



The Johns Hopkins University's



2010 ACG International  
Risk Adjustment Conference

MAY 10-12  
Tucson, Arizona  
Loews Ventana Canyon

# Predicting Hospitalization: Model and Applications

Presenter:

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Major contributor :

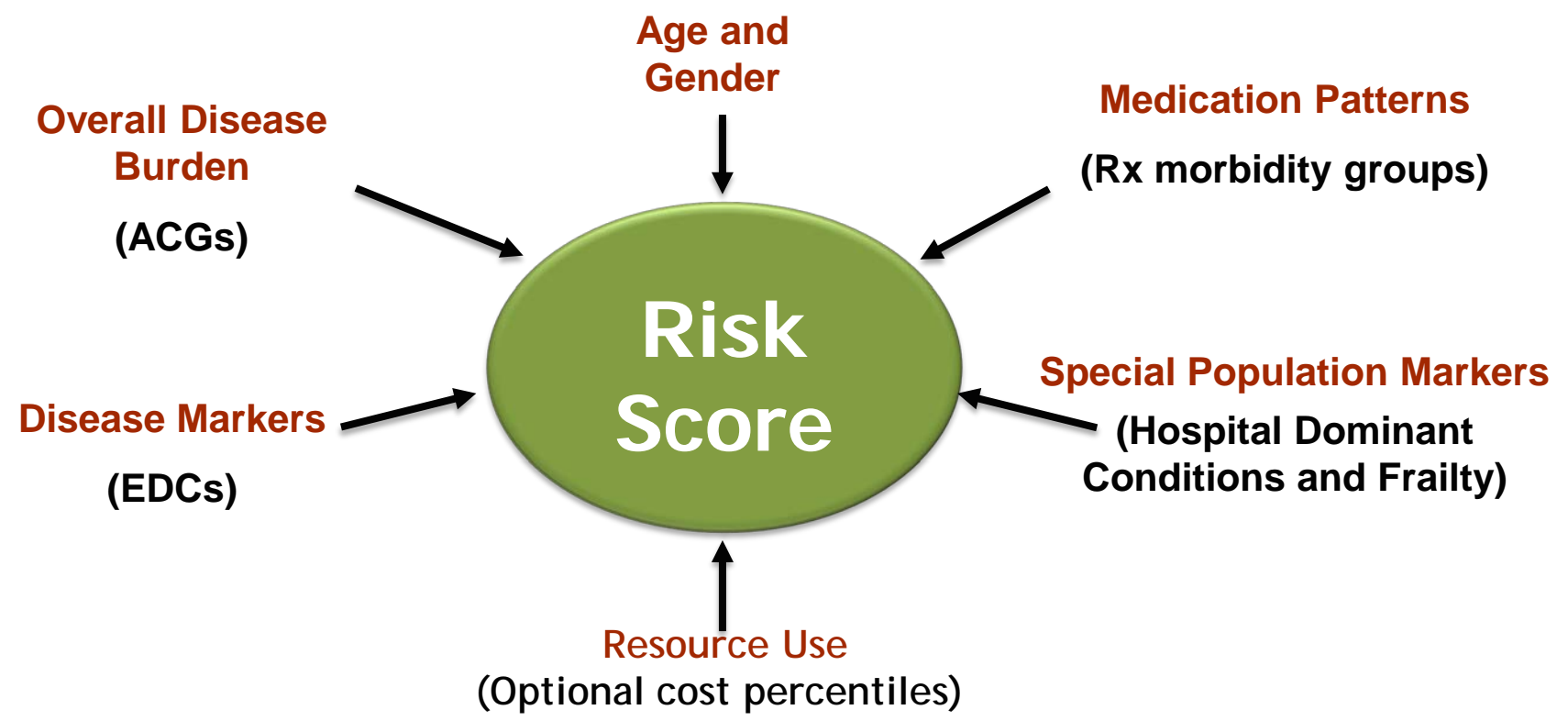
Jeanne Clark MD



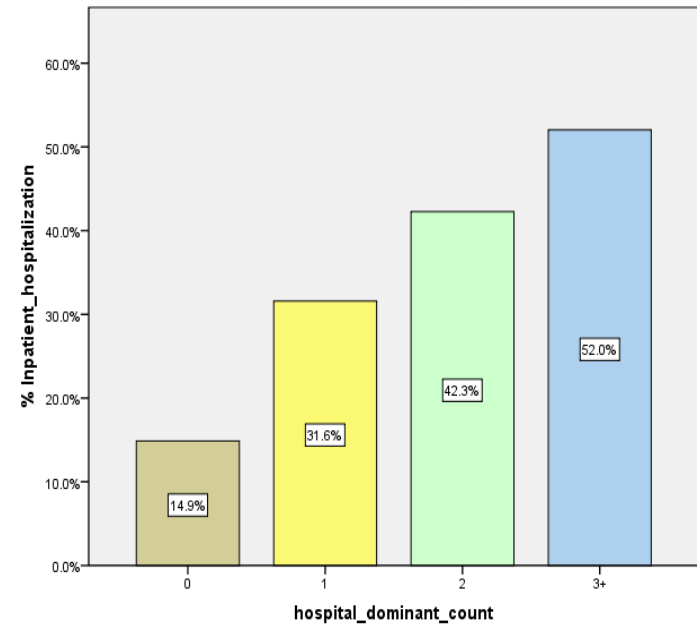
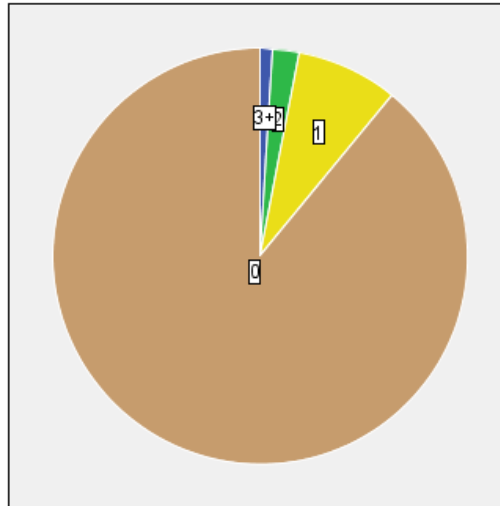
## Goals

- Improve upon the financial risk model as a predictor of individuals with unanticipated hospitalizations by calibrating a model specifically to hospitalization outcomes
- Enhance the role of predictive modeling in prioritizing high opportunity patients for care management

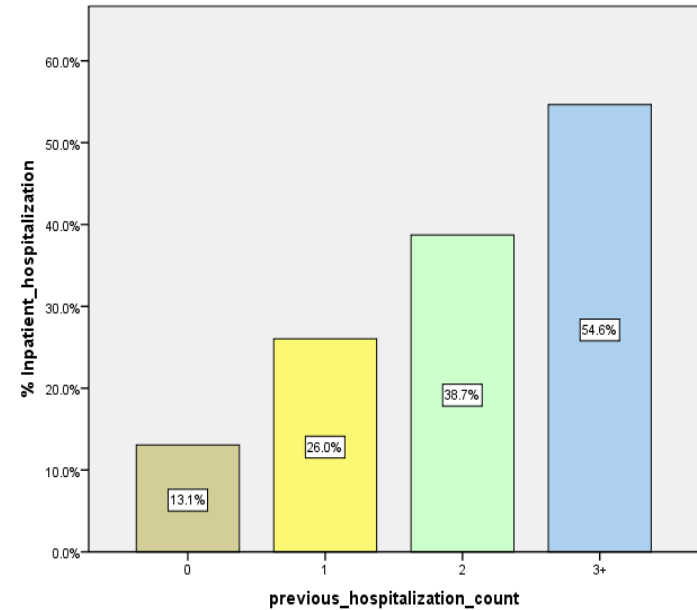
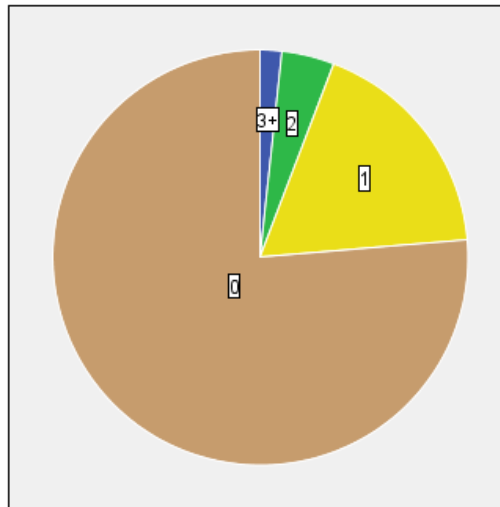
# Financial Risk Model



# Hospital Dominant Conditions “HosDom”



# Previous Hospital Stays





# Hospitalization Typology

## Unanticipated, no external cause

CHF, COPD, joint replacement

## Unanticipated, external cause

injury and poisoning

Anticipated, scheduled and unscheduled

C-section, elective surgery, childbirth,  
transplants



## Target Outcomes

- **Acute care hospitalization**
  - excluding childbirth and injury
  - 2 prediction periods: 6 and 12 months
- **Intensive care hospitalization (ICU/CCU)**
- **Extensive length of stay (12+ days cumulative)**
- **Injury-related acute care hospitalization**

# Hospitalization Risk Factors: Morbidity

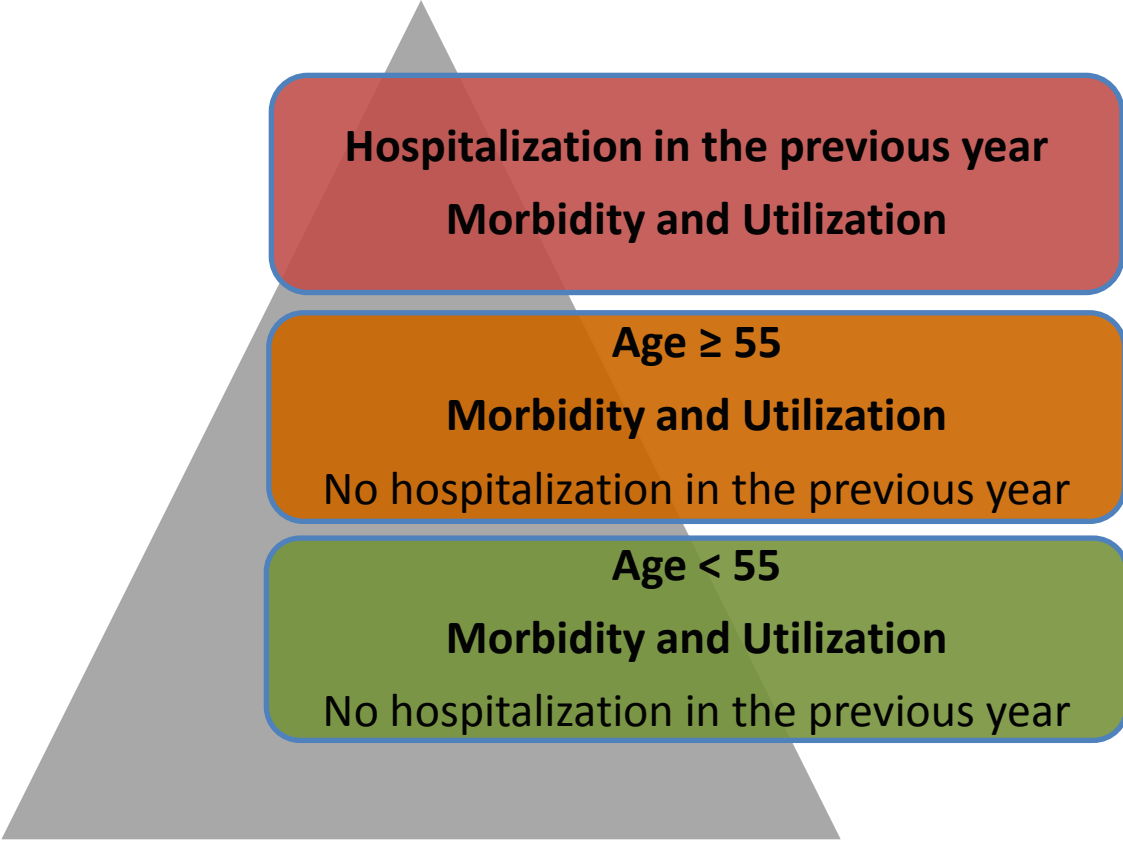
Risk Factor	Data Segments	Data Elements	Prevalence	Hospitalization Risk
<b>Dx morbidity groups, ACGs and EDCs</b>	Inpatient and Outpatient	ICD codes	Medium to low	Moderate to high
<b>Rx morbidity groups</b>	Pharmacy	Drug codes	High to low	Moderate to high
<b>HosDom conditions</b>	Inpatient and Outpatient	ICD codes	Low	High
<b>Frailty marker</b>	Inpatient and Outpatient	ICD codes	Low	Moderate



# Hospitalization Risk Factors: Utilization

Risk Factor	Data Segments	Data Elements	Prevalence	Hospitalization Risk
<b>Inpatient hospitalizations</b>	Inpatient	Place of service, Revenue codes	Low	Moderate to high
<b>Major procedures</b>	Inpatient	Procedure codes	Low	High
<b>Emergency room visits</b>	Outpatient ER	Revenue codes, Procedure codes	Medium to low	Moderate to high
<b>Outpatient visits</b>	Outpatient	Place of service	High to low	Low to high
<b>Dialysis services</b>	Outpatient	Procedure codes	Low	High
<b>Nursing services</b>	Outpatient	Procedure codes	Low	High
<b>Drug count</b>	Pharmacy	Drug codes	Low	Moderate

# Combining Hospitalization Risk Factors



**Hospitalization in the previous year**  
**Morbidity and Utilization**

**Age  $\geq$  55**  
**Morbidity and Utilization**  
No hospitalization in the previous year

**Age  $<$  55**  
**Morbidity and Utilization**  
No hospitalization in the previous year

# How the Hospital Risk Model works: Calculating a Patient's Probability of Hospitalization

Risk Factor	Characteristic	Weight
<b>Demographics</b>	65 year old female	0.252
<b>Risk of Hospitalization</b>	Hospital Dominant Condition – ICD	0.258
<b>Diabetes</b>	Type 2 diabetes with complication – ICD	0.142
	Hypoglycemic (non-insulin) drug – NDC	-.096
<b>Peptic Disease</b>	Peptic ulcer – ICD	0.084
	Peptic disease drug – NDC	0.003
<b>Chronic Liver Disease</b>	Chronic liver disease – ICD	0.027
<b>Psychosocial</b>	Anti-anxiety drug marker – NDC	0.056
<b>All other co-morbidities</b>	ICD and NDC	0.118
<b>Previous Utilization</b>	<u>1 Hospitalization</u> , 22 outpatient visits and total expenditure in 76 <sup>th</sup> – 90 <sup>th</sup> percentile	0.379
	<b>Sum of Weights</b>	<b>1.223</b>
<b><math>1/(1+\exp(-2.603+\text{sum weights}))</math></b>	<b>= Probability of Hospitalization</b>	<b>0.201</b>

# Options for Data Input and Hospital Risk Models:

## Patient File

- inpatient hospitalizations
- emergency room visits
- outpatient visits
- dialysis services
- nursing services
- major procedures

❑ “Business rules” for including visit counts and service markers in the patient file

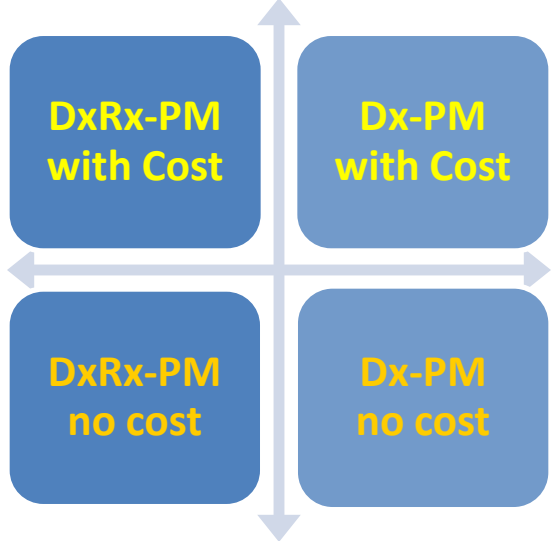
## Medical Service File

- Place of service codes
- Revenue codes
- Procedure codes

Software generates these visit counts and utilization markers!

❑ “Coding Standards” include CMS place of service codes, revenue codes, HCPCS and AMA CPT procedure codes

## Hospital Risk Model Variants



❑ “Best” model selection is based on ICD, Drug codes and cost data input



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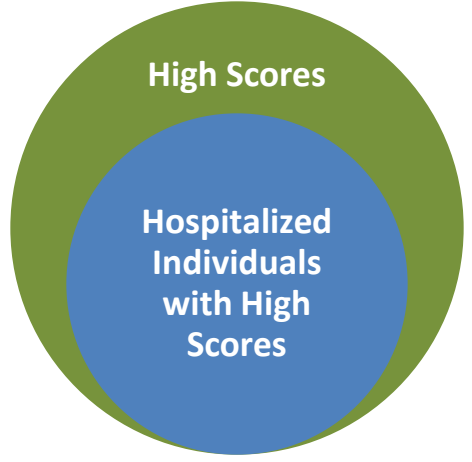
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# “Multi-faceted Addition to ACG Toolkit”

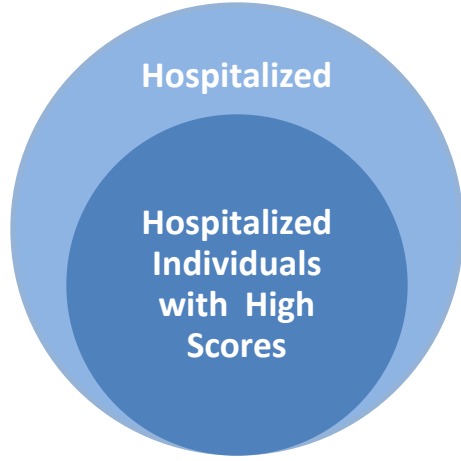
- five hospital risk scores
- two time horizons: 6 and 12 months
- based on ACG predictive modeling framework
- uses previous hospitalizations and HosDom
- uses new data inputs: procedures / place of service / revenue center codes
  - counts of previous hospitalization, emergency room, outpatient visits in patient file are optional
  - prior cost and pharmacy inputs are optional

# Concepts for an Empiric Evaluation of Hospital Risk Scores

## Positive Predictive Value (PPV)



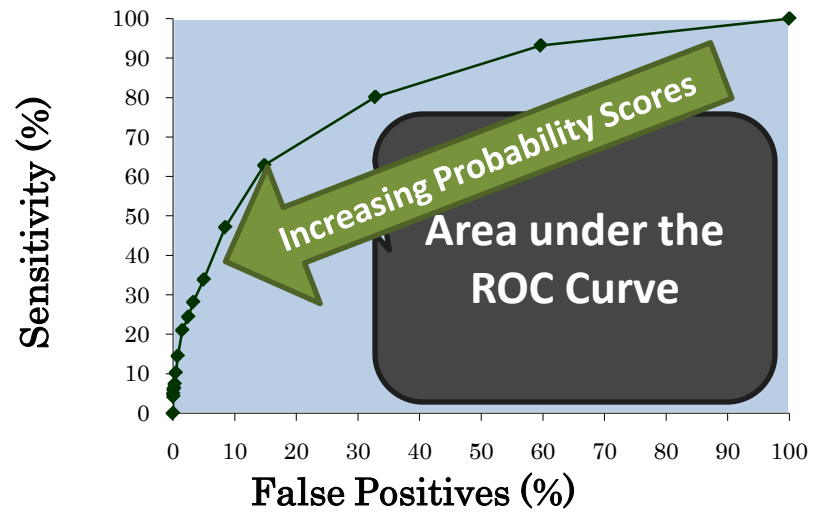
## Sensitivity



## True and False Positives

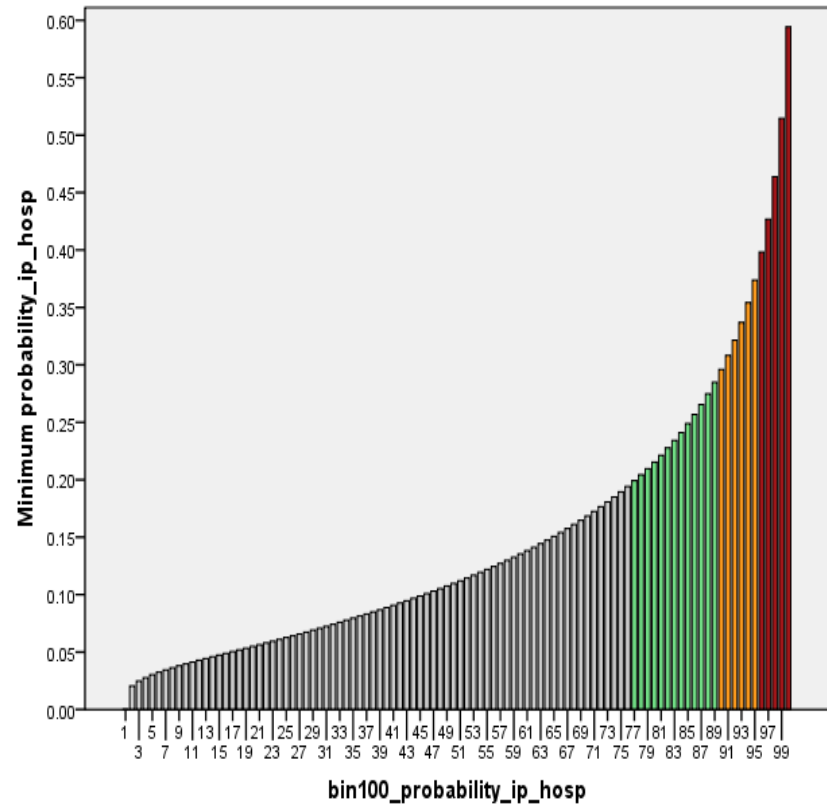
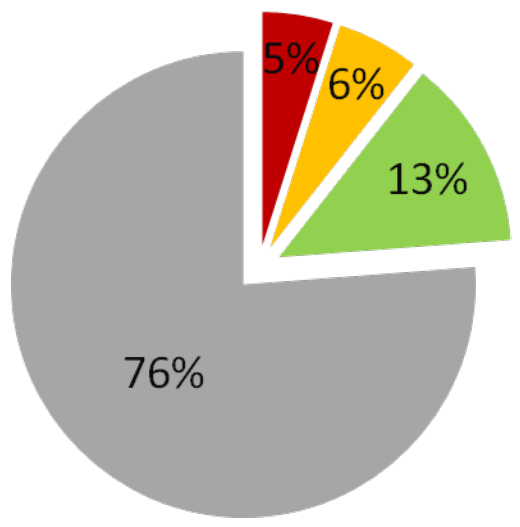


## ROC Curve



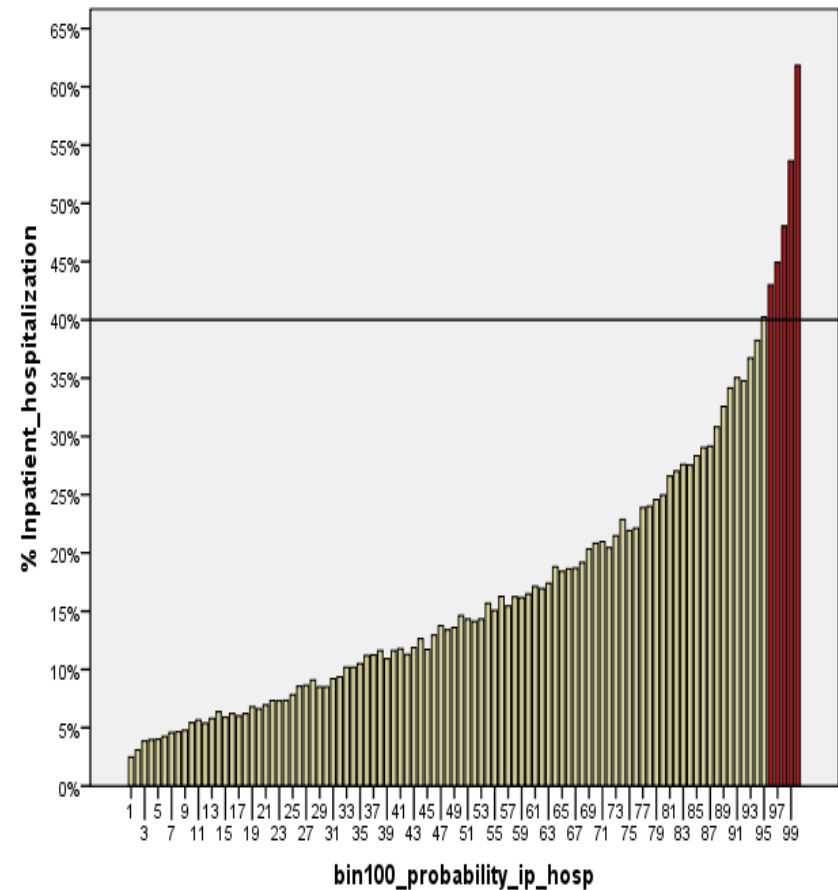
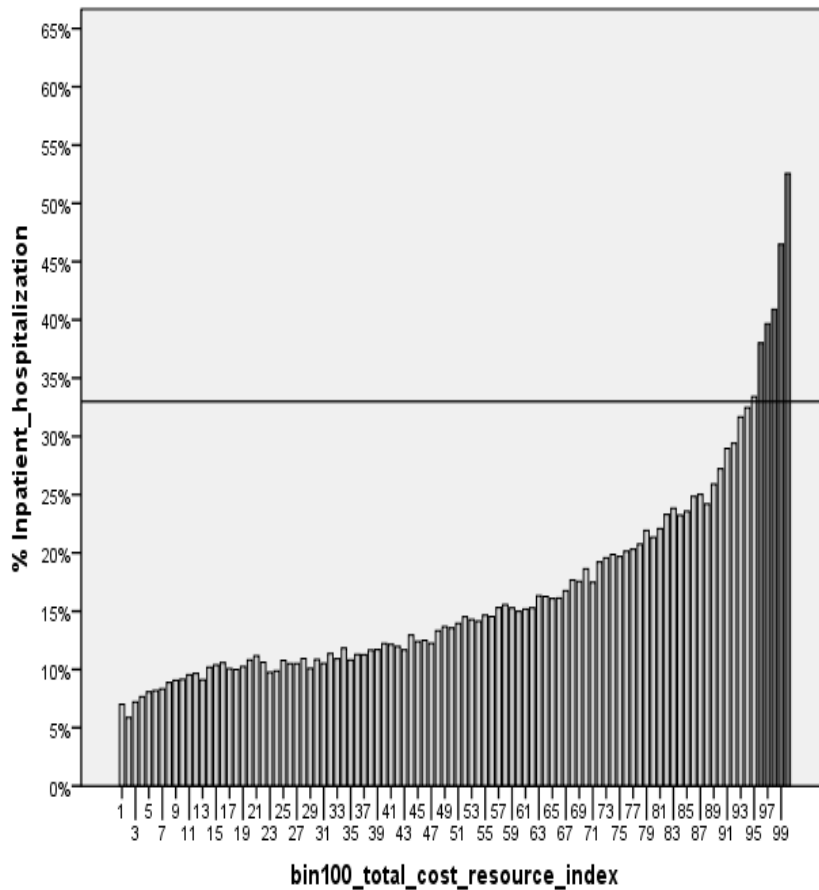
# Hospital Risk Scores in a Population with Multiple Chronic Conditions

- .4 to <= 1.0
- .3 to < .4
- .2 to < .3
- .0 to < .2

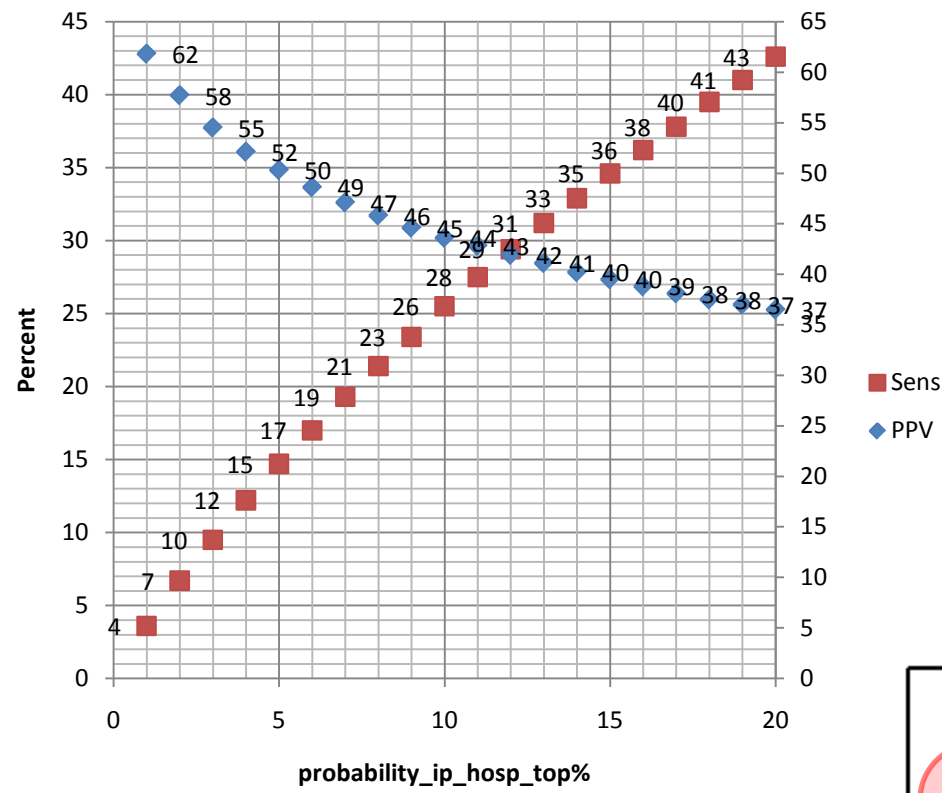


603,525 patients with 3 or more chronic conditions

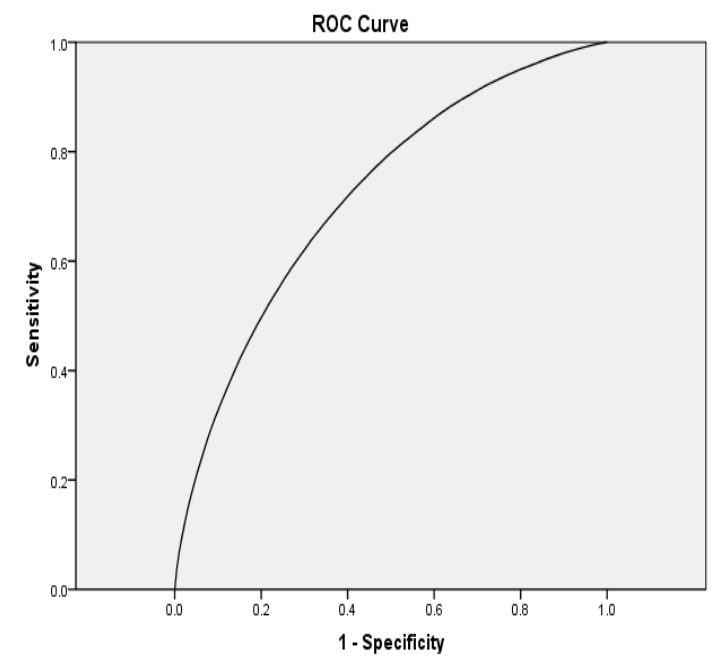
# How the Hospital Risk Model performs



## Sensitivity and PPV Trade-off



## ROC Curve and Area



Area	Std. Error <sup>a</sup>	Asymptotic Sig. <sup>b</sup>	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.721	.001	.000	.720	.723

# Multiple Hospitalization Models: PPV, Sensitivity, Area ROC

Category	Time Frame	Target Outcome	Top 5% Prob.Hosp. Range	Top 5% Prob.Hosp. Average	Positive Predictive Value	Sensitivity	Area under ROC curve
non-injury, non-childbirth	6 months	Inpatient Hosp. 6mo.	.264 to .896	.374	36.7%	17.6%	.728
	12 months	Inpatient Hosp.	.398 to .947	.515	50.2%	14.7%	.721
		ICU/CCU Hosp.	.139 to .900	.207	20.7%	17.1%	.727
		Extended Ip. Hosp.	.119 to .921	.206	14.3%	27.0%	.786
injury		Injury Hosp.	.086 to .798	.138	6.5%	20.5%	.756

Hospital risk scores in a population with multiple chronic conditions.



## Overlap between Hospital Risk Groups

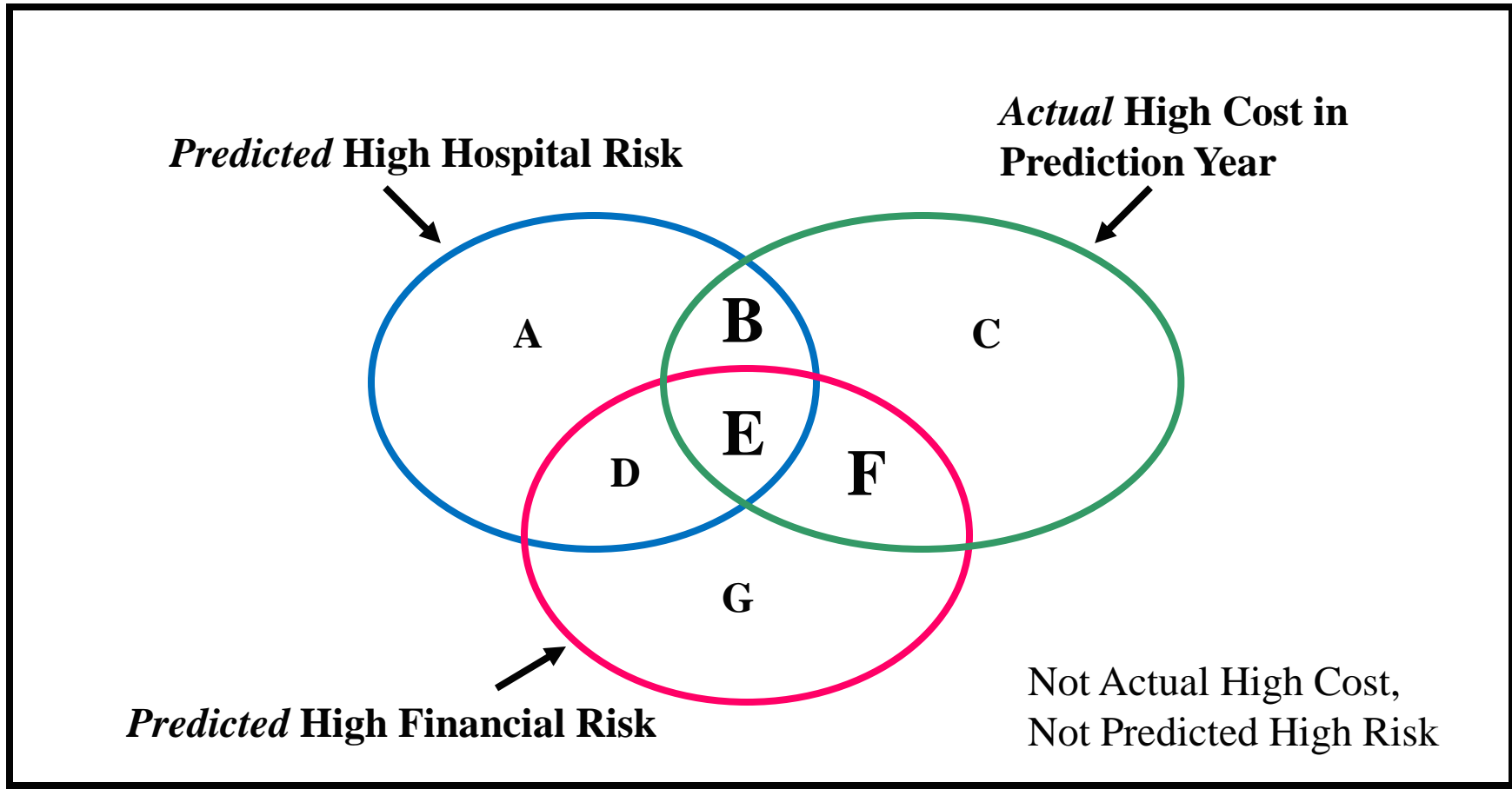
	Inpatient	ICU/CCU	Extended days	Injury-related
6 mo. Inpatient	90.8%	60.1%	74.7%	57.8%
Inpatient	100%	61.1%	72.8%	59.1%
ICU/CCU		100%	60.2%	50.2%
Extended days			100%	67.4%

Top 5% Hospital risk scores in a population with multiple chronic conditions.



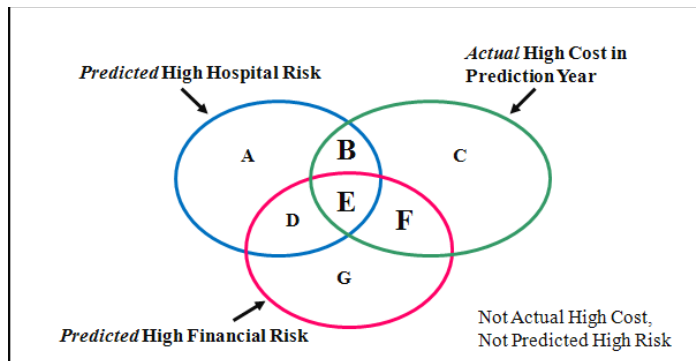
## Applications

- ✓ Using hospital risk scores to prioritize high opportunity patients for care management
- ✓ Enhancing care management reports
  - Provider profiling
  - Evaluation of care management initiatives

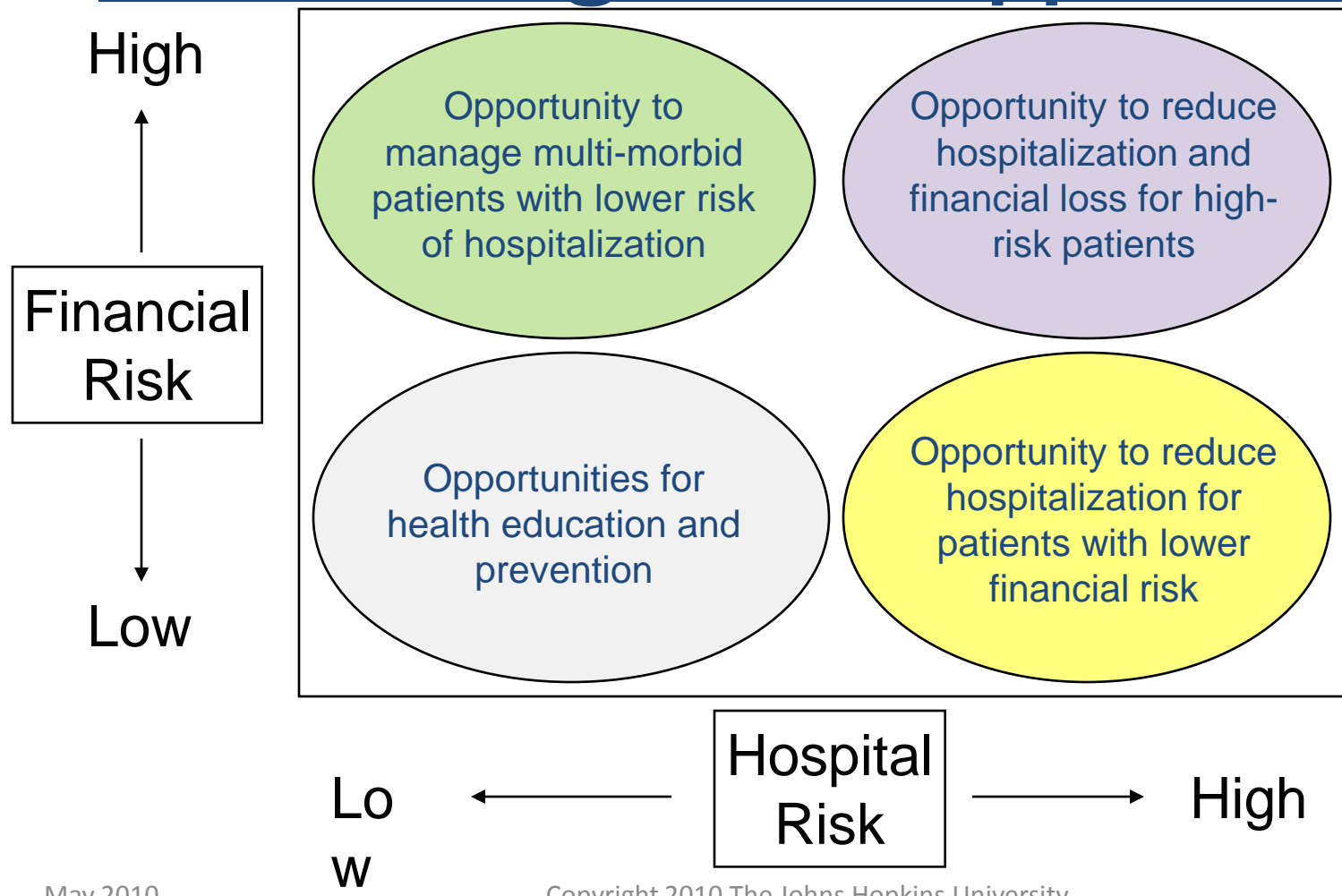


## Identifying High Cost Patients

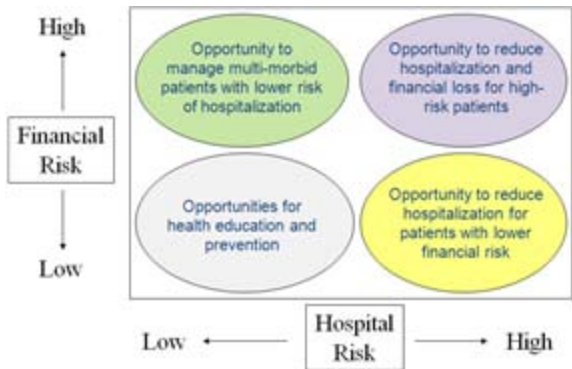
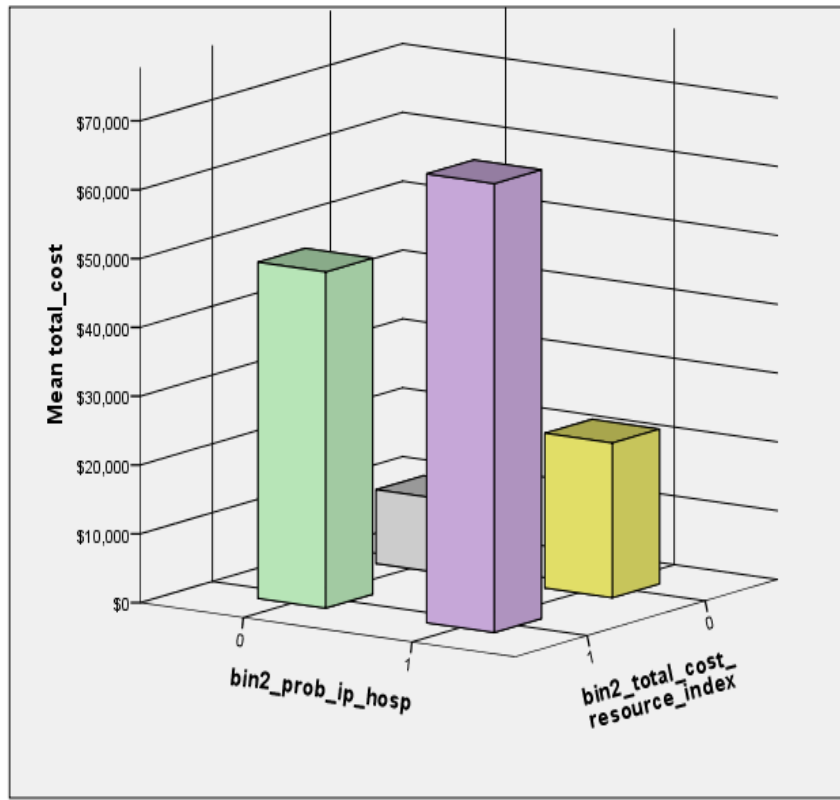
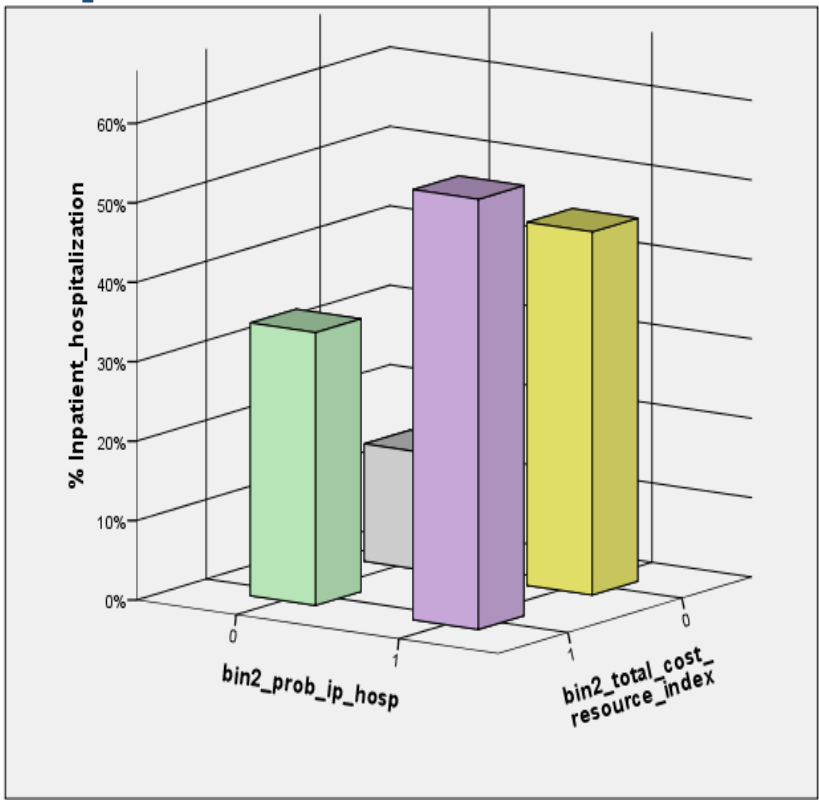
Label	Risk Group	Patients	PPV	Sensitivity	Avg. Cost
A+B	Hospital only	15,035	11.8	6.0%	\$23,709
D+E	<b>Financial AND Hospital</b>	15,141	37.0	<b>18.5%</b>	<b>\$67,343</b>
F+G	Financial only	15,035	29.3	14.6%	\$50,917
D+E+F+G	<b>Financial (top 5%)</b>	30,176	33.1	<b>33.1%</b>	<b>\$59,159</b>
A+B+D+E	Hospital (top 5%)	30,176	24.5	24.5%	\$45,602
A+B+D+E+F+G	Financial OR Hospital	45,211	26.1	39.1%	\$47,370



# Care Management Opportunities



# Hospitalization and Total Cost Outcomes



## Financial Risk (high 5%) -and- Hospital Risk (high 5%)

Risks and Outcomes	low--low	high--low	low--high	high--high
Financial risk score, mean	3.221	15.053	7.469	18.013
Hospital risk score, mean	0.126	0.267	0.479	0.551
<b>% Hospitalization</b>	<b>14.8%</b>	<b>34.6%</b>	<b>45.9%</b>	<b>54.6%</b>
% Hospitalization in 6 months	8.7%	23.5%	31.3%	40.7%
% ICU/CCU hospitalization	5.0%	13.3%	17.8%	24.6%
% Extended hosp (12+ days)	1.8%	9.5%	10.3%	18.4%
% Injury hospitalization	1.3%	3.1%	5.5%	5.8%
Total cost, mean	\$10,841	\$50,917	\$23,709	\$67,343
Inpatient cost, mean	\$3,483	\$14,692	\$11,409	\$26,012

# Patient Profile with “Probability of Hospital Admission” Scores

Age	50	Gender	M
PCP Id		Product	
Resource Utilization Band	5	Local Weight	14.53

<b>Model</b>		<b>Prior Costs</b>	
DxRx-PM - total cost - stringent dx -> total cost		Total Cost	\$ 287,852
DxRx-PM - rx cost - stringent dx -> rx cost		Rx Cost	\$ 6,213

<b>Predictive Values</b>		<b>Coordination of Care</b>	
Probability High Total Cost	0.95	Chronic Condition Count	8
Predicted Total Cost Range	>\$75,000	# Unique Providers Seen	6
Probability High Rx Cost	0.86	# Specialty Types Seen	3
Predicted Rx Cost Range	\$5,000-\$10,000	No Generalist Seen	N
High Risk Unexpected Pharmacy	N	% Visits Provided By Majority Source of Care	25
		Frailty Flag	Y

**Utilization**

Outpatient Visits	24
ER Visits	5
Inpatient Admissions	0
Major Procedure Performed	Y
Dialysis Service	Y
Nursing Service	N

**Likelihood of Hospitalization**

Hospital Dominant Count	4
Probability Hospital Admission (6 mos)	0.38
Probability Hospital Admission (12 mos)	0.62
Probability ICU/CCU Admission	0.43
Probability Injury-related Admission	0.43
Probability Long-term Admission (12+ days)	0.09



## Summary

- Care management helps to improve the quality and outcomes of care, while reducing costs for patients with complex health needs.
- The best screening tools for prioritizing high opportunity patients for care management programs are still evolving.
- Prior hospitalization is a good predictor of future hospitalization.
- Clinically based “predictive hospitalization models” provide a better screening tool than prior hospitalization information alone.
- Improvements to the accuracy of predictive hospitalization models will help to reduce unneeded, ineffective, and missed care management opportunities.