

Using a Longitudinal Patient History Sourced From Claims Data To Analyze and Predict Potentially Avoidable Utilization, Costs, and Adverse Outcomes

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My Background

- MD / JD: Harvard
- Internal Medicine: Duke
- Part-time medical practice for 20+ years
- Health Policy: House Ways & Means, Office of Management and Budget
- Health Care Management and Analytics: Regional health plans
- Analytics R & D: AHRQ and Blue Health Intelligence

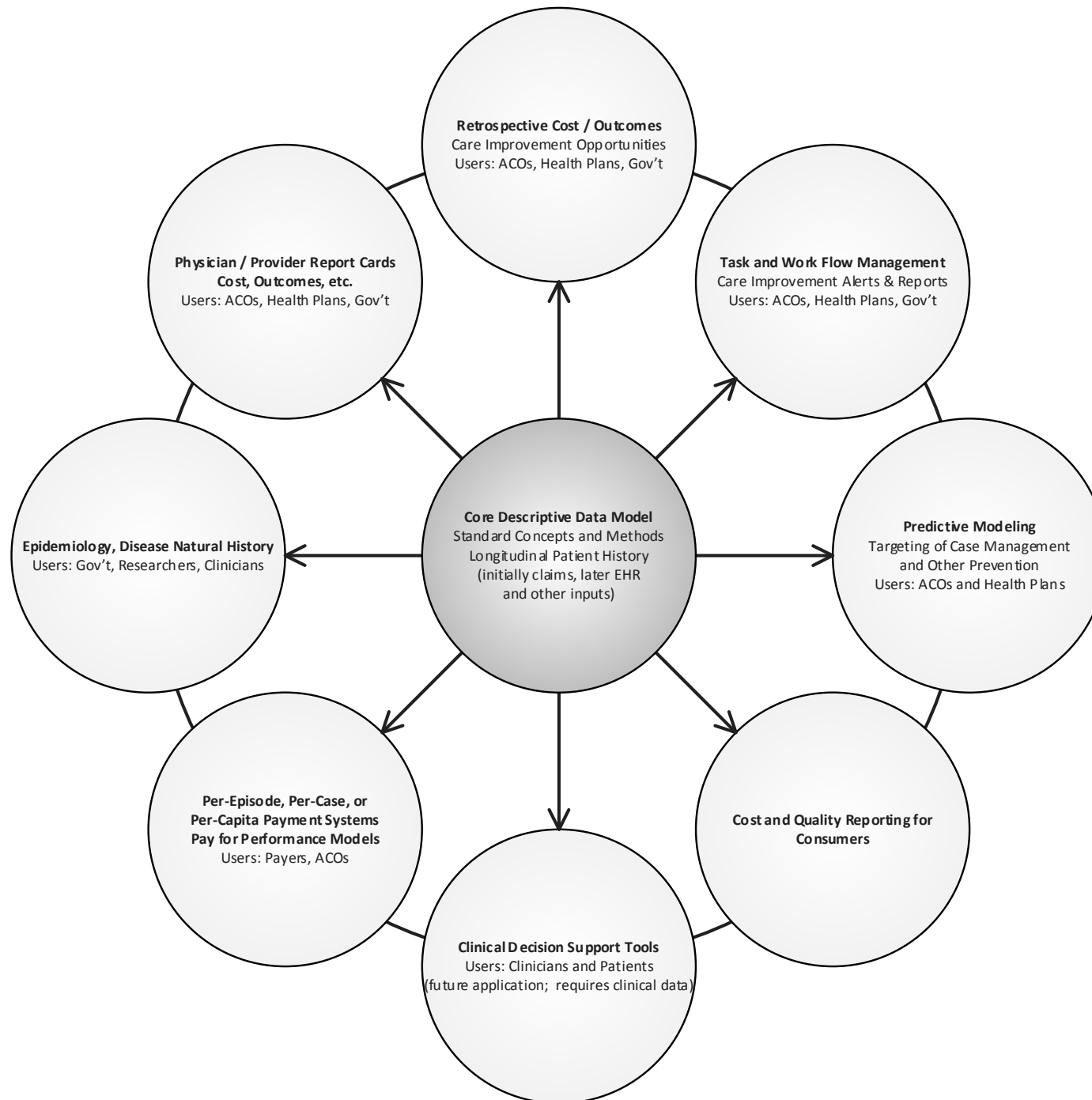
Identifying Opportunities to Improve Care

- A key first step for improving care is to identify situations where outcomes can be improved and / or resource use can be safely reduced
- Well-designed analytics can help identify these situations
- Because problems can involve any condition or aspect of care, analytics should ideally assess a comprehensive range of conditions and care
- Because there are a myriad of potential issues a comprehensive and semi-automated approach may be helpful to identify and prioritize issues
- The next several slides show how this can be done

Key Elements of Approach

- An 'analytic' longitudinal patient history constructed from claims data
 - Resulting 'constructs' mirror course of illness and care
 - Consistent multi-level classifications of conditions, services, and medications
- The resulting patient history can then be queried to answer a comprehensive range of questions and for predictive modeling

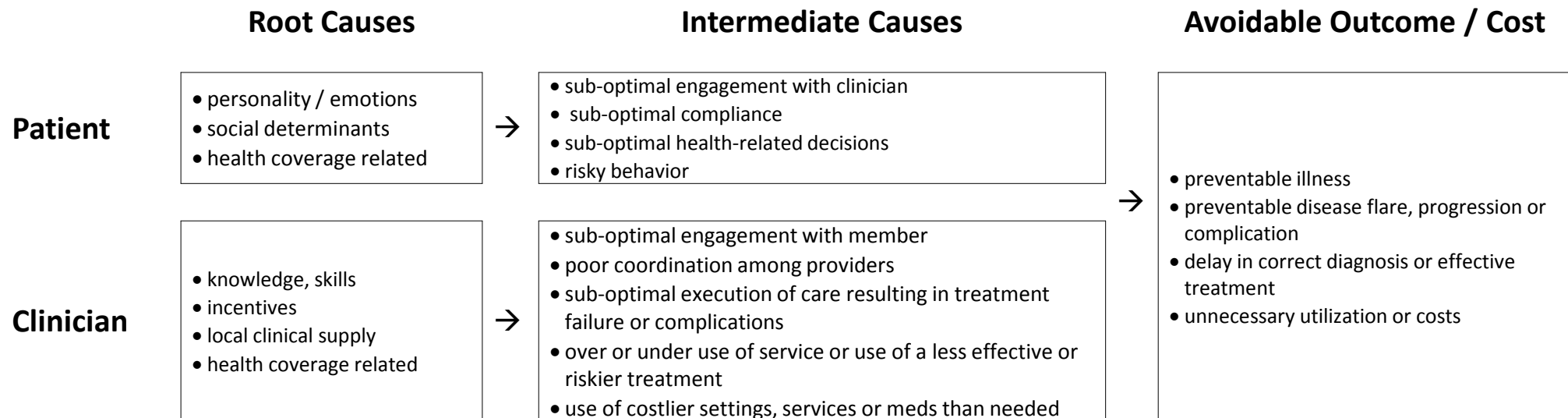
Possible Uses Cases



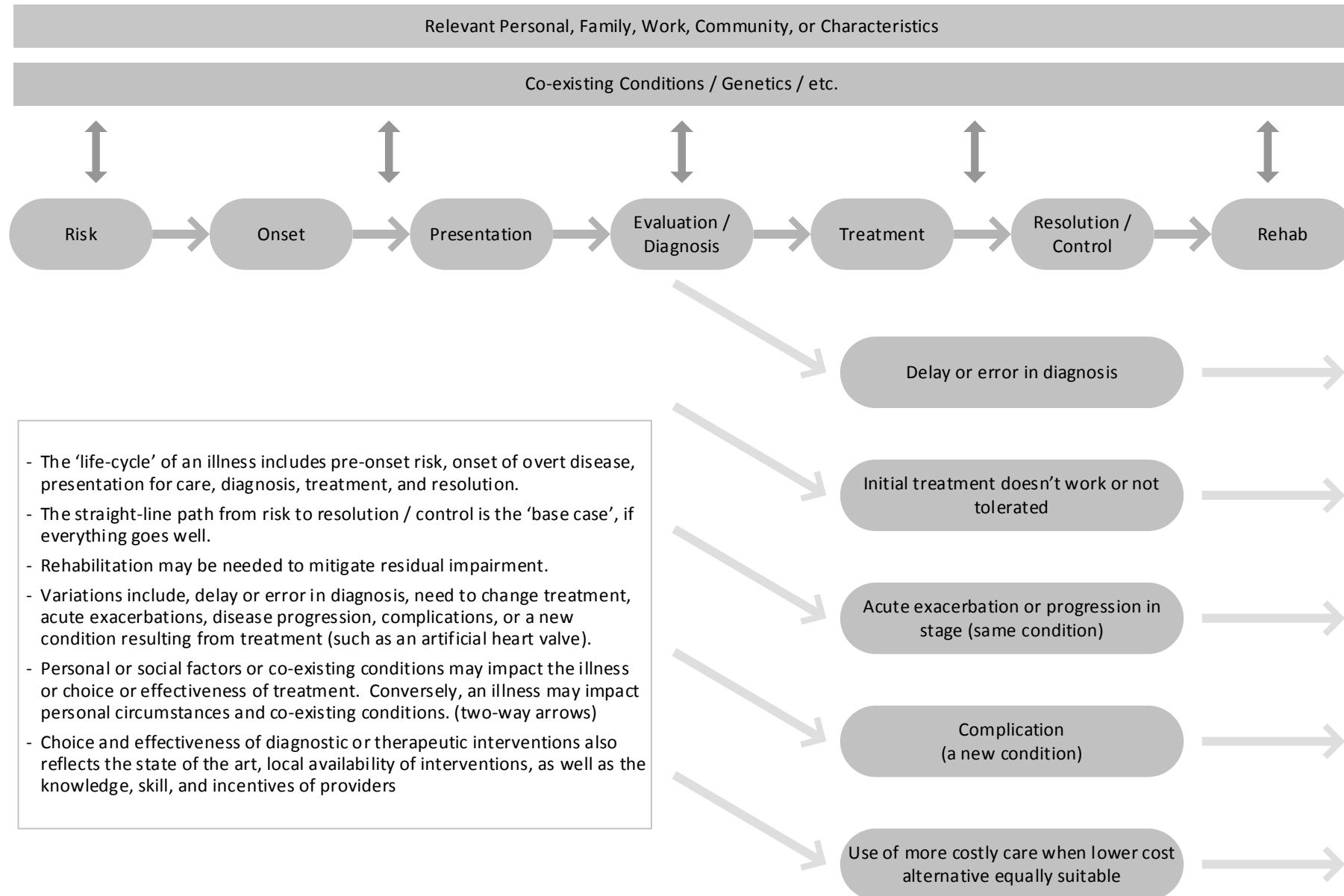
Conceptual Framework

Identifying Problems in Care and Their Causes

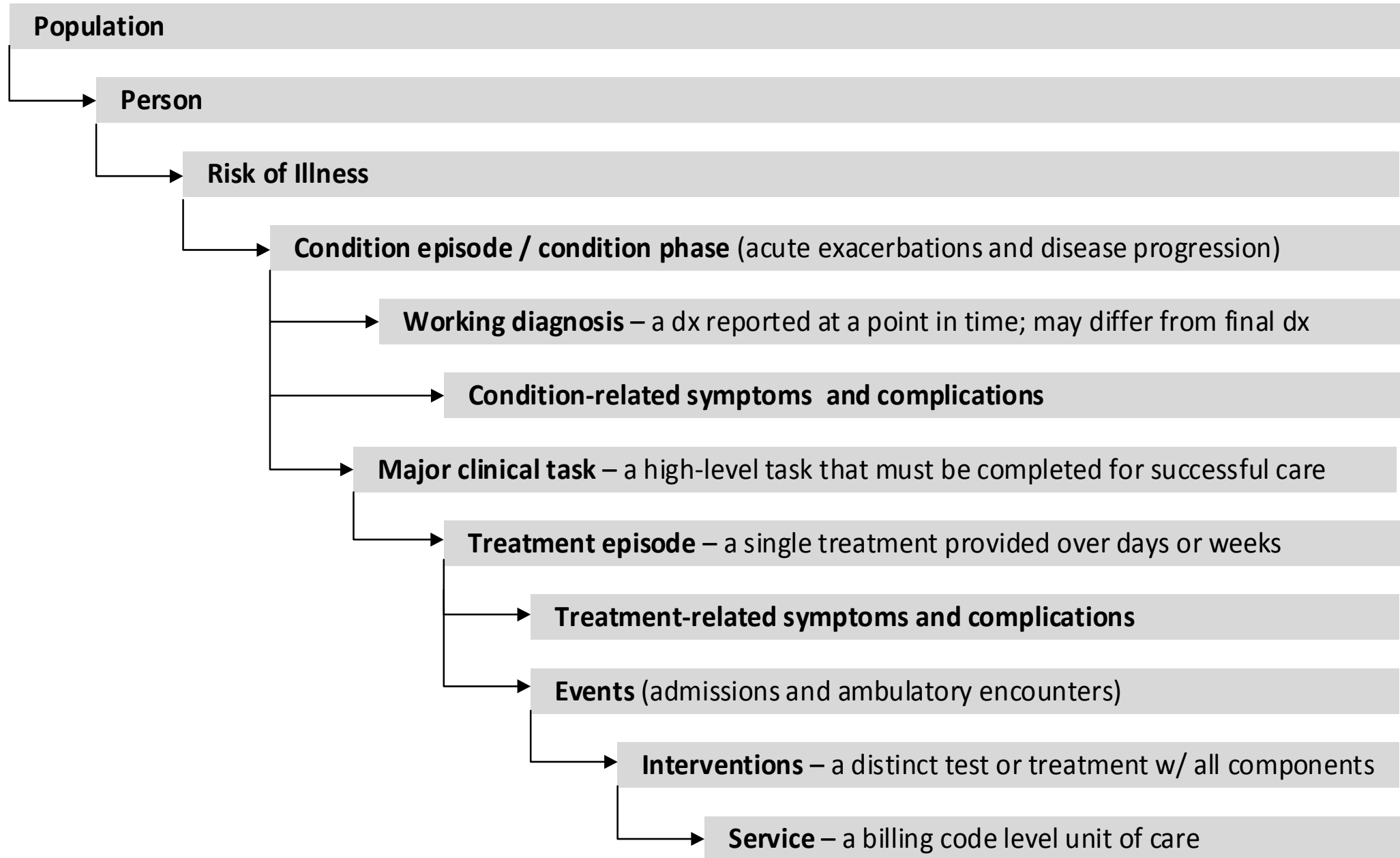
Potential Problems in Care	
Potentially avoidable adverse outcomes (with potential health and cost impacts)	<ul style="list-style-type: none"> • onset of preventable illness • late presentation of illness (with preventable adverse occurrences) • acute exacerbations (emergency hospitalization and ER visits) • readmissions / treatment failures • disease progression • illness and treatment complications
Potentially avoidable excess unit costs (use of more costly care when a similar lower-cost alternative is available)	<ul style="list-style-type: none"> • use of a costlier setting when a less costly setting is equally safe / effective • use of a costlier service or medication when less option is equally costly equally safe / effective • use of a costlier provider when less costly provider equally accessible / safe
Potentially avoidable units of care (cost impacts only)	<ul style="list-style-type: none"> • use of care that has little expected net benefit, for example



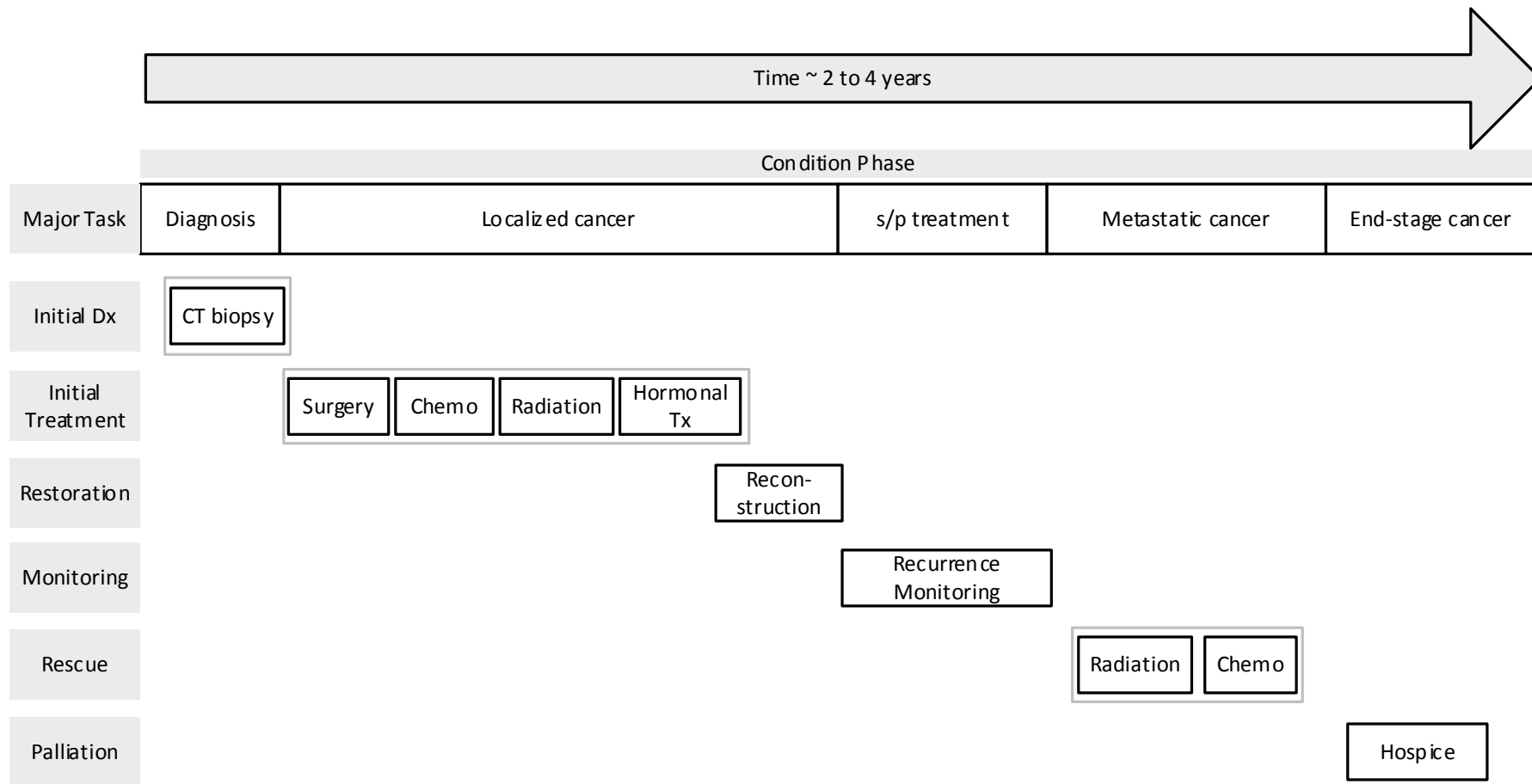
High Level Model of Illness, Diagnosis, & Treatment



'Analytic' Longitudinal Patient History Data Model

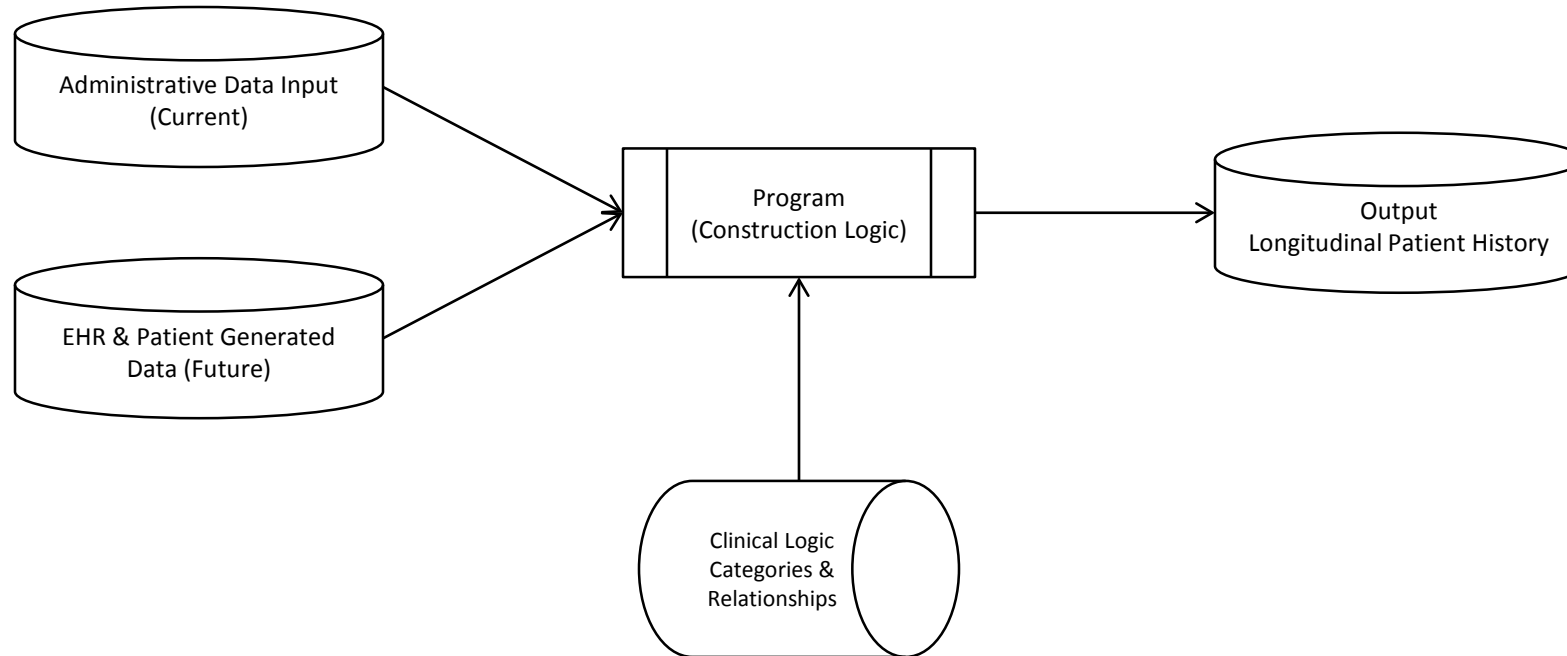


Care for Patient with Breast Cancer



- Health care involves solving specific clinical problems. Clinical problems can be defined in terms of condition, condition phase, and major clinical task.
- For example, initial treatment of localized breast cancer, post-treatment monitoring for recurrence, or treatment of metastatic cancer.
- To identify specific actionable opportunities for improving care, analytics must compare actual and expected costs and outcomes for each distinct clinical problem as outlined above.
- Units of analysis should align with clinical problems (as defined above) and with provider roles and responsibilities

High-Level Overview of Construction Process



- Claims data are transformed into a set of data tables that correspond to the core descriptive model or longitudinal patient history. For example, data tables are constructed for condition and treatment episodes and for events and interventions.
- In the future, EHR data, patient-generated data, and other clinical data could be combined with claims data as input to construct the patient history.
- The building of model constructs and relationships is controlled by a program that utilizes a set of clinical logic tables that identify model constructs and possible relationships between constructs (see next slide: focuses on construction of major elements of patient history).

Building Blocks: How Claims are Transformed into a Patient History

- Categorization Tables – Organizes codes for diagnosis, service, medications, and other concept into multi-level categories;
 - Used to define and / or characterize analytic constructs, such as condition episodes, treatment episodes, events, and interventions
- Relationship Tables – Identifies clinically valid relationships among concepts; used to create linkages among constructs
 - Relationship tables link a primary concept to a secondary (or related) concept, such as a cause and a symptom, or a primary service and a supporting service
 - Time intervals are included if validity is time-sensitive
 - Probability statistics are used to identify the most likely linkage

Classification of Conditions

Multi-Level Classification of Conditions				
Level	Description	Definition	How Used	Category Count
DX1	System or etiology	The body system or etiology category for a condition	High-level summary reporting	26
DX2	Condition class	A class of broadly similar conditions based on common anatomic location or mechanism	Summary reporting	463
DX3	Condition family	A set of closely related conditions that may be reported as working diagnoses for the same episode or may use substantially the same services	Linking 'similar' conditions and detailed reporting	1,513
DX4	Condition	A clinically meaningful and specific description of an illness, injury, symptom, or status. Answers the question: 'what's wrong with the patient?'	Basic unit of analysis Linking episodes to symptoms, signs, and complications Linking 'similar' conditions Identify 'relevant' services	3,211
DX5	Condition sub-type	A sub-set of a condition that requires different resources or carries different risks; varies from other DX5s contained within a DX4. Answers the question: 'how bad is the condition?'	Basis for calculating norms Used for constructing linkages among constructs	4,286

DX1 – DX5 Classification for Obstructive Lung Disease				
DX1 (system or etiology)	DX2 (condition class)	DX3 (condition family)	DX4 (condition)	DX5 (condition sub-type)
Respiratory system	Resp – lower respiratory disorders	Resp - obstructive lung disease	Resp - asthma	Resp - asthma
				Resp - asthma w/ flare
			Resp - copd	Resp - chronic bronchitis
				Resp - chronic bronchitis w/ flare
			Resp - emphysema	Resp - emphysema
			Resp - bronchiectasis	Resp - bronchiectasis

Classification of Services

Multi-Level Classification of Services and Medications				
Level	Description	Definition	How Used	Category Count
SVC1	Modality	A high-level modality, such as E & M, procedure, imaging, Rx, etc.	High-level summary reporting	20
SVC2	Service class	A class of broadly similar services within a SVC1 category based on body system, technique, or therapeutic category	Summary reporting	216
SVC3	Service family	A set of closely related services that are different but share key characteristics such as therapeutic intent or anatomic focus	Linking ‘similar’ services and detailed reporting	1,049
SVC4	Service	Identifies a specific service, such as cholecystectomy or ACE inhibitor. Defined in terms that are readily understood by clinicians	Basic unit of analysis	2,229
SVC5	Service sub-type	A sub-type of a SVC4 category that may differ in details such as route, such as open vs. laparoscopic cholecystectomy.	Can be used for calculating norms; also used for linking constructs	2,709

Svc1 - Modality	Svc2 – Service Class	Svc3 - Service Family	Svc4- Service Category	Svc5 - Service Sub-Category
Procedure	Procedure - Ortho	Shoulder – joint replacement procedures	Shoulder - joint replacement	Shoulder – hemiarthroplasty
				Shoulder - joint replacement – total
			Shoulder - joint replacement – revision	Shoulder - joint replacement – revision
			Shoulder - removal of joint prosthesis	Shoulder - removal of joint prosthesis

How Clinical Logic Tables and Probability Are Used to Link Constructs

Sample Records from Clinical Logic Used to Link Sequela to Causative Condition			
(A) Primary Condition	(B) Resulting Symptom or Complication	(C) Days Between First Svc Dates of A and B	Probability of B Given A and C
...
BH - alcohol abuse	NS - other speech/language deficit	0	0.009
		30	0.0011
		90	0.0007
NS - cerebral artery embolism w/stroke	NS - other speech/language deficit	0	0.2572
		30	0.0533
		90	0.0344
...

Example - Stroke is the More Likely Cause of Speech/Language Impairment For This Patient					
Person Identifier	Condition/Symptom	First Service Date	Days Between Condition and Symptom	Probability Speech/ Language Deficit	Probability Ratio
4567	Alcohol abuse	1-Jul-13	90	0.0007	
4567	Cerebral embolism with stroke	30-Aug-13	30	0.0533	76:1
4567	Speech/language deficit	29-Sept-13			

Example - Output Records After Linkage of Primary Condition with Related Condition			
Person Identifier	Epi_3_Episode	Epi_1_Episode	Relationship
4567
4567	Alcohol abuse	Alcohol abuse	Same Condition
4567	Alcohol abuse	Acute pancreatitis	Condition => complication
4567	Cerebral embolism with stroke	Cerebral embolism with stroke	Same Condition
4567	Cerebral embolism with stroke	Speech/language deficit	Condition => symptom
4567
...

Sample Use Cases

1. Analyzing Prevalence / Incidence, Utilization, Cost at a Population Level
2. Predicting Utilization and Cost by Condition / Service at a Member Level
3. Measuring Health at the Individual and Population Level

Use Case 1

Explaining PMPY Costs

- Age / gender / social determinants
- Prevalence / incidence of conditions (after age / gender / social determinants)
- Utilization and service mix per condition episode
 - Clinically substitutable services
 - Site of service
 - Provider
- Adverse occurrence and complication rates and mix per episode
- Pricing (allowed charge per 'RVU')

Partial Decomposition of PMPY Costs

Standardized amount per member per year (Std Amt PMPY) =

$$\begin{aligned}
 & \sum_{\text{Conditions}} \\
 & \quad (\text{Average \# of 1}^\circ \text{condition episodes per member per year}) \quad [\text{corresponds to incidence / prevalence of 1}^\circ \text{condition episodes}] \\
 & \quad * \\
 & \quad (\\
 & \quad \quad \sum_{\text{Unit of care}} \\
 & \quad \quad (\text{Average \# of units of care per 1}^\circ \text{condition episode}) \quad [\text{corresponds to utilization for 1}^\circ \text{condition episodes}] \\
 & \quad \quad * \\
 & \quad \quad (\text{Average standardized amount per unit of care}) \quad [\text{corresponds to intensity for 1}^\circ \text{condition episodes}] \\
 & \quad) \\
 & \quad + \\
 & \quad (\\
 & \quad \quad \sum_{\text{Complications}} \\
 & \quad \quad (\text{Average \# of adverse occurrences per 1}^\circ \text{condition episode}) \quad [\text{corresponds to adverse occurrence or complication rate}] \\
 & \quad \quad * \\
 & \quad \quad (\text{Average standard amount per adverse occurrences}) \quad [\text{corresponds average standardized cost of an adverse occurrence or complication}] \\
 & \quad) \\
 & \quad + \\
 & \quad (\text{Std Amt PMPY for care not included in condition episodes})
 \end{aligned}$$

- This decomposition of PMPY costs links complications to 1° condition episodes. For simplicity, pricing is omitted from this decomposition.

Top 30 Condition Roll-Up Categories – Condition Summary - Condition Plus Complication Costs - XYZ Region											
Condition Roll-Up Category	Episodes per 1000			Cost per Episode			Cost PMPY				
	Actual	AE Ratio	PMPYΔ	Actual	AE Ratio	PMPYΔ	Actual	AE Ratio	PMPYΔ	% of Total	% of Total Δ
Cancer - colorectal - new onset	1.4	1.08	\$3	\$35,709	1.19	\$8	\$50	1.28	\$11	1%	1%
Cancer - colorectal – ongoing	2.0	1.08	\$2	\$14,212	1.11	\$3	\$28	1.20	\$5	1%	1%
Cancer - breast - new onset	2.4	1.08	\$4	\$20,300	1.08	\$4	\$49	1.17	\$7	1%	1%
Cancer - breast – ongoing	3.3	0.92	-\$3	\$12,127	1.20	\$7	\$40	1.10	\$4	1%	1%
Cancer - prostate - new onset	2.7	1.07	\$4	\$20,163	1.00	\$0	\$54	1.07	\$3	1%	0%
Cancer - prostate – ongoing	9.8	1.13	\$5	\$4,771	1.00	\$0	\$47	1.13	\$5	1%	1%
Endo – diabetes	190.7	1.07	\$17	\$1,721	1.18	\$49	\$328	1.26	\$67	6%	9%
Immunity - rheumatoid arthritis/related	16.4	0.94	-\$2	\$2,246	1.03	\$1	\$37	0.97	-\$1	1%	0%
BH - organic mental ds	20.5	1.00	\$0	\$4,714	1.60	\$36	\$96	1.60	\$36	2%	5%
BH - depression/affective ds	55.8	0.93	-\$14	\$6,422	1.89	\$169	\$358	1.77	\$155	7%	21%
BH - psychotic ds	16.1	0.71	-\$46	\$13,337	1.91	\$103	\$215	1.36	\$56	4%	8%
NS – Parkinson’s	7.5	0.88	-\$3	\$4,506	1.59	\$12	\$34	1.40	\$10	1%	1%
NS - cerebral art occlusion - new onset	2.9	1.07	\$4	\$19,289	1.04	\$2	\$57	1.11	\$6	1%	1%
NS - sleep apnea	46.9	1.24	\$9	\$973	1.01	\$0	\$46	1.25	\$9	1%	1%
CV – hypertension	446.8	1.10	\$20	\$606	1.22	\$48	\$271	1.34	\$68	5%	9%
CV - coronary artery disease - new onset	14.7	1.13	\$22	\$11,962	0.95	-\$10	\$176	1.07	\$12	3%	2%
CV - coronary artery disease - ongoing	87.6	1.24	\$74	\$4,262	0.98	-\$8	\$373	1.21	\$66	7%	9%
CV - mitral valve ds	9.1	1.54	\$16	\$4,693	0.93	-\$3	\$43	1.43	\$13	1%	2%
CV - aortic valve ds	9.6	1.33	\$13	\$5,276	0.92	-\$4	\$50	1.23	\$9	1%	1%
CV - heart failure	45.6	1.10	\$19	\$4,704	1.03	\$7	\$214	1.14	\$26	4%	3%
CV - peripheral vascular ds - new onset	8.7	1.37	\$13	\$6,914	1.21	\$10	\$60	1.65	\$24	1%	3%
CV - syncope / hypotension / shock	35.7	1.08	\$3	\$964	0.78	-\$10	\$34	0.84	-\$6	1%	-1%
Resp – pneumonia	23.3	1.17	\$22	\$7,860	1.18	\$28	\$183	1.38	\$51	4%	7%
Resp – COPD	87.0	1.02	\$3	\$2,018	1.00	\$0	\$176	1.02	\$3	3%	0%
GI - cholecystitis/stones	8.5	1.19	\$10	\$7,036	0.98	-\$1	\$60	1.17	\$9	1%	1%
GU - chronic renal failure	6.6	1.04	\$9	\$39,362	1.04	\$9	\$259	1.08	\$19	5%	2%
GU - kidney/urinary infections	42.7	1.10	\$5	\$1,157	0.99	-\$1	\$49	1.09	\$4	1%	1%
Skin – cellulitis	37.1	1.11	\$3	\$934	1.07	\$2	\$35	1.19	\$5	1%	1%
MS – hip – fx	2.7	1.00	\$0	\$34,944	1.14	\$12	\$95	1.14	\$12	2%	2%
MS - knee – osteoarthritis	21.7	1.06	\$4	\$3,023	0.98	-\$1	\$66	1.04	\$2	1%	0%
<i>Subtotal of top 30 roll-up categories</i>	1,265.6	1.08	\$217	\$2,831	1.12	\$473	\$3,582	1.24	\$689	69%	93%
<i>Other 551 roll-up categories</i>	1,635.0	1.01	-\$4	\$985	1.03	\$59	\$1,612	1.04	\$55	31%	7%
All 581 roll-up categories	2,900.6	1.04	\$213	\$1,790	1.04	\$531	\$5,194	1.17	\$744	100%	100%

- Compares care in region XYZ ('actual') to all regions ('expected'). The top 30 categories account of 69% of total costs and 93% of excess in costs for the region.
- A primary prevention opportunity is suggested by higher than expected number of episodes per 1000 for coronary disease which adds \$96 PMPY to XYZ's costs.
- A care management opportunity is suggested by three behavioral health conditions that account for 34% of excess costs, - but only 13% of total costs.

Top 25 Cost Drivers – Condition-Only Costs - XYZ Region											
Care Type	Condition Roll-Up Category	Unit of Care	Units of Care per Episode			Cost per Unit of Care			Condition-Only Cost per Episode		
			Actual	AE Ratio	PMPYΔ	Actual	AE Ratio	PMPYΔ	Actual	AE Ratio	PMPYΔ
Event	BH - organic mental ds	IP - Acute -1° dx	0.12	1.58	\$9	\$11,721	1.24	\$6	\$1,453	1.97	\$15
		IP - SNF / Rehab -1° dx	0.06	1.04	\$1	\$16,667	1.39	\$6	\$1,033	1.46	\$7
		OPD	2.98	1.21	\$1	\$87	1.16	\$1	\$260	1.41	\$2
	BH - depression/affective ds	IP - Acute -1° dx	0.35	1.72	\$69	\$9,076	1.06	\$11	\$3,149	1.84	\$80
		IP - SNF / Rehab -1° dx	0.01	1.95	\$5	\$14,835	1.15	\$1	\$208	2.30	\$6
		OPD	12.77	2.02	\$67	\$208	1.12	\$16	\$2,651	2.27	\$83
	BH - psychotic ds	IP - Acute -1° dx	0.59	1.52	\$33	\$9,935	0.99	-\$1	\$5,901	1.50	\$32
		IP - SNF / Rehab -1° dx	0.02	2.07	\$2	\$13,079	1.22	\$1	\$275	2.56	\$3
		OPD	32.35	2.30	\$48	\$195	1.19	\$16	\$6,291	2.74	\$64
			<i>Subtotal -- 3 BH conditions</i>			\$234		\$56			\$291
	Endo – diabetes	IP - Acute -1° dx	0.01	1.15	\$2	\$10,016	1.15	\$2	\$70	1.34	\$3
		Home	2.37	1.12	\$6	\$179	1.31	\$19	\$424	1.46	\$25
	CV – hypertension	ER	0.17	1.20	\$2	\$167	0.96	-\$1	\$29	1.14	\$2
		Home	0.07	1.44	\$11	\$1,721	1.44	\$16	\$114	2.06	\$26
	Resp - bronchitis – acute	IP - Acute -1° dx	0.03	1.28	\$1	\$4,091	1.08	\$0	\$119	1.43	\$2
	Resp – pneumonia	IP - Acute -1° dx	0.61	1.15	\$13	\$7,571	1.08	\$8	\$4,618	1.23	\$21
		IP - SNF / Rehab -1° dx	0.10	1.40	\$7	\$9,951	1.02	\$0	\$1,035	1.41	\$7
	Resp – asthma	Home	3.19	1.17	\$1	\$90	1.10	\$1	\$288	1.29	\$2
Skin – cellulitis	IP - Acute -1° dx	0.10	1.11	\$2	\$5,798	1.11	\$2	\$603	1.22	\$4	
Skin - skin ulcers	IP - Acute -1° dx	0.03	2.15	\$1	\$24,391	1.28	\$1	\$610	2.67	\$2	
Treatment episode	Ca - lymphoma – ongoing	Therapy – chemotherapy	1.00	1.28	\$3	\$10,086	0.94	-\$1	\$10,086	1.21	\$2
	NS - carotid artery ds - new onset	Procedure - neck - thromboendartectomy	0.27	1.11	\$1	\$6,487	1.02	\$0	\$1,732	1.13	\$2
	CV - coronary disease - new onset	Procedure – ptca	0.37	1.12	\$5	\$8,251	0.94	-\$3	\$3,045	1.05	\$2
	CV - coronary disease – ongoing	Procedure – ptca	0.11	1.17	\$12	\$8,444	1.02	\$1	\$946	1.19	\$13
	CV - peripheral vascular ds - new	Procedure - lower extremity - atherectomy	0.29	1.58	\$7	\$7,384	0.99	\$0	\$2,134	1.57	\$7
	GU - chronic renal failure	Procedure - av fistula - repair/maintenance	0.70	2.16	\$6	\$2,567	1.01	\$0	\$1,789	2.19	\$6
		<i>Subtotal – Top 25 Cost Drivers – Condition-Only Costs</i>			\$314		\$102			\$417	
		<i>Total – 7,000 Cost Drivers – Condition-Only</i>			\$301		\$167			\$469	

- These 25 ‘top cost drivers’ were selected from among 7,000 possibilities and account for 89% of excess condition-only per episode costs (\$417 out of a total of \$469 PMPY).
- Each ‘top cost driver’ had utilization rates at least 10% above expected (Units of Care per Episode AE Ratio > 1.10)
- Three behavioral health conditions account for 62% of total excess condition-only per episode costs (\$291 out of a total of \$469 PMPY).
- Excess costs for these conditions are driven by very high utilization rates for facility-based care.
- Other cost drivers also reflect high per episode utilization (highlighted cells). Each represents a care management opportunity.

Top 25 Complications – Complication-only Costs per Episode - XYZ Region										
Condition Roll-Up Category	Complication	Complications per Episode			Cost Per Complication			Complication Cost Per Episode		
		Actual	AE Ratio	PMPYΔ	Actual	AE Ratio	PMPYΔ	Actual	AE Ratio	PMPYΔ
ID – HIV	BH - depression/affective ds	0.18	1.40	\$0.33	\$5,429	1.61	\$0.71	\$977	2.25	\$1.04
Ca - breast - ongoing	Ca - secondary - other	0.09	2.08	\$0.96	\$7,803	1.19	\$0.35	\$671	2.49	\$1.31
Endo – Diabetes	GU - acute renal failure	0.44	3.22	\$0.40	\$9,253	1.00	\$0.00	\$4,108	3.22	\$0.40
Blood – white blood cell disorder	ID - sepsis	0.05	2.75	\$0.41	\$41,273	1.00	\$0.00	\$2,064	2.78	\$0.41
BH - organic mental ds	Skin - skin ulcers	0.08	1.29	\$0.84	\$3,906	1.65	\$2.45	\$305	2.15	\$3.29
CV – hypertension	CV - heart failure	0.01	1.26	\$2.53	\$2,294	1.03	\$0.33	\$28	1.23	\$2.86
CV - thoracic aorta aneurysm – new	GU - acute renal failure	0.15	2.23	\$0.35	\$20,417	1.00	\$0.00	\$3,144	2.23	\$0.35
CV - abdominal aorta aneurysm - new	GU - acute renal failure	0.06	2.49	\$1.62	\$43,330	1.00	\$0.00	\$2,470	2.48	\$1.62
CV - peripheral vascular ds - new onset	MS - ankle/foot – infection	0.01	1.42	\$0.48	\$24,508	1.17	\$0.28	\$221	1.76	\$0.76
GI - esophagitis	Endo – malnutrition	0.01	1.57	\$0.78	\$7,634	1.44	\$0.96	\$69	2.60	\$1.74
GI - diverticulosis/itis	Complications - post-op wound disrupt	0.00	2.49	\$0.46	\$24,267	1.00	\$0.00	\$97	2.00	\$0.46
GI - hernia - inguinal	Complications - hematoma	0.00	2.20	\$0.38	\$44,609	1.00	\$0.00	\$134	3.00	\$0.38
GI - hernia - umbilical	GI - intestine - perforation/fistula	0.01	2.11	\$0.34	\$41,617	1.00	\$0.00	\$499	2.00	\$0.34
GI - cirrhosis-nos	GI - hepatic coma	0.18	2.16	\$1.03	\$13,344	1.08	\$0.15	\$2,389	2.32	\$1.18
GI - acute pancreatitis - new onset	Endo - malnutrition	0.01	2.04	\$0.27	\$33,968	1.00	\$0.00	\$408	2.00	\$0.27
GU - chronic renal failure	CV - vascular graft – malfunction	0.27	1.52	\$0.98	\$1,567	0.95	-\$0.13	\$415	1.44	\$0.85
	CV - vascular graft - infection	0.19	1.41	\$1.65	\$4,819	1.08	\$0.46	\$935	1.52	\$2.11
GU - other GI obstruction	ID – sepsis	0.08	2.13	\$0.39	\$9,510	1.03	\$0.02	\$723	2.17	\$0.41
MS – hip fracture	Resp – pneumonia	0.10	1.40	\$0.29	\$5,980	1.64	\$0.65	\$616	2.28	\$0.94
	MS – soft tissue complications	0.03	1.94	\$0.61	\$17,287	1.07	\$0.09	\$501	2.07	\$0.70
MS – fracture of femur	ID - sepsis	0.03	2.57	\$0.31	\$33,398	1.00	\$0.00	\$1,102	2.54	\$0.31
	MS - joint - complication	0.03	2.57	\$0.28	\$29,504	1.00	\$0.00	\$974	2.54	\$0.28
MS - bone – osteoporosis	MS - pelvis - fx	0.01	1.55	\$0.69	\$28,965	1.17	\$0.32	\$145	1.95	\$1.01
MS – septic arthritis	Complications - non-healing wound	0.03	2.25	\$0.28	\$33,566	1.00	\$0.00	\$1,041	2.21	\$0.28
Injury - head - new onset	Resp - pneumonia	0.01	2.77	\$0.39	\$39,402	1.00	\$0.00	\$355	3.00	\$0.39
<i>Top 25 Complications Total</i>				\$17.05			\$6.64			\$23.69

- 25 ‘top’ condition / complication combinations (out of 2000 possibilities) account for \$23.69 PMPY in excess costs or 28% of total excess complication costs.
- Each combination occurs much more often than expected (Complications per Episode AE Ratio > 1.40).
- Several possible targets for care improvement initiatives are highlighted in the table above.

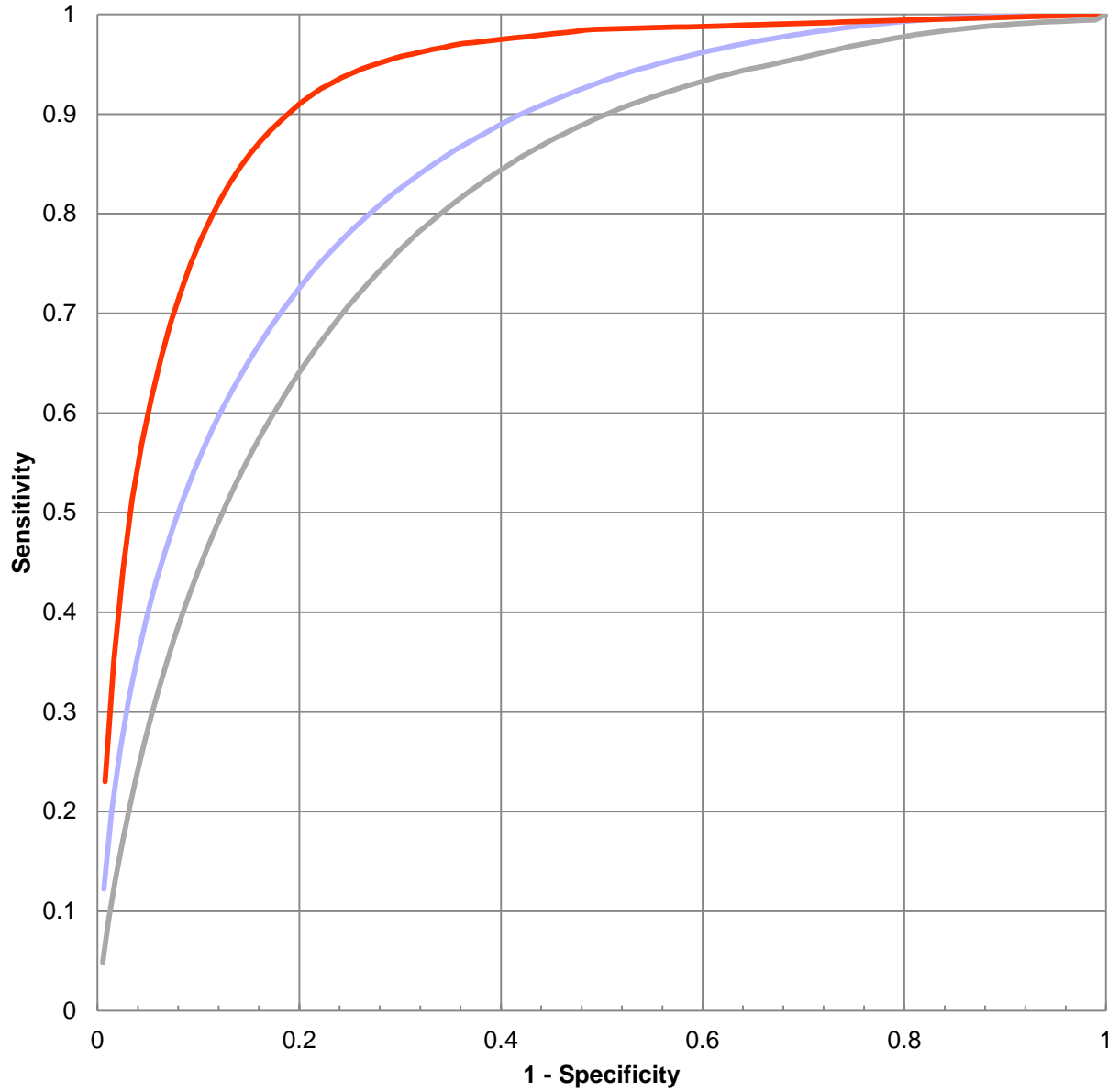
Use Case 2

Predicting Utilization and Cost by Condition and Service

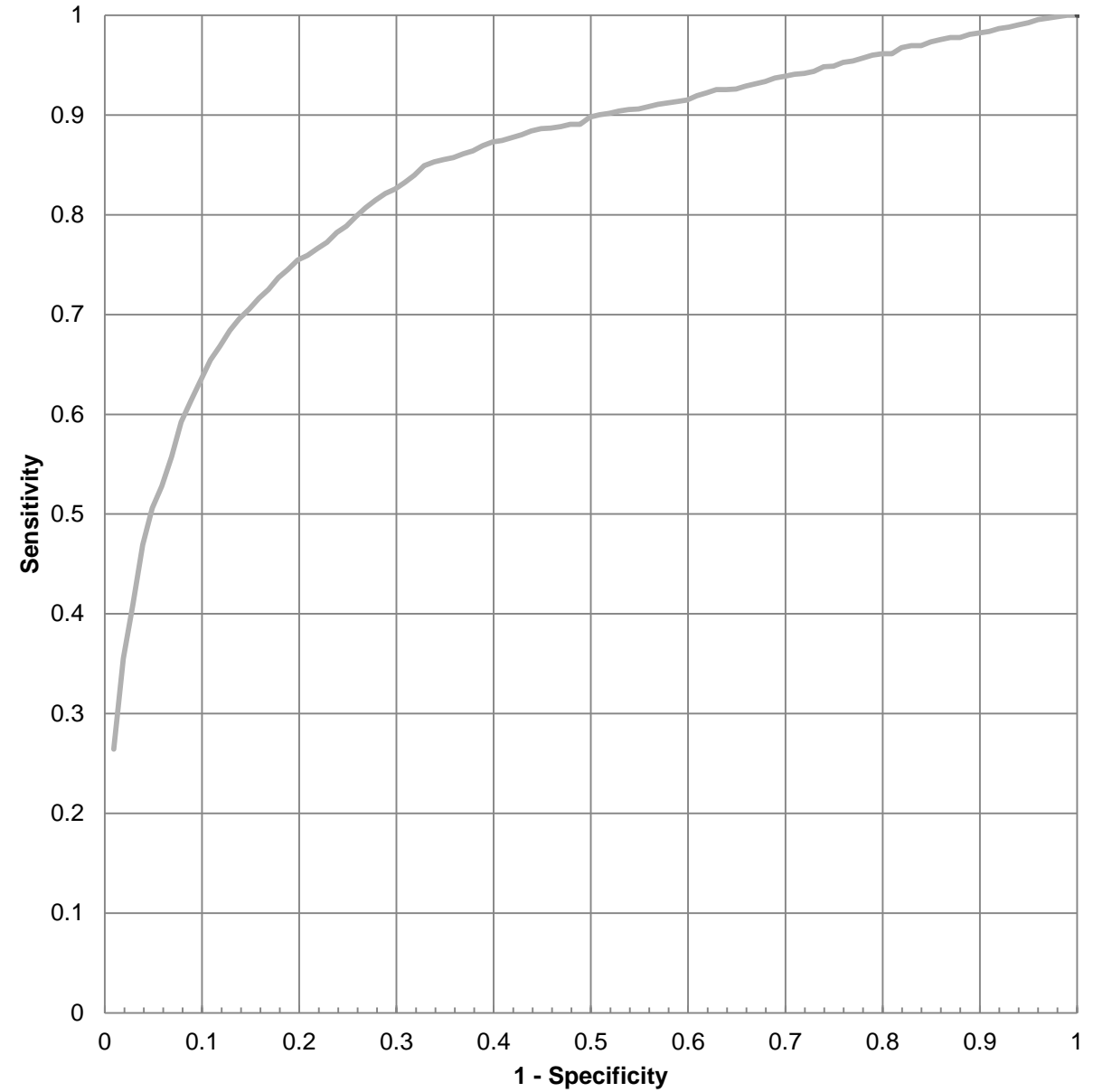
- Designed to support care management
- Predictions made for 1,600 conditions and 800 services / medications
 - A total of 12,000 distinct predictions
- This granularity needed to a detailed picture for care managers
 - Potentially avoidable adverse occurrences (e.g., emergency hospitalization)
 - And possible solutions (e.g., improved medication compliance)
- Model endpoints and predictors sourced from ‘analytic’ patient history
- The next several slides present some sample output

(Note: this is a work in progress with further enhancements planned)

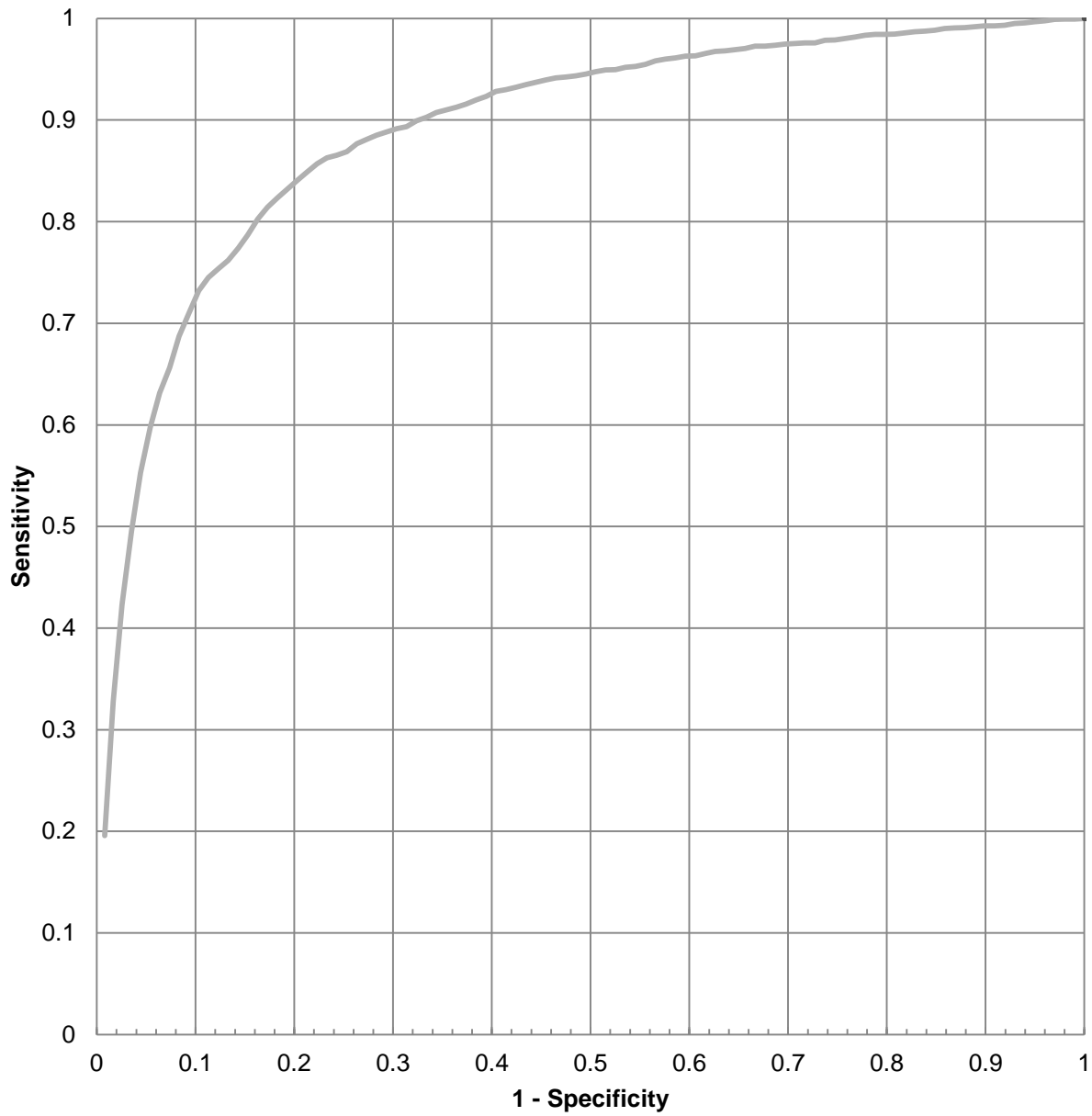
Predicting IP Admissions, ER Visits, and Readmissions
(AUCs: IP - 0.924, ER - 0.847, Readmit - 0.800)



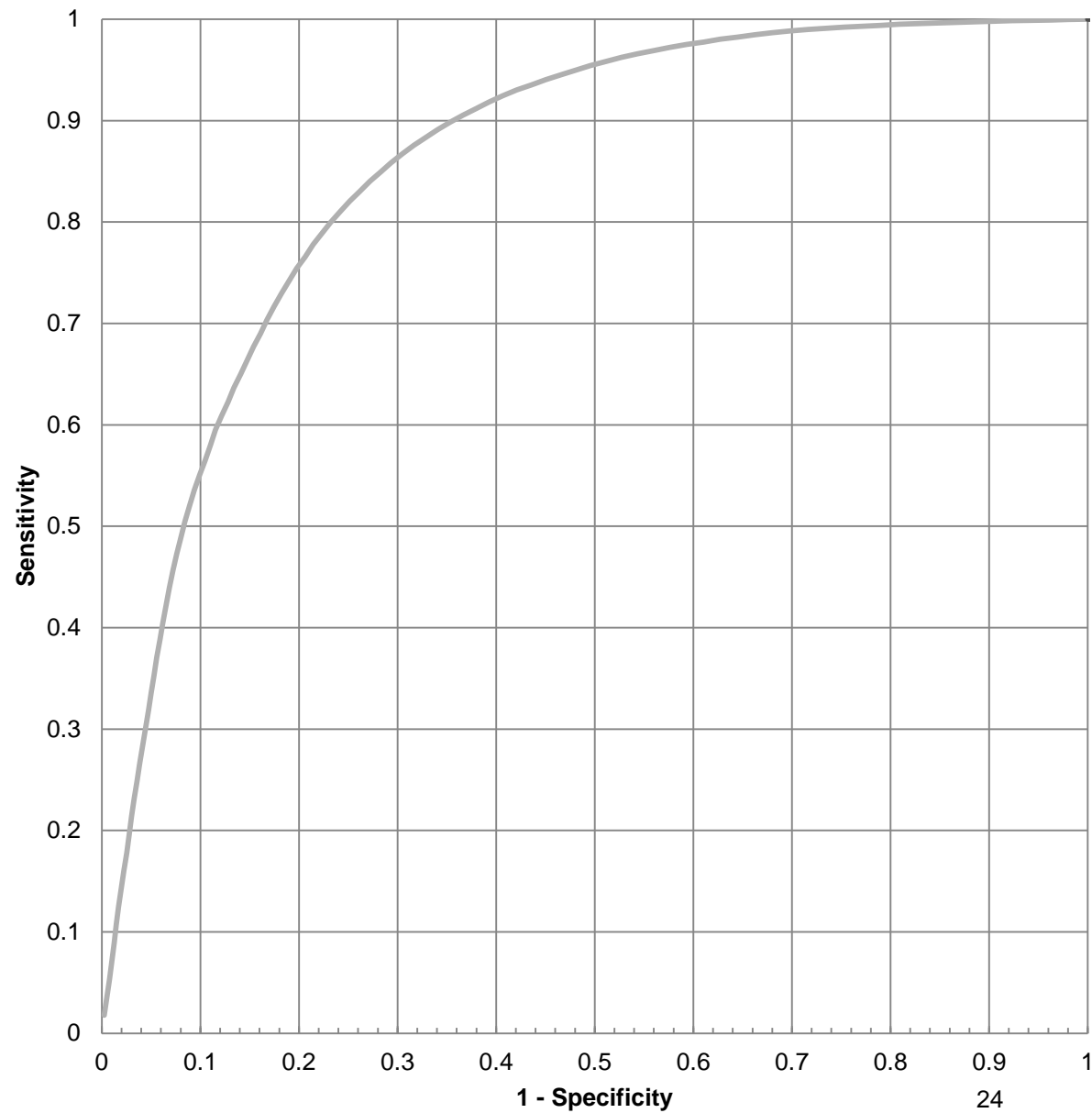
Predicting Asthma Inpatient Admissions - AUC: 0.844



Predicting Bariatric Surgery for Obesity - AUC: 0.889



Predicting Metofomin Adherence for Diabetes - AUC: 0.857

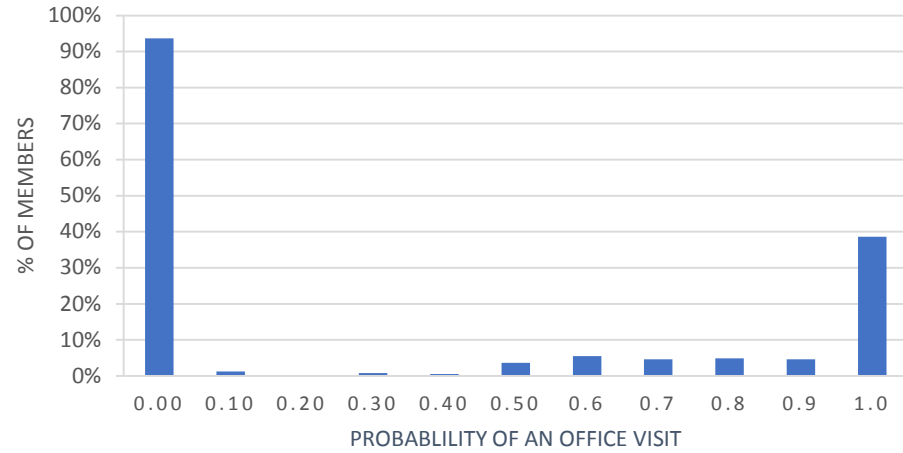


Selected Predictors for Hospitalization for Substance Abuse

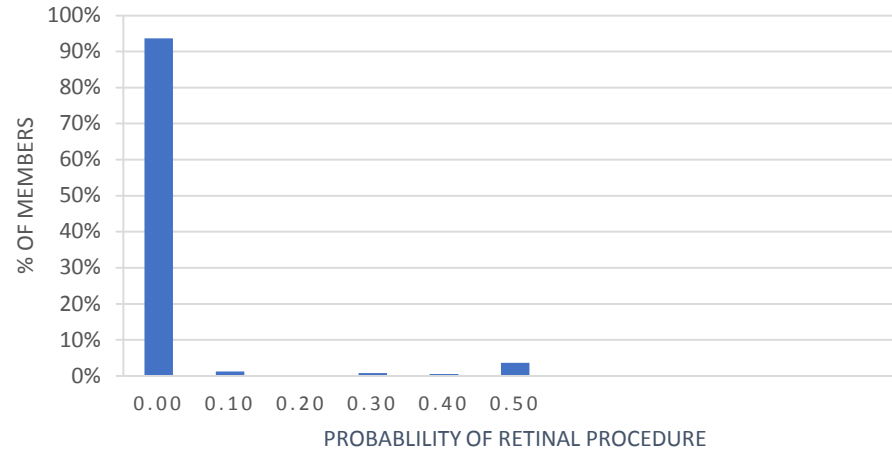
predictor type	predictor	lift	predictor type	predictor	lift	predictor type	predictor	lift
use yr 1 or yr2	E & M - 1 to 1	1.4	most recent use	ER - 0 to 89 days ago	2.5	dx yr 1 or yr2	MS - spine - sprain / strain	1.6
	E & M - 2 to 4	1.8		ER - 90 to 179 days ago	2.4		MS - hnd - fx - metacarpal - closed	1.7
	E & M - 5 to 5+	1.5		ER - 180 to 269 days ago	2.9		Inj - head - w/o fx - w/ concussion - loc nos	1.6
	E & M - no prior use	0.8		ER - 270 to 359 days ago	1.8	demographics	age 25 to 29 - M	2.5
	ER - 1 to 1	1.9		ER - 360+ days ago	1.6		age 20 to 24 - F	2.4
	ER - 2 to 5+	3.7		ER - no prior svc	0.9		other family w impaired health: 0	0.8
	ER - no prior use	0.9		Therapy - behavior - 0 to 89 days ago	2.4		other family w impaired health: 1	1.3
	Therapy - behavior - 1 to 1	1.1		Therapy - behavior - 90 to 179 days ago	2.6		other family w impaired health: 2	1.9
	Therapy - behavior - 2 to 4	1.7		Therapy - behavior - 180 to 269 days ago	1.8		other family w impaired health: 3	2.0
	Therapy - behavior - 5 to 5+	2.1		Therapy - behavior - 270 to 359 days ago	1.3		socio economics	poverty rate - decile 1
	Therapy - behavior - no prior use	0.7		Therapy - behavior - 360+ days ago	1.2	poverty rate - decile 10		0.6
	IP - 1 to 1	4.0		Therapy - behavior - no prior svc	0.7	% without high school diploma - decile 1		1.2
	IP - 2 to 2	8.3		Rx - buprenorphinel- naloxone - 0 to 89 days ago	1.2	% without high school diploma - decile 10		0.7
	IP - 3 to 5+	11.5		Rx - buprenorphinel- naloxone - 90 to 179 days ago	3.0	% of pop w english difficulty - decile 1		1.3
IP - no prior use	0.6	Rx - buprenorphinel- naloxone - 180 to 269 days ago	1.9	% of pop w english difficulty - decile 10	1.0			
Rx - buprenorphinel- naloxone ds yr2 - 0	1.9	Rx - buprenorphinel- naloxone - 270 to 359 days ago	2.8	% of housing w gt 10 units - decile 1	1.4			
Rx - buprenorphinel- naloxone ds yr2 - 1	4.1	Rx - buprenorphinel- naloxone - 360+ days ago	1.9	% of housing w gt 10 units - decile 10	1.1			
Rx - buprenorphinel- naloxone ds yr2 - 30	3.0	Rx - buprenorphinel- naloxone - no prior svc	0.8	% of mobile homes - decile 1	1.4			
Rx - buprenorphinel- naloxone ds yr2 - 90	1.7	IP - 0 to 89 days ago	6.9	% of mobile homes - decile 10	0.6			
Rx - buprenorphinel- naloxone ds yr2 - 180	1.3	IP - 90 to 179 days ago	6.9	% of dwellings with crowding - decile 1	1.2			
Rx - buprenorphinel- naloxone ds yr2 - 270	0.6	IP - 180 to 269 days ago	5.5	% of dwellings with crowding - decile 10	0.9			
Rx - buprenorphinel- naloxone ds yr2 - 360	0.4	IP - 270 to 359 days ago	3.4	% of households wo vehicle - decile 1	0.7			
Rx - buprenorphinel- naloxone - yr2 no prior use	0.8	IP - 360+ days ago	3.1	% of households wo vehicle - decile 10	1.0			
most recent use	E & M - 0 to 89 days ago	1.4	IP - no prior svc	0.6	% of pop in group quarters - decile 1	1.6		
	E & M - 90 to 179 days ago	2.2	dx5 yr 1 or yr2	BH - alcohol abuse	1.8	% of pop in group quarters - decile 10	1.1	
	E & M - 180 to 269 days ago	1.6		BH - other depression/affective ds	1.5	% uninsured - decile 1	1.5	
	E & M - 270 to 359 days ago	1.6		GI - hepatitis c - w/o coma	2.7	% uninsured - decile 10	0.9	
	E & M - 360+ days ago	1.2		Skin - cellulitis - arm	2.3			
	E & M - no prior svc	0.8						

Clinically Meaningful Predictions Are Made for All Conditions and Services: Members with Diabetes

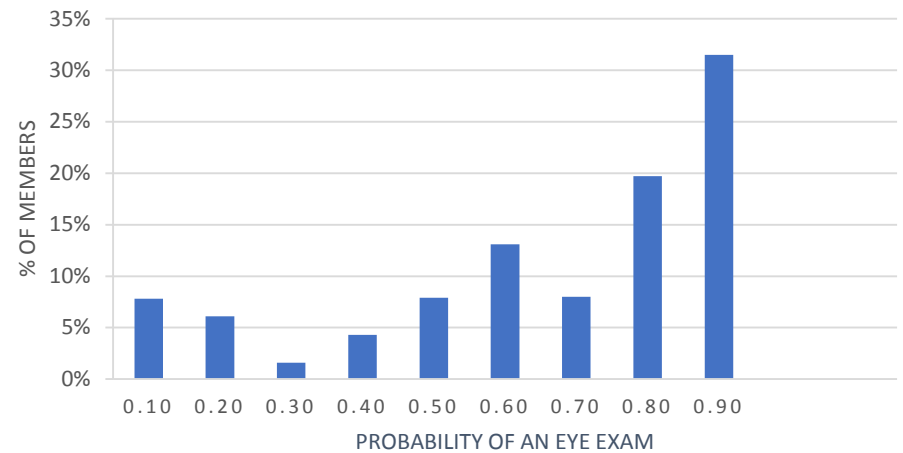
PROBABILITY OF AN OFFICE VISIT



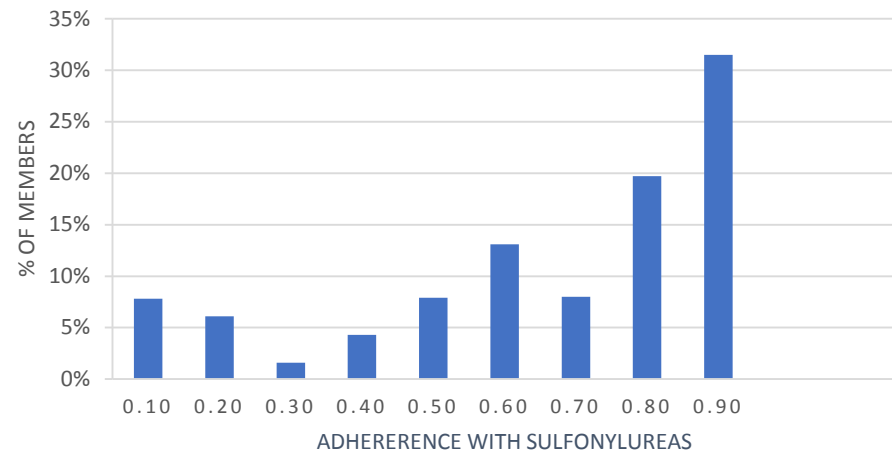
PROBABILITY OF RETINAL PROCEDURE



PROBABILITY OF AN EYE EXAM



ADHERENCE WITH SULFONYLUREAS



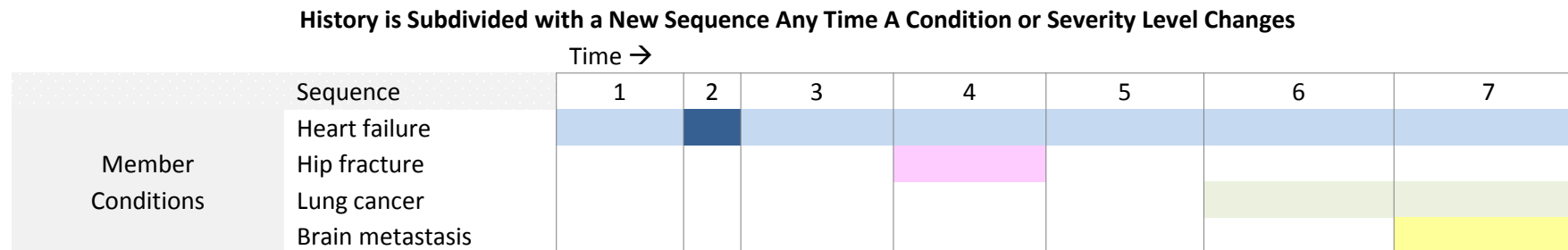
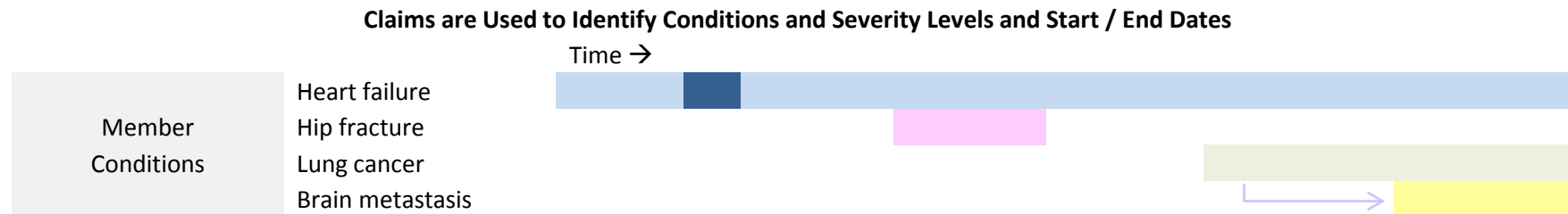
Use Case 3

Measuring Health: The Blue Cross Blue Shield Health Index

- The BCBSA Index is a Health-Adjusted Life Expectancy ('HALE') measure sourced from claims data on a day-by-day basis at the member level
- Health is measured as the current and future impact of known conditions and risks on longevity and 'quality' of remaining years of life
- A person with no symptoms or risks is in optimal health with an index value of 1.00 while a person who has 'lost' 20% of his healthy life expectancy has an index of 0.80

<https://www.bcbs.com/the-health-of-america/health-index>

Analytic File Contains YLLs / YLDs for Each Patient Condition on a Point-in-Time Basis for 40+ Million Members Over Six Year Period



- Conditions / symptoms / severity levels are identified with start and end dates
- Complications and symptoms are linked to causative conditions
- Disability weights and mortality risks are attached to each condition / sequence.
- YLLs / YLDs are calculated for each condition sequence over the member's entire future life up to age 100

2015 Index Results by Age and Gender				
Category	Life Expectancy of Healthy Cohort	Health Index	% of Optimal Life Expectancy Lost	Number of Healthy Years of Life Lost
All	46.6	0.924	7.6%	3.5
Females (all ages)	47.3	0.921	7.9%	3.7
Males (all ages)	45.7	0.927	7.3%	3.3
Ages Under 18	72.1	0.980	2.0%	1.4
Ages 18-34	56.2	0.960	4.0%	2.2
Ages 35-44	42.9	0.935	6.5%	2.8
Ages 45-54	33.4	0.898	10.2%	3.4
Ages 55-64	24.7	0.849	15.1%	3.7
Ages 65+	16.6	0.778	22.2%	3.7

Distribution of Health Index and Years Lost by Index Percentile – 2015					
Percentile	Health Index	% of OLE Lost	YLD	YLL	H-YLL
50	0.99	1%	0.5	0.1	0.5
75	0.92	8%	2.2	0.3	2.5
90	0.74	26%	6.7	2.7	9.4
95	0.56	44%	10.0	4.8	14.7
96	0.51	49%	10.0	6.2	16.1
97	0.43	57%	13.1	6.6	19.7
98	0.33	67%	15.2	7.7	22.9
99	0.16	84%	13.3	12.7	26.0

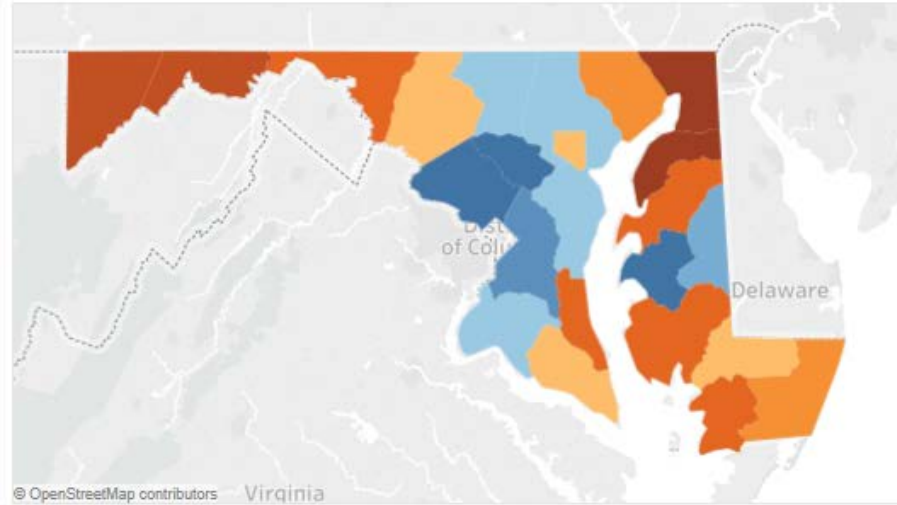
2015 Top Impact Condition Categories – Ranked Based on Population Impact								
Condition Categories	Persons w/ Condition			Entire Population with and without Condition				
	Healthy Years of Life Lost	% Reduction in Healthy Years of Life	PMPY	Healthy Years of Life Lost	% Reduction in Years of Healthy Life	% of Total Healthy Years of Life Lost	Prevalence	PMPY
Depression / Mood Disorders	1.98	5.3%	\$850	0.29	0.63%	12.4%	11.5%	\$103.95
Hypertension	0.89	3.2%	\$389	0.24	0.45%	10.6%	16.0%	\$66.09
Diabetes	1.84	6.5%	\$1,849	0.21	0.27%	9.3%	7.0%	\$137.03
High Cholesterol	0.75	2.8%	\$365	0.20	0.41%	8.6%	14.9%	\$58.35
Substance Use Disorders	6.97	17.5%	\$2,474	0.15	0.33%	6.7%	1.9%	\$49.02
Coronary Heart Disease	3.58	15.1%	\$4,929	0.14	0.06%	6.0%	2.0%	\$102.79
Chronic Obstructive Pulmonary Ds	4.70	18.1%	\$1,506	0.08	0.03%	3.6%	1.0%	\$15.62
Hyperactivity	2.18	4.1%	\$1,312	0.06	0.13%	2.7%	3.2%	\$44.12
Hypothyroidism	0.81	2.6%	\$289	0.06	0.13%	2.5%	4.7%	\$14.53
Breast Cancer	1.33	4.9%	\$3,632	0.05	0.09%	2.4%	2.4%	\$93.70
Rheumatoid Arthritis	5.67	18.0%	\$6,807	0.05	0.12%	2.4%	0.6%	\$46.35
Psychotic Disorders	14.11	28.7%	\$4,138	0.05	0.12%	2.3%	0.4%	\$16.91
Inflammatory Bowel Disease	6.81	18.8%	\$10,113	0.05	0.10%	2.1%	0.5%	\$59.38
Asthma	0.55	1.3%	\$565	0.04	0.06%	1.8%	7.0%	\$42.91
Spine / Neck / Back	0.17	0.5%	\$1,651	0.03	0.08%	1.5%	13.6%	\$243.24
Renal Failure	2.33	8.2%	\$8,705	0.03	0.04%	1.2%	0.7%	\$66.81
Heart Failure & Cardiomyopathy	3.30	12.1%	\$5,285	0.03	0.02%	1.2%	0.5%	\$27.49
Other Central Nervous System Ds	2.25	5.0%	\$2,250	0.02	0.02%	1.1%	1.0%	\$24.38
Leukemia, Lymphoma, Myeloma	7.14	23.9%	\$28,836	0.02	0.03%	1.0%	0.2%	\$63.66
Multiple Sclerosis	9.82	29.7%	\$20,874	0.02	0.03%	1.0%	0.2%	\$36.43
Heart Valve Disorders	1.04	3.8%	\$1,652	0.02	0.04%	1.0%	1.3%	\$22.68
Cirrhosis / Sequelae	2.44	9.3%	\$2,129	0.02	0.01%	1.0%	0.5%	\$11.79
Epilepsy	2.74	6.3%	\$3,367	0.02	0.04%	0.9%	0.7%	\$25.30
Other Autoimmune Disease	4.01	11.6%	\$2,150	0.02	0.03%	0.8%	0.3%	\$8.01
Total Top 25 Conditions	-	-	-	1.95	4.14%	85.1%	-	\$1,412.16

Health Index – Why Unique

- Can be implemented for operational use
 - Automated, based on detailed transaction data
- Comprehensive - maps all favorable and unfavorable health impacts onto a single scale
 - Integrates tens of thousands of distinct metrics thereby addressing a key problem in outcomes measurement (see next slide)
- Captures and quantifies impacts on a day-by-day basis
 - Captures both **permanent** and **transient** impacts (e.g., ‘near-misses’)
 - Captures delays in care, transient symptoms and complications, etc.
 - As such can create a comprehensive assessment of the health impacts of care

Substance Use Disorder affects 1 out of every 100 people nationwide

View By: County State County (All)

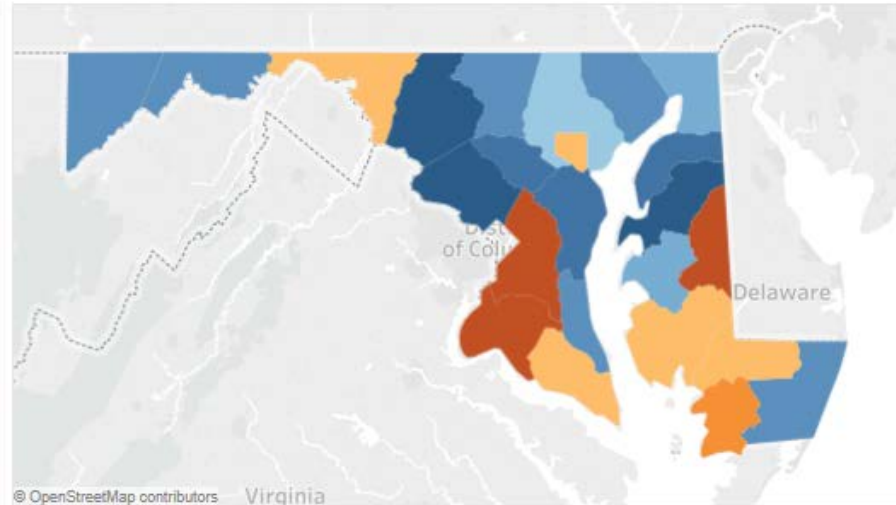


Select a color or click and drag across multiple colors to see areas that are more or less healthy. Deselect the color(s) to refresh the BCBS Health Index map.



Diabetes Type II affects 7 out of every 100 people nationwide

View By: County State County (All)



Select a color or click and drag across multiple colors to see areas that are more or less healthy. Deselect the color(s) to refresh the BCBS Health Index map.



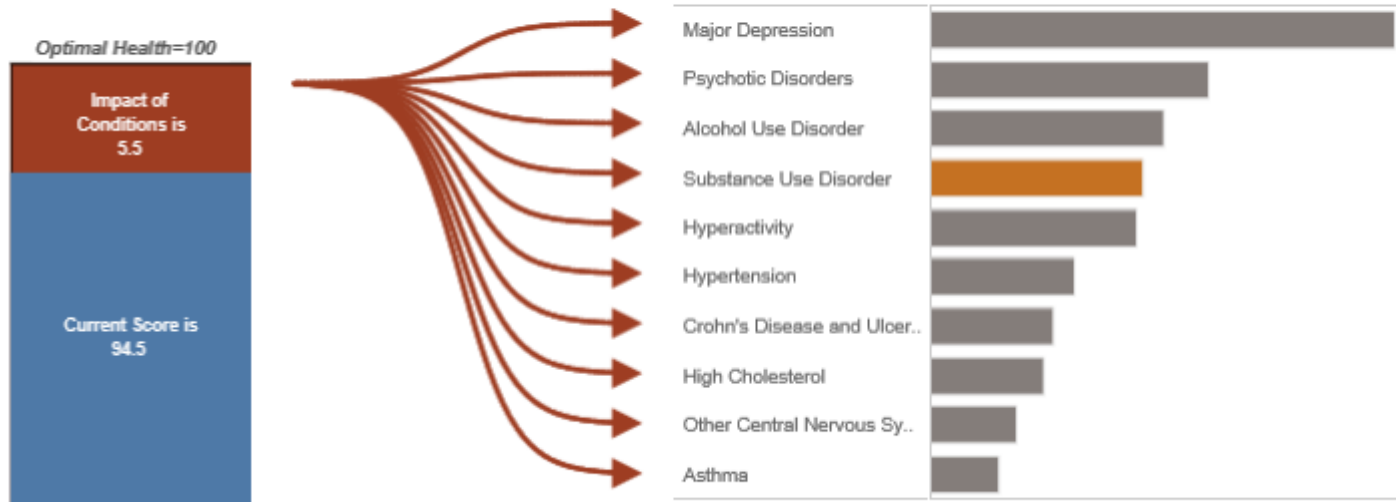
Source: <https://www.bcbs.com/the-health-of-america/health-index>

Maryland Condition Impact

Demographic Identifier

18-34

Select a gender or age range to see how the top 10 conditions and their impact differ across demographics.

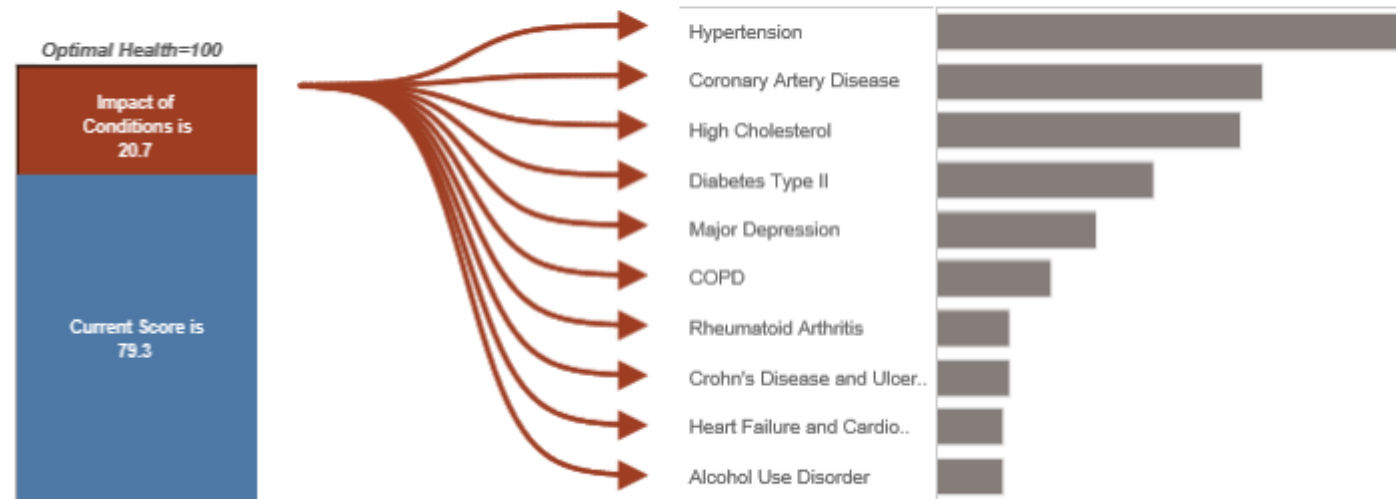


Maryland Condition Impact

Demographic Identifier

55-64

Select a gender or age range to see how the top 10 conditions and their impact differ across demographics.



Health Index – How Can it Be Used?

Current

- Assessing population health and prioritizing and tracking population health initiatives

Future

- Evaluating provider performance, tracking outcomes and identifying opportunities to improve
- Evaluating and tracking care management strategies
- Prioritizing members (and identifying key clinical issues) for case and disease management

A Work in Progress - Summary and Discussion

- Health and health care involves thousands of different illnesses, tests and treatments with complex clinical and social interactions
- Problems can arise at any step along the process of care for any condition or service
- Hence, analytics should ideally be able to address a broad range of possible issues in a consistent, 'interoperable', and scalable manner
- An overarching conceptual framework and an 'analytic' longitudinal patient history seems able to support a broad range of use cases
- While initially based on claims, clinical data could be used instead