Machine Learning & Decision Support in Healthcare

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Financial Disclosures

• None
Presentation Overview

- What is Machine Learning & how is it integrated into practice
- Coming of age of pharmacogenomics in decision support
Machine Learning

- Branch of AI where systems can learn from data, pattern recognition, and decision making.

https://www.ibm.com/analytics/machine-learning
Common Machine Learning Applications

- Amazon recommendations (Market Basket Analysis)
  - Pattern recognition ➔ Ex: If you buy salsa, what else will you buy?
More Machine Learning Applications

• Fraud Detection

Machine Learning Model

STEPS:
• Data from warehouse
• Determine health factors
• Split data → Training/Test
• Feed data into algorithms
• Analyze performance of algorithms
• Best performing algorithm becomes the model (least error – most correct classification)

https://orange.biolab.si/
Data Mining
Fruitful and Fun

Open source machine learning and data visualization for novice and expert. Interactive data analysis workflows with a large toolbox.

Download Orange
Classify Your Data

Transforming non-linear data by adding new dimension and using a hyperplane to classify data.

2D Space

3D Space

Hyperplane

Mapping Function

\( \varphi(x_1, x_2) = (x_1, x_2, z) \)
Projections
Variation in Data

Splitting data / classifying data using decision tree: The split will keep on going until there is variation in data.
• Analysis of health data can lead to \(\rightarrow\) Pattern Recognition
  – Labs
  – Vitals
  – Medications
  – Compliance
  – Follow up
  – Diagnoses
  – Genomics

• Pattern Recognition leads to \(\rightarrow\) PREDICTION
Example of Data Input (Social Determinants)

- Basic item defining factors
- Z-codes: social determinant codes
**Social Determinants of Health ICD-10 Code List**

Beginning on March 1st, 2018, the following ICD-10 diagnosis codes will be defined as **Social Determinants of Health** codes.

Please note that Social Determinants of Health codes may be added to or updated on a quarterly basis. Providers should remain current in their thorough utilization of these codes.

<table>
<thead>
<tr>
<th>ICD-Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z550</td>
<td>Illiteracy and low-level literacy</td>
</tr>
<tr>
<td>Z551</td>
<td>Schooling unavailable and unattainable</td>
</tr>
<tr>
<td>Z552</td>
<td>Failed school examinations</td>
</tr>
<tr>
<td>Z553</td>
<td>Underachievement in school</td>
</tr>
<tr>
<td>Z554</td>
<td>Educational maladjustment and discord with teachers and classmates</td>
</tr>
<tr>
<td>Z558</td>
<td>Other problems related to education and literacy</td>
</tr>
<tr>
<td>Z559</td>
<td>Problems related to education and literacy, unspecified</td>
</tr>
<tr>
<td>Z560</td>
<td>Unemployment, unspecified</td>
</tr>
<tr>
<td>Z561</td>
<td>Change of job</td>
</tr>
<tr>
<td>Z562</td>
<td>Threat of job loss</td>
</tr>
</tbody>
</table>
Ability to Localize Care Needs
End Goal

• Patient outreach:
  – Programs built around advanced analytics
  – How will you do with these patients?
## Social Determinants of Health for PTSD

<table>
<thead>
<tr>
<th>ICD-10 Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z560</td>
<td>UNEMPLOYMENT, UNSP</td>
</tr>
<tr>
<td>Z5681</td>
<td>SEXUAL HARASSMENT ON THE JOB</td>
</tr>
<tr>
<td>Z5682</td>
<td>MILITARY DEPLOYMENT STATUS</td>
</tr>
<tr>
<td>Z5689</td>
<td>OTHER PROBLEMS RELATED TO EMPLOYMENT</td>
</tr>
<tr>
<td>Z569</td>
<td>UNSP PROBLEMS RELATED TO EMPLOYMENT</td>
</tr>
<tr>
<td>Z590</td>
<td>HOMELESSNESS</td>
</tr>
<tr>
<td>Z591</td>
<td>INADEQUATE HOUSING</td>
</tr>
<tr>
<td>Z594</td>
<td>LACK OF ADEQUATE FOOD AND SAFE DRINKING WATER</td>
</tr>
<tr>
<td>Z595</td>
<td>EXTREME POVERTY</td>
</tr>
<tr>
<td>Z596</td>
<td>LOW INCOME</td>
</tr>
<tr>
<td>Z600</td>
<td>PROBLEMS OF ADJUSTMENT TO LIFE-CYCLE TRANSITIONS</td>
</tr>
<tr>
<td>Z602</td>
<td>PROBLEMS RELATED TO LIVING ALONE</td>
</tr>
<tr>
<td>Z609</td>
<td>PROBLEM RELATED TO SOCIAL ENVIRONMENT, UNSP</td>
</tr>
<tr>
<td>Z62810</td>
<td>PERSONAL HISTORY OF PHYSICAL AND SEXUAL ABUSE IN CHILDHOOD</td>
</tr>
<tr>
<td>Z62811</td>
<td>PERSONAL HISTORY OF PSYCHOLOGICAL ABUSE IN CHILDHOOD</td>
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<tr>
<td>Z62812</td>
<td>PERSONAL HISTORY OF NEGLECT IN CHILDHOOD</td>
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<tr>
<td>Z62819</td>
<td>PERSONAL HISTORY OF UNSP ABUSE IN CHILDHOOD</td>
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<tr>
<td>Z629</td>
<td>PROBLEMS RELATED TO UPBRINGING</td>
</tr>
<tr>
<td>Z630</td>
<td>PROBLEMS IN RELATIONSHIP WITH SPOUSE OR PARTNER</td>
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<tr>
<td>Z634</td>
<td>DISAPPEARANCE AND DEATH OF FAMILY MEMBER</td>
</tr>
<tr>
<td>Z635</td>
<td>DISRUPTION OF FAMILY BY SEPARATION AND DIVORCE</td>
</tr>
<tr>
<td>Z6371</td>
<td>STRESS ON FAMILY DUE TO RETURN OF FAMILY MEMBER FROM MILITARY DEPLOYMENT</td>
</tr>
<tr>
<td>Z6379</td>
<td>OTHER STRESSFUL LIFE EVENTS AFFECTING FAMILY AND HOUSEHOLD</td>
</tr>
<tr>
<td>Z650</td>
<td>CONVICTION IN CIVIL AND CRIMINAL PROCEEDINGS WITHOUT IMPRISONMENT</td>
</tr>
<tr>
<td>Z651</td>
<td>IMPRISONMENT AND OTHER INCARCERATION</td>
</tr>
<tr>
<td>Z652</td>
<td>PROBLEMS RELATED TO RELEASE FROM PRISON</td>
</tr>
<tr>
<td>Z653</td>
<td>PROBLEMS RELATED TO OTHER LEGAL CIRCUMSTANCES</td>
</tr>
<tr>
<td>Z654</td>
<td>VICTIM OF CRIME AND TERRORISM</td>
</tr>
<tr>
<td>Z655</td>
<td>EXPOSURE TO DISASTER, WAR, AND OTHER HOSTILITIES</td>
</tr>
<tr>
<td>Z7141</td>
<td>ALCOHOL ABUSE COUNSELING AND SURVEILLANCE OF ALCOHOLIC</td>
</tr>
</tbody>
</table>
Interpreting Machine Learning Results

- Which algorithmic model predicted most correctly?
  - Training data is classified and can confirm if machine “learned correctly”

<table>
<thead>
<tr>
<th>Predicted</th>
<th>0</th>
<th>1</th>
<th>Σ</th>
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<tr>
<td></td>
<td>0</td>
<td>95.0 %</td>
<td>4.2 %</td>
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<td></td>
<td>1</td>
<td>74.4 %</td>
<td>25.6 %</td>
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<tr>
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<td>Σ</td>
<td>4309</td>
<td>485</td>
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<table>
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<th>Σ</th>
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<td>0</td>
<td>89.0 %</td>
<td>12.0 %</td>
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<tr>
<td></td>
<td>1</td>
<td>65.6 %</td>
<td>34.4 %</td>
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<tr>
<td></td>
<td>Σ</td>
<td>3922</td>
<td>872</td>
</tr>
</tbody>
</table>
Support the Decision
Decision Support
5 Rights of CDS:

• Right information,
• Right person,
• Right format,
• Right channel,
• Right time in workflow.
• **Precision medicine** is a medical *model* that proposes the customization of healthcare, with medical decisions, treatments, *practices*, or *products* being tailored to the *individual* patient.

<table>
<thead>
<tr>
<th>Gene</th>
<th>Genotype</th>
<th>Phenotype</th>
<th>Alleles Tested</th>
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</thead>
<tbody>
<tr>
<td>ANKK1/DRD2</td>
<td>DRD2:Taq1A A/G</td>
<td>Altered DRD2 function</td>
<td>DRD2:Taq1A</td>
</tr>
<tr>
<td>Apolipoprotein E</td>
<td>ε3/ε4</td>
<td>Altered APOE function</td>
<td>ε2, ε4</td>
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<tr>
<td>COMT</td>
<td>Val158Met A/G</td>
<td>Intermediate COMT Activity</td>
<td>Val158Met</td>
</tr>
<tr>
<td>CYP3A4</td>
<td>*1/*1</td>
<td>Normal Metabolizer</td>
<td>*1B, *2, *22, *3</td>
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<tr>
<td>Factor II</td>
<td>rs1799963 GG</td>
<td>Normal Thrombosis Risk</td>
<td>rs1799963</td>
</tr>
<tr>
<td>Factor V Leiden</td>
<td>rs6025 CC</td>
<td>Normal Thrombosis Risk</td>
<td>rs6025</td>
</tr>
<tr>
<td>MTHFR</td>
<td>c.665C&gt;T GG</td>
<td>Normal MTHFR Activity</td>
<td>c.665C&gt;T</td>
</tr>
<tr>
<td>MTHFR</td>
<td>c.1286A&gt;C TT</td>
<td>Normal MTHFR Activity</td>
<td>c.1286A&gt;C</td>
</tr>
<tr>
<td>OPRM1</td>
<td>A118G A/G</td>
<td>Altered OPRM1 Function</td>
<td>A118G</td>
</tr>
<tr>
<td>SLCO1B1</td>
<td>521T&gt;C T/T</td>
<td>Normal Function</td>
<td>521T&gt;C</td>
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<tr>
<td>VKORC1</td>
<td>-1639G&gt;A G/G</td>
<td>Low Warfarin Sensitivity</td>
<td>-1639G&gt;A</td>
</tr>
</tbody>
</table>
### Meaning of Results

#### Potentially Impacted Medications

<table>
<thead>
<tr>
<th>Category</th>
<th>Standard Precautions</th>
<th>Use With Caution</th>
<th>Consider Alternatives</th>
</tr>
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<tbody>
<tr>
<td>Anti-HIV Agents</td>
<td>Dolutegravir (TivKary®, TruStone®)</td>
<td></td>
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<tr>
<td></td>
<td>Raltegravir (Isentress®, Dapivir®)</td>
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<tr>
<td>Anti-Hyperuricemics and Anti-Gout Agents</td>
<td>Colchicine (Mitigare®, Colchic®)</td>
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<tr>
<td></td>
<td>Febuxostat (Uloric®, Osteo®)</td>
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<tr>
<td></td>
<td>Lesinurad (Zurampic®, Zureli®)</td>
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<tr>
<td>Antimalarials</td>
<td>Proguanil (Malarone®, Malaron®)</td>
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<tr>
<td>Antiplatelets</td>
<td>Prasugrel (Effient®, Effient®)</td>
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<tr>
<td></td>
<td>Ticagrelor (Brilinta®, Rentia®, Rentia®)</td>
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<td></td>
<td>Vorapaxen (Zontivity®, Zontivity®)</td>
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<tr>
<td>Antipsychotics</td>
<td>Aripiprazole (Abilify®, Aristada®)</td>
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<td></td>
<td>Asenapine (Saphris®, Serentia®)</td>
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<td></td>
<td>Brexpiprazole (Rexulti®, Rexulti®)</td>
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<td></td>
<td>Cariprazine (Vraylar®, Vraylar®)</td>
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<td></td>
<td>Chlorpromazine (Thorazine®, Thorazine®)</td>
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<td></td>
<td>Fluphenazine (Prolixin®, Prolixin®)</td>
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<td></td>
<td>Haloperidol (Haldol®, Haldol®)</td>
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<td></td>
<td>Loperidine (Perfalg®)</td>
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<td></td>
<td>Loxapine (Loxizine®, Loxizine®)</td>
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<tr>
<td></td>
<td>Adasuve® (Adasuve®, Adasuve®)</td>
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<tr>
<td></td>
<td>Lurasidone (Latuda®, Lurasidone®)</td>
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<tr>
<td></td>
<td>Paliperidone (Invega®, Invega®)</td>
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<td></td>
<td>Perphenazine (Trilafon®, Trilafon®)</td>
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<tr>
<td></td>
<td>Pimavanserin (Nuplazid®, Nuplazid®)</td>
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<tr>
<td></td>
<td>Pimozide (Orap®, Orap®)</td>
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<tr>
<td></td>
<td>Quetiapine (Seroquel®, Seroquel®)</td>
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</tr>
<tr>
<td></td>
<td>Risperidone (Risperdal®, Risperdal®)</td>
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</tr>
<tr>
<td></td>
<td>Clozapine (Clozaril®, Clozaril®)</td>
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</tr>
<tr>
<td></td>
<td>Olanzapine (Zyprexa®, Zyprexa®)</td>
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</tbody>
</table>
Deeper Interpretation

**Bupropion (Wellbutrin®, Zyban®, Aplenzin®, Contrave®)**
Possibly Decreased Response to Bupropion (CYP2B6 *1/*6 Intermediate Metabolizer)  
Evidence Level: Informative
Bupropion is metabolized to its active metabolite hydroxybupropion by CYP2B6. This metabolite contributes to the therapeutic effects of bupropion when used as a smoking cessation agent or as an antidepressant. Individuals who are CYP2B6 intermediate metabolizers may or may not have lower blood levels of hydroxybupropion which may or may not result in a reduced response to bupropion treatment. Bupropion can be prescribed at standard label-recommended dosage with careful monitoring of the patient’s response. Therapeutic monitoring of hydroxybupropion levels may be considered to guide dosing adjustment.

**Clozapine (Clozaril®)**
Possible Non-Response to Clozapine (CYP1A2 *1A/*1W Normal Metabolizer, Possible Inducibility)  
Evidence Level: Informative
Smokers may be at risk for non-response at standard doses and may require higher doses. There is an association between high clozapine doses and the risk of seizures, and therefore careful monitoring is recommended during dosing adjustment. Smoking cessation may increase plasma drug levels, leading to adverse events. Therefore, therapeutic drug monitoring accompanied by dose reduction is recommended in patients who have quit smoking.

**Dexmethylenphendiate (Focalin®)**
Decreased Response to Dexmethylenphendiate (COMT Val158Met A/G Intermediate COMT Activity)  
Evidence Level: Informative
Integrate the Results!

- Input of results obtained in a structured manner
- Hard wire drug orders to those results
  - Lab orders linked to alerts
  - Allergy profiles liked to medication orders
  - Drug-drug interactions
Administrative Decision Support

Number of ED visits count by day and disposition

- Forecast indicator
  - Actual
  - Estimate

- Sun 2/24: 85
- Sat 3/2: 95
- Fri 3/1: 118
- Thu 3/2: 126
- Wed 3/2: 118
- Tue 3/3: 135
- Mon 3/4: 156
- Sun 3/5: 95
- Sat 3/6: 138
- Fri 3/7: 148
- Thu 3/14: 131
- Wed 3/20: 131
- Tue 3/21: 137
- Mon 2/18: 113
- Sun 2/23: 99
- Sat 2/23: 128
- Fri 2/22: 125
- Thu 2/21: 125
- Wed 2/20: 128
- Tue 2/19: 138
- Mon 2/25: 155

The graph illustrates the number of ED visits over a period, with actual and estimated counts for each day.
Discussion

• Lets collaborate!

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