Risk Adjustment for Cost Analyses: Development and Implementation of the V21 and Nosos Systems

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Cyberseminar Outline

- Background of risk adjustment for cost data
- Nosos and V21 availability
- Looking under the hood:
  - Development of Nosos
  - Statistical comparability across risk models

Risk adjustment for cost data

What is risk adjustment?

- Statistical method to adjust for the observable differences between patients
  - Classify patients into homogeneous clinical categories
  - Calculate a single dimension risk score using clinical categories

Why risk adjust?

- The goal is to identify opportunities for improvement and develop / test innovations.

- Risk adjustment is necessary to address many of these questions

Risk Adjustment Systems

- Verisk Risk Smart/Risk Solutions (DxCG)
- Charlson co-morbidity index
- CAN score
- Adjusted Clinical Groups (ACGs)
- Chronic Illness & Disability Payment System (CDPS)
- CMS Risk Adjustment Model (V21)
- Nosos

Poll (1)

- Have you used any of the following:
  - Charlson
  - Elixhauser
  - CAN

Poll (2)

- Have you used any of the following:
  - ACG
  - CMG
  - DxCG
  - CDPS
  - V21

Poll (3)

- Have you used any of the following:
  - RxRisk
  - Medicaid Rx

Risk Adjustment Systems

- Often used to identify clinical groups

Create multiple condition categories
- Charlson
- DxCG
- V21
- ACGs

- Sometimes used to create a risk score

Create a single index (risk score)
- DxCG
- V21
- Nosos

Time Horizon

- Often risk adjustment is needed to estimate the present clinical risk of population

- Sometimes needed to estimate the future risk
  - Risk of readmission
  - Risk of being more costly next year

Time Horizon in Cost Data

- Concurrent: Uses current year diagnoses to predict current year's expenditures
  - Places importance on acute conditions

- Prospective: Uses current year diagnoses to predict next year's expenditures
  - Places importance on chronic conditions

Risk and Reimbursement

- Most providers outside of VA link risk to reimbursement
- CMS reimburses Medicare Advantage plans based on a risk adjustment model
- For this talk, I'm focusing on using risk adjustment for research (not payment)

Risk adjustment at VA

- Used by operations and research to:
  - Assess medical center efficiency and productivity
  - Conduct health services research (e.g., cost associated with innovations)
- Historically, VA contracted with Verisk to obtain calculate risk scores for VA data

Verisk Versions

- Risk Smart algorithm creates 184 hierarchical condition categories (HCC) and risk scores
- Verisk is phasing out Risk Smart and moving to Risk Solutions, which creates 394 HCCs and risk scores
- We focused on the latter, more recent version (Risk Solution)

DxCG Risk Solutions

- Hereafter DxCG refers to Risk Solution model

- Model produces 3 risk scores
  - Medicare prospective risk without Rx
  - Medicare concurrent risk without Rx
  - Medicaid prospective risk *with* Rx

CMS Version 21

- Generates 189 HCCs (89 HCCs populated)
- Produces 3 prospective risk scores
  - Community
  - Institution
  - New enrollee
- No concurrent risk score

Nosos

- Greek for ‘chronic disease’
- V21 risk scores plus additional factors used in regression model to model annual VA costs per patient
- Produces prospective and concurrent scores

Access to V21 and Nosos

Data Location

- SAS datasets available for FY2006-2014 at \\vhacdwapp15\RiskScores

- SAS Programs available on VINCI SAS Grid at /data/ops/OPES_CMSHCCV21/nososmacros

Access to Nosos/V21

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Technical Report

- Describes SAS programs and input datasets

http://www.herc.research.va.gov/include/page.asp?id=technical-report-risk-adjustment

Data Updates

- Annual updates use the full fiscal year (Q1-4) of utilization and cost data

- Quarterly updates use the most recent 4 quarters of utilization and cost data
  - Example: To calculate FY14 Q2 scores, use FY13 Q3-4+FY14 Q1-2

Data Updates

- *ICD-9, demographics*: MedSAS, CDW
  - Regularly updated in CDW
- *Non-VA care:* Fee Basis/Purchased Care
  - Regularly updated in CDW
- *Priority*: ADUSH Enrollment file
  - Regularly updated in CDW
- *Cost, pharmacy*: MCA (DSS), HERC Average Cost
  - Regularly updated in CDW/VINCI
- *Registry*: ARC
  - Requested annually from ARC

List of VA Registries

Registry Number	Registry Name
1	Spinal cord injury
2	Chronically mentally ill
3	Blind
4	Post-traumatic stress disorder (PTSD)
5	Alcohol
6	Stroke
7	Hepatitis C virus
8	Home health
9	Domiciliary
10	Long term care
11	Brain
12	AIDS
13	Transplant
14	End-stage renal disease (ESRD)
15	Homeless
16	Care coordination home telehealth

Input files for ICD-9 codes

MedSAS Files

VA file (short)	VA file (full)	AITC Mainframe Location	VINCI Libref	VINCI Name
PTF-PM	MedSAS inpatient acute care main	MDPPRD.MDP.SAS.PMyy	PTF_INP	MedSAS/INPATIENT
PTF-PM census`	MedSAS inpatient acute care main census	MTPPRD.MED.SAS.CENSUS.PMyy.QTRz	CEN_PTF	MedSAS/INPATIENT_CENSUS
PTF-PMO	MedSAS inpatient observation care main	MDPPRD.MDP.SAS.PMOyy	PTF_OBS	MedSAS/INPATIENT/OBSERVATION_BEDS
PTF-PMO census	MedSAS inpatient observation care main census	MTPPRD.MED.SAS.CENSUS.PMOyy.QTRz	CEN_PTF	MedSAS/INPATIENT_CENSUS
PTF-XM	MedSAS inpatient extended care main	MDPPRD.MDP.SAS.XMyy	PTF_EXT	MedSAS/INPATIENT/EXTENDED_CARE
PTF-XM census	MedSAS inpatient extended care census	MTPPRD.MED.SAS.CENSUS.XMyy.QTRY	CEN_EXT	MedSAS/INPATIENT_CENSUS/EXTENDED_CARE
NPCD-SE	MedSAS Outpatient visits file	MDPPRD.MDP.SAS.SEyy	OUTP	MedSAS/OUTPATIENT
NPCD-SF	MedSAS Outpatient events file	MDPPRD.MDP.SAS.SFyy	OUTP	MedSAS/OUTPATIENT
NPCD-IE	MedSAS Inpatient encounters file	MDPPRD.MDP.SAS.IEyy	OPC_IE	MedSAS/INPATIENT/PCE

Fee Basis (Purchased Care) Files

VA file (short)	VA file (full)	AITC Mainframe Location	VINCI Libref	VINCI Name
Fee Basis-INPT	Fee basis inpatient stays	MDPPRD.MDP.SAS.FEN.FYyy.INPT	FEE_INPT	MedSAS/FEE/Inpatient
Fee Basis-ANCIL	Fee basis inpatient ancillary services and physician charges	MDPPRD.MDP.SAS.FEN.FYyy.INPT.ANCIL	FEE_ANCL	MedSAS/FEE/Ancillary
Fee Basis-MED	Fee basis outpatient services	MDPPRD.MDP.SAS.FEN.FYyy.MED	FEE_OUTP	MedSAS/FEE/Outpatient

Development of Nosos and Comparability of V21 and Nosos to DxCG

Aims

1. How do the DxCG and V21 risk scores compare?

2. What is gained by adding variables and recalibrating the risk scores to fit VA?

Aim 1:

How do the computed DxCG and V21 risk scores compare?

Six Study Samples

1. General sample
2. High cost Veterans
3. Veterans with mental health/substance use disorder (MH-SUD)
4. Veterans over age 65
5. Veterans with multi-morbidity
6. Healthy Veterans

Samples

- General sample: 2 million randomly selected Veterans

- High Cost Users: most costly 5% VA users. Most costly was based on HERC national costs to remove geographic wage variation

Samples (cont)

- MH-SUD: All patients with a MH or SUD diagnosis in VA. We used diagnostic codes from MHO

- Over 65: Veterans >=65

Samples (cont)

- Multi-morbidity and healthy used the AHRQ body indicator
- Multi-morbid: 2 or more Body System Indicators
- Healthy:
  - not multi-morbid
  - just one body system indicator
  - Had a V code for a physical V70x,V71x,V72x

Body System Indicator

1 = Infectious and parasitic disease
2 = Neoplasms
3 = Endocrine, nutritional, and metabolic diseases and immunity disorders
4 = Diseases of blood and blood-forming organs
5 = Mental disorders
6 = Diseases of the nervous system and sense organs
7 = Diseases of the circulatory system
8 = Diseases of the respiratory system
9 = Diseases of the digestive system
10 = Diseases of the genitourinary system
11 = Complications of pregnancy, childbirth, and the puerperium
12 = Diseases of the skin and subcutaneous tissue
13 = Diseases of the musculoskeletal system
14 = Congenital anomalies
15 = Certain conditions originating in the perinatal period
16 = Symptoms, signs, and ill-defined conditions
17 = Injury and poisoning
18 = Factors influencing health status and contact with health services

Outcomes

- Total costs in current year (FY10) and prospective year (FY11)
  - VA inpatient (MCA/DSS)
  - VA outpatient (MCA/DSS)
  - VA pharmacy (MCA/DSS)
  - Fee Basis (purchased care)

Data

- VA care (utilization, cost, diagnostic information)
  - MedSAS (NPCD, PTF)
  - MCA/DSS
  - HERC Average Cost data
- Non-VA care
  - Fee Basis

Descriptive Statistics

	General	Over 65	High cost	MH-SUD	Multi-morbid	Healthy
N	1,995,620	644,524	261,487	830,832	817,951	78,032
Age (SD)	62.0 (15.9)	81.4 (4.6)	62.5 (13.4)	56.9 (15.2)	62.2 (13.8)	48.2 (17.4)
Male	94%	98%	95%	91%	94%	86%
Total Costs*						
Mean	8,819	8,067	76,920	15,067	21,345	2,435
Median	2,563	1,908	52,954	5,637	9,337	1,093
SD	24,976	25,624	76,697	33,560	40,603	5,203
Maximum	1,660,240	1,597,986	2,979,525	2,476,373	2,979,525	275,166

*Total Costs include inpatient, outpatient, pharmacy and Fee Basis care
- Veterans whose DSS Rx costs exceed $50,000 were excluded from these analyses.
- Negative DSS VA in/out costs and DSS Rx costs were also replaced with zeros.
- High cost sample developed using HERC average costs, not DSS costs

Comparing Risk Scores: regression models

- Ordinary least squares (OLS)
- Log-OLS
- Square-root OLS
- Generalized linear model (GLM) with gamma distribution and log-link
- GLM with gamma distribution and square root link

- Covariates: age, age-squared, gender

Average Risk Scores

	CMS V21	DxCG Medicare		DxCG Medicaid
	Prospective without Rx	*Prospective without Rx*	*Concurrent without Rx*	*Prospective with Rx*
General	0.756 (0.730)	0.661 (0.698)	0.497 (0.879)	1.756 (2.126)
Over 65	1.065 (0.750)	0.921 (0.656)	0.504 (0.874)	2.020 (2.267)
High cost	2.234 (1.580)	2.077 (1.628)	2.684 (2.243)	7.228 (4.323)
MH-SUD	0.893 (0.850)	0.802 (0.802)	0.770 (1.092)	2.487 (2.708)
Multi-morbid	1.160 (1.024)	1.044 (1.002)	1.004 (1.343)	3.146 (3.027)
Healthy	0.295 (0.234)	0.236 (0.219)	0.152 (0.244)	0.708 (0.708)

Mean (SD)

How do Risk Scores Fit the VA Data?

- R-squared
- Root mean squared error
- Mean absolute error
- Hosmer-Lemeshow goodness of fit

R-squared

	CMS V21	DCG Medicare		DCG Medicaid
	Prospective without Rx	*Prospective without Rx*	*Concurrent without Rx*	*Prospective with Rx*
General	0.4287	0.4308	0.5122	0.5682
Over 65	0.4108	0.3876	0.4802	0.5907
MH-SUD	0.3985	0.4191	0.4876	0.5738
High cost	0.1920	0.1999	0.2650	0.3779
Multi-morbid	0.3910	0.3906	0.4790	0.5377
Healthy	0.1646	0.1966	0.2694	0.2701

Results shown were from an Square root OLS model

Root Mean Squared Error

	CMS V21	DCG Medicare		DCG Medicaid
	Prospective without Rx	*Prospective without Rx*	*Concurrent without Rx*	*Prospective with Rx*
General	20,576	21,829	22,060	17,884
Over 65	22,018	23,377	23,761	18,464
MH-SUD	27,942	29,215	28,865	23,895
High cost	70,312	70,003	67,206	62,716
Multi-morbid	34,035	35,043	33,708	29,888
Healthy	4,945	5,045	4,782	4,605

Results shown were from an Square root OLS model

Mean Absolute Error

	CMS V21	DCG Medicare		DCG Medicaid
	Prospective without Rx	*Prospective without Rx*	*Concurrent without Rx*	*Prospective with Rx*
General	7,415	7,423	6,783	6,398
Over 65	7,320	7,552	6,812	6,077
MH-SUD	11,843	11,607	10,774	9,942
High cost	41,640	41,266	39,120	36,720
Multi-morbid	15,225	15,236	13,868	13,234
Healthy	2,087	2,035	1,937	1,941

Results shown were from an Square root OLS model

Hosmer-Lemeshow Tests

	CMS V21	DCG Medicare		DCG Medicaid
Deciles	*Prospective without Rx*	*Prospective without Rx*	*Concurrent without Rx*	*Prospective with Rx*
General Sample				
1	-1,651	-2,530	-2,561	-1,286
2	-1,464	-2,187	-2,455	-1,287
3	-1,432	-2,059	-2,300	-1,296
4	-1,431	-1,954	-2,035	-1,636
5	-1,495	-1,701	-1,542	-1,234
6	-1,415	-1,493	-867	-335
7	-730	-567	188	179
8	301	1,014	1,115	1,049
9	2,694	3,579	4,479	1,199
10	6,645	7,922	6,000	4,663

Findings

- Concurrent risk:
  - DxCG offers concurrent risk scores; CMS V21 does not
  - Concurrent risk models tend to produce better fit statistics than prospective risk models
- Prospective risk:
  - DxCG and V21 produce similar results across a range of samples and regression specifications
- Prospective risk with pharmacy:
  - DxCG offers better fit than V21, which does not include pharmacy

Aim 2

What is gained by adding clinical detail and recalibrating the risk models to fit VA?

Recalibration to Nosos

- Added more covariates
  - Race, Marital status, Other health insurance, Veteran priority level status
  - Exposure registry (e.g., Agent Orange)
  - 46 psychiatric condition categories (Rosen)
  - Pharmacy
- Re-ran analytic models from Aim 1, and estimated new risk score for each patient

Pharmacy

- Prior year's pharmacy spending
- Any use of medication in 26 drug class categories

Drug Class

- PBM maintains an alphanumeric list of 580 drug types within 29 drug classes

- Three classes were rarely used, resulting in the final list of 26

VA Drug Codes

Abbreviation	Description
AH	Antihistamines
AM	Antimicrobials
AN	Antineoplastics
AP	Antimalarials, Antiprotozoals
AU	Autonomic agents
BL	Blood-related agents
CN	Central nervous system agents
CV	Cardiovascular agents
DE	Topical agents
DX	Diagnostic agents
GA	Gastrointestinal agents
GU	Genitourinary agents
HS	Hormonal agents
IM	Immune agents
MS	Musculoskeletal agents
NT	Nose and throat agents
OP	Ophthalmic agents
OR	Oral agents
OT	Otic agents
RE	Respiratory agents
RS	Rectal solutions
TN	Electrolytes and nutrients
VT	Vitamins
XA	Devices and supplies
OTHER	Miscellaneous agents

R-squared

	CMS V21	Nosos	DxCG Medicare		DxCG Medicaid
	Prospective without Rx	*Prospective with VA drug class indicators*	*Prospective without Rx*	*Concurrent without Rx*	*Prospective with Rx*
General	0.5793	0.6924	0.5819	0.6274	0.6351
Over 65	0.5728	0.6772	0.5677	0.6233	0.6397
MH-SUD	0.5820	0.6810	0.5896	0.6268	0.6509
High cost	0.3559	0.4281	0.3544	0.4244	0.4241
Multi-morbid	0.5350	0.6331	0.5326	0.5957	0.5943
Healthy	0.2922	0.4573	0.3113	0.3508	0.3778

Hosmer-Lemeshow

Deciles	CMS V21 *Prospective without Rx*	Nosos *Prospective with VA drug class indicators*	DxCG Medicare *Prospective without Rx*	DxCG Medicare *Concurrent without Rx*	DxCG Medicaid *Prospective with Rx*
General Sample					
1	-1,056	-650	-1,349	-1,244	-1,066
2	-1,050	-742	-1,379	-1,251	-1,149
3	-1,037	-623	-1,322	-1,282	-1,064
4	-944	-624	-1,210	-1,138	-950
5	-796	-670	-1,017	-981	-755
6	-570	-686	-678	-659	-343
7	-312	-746	-160	-71	96
8	12	-740	468	590	612
9	693	-211	1,883	2,149	659
10	5,072	5,707	4,776	3,897	3,968

Predicting Risk

- Use regression model to predict person's costs, then divide by average predicted costs

- Split-sample validation

Predicted Risk Scores

Sample	n	Mean	Std. Dev	Min	Max
General	1,988,053	1.00	1.62	0.14	41.26
Over 65	641,048	0.91	1.56	0.14	40.75
MH-SUD	819,707	1.64	2.19	0.14	44.02
High cost	255,661	5.58	3.92	0.16	45.92
Multi-morbid	815,088	2.06	2.48	0.14	45.92
Healthy	77,357	0.38	0.36	0.15	11.20

Results

- Model matters

	CMS V21	Nosos	DxCG Medicare		DxCG Medicaid
	Prospective without Rx	*Prospective with VA drug class indicators*	*Prospective without Rx*	*Concurrent without Rx*	*Prospective with Rx*
OLS	0.3141	NA	0.3371	0.4373	0.4441
SQRT OLS	0.4287	NA	0.4308	0.5122	0.5682

Results

- Notable gain from Pharmacy

	CMS V21	Nosos	DxCG Medicare		DxCG Medicaid
	Prospective without Rx	*Prospective with VA drug class indicators*	*Prospective without Rx*	*Concurrent without Rx*	*Prospective with Rx*
OLS	0.3141	NA	0.3371	0.4373	0.4441
SQRT OLS	0.4287	NA	0.4308	0.5122	0.5682

Results

- Recalibration is possible and yields improved fit

	CMS V21	Nosos	DxCG Medicare		DxCG Medicaid
	Prospective without Rx	*Prospective with VA drug class indicators*	*Prospective without Rx*	*Concurrent without Rx*	*Prospective with Rx*
Basic	0.4287	NA	0.4308	0.5122	0.5682
Recalibrated	0.5793	0.6924	0.5819	0.6274	0.6351

Limitations

- Comparison of only 2 systems
- Risk adjustment systems are concerned with gaming
  - VERA (Veterans Equitable Resource Allocation)
  - These risk models would not be used for payments

Future risk adjustment

- Areas for improving risk system
  - Move to ICD-10
  - Replacing MedSAS with CDW data
- Opportunity for discussion and collaboration in future versions
  - Frailty: GEC
  - Multi-year diagnostic data

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Questions?

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