Temporal Clinical pathways as risk markers in T2D Patients

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Introduction

Chronic T2D patients

Histories lasts 10+ years

Histories are composed by:
Follow-up visits – Drug purchases
Hospitalization for acute events

Diabetes Chronic Complications
EU funded project

Models and simulation techniques for discovering diabetes influence factors
Data gathering

CLINICAL

- FROM HOSPITALS
- Follow up visits
- Medications
- Labs

What happens to the patient inside the hospital

ADMINISTRATIVE

- FROM LOCAL HEALTHCARE AGENCIES
- Drugs Purchases
- Hospitalizations

What happens to the patient outside the hospital

ENVIRONMENTAL

- FROM REGIONAL OPEN DATA
- Temperatures
- Pollution

Environmental conditions in which subjects are involved

Data set → 1.000 T2D patients from Pavia Hospital
The technical infrastructure

- Regular data entry
- Periodic data sync
- T2DM EMR
  - Administrative Data (ASL)
    - Periodic update
    - Temporal Abstractions (JTSA)
  - I2b2 DW
    - Query Engine
      - Data Mining Module
    - Dashboard
The technical infrastructure

- **T2DM EMR**
- **I2b2 DW**
- **Administrative Data (ASL)**
- **Dashboard**
- **Query Engine**
- **Data Mining Module**

**Data collection and storage**

- Regular data entry
- Periodic data sync
- Periodic update
The technical infrastructure

Analysis tools and user interface

- T2DM EMR
- Administrative Data (ASL)
- Temporal Abstractions (JTSA)
- I2b2 DW
- Data Mining Module
- Query Engine
- Dashboard
Methods – Markers from patterns of drug purchases

Each drug purchase is described by its Defined Daily Dose (DDD) that allows computing the expected number of therapy days related to that purchase.
Expected drug purchases in a semester (182 days) are calculated as:

\[ EDP = \frac{DDD}{182 \text{ days}} \]
b. Patients stratification on the basis of patterns of drug purchase

Less than expected (non adherent)  
Expected (adherent)  
More than expected (over adherent)
1. For each patient and each drug:
   - calculate median values of EDP for the whole prescription period
   - classify if **LESS** or **MORE ADHERENT** compared with median values of the population EDP (Wilcoxon Rank-Sum Test)

2. For each patient and each drug labeled as MORE ADHERENT
   - if median values are <100% then classify as **ADHERENT**
   - if median values are >100% then classify as **OVER ADHERENT**

3. For each patient:
   - count the number of drugs for which the patient is NON - ADHERENT – OVER
   - If the behavior is detected for >50% over the total drug purchased then classify as **NON – ADHERENT – OVER** Adherent
Adherence patterns

- Non adherent: 47%
- Adherent: 29%
- Over adherent: 24%
Results – Over adherent population

Complications

- Chronic ischemic heart disease: 23.08%
- Fat Liver Disease: 3.33%
- Nephropathy: 19.23%
- Neuropathy: 19.23%
- Occlusion and stenosis of carotid artery: 15.38%
- Peripheral vascular disease: 11.54%
- Retinopathy: 7.69%
Results – Over adherent population

Diet

<table>
<thead>
<tr>
<th>Category</th>
<th>BAD</th>
<th>GOOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non Adherent</td>
<td>176</td>
<td>283</td>
</tr>
<tr>
<td>Adherent</td>
<td>83</td>
<td>197</td>
</tr>
<tr>
<td>Over Adherent</td>
<td>99</td>
<td>140</td>
</tr>
</tbody>
</table>

p-value <<0.001
Results – Over adherent population

**Clinical variables**

**BMI**
- Not Adherent
- Adherent
- Over Adherent

p-value << 0.0001

**HbA1c**
- Not Adherent
- Adherent
- Over Adherent

p-value << 0.001
Kruskal-Wallis chi-squared = 31.6139, df = 2, p-value = 1.365e-07
Pavia’s District and environmental data

Endocrine, nutritional and metabolic diseases hospitalizations - % on TOTAL of hospitalization

Lomellina: 8.6%
Pavese: 9.5%
Oltrepo: 10.1%
With satellites – air quality data
February 14, 2013: Air quality

Very Good  Good  Medium  Bad  Very Bad
What’s happening to the patients treated by the hospital?

Hospitalization (%)

- **PAVESE**
  - Feb: 27.14%
  - Giu: 38.57%
  - Ago: 25.71%
  - Dic: 41.67%

- **OLTREPO**
  - Feb: 8.33%
  - Giu: 25.00%
  - Ago: 25.00%
  - Dic: 8.57%

- **LOMELLINA**
  - Feb: 31.58%
  - Giu: 26.32%
  - Ago: 21.05%
  - Dic: 21.05%
But ... be careful

Divorce rate in Maine correlates with Per capita consumption of margarine (US)

Correlation: 0.992558  Spurious correlations
Conclusion and Future Works

• Implementation of a framework able to integrate heterogeneous temporal data from different hospitals
• A system dedicated to find meaningful healthcare pathways in chronic T2D patients
• Patterns mining to identify group of patients with similar disease progression
• Behaviours detection to identify the most critical situations

• Application of the framework to the complete data set (Pavia, Valencia and Athens data ➔ over 3,000 subjects)
• Validation with policy makers and clinicians
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UNIVERSITÀ DI PAVIA
**The Dashboard - Hospital Care management**

**a.** The user can choose a patient set through the distribution of clinical variables related to the cohort

- Day Hospitals
- High BG Level
- Acute CV Event
- Acute CV Event
- Day Hospitals
- Adherence to Diet
- Good BG Control
- Poor BG Control
- Metformin prescription
- High Cholesterol Level

**b.** the most frequent pathways are mined, retrieved and shown

- Cardiovascular: 53%
- Retinopathy: 22%
- Neuropathy: 15%
- Nephropathy: 10%

**c.** the user can select a particular pathway to investigate

**d.** the main characteristics of the selected population are displayed
The Dashboard - Clinical Decision support

a. Selection of a single patient to investigate

b. Histories of the selected subject are displayed

c. The individual pattern history is compared with histories of similar patients

Complexity disease stage

| STABLE | First COMPLICATION | HOSPITALIZATION |

Therapy Adherence - Metformin

| Adherent | NOT Adherent | Interrupted |

Life Style

| Diet: Good | Weight on Target | Diet: Bad |

Blood Glucose control

Optimum Follow Up

- Check Metformin Adherence
- Check Diet
- Blood Glucose Test