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Process Modelling (BPM) in Healthcare – Breast Cancer Screening

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Abstract. Breast cancer is a malignant epithelial neoplasm and it is a public health problem that has high incidence and mortality in women. Focusing the clinical performance on processes is proving to be the way to improve morbidity and mortality statistics. Business process management (BPM) is a management field that improves and analyzes business processes according to organizations' strategies. 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. BPM usage will enable optimize and manage all processes from the screening until the diagnosis and treatment. The aim of this study is identification and modelling of BPM processes for the healthcare sector, namely, for Portuguese organized breast cancer screening. To achieve this goal, it was required the identification of the main processes by an interview to the employees and the development of "As-Is" diagrams. Some of the problems in a macroscopic way were detected and improvement suggestions were made.

Keywords: Business Process Management, Oncology, Frameworks.

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 [1]–[3]. 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 [4].

Breast cancer is a malignant epithelial neoplasm, characterized by an uncontrolled growth of the abnormal breast cells with metastasis capacity [5]. The early diagnosis of breast cancer is of great importance since the detection of small tumors or tumors in evolutionary phase non-invasive, will enable treatments less mutilating, with more conservative surgeries and a longer disease-free survival [5]. Oncology screenings allow earlier diagnosis of the disease and aims the reduction of cancers' mortality [6]. Any screening program is dependent of a sequence of interventions, beginning in the identification of the target population until the post treatment [6].

Business process management (BPM) is a management field characterized for being a well-designed, implemented, executed, integrated, monitored and controlled approach, that improves and analyses business processes according to organizations' strategies [7], [8]. A business process is composed by structured and interconnected activities, which produce a service or product focused in the client's needs [8].

Targeting optimal patient outcomes is the aim of health service delivery. However, focusing the clinical performance on processes is proving to be the way to improve morbidity and mortality statistics [7].

Although the application of BPM techniques has been increasing in the healthcare sector, there are still some failures due to improper adoption of BPM and because of content and structural issues present in the health care sector [7]. BPM principles may be applied in hospitals, in primary care and public health [7].

With the current widespread of technology and its importance in several different areas, its usage in the diagnosis and treatment of oncology diseases can be an important feature to improve the quality and the implementation of preventive and screening actions. Organized screening programs, with all elements properly prepared, revealed to be more efficient than the opportunistic screenings (non-organized and unmonitored) [6]. It's here that BPM gets its importance since with this technique it will be possible to optimize and manage all processes from the screening until the diagnosis and treatment.

The goal of this paper is the identification and modelling of BPM processes for the healthcare sector, more precisely, processes for the breast cancer screening, by:

- Identification of the AS-IS model for the processes of the screening of breast cancer, according to the Portuguese League Against Cancer (LPCC);
- Description of each activity present in the process and the role of each stakeholder;
- Identification of bottlenecks and problems;
- Proposal of process improvements considering the available information and AS-IS model analysis.

The structure of the paper is as follows: Literature Review, Methodology, Critical analysis, Conclusion and Future Work.

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 [9]. 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 [9], [10]. 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 [9]–[11]. The tumor can be classified as benign or malign according to its features [9]–[11]. 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 [9], [10]. 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 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 [3], [10]. Breast cancer is one of the most treatable types of cancer when early detected [2].

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 [3]. The principal elements of secondary prevention are screening and early clinical diagnosis and they are essential components of any cancer control program [3].

Screening programs can enable the detection of cancer in earlier stages which allow the usage of suitable treatment [3]. The implementation of these programs has as expected outcome the decrease of mortality rates [12].

There are two types of screening programs, being classified as organized, also called population-based, or opportunistic screening programs. Organized screening programs are at national or reginal level, have a team responsible for health care and organization, 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) [3]. Population-based screenings reach women who haven't participated in opportunistic screening and are the programs that enable more equity in access, guaranteeing that all women including those from lower socioeconomic groups obtain adequate diagnosis and treatment [3], [13]. However, it doesn't completely eliminate social inequalities access [3], [12].

Breast Cancer Organized Screening

Since the late 1980s, with the results of the effectiveness of the trials on breast cancer screening becoming available, that its programs have been in place in Europe [12]. The council recommendation of December 2nd, 2003, at European Union level, stab-

lished a list of requirements to implement an organized, population-based breast cancer screening program [12].

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 [1]. 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 [3]. A decrease on the breast cancer mortality in women aged 50 to 74 years has been shown [1].

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 [3]. 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 [11]. From all the breast cancers detected by mammography screening, less than one third would also be detectable by clinical examination [3]. Normally, in the screening programs, the mammography involves two views (X-ray images) of each breast and double reading [11]. With this technique it is possible the early detection of malignant tumours before the tumour spreads [11].

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 [1], [11], [14]. 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 [11].

Challenges for breast Cancer Organized screening.

Although mammography continues to be the gold standard of the screening methods [14], it has some limitations. Nowadays, research and discussions moved on to the use of digital breast tomosynthesis as routine for screening programs but until now no screening program has changed to routinely use it [3]. Digital breast tomosynthesis produces quasi three-dimensional images, reducing the effect of tissue superimposition, which allows better visualization and localization of potential lesions, improving mammography interpretation [3]. It improves the rate of cancer detection and reduce the proportion of patients' recall for additional imaging studies [15]. 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 [3].

Another studies have shown that breast ultrasonography and breast Magnetic Resonance Imaging (MRI) are the best alternatives for mammography and may improve the breast cancer prognosis [16]. 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. Ultrasonography-only detected cancers were usually early-stage cancers, comparable or even in earlier stages than cancers detected through mammography [3]. Breast MRI have been proving to be a good alternative to mammography since it doesn't involve radia-

tion exposure however, its specificity is too low and the interpretation is complex and not standardized, being recommended only for screening of high-risk women [16].

Molecular diagnostics are revolutionizing human oncology in order to enable early detection, target therapies or monitoring treatment [17]. Liquid biopsies, through the identification of genetic signatures associated with cancers, allow the detection of tumours in preclinical stages [17], [18].

In order to early and accurately identify the breast cancer it's important and needed the extraction of information from previous diagnosis data [9], [10]. Since machine learning techniques enable computers to learn from past data and patterns its usage in medical diagnosis is gradually increasing [10]. Computer-aided diagnosis systems are being proposed since it helps reducing the number of unnecessary breast biopsies [11]. As concluded by Mušić et Gabeljić [19], the use of neural network to classify mammographic tumors is beneficial 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) 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 5 regional nuclei: Azores, Centre, Madeira, North and South [20].

The LPCC is known as a reference organization in breast population-based screening program. LPCC screening activities are implemented in all geographic regions, excluding Algarve [21]. Their action is supported in protocols with Governmental Regional Health Administrations (North, Center, Lisbon and Tagus Valley, Alentejo) under the Ministry of Health.

In this paper the breast cancer screening process provided by the LPCC nuclei of the south will be used as a case study.

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 [22].

When starting a BPM initiative, the first question that needs to be clarified should be: "Which business processes do we aim to improve?" [23]. Before applying BPM, the team needs to have an idea of what business processes may be causing the problems [23]. Considering this, it's important to start the BPM practices by describing the processes of the organization, building "AS-IS" models, and analysing them according to the organization's data and the knowledge of its employees [24]. A critical step in BPM is understand the value delivered by a process, by measuring it with process performance measures. There are four fundamental measurements [23], [25]:

- Time – Associated with process duration.
- Cost – Value associated with a process, which is typically a monetary value;

- Capacity – Amount or volume of a realistic output related to a process;
- Quality – Normally expressed as a percentage of actual to optimal.

With the previous analysis, an understanding of the issues in the process and the potential solutions can help prepare an improved process model, the "TO-BE" model [23], [24].

3 Methodology

3.1 Identification of processes

The existing processes for Breast Cancer Organized Screening performed by LPCC were studied. In order to completely understand the processes an interview was done to the employees.

Table 1. Identified processes of the Breast Cancer Organized Screening

Number	Name	Type
1	Patients' invitation	Process
2	Screening	Process
3	Reading of the exam	Process
3.1	Sending Results	Sub-process
3.2	Check-up consultation	Sub-process
4	Sending Results	Process
5	Check-up consultation	Process

3.2 Recognition of entities

Within a business process, there are several organizational entities that can interact with each other. To analyse and transform a process, it's necessary to completely understand what are the entities present and their relationship.

The entities can be:

- Actors - people that perform the activities in the process;
- Systems - software used by the actors to perform their functions and to communicate with various stakeholders;
- Documents - methods used by the actors to share information that can be digital or non-digital documents.

Table 2. Identified actors of the Breast Cancer Organized Screening

Actor	Description
Administrative Technician	Person who gives administrative support for all the process
Radiologist Technician	Person who is responsible for the screening exam
Radiologist	Person who is responsible for reading the exam and classify it

Family Doctor	Person who will receive the letter with the screening result to deliver to the patient
Patient	Person submitted to the screening process

Table 3. Identified systems of the Breast Cancer Organized Screening

System	Description
SIRCM	Informatic system that monitors every activity in the screening program
Post mail	System used to send the invitation letters
Telephone	System used to re-invite eligible women for screening
Microsoft Excel	Database of patients' information

Table 4. Identified documents of the Breast Cancer Organized Screening

Document	Description
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 (15 days before screening)
Exam	It is a digital document with the exam
Letter with the result	Letter sent to family doctor with the screening result
Anamnesis	Printed form filled by the patient with personal information and relevant questions for the screening

3.3 Design of Diagrams

Modelling processes helps understand the process and share this understanding with the people involved in it while identifying and preventing issues. In this work, Bizagi will be used as software to develop the diagrams.

Macroprocess

The macroprocess is presented in Fig.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.

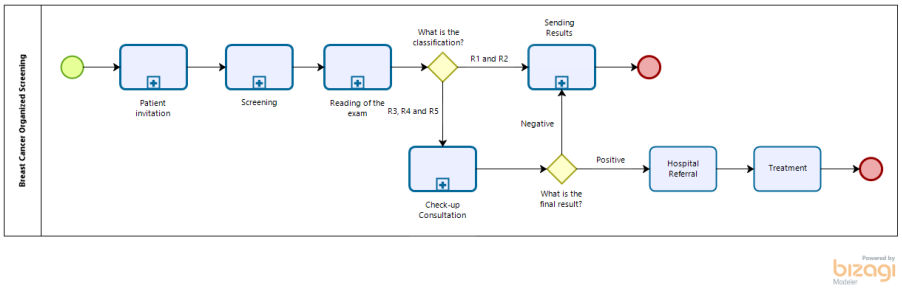

Fig. 1. Macroprocess for the Breast Cancer Organized Screening

Process "Patients' invitation"

The process "Patients' invitation" is performed by the administrative support unit which uses data provided by the ACES. The patients' database is sent as a Microsoft excel sheet and all that information is imported to the server SIRCM.

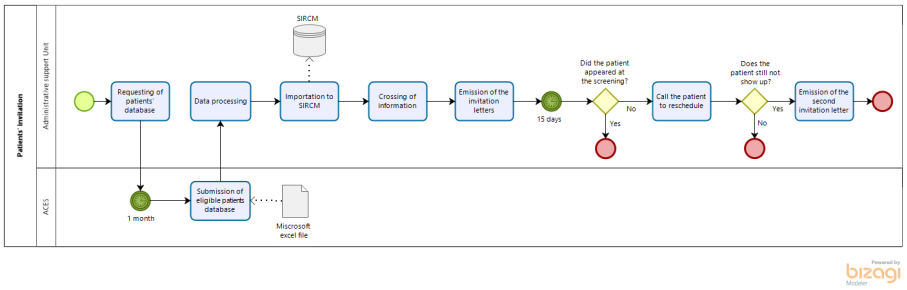

Fig. 2. Process "Patients' invitation"

Process "Screening"

The process "Screening" is performed by an administrative technician and two radiologist technicians to an eligible woman which is called as patient. In this process there is one important document, the anamnesis that must be filled out by the patient every time she is screened.

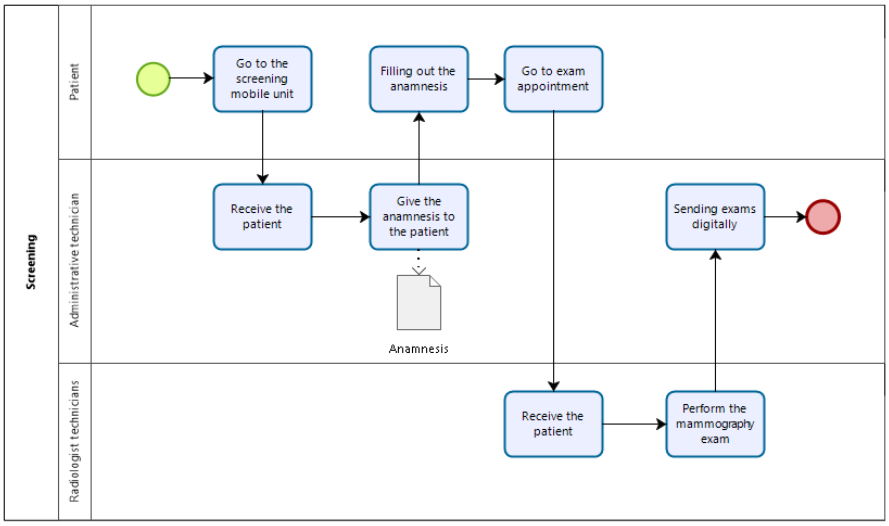

Fig. 3. Process "Screening"

Process "Reading of the exam"

The process "Reading of the exam" 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.

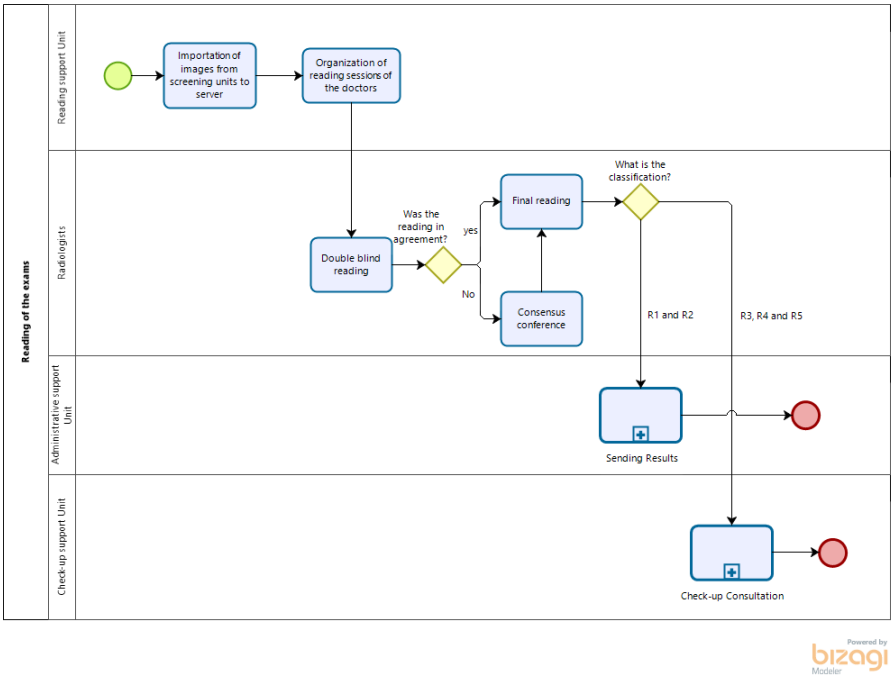

Fig. 4. Process "Reading of the exam"

Process "Check-up Consultation"

The process "Check-up consultation" is performed by the check-up support unit and the doctors to the patient.

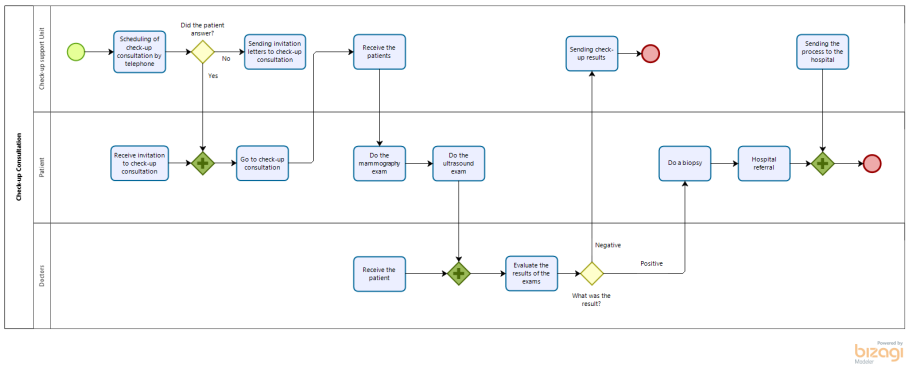

Fig. 5. Process "Check-up Consultation"

Process "Sending Results"

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

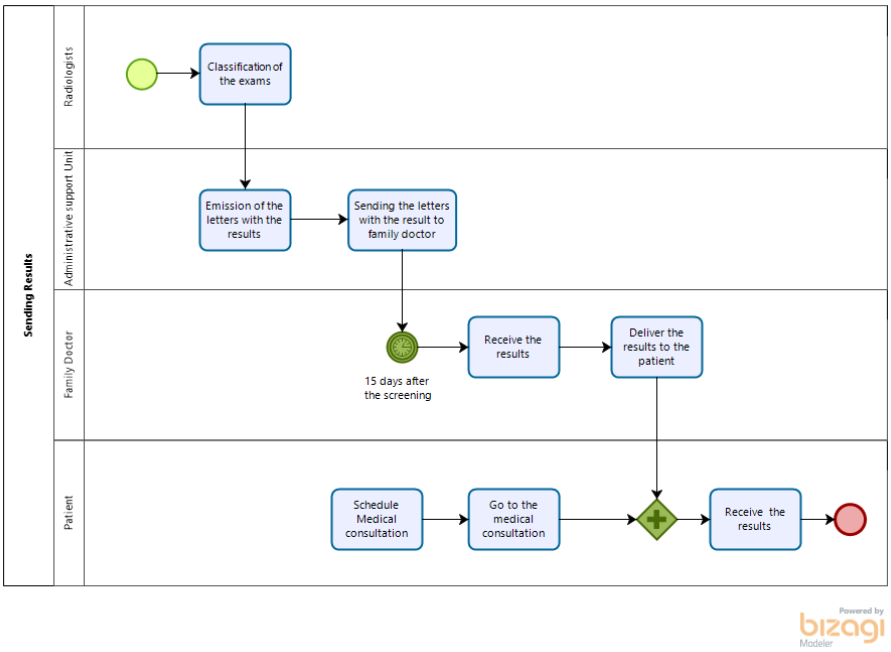

Fig. 6. Process "Sending Results"

4 Critical Analysis

Before updating a process is required a shared understanding of the current state of the process and if it's in agreement with the stated organization's objectives or not. This is achieved by process analysis [25].

The Breast Cancer Organized Screening under study follows the recommendation for the European countries, being well stablished the processes involved. However, breast cancer mortality rates can still be decreased, being an opportunity field to improve.

In the mainly important processes identified some critical analysis and improvements can be done as for example:

- In the process "Patients' invitation" an invitation letter is sent 15 days earlier to the patient but no telephone contact is done before the screening. The patient is only contacted by telephone if she didn't appear in the day of the screening. An improvement could be sending a message in the day before the screening, remembering the appointment, avoiding forgetfulness absences.

- In the process "Screening" the anamnesis is a printed form but it will be required in the process "Reading of the exams" where the radiologist will combine it with the mammography exams and previous information. The form could be changed into a digital format improving the file organization and crossing of information.
- In the process "Reading of the exam" it is necessary to combine the schedules of the five radiologists to organize the consensus conference what can delay the answering time. This time could be decreased using machine learning techniques to complement the evaluations in case of disagreement in the reading of the exam.
- Another aspect that could improve the time that all the process of Breast Cancer Organized Screening takes is the process that follows a classification higher than R3 in the exams. Currently classifications between R3 and R5 follows the same procedure however, knowing that R5 corresponds to a strong suspicious of cancer and that breast cancers can evolve quickly probably this type of classification should have priority or should do a biopsy already in the check-up consultation.

5 Conclusion

This is a positioning paper, where the mainly processes involved in the breast cancer organized screening with the appropriate entities (actors, systems and documents) were identified and modelled as "As-Is" diagrams. Some of the problems in a macroscopic way were detected and improvement suggestions were made in order to optimize the process and achieve the main objective of the process, the early detection of breast cancer.

6 Future Work

In future work a more detailed analysis will be performed in order to completely understand underlying issues and to allow the construction of high relevant "To-Be" models that could bring more efficiency to the screening processes.

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