CANCER DIAGNOSTIC DELAY REDUCTION

Disclaimer

This case study shows the application of process mining as an analysis method to analyze *process flows* in a healthcare environment. *It does not make any medical claims.*

Summary

The IT Service team of the university hospital Universitario Lucus Augusti (HULA) is leading a digitalization project to avoid the use of classic paper processing in our three regional hospitals (1,200 beds), covering a population of 300,000 persons.

This Zero-Paper project is a strategic action for our regional Health Care system (Galicia - NW Spain), aiming to integrate all the patient information in a unique access point, avoiding mistakes, administrative paperwork and duplicates. The project, while improving security and the treatment of patients and professionals, will help to decrease healthcare cost by reducing inefficiencies. This project will be extended to all public hospitals in our region and is EU funded. It covers scanning old patient files when needed and incorporating them into the corporate electronic Electronic Health Record (EHR), called IANUS.

Nevertheless, besides clinical information, in our organization there are still plenty of classic paper process documents (administrative, test requests, etc.). It was necessary to introduce a whole new system to create electronic documents for communication between professionals, to give to patients, and for other clinical or administrative tasks.

- **Process mining case study in Healthcare**
- **Revealed bottlenecks that can lead to faster cancer diagnosis**
- **Key success factor was the simplification of the complex data**

This system, called Escriba, allows to create smart forms to authorize or deny tests, based on algorithms with medical or organizational criteria. More than 730 different forms are being used in our hospitals.

Within Escriba (see a screenshot in Figure 1), petitions can be electronically signed, saved, and traced (e.g., asking for a radiology test, informed consent, and others). Until now, more than 1,500,000 documents were done electronically. We saved more than 6,000,000 paper sheets with this project.

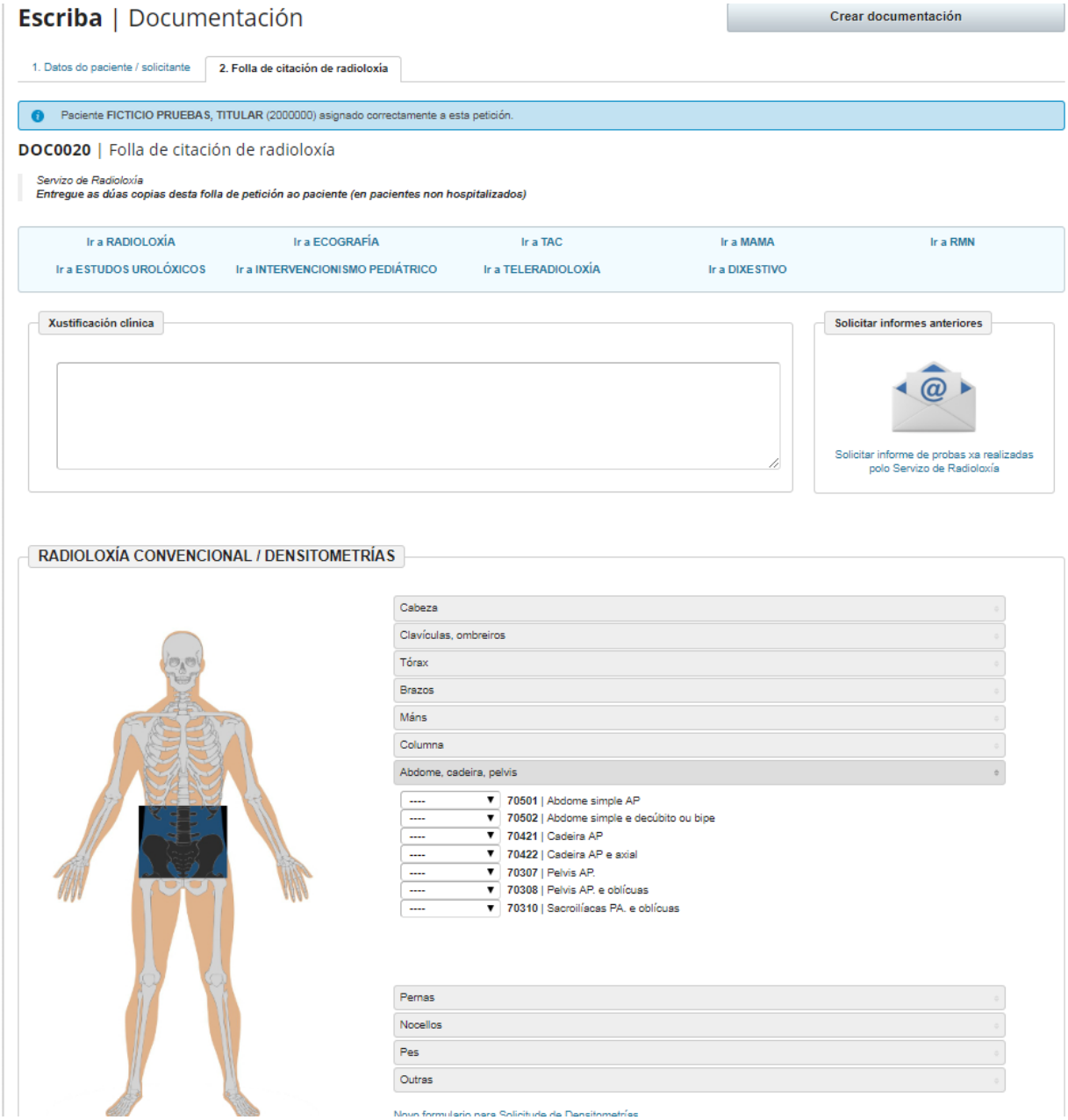

Figure 1: Escriba Smart Forms System

Trying to mimic a classic paper process in an electronic system is constantly revealing inefficiencies, mistakes, and untraceable processes. Such inefficiencies and mistakes can result

in potential quality and security problems for patients and professionals (non-standardized protocols, unknown actions, lost papers, etc.) as well as treatment delays.

However, by revealing these problems, we have a huge opportunity for improvement. Therefore, the IT Department decided to use process mining techniques to analyze the hospital processes in order to improve them. The hospital's management team agreed on the potential of process mining but, as a large organization with millions of different processes, they considered it essential to carefully prioritize where to start.

We decided to study the so called 'Fast Paths' as a proof of concept to show how process mining tools can be applied in a hospital environment. In the Galician public healthcare system there are priority lanes - Fast Paths - for some types of cancer and other acute diseases, which establish strict referral protocols between Primary Care physicians and hospitals, and faster tests and treatments than other, less urgent diseases. For example, fast referrals from Primary Care practitioners to oncologists at the hospital are in place for diseases like breast cancer, prostate cancer, colon cancer, and others. By law, there are also maximum treatment times defined.

As these types of diseases respond well to early treatment, it is crucial to analyze if patients are really following the theoretical path for treatment or not.

We have identified 250 patients eligible to those Fast Paths. For 46 of these patients we studied their paths into our hospital using the process mining software Disco. The focus of this study has purely been the analysis of the process flows for these patients (not any medical aspects) and it serves as an example of how process mining can be used in conjunction with clinical research to improve healthcare processes.

Using process mining, we have been able to find bottlenecks in our hospital and identify the real paths that patients follow. The goal is to use this knowledge to take actions that will improve processes and reduce treatment times, which ultimately may increase patient survival.

"Process mining can help identify points of improvement in the care process, as well as help establish adequate strategies for early diagnosis."

-DAVID BALTAR BOILÈVE, HOSPITAL UNIVERSITARIO LUCUS AUGUSTI

Organization

HULA is a 900-bed public hospital. It is the main healthcare center of the 300,000 inhabitants' province of Lugo in the Northwestern Spanish region Galicia. Two other hospitals (150 beds each) in the province are depending on HULA as a main center.

The hospital's management is strongly process-oriented. They have promoted a project called Hermes that aims to improve coordination between primary care and hospitals, and to reduce waiting times. The Hermes project gives the guidelines to refer patients to the hospital, standardize emergency referrals, specialists' consultation appointments, and fast

paths (see Figure 2). For example, the green box ‘Derivación por Via Rápida’ refers to the Fast Path route.

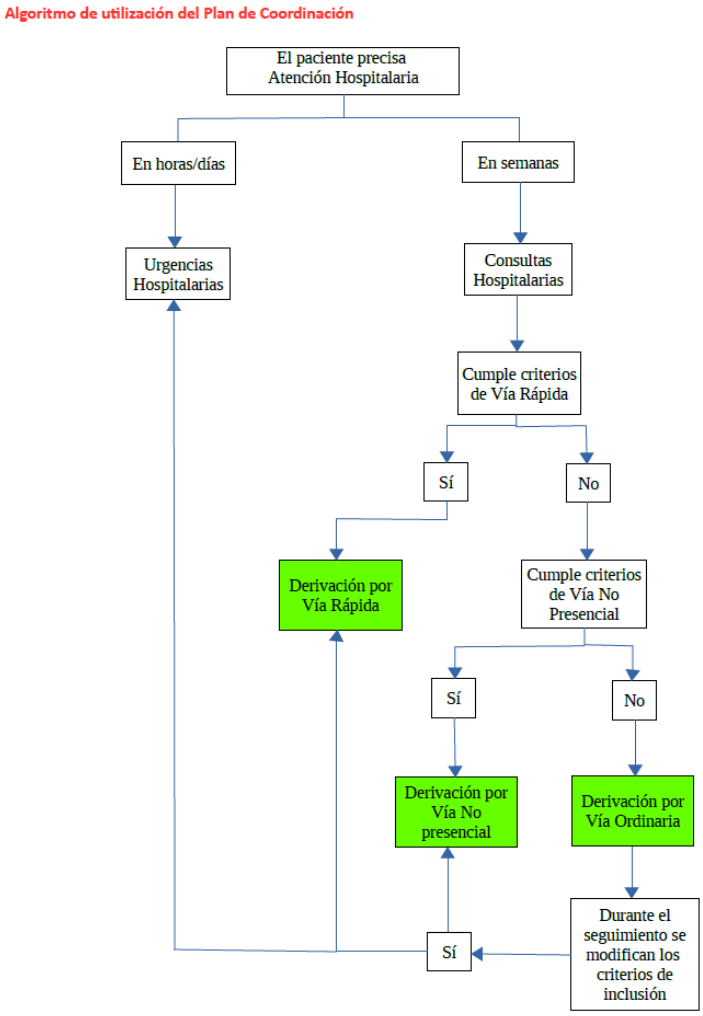

Figure 2: Hermes Coordination Plan (HULA)

Although the hospital’s management team is data-oriented and, for example, deploys Business Intelligence (BI) dashboards for the monitoring of important process characteristics, process mining techniques were completely unknown inside the organization. So, our process mining approach for this project was totally new for the doctors and other medical professionals.

The application of process mining in the public healthcare domain can have the following objectives:

- Improving *processes* within the hospital services (Reduction of costs, redistribution of limited resources),
- Improving *patient care quality* (time reduction, bottleneck analysis, reduced errors, diagnosis and treatment flow improvements).

Departments like Radiology, Oncology, Cardiology and Emergencies at HULA have shown great interest in applying process mining techniques to give the best possible quality healthcare.

Process

The Hermes project's main point is to define how to prioritize diseases according to their importance, indicating when a doctor must refer the patient to Emergencies, the Fast Path, or to an ordinary consultation.

With process mining, we have analyzed the patient journey of some cancer patients[1] to learn why some patients were not going through the Fast Path to receive treatment. The purpose of this study is to analyze whether the Fast Paths are working efficiently and to find possible problems in the circuit taken by patients that do not follow this ideal path.

According to [1], Clinical Guidelines aim to improve the quality of care processes through well-established procedures. See Figure 3 for an example of the medical procedure for a suspect of breast cancer. Despite those standards, medical processes must be flexible enough to be adapted to different patients' needs.

On the other hand, organizational processes provide an administrative framework for processes like referrals from the general practitioner to specialists, allowing (or not allowing) specific tests, referrals between specialists, etc. This is covered by the Hermes project and Escriba. These processes must be clear and they must cover all the possibilities of the flexible medical process, but without loosing the "priority lane". See Figure 4 for the admission criteria to the Fast Path in breast cancer as an example.

We have found that the hospital's administrative processes are too rigid to support medical process variability. With our process mining analysis, we have shown that if the administrative process fails and the patient loses their "Fast Lane", clinical guidelines will not work correctly. Referral maximum times will be exceeded and patients will be treated at critical stages of their cancer. Therefore, we will have less survival and highly increased costs.

Process mining can help identify points of improvement in the care process, as well as help establish adequate strategies for early access to a Fast Path. We have used process mining to find out the real paths and to analyze where they were different from the ideal path (i.e., the fast track, or de jure model).

Data

Every patient that is treated in the hospital, their pathologies, and the related procedures are codified in databases according to the harmonized classification ICD 9 and 10 at their departure.

To identify patients for the study, we performed searches in the hospital's databases for patients diagnosed with the target pathologies. We then extracted data about the process steps that

[1] Note that one advantage of process mining as an analysis method is that it focuses purely on the process flow perspective and, therefore, all confidential patient data can either be left out completely or anonymized [2].

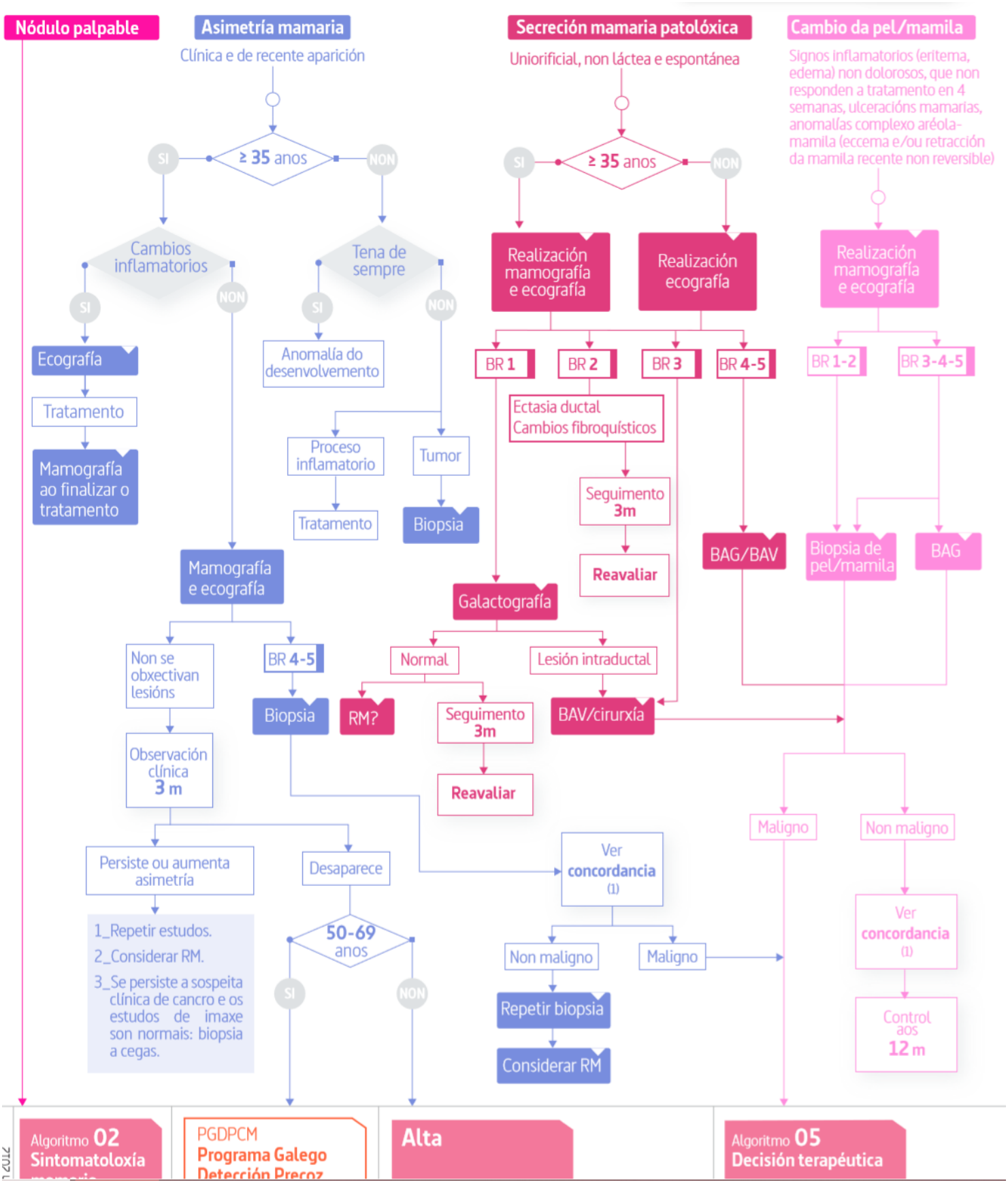

Figure 3: Example of medical procedure for suspect of breast cancer (Servicio Galego de Saude)

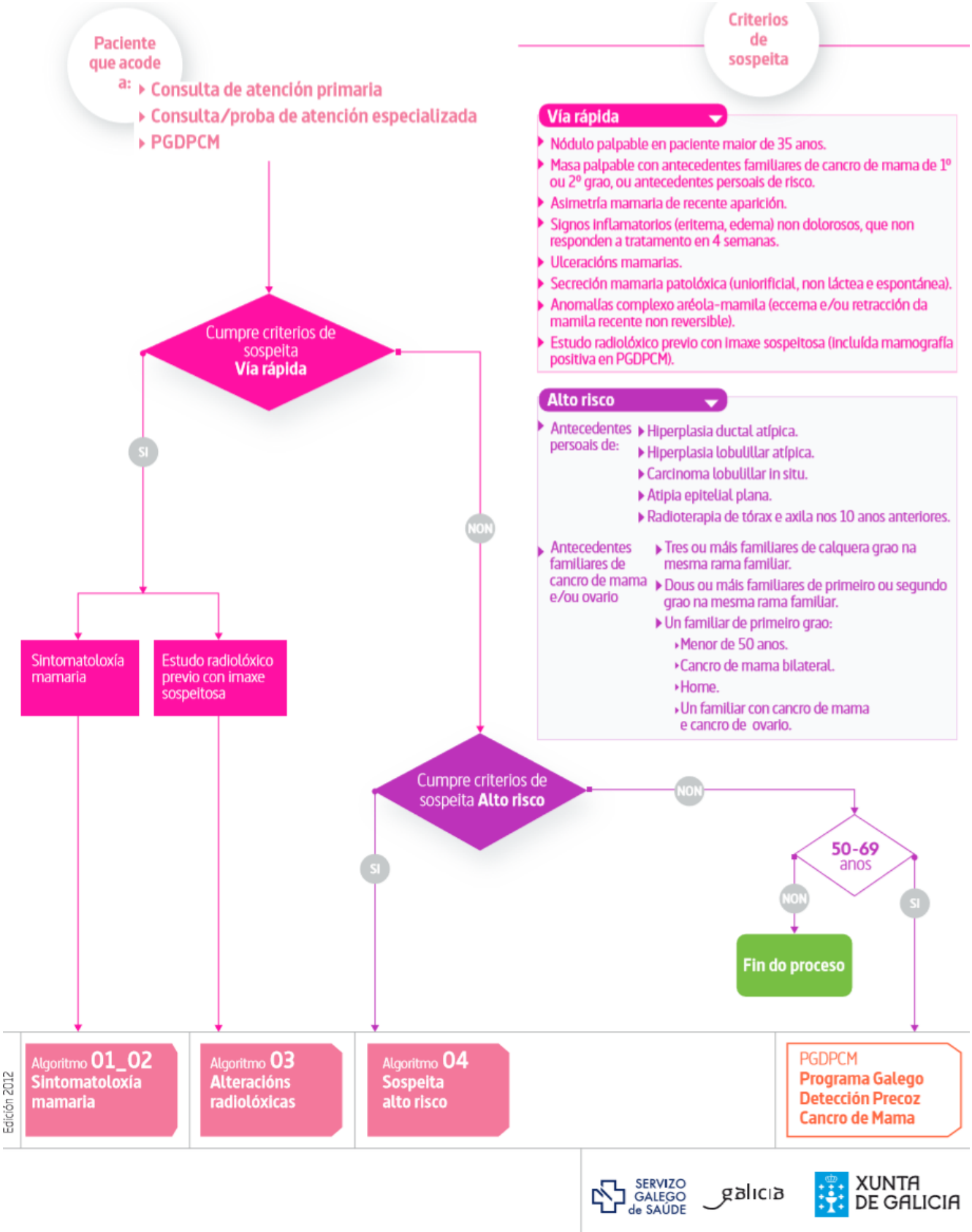

Figure 4: Admission criteria to Fast Path in breast cancer (Servicio Galego de Saude)

these patients had followed within the healthcare system (consultations, procedures, and diagnoses with their corresponding timestamps). Only information about these process steps (and no information about the patients themselves) was needed for the process mining analysis.

To test our approach, we initially limited the data set to 46 patients. The patient ID served as the case ID for the process mining analysis. The data contained between 100 and 150 events (performed activities with a timestamp) for each patient (case).

Extract, Transform, Load (ETL) techniques were used to enrich these appointment logs with pathological anatomy results from the Oracle database. We used Rapidminer to access these databases and perform SQL queries on them to unify and format the data into a single CSV file for the analysis (see the ETL workflow in Figure 5).

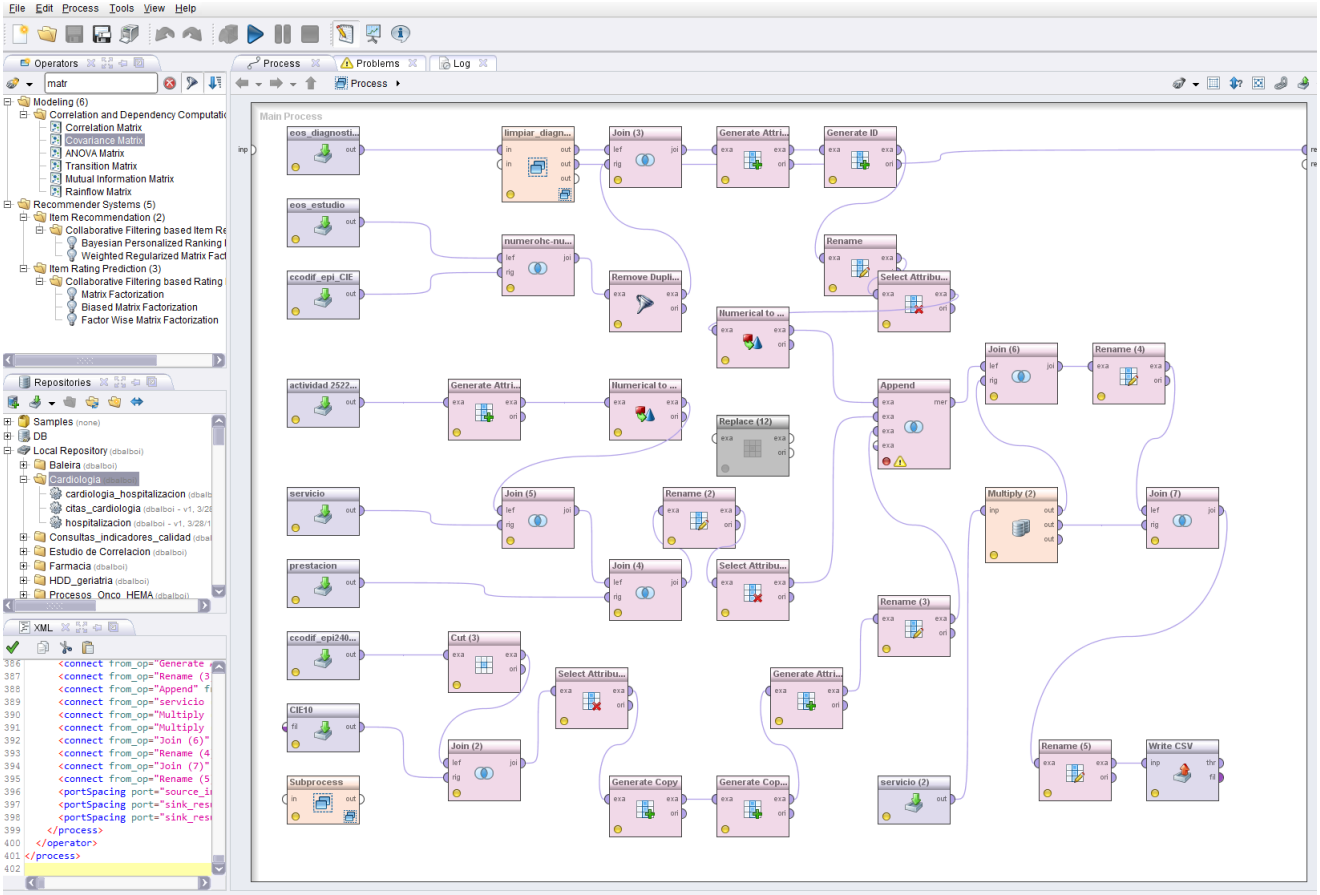

Figure 5: Unifying and enriching logs with Rapidminer

Next, we used the process mining software Disco to analyze the elapsed time between the initial appointment request and different activities in the process (consultation, radiology, pathology, etc.). To do this, one challenge - not only for this process but any healthcare process - is the sheer complexity of the patient journey paths. The path of almost every patient is unique. As a consequence, there are often as many variants as patients in this process. To be able to successfully analyze this data with process mining techniques, we therefore needed to deploy simplification strategies [3].

Specifically, we used the following two simplification strategies:

1. We used Disco's Attribute filter to eliminate events that are not related to a pathology Fast Path such as, for example, consultations in the traumatology department (Simplification Strategy No. 9 in [3]).

   This helped to significantly simplify the analysis by reducing the number of activities in the process map. Furthermore, it helped to increase the visibility on the relevant process steps for individual cases by reducing the number of events per case.

2. Considering that cancer patients' paths, once they are diagnosed, are quite similar and are estimated to be reasonably efficient (varying only in duration depending on the severity of the cancer), we focused our analysis on the process part *until the moment of diagnosis* (Strategy No. 6 in [3]).

   To eliminate all events that happened after the first Oncology (ONC) consultation, we used Disco's Endpoints filter in 'Trim first' mode (see screenshot in Figure 6). The first ONC consultation is assumed to be the moment in time at which the treatment will begin.

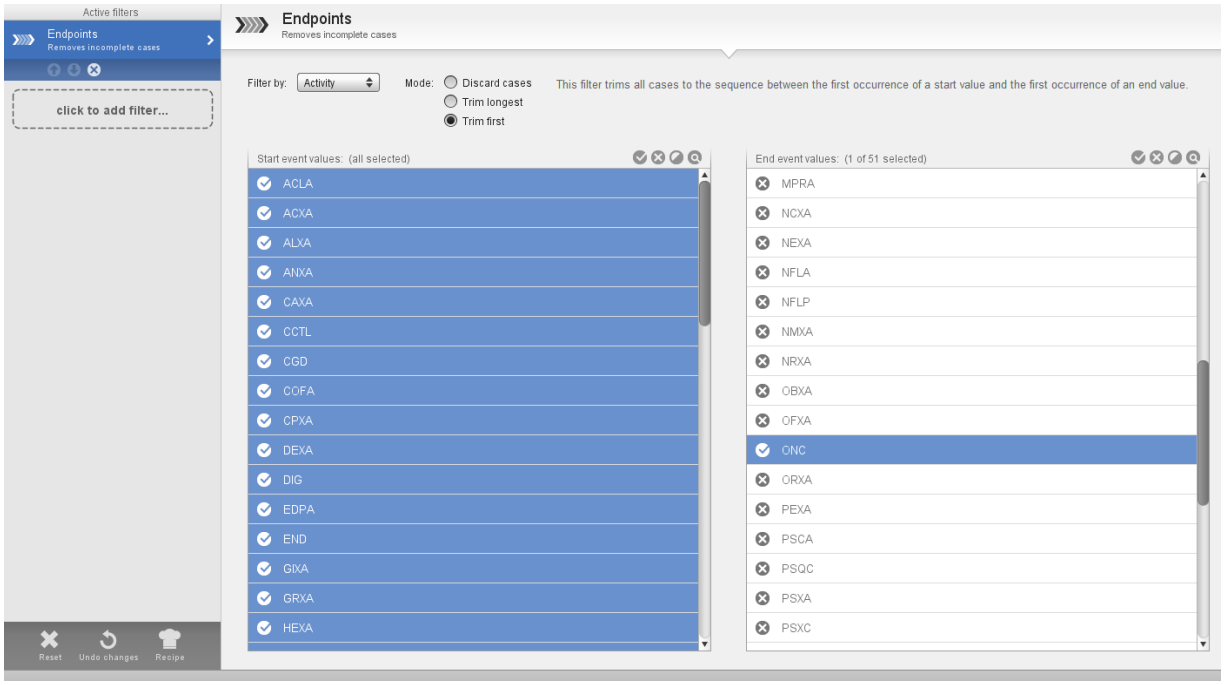

Figure 6: Cutting out all events that happened after the diagnosis in Disco (to focus on the process part that leads up to the diagnosis)

The resulting data set after applying these two simplification strategies allows us to *study the process prior to the diagnosis*, so that we can analyze all the deviations and delays. Figure 7 shows a screenshot of this part of the process.

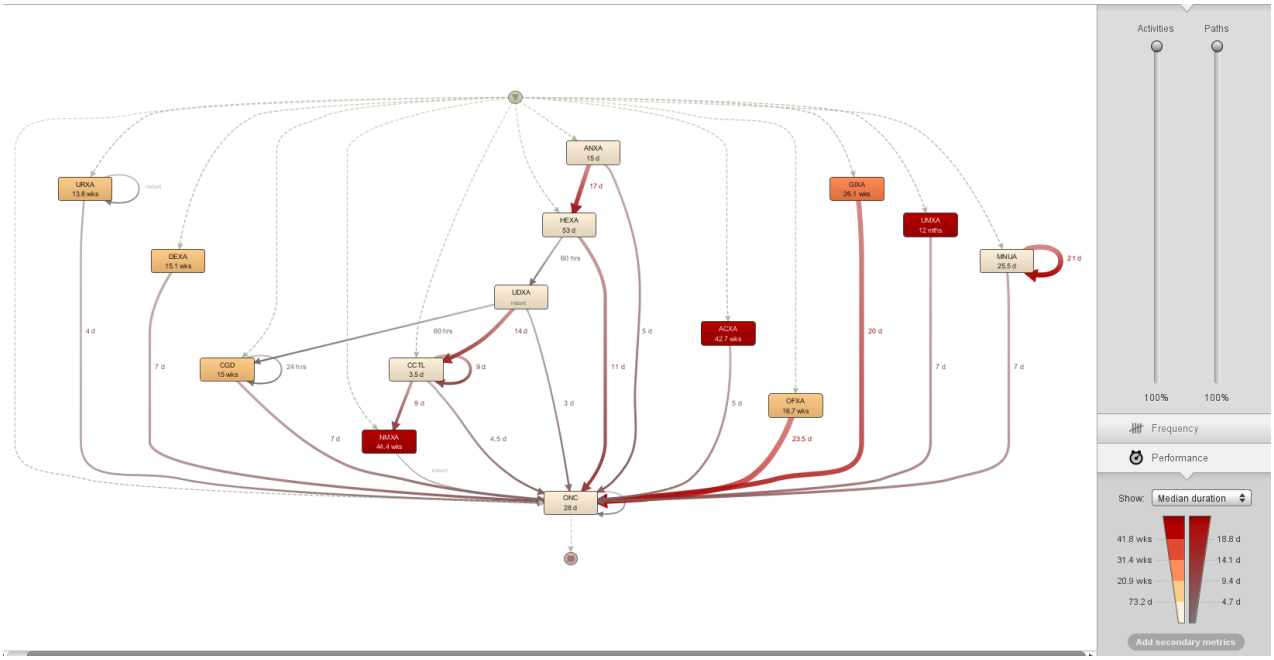

Figure 7: Process map in Disco after filtering events

Results

One of our analysis goals was to find out how many patients are taking the cancer Fast Path. Process mining showed us that only 20% of the patients in our data set were going through the Fast Path.

Those 20% of the patients arrived directly at the Oncology department (see Figure 8), which means that they were correctly referred to the Oncologist.

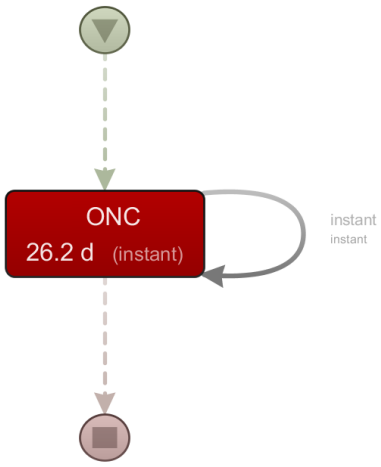

Figure 8: Fast Path to ONC

Possible reasons for this low percentage could be, for example, unspecific symptoms or not enough training for the generalist on detecting the initial signs. As a result, patients may be referred to other specialists (e.g., pneumologist, digestive, or endocrinology specialists depending on the cancer).

The goal of our process flow analysis was to find out how to arrive as soon as possible at the ONC specialist, with little or no deviations, and to identify where the bottlenecks and deviations occur for those that do not follow the Fast Path.

We have been able to identify four main problems in our cancer process.

Problem No. 1. Bottlenecks and Delays Inside the Radiology Department

The Radiology Department is a central department in the hospital (see Figure 9). With up to 400.000 tests a year, it accumulates 45% of the total hospital's activity. Except for urgent diseases, the waiting time to make tests can be quite long (up to 10 months).

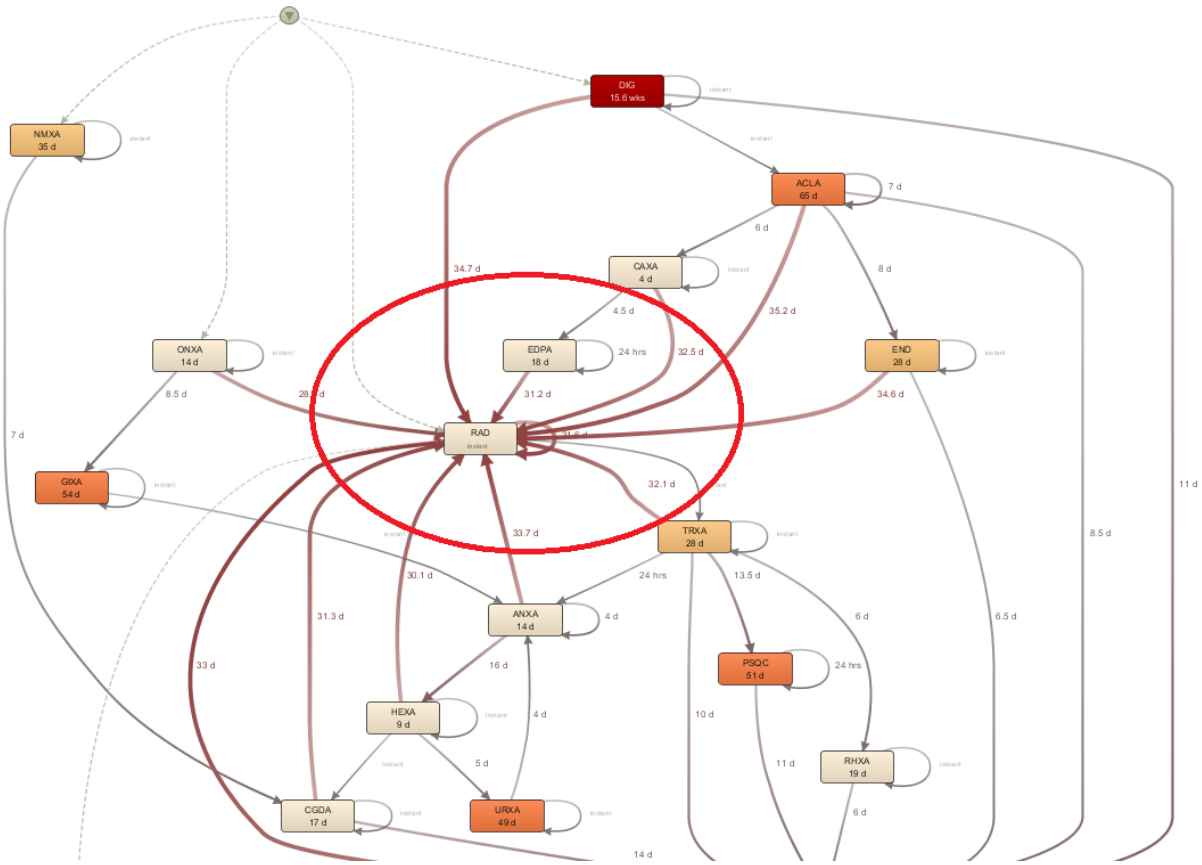

Figure 9: Radiology is a central department

Furthermore, we can find loops within the Radiology department in our patients' paths, which results in a loss of time. In fact, we have found that 12 patients did this loop on average 14 times, with a mean waiting time of 31,6 weeks (see Figure 10).

It seems that patients are repeating tests (maybe more accurate ones) but sometimes with too long intervals in between.

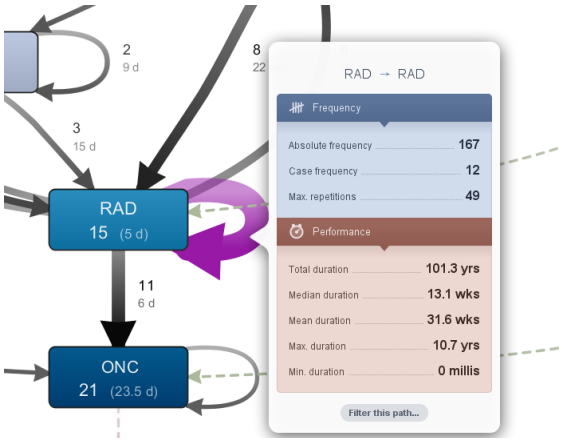

Figure 10: Loops within Radiology

Problem No. 2. Inefficient Paths Out From Radiology Department

The second problem is that, since the patient is arriving at Radiology through the referral of a specialist, they must go back to this specialist to be informed of the results (see Figure 11).

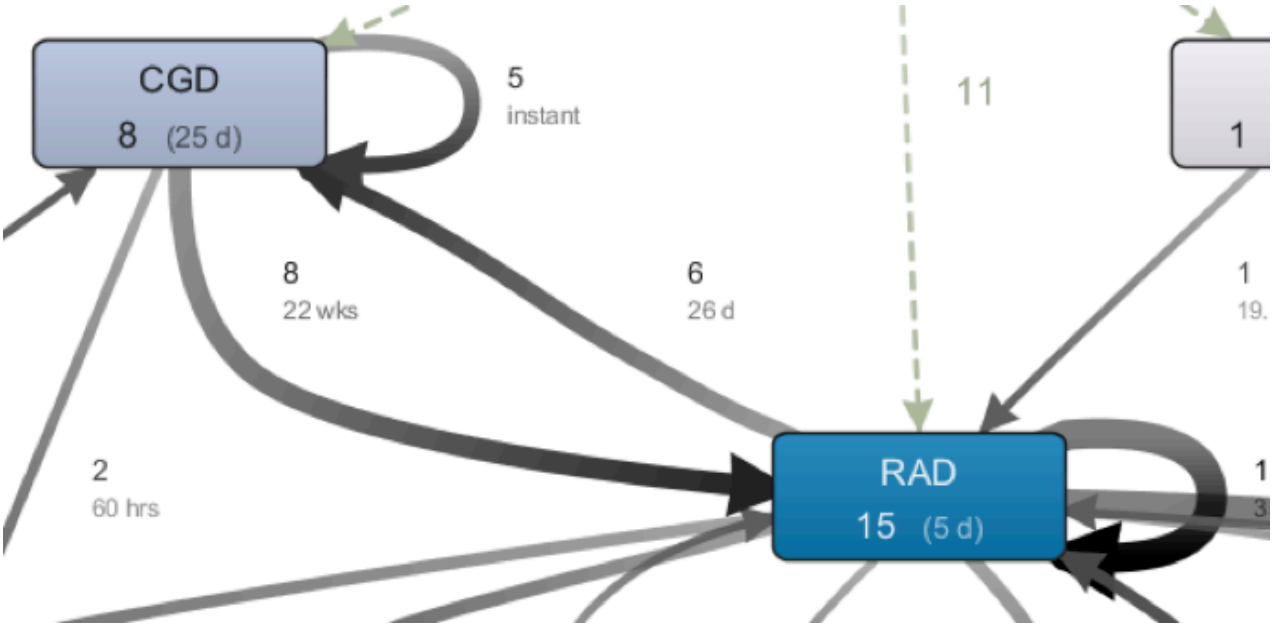

Figure 11: From CGD to Radiology and back to CGD

In all the cases the specialist is then sending the patient back to Radiology or another specialist. But none are later taking the Fast Path.

We have discovered that our electronic referral system (inside the EHR - Ianus) is only allowing to take the Fast Path from the generalist practitioner but not from other specialists. As a result, it is not possible for a specialist to include a patient into a Fast Path and this means that there is no protocol for this.

Problem No. 3. Initial Referral From General Practitioner

The initial referral of the general practitioner (GP)[2] to a specialist other than ONC results in great variability and generally more time until the diagnosis, because the first consultation at the specialist may have long delays (see Figure 12 below).

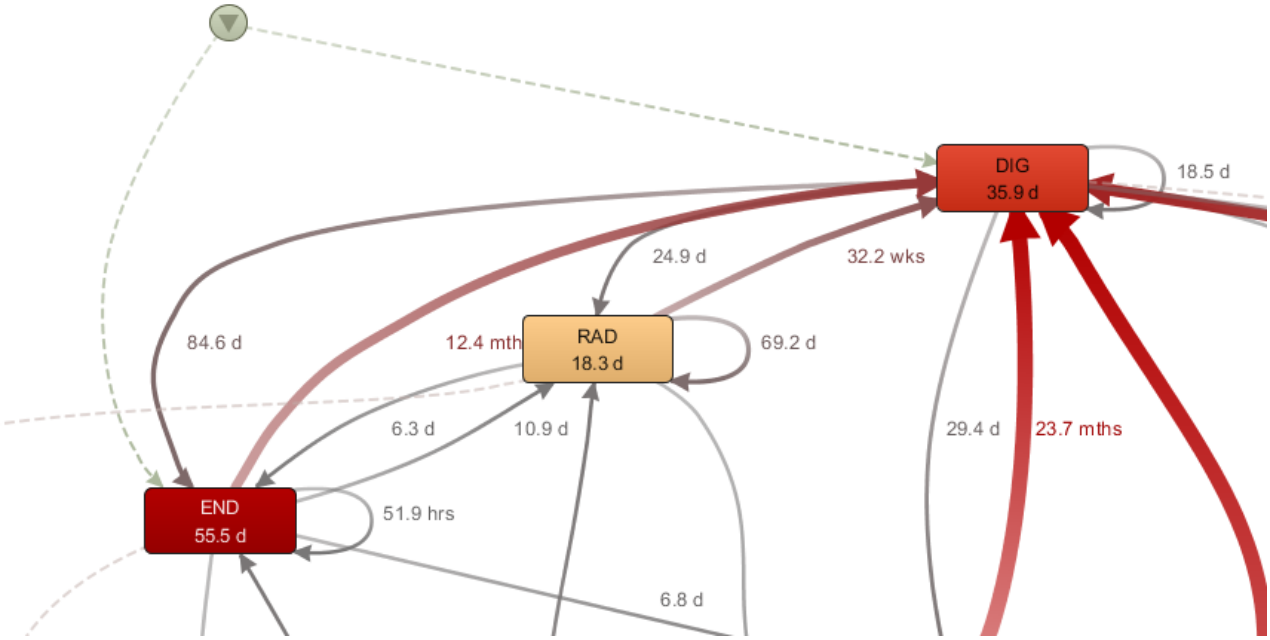

Figure 12: Initial referral from GP to Digestive and Endocrinology, then Radiology and back

As discussed before, the ‘fast routes’ for cancer patients establish referral protocols and faster tests comparing to other diseases. However, only 20% of patients in our data set followed this Fast Path.

This indicates that there are problems in identifying the initial symptoms at the GP, since they are referring the patient to the wrong specialist. In addition, those specialists (like Digestive) usually have a longer waiting list than ONC.

Problem No. 4. Cancer ‘Fast Path’ Not Available Between Two Specialists

As mentioned before, we have discovered that the IT system does not allow specialists to include patients in the Fast Path anymore. Instead, it is only possible to take the Fast Path between Generalist and Specialist. This means that if the first referral is incorrect (for example, to the Pneumologist - See NML in Figure 13), then the delay increases enormously.

[2] Note that the GP visit is not visible in the data and therefore not shown in the process map. The dashed lines show the start point of the process and imply a referral from the GP in this process.

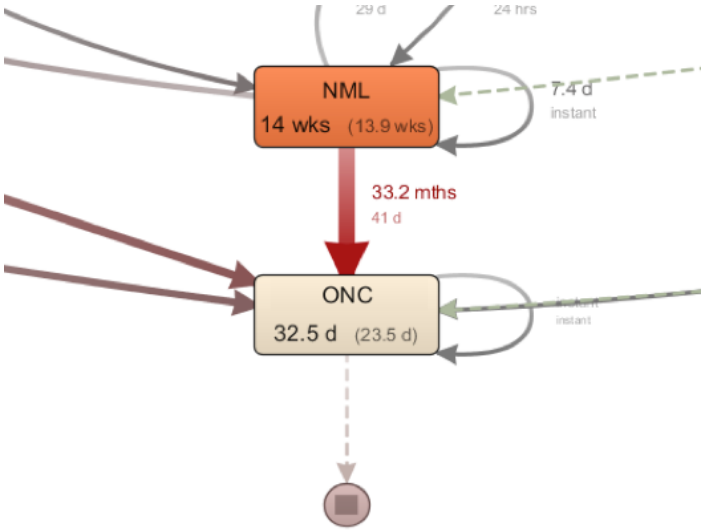

Figure 13: No Fast Path between Pneumology and ONC

Impact

After our initial analysis, we are currently working with the healthcare professionals to validate the results. We will refine our analysis based on their input and increase the sample size of the data set for the follow-up analyses.

This analysis is only a first step and care must be taken to interpret everything correctly in the context of the clinical care before any actions can be taken. For example, sometimes the standard path cannot be taken for clinical reasons. Furthermore, taking actions in a healthcare process like this one involves a big number of healthcare professionals and is not easy.

Nevertheless, this case study shows us the enormous potential of using IT data analysis techniques like process mining for complementing the classical medical research with an analysis of the *process perspective*.

Ultimately, we hope to achieve four kinds of impacts from this process mining analysis:

1. **Better and faster healthcare for cancer patients**, as Fast Paths in the IT systems will be modified (not only for cancer, but other diseases).

2. **Better understanding of the cancer path itself**, as we have identified the moment when the patient is being diagnosed.

3. **Faster diagnosing of the cancer.** The following actions may be established to try to improve early detection and reduce the time before treatment:

    - *Specific training in early diagnosis in involved departments*, such as Endocrinology, Pneumology, Digestive and General Practitioner.
    - *Specific training for private doctors* (outside the Hospital) that can likely identify first symptoms, depending on the type of cancer.

4. **Using process mining techniques for other healthcare processes.** The IT department is now in a position to help other departments like Cardiology (up to 6.000 appointments a year) and Radiology to optimize their processes. Also the Emergency department is very interested in optimizing their paths.

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[3] Simplification Strategies for Process Mining: http://processminingbook.com/simplification.html