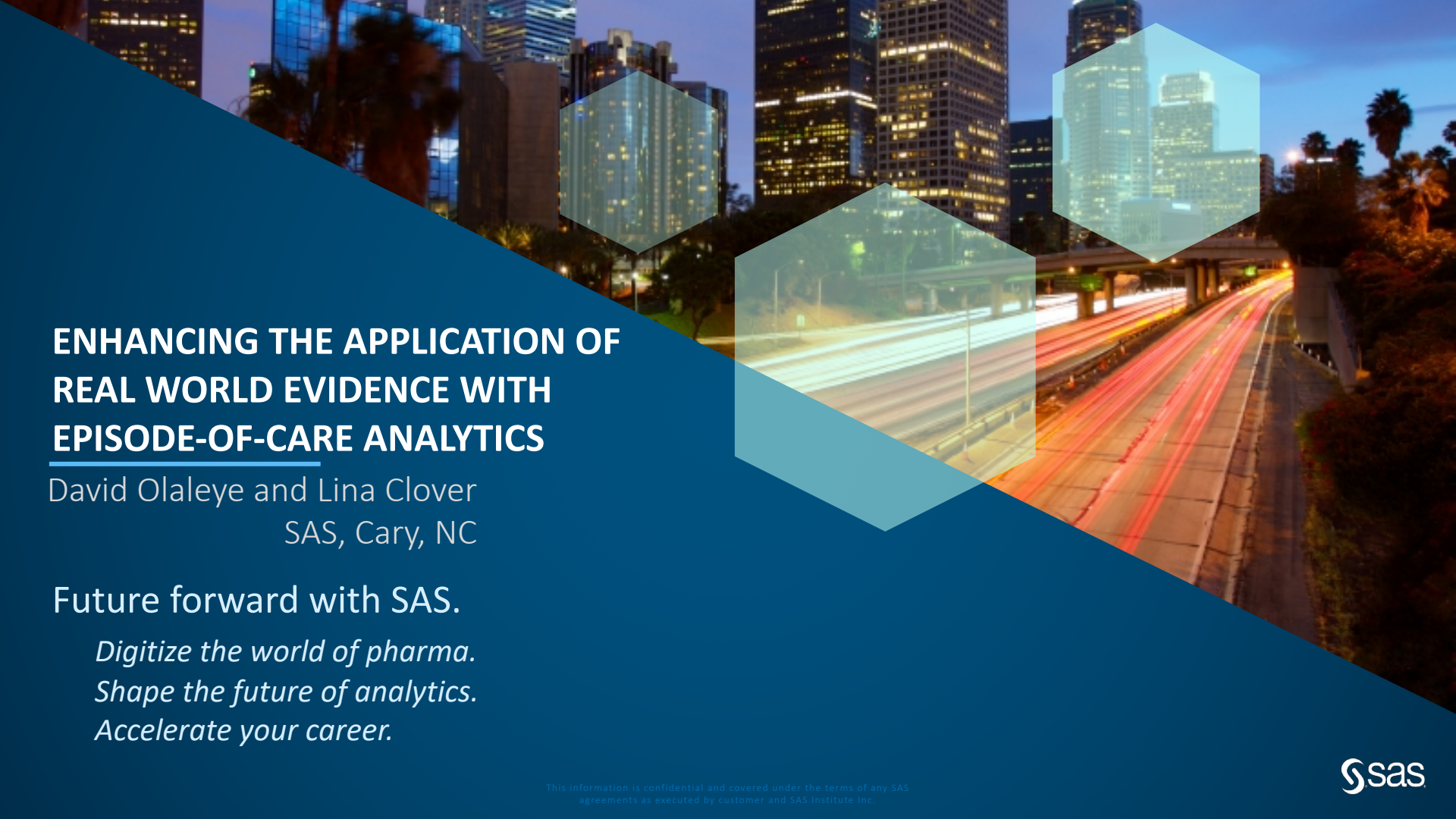




ENHANCING THE APPLICATION OF REAL WORLD EVIDENCE WITH EPISODE-OF-CARE ANALYTICS

David Olaleye and Lina Clover
SAS, Cary, NC

Future forward with SAS.

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

About the Authors

David Olaleye, PhD

David is Senior Manager and Principal Research Statistician at SAS 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, and statistical algorithms for mining healthcare and clinical trials databases. David has authored and published articles in peer-reviewed journals.

Lina Clover

Lina is the Director of Research and Development at SAS in Cary, NC. Since joining SAS, Lina has held several leadership roles, and currently leads the healthcare solutions development effort and the development teams responsible for SAS® Episode Analytics and SAS® Real World Evidence.

Agenda

- Introduction
- Solving Complex Problems
- SAS Real World Evidence
- Supervised and Unsupervised Signal Detection Methods
- Use Case
 - Diabetes Medications and Acute Myocardial Infarction
- Conclusion

Solving Complex Problems

WHAT

Real World
Data

Volume
Velocity
Variety
Veracity

HOW

Real World
Patients

Patient safety and
drug surveillance

Treatment pathways

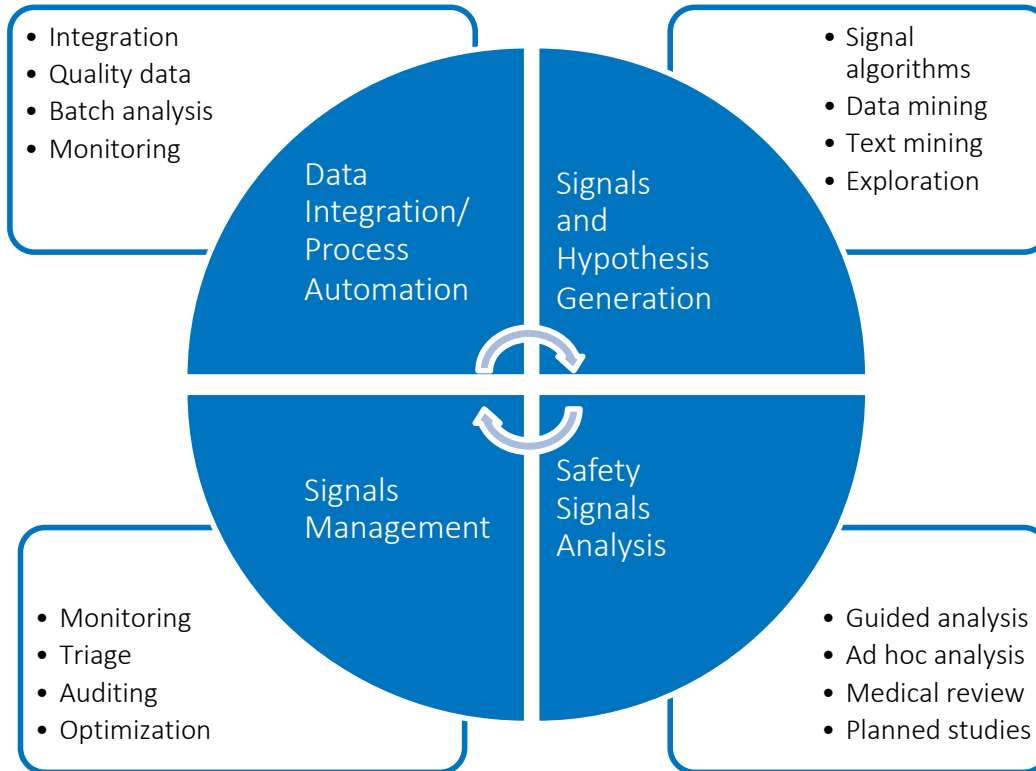
EXECUTE

Real World
Questions

Market safe and
effective products

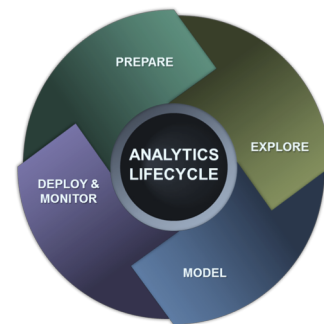
Increase shareholder
value

Keys to Signals Detection and Safety Analysis



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

SAS® Real World Evidence

David Olaleye

home > clave_project > Diabetes Rx Surveillance

Name: Diabetes Rx Surveillance

Description: Diabetes Rx Surveillance with CMS 800K

Date Range: Jan 1, 2008 - Dec 31, 2010

Data source: 800K_CMS_ICD10_RWE43_20180511 n=711,479

Data source description: 800K_CMS_ICD10_RWE43_20180511

Enrollment: None n=636,980 : 89.53%

Type: Index Event Cohort

Actions

1 Cohort

2 Analysis Variables

3 Add-ins

Search

Demographics

Diagnoses - Dx

Diagnosis Related Groups

Laboratory Tests

Prescriptions - Rx

Procedures - Px

Visits

Vitals

Index Events

Index Event DM RXs IED n=163,582 23%

Inclusion/Exclusion Criteria n=103,802 15%

AND OR NOT

> ☒ AGE_GE18 n=163,582

> ☒ AMI n=13,189

> ☒ Biguanides n=86,506

> ☒ Dopamine agonist n=18,841

> ☒ DPP-4 inhibitors n=4,817

> ☒ Glucagon n=912

> ☒ Meglitinides n=5,740

> ☒ SGLT2 inhibitors n=0

> ☒ Sulfonylureas n=82,081

> ☒ Thiazolidinediones n=16,234

> ☒ Diabetes_ECOM n=103,802

Cohort Variables

Filters

Name	Count / %
AGE_GE18	163,582 / 100%
AMI	13,189 / 8%
Biguanides	86,506 / 53%
Dopamine agonist	18,841 / 12%
DPP-4 inhibitors	4,817 / 3%
Glucagon	912 / 1%
Meglitinides	5,740 / 4%

User-defined Analysis Variables

Name	Count / %
☐ Candida Infection	8,418 / 5%
☐ C-Difficile Infection	3,143 / 2%
☐ rhabdomyolysis	2,108 / 1%
☐ Diabetes poor control	38,392 / 23%
☐ Overdose Poisonings	182 / 0%
☐ Complications from Amputation	779 / 0%
☐ Severe Sepsis	5,269 / 3%

Simplified Cohort Creation Logic and Rules

Cohort Properties

Name:	Diabetes Rx Surveillance
Description:	Diabetes Rx Surveillance with CMS 800K
Index Event Expression:	<pre>(greater than or equal to 1 occurrence of "CODE_VALUE" is one of ("RX:43063042830", "RX:42291058260", "RX:65841081016", "RX:42806021501", "RX:10544094790", "RX:67877056101", "RX:50090217304", "RX:50090076600", "RX:63629139708", "RX:53746017930", "RX:55154205800", "RX:13668001330", "RX:61442036105", "RX:63629139702", "RX:60505026002", "RX:33261014560", "RX:33261014510", "RX:70518043500", "RX:00615762739", "RX:43353093686", "RX:54569561904", "RX:42806022101", "RX:43063052760", "RX:55111069510", "RX:43063054594",</pre>
Cohort Expression:	<pre>("AGE_AT_INDEX_DT" greater than or equal to "18") AND (greater than or equal to 1 occurrence of "CODE_VALUE" is one of ("DX:I210", "DX:I2101", "DX:I2129", "DX:I21A1", "DX:I2102", "DX:I2111", "DX:I212", "DX:I21", "DX:I219", "DX:I2119", "DX:I213", "DX:I21A", "DX:I2121", "DX:I21A9", "DX:I214", "DX:I2109", "DX:I211") on or after: the index event) AND</pre> Copy to Clipboard
Type:	Index Event Cohort
Owner:	daolal
Date created:	Oct 14, 2018, 5:32:34 PM
Date modified:	Oct 14, 2018, 6:03:55 PM
Modified By:	daolal
Cohort ID:	CE3HGGJD2
Project ID:	PRIYEJVJ

Close

User-defined and Pre-defined Analysis Variables

SAS® Real World Evidence

Home > dave_project > Diabetes Rx Surveillance

Name: Diabetes Rx Surveillance Data source: 800K_CMS_JCD10_RWE43_20180511 n=711,479 Type: Index Event Cohort Actions

Description: Diabetes Rx Surveillance with CMS 800K Data source description: 800K_CMS_JCD10_RWE43_20180511

Date Range: Jan 1, 2008 - Dec 31, 2010 Enrollment: None n=636,980, 89.53%

1 Cohort 2 Analysis Variables 3 Add-ins

Filter

Pre-defined Variables

- Demography Variables
 - AGEGROUP_10: Age Group (0-9, 10-19, 20-29, 30-...
 - AGEGROUP_2: Age Group (<65, >=65)
 - AGEGROUP_4: Age Group (0-17, 18-44, 45-64, 65+)
 - AGEGROUP_5: Age Group (0-17, 18-39, 40-54, 55-...
 - AGEGROUP_6: Age Group (0-17, 18-34, 35-44, 45-...
 - CENSUS_STATE: Census State Classification
 - ETHNICITY: Ethnicity
 - GENDER_CD: Gender
 - RACE: Race
 - ZIP: Zip Code
- Diagnosis Variables
- Drug Variables
 - ACE_INHIBITO: Angiotensin converting enzyme in...
 - ALPHAGLUC: Alpha-glucosidase inhibitors
 - ANG2_INHIBIT: Angiotensin II inhibitors
 - ANTIHYPER_CO: Antihypertensive combinations
 - ARI_5: 5-alpha-reductase inhibitors
 - ASTHMA_CM: Asthma Controller Medications
 - ASTHMA_RM: Asthma Reliever Medications
 - BETABLOCKER: Beta-Blocker Medications
 - CORTICOSTEROID: Corticosteroid Medications

Post Process Variables Final Cohort Count: n=103,802 Apply

Pre-defined Variables Risk Factors

Name	Description	Remove
ICUCARE	ICUCARE: ICU Critical Care	
EDVISIT	EDVISIT: Emergency Department Visit	
THIAZOLID	THIAZOLID: Thiazolidinediones	
SULFONYL	SULFONYL: Sulfonylureas	
SGLT2	SGLT2: Sodium glucose cotransporter 2 (SGLT2) inhibitor	
MEGLITINIDE	MEGLITINIDE: Meglitinides	
INSULIN	INSULIN: Insulin	
GLP1	GLP1: Glucagon-like peptide-1 (GLP1) agonists	
DDP4	DDP4: Dipeptidyl peptidase-4 (DDP-4) inhibitors	

Built-in Add-in Model and Analysis Templates

SAS® Real World Evidence

Home > dave project > Diabetes Rx Surveillance

Name: Diabetes Rx Surveillance

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Data source: 800K_CMS_JCD10_RWE43_20180511 n=711,479

Data source description: 800K_CMS_JCD10_RWE43_20180511

Enrollment: None n=636,980; 89.53%

Type: Index Event Cohort

Actions

1 Cohort

2 Analysis Variables

3 Add-ins

CEOR Nonnested Causal Effect Estimation

Oct 15, 2018, 10:16:03 AM

n=103,802

Delete

Run

Add-ins for: daolal

☐ Show add-ins for all users

Cohort Characterization Reports (1)

Cohort Characterization

Comparative Effectiveness & Outcomes Research (C...)

CEOR Nonnested Causal Effect Estimation (3)

Oct 15, 2018, 11:14:24 AM

Oct 15, 2018, 11:04:17 AM

Oct 15, 2018, 10:03:36 AM

Comparative Cohorts Analysis

Costs and cost-effectiveness analysis

Costs and cost-effectiveness analysis v1

Non-nested propensity score model

PSMATCH Nested propensity score model

Incidence and Prevalence Rates (2)

Patient-level Outcomes Predictive Model (2)

Treatment Patterns and Pathways (1)

Custom Add-ins (18)

Description (optional)

Study Design and Modeling

Instructions

Choose which study cohort (denominator) to use for analysis:

Final Study Cohort

☒ Limit analysis to only incident cases of index event cohort population

Exposure Groups and Outcome Event(s)

Target exposure group variable:

_PQS9_Thiazolidinediones

Comparator exposure group variable:

_PQS1_Biguanides

Outcome event variable of interest (maximum of 4 variables):

_IV11_AMI

Data Preparation and Model Estimation

☒ Perform causal effect estimation analysis

Estimate propensity score-matched potential treatment or exposure group effect using:

Inverse probability weights with ratio and scale adjust...

Probability distribution type (non-binary outcome events):

Poisson

Reports

Output Data Preview

Log

rwe_addin_baseline_report

Generated on October 15, 2018 at 10:13:05 AM

Cohort name: Diabetes Rx Surveillance

Cohort type: Index Study

Index event identification window: 2008-01-01 - 2010-12-31

Baseline Characteristics and Covariates of Cohort Members

Characteristic	Value	Comparator Group	Target Group	Statistic (P-value)
Total	Total	N=43619	N=6839	
Gender	F	26862 (61.6)	4202 (61.4)	0.050 (0.8230)
	M	16757 (38.4)	2637 (38.6)	
Race	Black	4843 (11.1)	740 (10.8)	2.495 (0.4762)
	Hispanic	1260 (2.9)	218 (3.2)	
	Other	1899 (4.4)	307 (4.5)	
	White	35617 (81.7)	5574 (81.5)	
Charlson Risk Factor Set Risk Score Group	1	9541 (21.9)	1451 (21.2)	7.239 (0.1238)
	2-3	8523 (19.5)	1378 (20.1)	
	4-7	2917 (6.7)	437 (6.4)	
	8+	293 (0.7)	32 (0.5)	
	<1	22345 (51.2)	3541 (51.8)	
Charlson: Cancer	CHAR_CANCER	0.050 (0.219)	0.049 (0.218)	0.537 (0.5945)

Signal Detection Methods

Goal: Measure strength of dependency between a product and a specific AE term

- Unsupervised (disproportionality analysis) methods

- Frequentist: PRR, ROR, Chi-square
- Bayesian: BCPNN/IC-2SD, MGPS/EBGM, BBR, AdjRS

- Supervised methods

- Propensity score and causal analysis
- Logistic/Linear/Mixed-effects regression
- Advanced machine learning methods
 - Neural Networks, Decision Tree, SVM, etc.
- Others
 - SAS® Detection and SAS® Visual Investigator

Condition	Event	No Event	Total
Drug			
Exposed	n_{11}	n_{10}	$n_{1.}$
Not exposed	n_{01}	n_{00}	$n_{0.}$
Total	$n_{.1}$	$n_{.0}$	$n_{..}$

$$\text{Score} = \text{Observed}(O) / \text{Expected}(E)$$

Unsupervised Methods

BCPNN/IC – Lindquist and Bates et. al. (1998)

- Score metric (IC): $E(IC) - 2\sqrt{V(IC)} > 0$
- $E(IC_{ij}) = \log_2\left\{ \frac{[(c_{ij} + \gamma_{ij})(C + \alpha)(C + \beta)]}{[(C + \gamma)(c_i + \alpha_i)(c_j + \beta_j)]} \right\}$
- $\gamma = \gamma_{ij} \left\{ \frac{[(C + \alpha)(C + \beta)]}{[(c_i + \alpha_i)(c_j + \beta_j)]} \right\}$ and
- $\gamma_{ij} = 1, \alpha_i = 1, \alpha_j = 2, \beta_i = 1, \beta_j = 2; C = n_{..}, c_i = n_{i.}, c_j = n_{.j}$

MGPS/EBGM/EB05 – DuMouchel (2000)

- Score metric: $EB_{05} > 2$
- $EBGM_{ij} = 2^{EB \log 2 ij}$
- $EB_{05} \approx EBGM_{ij} * \exp \{-1.645/\sqrt{c_{ij} + 1}\}$ and
- $EB_{95} \approx EBGM_{ij} * \exp \{1.645/\sqrt{c_{ij} + 1}\}$

where $c_{ij} = n_{11}$

ROR

- Score metric: $(ROR - 1.96SE) > 1$
- $ROR = (n_{11} * n_{00}) / (n_{10} * n_{01})$
- $SE(\ln ROR) = \sqrt{(1/n_{11} + 1/n_{10} + 1/n_{01} + 1/n_{00})}$

PRR – Evans et. al. (2001)

- Score metric: $(PRR - 1.96SE) > 1$
- $PRR = (n_{11}/n_{1.}) / (n_{01}/n_{0.})$
- $SE(\ln PRR) = \sqrt{(1/n_{11} - 1/n_{1.} + 1/n_{01} - 1/n_{0.})}$

Supervised Methods

PROC STDRATE

- computes directly standardized rates and risks for study populations.
- PROC STDRATE data=<name of dataset> METHOD=mh STAT=risk/rate EFFECT=diff/ratio plots=all;
POPULATION GROUP=<treatment variable> EVENT=<outcome event> TOTAL=<Patients/PYears>;
STRATA <List of stratification variables> / order=data STATS(cl=<options>) EFFECT; RUN;

PROC CAUSALTRT

- estimates the average causal effect of a binary treatment, T, on a continuous or discrete outcome, Y. Good for data from nonrandomized trials or observational studies.
- PROC CAUSALTRT data=< name of data set > method=AIPW covdiffps PPSMODEL
POUTCOMEMOD;
 - CLASS < list of class variables >;
 - PSMODEL <treatment variable> = < List of variables for propensity score matching > /
plots=(PSDist pscovden(effects(name of variables))));
 - MODEL <outcome variable> = < List of variables for outcome event prediction > / <options>;
 - BOOTSTRAP bootci(all) plot=hist seed=1234; RUN;

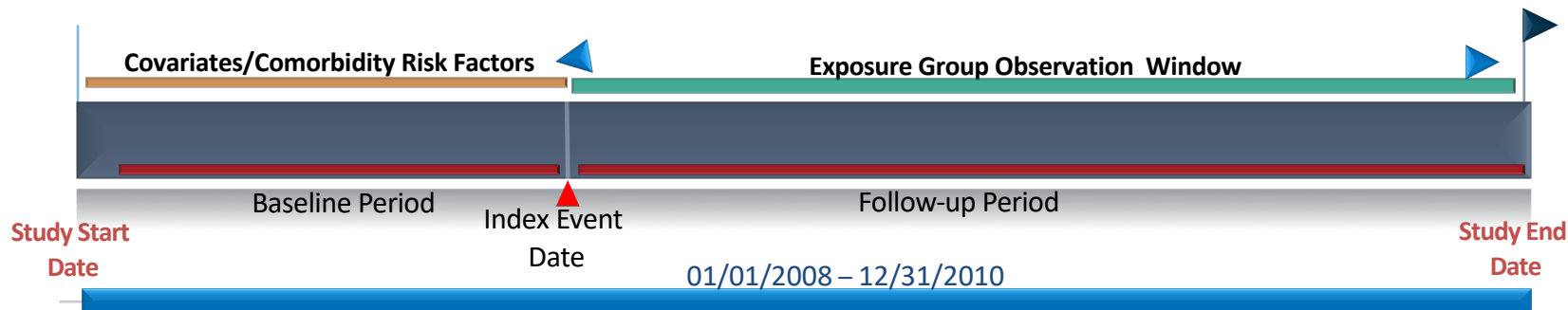


Cohort Use Case and Demonstration

Use Case: Study Objectives

- Perform unsupervised signal detection of adverse events that may be associated with disproportionate reporting of diabetes medication drug codes
- Investigate association between diabetes medication drug codes and incidence of AMI in T2DM patient cohort

Use Case: Study Cohort Design and Setup



- At least one prescription for diabetes medications in the following drug classes: alpha-glucosidase inhibitors or dopamine agonist or dipeptidyl peptidase-4 or glucagon or meglitinides or sodium glucose transporter or sulfonylureas or thiazolidinediones or biguanides (Medication first-fill date = index event date)
- Diabetes Dx: ECQM value set = "2.16.840.1.113883.3.464.1003.103.12.1001"
- Age ≥ 18
- Demographics, Charlson comorbidity risk factors, etc.

Use Case: Study Cohort Setup Using SAS® RWE

SAS® Real World Evidence

Home > [diabetes project](#) > **Diabetes Rx Surveillance**

Name: Diabetes Rx Surveillance
 Description: Diabetes Rx Surveillance with CMS 800K
 Date Range: Jan 1, 2008 - Dec 31, 2010

Data source: 800K_CMS_ICD10_RWE43_20180511 n=711,479
 Data source description: 800K_CMS_ICD10_RWE43_20180511
 Enrollment: None n=636,980; 89.53%

Type: Index Event Cohort

Actions

1 Cohort — 2 Analysis Variables — 3 Add-ins

Index Event DM RXs IED n=163,582 23%

Inclusion/Exclusion Criteria n=103,802 15%

AND OR NOT Apply

- > ☒ AGE_GE18 n=163,582
- > ☒ AMI n=13,189
- > ☒ Biguanides n=86,506
- > ☒ Dopamine agonist n=18,841
- > ☒ DPP-4 inhibitors n=4,817
- > ☒ Glucagon n=912
- > ☒ Meglitinides n=5,740
- > ☒ SGLT2 inhibitors n=0
- > ☒ Sulfonylureas n=82,081
- > ☒ Thiazolidinediones n=16,234
- > ☒ Diabetes_ECOM n=103,802

Cohort Variables

Filters

Name	Count / %
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Biguanides	86,506 / 53%
Dopamine agonist	18,841 / 12%
DPP-4 inhibitors	4,817 / 3%
Glucagon	912 / 1%
Meglitinides	5,740 / 4%

User-defined Analysis Variables

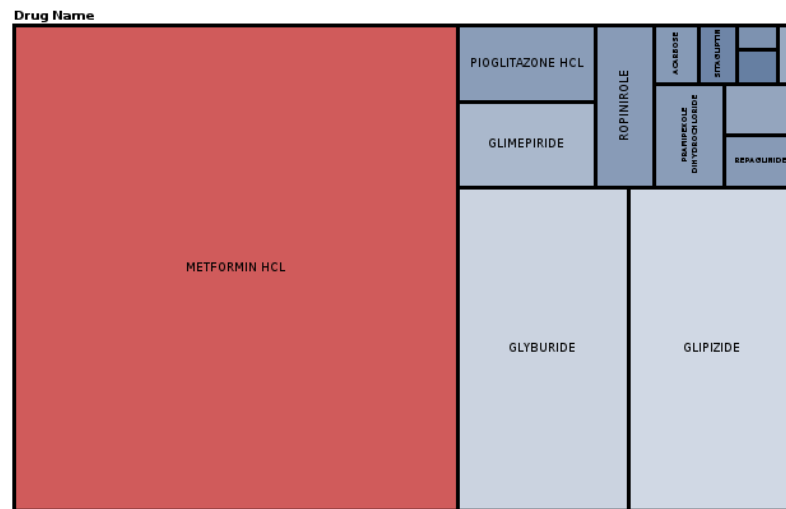
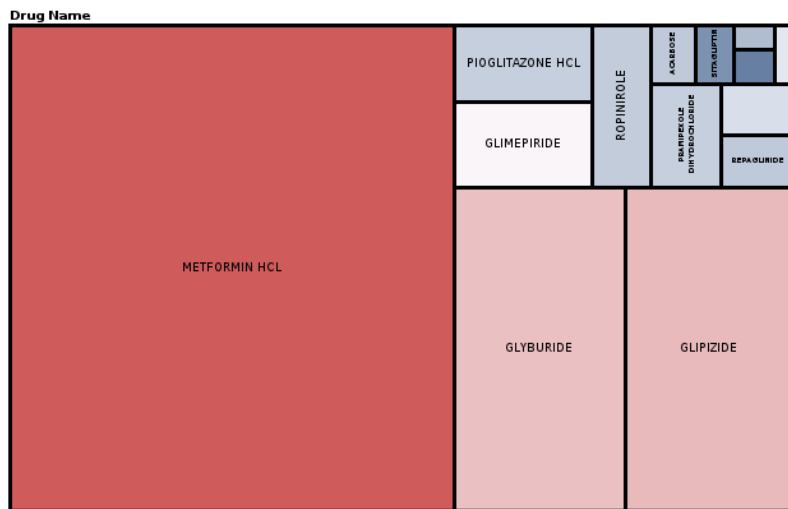
Name	Count / %
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☐ C-Difficile Infection	3,143 / 2%
☐ rhabdomyolysis	2,108 / 1%
☐ Diabetes poor control	38,392 / 23%
☐ Overdose	182 / 0%
☐ Poisonings	779 / 0%
☐ Complications from Amputation	779 / 0%
☐ Severe Sepsis	5,269 / 3%

Unsupervised (Disproportionality) Signal Detection Analysis

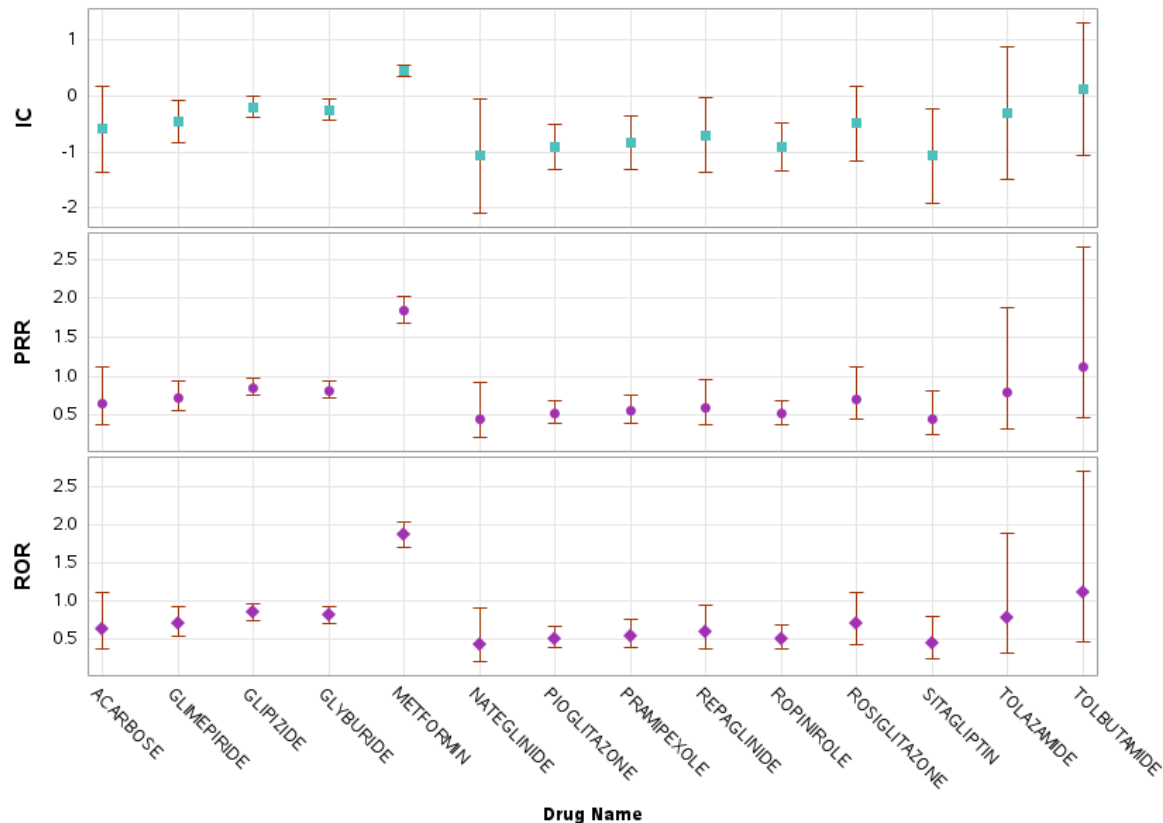
			Unsupervised disproportionality signaling method								
			PRR			ROR			BCPNN		
Generic Drugname	No. of Patients	Observed Events	Expected Events	PRR	95% CI	Expected Events	ROR	95% CI	Expected Events	IC	IC-2SD
ACARBOSE	1107	13	20.11	0.646	(0.375, 1.113)	20.25	0.642	(0.371, 1.112)	20.04	-0.590	-1.368
GLIMEPIRIDE	4402	58	80.64	0.719	(0.554, 0.933)	81.07	0.715	(0.550, 0.931)	79.68	-0.453	-0.836
GLIPIZIDE	16826	266	312.04	0.852	(0.749, 0.970)	312.91	0.850	(0.746, 0.969)	304.58	-0.196	-0.385
GLYBURIDE	17864	273	333.84	0.818	(0.720, 0.929)	335.00	0.815	(0.716, 0.927)	323.37	-0.244	-0.431
METFORMIN HCL	42742	1060	573.30	1.849	(1.689, 2.024)	566.68	1.871	(1.706, 2.051)	773.71	0.453	0.342
NATEGLINIDE	873	7	15.88	0.441	(0.210, 0.925)	16.04	0.436	(0.207, 0.919)	15.80	-1.073	-2.100
PIOGLITAZONE HCL	5431	52	100.87	0.516	(0.392, 0.679)	101.79	0.511	(0.387, 0.674)	98.31	-0.907	-1.310
PRAMIPEXOLE DIHYDROCHLORIDE	3570	36	65.64	0.548	(0.395, 0.762)	66.20	0.544	(0.390, 0.758)	64.62	-0.828	-1.309
REPAGLINIDE	1654	18	30.13	0.597	(0.376, 0.949)	30.36	0.593	(0.372, 0.946)	29.94	-0.705	-1.374
ROPINIROLE	4842	46	89.69	0.513	(0.383, 0.687)	90.51	0.508	(0.379, 0.682)	87.65	-0.916	-1.344
ROSIGLITAZONE	1408	18	25.59	0.703	(0.443, 1.117)	25.73	0.700	(0.438, 1.116)	25.49	-0.481	-1.151
SITAGLIPTIN	1337	11	24.37	0.451	(0.250, 0.815)	24.62	0.447	(0.246, 0.810)	24.20	-1.072	-1.911
TOLAZAMIDE	352	5	6.38	0.784	(0.327, 1.878)	6.40	0.781	(0.323, 1.891)	6.37	-0.301	-1.491
TOLBUTAMIDE	248	5	4.49	1.114	(0.466, 2.661)	4.48	1.116	(0.460, 2.710)	4.49	0.123	-1.071

Note: For unsupervised disproportionality analysis, only drugs with N>=100 patients and drug/event combination with N>=5 cases are shown.

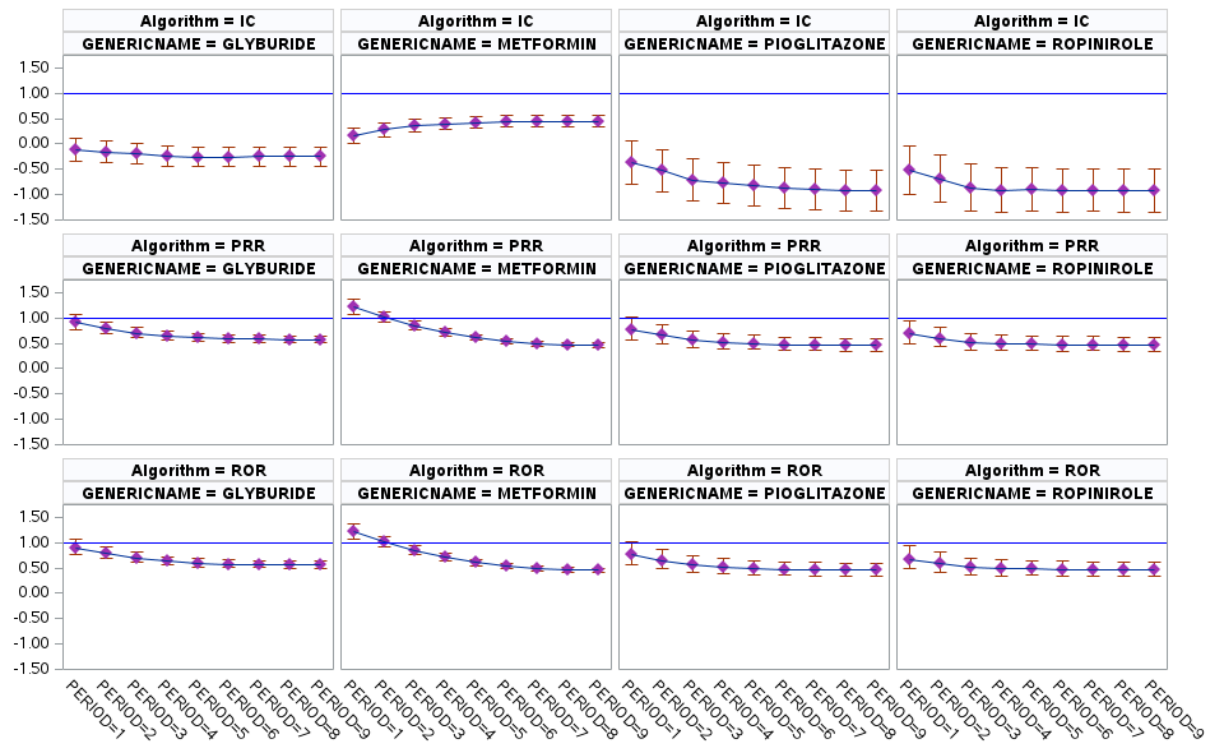
Disproportionality Analysis: Diabetes Medications and AMI



Disproportionality Analysis: Diabetes Medications and AMI



Disproportionality Trend Analysis: Selected Diabetes Medications and AMI

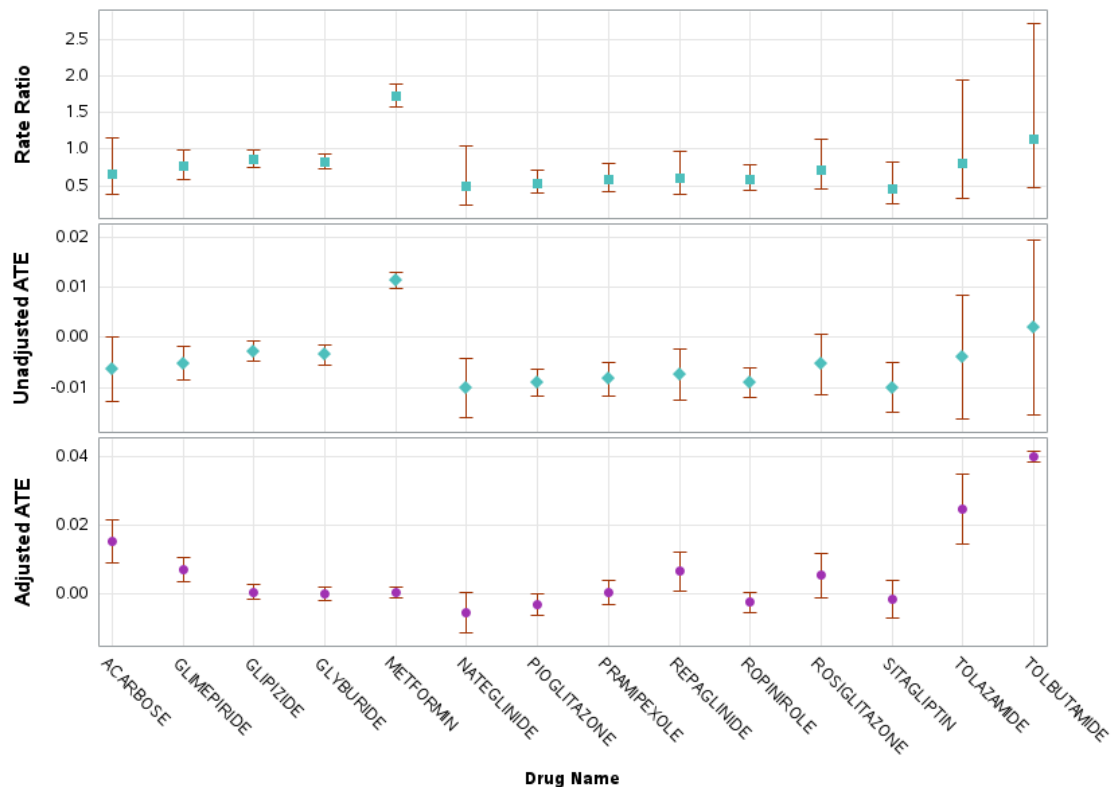


Supervised Signal Detection Analysis: Diabetes Medications and AMI

		Supervised method								
		Unadjusted			Unadjusted			Adjusted		
Generic Drugname	N(Patients)	Rate Ratio	Z Score	95% CI	ATE	Z Score	95% CI	ATE	Z Score	95% CI
ACARBOSE	1107	0.6668	-1.45636	(0.386, 1.150)	-0.0064	-1.96866	(-0.013, -0.000)	0.0152	4.85830	(0.009, 0.021)
GLIMEPIRIDE	4402	0.7601	-2.05667	(0.585, 0.987)	-0.0051	-2.90546	(-0.009, -0.002)	0.0068	3.74226	(0.003, 0.010)
GLIPIZIDE	16826	0.8629	-2.22744	(0.758, 0.982)	-0.0027	-2.56976	(-0.005, -0.001)	0.0003	0.31049	(-0.002, 0.002)
GLYBURIDE	17864	0.8283	-2.87741	(0.729, 0.942)	-0.0034	-3.31455	(-0.005, -0.001)	-0.0001	-0.07938	(-0.002, 0.002)
METFORMIN HCL	42742	1.7223	11.68550	(1.572, 1.887)	0.0114	12.87206	(0.010, 0.013)	0.0004	0.53812	(-0.001, 0.002)
NATEGLINIDE	873	0.4929	-1.86815	(0.235, 1.035)	-0.0102	-3.33729	(-0.016, -0.004)	-0.0057	-1.91351	(-0.012, 0.000)
PIOGLITAZONE HCL	5431	0.5351	-4.44679	(0.406, 0.705)	-0.0090	-6.47450	(-0.012, -0.006)	-0.0033	-2.08268	(-0.006, -0.000)
PRAMIPEXOLE DIHYDROCHLORIDE	3570	0.5850	-3.18590	(0.421, 0.814)	-0.0083	-4.81301	(-0.012, -0.005)	0.0002	0.10577	(-0.003, 0.004)
REPAGLINIDE	1654	0.6057	-2.11722	(0.381, 0.963)	-0.0073	-2.83770	(-0.012, -0.002)	0.0064	2.17497	(0.001, 0.012)
ROPINIROLE	4842	0.5846	-3.59644	(0.436, 0.783)	-0.0090	-6.18627	(-0.012, -0.006)	-0.0027	-1.83875	(-0.006, 0.000)
ROSIGLITAZONE	1408	0.7149	-1.41685	(0.449, 1.137)	-0.0054	-1.78333	(-0.011, 0.001)	0.0052	1.58168	(-0.001, 0.012)
SITAGLIPTIN	1337	0.4540	-2.61133	(0.251, 0.821)	-0.0100	-3.99247	(-0.015, -0.005)	-0.0019	-0.65863	(-0.007, 0.004)
TOLAZAMIDE	352	0.8089	-0.47348	(0.336, 1.946)	-0.0039	-0.61867	(-0.016, 0.008)	0.0246	4.67275	(0.014, 0.035)
TOLBUTAMIDE	248	1.1281	0.26925	(0.469, 2.714)	0.0021	0.23106	(-0.015, 0.020)	0.0401	52.05805	(0.039, 0.042)

Note: For supervised signaling method, only drugs with N>=100 patients and drug/event combination with N>=5 cases are shown.

Supervised Signal Detection Analysis: Diabetes Medications and AMI



Conclusion

WHAT

Observational
Data

Early detection of
drug safety issues

Patient healthcare
journeys

HOW

SAS Real World
Evidence

Investigate and
answer real world
questions

Discover and visualize
patient cohort

EXECUTE

Signal detection
analyses

Proactively detect
and act on adverse
drug reactions

Minimize errors and
reduce false-positive
signals



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