Washington University in St. Louis

School of Medicine

Ranking Providers Instead of Comparing Treatments

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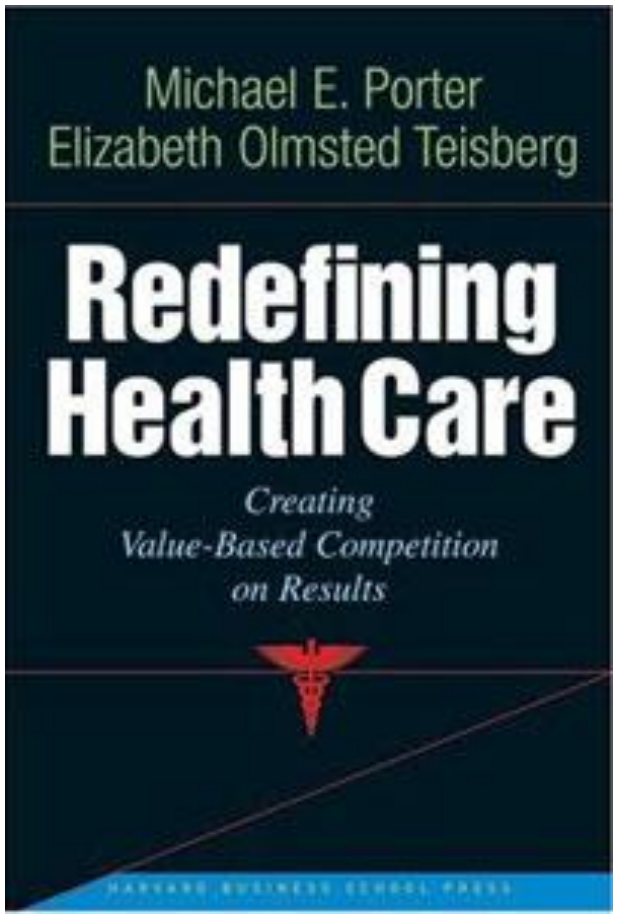
Competition in Business

- Improve processes/methods or innovate to
  - Reduce costs
  - Increase quality
  - Speed up diffusion
  - Eliminate inferior competitors
  - Expand markets

- Trajectory common among industries
  - Computers, mobile communications, banking, auto, restaurants,…

…But Not Health Care



- Health care reform is a zero sum game to ***capture existing value***
  - Shift costs to someone else
- Need to refocus on quality to ***create more value***, e.g.,
  - Reward for curing disease

Capture Existing Value (Shift Costs to Someone Else)

- Cost shifting (Value chain)
  - Co-pay shifts cost to patient
- Consolidation (Economy of scale)
  - Improves bargaining position
- Access (Innovation)
  - Networks/clinical pathways limit innovation

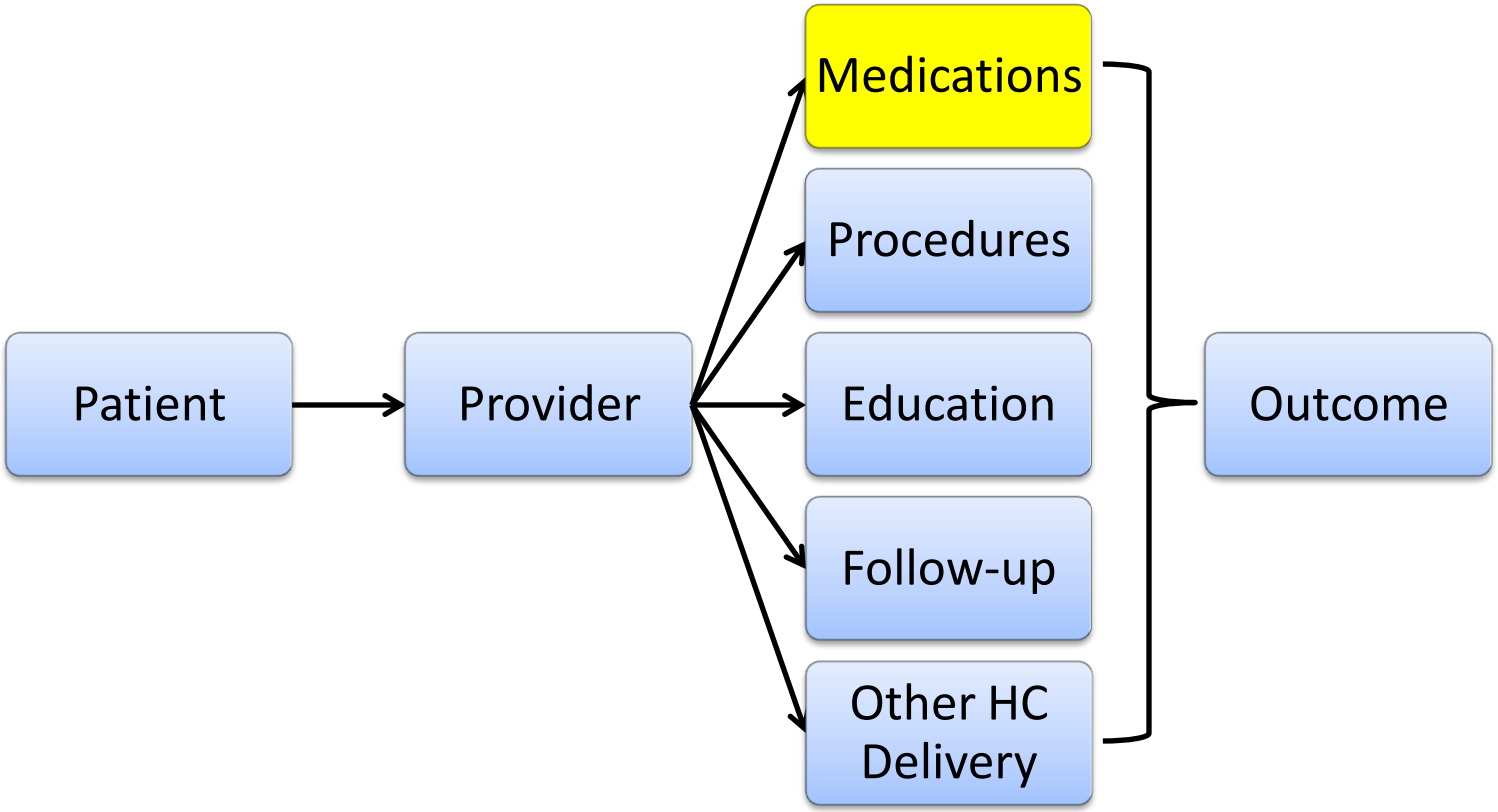
Create More Value (Reward for Curing Disease)

- Healthcare will improve faster if providers
  - Face competitive pressure to produce truly good results, patient by patient and condition by condition
  - Shifts focus from "Who pays?" to "Who provides the best value?“

- ***Ranking providers from best to worst based on ‘improved outcomes at lower total cost’ will achieve this***

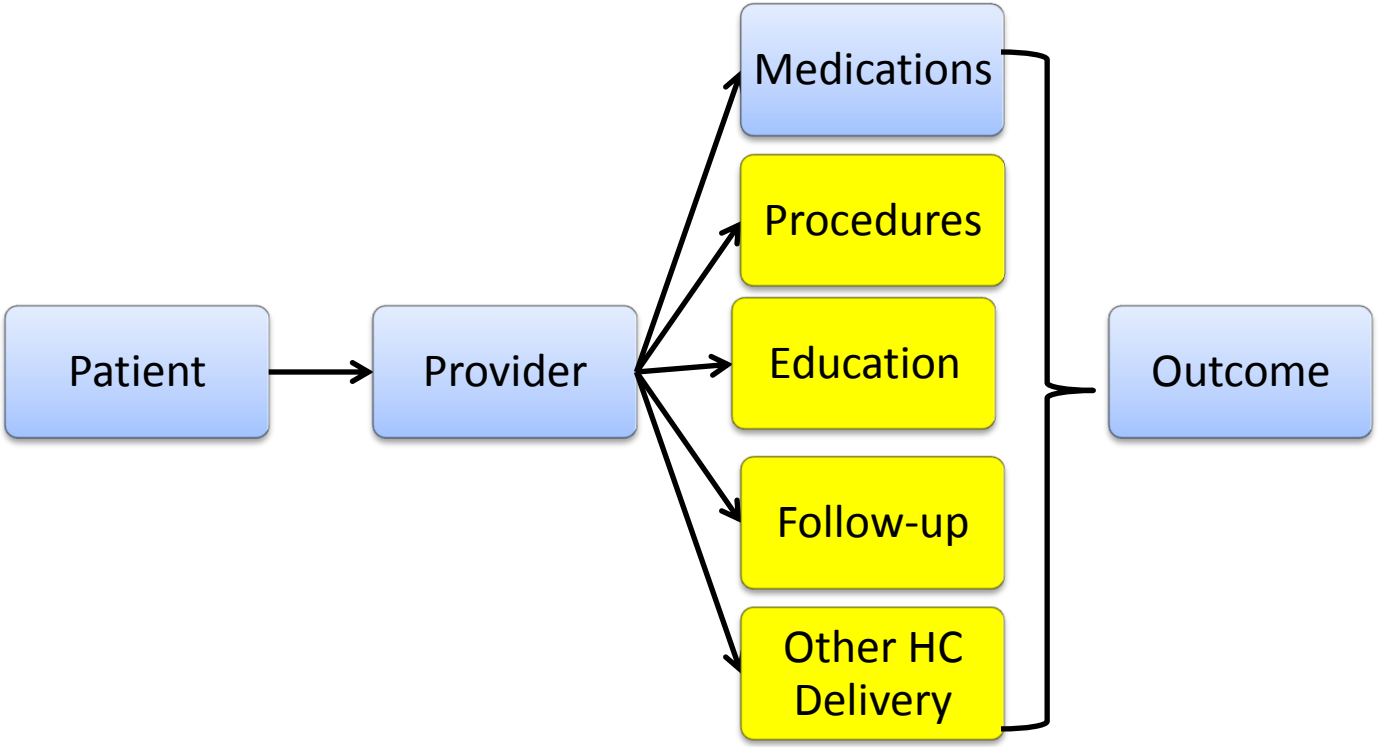
Comparative Effectiveness Research

- Test medication effect on outcomes



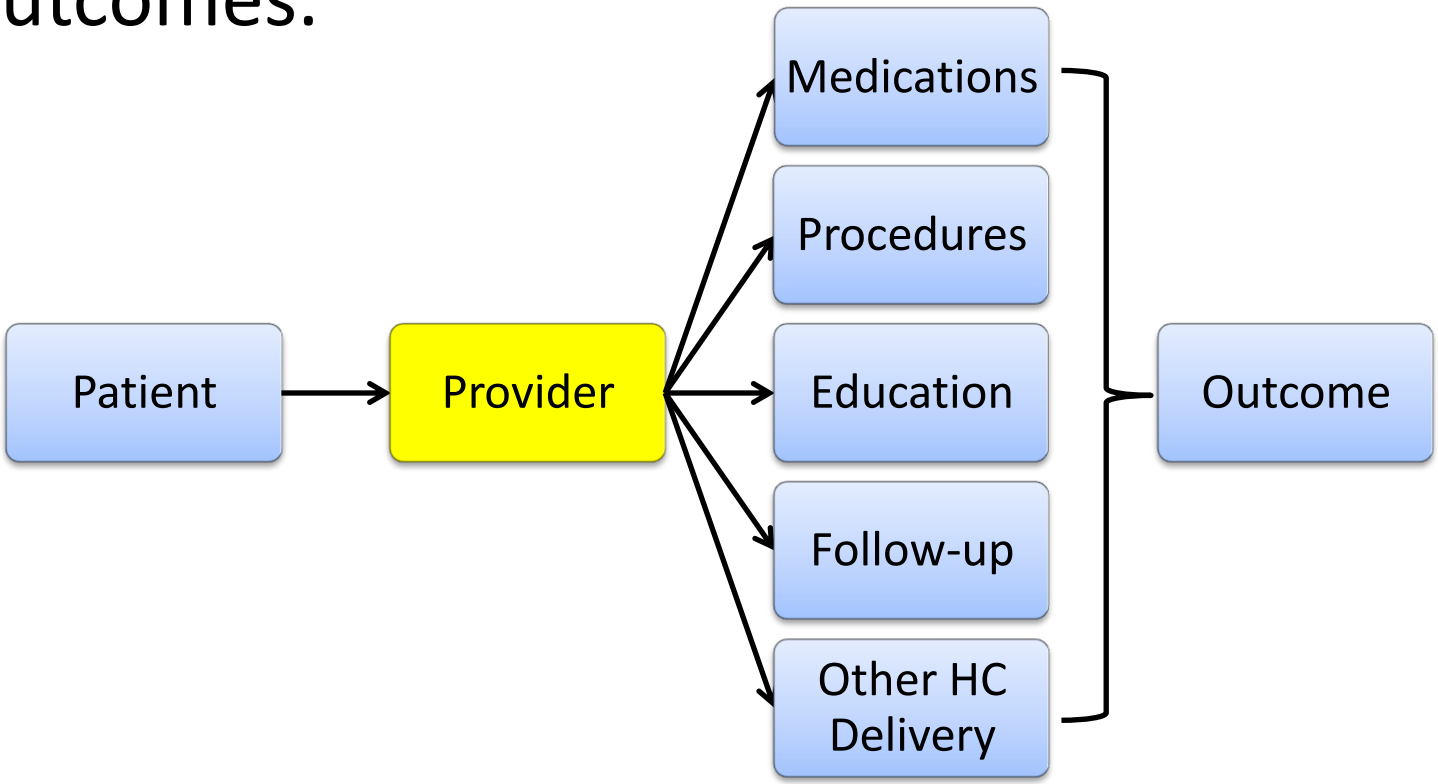
Control Other Interventions

- If we can statistically control for other interventions why would we ever use RCTs?



CER Should Focus on Provider

- Measure providers' ability to generate good outcomes.



Health Care Ranking (O-to-E)

- One viable business model
  - Define patient variables that impact outcomes
  - Build a large “reference” database of patient data
  - Model outcomes as a **risk-adjusted function of patient data**

- Hospitals submit their patient data to obtain estimates of expected outcomes which are compared with actual outcomes

Observed-to-Expected

- Which is the better performing hospital?

Hospital	Expected Outcome	Observed Outcome	Obs – Exp (Want < $0)	Obs / Exp (Want < 1)
A	$5,000	$6,000	$1,000	1.20
B	$10,000	$11,500	$1,500	1.15

Observed-to-Expected

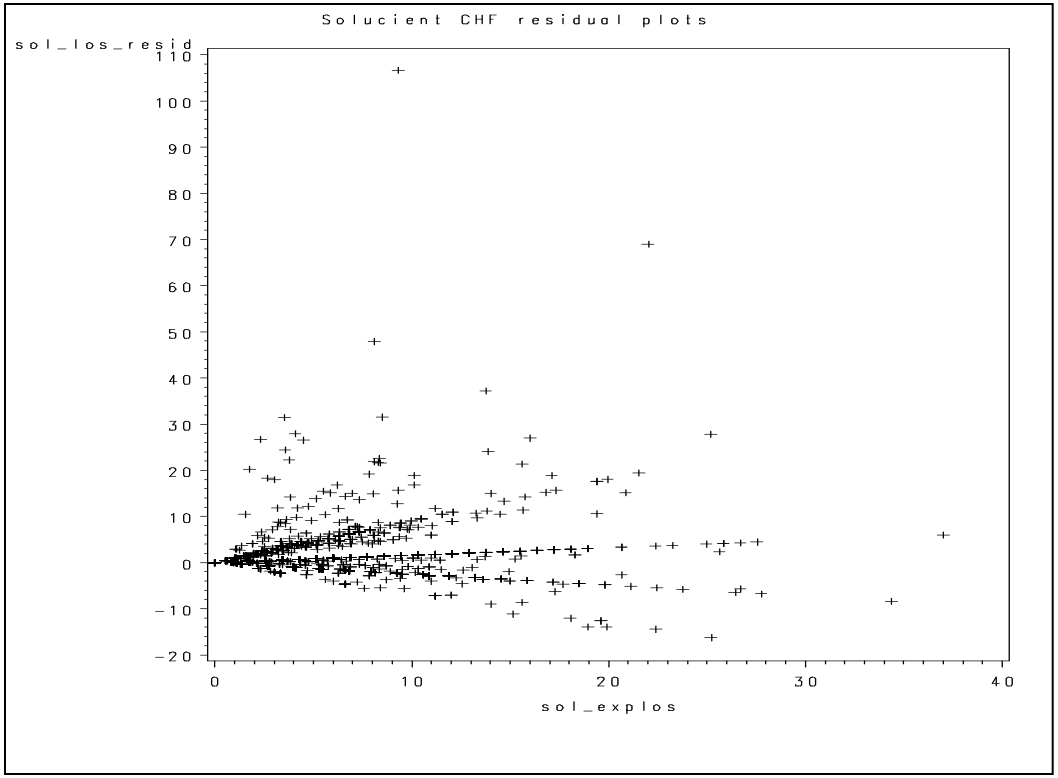
- What is the impact of population differences?

AMI patients			
	Standard Population		BJC
Age	N	%	%
< 65	**314,587**	**33.6**	**40.2**
65 - 74	209,581	22.4	22.7
75 - 79	131,770	14.1	12.4
80 +	281,112	30.0	24.7

Pneumonia patients			
	Standard Population		BJC
Co-Morbidity	N	%	%
Cancer	**224,375**	**37.2**	**23.0**
Liver Disease	57,883	9.6	6.7
Heart Disease	**82,784**	**13.7**	**42.6**
Renal Failure	**237,645**	**39.4**	**27.7**

Observed-to-Expected

- Do the models fit the submitted data well?



Healthcare Reform as a Tournament

- Match patients 1-to-1 across provider pairs*
  - "Winning" provider (patient with better outcome)
  - "Losing" provider (patient with worse outcome)
  - "Tie" (patients have same outcome)

- Use #wins/losses/ties to rank providers in terms of quality (risk adjusted) outcomes

* Risk Adjustment: Propensity score, bipartite graph matching

Propensity Score

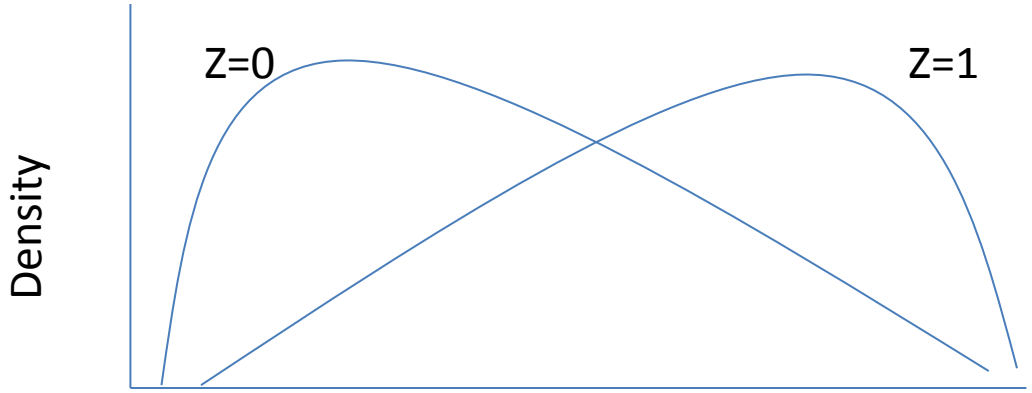
- Suppose we have data on
  - Providers (**Z** = 0, 1, 2,…)
  - Outcome (**Y** = death, LOS, INR, complication, readmit)
  - Patient covariates (**X** = demographics, history, labs)

- Patients go to provider **Z** (assume 0 or 1 for now) in a non-random fashion with a measurable probability (propensity score)

$$p(x) = \Pr(Z = 1 | X = x)$$

Propensity Score Matching

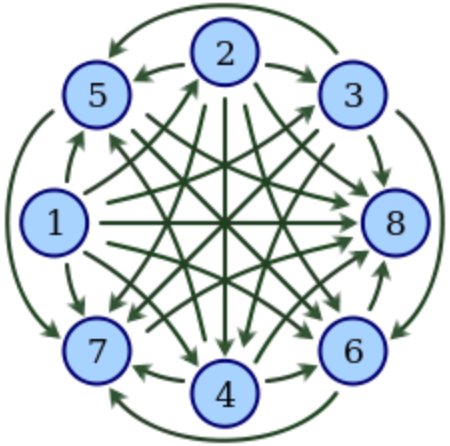
- Matching patients with similar p(x) balances patient covariates

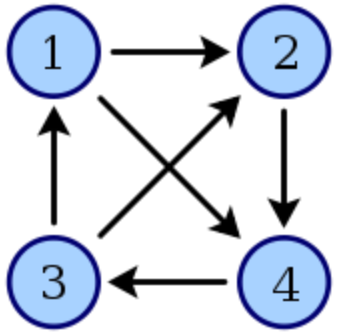


$$p(x) = \Pr(Z = 1 | X = x)$$

Tournament

- Directed graph
  - Nodes represent providers
  - Edge is result of tournament (points from winner to loser)
  - Every pair of nodes is connected by one edge





Ranking

- Transitivity
  - For any 3 providers (Z_i, Z_j, Z_k), if $Z_i > Z_j$ and $Z_j > Z_k$, then $Z_i > Z_k$
- Comparability
  - For any pair of providers (Z_i, Z_j), either $Z_i > Z_j$ or $Z_i < Z_j$ or $Z_i = Z_j$
- **Ranking depends on how providers are related by the relations >, <, and =, and *to what degree***

A Ranking Exists (Proven)

- THEOREM 1
  - Every tournament in which all teams are comparable has a unique ranking

- THEOREM 2
  - Every tournament has a unique partial ranking

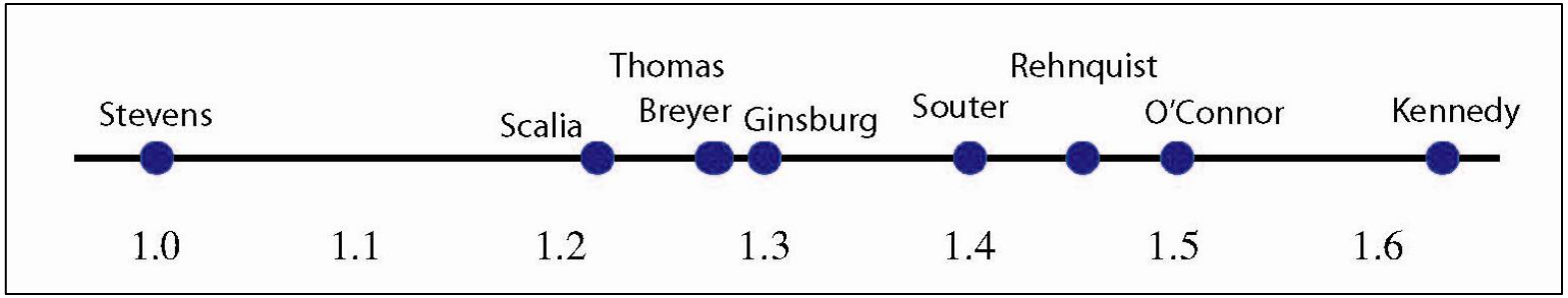
'The Ranking of Incomplete Tournaments: A Mathematician's Guide to Popular Sports', Thomas Jech, The American Mathematical Monthly, Vol. 90, No. 4, 1983

Bradley-Terry-Luce (1950's) model uses maximum likelihood (statistical)

Rank Supreme Court Justices

Pairwise supreme court comparisons

	Rehnquist	Stevens	O'Connor	Scalia	Kennedy	Souter	Thomas	Ginsburg	Breyer
Rehnquist	0	145.5	125	130.5	119.5	125.5	131.5	127.5	129
Stevens	99.5	0	93	99	88	98.5	99	105	103.5
O'Connor	129	143	0	129	117	122	130	124.5	124
Scalia	110.5	124	103	0	99.5	101.5	116.5	106.5	106.5
Kennedy	133.5	145	126	134.5	0	124.5	135	129.5	128.5
Souter	118.5	135.5	115	119.5	106.5	0	122.5	122.5	119.5
Thomas	118.5	128	112	121.5	105	106.5	0	111.5	112.5
Ginsburg	115.5	129	108.5	114.5	104.5	113.5	116.5	0	117
Breyer	110	129.5	107	110.5	100.5	113.5	111.5	116	0



Application

- 61,950 patients admitted to a BJC hospital
- Rank hospitals based on rates of readmission
- Stratified among four conditions:
  - acute myocardial infarction (AMI)
  - chronic obstructive pulmonary disease (COPD)
  - community acquired pneumonia (CAP)
  - congestive heart failure (CHF)

Risk-Adjusting Readmission Rates

- Hospital's expected readmission rate

$$ERR_j = \sum_{i=1}^{n_j} p_{ij} / n_j$$

- Hospitals observed readmission rate

$$ORR_j = \sum_{i=1}^{n_j} o_{ij} / n_j$$

- Risk adjusted readmission rate

$$RARR_j = (ERR_j / ORR_j) \times SRR$$

O-to-E CHF Rankings

		RARR Rankings										
Hosp.	N	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	Mean
BWC	1347	724	153	69	24	17	6	5	2	0	0	1.505
BHC	173	147	494	244	74	30	10	0	1	0	0	2.381
MBS	579	72	155	202	160	116	94	80	63	37	21	4.379
CHE	275	1	26	161	289	287	153	64	18	1	0	4.646
BSP	238	20	68	160	168	172	172	146	62	25	7	5.013
MBH	2012	2	9	48	114	206	266	201	125	22	7	5.921
PWH	315	31	88	93	110	87	98	113	120	104	156	6.196
AMH	2038	2	2	15	39	59	110	183	226	230	134	7.661
BJH	3786	0	0	0	2	8	30	111	274	390	185	8.557
PKL	480	1	5	8	20	18	61	97	109	191	490	8.741

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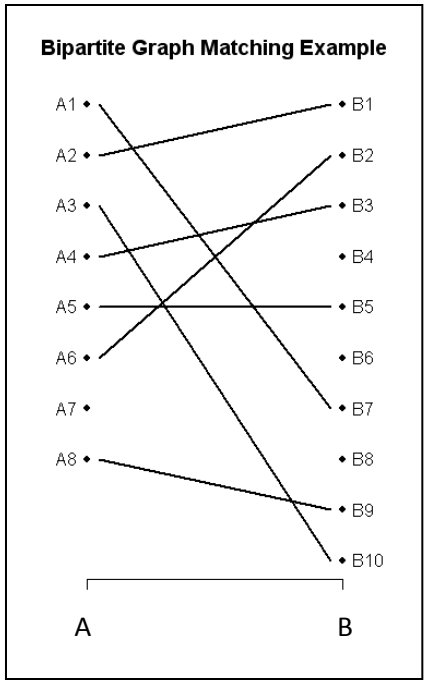
Tournament Ranking

- For hospital pairs match patients, compare readmission, run tournament ranking



	A	B	C	D
A		>	>	>
B	<		=	>
C	<	=		>
D	<	<	<	

Tournament CHF Rankings

Hosp.	N	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	Mean
BWC	1347	850	143	6	0	1	0	0	0	0	0	1.159
BHC	173	149	820	31	0	0	0	0	0	0	0	1.882
BSP	238	0	12	443	369	120	47	5	2	2	0	3.78
MBS	579	1	23	432	352	121	44	23	3	1	0	3.814
MBH	21012	0	0	19	103	275	293	205	91	12	2	5.893
PWH	315	0	2	52	106	223	177	205	130	71	34	6.215
CHE	275	0	0	17	60	204	301	254	118	41	5	6.258
AMH	2038	0	0	0	9	51	93	182	320	247	98	7.886
BJH	3786	0	0	0	0	2	26	100	253	416	203	8.664
PKL	480	0	0	0	1	3	19	26	83	210	658	9.449

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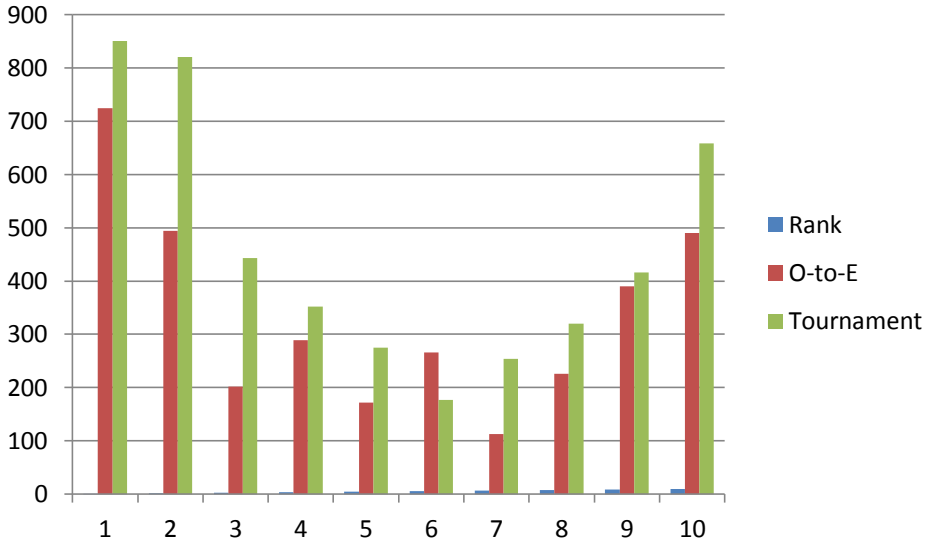
CHF Rankings

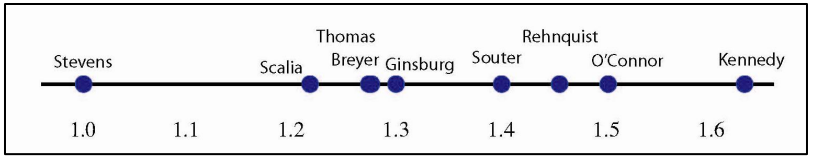
Indirect Standardization

Hosp.	N	1	2	3	4	5	6	7	8	9	10	Mean
BWC	1347	724	153	69	24	17	6	5	2	0	0	0.724
BHC	173	147	494	244	74	30	10	0	1	0	0	0.494
MBS	579	72	155	202	160	116	94	80	63	37	21	0.202
CHE	275	1	26	161	289	287	153	64	18	1	0	0.289
BSP	238	20	68	160	168	172	172	146	62	25	7	0.172
MBH	2012	2	9	48	114	206	266	201	125	22	7	0.266
PWH	315	31	88	93	110	87	98	113	120	104	156	0.113
AMH	2038	2	2	15	39	59	110	183	226	230	134	0.226
BJH	3786	0	0	0	2	8	30	111	274	390	185	0.39
PKL	480	1	5	8	20	18	61	97	109	191	490	0.49



Tournament

Hosp.	N	1	2	3	4	5	6	7	8	9	10	Mean
BWC	1347	850	143	6	0	1	0	0	0	0	0	0.85
BHC	173	149	820	31	0	0	0	0	0	0	0	0.82
BSP	238	0	12	443	369	120	47	5	2	2	0	0.443
MBS	579	1	23	432	352	121	44	23	3	1	0	0.352
MBH	21012	0	0	19	103	275	293	205	91	12	2	0.275
PWH	315	0	2	52	106	223	177	205	130	71	34	0.177
CHE	275	0	0	17	60	204	301	254	118	41	5	0.254
AMH	2038	0	0	0	9	51	93	182	320	247	98	0.32
BJH	3786	0	0	0	0	2	26	100	253	416	203	0.416
PKL	480	0	0	0	1	3	19	26	83	210	658	0.658



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COPD

	1	2	3	4	5	6	7	8	9	10
BHC	216	279	247	122	68	30	22	12	4	0
PWH	344	215	132	116	57	51	28	24	22	11
BWC	265	199	167	104	74	52	51	36	35	17
AMH	29	64	103	147	183	150	121	92	73	38
CHE	4	15	64	107	191	155	161	147	107	49
MBS	124	174	150	123	91	87	68	55	65	63
MBH	4	23	47	83	118	161	156	169	134	105
PKL	9	20	49	88	106	139	162	154	145	128
BSP	3	10	28	82	83	114	140	179	176	185
BJH	2	1	13	28	29	61	91	132	239	404

	1	2	3	4	5	6	7	8	9	10
PWH	555	255	129	46	10	4	0	1	0	0
BHC	253	383	265	82	16	1	0	0	0	0
BWC	158	250	324	173	59	30	2	4	0	0
MBS	28	89	183	305	199	94	48	33	13	8
AMH	6	23	82	272	331	162	80	30	12	2
MBH	0	0	10	58	163	267	213	176	87	26
CHE	0	0	2	26	80	152	197	208	217	118
BSP	0	0	3	21	66	135	193	222	224	136
PKL	0	0	2	14	68	123	189	218	235	151
BJH	0	0	0	3	8	32	78	108	212	559

CAP

	1	2	3	4	5	6	7	8	9	10
PWH	438	263	151	79	40	21	4	4	0	0
BHC	111	299	342	191	50	5	1	1	0	0
BWC	323	217	154	115	67	67	26	16	11	4
MBS	123	191	229	217	117	62	32	20	8	1
CHE	0	7	60	223	404	226	68	9	3	0
PKL	5	21	52	133	181	223	177	127	55	26
AMH	0	2	11	38	111	246	314	181	73	24
MBH	0	0	0	3	22	121	291	393	137	33
BSP	0	0	1	1	8	25	73	154	328	410
BJH	0	0	0	0	0	4	14	95	385	502

	1	2	3	4	5	6	7	8	9	10
PWH	680	212	77	29	1	1	0	0	0	0
BWC	151	279	248	266	43	12	1	0	0	0
MBS	109	280	268	300	35	8	0	0	0	0
BHC	60	228	383	301	26	2	0	0	0	0
PKL	0	1	19	58	520	320	75	7	0	0
CHE	0	0	5	45	328	490	110	20	2	0
AMH	0	0	0	1	42	138	567	246	6	0
MBH	0	0	0	0	5	27	245	692	31	0
BSP	0	0	0	0	0	2	2	34	723	239
BJH	0	0	0	0	0	0	0	1	238	761

AMI

	1	2	3	4	5	6
BHC	454	339	122	60	23	2
BSP	373	259	165	97	71	35
CHE	55	193	338	245	130	39
BJH	15	75	148	267	323	172
MBH	29	64	136	228	318	225
AMH	74	70	91	103	135	527

	1	2	3	4	5	6
BHC	660	264	59	15	1	1
BSP	267	420	184	84	34	11
CHE	39	165	352	209	162	73
BJH	10	67	163	303	282	175
MBH	2	28	136	233	334	267
AMH	22	56	106	156	187	473

Summary

- Michael Porter, Harvard Business School
- Focus on provider quality, not medication efficacy
- O-to-E works for comparable populations
- Healthcare reform as a ‘tournament’
- Jech/Bradley-Terry-Luce
- Advantages…

Advantages

- Flexible – any **X**, **Y**, **Z** data
- Focused – compare within, not just across, systems
- Transparent – no proprietary information
- **Modifiable – incorporate new data on demand**
- Comprehensive – (most) any list of providers can be ranked

	# High Risk Patients	# Low Risk Patients
Hospital A	50	50
Hospital B	75	20
Hospital C	100	0
Hospital D	0	100

People/Funding

- WUSM
  - Clay Dunagan, MD, VP BJC, co-investigator
  - Elena Deych, statistics
  - Ally McWilliams, project management
  - Berkley Shands, programming
- WU Political Science
  - Maggie Penn, faculty, co-investigator
  - Keith Schnakenberg, PhD student

- NIH RC4 LM010958-01 “New Observational Data Analysis Methods for Comparative Effectiveness Research”