Real world evidence and analytical use cases

Yang Xiao & David Olaleye
Sep. 2017
Outline

- Introduction
- RWE use cases and applications
- Analytical use case 1: Charlson Comorbidity Index and risk score
- Analytical Use case 2: Incident and prevalent cases analysis
- Questions & Discussions
Introduction

What is real world data (RWD) and real world evidence (RWE)?

- RWD is “Big data”; RWD is not just “Big Data”.
- RWD is the integration of multiple sources of data.
- RWE can find patterns, generate key conclusions and insights.
- RWE is a proof of meaningful use of RWD.
Introduction
Past to current

• Use of patient outcomes data in medical evidence for many years.
• Observational studies using insurance claims and/or EMR data.
• Drug Safety Surveillance.
• Health economics and outcomes research (HEOR).
• Value optimization and risk mitigation.
• Population Health Analytics and intelligence.
Introduction
Current development areas

• Understanding of the efficacy of medical treatments:
  ✓ Comparing treatment effectiveness
  ✓ Negotiating drug prices based on outcomes
  ✓ Increasing patient medication adherence

• Common data model:
  ✓ Observational Health Data Sciences and Informatics (OHDSI)
  ✓ The FDA Mini-Sentinel Program
  ✓ The National Patient Centered Clinical Research Network (PCORnet)
Three Pillars of Real World Evidence

01 Management of data assets

02 Identifying patient cohorts of interest

03 Knowledge and insights via analytics
Introduction

Now and future

• Standards-Based, Efficient, and Democratized ecosystem.

• Open, Transparent, and Collaborative.

• **Internet of things (IOT)** measures various aspects of patient health –more and more data.

• **Block chain technology** will enable the secure storage of patient health data and the direct transmission of anonymized data to Pharmaceutical companies.

• **Cognitive computing** will enable deeper insights to be gained from the stores of RWE data.
Real World Evidence Applications

- Pharmacovigilance & Safety Surveillance
  - Adverse Events
  - Signal Detection
  - Drug Utilization
- Health Economics and Outcomes Research
  - Market Access
  - Comparative Effectiveness Analysis
  - Patient Journey
- Clinical Research & Development
  - Trial Design / Optimization
  - Patient Recruitment
  - New Indications
- Marketing and Commercial
  - Brand Analysis and tracking
  - Market / Cost Effectiveness Analysis
  - Patient Journey

- claims
- social media
- Rx
- survey
- registry
- labs
- EMR
- safety
Welcome, Yang Xiao!

Here are a few quick tips:

- Add application shortcuts to your home page. You can customize the color and the name.
- Click the icon beside “SAS® Home” in the banner to access your applications using a side menu.
- Sign out of your application by selecting your name and clicking “Sign Out”.
- Join a SAS community for great discussions on tips and best practices.

https://communities.sas.com/welcome

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- Exploration 3
  Aug 29, 2017, 1:54:53 PM
- IWE Cohort Summary
  Aug 25, 2017, 3:28:00 PM

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Links will be displayed here. Add links now or later.

Visual Analytics Samples
/Products/SAS Visual Analytics/Visual Analytics Samples
- SAS Visual Analytics Sample In...
  SAS report (2G)
- SAS Visual Analytics Sample
  SAS report (2G)
### Population Cohorts

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Group</th>
<th>Status</th>
<th>Owner</th>
<th>Patient Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>pop diabetes</td>
<td></td>
<td></td>
<td></td>
<td>yopark</td>
<td></td>
</tr>
</tbody>
</table>

### Index Event Cohorts

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Group</th>
<th>Index Event Definition</th>
<th>Status</th>
<th>Owner</th>
<th>Patient Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>index diabetes</td>
<td></td>
<td></td>
<td>Diabetes ICD10</td>
<td></td>
<td>yopark</td>
<td></td>
</tr>
</tbody>
</table>
Total population count: 50000

Name: index diabetes

Description:

Group:

Created: Aug 29, 2017 by yopark

Modified: Aug 29, 2017 by yopark

Id: CR3C2J82
<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Modified</th>
<th>Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Score and Comorbidity Report</td>
<td>Risk and comorbidity factors profile report.</td>
<td>Aug 29, 2017, 4:29:00 PM</td>
<td>yaxiao</td>
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<tr>
<td>Incidence and Prevalence Analysis</td>
<td>Model for profiling and computing incidence and prevalence rates for an index event.</td>
<td>Aug 29, 2017, 4:38:07 PM</td>
<td>yaxiao</td>
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<tr>
<td>Name</td>
<td>Description</td>
<td>Owner</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>--------</td>
<td></td>
</tr>
<tr>
<td>Condition and Event Monitoring Analysis</td>
<td>Model for exploring and monitoring effects of risk factors on a given condition over time.</td>
<td>yopark</td>
<td></td>
</tr>
<tr>
<td>Cost Analysis</td>
<td>Model for clustering and predicting total costs associated with diagnoses and procedures.</td>
<td>japaul</td>
<td></td>
</tr>
<tr>
<td>Export Administration Report</td>
<td>Report lists all exports for determining export clean up or archiving.</td>
<td>SAS</td>
<td></td>
</tr>
<tr>
<td>Export Cleanup</td>
<td>Deletion of a user’s export.</td>
<td>SAS</td>
<td></td>
</tr>
<tr>
<td>Export Report</td>
<td>Report contains a list of exports owned by the user.</td>
<td>SAS</td>
<td></td>
</tr>
<tr>
<td>Incidence and Prevalence Analysis</td>
<td>Model for profiling and computing incidence and prevalence rates for an index event.</td>
<td>SAS</td>
<td></td>
</tr>
<tr>
<td>Length of Stay Analysis</td>
<td>Model for profiling and modeling inpatient length of stay (LOS) for a study cohort.</td>
<td>SAS</td>
<td></td>
</tr>
<tr>
<td>Mortality Analysis</td>
<td>Population Health Management (deprecated - not shipped with 4.2)</td>
<td>japaul</td>
<td></td>
</tr>
<tr>
<td>Propensity Score Matched Case-Control</td>
<td>Model for performing standard propensity score matched case-control analyses.</td>
<td>danial</td>
<td></td>
</tr>
</tbody>
</table>
Incidence and Prevalence Rate Analysis

Incident Cases within the Identification Window (New Cases) | Midpoint Population* | Incidence Rate
--- | --- | ---
15,032 | 44,322 | 33.92%

*Midpoint Population = population alive on February 14, 2010

All Cases at Midpoint (New and Preexisting Cases) | Midpoint Population* | Point Prevalence at Midpoint
--- | --- | ---
28,253 | 44,322 | 63.74%

*Midpoint Population = population alive on February 14, 2010

All Cases within the Identification Window (New and Preexisting Cases) | All Population Members | Period Prevalence
--- | --- | ---
31,985 | 44,574 | 71.76%
### Libnames generated for this Add-in

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<thead>
<tr>
<th>Name</th>
<th>Path</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>wdata</td>
<td>/rwe/warehouse/rwe42/rwesets/eb9066f6-359c-433e-bb8b-e615f63766a</td>
<td>folder containing workspace data</td>
</tr>
<tr>
<td>odsout</td>
<td>&amp;ods_temp_folder</td>
<td>temp folder to write ODS output and any JSON files</td>
</tr>
<tr>
<td>dataout</td>
<td>&amp;output_folder</td>
<td>permanent folder to write SAS datasets</td>
</tr>
<tr>
<td>cohort1</td>
<td>/rwe/warehouse/rwe42/rwesets/WKDF390W/cohorts/CG1NSA6N</td>
<td>Cohort libref</td>
</tr>
</tbody>
</table>

**Add-in Details:**
- **Names:** yaxiao 2972017-165555
- **Description:** Add-in created by yaxiao on 8/29/2017, 4:55:53 PM
- **Test with data from:**
  - **Workspace:** 50K CMS ICD10 non-ICV coded
  - **Cohort:** pop diabetes

**Add-in Cohort Type:**
- Population Cohorts
- Index Event Cohorts

**Add-in Settings:**
- Public
- Example (for use within the Add-in Builder only)

[Download Add-in]
/* A simple proc print has been supplied for you. */
/* ODS statements are also included to generate both HTML and PDF output. */
ods_all_close;
ods select all;
ods HTML5 style=plateau
FILE=%sysfunc(quote(&ods_temp_folder/ProcPrintReport.html))
OPTIONS(BITMAP_MODE=INLINE);
ods PDF style=PRINTER SAS
FILE=%sysfunc(quote(&ods_temp_folder/ProcPrintReport.pdf));
proc print data=sashelp.class; run; quit;
ods_all_close;
quit; run;
### Test Condition and Event Monitoring

**Risk Factors**

<table>
<thead>
<tr>
<th>Model period:</th>
<th>Calendar quarter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk/comporbidity factor group type:</td>
<td>Standard</td>
</tr>
<tr>
<td>Minimum percentage of unique members required for positive risk factor selection:</td>
<td>10</td>
</tr>
<tr>
<td>Variable selection method:</td>
<td>Automatic</td>
</tr>
</tbody>
</table>

**Process Monitoring**

| Maximum number of clusters: | 5 |

- Output risk factors to a data set
Add-in Builder:

Name:
Risk Score and Comorbidity Report

Description:
Risk and comorbidity factors profile report.

Text with data from:
Workspace: 50K CMS ICD10 in norm vitals coded
Cohort: pop diabetes

Add-in Cohort Type
☑ Population Cohorts
☑ Index Event Cohorts

Add-in Settings
☑ Public
☐ Example (for use within the Add-in Builder only)

Download Add-in

Risk Score Summary Report

Generated on August 29, 2017 at 8:12:04 PM

Cohort name: pop diabetes
Cohort type: PopulationStudy
Study period: 2007-12-01 - 2011-12-31
Risk/comorbidity factor group type: CMS-HCC

Summary Statistics of Risk Score by Gender and Age Group (N = 4,650)

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Median</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>18-44</td>
<td>119</td>
<td>26.0</td>
<td>9.17</td>
<td>24.0</td>
<td>7</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>45-64</td>
<td>391</td>
<td>23.9</td>
<td>10.04</td>
<td>24.0</td>
<td>1</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>65-74</td>
<td>1,749</td>
<td>22.5</td>
<td>9.32</td>
<td>22.0</td>
<td>1</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>85+</td>
<td>445</td>
<td>24.0</td>
<td>9.45</td>
<td>24.0</td>
<td>2</td>
<td>49</td>
</tr>
<tr>
<td>Male</td>
<td>18-44</td>
<td>106</td>
<td>22.1</td>
<td>9.60</td>
<td>21.6</td>
<td>1</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>45-64</td>
<td>374</td>
<td>23.0</td>
<td>9.97</td>
<td>22.0</td>
<td>1</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>65-74</td>
<td>1,267</td>
<td>22.6</td>
<td>9.33</td>
<td>22.0</td>
<td>1</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>85+</td>
<td>209</td>
<td>24.9</td>
<td>9.64</td>
<td>24.0</td>
<td>2</td>
<td>51</td>
</tr>
</tbody>
</table>

Age is calculated at study period start.

Boxplots of Risk Score by Gender and Age Group

Female

Male
Charlson Comorbidity Index (CCI)

Description

- The Charlson comorbidity index predicts the one-year mortality for a patient who may have a range of comorbid conditions, such as heart disease, AIDS, or cancer (a total of 22 conditions).

- Each condition is assigned a score of 1, 2, 3, or 6, depending on the risk of dying associated with each one. Scores are summed to provide a total score to predict mortality.

- Many variations of the Charlson comorbidity index have been presented, including the Charlson/Deyo, Charlson/Romano, Charlson/Manitoba, and Charlson/D'Hoores comorbidity indices.

- For a physician, this score is helpful in deciding how aggressively to treat a condition. A questionnaire for patients to answer or chart review by nurse to determine whether a particular condition was present in order to calculate the index.

- Administrative data such as claims data a.k.a one of the source of real world data can derive CCI and scores as predictors in statistical analysis.

- The Charlson index, especially the Charlson/Deyo, followed by the Elixhauser have been most commonly referred by the comparative studies of comorbidity and multimorbidity measures.
Charlson Comorbidity Index (CCI)

Background

• Originally developed by Charlson et al. (1987) “A new method of classifying prognostic comorbidity in longitudinal studies: development and validation.

• 19 categories of comorbidity and weights (1-6) were identified based on the adjusted relative risk of one-year mortality.

• Charlson Comorbidity Score (CCS) is derived by summing up each individual weights.
Charlson Comorbidity Index (CCI)

More development

- Deyo et al. (1992) published “Adapting a clinical comorbidity index for use with ICD-9-CM administrative database”.
- Two of the categories “Leukemia” and “Lymphomas” from Charlson et al. (1987) were combined into one category “Any Malignancy”.
- Total of 17 categories.
- Halfon et al. (2002) translated to ICD-10 and developed weights in their publication “Measuring potentially avoidable hospital readmissions”.
- Quan et al. (2005) followed Deyo’s coding algorithm to develop Charlson and Elixhauser comorbidities in “Coding algorithm for defining comorbidities in ICD-9-CM and ICD-10 administrative data”.


Charlson Comorbidity Index (CCI)
Comparison and validation

• A table compared Halfon’s and Quan’s translations of the CCI using ICD-10 codes: (link)

• Sundararajan et al.(2007) compared performance of three versions of the ICD-10 CCI coding and found all performed well.

• Li et al.(2008) assessed performance of the CCI and Elixhauser Comorbidity Index between ICD-9 and ICD-10 coding system in “Risk adjustment performance of Charlson and Elixhauser comorbidities in ICD-9 and ICD-10 administrative databases.”

• Sharbaiani e al.(2012) reviewed 54 articles to compare Charlson, Elixhauser, and their variants performance for different patient group and outcome. In "Systematic review of comorbidity indices for administrative data“.

• Austin el al.(2015) provide an proof of the utility of comorbidity summary in “Why summary comorbidity measures such as the Charlson Comorbidity Index and Elixhauser score work” using SEER-Medicare data.
Charlson Comorbidity Index (CCI)

Notes and limitations

• Include or exclude complication diagnosis code?
• Developed via hospital abstracts data using the most granular level of ICD-9 and ICD-10 codes.
• Using only 3-digit ICD codes is not recommended.
Risk scores exploration and comparison
Risk scores exploration and comparison
Summary

• Risk Scoring capabilities that provide a holistic depiction of member health.

• Unlike the calculation of one Risk Score for each member, the calculation of Risk Scores by disease state allows organizations to better understand and serve the medical needs of each member.
Incident and prevalent cases analysis

Definition

• Incidence: The occurrences of new cases of a disease or condition in a population over a specified period of time, typically one year.
• Incident population: newly identified patients.
• Incident population example:
  • Those who are diagnosed with chronic conditions during the period, or
  • Those who joined the health plan during the period with existing chronic conditions prior to enrollment.
• Prevalence: A measurement of the total number of cases of a disease in a population at a given time, usually given as the proportion of affected people in the population.
• Prevalent population: patients identified before study start date or index event date.
Incident and prevalent cases analysis
Questions and results

• Sample questions:
  ✓ Create a cohort with newly diagnosis of diabetes
  ✓ Create a cohort with newly use of a drug

• Results:
  ✓ Summary statistics and incident rate.
  ✓ Standardized rates adjusted for demographic variables.
### Incident and Prevalence Rate Analysis

#### Incidence Cases within the Identification Window (New Cases)

<table>
<thead>
<tr>
<th>Incident Cases within the Identification Window (New Cases)</th>
<th>Midpoint Population*</th>
<th>Incidence Rate</th>
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*Midpoint Population = population alive on February 14, 2010

#### All Cases at Midpoint (New and Preexisting Cases)

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<td>31,985</td>
<td>44,574</td>
<td>71.76%</td>
</tr>
</tbody>
</table>
Incident and prevalent cases analysis
Summary report

The STDRATE Procedure

Strata Distribution Plot

Strata Rate Ratios with 95% Lognormal Confidence Limits

Directly Standardized Rate Estimates
Rate Multiplier = 1000

<table>
<thead>
<tr>
<th>gender</th>
<th>Study Population</th>
<th>Reference Population</th>
<th>Standardized Rate</th>
<th>95% Normal Confidence Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>8481 37321 228.9</td>
<td>14978.8 65597 227.8</td>
<td>2.4774 222.1 231.8</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>6561 28676 228.9</td>
<td>15143.7 65597 229.5</td>
<td>2.8666 223.9 235.1</td>
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</tr>
</tbody>
</table>