About the Author

David Olaleye, PhD
David is Senior Manager and Principal Research Statistician at SAS Institute in Cary, NC. He received his postgraduate training in statistics, demography, and clinical epidemiology from the University of Pennsylvania School of Arts and Sciences, and School of Medicine, Philadelphia. His areas of specialization include episode-of-care analytics, real world evidence, pharmacovigilance and drug safety, data science, and developing statistical algorithms for mining healthcare and clinical trials databases. David has authored and published articles in peer-reviewed journals.
AGENDA

01 Introduction

02 Real World Data
   • Solving complex problems

03 Real World Patients
   • SAS® Episode Analytics
   • SAS® Real World Evidence

04 Real World Questions
   • Readmissions
   • Cost prediction

05 Conclusion
Solving Complex Problems

WHAT
Real World Data
Volume
Velocity
Variety
Veracity

HOW
Real World Patients
Patient safety and drug surveillance
Treatment pathways

EXECUTE
Real World Questions
Market safe and effective products
Increase shareholder value
A diabetic patient’s episode journey
A diabetic patient’s episode journey

What is the likelihood that I will develop the disease?

What are my best treatment options?

Which treatment did other ‘patients like me’ choose after diagnosis?

What are the odds that I will experience adverse outcomes?

Treatment
Outcomes & Evaluation Phase
Key Challenges

- Q: leverage claims, clinical, survey, and care management data to perform prospective and retrospective analysis on my patient population?
- Q: uncover insights, patterns and determine which episodes are clinically related?
  - Intelligent episode-of-care data aggregation

- Q: proactively identify high risk members for targeted care outreach?
- Q: predict patients at risk of index- or re-admission based on their clinical profiles?
  - Predictive analytics

- Q: uncover relationships between provider practice patterns and quality of care?
- Q: identify gaps in care and minimize adverse health outcomes
  - Prescriptive analytics
Episode Analytics Life Cycle Flow

Data Preparation
- Profile
- Cleanse
- Episode Definition

Route: Journey
- Index Cohort
- Episode Construction
- Care Pathways

Analytics
- Machine Learning
- Logistic Regression
- Risk Segmentation

Exploration
- Frequencies
- Correlations
- Categories

Meaning
- Readmission/Cost
- Mortality/Survival
- Efficiency/Value

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Episode of Care Journey Profile

Episodes Characterization Journey of Patients with Diabetes

Episode Journey Timeline

Condition
- DEPSN
- INTOBES**
- CAD
- LBP
- BLP
- DLIVEMN**
- CHF
- URI
- PCI
- PNE*
- LBRFAM
- ASTHMA
- GIBLD**
- DVTPE**
- COLOL
- PCHFR
- OSTECA
- GBURG
- HPIPLR
- ARRBLK
- STR/HICB*
- SEPSIS**
Episode of Care Journey Profile

Episodes Characterization Journey of mCRPC Patients

Medical Condition:
- COLCS
- PRSCMY
- PRSTCA
- HTN
- URI
- DEPRS
- GERD
- KNRPL
- OSTE0A
- EG5
- GBSJRG
- RHNTS
- CLNCAN
- COLON
- DIAB
- IMBALIN
- PNE
- CAD
- COPD
- ASTHMA
- GLCOMA

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Cohort Builder: SAS® Real World Evidence

• SAS® Visual Analytics platform
  • Manage, analyze, and visualize real world data
  • Cohort creation and discovery
    - Process cohorts based on simple/complex query logic and rules
    - Temporal relationships across different event codes – diagnoses, procedures, prescriptions, labs, etc.
    - Create user-defined and pre-defined analysis variables
• Pre-built analytical add-in models
• Integrated with SAS Visual Analytics for visualization and reporting
• Advanced analytics using SAS® Viya® machine learning algorithms
Analytic Cohort Discovery and Creation
Episodes Builder: SAS® Episode Analytics

Episode bundling solution for payers and providers
• automated construction of episodes for chronic, acute, surgical conditions, etc.
• industry-standard and user-customized episode definitions
• cost allocation, filtering and episode association logic
• provider attributed episodes assignment
Models

Risk adjustment models
• analytic model plug-in engine and creation of analytical-ready data sets
• choice of comorbidity risk factors
  • CMS-HCC, Charlson, Elixhauser
• choice of cost prediction models
  • one-part/two-part models
  • Tweedie, normal, gamma, etc.
• population health focused models
  • readmissions, provider-profiling
• interactive visualization and reporting
  • patient’s journey, cost analysis
Model Add-in Builder and Templates
Use Cases and Demonstration

- Case Study: Episode-of care based hospital readmissions analytics
  - Find members with higher likelihood of readmission to an acute hospital
  - Find members who have higher costs associated with preventable readmissions
  - Model built at member-level and episode-level
Real World Application

• Data Source
  • Random sample of 800K patients from publicly available 2008-2010 CMS Synthetic PUF Medicare data

• Patient Population
  • Created episodes of care data for two medical conditions
  • COPD (n=6,094) and Diabetes (n=13,503)

• Analytic Models
  • Episode cost risk adjustment model
  • Readmission model
  • Predictor variables include patient demographic characteristics and Charlson and Elixhauser comorbidity factors
• **Readmission definition**
  - readmission to a hospital within 30/45/60 days of a discharge from the same or another hospital
  - target readmission time interval: 30/45/60-day

• **Identifying episode-related readmissions**
  - anchor claim: IP claim during the study period
  - anchor condition: index condition on the anchor claim
  - subsequent IP claims at an acute facility that occur 2 or more days after the initial stay (or at the same acute facility regardless of the number of days) - assigned to the episode as PAC
  - inpatient stay after an episode is signaled by an outpatient or professional services claim - assigned to the episode as a complication
  - readmissions to an acute care facility within a related open episode - assigned to the episode as PAC
  - transfer to another acute care facility within the same day or the next day following the discharge from the first acute care facility - assigned to the episode as typical
  - transfer to a post-acute (rehabilitation, long-term, or skilled nursing) facility - assigned as typical or typical w/complication based on the diagnoses on the stay.
EXAMPLE: A MEMBER READMISSION PROFILE

Member ID=0000377379 Episodes during Study Period

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<th>Member ID</th>
<th>Episode ID</th>
<th>Condition</th>
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<th>Episode End Date</th>
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Route: Journey
- Index Cohort
- Episode Construction
- Care Pathways

In-patient claims

Readmit claim

Surgery

Readmit

1 Month
## Exploration: Risk Factors

- Frequency and percentage distribution of demographic and comorbidity risk factors

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</table>
Actual and Risk-adjusted Episode Costs

- Among patients with COPD episodes, unadjusted and adjusted mean episode costs were $2325 and $2360, respectively.
- For Diabetes, an unadjusted and adjusted cost of $3201 and cost of $3253.
Hospitalization and Readmission

- Total admissions were 2204 (16.3%) and 1165 (19.1%) in Diabetes and COPD cohorts, respectively.
- About 1.5% and 1% resulted in 30-day readmissions based on total admissions.
- Higher percentages of readmissions were observed among males aged 55+

<table>
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<tr>
<th>Condition</th>
<th>Gender</th>
<th>Age Group</th>
<th>Number of Episodes</th>
<th>Number of Admissions</th>
<th>Number of Readmissions</th>
<th>Percent of Episodes</th>
<th>Percent of Admissions</th>
<th>Percent of Readmissions</th>
<th>Percent of Admissions in Group</th>
<th>Percent of Readmissions in Group</th>
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<tbody>
<tr>
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<td>55+</td>
<td>3939</td>
<td>611</td>
<td>7</td>
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<td>100.00</td>
<td>100.00</td>
<td>19.12</td>
<td>1.03</td>
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Readmission Model

- Fitted logistic regression model
- Notable findings include:
  - For Diabetes cohort - male gender, older age group, myocardial infarction, pulmonary disease, renal disease but not significant
  - For COPD cohort – renal disease, cancer elevated risk of readmission, but not significant.
Cost Model

- Fitted generalized gamma regression model
- Notable predictors of cost include:
  - lower age group
  - length of episode duration
  - patients with episode complications
  - congestive heart failure
  - chronic pulmonary disease
  - renal disease

<table>
<thead>
<tr>
<th>Medical Condition</th>
<th>Model Parameter</th>
<th>Model Estimate</th>
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<th>Upper Confidence Limit</th>
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Observational Data
- Early detection of drug safety issues
- Patient healthcare journeys

Cohort and Episode Builder
- Investigate and answer real world questions
- Discover and visualize patient cohort

Risk Assessment & Prediction
- Proactively detect at-risk patients for hospitalization, readmission, and length of stay

Conclusion
Future forward with SAS.

Digitize the world of pharma.
Shape the future of analytics.
Accelerate your career.