Predicting Re-admissions among Medicare Patients in a California Hospital

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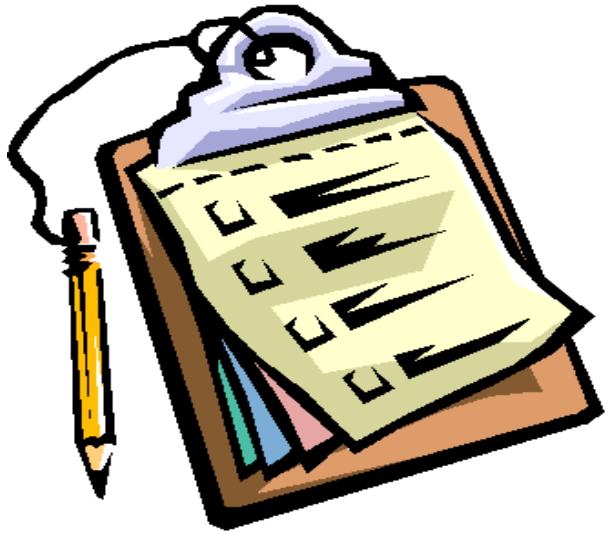
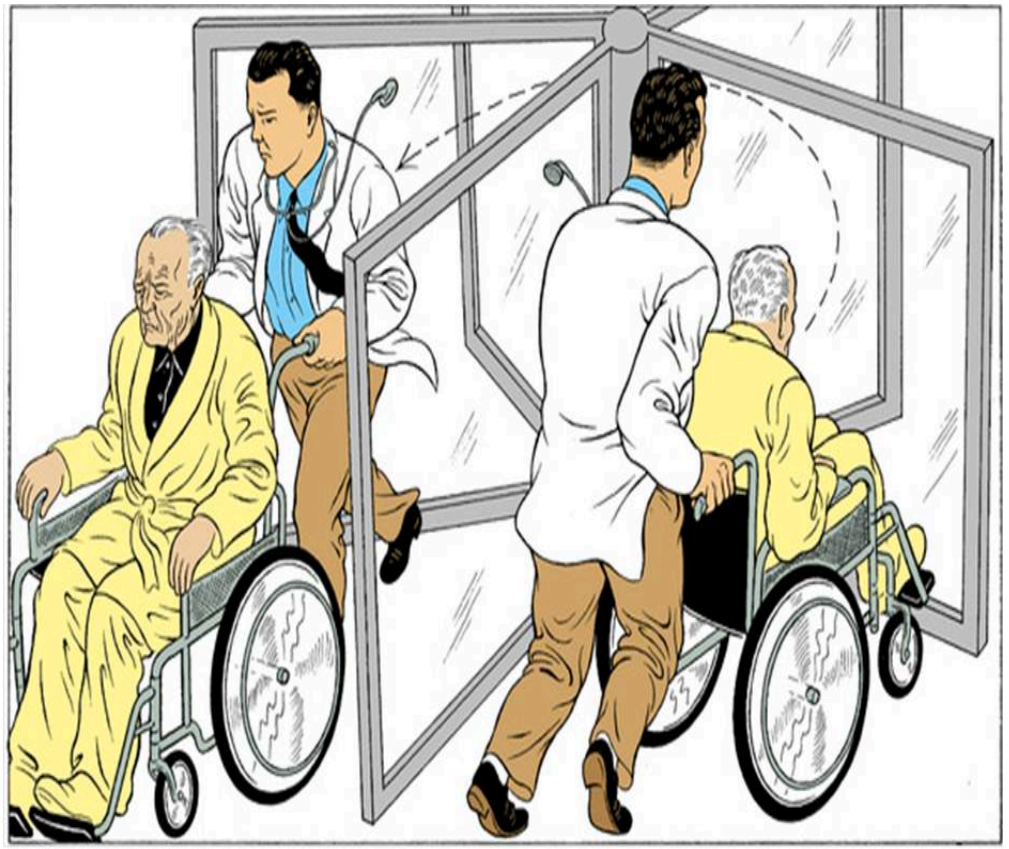
Agenda

1. Hospital Readmission Rate Reduction Program (HRRP)
2. LACE index
3. Data summary
4. Logistic model and result
5. Model validation
6. Cost analysis



1. Defining a Hospital Readmission


Courtesy of the NYTimes.com

Hospital readmission occurs when:

- Patients are admitted to a hospital within 30 days after being discharged from an initial hospitalization.
- Diagnoses of initial hospitalization: acute myocardial infarction (AMI), heart failure (HF), and Pneumonia.
- Measures “all-cause” readmission.
- Includes hospital readmissions to any hospital.

Readmission Rate Reduction Program (HRRP)

- Began in October 1, 2012.
- Penalizes hospitals with relatively higher rates of Medicare readmissions.
- Aims to:
  - Improve health care quality
  - Improve the health of the U.S. population
  - Reduce the costs of health care.
  - *"Better care, smarter spending, heathier people"*

2. Development of LACE

Table 1: Components of the LACE index.

Variable	Value	Points
Length of stay, days	<1	0
	1	1
	2	2
	3	3
	4–6	4
	7–13	5
	≥14	7
Acute (emergent) admission	Yes	3
Charlson comorbidity index score	0	0
	1	1
	2	2
	3	3
	≥4	5
Emergency department visits during previous 6 months	0	0
	1	1
	2	2
	3	3
	≥4	4

The LACE score is calculated by summing the points of the above 4 variables.

- Data source: 11 hospitals in Ontario, Canada (2002-2006)
  - 6 university affiliated
  - 5 community
- 4821 medical and surgical patients.
- Collected data before discharge from hospitals.
- Validation:
  - Internal data
  - Historical administrative data in 2004-2008
- LACE ranges 0-19:
  - Low risk: 0-4
  - Moderate risk: 5-9
  - High risk: >=10
- Predict early death and urgent readmission.
- Paper tool, used existing resources.
- Easy to use in daily workflow.

Why should hospitals not rely solely on LACE?

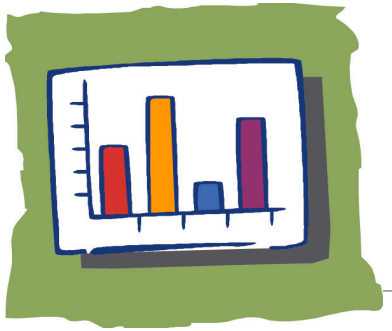
- Assumption: valid to use on different hospitals' populations.
- NOT clinical data.
- Accuracy of the score (c-statistic) is .72
- Does not account for specific information on the patients (Ex: race, age, sex…)

"Until the LACE index is externally validated with primary data, we recommend that it be used for outcomes research and quality assurance rather than in decision-making for individual patients."

Van Walraven C, Dhalla IA, Bell C, et al. Derivation and Validation of an Index to Predict Early Death or Unplanned Readmission After Discharge From Hospital to the Community. CMAJ 2010; 182: 551-557

What we hope to do?

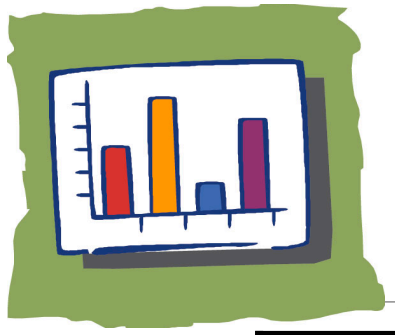
- Create models that can be used to predict the risk of readmission
- Understand causes of readmissions
- Vulnerable Groups
  - Are there specific age, race or gender groups that are at a higher risk of being readmitted?



3. Data summary

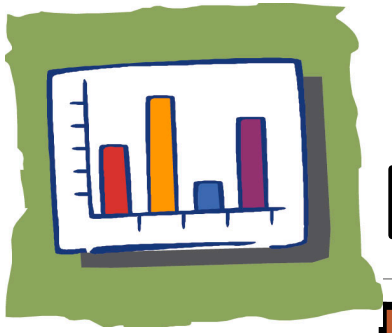
Variable	Type	Summary
Race	Category	White: 75%
		Hispanic: 19%
		Asian: 2%
		Black: 2%
		Native American, Hawaiian/Pac Island, Other & Unknown: 2%
DRG Class	Category	DRG Medical: 50%
		DRG Surgical: 43%
		DRG Ungroup: 7%
Gender	Category	Female: 59%
		Male: 41%

- DRG (Diagnosis-Related Group):
  - A system for classification of conditions and services for convenient comparison.
  - Patients are grouped into categories based on similar conditions and cost to treat the patients.
  - Numerical from 0-999
  - Mapped codes from numerical to three classes: medical, surgical, and ungroupable.



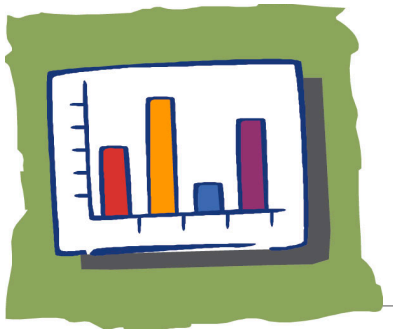
Data summary (Contd.)

Variable	Type	Summary
Admit From Type	Category	Emergency: 43%
		Pre Admit: 36%
		Observation: 15%
		Pre Clinic, Clinic, and SDC & Other: 6%
Readmission	Category	No Readmission: 93%
		Readmission: 7%
Length of Stay	Numeric	Min:0
		Median:3
		Mean: 4.04
		Max: 239
Age	Numeric	Min: 15
		Mean: 58
		Max: 112



Data summary (Contd.)

Variable	Type	Summary
ED Visits in 2010	Numeric	Min: 0
		Mean: 0.16
		Max: 43
ED Visits in 2011	Numeric	Min: 0
		Mean: 0.16
		Max: 41
ED Visits in 2012	Numeric	Min: 0
		Mean: 0.18
		Max: 38
ED Visits in 2013	Numeric	Min:0
		Mean: 0.18
		Max:38
ED Visits in 2014	Numeric	Min: 0
		Mean: 0.18
		Max:38

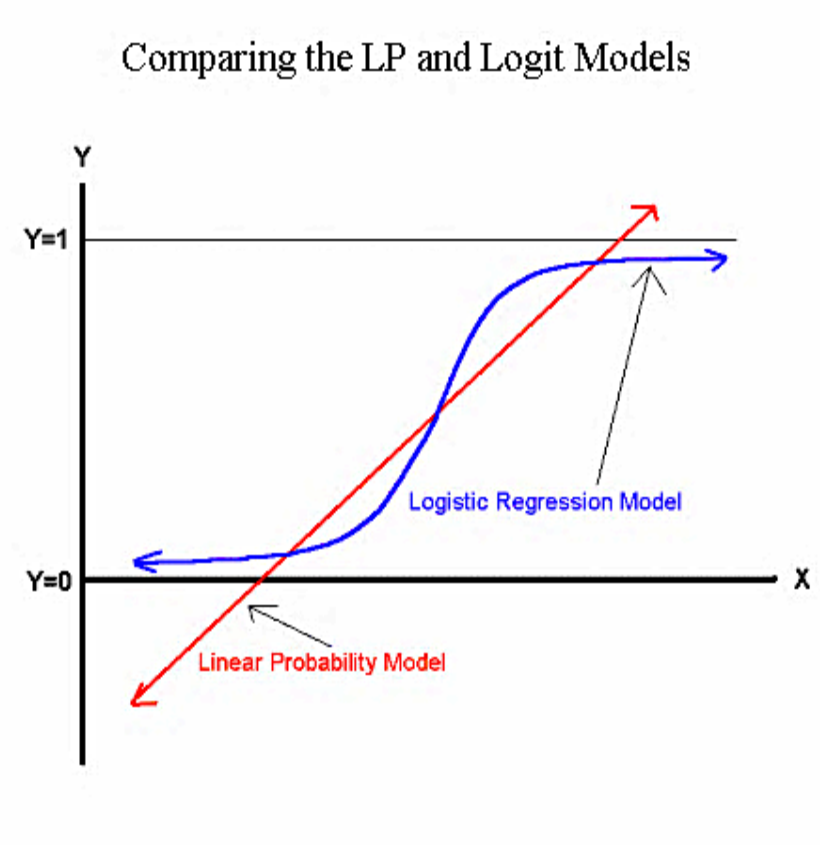


Data summary for created variables

- **Chronic Illness and Disability Payment System (CDPS) Risk Score**:
  - Diagnostic based-risk model that uses ICD-9 codes to assess risk.
  - Provides a summary measure of the burden of illness.
  - Reduce dimensions of the data significantly.
- **LACE Index**:
  - Length of stay
  - Number of Charlsons' comorbidity
  - Acuity of admission
  - Number of ED visits in previous 6 months

Variable	Type	Summary
CDPS Risk Score	Numeric	Min: 0.14
		Mean: 3.24
		Max: 29.85
LACE Index	Numeric	Min: 0
		Mean: 5.87
		Max: 19

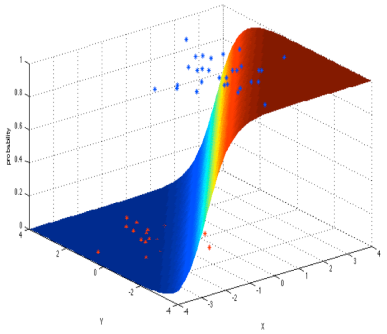
4. GLM-Logistic Model



- Model the probability of an event occurring depending on the values of the independent variables.
- Estimate the probability that an event occurs for a random selected observation versus the probability that event does not occur.
- In logistic regression:
  - **Response variable:** Y_i *indep* Bernoulli $(1,\pi_i)$
  - **Systematic component**: linear predictors, $\eta_i=\sum_{j=1}^{p}\beta_j x_{ij}$
  - **Link function**: $\eta_i = g(\mu_i) = \log\left(\frac{\pi_i}{1-\pi_i}\right)$

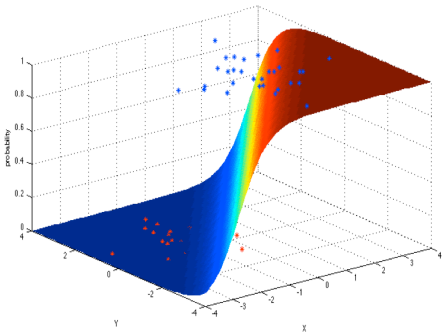
Equation: $$log_e\left(\frac{\pi_i}{1-\pi_i}\right)=\sum_{j=1}^{p}\beta_j x_{ij}$$

Or $$\Pr(Y=1)=\frac{\exp(\beta_0+\beta_1 x_1+\beta_2 x_2+\cdots+\beta_p x_p)}{1+\exp(\beta_0+\beta_1 x_1+\beta_2 x_2+\cdots+\beta_p x_p)}$$



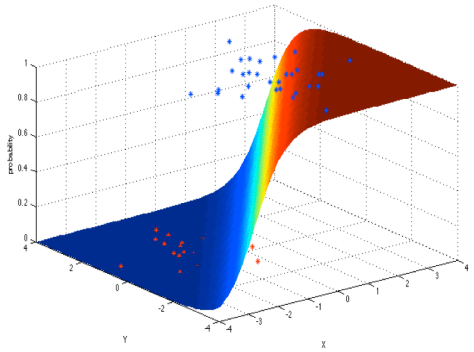
Result

Variable	Coefficient	Odds Ratio	95% CI of odds ratio
Intercept	-3.13	0.044	(.032,0.059)
Sex Male (vs. Female)	0.079	1.072	(1.004,1.145)
Race Black (vs. Asian)	0.198	1.219	(0.885,1.686)
Race Hispanic (vs. Asian)	0.299	1.348	(1.054,1.749)
Race White (vs. Asian)	0.101	1.106	(0.873,1.423)
Race Other (vs. Asian)	-0.41	0.664	(0.409,1.047)



Result (Contd.)

Variables	Coefficient	Odds Ratio	95% CI of odds ratio
Intercept	-3.13	0.044	(.032,0.059)
Admission From ED (vs. No Admission From ED)	0.42	1.522	(1.403,1.653)
DRG Surgical (vs. DRG Medical)	-0.761	0.467	(0.429,0.508)
DRG Ungroup (vs. DRG Medical)	0.128	1.137	(1.021,1.263)
LACE Low (vs. LACE High)	-1.157	0.314	(0.270,0.365)
LACE Moderate (vs. LACE High)	-0.24	0.786	(0.723,0.855)



Result (Contd.)

Variables	Coefficient	Odds Ratio	95% CI for odds ratio
Intercept	-3.13	0.044	(.032,0.059)
Age	0.003	1.208	(1.211,1.211)
CDPS Risk Score	0.101	1.107	(1.096,1.118)
Length of Stay	0.014	1.014	(1.009,1.019)
ED visits in 2010	0.069	1.072	(1.050,1.093)
ED visits in 2011	0.093	1.098	(1.073,1.123)
ED visits in 2012	0.106	1.112	(1.090,1.135)
ED visits in 2013	0.081	1.085	(1.061,1.108)
ED visits in 2014	0.075	1.078	(1.057,1.100)

Patient Example:

Age :70

Sex :Female

Race :Hispanic

Admission from ED: Yes

DRG Group: Surgical

Length of stay: 3

LACE level: Moderate

ED visits in 2010: 0

ED visits in 2011: 0

ED visits in 2012: 2

ED visits in 2013: 1

ED visits in 2014: 1

$$\Pr(Y=1) = \frac{e^{b_1+b_2*AGE+b_3*SEX+b_4*EDvisits+.....}}{1+e^{b_1+b_2*AGE+b_3*SEX+b_4*EDvisits+.....}}$$

= 0.056

5. Model Validation

VALIDATION		True Readmission Status	
		YES	NO
Predicted Readmission Status	YES	a	b
	NO	c	d

Sensitivity = the percentage of true readmissions that the model correctly predicts

= a/(a + c)

Positive Predicted Value = the probability the model predicts a patient as readmitted and the patient is a true readmission

= a/(a + b)

Specificity = the percentage of true non-readmissions that the model correctly predicts

= d/(b + d)

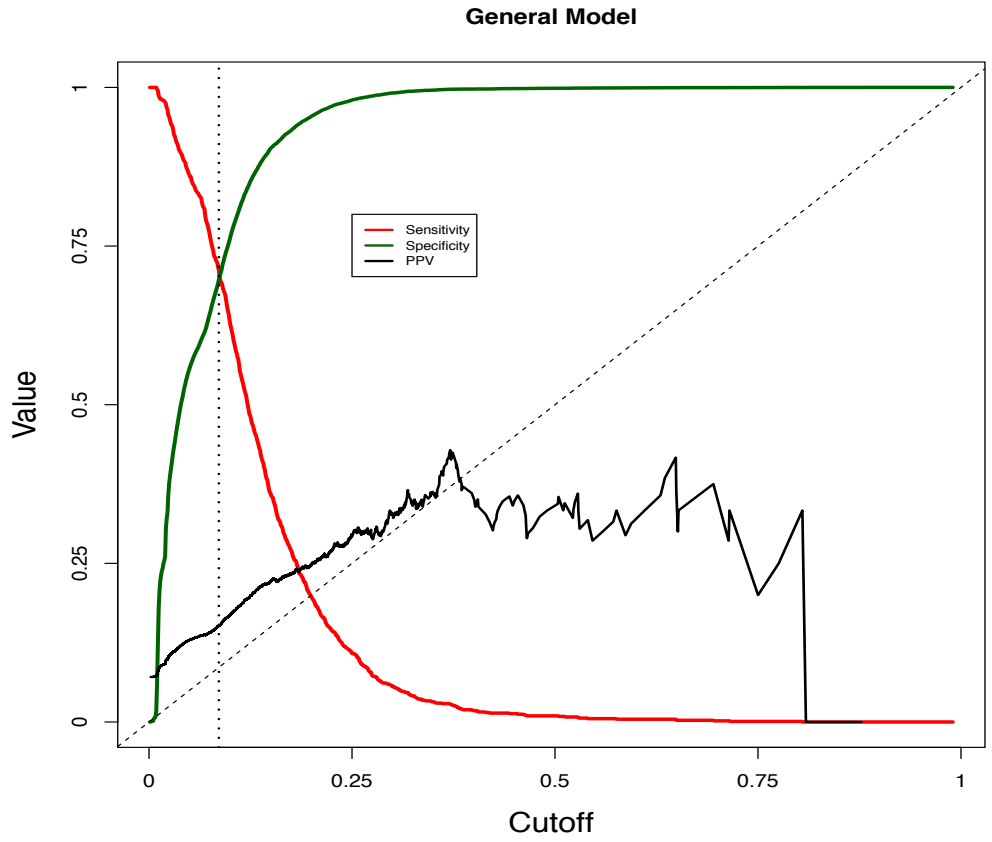
AUC = Area Under The Curve

Accounts for specificity and sensitivity

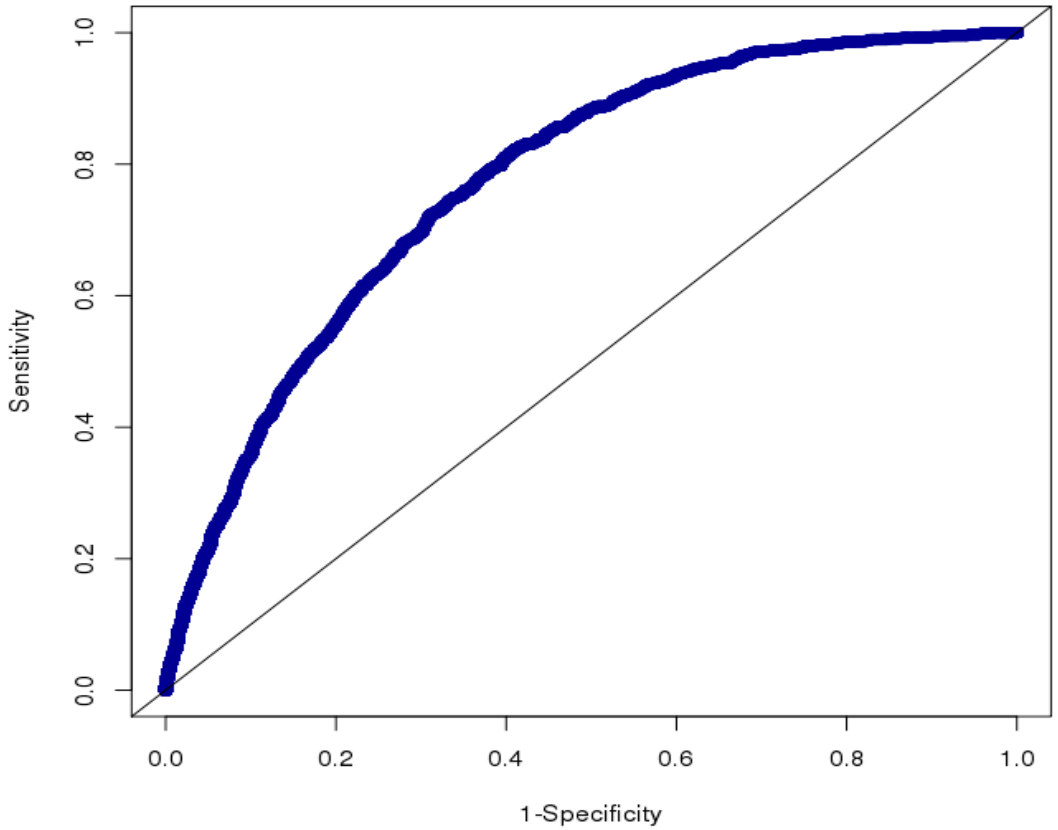
Method of determining accuracy of test

- .90-1 = excellent (A)
- .80-.90 = good (B)
- .70-.80 = fair (C)
- .60-.70 = poor (D)
- .50-.60 = fail (F)

Determine Cutoff Value



ROC Curve



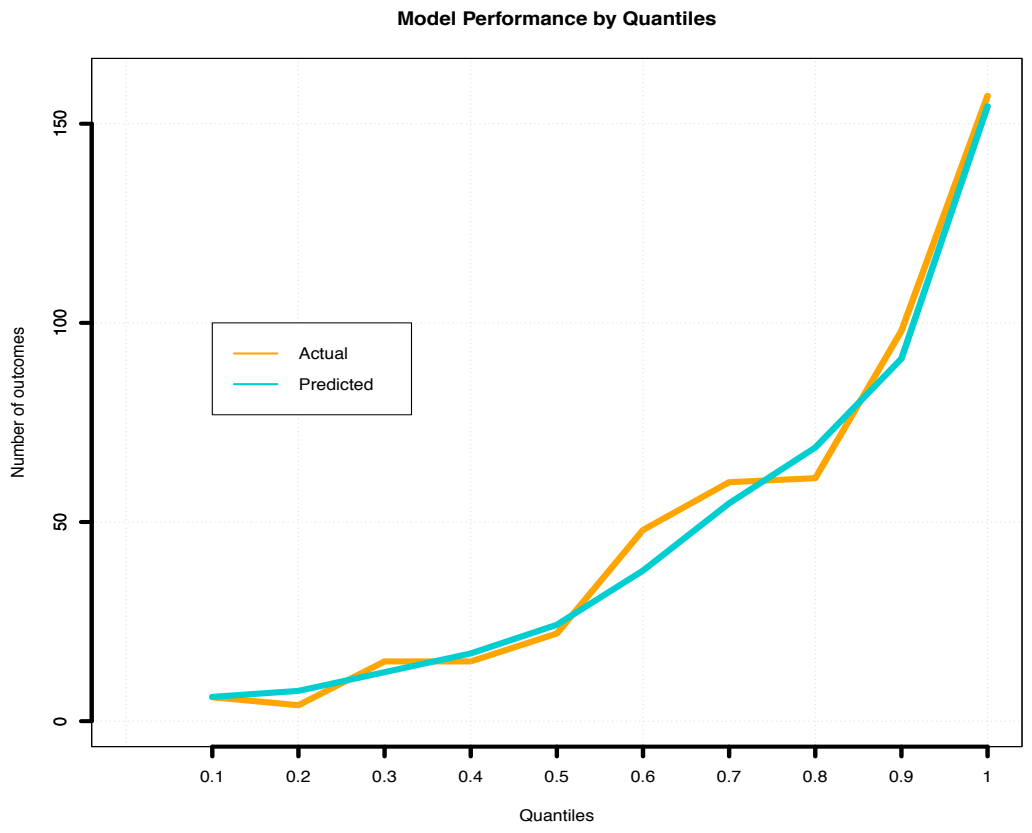
Models comparison

Criteria	General Model	Age 65+ and Penalty Conditions Model
Cutoff Values	0.0856	0.124
Sensitivity	0.7	0.66
Specificity	0.7	0.66
PPV	0.15	0.21
AUC	0.78	0.71

Criteria	LACE	Age 65+ and Penalty Conditions Model
Cutoff Values	HIGH	0.124
Sensitivity	0.43	0.66
Specificity	0.88	0.66
PPV	0.17	0.21

6. Cost Analysis for Medicare Population

Quantile	Number in Quantile	Mean Prediction Within Quantile	Actual	Predicted Readmissions
0-10	666	0.0092	6	6.1
10-20	666	0.0114	4	7.6
20-30	666	0.0185	15	12.3
30-40	666	0.0255	15	17
40-50	666	0.0364	22	24.2
50-60	666	0.0568	48	37.8
60-70	666	0.0821	60	54.7
70-80	666	0.1032	61	68.7
80-90	666	0.1366	98	91
90-100	666	0.2319	157	154.4
Total	**6660**		**486**	**473.8**



Thank you

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Table 1. The Hospital Readmission Reduction Program (HRRP): 3-year phase in			
Year penalty applied (Penalties: percentage reductions in payments for all Medicare admissions in the year)	**FY 2013**	**FY 2014**	**FY 2015**
Performance (measurement) period	June 2008-July 2011	June 2009-July 2012	June 2010-July 2013
Diagnoses of initial hospitalization	Heart attack Heart failure Pneumonia	Heart attack Heart failure Pneumonia	Heart attack Heart failure Pneumonia COPD Hip or knee replacement
Maximum rate of penalty	1%	2%	3%
Average hospital payment adjustment (among penalized and non-penalized hospitals)	-0.27%	-0.25%	-0.49%
Average hospital penalty (among penalized hospitals only)	-0.42%	-0.38%	-0.63%
Percent of hospitals penalized	64%	66%	78%
Percent of hospitals at maximum penalty	8%	0.6%	1.2%
CMS estimate of total penalties	$290 million	$227 million	$428 million

NOTES: Penalties are applied to each hospital in the fiscal year shown, based on its performance during a preceding 3-year measurement period, also shown. Analysis excludes hospitals not subject to HRRP, such as Maryland hospitals and other hospitals not paid under the Medicare Hospital Inpatient Prospective Payment System, such as psychiatric hospitals. COPD: Chronic obstructive pulmonary disease. FY: fiscal year.
SOURCE: Kaiser Family Foundation analysis of CMS Final Rules and Impact files for the Hospital Inpatient Prospective Payment System.