rcm.admin@ligacontracancro.pt • www.ligacontracancro.pt

Annex II – Anamnesis form

Programa de Rastreio de Cancro da Mama

Concelho _____ Nº Rastreio_____

Nome _____

Data Nascimento: ___/___/____

Cartão de Utente nº_____ B.I/Cartão Cidadão nº _____

Naturalidade: _____

Morada _____

Freguesia: _____ Concelho: _____ Distrito:_____

Cód.Postal:____ _____

Unidade Saúde:_____ Processo Clínico:_____ Méd.Família: _____

Contactos _____/_____

ANAMNESE

Menarca ____ Menopausa ___ THS: Nunca Fez ___ Faz – 1 ano ___ Faz + 1 ano___ Faz + 5 anos___ Já Fez ___

Gravidez : Sim ___ Não ___ Nº Gravidezes ____ 1ª ____ Amamentou: _____ Anovulatórios:__ ___

Cancro da Mama em Familiares: Sim ___ Não ___ Quem _____

Doenças Mamárias: Não ____ Sim _____ - _____

Operações à mama: _____

Mamografias: Não ___ Sim ____ Exame clínico: Não___ Sim___ Auto-exame: Não ___ Sim ___

Dor: Não ___ Sim ___ ; Aumento: Não ___ Sim ___ ; Nódulos: Não ___ Sim ___; R.Mamária: Não ___ Sim___

Modificação da Pele: Não ___ Sim ___

A Administrativa _____

A Técnica Radiologia _____

OBSERVAÇÕES: _____

_____

Data : ___/___/____