Demo: Cohort Visualization and Analysis of Patients with Inflammatory Bowel Disease

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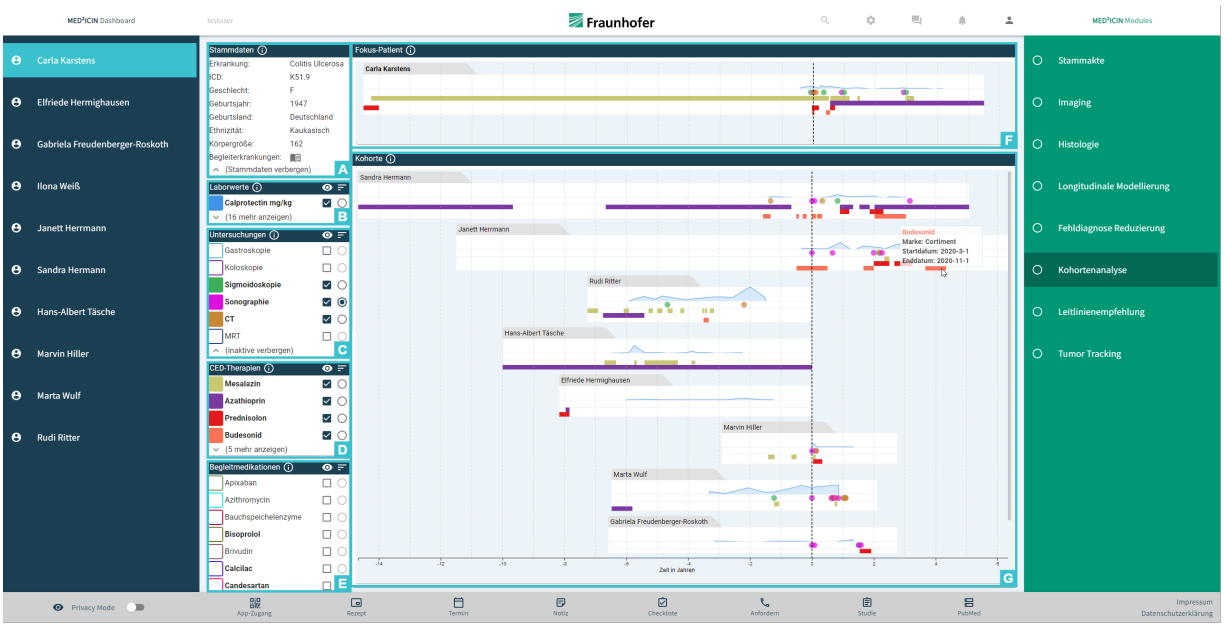

Figure 1: Visualisation of a cohort of a patient with inflammatory bowel disease. A detailed description is given in Section 2.

Abstract

This demo paper introduces the final version of a cohort analysis module for the support of treating patients with inflammatory bowel disease (IBD). It is not trivial to correctly diagnose the specific IBD in patients, and wrongly treated patients have to endure the disease effects for a long time, with large costs for the individuals and the healthcare systems. The goal of this work is complementing the examination of individual patients with interactive analyses of cohorts and populations with similar disease patterns to support learning from such similarities for future treatments. We report on additional data and functionality compared to 2021 and discuss an evaluation with eight IBD experts.

Index Terms: Human-centered computing—Visualization—Visual Analytics; Applied computing—Life and medical sciences—Health care information systems

1 Introduction

Inflammatory bowel disease (IBD) is a increasingly prevalent disease that affects a large proportion of the population [8]. Patients with IBD often develop this disease at a young age, having to endure long and complicated treatments due to the chronic nature of the disease. Treating IBD continues to be costly in both the medical procedures but also with regard to the effect of the disease on economic productivity [4].

Visualization research for medical professionals remains a highly active area in the visualization community. Many medical disciplines improve patient care with the use of dashboards or similar data visualization. Several dashboard approaches have been developed concerning general public health [5, 13], patient-doctor interactions [7, 12], COVID-19 [2, 3, 11], and virtually every medical discipline. In the IBD area, dashboard-driven approaches are popular for their ability to help with identifying relevant information concerning specific treatments [6, 9, 10]. Building on our own work and new developments in the field, we took a user-centric approach to meet needs and requirements of our experts. Thus, for our latest version, we have conducted further user studies to improve and fine-tune our module for optimal use by medical experts in the IBD area.

This work complements the examination of individual patients with interactive analyses of cohorts and populations with similar disease patterns. In addition to temporal aspects, this project looks at a whole range of attributes that are stable per patient, but form interesting correlations and contain insights across larger populations. Our tool is aimed to get to the bottom of different outcomes of similar patients with similar treatments. The compilation and visualization of the data available in the cohort allows conclusions to be drawn about biological or medical relationships. In particular, the structured presentation of the large amount of patient data over a long period of time helps to uncover similarities and differences between different treatment methods. This also represents a key driver of cost intelligence and reduction through the goal of reducing unnecessary treatments or medications.

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This demo paper introduces the final version of a cohort analysis tool for the support of treating patients with IBD. The paper complements our publication at VAHC 2021 [1] that presented the general idea of the cohort visualization and a first evaluation round with collaborating doctors. For VAHC 2023 we would like to demonstrate the capabilities of the final version and describe the main developments during the last two years, focusing specifically on the iterative development of the module for visual cohort analysis.

2 Overall System and Cohort Module

Our contribution runs as part of the MED²ICIN dashboard, which is a web application that was collaboratively developed by seven Fraunhofer institutes. The overall dashboard focuses on providing tools to improve the treatment choice and the cost intelligence in a data-driven approach. The data sets used in this application come from two university hospitals, Frankfurt and Leipzig. Both data sets contain similar attributes consisting of lab measurements that are represented as time series, event and medication data represented as event sequences, as well as time-invariant attributes. The dashboard integrates multiple modules that communicate with each other, each reflecting a different aspect of the IBD treatment.

2.1 Cohort Module

Our module focuses on the analysis of treatment histories of similar patients to a single patient of interest. To enable this task, we build and display a cohort by finding patients that are similar to the focal patient based on common attributes in the treatment data. This allows experts to perform a visual comparative analysis and gain insights in potential treatments and their effectiveness based on past treatments in the cohort. Our visual-interactive module comprises longitudinal visualizations of treatments and medications, clinical events, and lab value histories of multiple patients. These can be found in the center are of the application as shown in Figure 1F&G. Here, the visual representation of the focus patient is at the top, followed by a list of patients that represent the cohort in a scrollable section beneath it. Patient data that are not dependent on time like the disease classification, demographic data, pre-existing conditions etc. are displayed on the left of our module (Figure 1A). Additionally, the left side contains multiple control panels to manipulate the visualization (Figure 1B-E). Here, medical experts can interactively determine the amount of information displayed for their analysis goals. They can also synchronize the progressions in the visualization either to the beginning of certain treatments, medications, and events, or to the time of the highest or lowest values of the specific lab parameter. It is also possible to customize the colors in the visualization to identify harmful patterns like excessive prescriptions of steroids.

Common scenarios for the usage of the interactive cohort visualization may look like this: clinicians select and synchronize treatments they consider to apply to their patient and check how these treatments were received by similar patients in the past by examining lab measurements that indicate the patient's well-being. Also, the medical experts can examine spikes in specific lab measurements by synchronizing to the highest values, and inspect which events or treatments might have led to this spike or which treatments and medications were used in the past with similar patients to improve the situation.

2.2 Changes since 2021

Since our 2021 publication about the cohort visualization approach, we acquired a second data set to work with. This data set features comprehensive data about patients with IBD, their extensive demographic data and their concomitant diseases and medications. We developed further functionality to display and interact with this data. This helps physicians to further enhance treatment options through the visualization of additional relevant information. In particular, we were able to divide the data into general data (Figure 1A), lab values (Figure 1B), physical examinations (Figure 1C), CED-specific therapies (Figure 1D) and concurrent medications (Figure 1E). General data includes demographic data, the ICD (International Statistical Classification of Diseases and Related Health Problems) score, and co-morbidities in the form of a pop-up menu. Since we are now displaying considerably more data, we have added the function to hide non-visualized data points in the sidebar. Furthermore, the attributes of the focus patient are marked in bold font. Following feedback from our experts, the focus patient is now more distinct from their associated cohort (Figure 1F). We also added comprehensive explanations to each component through tool tips. Especially the cohort component (Figure 1G) benefits from such an explanation as it is the most complex component of our visualization.

3 Feedback and Discussion

The MED²ICIN dashboard was evaluated from different angles. An external evaluator assessed the technical setup of the system, which is more focused on the overall dashboard than the cohort module presented in this paper. Nevertheless, the results showed that the web-based modularized setup with its underlying abstracted patient database is suitable for clinics and practitioners, and especially supports the integration of new data sources. At the moment, the dashboard is already used for medical research, but is not certified for the use in clinical settings.

The cohort module as part of this dashboard was also evaluated with medical experts to assess the suitability for typical tasks and questions within the scope of IBD. This evaluation took place between July and November 2022, and involved eight practicing IBD experts (5f, 3m; ages between 31 and 44 years) on two levels of seniority (3 with more than 6 years of professional experience, 5 with less experience; the mean value of experience was 8.25 years). Feedback was gathered with respect to three different aspects: cost savings, time savings, and improvement of the IBD treatment. The cohort module was especially positively assessed for its potential to provide insights that support treatment decisions. The levels of seniority were important for the evaluation of the cohort module, where junior doctors could relate to the module's visualization less well. They suggested adding explanatory information to better understand the significance of previous treatments for the focus patient. The more senior doctors rated the potential for IBD treatment especially high for the possibility to learn from past experiences.

The experts also identified several issues and challenges for bringing this dashboard and its modules into broader use in clinics and practices. Apart from the medical system approval, the main obstacle is the cost of acquiring and integrating the system with the existing clinical information system (CIS), which is usually the predominant IT system in a clinic. The compatibility with the CIS is also closely coupled with the challenge to link data sources from the CIS to any other system. This is best feasible with a third-party system depending on the CIS vendor. All these, and a few minor challenges, are technically solvable, but remain a serious obstacle to the adoption of new visualization techniques in clinical settings.

4 Conclusion

This paper presents the final version of a cohort visualization module to analyze patients with IBD. The approach uses similarities based on static and temporal attributes to learn for future treatments of IBD patients. We reported on (and will demonstrate) new data and functionality that was added to the module after VAHC 2021. The system was evaluated by eight IBD experts, of which especially the senior experts saw the most benefits for their work and research.

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