

# Composer: Visual Cohort Analysis of Patient Outcomes

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**visualization**  
**design lab**

# Lower Back Pain is a Significant Health Burden

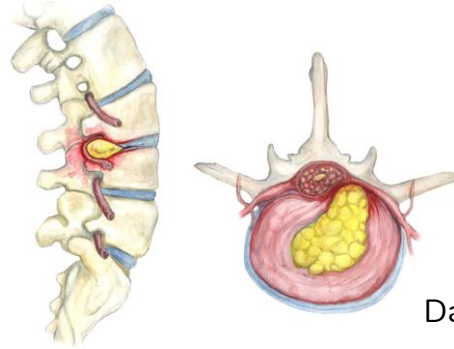
**2.6 Million** Emergency Room visits

Treatment exceeding **\$100 Billion**

This is Frank.  
He has a herniated disc.



# Intervertebral herniated disc



Dakota Harr

lower back pain  
weakness in legs  
bladder and bowel problems

Three treatment options to consider  
with his doctor.



SURGERY

PHYSICAL  
THERAPY

INJECTION



Surgery **mostly** effective for persistent symptoms

Risk involved, takes time to recover

**12%** will need another one within 4 years.

**43%** of these will need fusion

Frank has some pre-existing conditions.

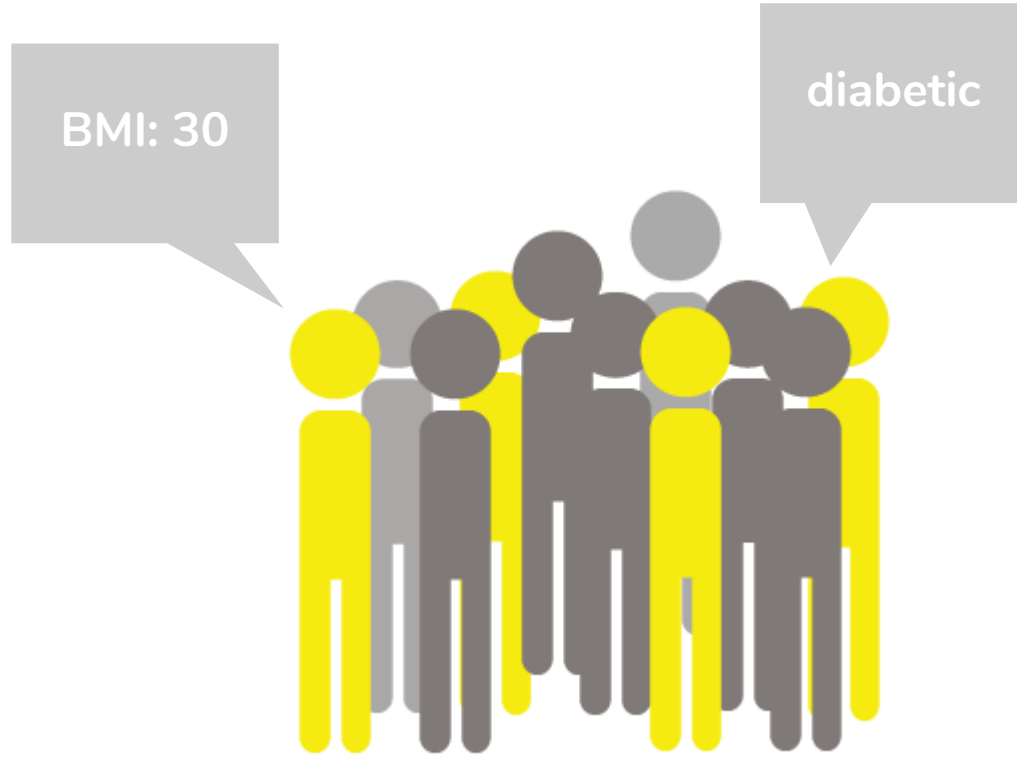


Takes these into account along with **past experience** and **clinical guidelines**.





**general population** may not provide an accurate reflection of potential outcomes for **patients with pre-existing conditions**.



## EHR for evidence based comparisons

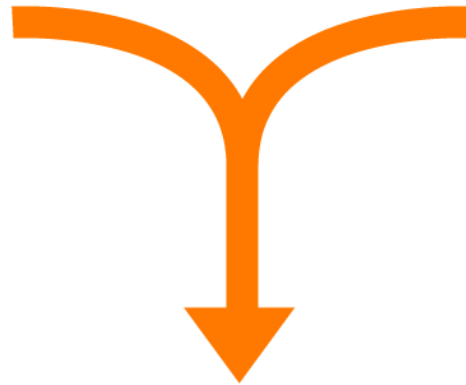
Identify factors that can **influence recovery**  
and more accurately **predict outcomes**



# Dataset of Prior Cases

Accurate Cohort  
Definition

Outcome  
Measures at Many  
Timepoints



**Prognosis Under Different Treatment  
Options**

**Cohorts:** subset of the general population  
shares defining characteristics



**Effective for identifying influential factors.**





Investigating  
**Patient Reported Outcomes** as measure of well-being

# PROMIS

Patient Reported Outcome Measurement Information System.

Evaluate and monitor physical, mental, social health.



Focus on  
**PROMIS physical function** scores.



32:  
Can stand for  
short time.



55:  
Can go on a  
short hike.



72:  
Can run 10  
miles.



**Way to quantify the physical ability**

34:  
2 weeks after surgery

The image features a line graph with a black line on a white background. The line starts at the bottom left, rises to a peak, dips slightly, rises again to a higher peak, and then continues to rise towards the right edge. Three grey speech bubble callouts are attached to the line at different points, each containing text. The first callout is at the first peak, the second is at the second peak, and the third is at the end of the line on the right.

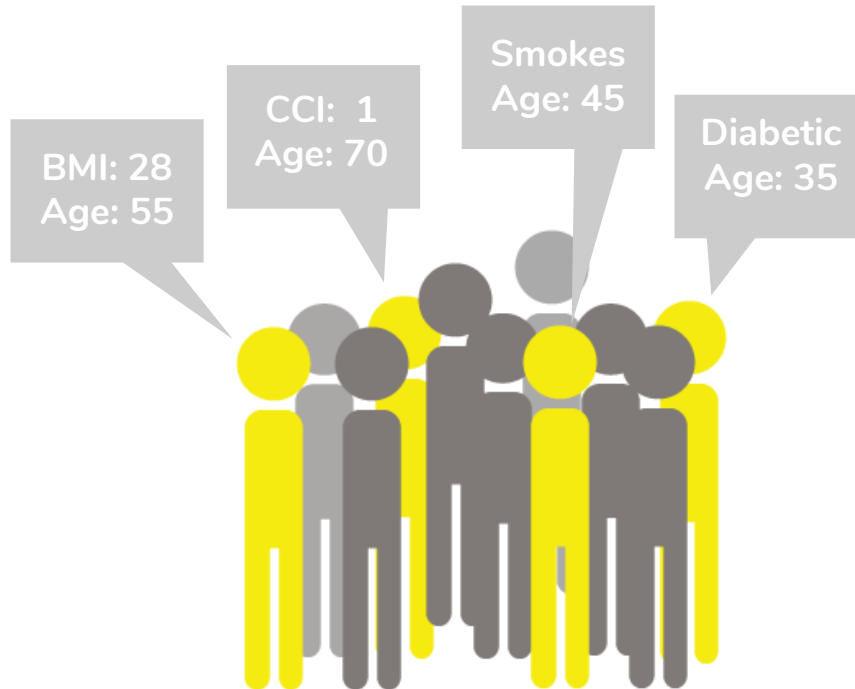
55:  
1 month after surgery.

65:  
2 months after surgery.

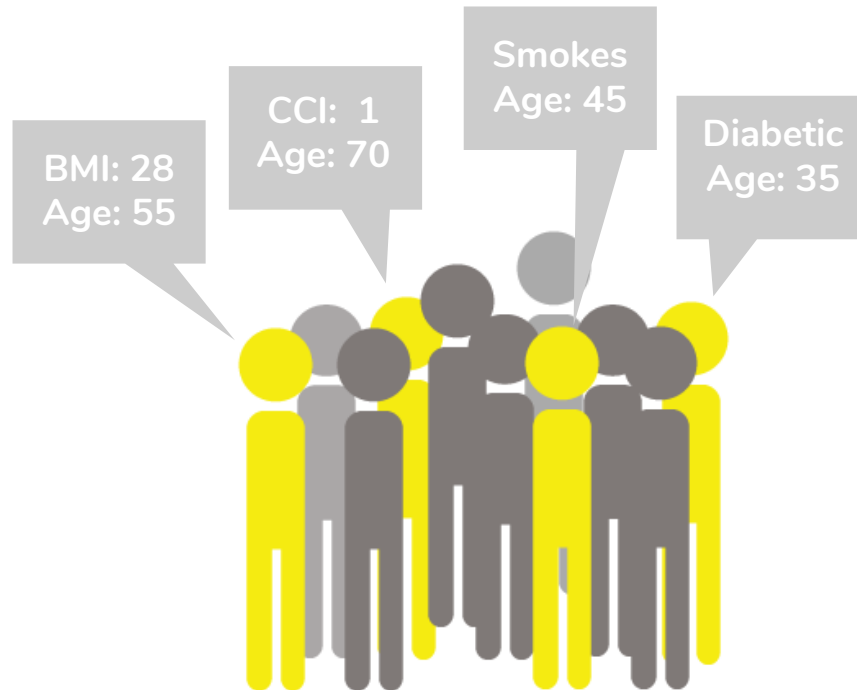
Collected over time  
Track patient progression

use **PROMIS PF** to more **accurately** evaluate progression

To compare outcomes



# Lack tools that use **PROMIS PF** trajectories



# Dataset

**PROMIS PF** scores for **6071** patients  
beginning in **2013**

Range of **1** to more than **20** scores

ICD/CPT codes,  
demographic data, comorbidities

## 3 requirements for functionality

1. Define **meaningful cohorts** of patients
2. Compare outcomes of different **cohorts**
3. Compare outcomes of different **treatments**

## Domain Requirements

1. **Define meaningful cohorts** of patients.



## Domain Requirements

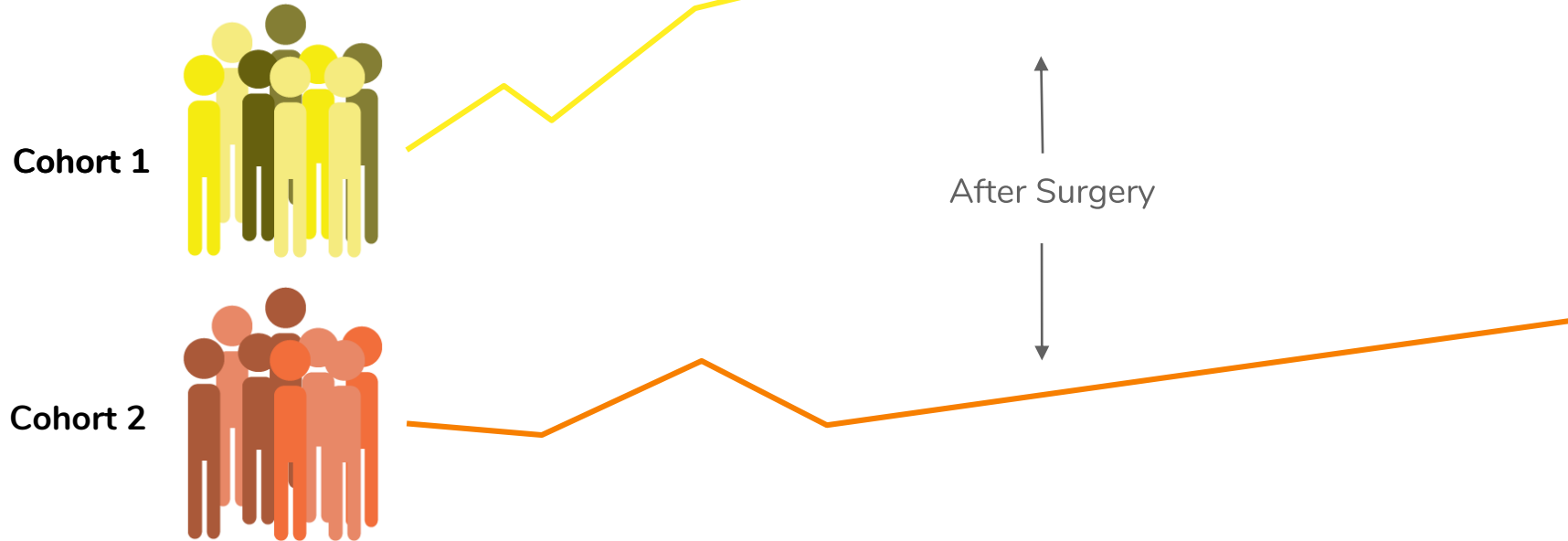
1. **Define meaningful cohorts** of patients.





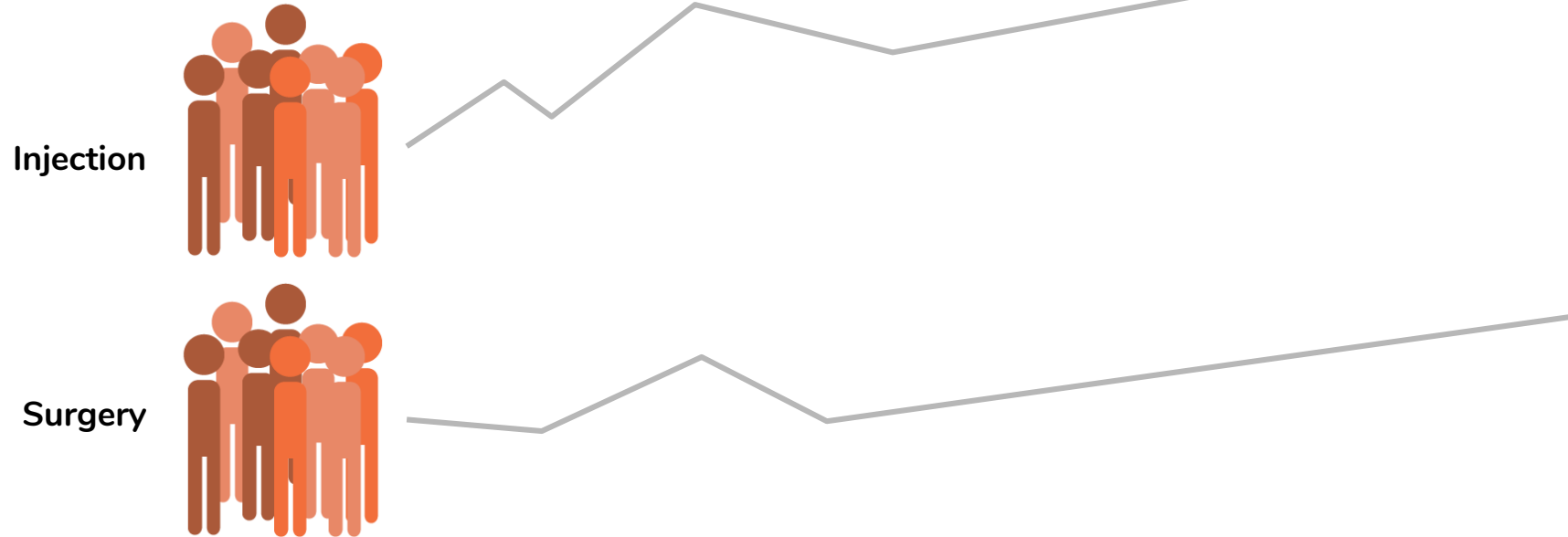
# Domain Requirements

2. Compare outcomes of **different cohorts**.



# Domain Requirements

3. Compare outcomes of **different treatments**.

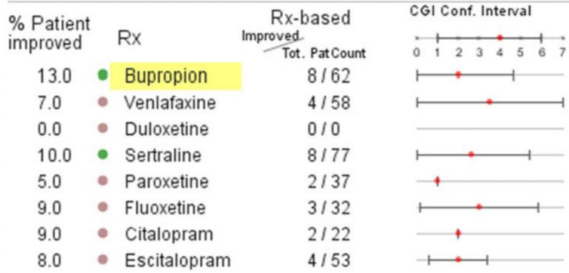


# Related Work

Patient MRN # 15057

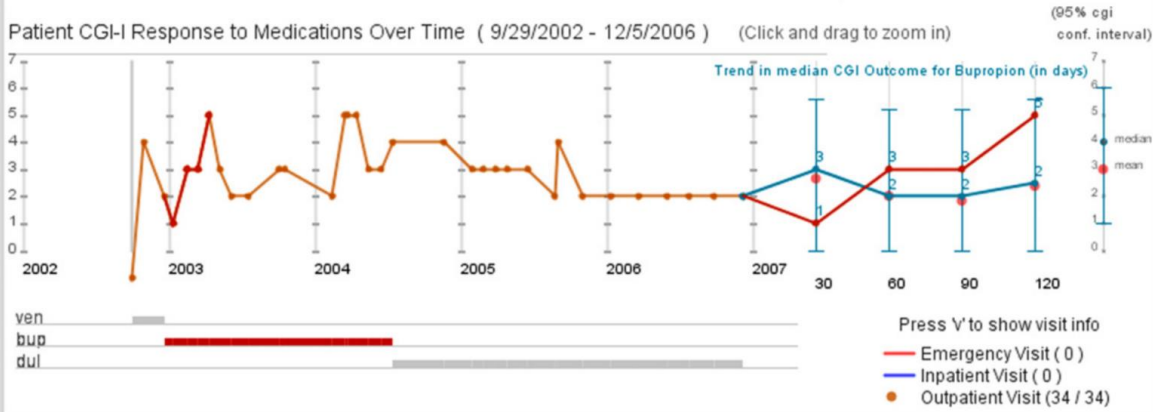
Age: 37 | Sex: Female | Race: White

% of Patients with Improved Treatment Response to Medications



CoMorbid Conditions: Patient (red) and Comparative Population (black)

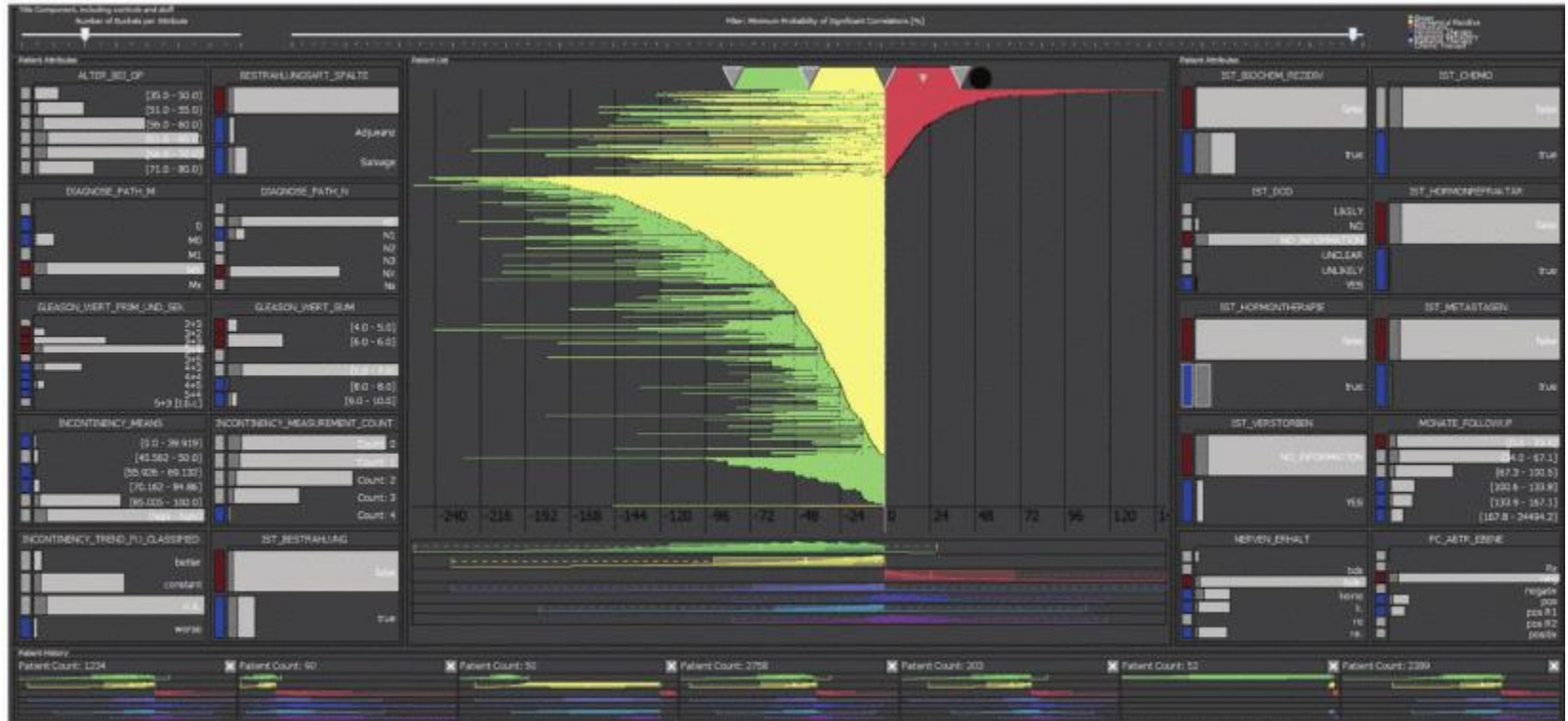
- Y N Disorders of Infancy/Childhood Adolescence (10)
- Y N Delirium Dementia Amnesic/Other Cognitive Disorders (0)
- Y N Mental Disorders due to General Medical Condition (0)
- Y N Substance -Related Disorders (6)
- Y N Schizophrenia and Other Psychotic Disorders (0)
- Y  Mood Disorders (0)
- Y N Anxiety Disorders (20)
- Y N **Somatoform Disorders (1)**
- Y N Factitious Disorders (0)
- Y N Dissociative Disorders (0)
- Y N Sexual and Gender Identity Disorders (0)
- Y N Eating Disorders (0)
- Y N Sleep Disorders (3)
- Y N Impulse Control Disorders Not Elsewhere Classified (0)
- Y N Adjustment Disorders (1)
- Y N Personality Disorders (9)
- Y N Other Conditions of Possible Clinical Focus (12)
- Y N Additional Codes (25)



Patient score trajectories in the context of a similar group of patients.

Mane, K.K., Bizon, C., Schmitt, C., Owen, P., Burchett, B., Pietrobon, R. and Gersing, K., 2012. VisualDecisionLinc: A visual analytics approach for comparative effectiveness-based clinical decision support in psychiatry. Journal of Biomedical Informatics, 45(1), pp.101-106.

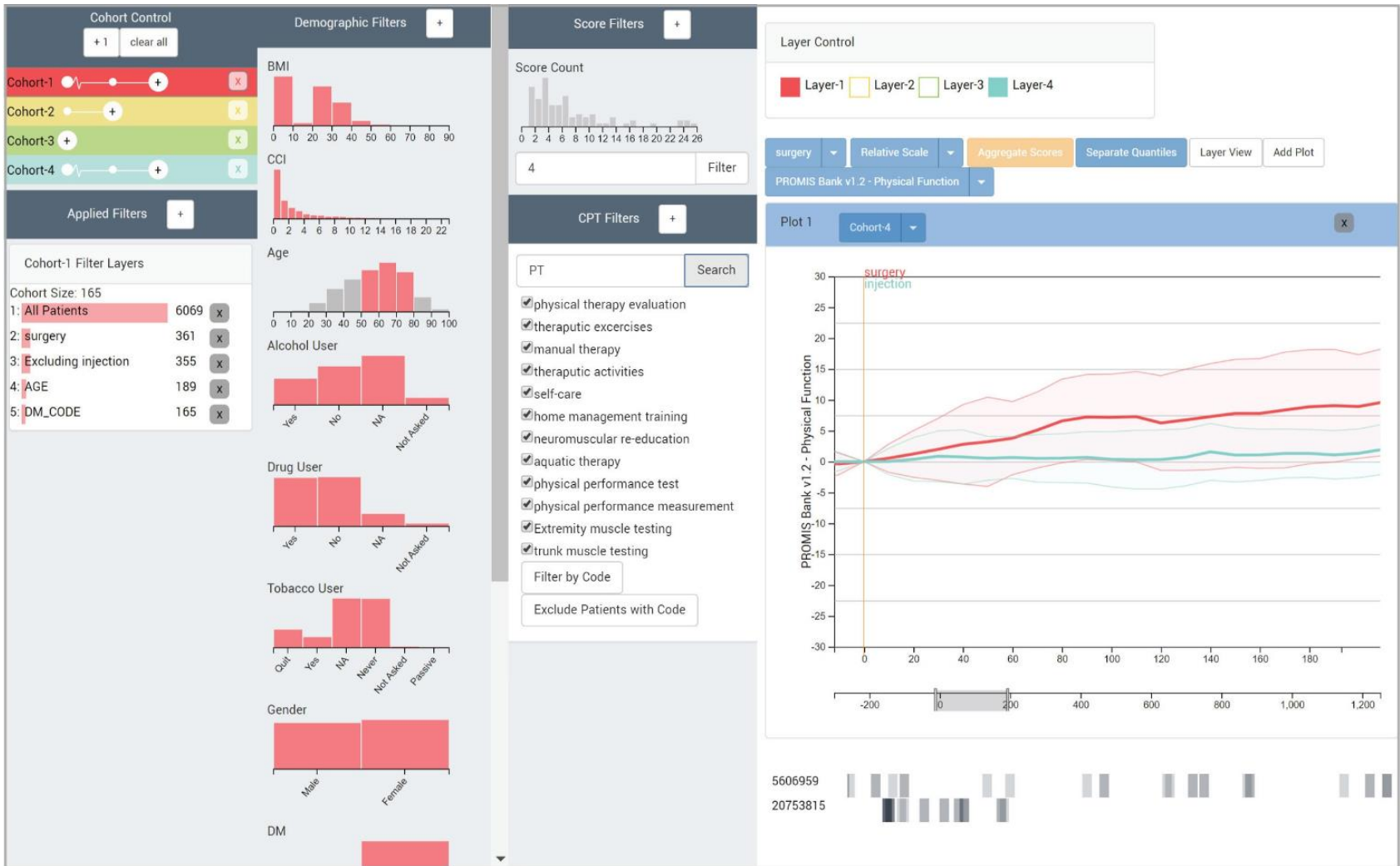
# Iterative cohort refinement.



Bernard, Jürgen, et al. "A visual-interactive system for prostate cancer cohort analysis." *IEEE computer graphics and applications* 35.3 (2015): 44-55.

# Contributions

**Comparison of treatment options** measured by patient score trajectories  
Ability to **normalize and adjust representation** of trajectories  
**Flexible definition** of multiple patient cohorts for comparison



### Cohort Control

+1 clear all

Cohort-1 + x

Cohort-2 + x

Cohort-3 + x

Cohort-4 + x

Applied Filters +

Cohort-1 Filter Layers

Cohort Size: 165

- All Patients 6069 x
- surgery 361 x
- Excluding injection 355 x
- AGE 189 x
- DM\_CODE 165 x

### Demographic Filters

BMI

CCI

Age

Alcohol User

Drug User

Tobacco User

Gender

DM

### Score Filters

Score Count

4 Filter

### CPT Filters

PT Search

- physical therapy evaluation
- therapeutic exercises
- manual therapy
- therapeutic activities
- self-care
- home management training
- neuromuscular re-education
- aquatic therapy
- physical performance test
- physical performance measurement
- Extremity muscle testing
- trunk muscle testing

Filter by Code

Exclude Patients with Code

### Layer Control

Layer-1 Layer-2 Layer-3 Layer-4

surgery Relative Scale Aggregate Scores Separate Quantiles Layer View Add Plot

PROMIS Bank v1.2 - Physical Function

Plot 1 Cohort-4

5606959

20753815



**Cohort Control** +1 clear all

Cohort-1 + x  
Cohort-2 + x  
Cohort-3 + x  
Cohort-4 + x

**Demographic Filters** +

BMI

CCI

Age

Alcohol User

Drug User

Tobacco User

Gender

DM

**Applied Filters** +

**Cohort-1 Filter Layers**

Cohort Size: 165

1: All Patients	6069	x
2: surgery	361	x
3: Excluding injection	355	x
4: AGE	189	x
5: DM_CODE	165	x

**Score Filters** +

Score Count

4 Filter

**CPT Filters** +

PT Search

- physical therapy evaluation
- therapeutic exercises
- manual therapy
- therapeutic activities
- self-care
- home management training
- neuromuscular re-education
- aquatic therapy
- physical performance test
- physical performance measurement
- Extremity muscle testing
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Filter by Code

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**Layer Control**

Layer-1 Layer-2 Layer-3 Layer-4

surgery Relative Scale Aggregate Scores Separate Quantiles Layer View Add Plot

PROMIS Bank v1.2 - Physical Function

Plot 1 Cohort-4 x

**PROMIS Bank v1.2 - Physical Function**

5606959  
20753815

Define a cohort for Frank by filtering based on attributes.



COMPOSER

Cohort Control

+ 1 clear all

Cohort-1 + x

Cohort-2 + x

Cohort-3 + x

C-3 Branch-1 + x

Applied Filters +

C-3 Branch-1 Filter Layers

Cohort Size: 139

1: All Patients	6069	x
2: surgery	361	^
3: Excluding injection	355	x
4: AGE	185	x
5: BMI	139	x

## Filter History.

Patient count of cohort at each filter stage

COMPOSER

Cohort Control

+ 1 clear all

Cohort-1 + x

Cohort-2 + x

Cohort-3 + x

C-3 Branch-1 + x

Applied Filters +

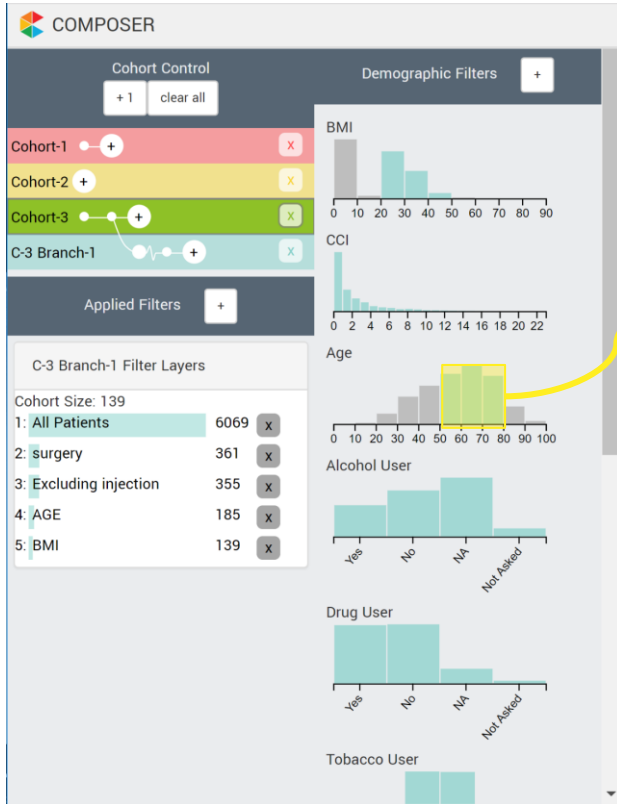
C-3 Branch-1 Filter Layers

Cohort Size: 139

1: All Patients	6069	x
2: surgery	361	x
3: Excluding injection	355	x
4: AGE	185	x
5: BMI	139	x

Filter History.

Remove and recalculate



Demographic Filters.

COMPOSER

Cohort Control  
+1 clear all

Cohort-1 + X  
Cohort-2 + X  
Cohort-3 + X  
C-3 Branch-1 + X

Score Filters +

Score Count

0 2 4 6 8 10 12 14 16 18 20 22 24 26

Min Score Count Filter

Applied Filters +

C-3 Branch-1 Filter Layers

Cohort Size: 139

1: All Patients	6069	X
2: surgery	361	X
3: Excluding injection	355	X
4: AGE	185	X
5: BMI	139	X

CPT Filters +

PT Search

- physical therapy evaluation
- therapeutic exercises
- manual therapy
- therapeutic activities
- self-care
- home management training
- neuromuscular re-education
- aquatic therapy
- physical performance test
- physical performance measurement
- Extremity muscle testing
- trunk muscle testing

Filter by Code

Exclude Patients with Code

## Score & CPT Filters.

Cohort Control

+1 clear all

Cohort-1 + X

Demographic Filters +

Score Filters +

Applied Filters +

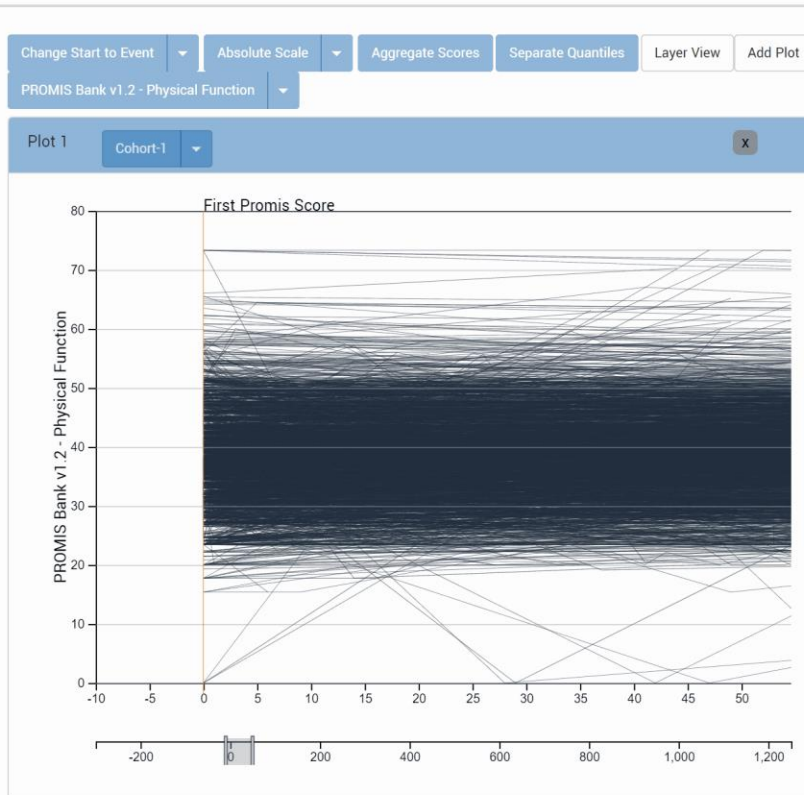
CPT Filters +

Cohort-1 Filter Layers

Cohort Size: 3516

- 1: All Patients 6069 X
- 2: AGE 4512 X
- 3: DM\_CODE 3516 X

CPT Name/Code Search



Filtering by attributes to define a cohort like Frank

COMPOSER

Cohort Control

+1 clear all

Cohort-1

Applied Filters

Cohort-1 Filter Layers

Cohort Size: 100

1: All Patients	6069	
2: surgery	361	
3: BMI	285	
4: AGE	100	

Added

Cohort control panel.



COMPOSER

Cohort Control

+ 1 clear all

Cohort-1

Applied Filters +


Cohort-1 Filter Layers

Cohort Size: 100

1: All Patients	6069	
2: surgery	361	
3: BMI	285	
4: AGE	100	



Cohort control panel.



Branched

 COMPOSER

Cohort Control

+ 1 clear all





Cohort-1  + 

C-1 Branch-1  + 

Applied Filters +

C-1 Branch-1 Filter Layers

Cohort Size: 100

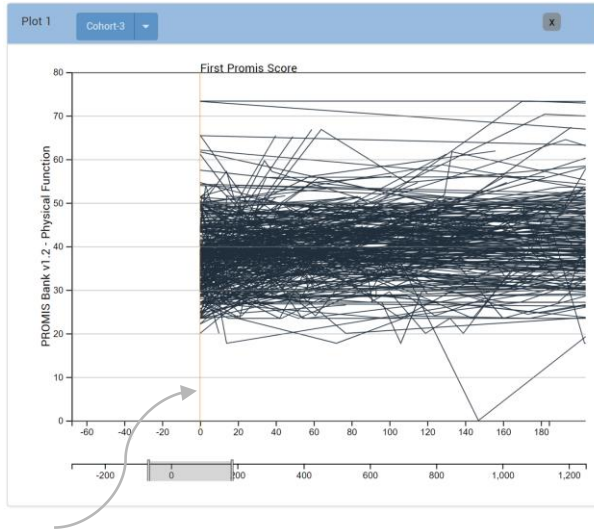
1: All Patients	6069	
2: surgery	361	
3: BMI	285	
4: AGE	100	

Remove

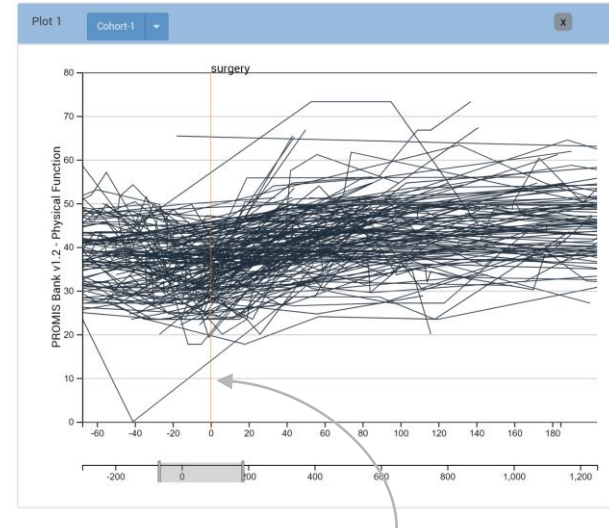
Cohort control panel.

How did patients like Frank progress **after surgery**?

## Realign scores to see trend after surgery



Aligned by first recorded PROMIS score



Aligned by surgery

Cohort Control

+1 clear all

Cohort-1  + X

Demographic Filters +

Score Filters +

Applied Filters +

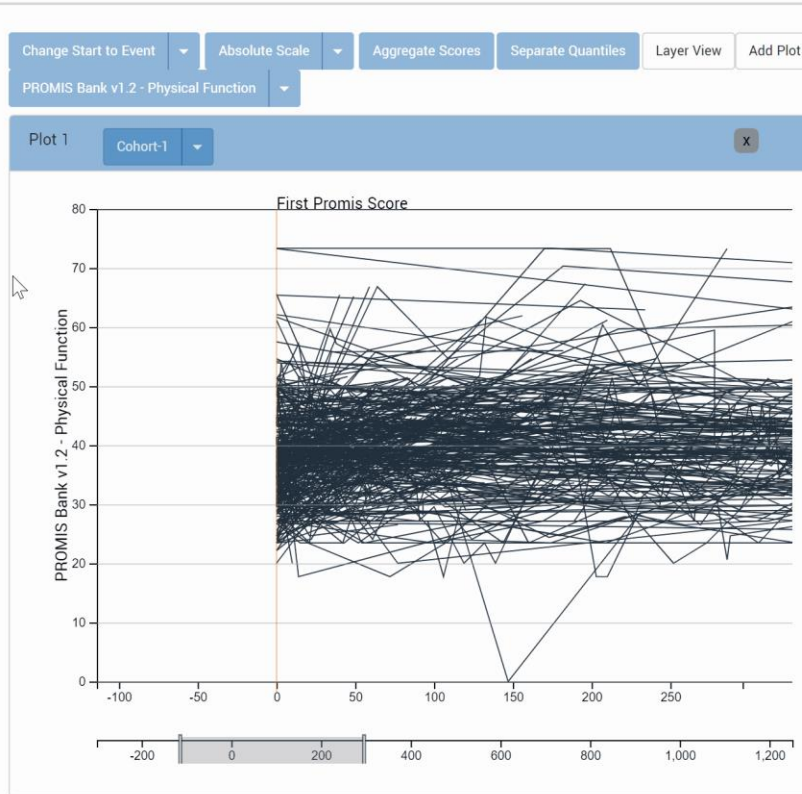
CPT Filters +

Cohort-1 Filter Layers

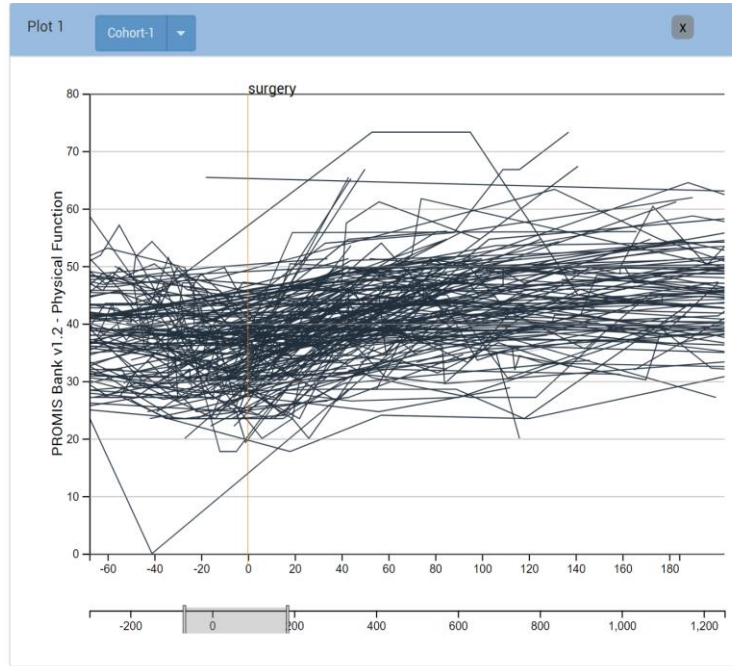
Cohort Size: 361

1: All Patients	6069	X
2: surgery	361	X

63030 Search

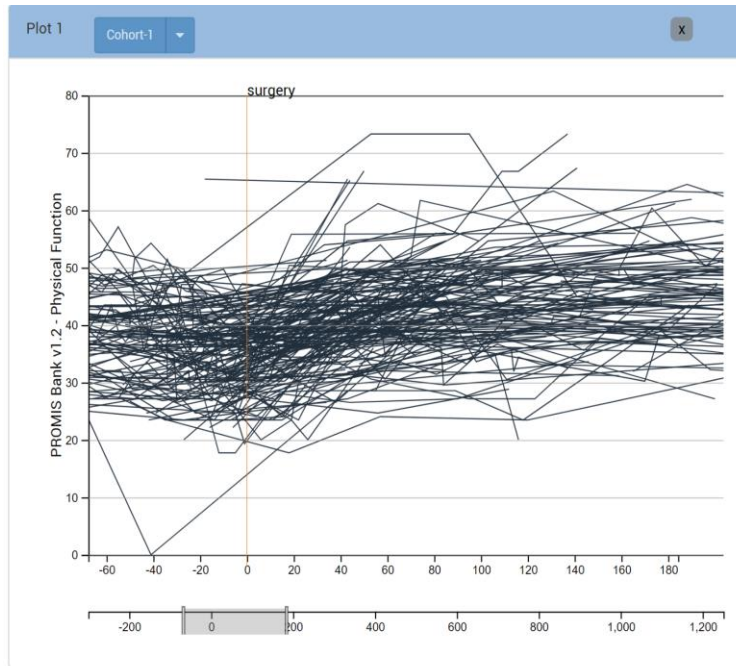


Aligning  
by event



Patient score trajectories have **different baselines**

Small change (2-8) **clinically meaningful**



Hard to see **measured change** in scores

Cohort Control  
+1 clear all

Cohort-1  + x

Demographic Filters +

Score Filters +

Applied Filters +

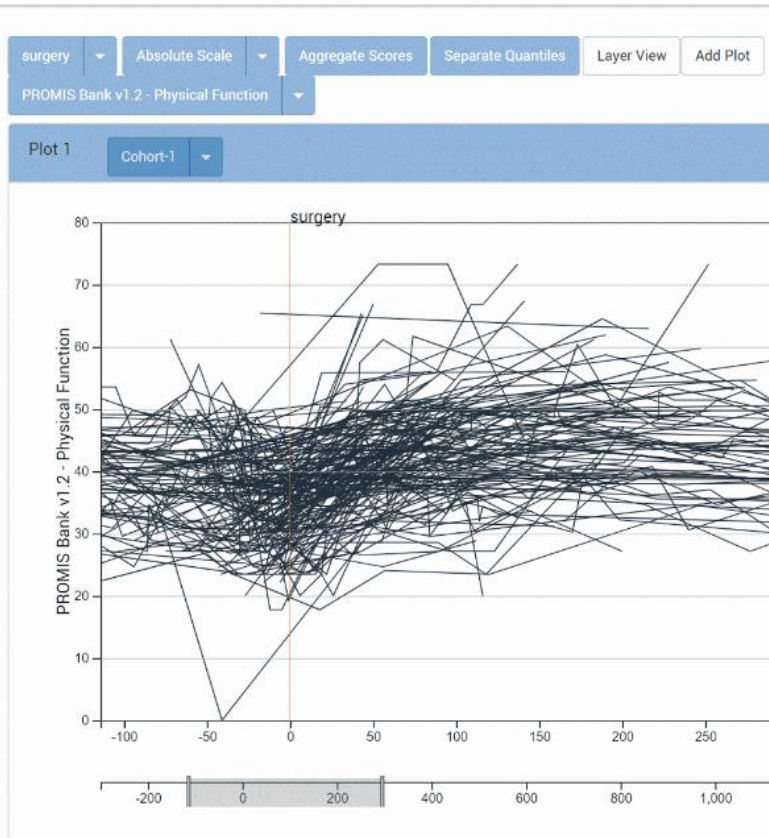
CPT Filters +

Cohort-1 Filter Layers

63030 Search

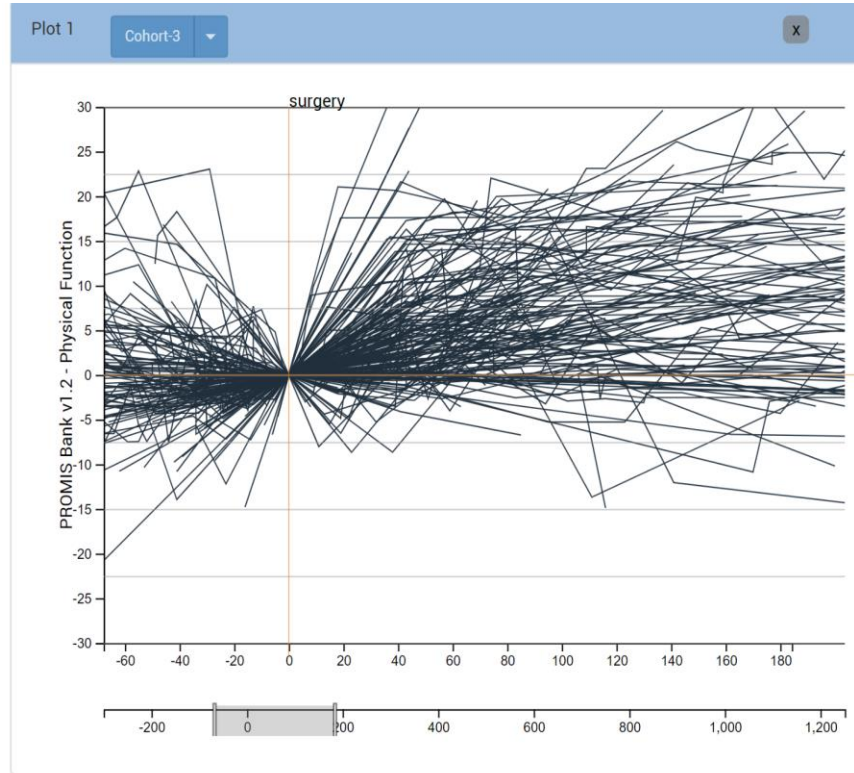
Cohort Size: 361

- 1: All Patients 6069 x
- 2: surgery 361 x

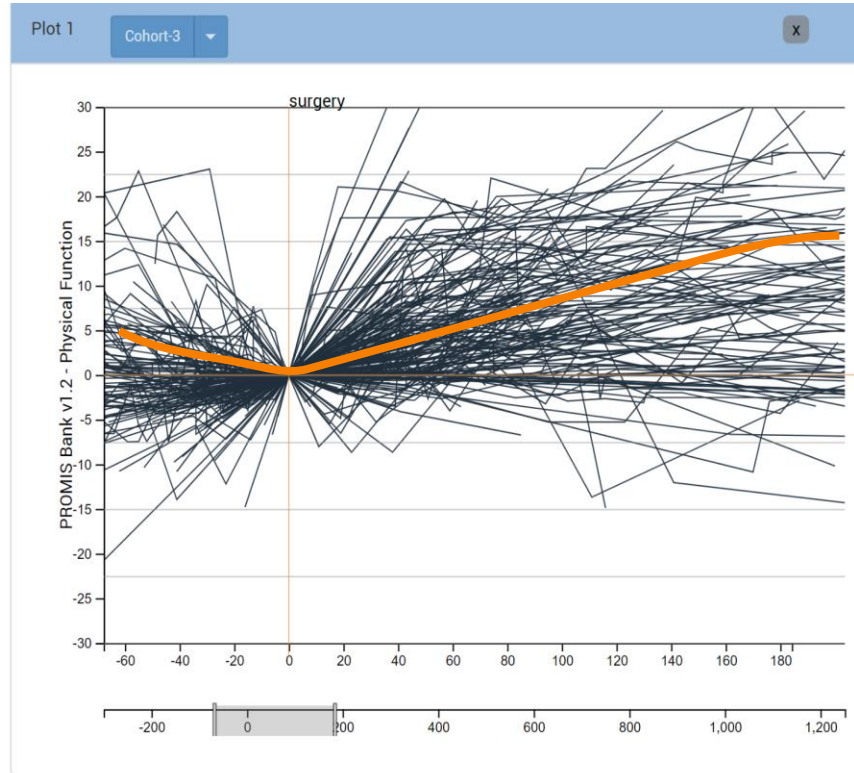


Changing scales to relative score change





This is messy.



We want to see the **general trend** in score fluctuation

Cohort Control

+1 clear all

Cohort-1 + x

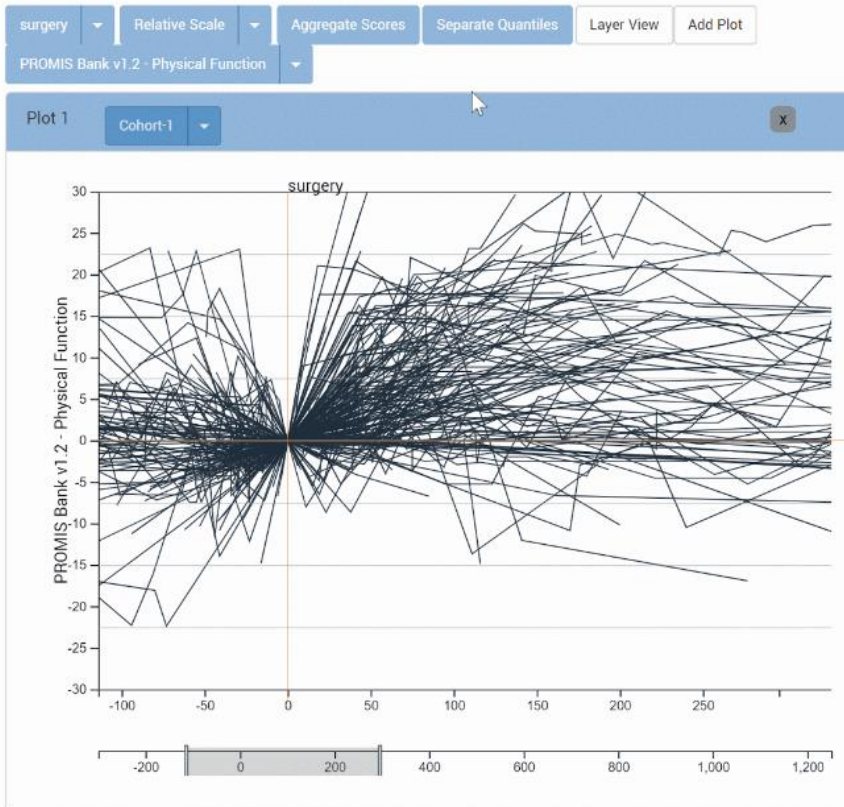
Applied Filters +

Cohort-1 Filter Layers

Cohort Size: 361

1: All Patients 6069 x

2: surgery 361 x

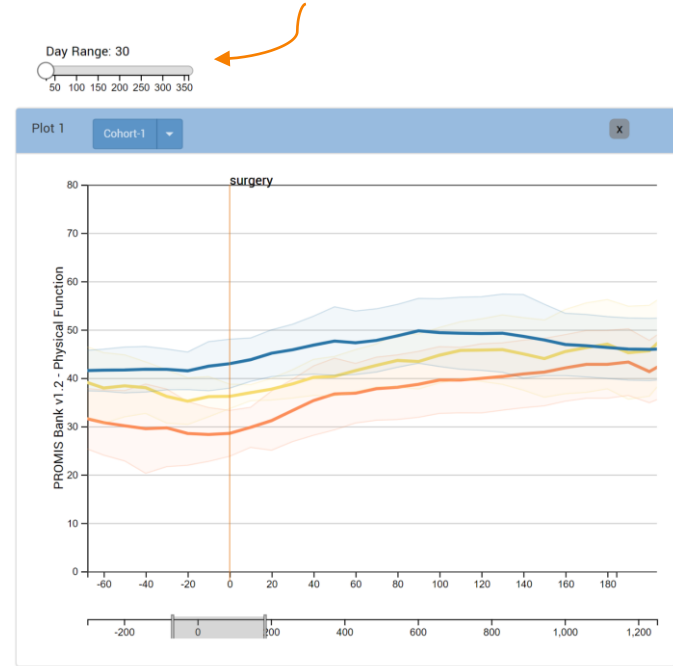
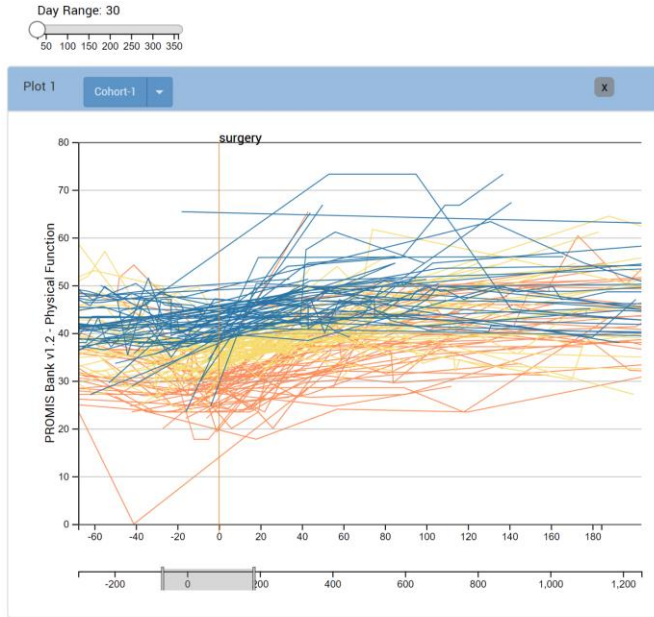


Aggregation  
of scores

How did the patients with the most **positive change** in score progress?

What about the **bottom quantile** for score change?

Adjust the day range to calculate average score change.



Separation of Scores by Quantiles.

How did patients like Frank progress **after surgery vs injection?**

Cohort Control

+1 clear all

Cohort-1 + x

Cohort-2 + x

Layer Control

Layer-1 Layer-2

Applied Filters +

injection Absolute Scale Aggregate Scores Separate Quantiles Layer View Add Plot

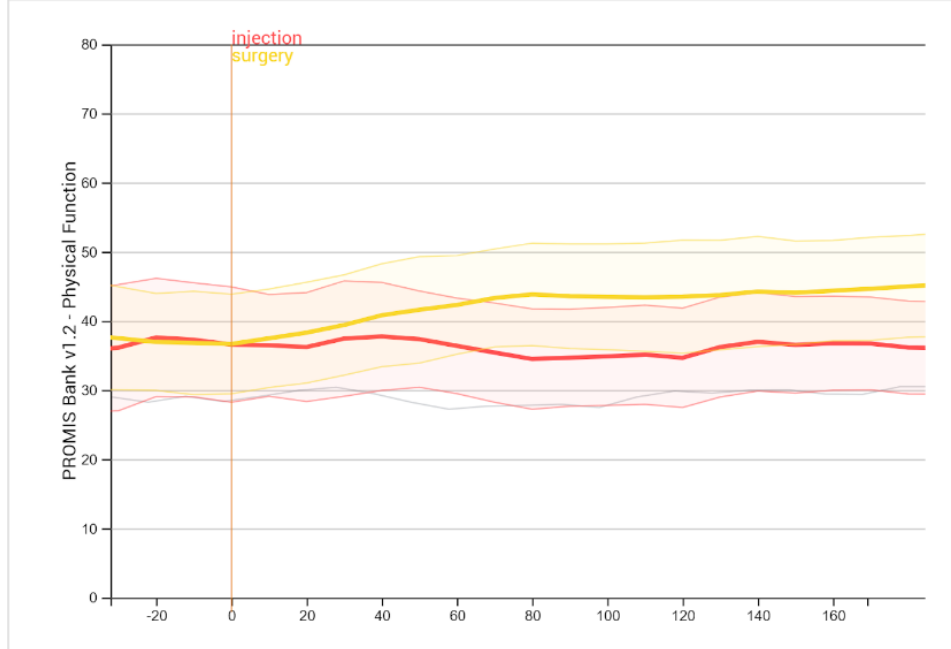
PROMIS Bank v1.2 - Physical Function

Cohort-1 Filter Layers

Cohort Size: 146

1: All Patients	6069	x
2: injection	152	x
3: Excluding surgery	146	x

Plot 1 Cohort-1 x

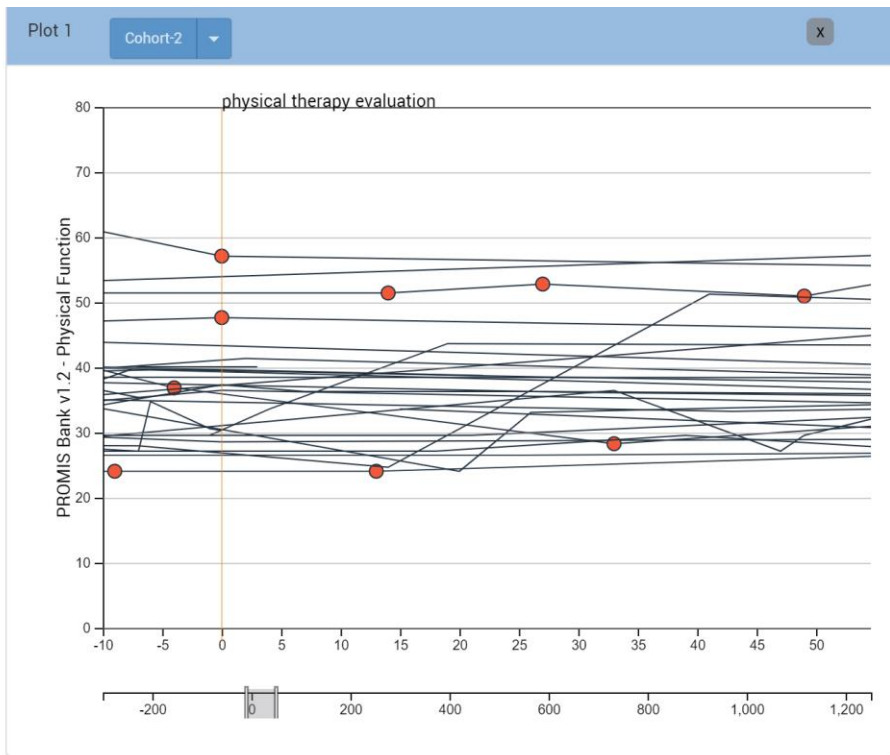


Compare cohorts in layer view

We find a patient line of interest

What **other events** are present in their medical histories?





Drill down into **individual patient histories**

4158325  
5265384  
13507793  
13641782  
20563421



# Moving Forward

**Generalize** to a broader clinical base

Development of a **shared decision-making interface**

# Thank You

Learn more about our lab:

<http://vdl.sci.utah.edu/>

Learn more on the project website:

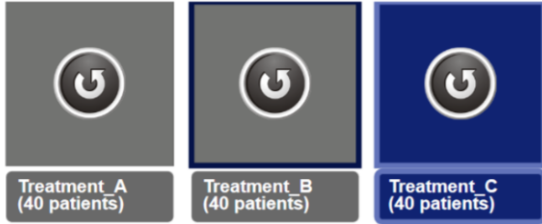
[http://bit.ly/composer\\_paper](http://bit.ly/composer_paper)



# Comparison of multiple treatment outcomes.

Treatment Comparison Prepared for:

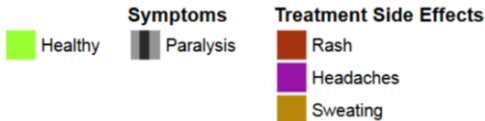
C. Oswald



Treatment\_C

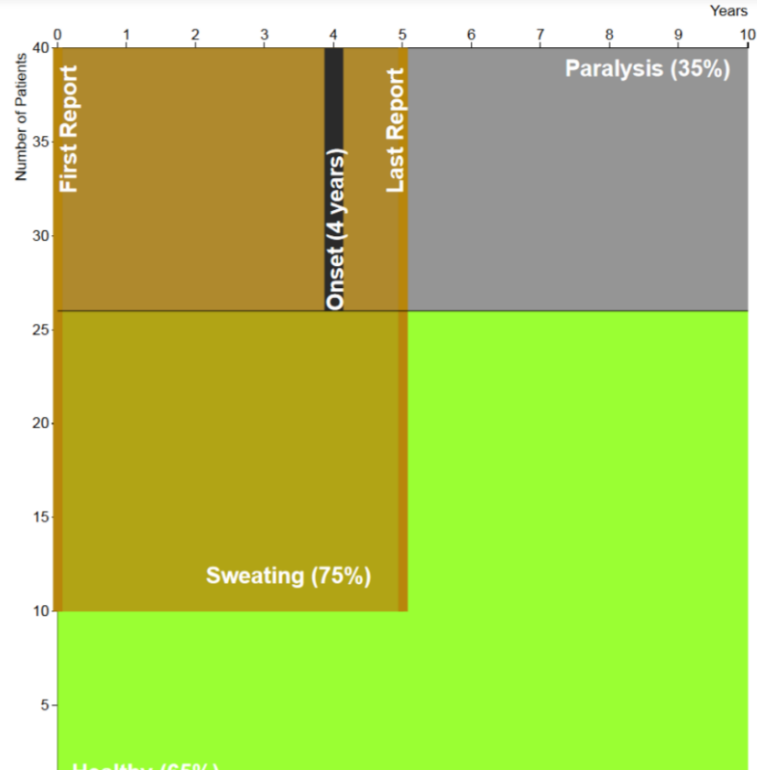
- 65% of patients who choose Treatment\_C remain healthy.
- 35% of patients who choose Treatment\_C develop Paralysis
- Their average onset of Paralysis is 4 years.
- 75% of patients report Sweating. The earliest report is 0 years after treatment. The latest report is 5 years after treatment.

Color Guide



Hide In-Graphic Labels

Show Exact Distribution



Franklin, L., Plaisant, C., Minhazur Rahman, K. and Shneiderman, B., 2014. TreatmentExplorer: An interactive decision aid for medical risk communication and treatment exploration. *Interacting with Computers*, 28(3), pp.238-252.

## Separating By quantiles

Utah Health  
Using **PROMIS** scores longer than any other  
institution in the country.

**PROMIS physical function** scores.

The screenshot displays the 'COMPOSER' interface. At the top, there is a 'Cohort Control' section with a '+ 1' button and a 'clear all' button. Below this, four cohorts are listed: Cohort-1 (red), Cohort-2 (yellow), Cohort-3 (green), and C-3 Branch-1 (teal). Cohort-3 is expanded to show C-3 Branch-1. Each cohort has a '+' button for adding and an 'x' button for deleting. Below the cohorts is an 'Applied Filters' section with a '+' button. The 'C-3 Branch-1 Filter Layers' section shows a list of filters with their respective patient counts and delete buttons:

Filter Layer	Count	Action
1: All Patients	6069	x
2: surgery	361	x
3: Excluding injection	355	x
4: AGE	185	x
5: BMI	139	x

## Cohort control panel.

Cohorts can be added, branched and deleted.

# Adding, Branching, Removing Cohorts