Composer: Visual Cohort Analysis of Patient Outcomes

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Figure 1: Composer consists of interfaces for displaying the physical function scores of patients treated for back problems over time, and for flexibly defining cohorts. Patient cohorts can be defined based on demographic variables and events in their medical history. The physical function scores of a cohort can be divided into quantiles to communicated best case, worst case and average case outcomes plus uncertainties. A zero-point for the promise scores can be flexibly defined to align all patients by a specific event, such as a medical intervention.

Abstract

Visual cohort analysis utilizing electronic health record (EHR) data has become an important tool in clinical assessment of potential outcomes for patients. In this poster we introduce Composer, a visual analysis tool for Orthopaedic surgeons to analyze and compare the change in physical functions of a patient cohort following various spinal procedures. The goal of our project is to aid physicians and patients in making informed decisions about treatment alternatives by evaluating likely outcomes. In our tool, Composer, analysts can dynamically define a patient cohort using demographic information and events in their medical history and then analyze the physical function scores for the cohort over time. Methods to dynamically align and stratify the temporal data enable analysts to flexibly define relevant reference events and consider various scenarios.

Index Terms: Visual cohort analysis — EHR analysis

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1 Introduction

Determining the best treatment option for patients with back pain involves an assessment of their medical histories as well as those of similar patients that have previously undergone similar procedures. With an increasing amount of available data collected for patient populations in the form of Electronic Health Records (EHR), visual cohort analysis has gained attention as an informative analytic tool in healthcare. Recent work has shown the efficacy of using subsets of similar patients (cohorts) for outcome analysis and prediction in a "patient-like-me" approach [4, 6]. In this project we collaborate with domain experts at the University of Utah's Orthopaedic research center to incorporate outcome scores that are frequently measured over the course of treatment in the decision making process. We use these Patient-Reported Outcomes Measurement Information System (PROMIS) [2] scores as a metric for physical function. PROMIS scores are numerical, yet a specific score is well defined in terms of the abilities (e.g., walk a flight of stairs, run 10k) a patient has at a certain score. In this abstract we introduce Composer, a visual analysis tool for comparison of patient outcomes in cohorts under alternative treatment options.

2 Related Work

Retrospective analysis on event sequences allows clinicians to determine significant sequences of events that influence patient outcomes following various procedures [1, 5, 7]. Determining important influencing factors within a cohort similar to a given target patient has been used to develop predictive tools that help domain experts determine the best treatment options for a given patient [3, 5]. Data collected on a general population of patients may not provide an

accurate reflection of potential outcomes for subsets of patients with preexisting conditions and comorbidities. Because of this, there is interest in using EHR data to better identify factors that can influence recovery of patients with preexisting comorbidities or similar characteristics. Cohorts of patients formed based on EHR data has the potential to be used for "patients like me" comparisons [4]. Visual analysis is used to compare outcomes for patients following a specified sequence of events, specifically procedures, to align similar groups of patients by events in their medical time lines to assess and compare outcomes [5].

3 Domain Goals and Tasks

Our four collaborators investigate the use of PROMIS scores to measure patient well-being and track progression of a patient's physical function following various procedures for spinal ailments. They use EHR records for analysis and prediction of potential outcomes for patients following treatment. By assessing a patients medical history and preexisting conditions, as well as prior knowledge of previous patients trajectories, they can recommend specific procedures that will result in best outcomes when also considering other factors, such as recovery time and cost. The clinicians current assessment of a patient's EHR records is done from a tabular structure, records from other patients are manually compared. Because the medical histories and collected EHR data for the patient population is expansive and involve a variety of records and data types, we sought to develop a visual analysis solution that combines their data into a comprehensive dynamic interface that assists them in identifying trends in patient outcomes under a variety of conditions. Meeting with our collaborators on a bi-weekly basis, we collected a corpus of notes and documentation on current EHR and PROMIS score use within the Orthopaedic research center to identify domain goals and inform the design of the prototype.

A key requirement for clinicians is the ability to form meaningful cohorts of patients and analyze how this subset of patients react to various treatments and procedures. They need to be able to form cohorts from the EHR data based on demographic information, treatment history, as well as their initial physical function scores. The main goals for the domain experts are the following: (1) Create cohorts of patients based on demographic attributes and medical history. (2) Visually compare physical function outcomes following different treatment options.

4 Composer Design

Composer, shown in Figure 1, consists of two components: the visualization of PROMIS scores, and a cohort definition interface.

Cohort Creation Cohorts can be created based on demographic information such as age or gender, in addition to other factors deemed relevant, such as smoking habits. We use histograms to visualize the distributions of attributes and for the interaction with filters. In addition to demographic variables, cohorts can also be defined based on procedure codes present in patient histories. This allows analysts to, for example, separate patients that have received surgery from those who have not. With each cohort refinement, a filter layer is added to the sidebar to provide a history of filters used and the size of the cohort.

A central goal for the domain experts is the facilitated comparison of patients' potential physical function following various procedures. After a user defines a cohort, they have the ability to branch the cohort to plot the same cohort's score measurements following various procedures. This provides a more direct way to assess the differences in outcomes for the same cohort after different treatment options to assist the user in determining treatment options for similar patients.

Outcome Score Comparison PROMIS scores for the defined cohort are initially visualized as individual lines and are aligned by the first promise score recorded. While this is a sensible default, in practice, alignment by a specific clinical event, such as surgery or the start of physical therapy, are often more informative.

The physical function scores used by the domain experts are often subtle in absolute measured change, yet these subtle changes often have significant impact on the perceived well-being of patients. Change in patient scores are further obscured as patients in the same cohort have different baseline scores. To emphasize change and normalize the baseline, analysts can view the scores on a normalized scale that shows relative score change for the patients. With the option of both absolute and relative score scales, the user can assess the cohort's overall trend in baseline score measurements as well as trends in score fluctuation.

Frequently, however, our collaborators do not need to view individual patients, but rather are interested in aggregate representation. To address this, we provide means to aggregate the scores of a cohort into an area chart centered on the mean of the data and extending by plus/minus one standard deviation. This aggregation can be done with the cohort in an absolute or relative score scale. Cohort scores can also be separated by top middle and bottom quantiles to more clearly identify any difference in score change within subsets of the cohort that have different baseline measurements. Visually separated by color, they can be hidden by selection in the sidebar or aggregated.

For further analysis of procedure code distributions and frequency of procedures used to filter the given cohort, procedure code histories of patients can be viewed by selecting individual patients in the score chart. These codes are shown as rectangles plotted along the same x-axis as the PROMIS score chart. We use color codes to identify the type of event and tool-tips to reveal specifics. These events can provide context but can also be used to further filter a cohort.

5 Implications and Future Work

In the future, we will include a more extensive statistical breakdown of the cohort medical history, and improve our ability to compare outcomes. We also plan to develop a patient-facing interface that physicians can use in a shared decision making process.

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