A Visual Analysis Approach to Cohort Study of Electronic Patient Records

Chun-Fu Wang[1], **Jianping Li**[1], Kwan-Liu Ma[1],
Chih-Wei Huang[2], Yu-Chuan Li[2]

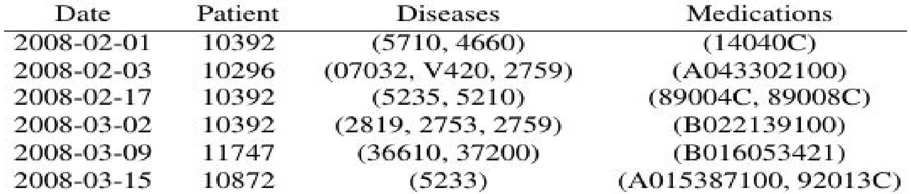
1 University of California at Davis
2 Taipei Medical University

ViDi
Visualization & Interaction
Design Institute

Electronic Medical Record (EMR)

- Rich information, great value
- 500 petabytes in 2012, 25000 petabytes expected in 2020
- Large and complex - challenges and opportunities

Challenges to Analyze EMRs



Date	Patient	Diseases	Medications
2008-02-01	10392	(5710, 4660)	(14040C)
2008-02-03	10296	(07032, V420, 2759)	(A043302100)
2008-02-17	10392	(5235, 5210)	(89004C, 89008C)
2008-03-02	10392	(2819, 2753, 2759)	(B022139100)
2008-03-09	11747	(36610, 37200)	(B016053421)
2008-03-15	10872	(5233)	(A015387100, 92013C)

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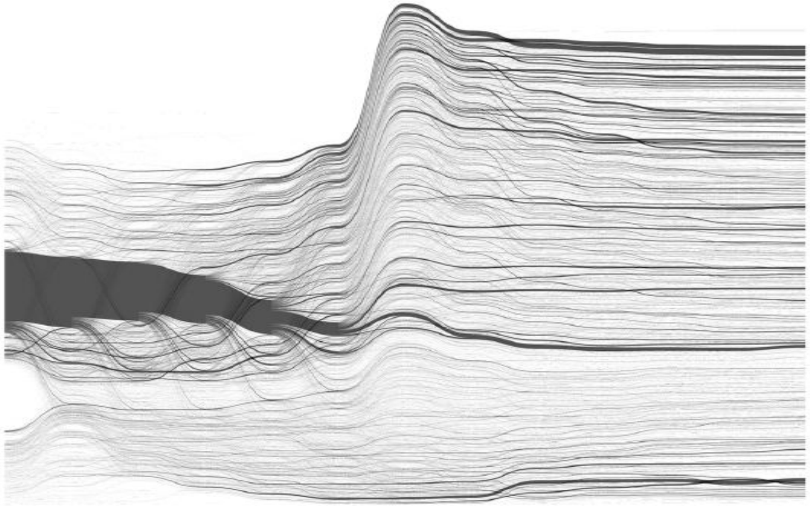
Complexities in EMR

- multidimensional
- high variance



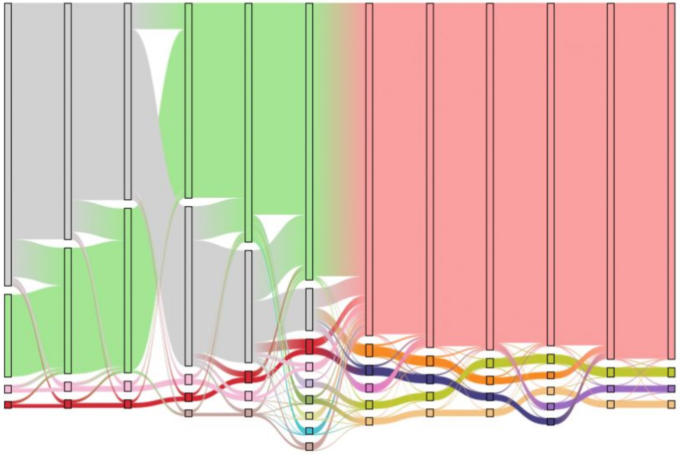
14,567 patients histories in 24 years

Opportunities for EMR Visual Analysis

EMRs

+

Domain Expertises



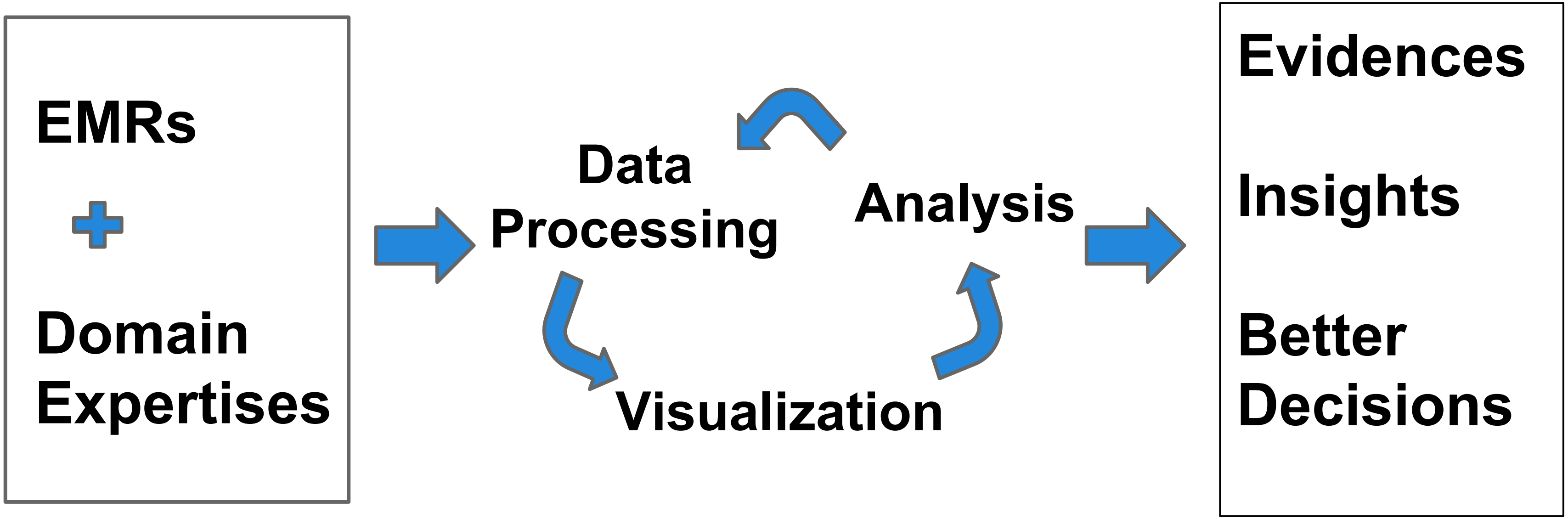
Visual Mining and Analysis

Evidences

Insights

Best Decisions

Iterative Visual Mining



EMRs

+

Domain Expertises

Data Processing

Analysis

Visualization

Evidences

Insights

Better Decisions

Our Approach

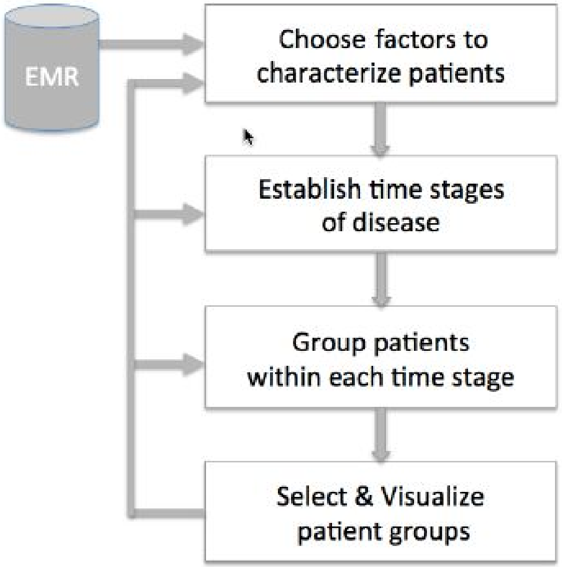
- An iterative workflow for analyzing large and complex EMR data.
- An interactive visualization system to support exploration of EMRs

Related Work

- **LifeFlow** - novel visualization tool to simplify and aggregate temporal event sequences into a tree-based summary
- **V-model** - compressed causal relationship along the linear time-scale to an ordinal representation
- **LifeLines2** - visual summary of prevalence and comparison of multiple groups

Workflow

- Choose factors based user knowledge
- Filter patient records using the factors
- Define time stages by partition and align
- Aggregate patients into groups(cohorts)



EMR

Choose factors to characterize patients

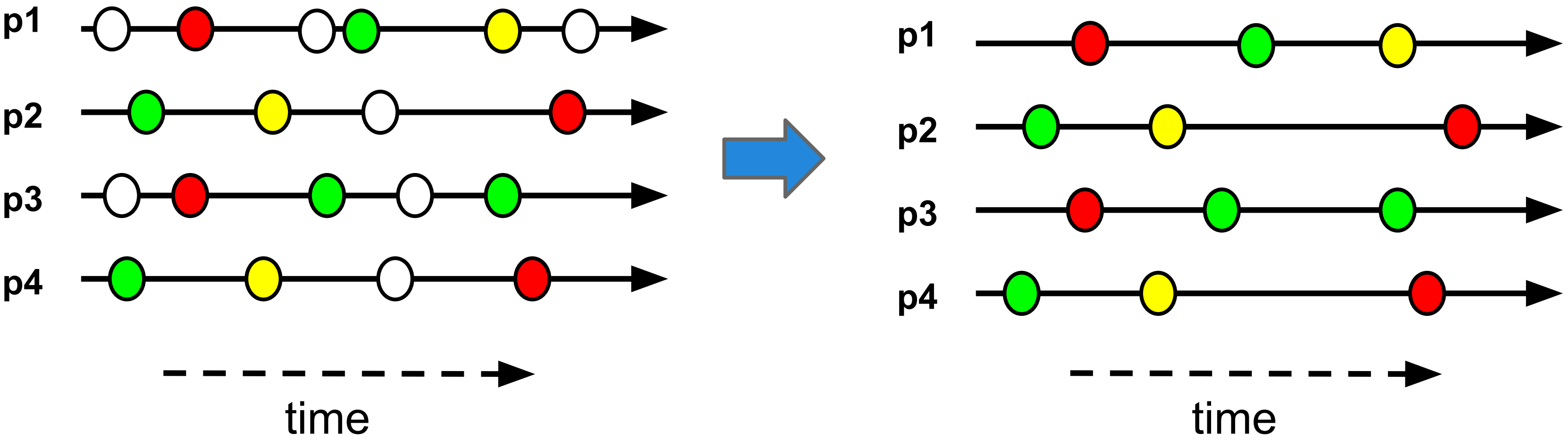
Establish time stages of disease

Group patients within each time stage

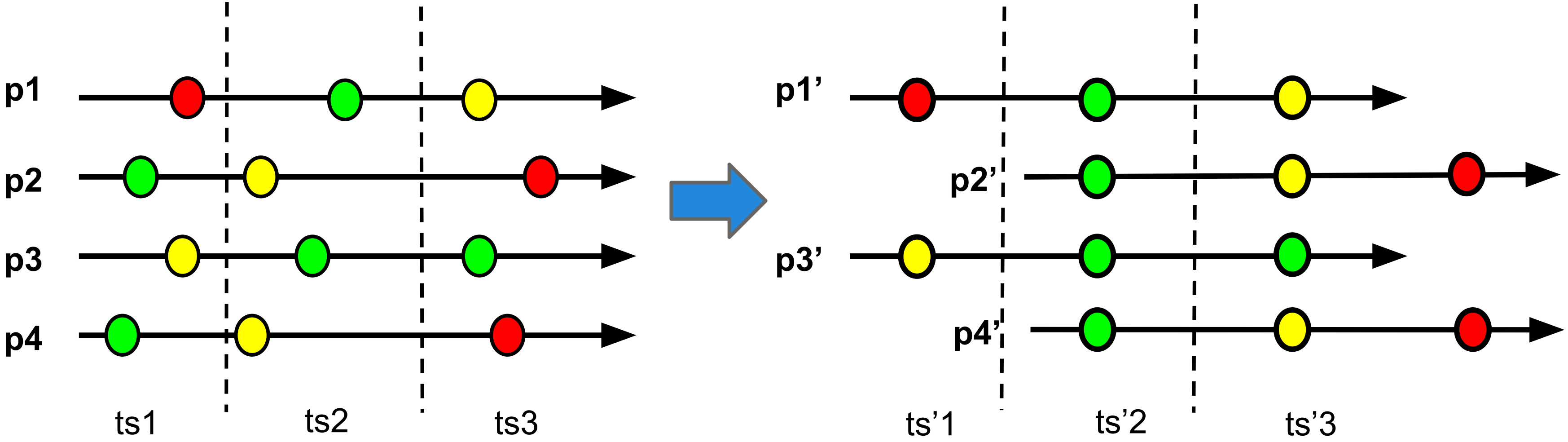
Select & Visualize patient groups

Factors and Filtering

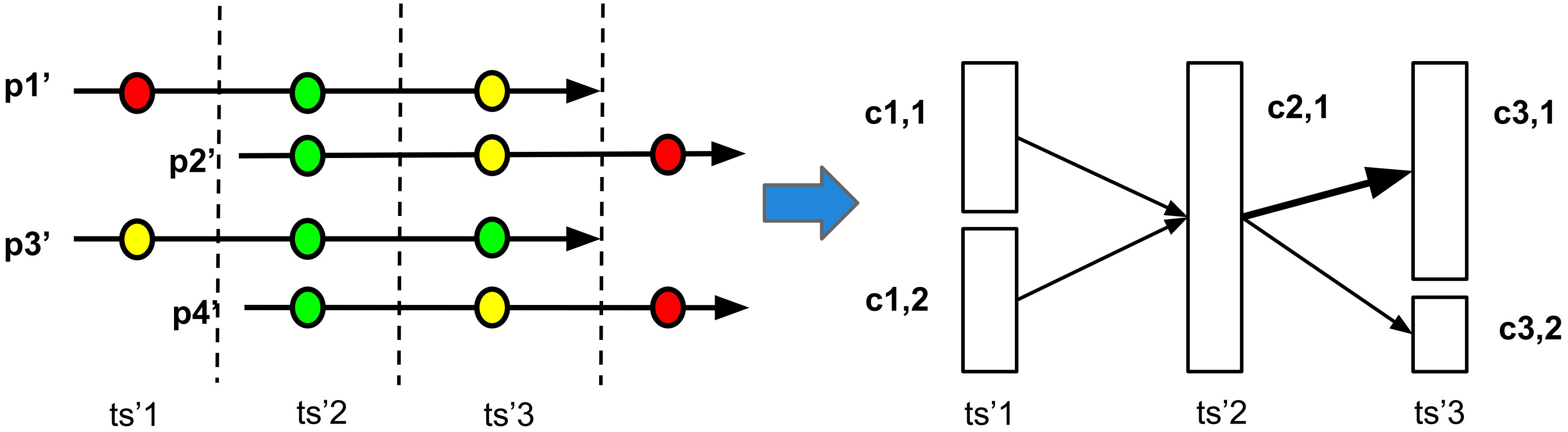
Factors (diseases): 🔴 🟢 🟡



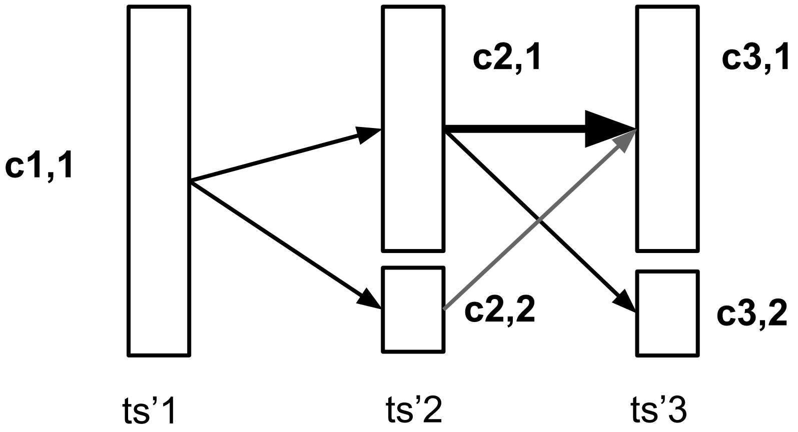
Partitioning and Aligning

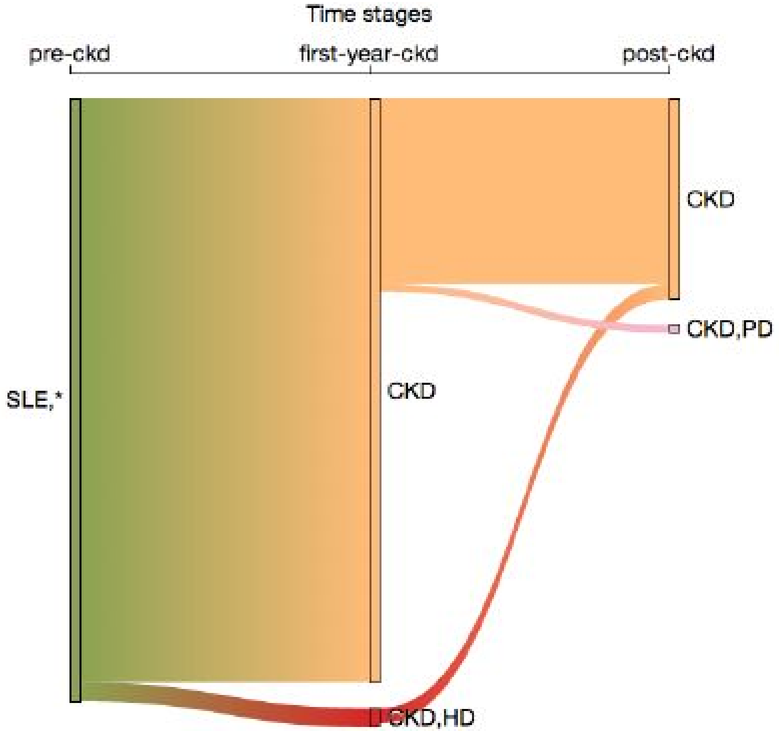


Aggregating to Cohorts

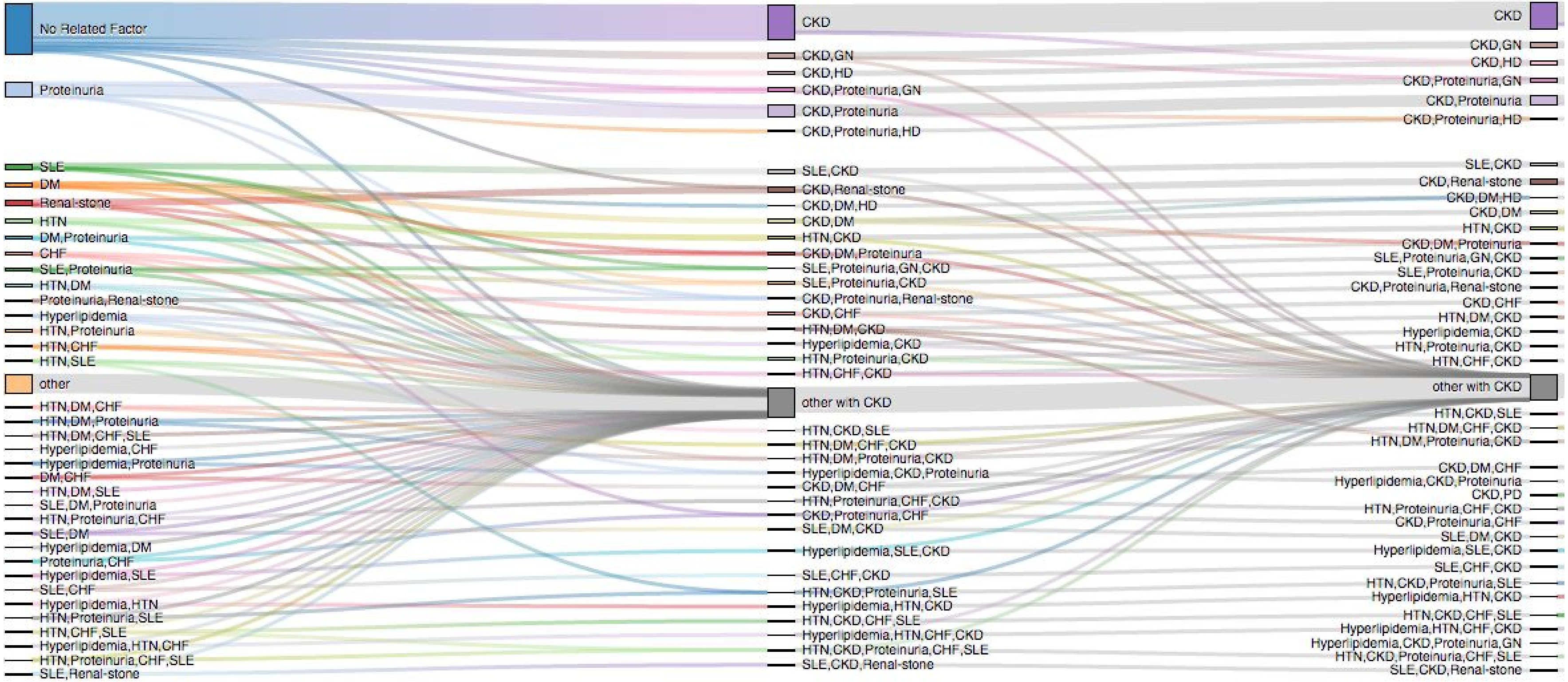


Visual Representation





But with Big Data ...



Cohorts Clustering

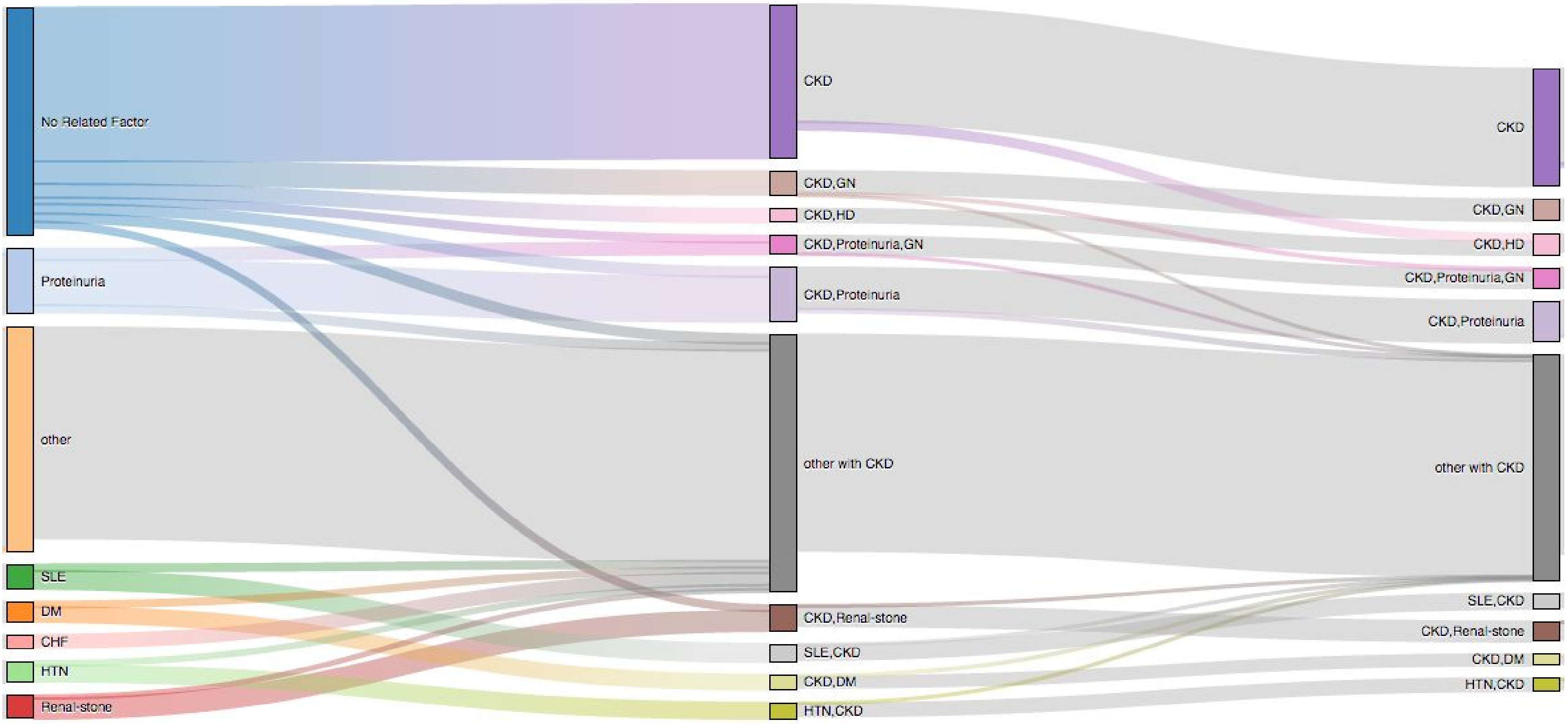
- Frequency-based clustering:
  - aggregate small cohorts into a cluster if the number of patient in the cohort is below the threshold

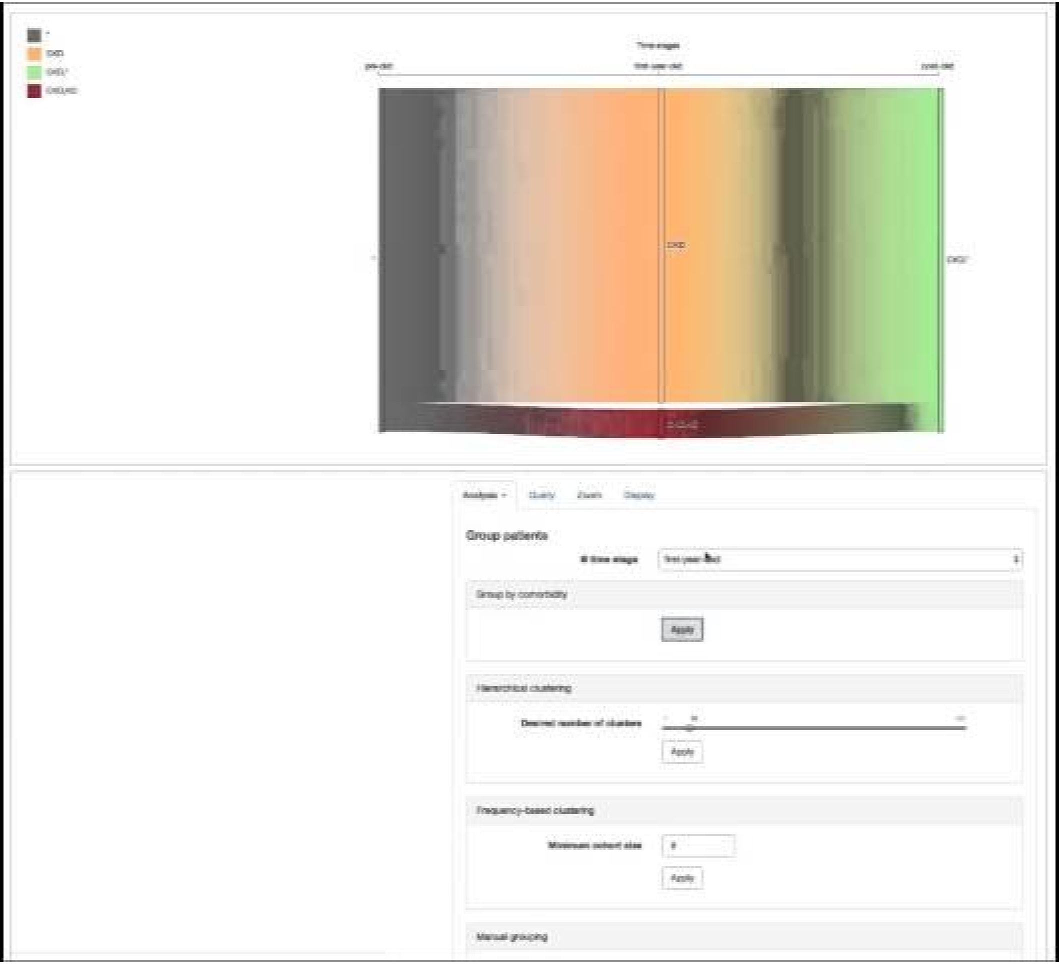
$$\text{cluster}\left(\mathbf{C}_l\right) = \begin{cases} \mathbf{c}_{l,h} & \text{if } \left|\mathbf{c}_{l,h}\right| \geq x \\ \text{others} & \text{if } \left|\mathbf{c}_{l,h}\right| < x \end{cases}$$

- Hierarchical clustering
  - cluster the cohorts based on the common factors

$$\text{similarity} = \frac{\left|\mathbf{s}_1 \cap \mathbf{s}_2\right|}{\sqrt{\left|\mathbf{s}_1\right| \left|\mathbf{s}_2\right|}}$$

Frequency-based Clustering (threshold=300)





Group patients

At time stage: first-year-dial

Group by comorbidity

Hierarchical clustering

Desired number of clusters

Frequency-based clustering

Minimum cohort size: 8

Manual grouping

Case Study - Chronic Kidney Disease(CKD)

14,567 CKD patients extracted from Taiwan NHIDB with over 1 million patients

- Dataset:
  - 6 million records
  - from 1998 to 2011
- Codes:
  - ICD 9-CM
  - NHIDB procedure/drug

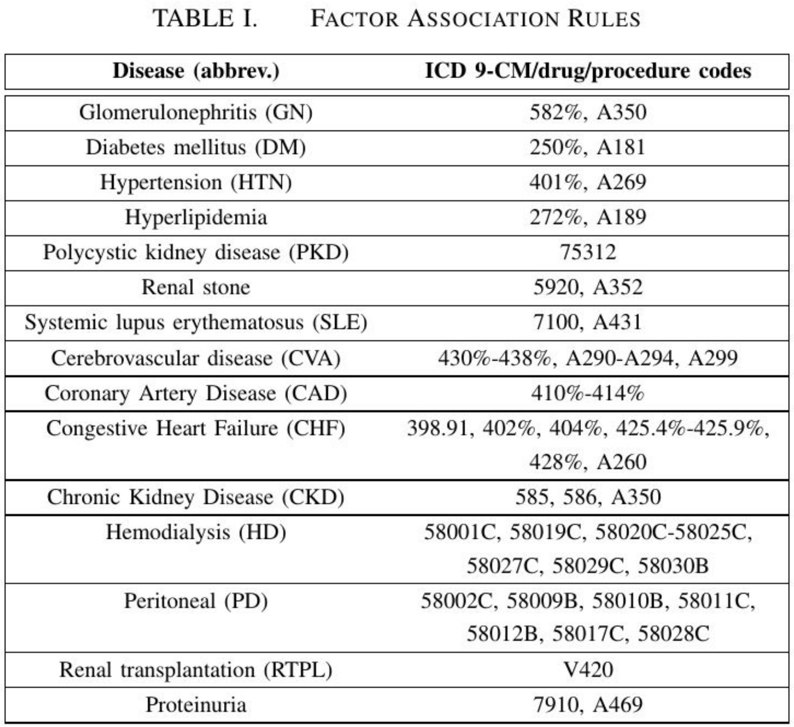
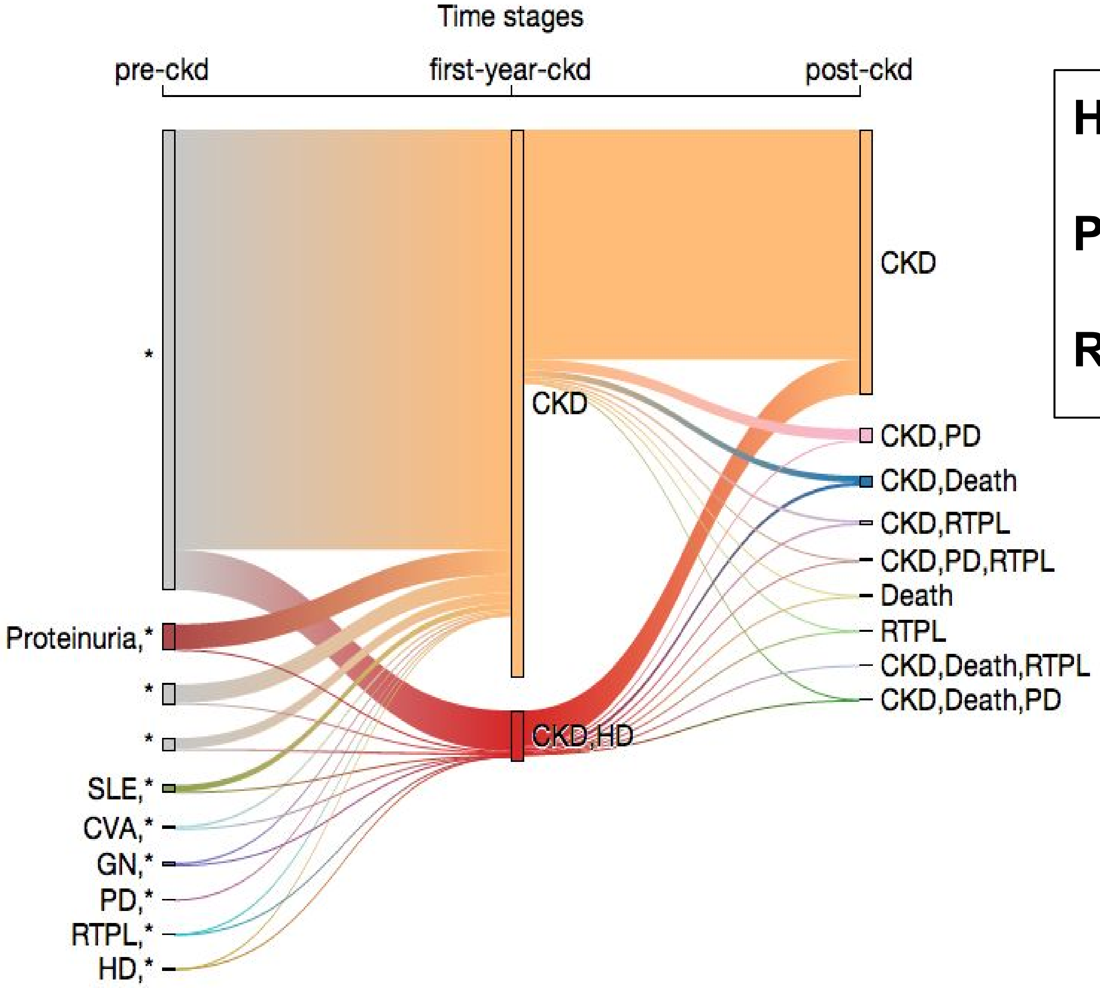


TABLE I. FACTOR ASSOCIATION RULES

Disease (abbrev.)	ICD 9-CM/drug/procedure codes
Glomerulonephritis (GN)	582%, A350
Diabetes mellitus (DM)	250%, A181
Hypertension (HTN)	401%, A269
Hyperlipidemia	272%, A189
Polycystic kidney disease (PKD)	75312
Renal stone	5920, A352
Systemic lupus erythematosus (SLE)	7100, A431
Cerebrovascular disease (CVA)	430%-438%, A290-A294, A299
Coronary Artery Disease (CAD)	410%-414%
Congestive Heart Failure (CHF)	398.91, 402%, 404%, 425.4%-425.9%, 428%, A260
Chronic Kidney Disease (CKD)	585, 586, A350
Hemodialysis (HD)	58001C, 58019C, 58020C-58025C, 58027C, 58029C, 58030B
Peritoneal (PD)	58002C, 58009B, 58010B, 58011C, 58012B, 58017C, 58028C
Renal transplantation (RTPL)	V420
Proteinuria	7910, A469

Case Study Objectives

- Investigate CKD related diseases co-occurrence (comorbidity)
- Explore the causal relationship between hemodialysis (HD) and other factors in early stage of CKD and identify the common driving factors of HD
- Explore global structures of cohorts and their changes over time stages

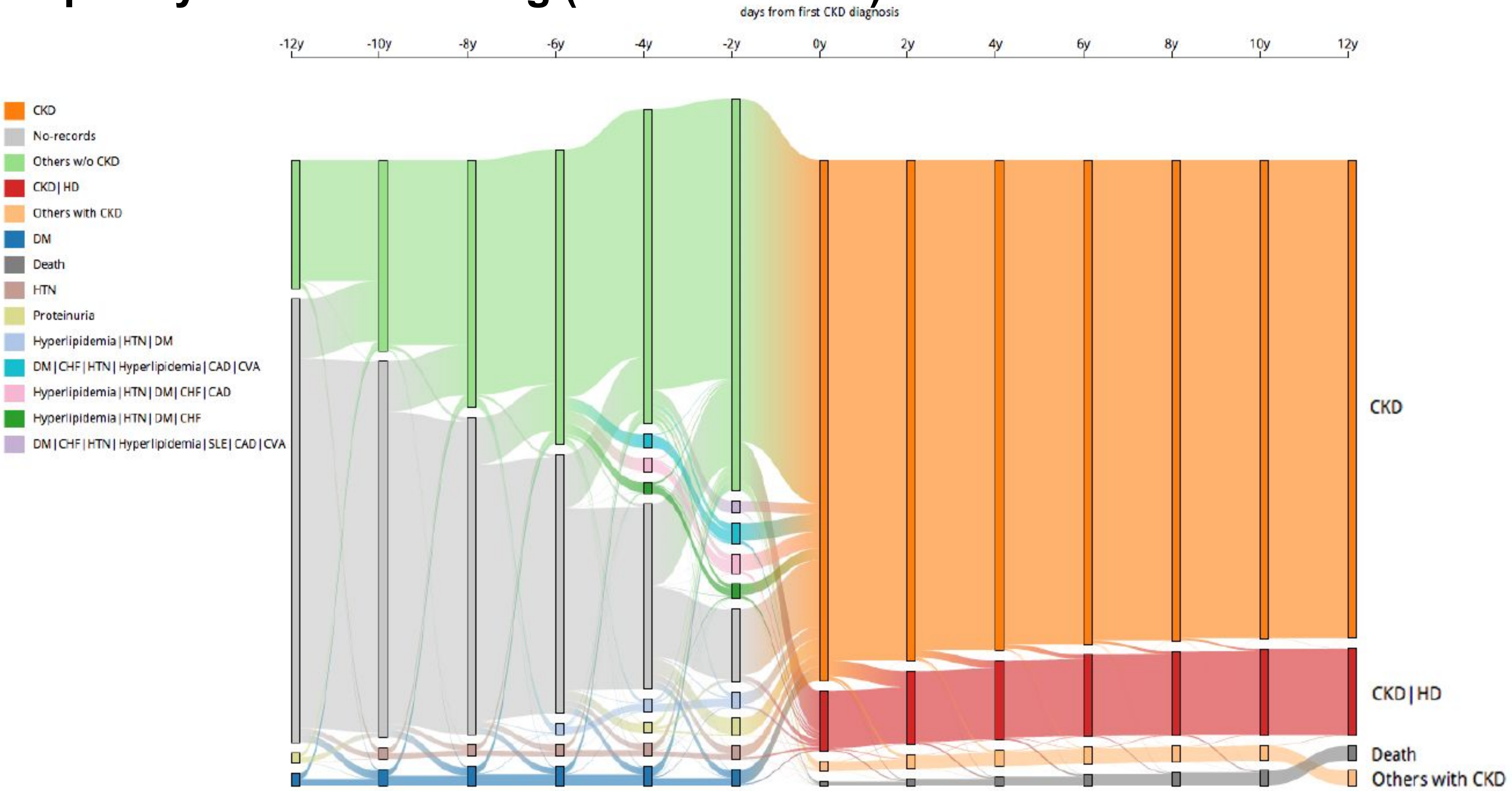


HD - Hemodialysis

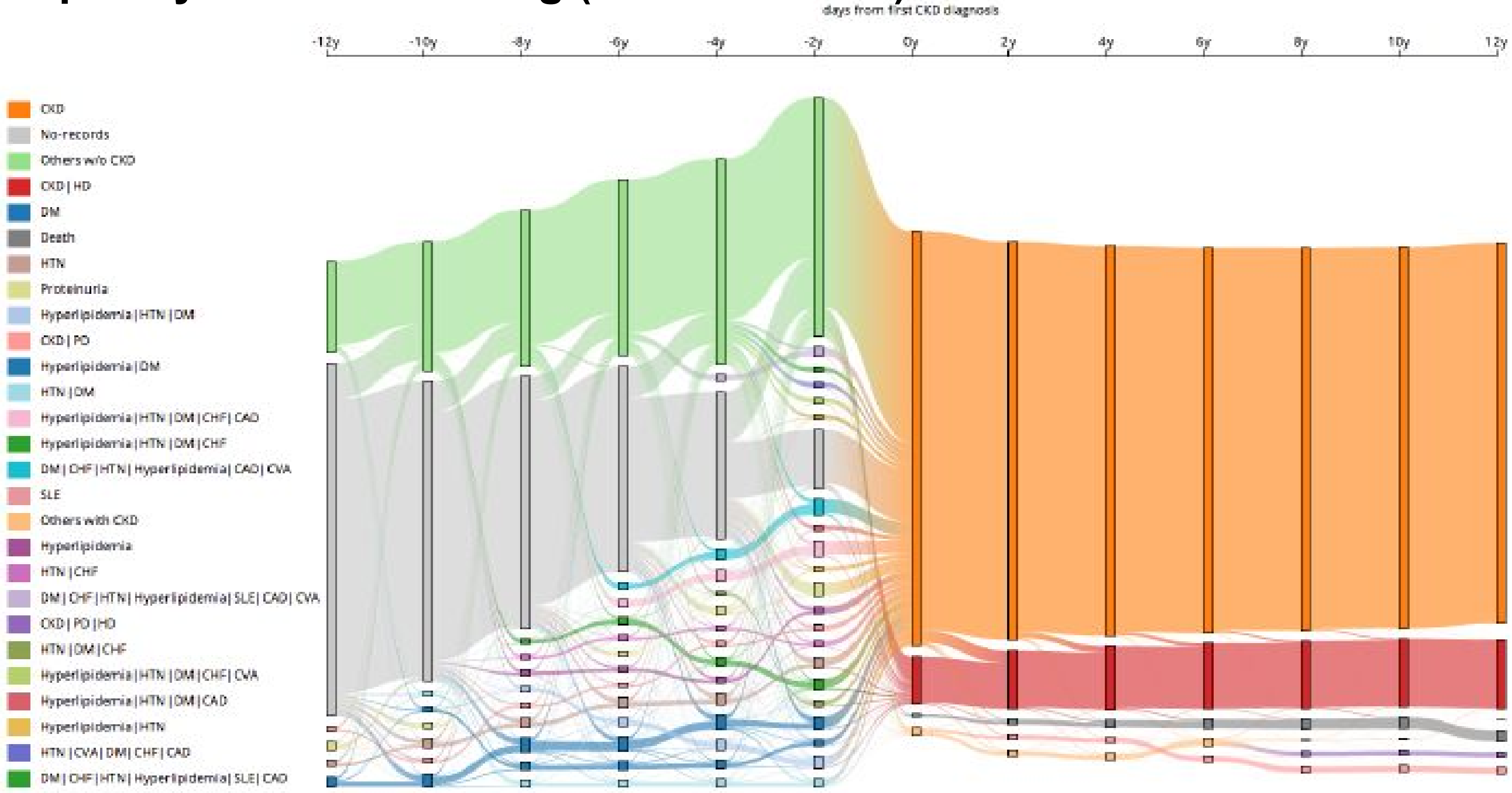
PD - Peritoneal

RTPL - Renal Transplantation

Frequency-based clustering (threshold=250)



Frequency-based clustering (threshold=150)



Conclusion

- EMRs
  - Large and complex
  - Rich and valuable information
- A new EMR visualization tool
  - An iterative process for EMR visual mining
  - An interactive system for visual analysis of EMR

Future Work

- Usability evaluation and improvement
- Comparative visualization
- High performance and scalable visual analytics system for large scale EMR data

Acknowledgement

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Thank You