ONKOVIS, Co-designed Oncology Follow-up Visualisation Tool

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Abstract: This paper presents a medical oncology follow-up visualisation tool developed following a co-design approach. The co-design and development of the solution has succeed involving a team of end-users (oncologists and nurses), UX and design experts and technology development experts. As a result, a medical oncology follow-up visualisation solution has been developed showing temporally aligned heterogeneous health data. The outcome of the co-design process has been to develop the solution in four different aggregation level views; (1) General timeline overview, (2) Medication treatment cycle view, (3) Detailed patient reported outcome / bloodwork's' view and (4) Medical image analysis focussed view.

1 INTRODUCTION

In recent years, the practice of medical oncology has evolved with new treatments and technology that have improved the prognosis of patients. However, as a result of different factors as for example the aging of the population or an increasingly earlier detection, the number of total cases has not only remained but increased for certain types of cancer. As a consequence, the assistance pressure for oncologists has been augmented.

The follow-up information on the patient's evolution handled by oncologists can be classified into four categories: Diagnostic, toxicological effects of the treatment, symptoms and treatment information. In general, they do not have an integral vision of the case, since these data come from different information sources. Furthermore, the information on symptoms and toxicology is incomplete and is based on the patient's testimony over a long period of time. Neither is adherence information available if the treatment is done at home.

Time is another issue to take into consideration for oncologists, as the time available for appointments with their patients is in fact limited. In addition, patients can be treated by another oncologist due to the unavailability of their usual doctor. These factors, coupled with an increasing assistance pressure and the complexity and variability of the cases, make the practice of medical oncology hard to deal with.

In this context, we have developed a medical oncology follow-up visualisation tool called ONKOVIS which provides an integral view of temporally aligned heterogeneous health data to oncologists. Considering the amount of data to master and the limited time available per each follow-up session, we have opted to follow a co- design approach for its development.

In this paper, we first briefly explain the existing work related to our contribution in section 2. Section 3 details the project context where ONKOVIS was developed and the followed co-design methodology. In section 4, we describe the implementation of the oncology follow-up visualisation tool and the implementation technologies. In Section 5 we summarise the paper and present our conclusions.

2 RELATED WORK

2.1 Oncology Tools

In recent years, different ICT applications have been developed in the oncology field (Ando, 2014; Bender et al., 2013; Evans et al., 2014; Giunti et al., 2018; Limkin et al., 2017). These are usually targeted to

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either the hospital environment (Ando, 2014; Evans et al., 2014; Limkin et al., 2017), patient follow-up or patient support (Bender et al., 2013; Giunti et al., 2018).

Hospital environment applications are mainly focussed on visual follow-up through medical images or treatment (GE Healthcare, 2018; Limkin et al., 2017; Varian Medical Systems, 2018) but none of them offer a visual follow-up solution combining both levels.

Regarding patient follow-up apps, the vast majority are smartphone or smartwatch apps aimed at capturing the patient reported outcome or self-helping with theoretical information. Nevertheless, few of the questionnaires provide symptom-centred questions and some of them do not even offer an interaction with the doctor (Bender et al., 2013).

We have not found referent applications with such a complete system, targeted at the clinician, as the one pursued in this study. Therefore, there is an acceptable niche to develop this solution and achieve an aligned visualisation app of heterogeneous sources of health in the field of medical oncology follow-up.

2.2 Medical Events Visualisation Tools

There is a growing research on the use of visualisations approaches to support clinical research (Hu et al., 2016) and patient care (Klimov et al., 2010; Perer and Sun, 2012; Plaisant et al., 1998; Wongsuphasawat et al., 2011).

Related to the temporally aligned heterogeneous health data visualisation aimed at this contribution, the main related projects are: Lifelines (Plaisant et al., 1998), which represents temporally aligned heterogeneous data for a specific patient, showing each set of data in a separate timeline placed vertically; LifeFlow (Wongsuphasawat et al., 2011), which is focussed on summarizing and representing temporal spacing of the events within sequences for a patient; and MatrixFlow (Perer and Sun, 2012), which rather focuses on visualizing event networks of a patient population based on event co-occurrence.

Despite Lifelines (Plaisant et al., 1998) has a similar goal to ours, it does not support the visualisation of heterogeneous health data within the same timeline. Additionally, it only proposes a single-entry view approach (despite it loads medical images upon interaction), which can be quite limited for scenarios where different level of detail in patient's case history, or incremental learning of patient's case is seek.

3 THE ONKO PROJECT

The ONKO project aims to develop an application that provides an agile and integral view of the patient´s follow-up, including all the information available through the different treatment cycles such as the clinical events, objective tests, symptomatology or toxicological effects. This project comprises three independent but related modules that allow the developers to achieve their objectives: (1) the ONKOVIS visualization app, (2) the information system and (3) the patient mobile app.

The ONKOVIS app defines a follow-up visualisation tool showing temporally aligned heterogeneous health data such as medical images, bloodwork results and patient reported outcome. The main objective from the clinical point of view, is to help the clinicians when making decisions, offering the most complete and accessible set of information, making them able to assess with greater facility and efficiency the efficacy-vs-toxicity balance in each case. It is willing to maximise the interaction time in appointments, by optimising the presentation of the information to the oncologist. In order to do so, the application displays the data in a timeline-based system that allows a clear visualisation of the evolution of different parameters and aspects.

In addition, an information system has been set for the collection, organisation, storage and communication of all information that is needed for all the ONKO operations.

Regarding the state of the patient, the tumour evolution is visualised by means of series of medical images. In order to do so, the medical image connector software was developed as a submodule within the information system module, to select and display the most relevant medical images that had been previously marked as key objects and saved in the hospital´s PACS by the radiologist. This solution provides a clear way to visualise and compare different studies.

Another matter of interest is that the most appropriate treatment not only depends on the approved therapies. To a large degree, the specific situation and characteristics of each patient are taken into consideration to improve both the decision making and the treatment. To that end, a mobile app to carry out a remote follow-up of the evolution of the symptoms and toxicological effects has been developed. The patient can download the app in the mobile and fill the symptoms forms.

The architecture associated to the ONKO project is described in the figure 1.

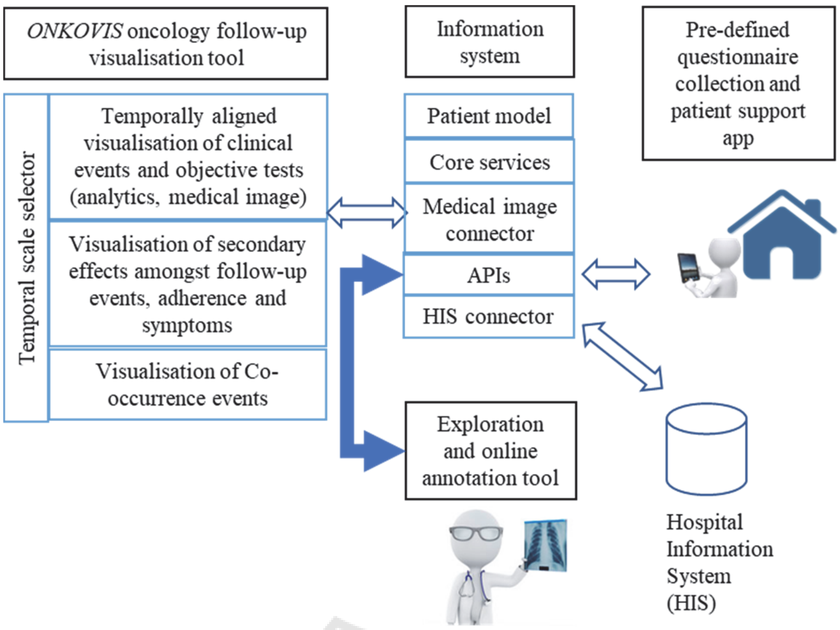

Figure 1: The ONKO Project.

3.1 Co-design Methodology

Co-design methodologies aim to engage users more actively in all stages of the design process, to provide the design process with their experience and knowledge (Rizzo, 2011). Benefits of these methodologies are not limited to creating solutions that better fit users, but also to organisations creativity and to services efficiency (Steen et al., 2011).

The co-design and development of the solution has succeed involving a team of end-users (oncologists and nurses), UX and design experts, and technology development experts. The co-design team involved two persons of each profile, all of them participating in the different meetings.

The chosen methodology started with a face-to-face meeting where a storytelling tool was used to gather and formulate a common background. End-users introduced the problematic and the way they work with the currently available tools, so the co-design team was able to detect the main necessities in the area. Within this meeting, the design and development team also had the opportunity to understand the terminology and context, as they worked side-by-side with the end-user's IT team.

The main issue detected in this first meeting was the non-existence of a visualization tool where heterogeneous data from multiple sources could be intuitively displayed and managed. Consequently, the creation of a tool solving this issue became the main goal of the ONKO project. The team also defined that this tool should offer different aggregation level views, so a larger amount of data and data types can be analysed within the same application. The need of a comprehensive visualization tool was mainly motivated by the limited time that is available in the hospital to attend each patient, the heterogeneity of patients they treat, and the limited time available to analyse and understand the per-patient disease history.

Furthermore, initial visual drafts were collaboratively drawn with limited detail using a co-design sketching tool. These visual drafts helped the team to define the main needed functionalities, apart from defining the appearance of the application.

Next, iteratively and based on the previous sketches, partially-interactive digital mock-ups were built by the design team and were discussed with the whole co-design team using an online meeting software. These digital mock-ups were developed using both HTML editor and graphic editors to reflect the outcome of all the co-design discussions. The mock-up was refined through seven sessions of remote online meetings, and one extra face-to-face meeting, where the partially-interactive digital mock-up was contrasted with oncologists that were not involved in the co-design team, to obtain their feedback.

Figure 2 shows some initial paper-based drafts, while figure 3 shows the final version of the partially-interactive digital mock-ups.

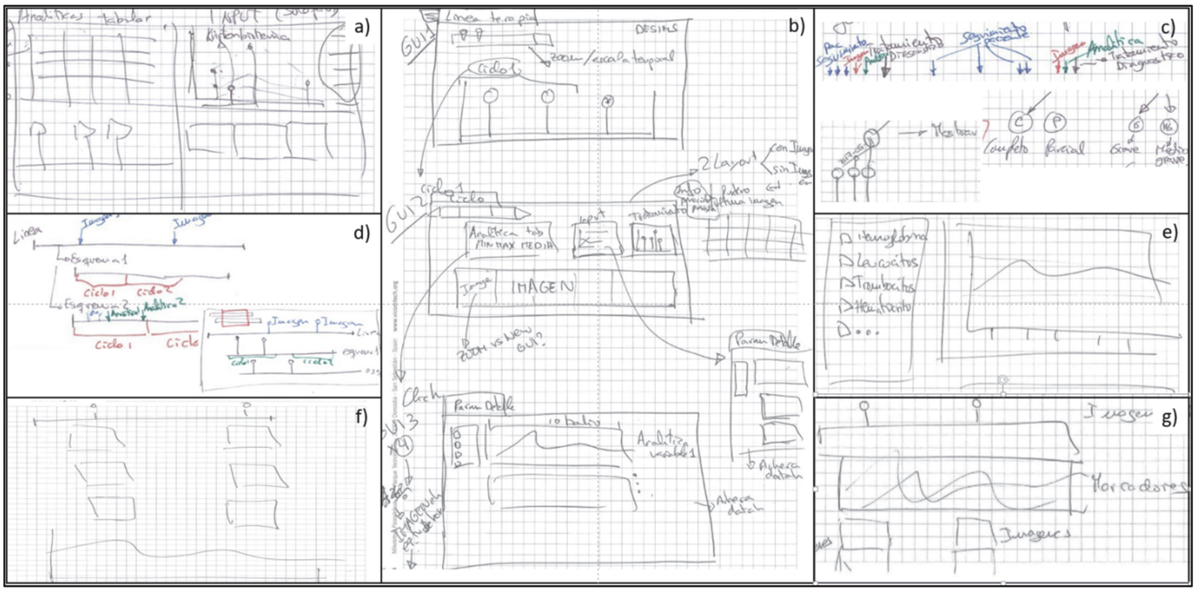

Figure 2: Paper-based drafts. a) Initial multi-entry level visualisation discussed; b) Final individual view-based multi-level entries to visualisation tool; c) Discussions on combining colours, same-date multiple events, usage of text / number on timeline events; d) General timeline overview entry point design discussion; e) Detailed patient report outcome / bloodwork's view prototype; f) Initial medical image analysis focussed view mock-up; g) Final medical image analysis focussed view mock-up.

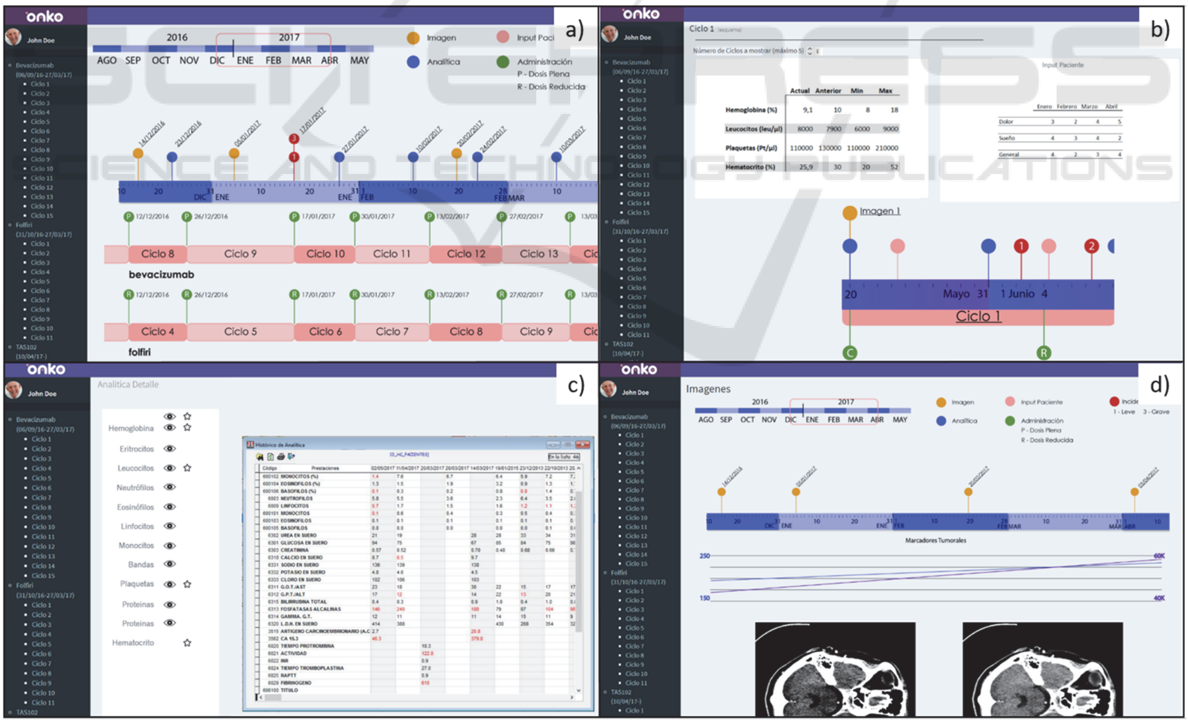

Figure 3: Final version of (partially-interactive) digital mock-up. a) General timeline overview entry point digital mock-up; b) Medication cycle view mock-up; c) Detailed patient report outcome / bloodwork's view mock-up; d) Medical image analysis focussed view mock-up. Check the implementation figures for further details on each image (Figures 4, 5, 6, 7 respectively).

4 ONKOVIS

The ONKOVIS solution has been developed in four different aggregation level views: (1) General timeline overview, (2) Medication treatment cycle view, (3) Detailed patient reported outcome / bloodwork's' view and (4) Medical image analysis focussed view.

In the following subsections, each view is explained in detail. Additionally, in a last subsection the technologies used in the implementation are described.

4.1 General Timeline Overview

The purpose of this view is to show the complete medical record of the patient in the clearest way possible.

It is the main page of the visualisation tool. The time range to be visualised is selected in a range slider placed in the top left of the window. The information is displayed in a timeline-based system where all the clinical events are shown in their respective dates.

These timelines are classified into two categories: the general timeline and medication timelines (figure 4). Regarding the general timeline, information related to blood tests, patient reported outcome, incidences and medical images is visualised by different colour pin markers, making them easy to distinguish. On the other hand, a medication timeline is displayed for each treatment scheme prescribed to the patient. In these timelines, the type of administration (reduced or complete), the name of the main drug compound associated to that timeline and the scheme cycles (i.e. the time period between one administration and the next one) are visualised.

All the timelines are temporally aligned, and the oncologist is able not only to move them using a slider, but also to choose or hide the clinical events that are displayed on them (by interacting with the colour legend area on the top right of the window).

Moreover, the tool provides a detailed view of each cycle of the timeline (detailed in section 4.2) by selecting them in the left sidebar of the page.

4.2 Medication Cycle View

This view provides the most significant results of the bloodwork and patient reported outcome that correspond to the chosen cycle, along with a detailed timeline view of the cycle selected by the oncologist.

The page is displayed when the oncologist selects any cycle from the side bar, and it offers an intermediate level of information. Two tables are visualised, showing a summary of the most significant variables and values of both blood tests and patient reported outcomes. The exposed variables are the ones that had out-of-range values in the most recent test and, additionally in the bloodwork table, the variables identified as tumour markers. Along with these values, previous tests' values are displayed to compare and observe the evolution of the variables.

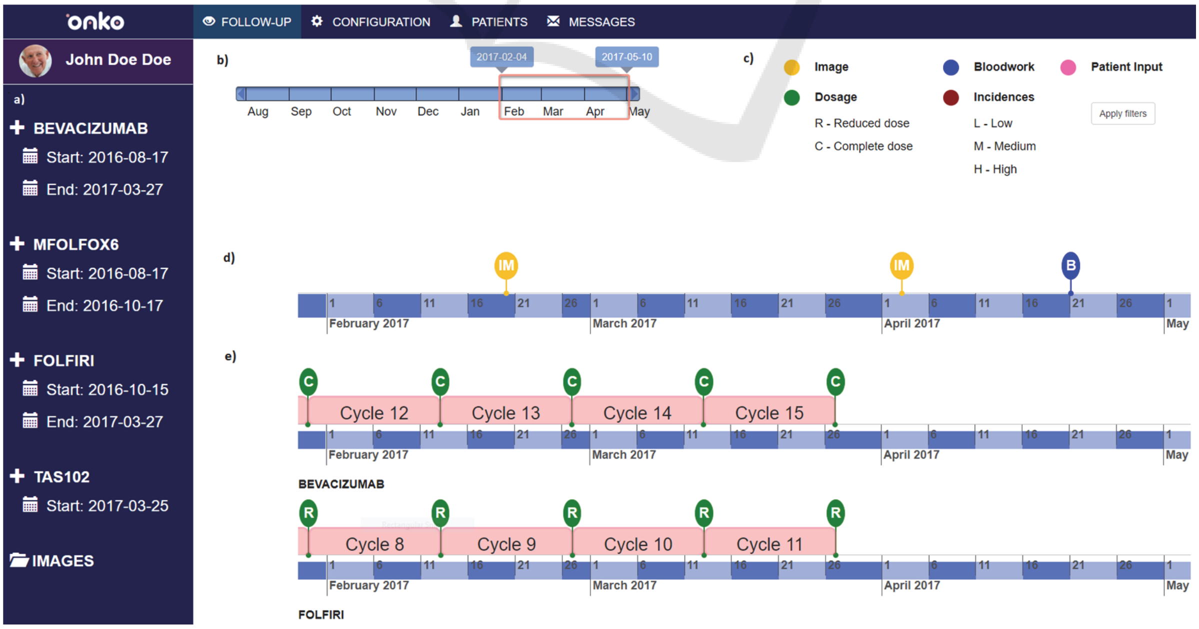

Figure 4: General timeline overview page. a) Sidebar cycle list; b) Time range slider; c) Filtering legend; d) General timeline; e) Medication timelines.

These tables are clickable, offering a detailed view of the whole bloodwork results and patient reported outcomes data (detailed in section 4.3).

At the bottom of the window a timeline is displayed, where all the events that have been carried out from the beginning to the end of the selected cycle are shown. On the top of the window, the user can select the number of cycles to display in this timeline. This view is illustrated in figure 5.

4.3 Detailed Patient Report Outcome / Bloodwork's View

This view provides a detailed and clear view of results of blood tests and patient reported outcome questionnaires filled-out in different tools, following the same approach.

Both pages are quite similar and they have the same options available. On the right side, all the variables and values are displayed in a table, so the oncologist is able to compare different registered results along time. Out-of-range values are marked in red, making them easier to be distinguish.

On the left side, there is a second table where the user can perform several operations. The user can select or hide the desired variable that is going to be shown in the previously described right-side table by clicking on an eye icon. There is also an option to personalise the variables that are displayed in the Medication cycle view tables (introduced in section 4.2) by clicking in the star icon. By default, this star is activated only for the out-of-range variables and tumour marker variables.

Furthermore, the oncologist has the option to plot each selected variable in a chart to provide a graphical view of the chosen variable evolution, as it can be seen in figure 6.

The patient reported outcome data is assessed in the ONKO's patient mobile app, based on the Functional Assessment of Cancer Therapy - General (FACT-G) questionnaire. FACT-G is a patient-reported outcome questionnaire used to assess health-related quality of life in patients undergoing cancer therapy. The survey assesses the impacts of cancer therapy in four domains: i.e. in the physical, social/family, emotional, and functional domains. All these data is summarized in the patient reported outcome view.

4.4 Medical Image Analysis Focussed View

This view offers a follow-up view of the tumour, guided by medical images and tumour markers.

This page displays a timeline focussed on medical image events, as it only shows the events associated with medical image captures (see figure 7). In addition, the type of medical image that has been taken is also specified in the timeline (e.g. CT, MRI, or RX type medical images).

Subsequently, the evolution of the tumour markers is shown by means of a chart, where the user has the possibility to choose the desired markers to be inspected.

Lastly, the most significant medical images (as defined by the radiologist) that correspond to the medical image events shown in the timeline are displayed at the bottom of the window. Also, the oncologist is able to select in the timeline the medical image events they are interested on, and those will be shown beneath the timeline (Users are able to choose three capture events at most). Thereby, the specialist has the option to visualise in parallel key images from different capture events so that the inspection becomes more complete.

4.5 Implementation Technologies

For the implementation of the visualisation tool, the Angular IO web application framework was chosen due to its multiple conveniences when programming and its growing community (Angular IO, 2018).

Regarding web development libraries, Bootstrap (Bootstrap, 2018) has been used as core for the responsive web development library for the user interface development; Vis.js has been used for the timelines creation (vis.js, 2018); Charts.js has been used for the visualisation of charts (Chart.js, 2018); and jQRangeSlider has been used for data range selection (jQRangeSlider, 2018).

5 DISCUSSION

In this paper we proposed a medical oncology follow-up visualisation tool along with the co-design approach that was followed, to provide an integral view of the patient´s follow-up data to the oncologist.

After having analysed different oncology and visualisation tools, we did not find any existing application that provided full follow-up information displayed within a timeline-based system. As a result, the ONKO project has developed a medical oncology follow-up visualisation tool of temporally aligned heterogeneous health data.

Concurrently, the co-design process has been explained with the outcome of developing the solution in four different aggregation level views.

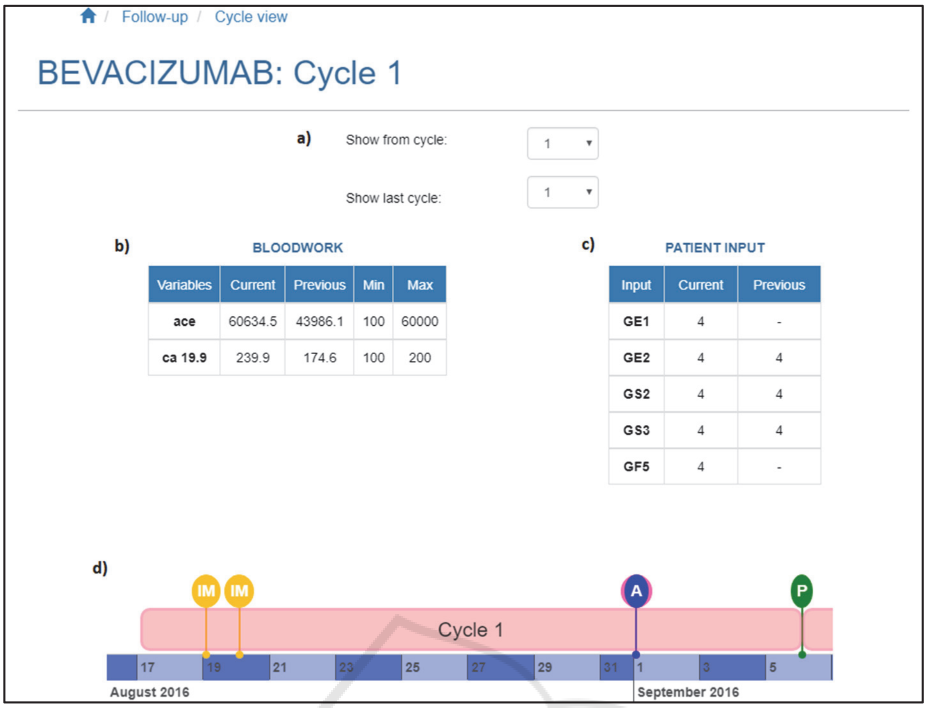

Figure 5: Medication cycle view (Navigations and side bars excluded). a) Cycles selector; b) Bloodwork table; c) Patient reported outcome tables; d) Cycle timeline.

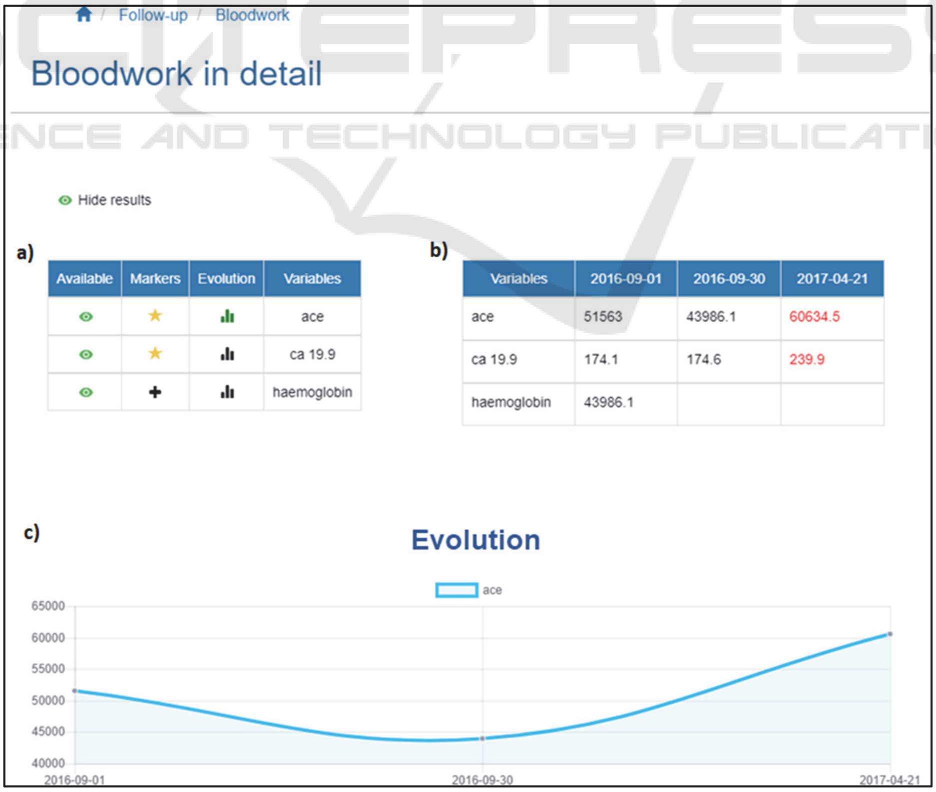

Figure 6: Detailed patient report outcome / bloodwork's view (Navigations and side bars excluded). a) Operations table; b) data table; c) Data evolution chart.

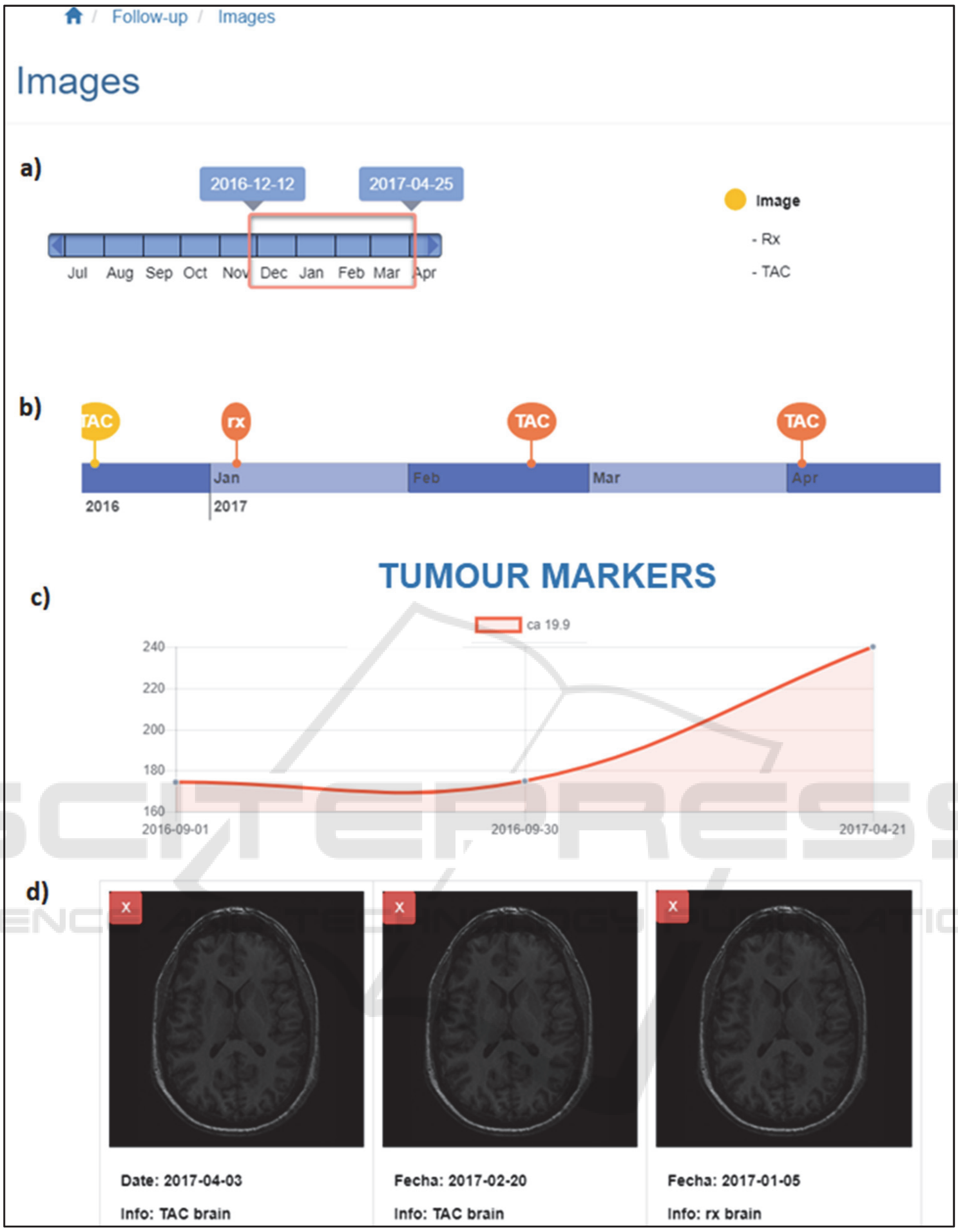

Figure 7: Medical image analysis focussed view (Navigations and side bars excluded). a) Time range slider; b) Images timeline; c) Tumour markers evolution chart; d) Most relevant/chosen images.

6 CONCLUSIONS

The chosen methodology allow the ONKO team to successfully capture the end-user necessities and co-develop a solution that appears to be accepted and appreciated by the end-user. Nevertheless, the project is currently on its validation phase, and further feedback from end-users not involved in the project will be captured on this phase.

The feedback that has been given so far by end-users involved in the project has been positive, yet some minor improvements have been identified.

Besides including the suggested minor changes, the future work associated to the ONKO project will be focused in three areas: Development of predictive models enriched rule-based alarms for nurses and doctors for early identification of deterioration and prompt action, creation of a tool for treatment and appointment handling based on the data collected in the ONKO mobile app, and offering a population-based visualization tool where the data associated to multiple patients can be observed and analysed at the same time, providing a global insight and a comparative visualization tool.

REFERENCES

Ando, Y., 2014. Oncology Information System, in: Tsujii, H., Kamada, T., Shirai, T., Noda, K., Tsuji, H., Karasawa, K. (Eds.), Carbon-Ion Radiotherapy: Principles, Practices, and Treatment Planning. Springer Japan, Tokyo, pp. 113–117. https://doi.org/10.1007/978-4-431-54457-9_13.

Angular IO, 2018. Angular web framework [WWW Document]. URL https://angular.io/ (accessed 6.12.18).

Bender, J.L., Yue, R.Y.K., To, M.J., Deacken, L., Jadad, A.R., 2013. A lot of action, but not in the right direction: systematic review and content analysis of smartphone applications for the prevention, detection, and management of cancer. J. Med. Internet Res. 15, e287. https://doi.org/10.2196/jmir.2661.

Bootstrap, 2018. Bootstrap [WWW Document]. URL https://getbootstrap.com/ (accessed 6.12.18).

Chart.js, 2018. Chart.js | Open source HTML5 Charts for your website [WWW Document]. URL http://www.chartjs.org/ (accessed 6.12.18).

Evans, W.K., Ashbury, F.D., Hogue, G.L., Smith, A., Pun, J., 2014. Implementing a regional oncology information system: approach and lessons learned. Curr Oncol 21, 224–233. https://doi.org/10.3747/co.21.1923.

GE Healthcare, 2018. OncoQuant - Advanced Visualization - Products [WWW Document]. URL http://www3.gehealthcare.com/en/products/categories/advanced_visualization/applications/oncoquant (accessed 6.12.18).

Giunti, G., Giunta, D.H., Guisado-Fernandez, E., Bender, J.L., Fernandez-Luque, L., 2018. A biopsy of Breast Cancer mobile applications: state of the practice review. International Journal of Medical Informatics 110, 1–9. https://doi.org/10.1016/j.ijmedinf.2017.10.022.

Hu, J., Perer, A., Wang, F., 2016. Data Driven Analytics for Personalized Healthcare, in: Healthcare Information Management Systems, Health Informatics. Springer, Cham, pp. 529–554. https://doi.org/10.1007/978-3-319-20765-0_31.

jQRangeSlider, 2018. jQRangeSlider: jQuery plugin for range sliders [WWW Document]. URL http://ghusse.github.io/jQRangeSlider/ (accessed 6.12.18).

Klimov, D., Shahar, Y., Taieb-Maimon, M., 2010. Intelligent visualization and exploration of time-oriented data of multiple patients. Artificial Intelligence in Medicine 49, 11–31. https://doi.org/10.1016/j.artmed.2010.02.001.

Limkin, E.J., Sun, R., Dercle, L., Zacharaki, E.I., Robert, C., Reuzé, S., Schernberg, A., Paragios, N., Deutsch, E., Ferté, C., 2017. Promises and challenges for the implementation of computational medical imaging (radiomics) in oncology. Ann Oncol 28, 1191–1206. https://doi.org/10.1093/annonc/mdx034.

Perer, A., Sun, J., 2012. MatrixFlow: Temporal Network Visual Analytics to Track Symptom Evolution during Disease Progression. AMIA Annu Symp Proc 2012, 716–725.

Plaisant, C., Mushlin, R., Snyder, A., Li, J., Heller, D., Shneiderman, B., 1998. LifeLines: using visualization to enhance navigation and analysis of patient records. Proc AMIA Symp 76–80.

Rizzo, F., 2011. Co-design versus User Centred Design: Framing the differences, in: Guerrini, L. (Ed.), Notes on Doctoral Research in Design. Contributions from the Politecnico Di Milano: Contributions from the Politecnico Di Milano. pp. 125–132.

Steen, M., Manschot, M., De Koning, N., 2011. Benefits of co-design in service design projects. International Journal of Design 5, 53–60.

Varian Medical Systems, 2018. Aria Oncology Information System Medical Oncology - Certified for Meaningful Use. Varian Medical Systems [WWW Document]. URL https://www.varian.com/sites/default/files/resource_attachments/ARIAMedOncProductBrief.pdf (accessed 6.12.18).

vis.js, 2018. vis.js - A dynamic, browser based visualization library. [WWW Document]. URL http://visjs.org/ (accessed 6.12.18).

Wongsuphasawat, K., Guerra Gómez, J.A., Plaisant, C., Wang, T.D., Taieb-Maimon, M., Shneiderman, B., 2011. LifeFlow: Visualizing an Overview of Event Sequences, in: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, CHI ’11. ACM, New York, NY, USA, pp. 1747–1756. https://doi.org/10.1145/1978942.1979196.