The Effects of ICU Utilization on Discharge and Readmission Rates

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Background

- Many hospital resources are required for surgery
  - Operating rooms
  - Nurses
  - Anesthesia team
  - Post-operative beds for recovery
- If downstream beds are unavailable, surgery might be postponed or cancelled
- Surgeons decide when patients are discharged
  - Surgeons are paid to do surgery

Research Question 1

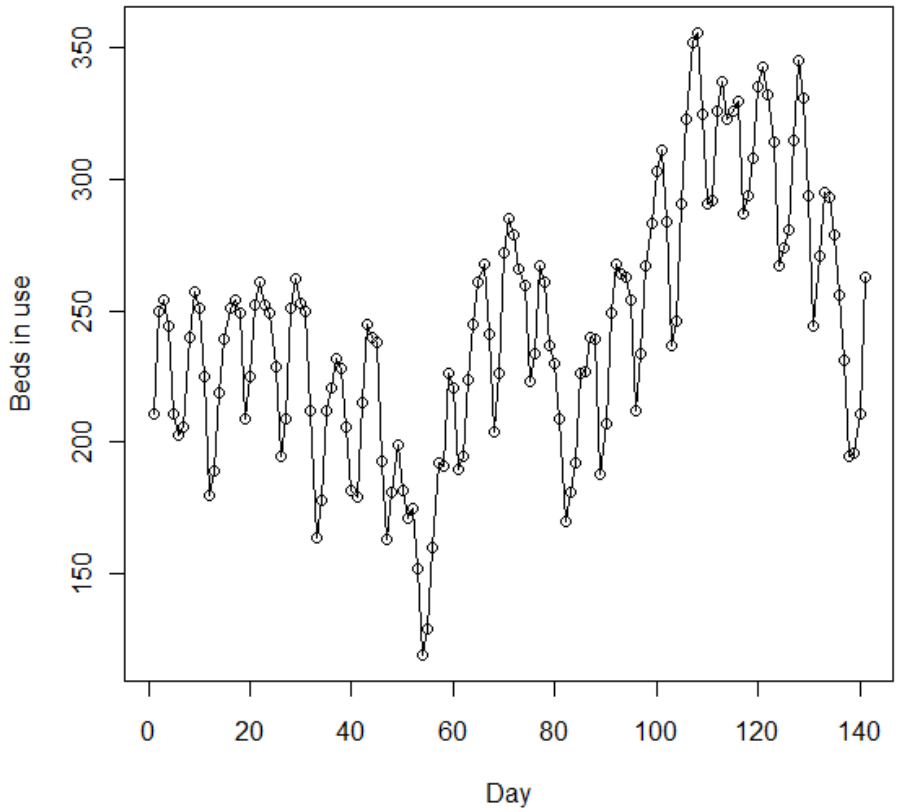
- Does the utilization of downstream beds affect the discharge decisions of surgeons?
  - Hypothesis: There is an increased discharge rate on days when post-operative utilization is high

Data

- Data collected on every surgery performed at a large US hospital from Jan 1, 2007 to May 31, 2007
- 7809 patients, of which 6482 were admitted to the hospital and stayed for at least one night
- Data provided on age, race, gender, surgical line, date of surgery, discharge date, and surgery type (scheduled vs. emergency)

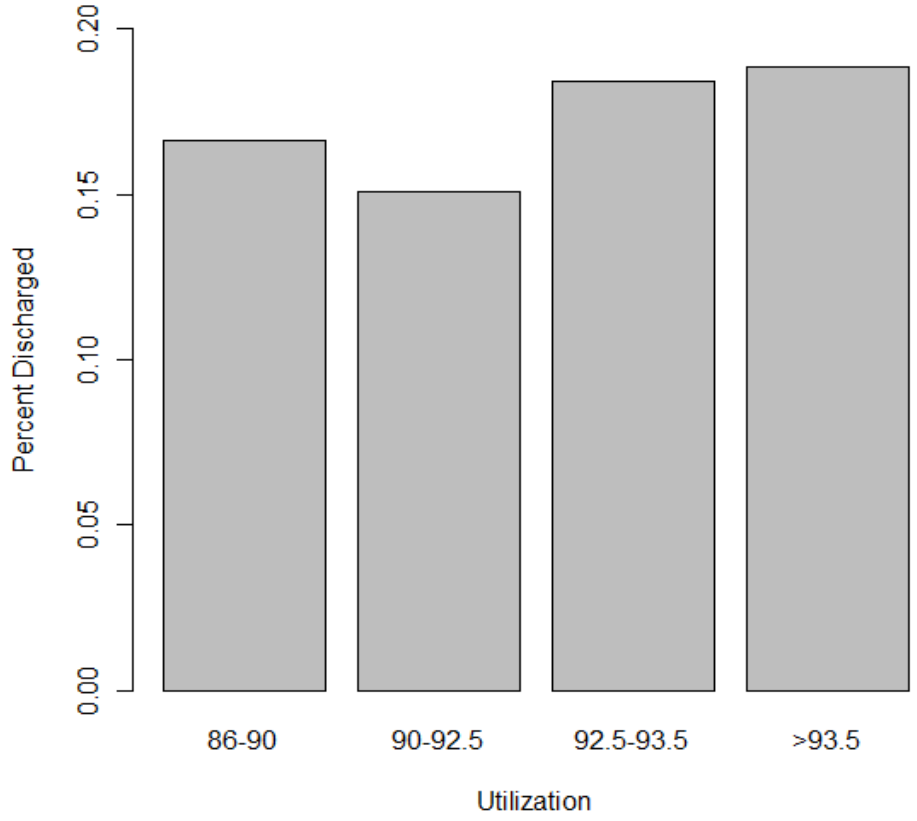
Hospital Utilization

- Utilization of post-operative beds varies widely



Discharge Rates

- Discharge rates have positive correlation with utilization



Utilization Measures

- We compute two measures of utilization
  - Discrete measure – a variable that is 1 when utilization exceeds a given threshold (e.g., 93%), and 0 otherwise
  - Continuous measure – a variable that counts the number of beds in use on each day
- Compare marginal effect of each bed in use vs. a discrete change in discharge probability when utilization exceeds a threshold

Discrete Time Survival Analysis

- Our variable of interest is time dependent -- utilization changes each day.
- Can't use logistic regression because observations are correlated -- a patient discharged on the fifth day cannot be discharged on the first four days
- Singer and Willet (1993) show how to handle discrete time survival data
- For each day, we record whether or not each patient is discharged, and use this as the outcome variable
- The outcome variable is regressed on our utilization measures and our control variables
- We control for the patient's age, race, gender, severity, and surgery type

Variables

Variable Name	Description
DISCHARGE	A dummy variable that is 1 if the patient is discharged on a given day, and 0 otherwise.
READMISSION72	A dummy variable that is 1 if the patient is readmitted within 72 hours of discharge, and 0 otherwise.
FULL	A dummy variable that is 1 if the unit was above a utilization threshold, and 0 otherwise.
BEDS	The number of beds in use when the patient was discharged.
AGE	The age, in years, of the patient on the day of the surgery.
ELECTIVE	A dummy variable that is 1 if the surgery is elective, and 0 if the surgery is urgent.
ASIAN, HISPANIC, BLACK	Dummy variables that indicate the race of each patient. There are four races including white, so we use three indicator variables.
TRANSPLANT, TRAUMA ,…, NEURO	Dummy variables that indicate which service line performed the surgery on the patient. There are 10 different service lines in our data set, so we use nine indicator variables.
MALE	A dummy variable that indicates the gender of our patient. It is 1 if the patient is a male, and 0 if the patient is female.

Results

Variable	Estimate	z value	*p*-value
Age	- .00943	-14.299	<.001
Elective	.433	5.634	<.001
Full	.124	2.327	.0199
D1	- .993	-11.831	<.001
D2	-1.33	-15.197	<.001
D3	-1.60	-17.560	<.001
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When the utilization threshold is exceeded, the odds of discharge for any given patient increase. The estimate for Full is positive and significant.

Results

Variable	Estimate	z value	*p*-value
Age	- .00943	-14.291	<.001
Elective	.434	5.650	<.001
Beds	.000673	2.330	.0198
D1	-1.16	-11.831	<.001
D2	-1.49	-15.197	<.001
D3	-1.76	-17.560	<.001
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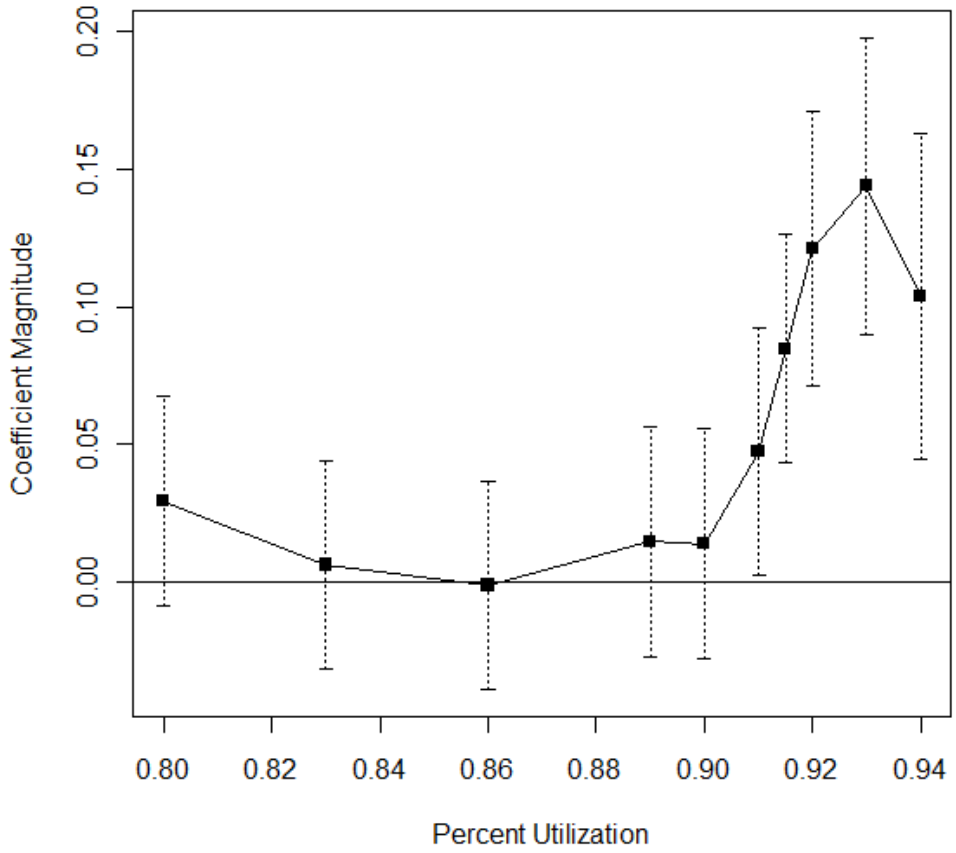
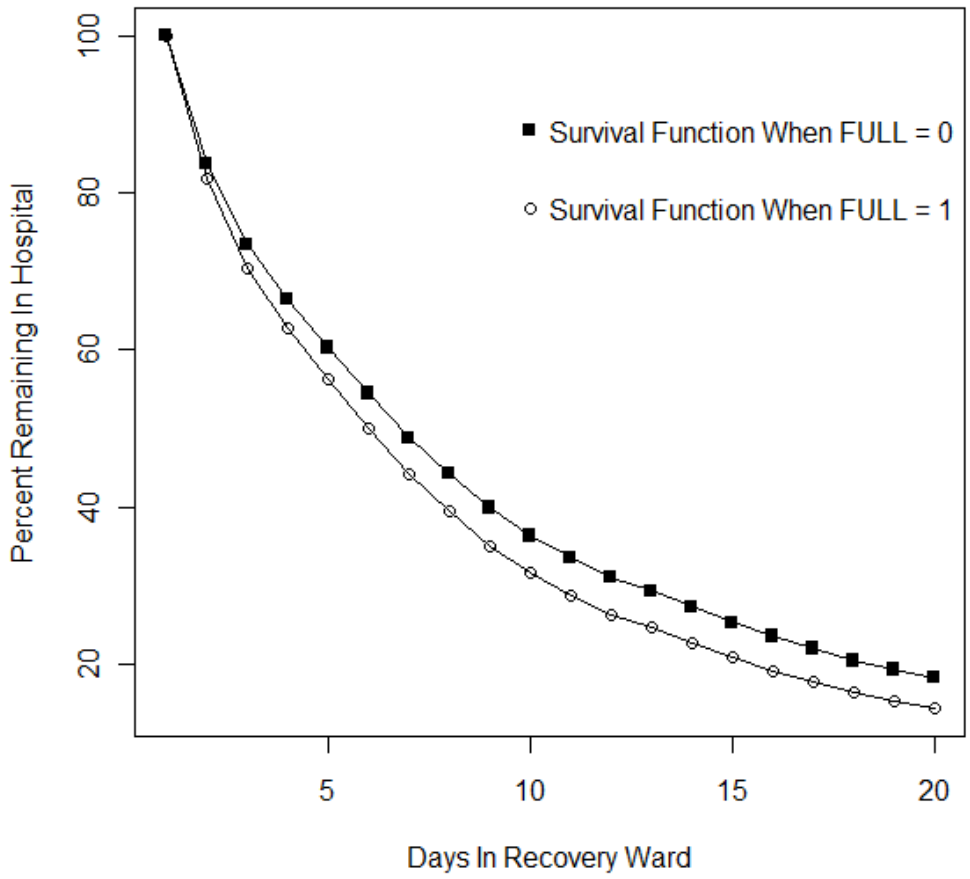
Each additional bed in use increases the odds that a patient will be discharged. The estimate for Beds is positive and significant.

Definition of Full Threshold



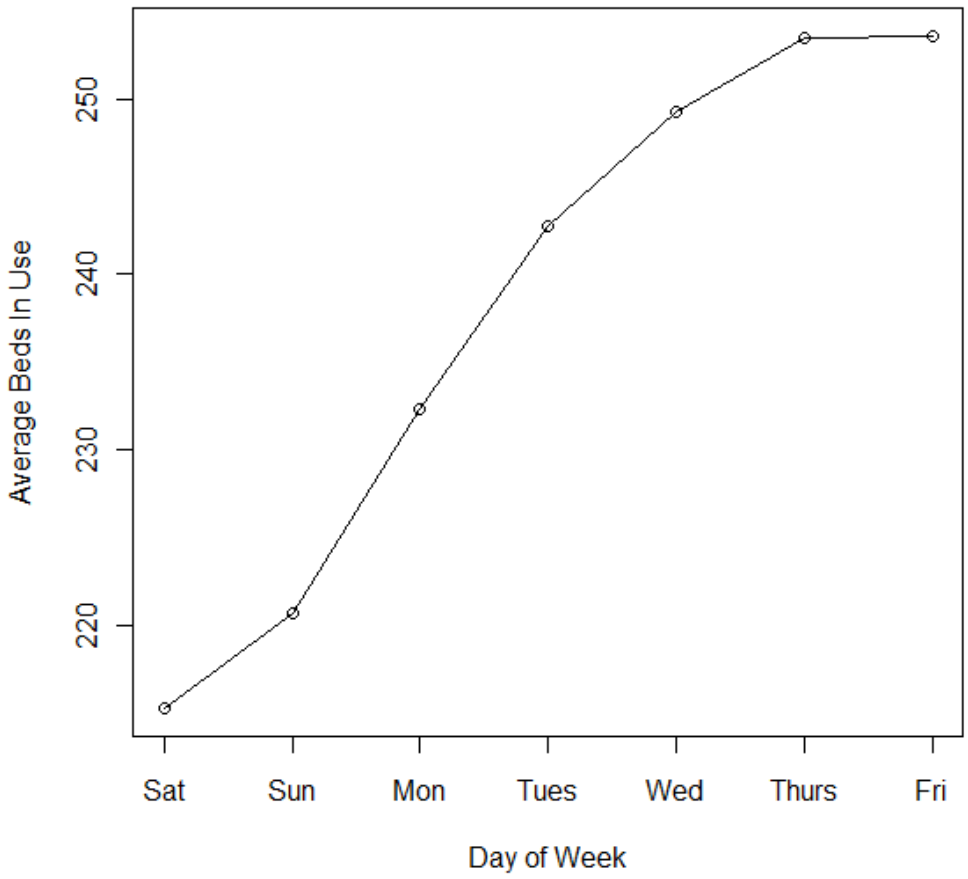
We regressed Discharge on Full and the controls, with different thresholds for Full. The coefficient for Full was statistically significant ($p < .05$) when the threshold was above 91.5%.

Effect of Full



Patients are discharged at a higher rate when the post-operative beds are full.

Controlling Weekly Variation



Beds fill up during the week, and then clear out over the weekend.

Observations

- Discharge rates increase as utilization increases, regardless of how utilization is measured
- Either some patients are held too long and discharged when space is needed, or some patients are discharged too early when utilization is high
- Our results cannot distinguish between these two explanations

Research Question 2

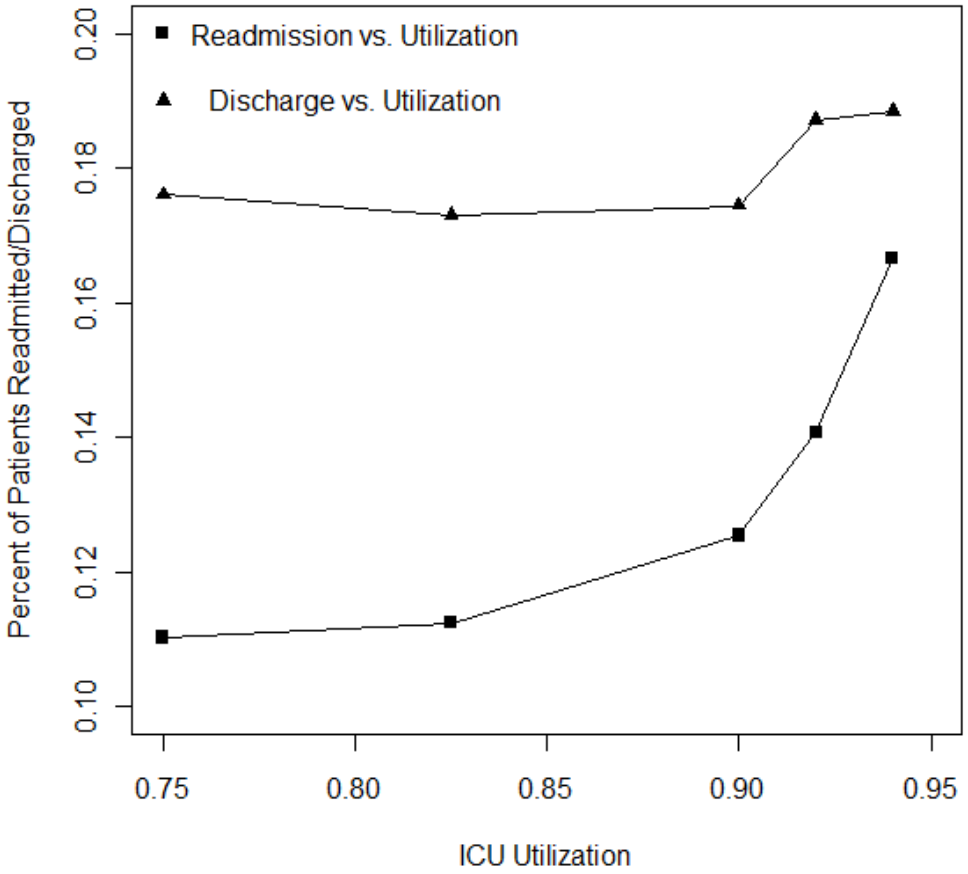
- Are patients who are discharged when utilization is high more likely to be readmitted?
  - Hypothesis: An increase in the discharge rate will lead to some patients with shortened lengths of stay. This will cause an increase in the readmission rate for those patients.

Analysis

- Using the same data set, we apply logistic regression to study the effect that utilization has on the probability of readmission for a specific patient
- We use readmission within 72 hours as our dependent variable
- Hypothesized regression model

$$logit(READMISSION72) = AGE + BLACK + ASIAN + HISPANIC + FULL + ELECTIVE + TRANSPLANT + TRAUMA + \ldots + NEURO + MALE + \varepsilon$$

Utilization – Readmission Relationship



The discharge rate and readmission rate both increase as utilization increases.

Results

Variable	Odds Ratio	95% Confidence Interval	*p*-value
(Intercept)	0.088	[0.055 , 0.14]	<.001
FULL	2.341	[1.54 , 3.556]	<.001
BLACK	1.359	[1.055 , 1.748]	0.016
HISP	0.969	[0.449 , 2.084]	0.946
ASIAN	1.222	[0.344 , 4.335]	0.534
AGE	0.992	[0.984 , 0.998]	0.023
MALE	1.649	[1.279 , 2.126]	<.001
ELECTIVE	0.812	[0.639 , 1.029]	0.086
TRANS	9.772	[6.97 , 13.7]	<.001
NEURO	0.901	[0.54 , 1.502]	0.77
PLASTIC	1.029	[0.456 , 2.319]	0.791
GYNO	0.586	[0.309 , 1.11]	0.134
URO	5.447	[1.922 , 15.436]	0.001
OPTH	1.745	[0.98 , 3.105]	0.043
CARDIAC	1.545	[0.486 , 4.914]	0.334
TRAUMA	2.249	[1.361 , 3.716]	0.001
THORACIC	0.301	[0.089 , 1.009]	0.095

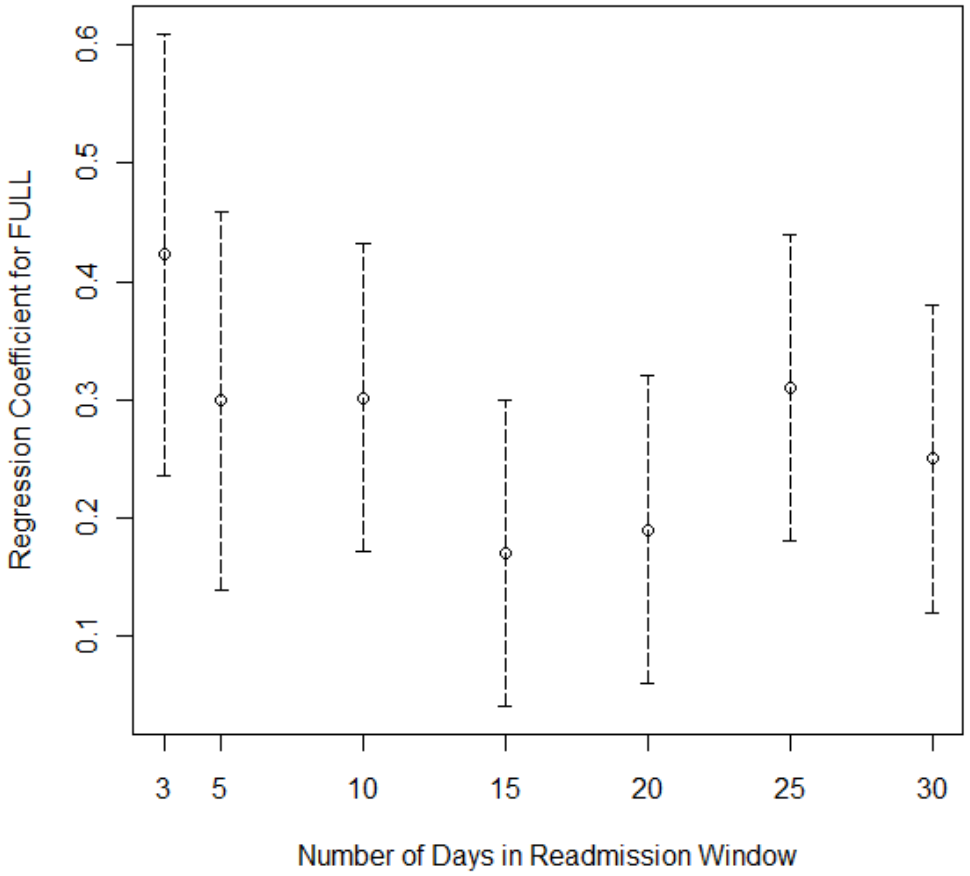
Controlling for race, age, gender, and the type of surgery, being discharged from a full post-operative unit increases the odds of readmission by a factor of 2.341. The 95% confidence interval is [1.54 , 3.556].

Results

Variable	Odds Ratio	95% Confidence Interval	p-value
(Intercept)	0.011	[0.002 , 0.044]	<.001
BEDS	1.008	[1.003 , 1.012]	0.001
BLACK	1.332	[1.035 , 1.714]	0.025
HISP	0.984	[0.461 , 2.1]	0.913
ASIAN	1.324	[0.373 , 4.69]	0.452
AGE	0.991	[0.983 , 0.998]	0.015
MALE	1.664	[1.29 , 2.145]	<.001
ELECTIVE	0.828	[0.653 , 1.051]	0.121
TRANS	9.790	[6.979 , 13.733]	<.001
NEURO	0.883	[0.529 , 1.472]	0.713
PLASTIC	1.053	[0.468 , 2.367]	0.748
GYNO	0.609	[0.322 , 1.15]	0.166
URO	6.057	[2.185 , 16.785]	<.001
OPTH	1.669	[0.938 , 2.97]	0.061
CARDIAC	1.624	[0.511 , 5.159]	0.293
TRAUMA	2.220	[1.343 , 3.665]	0.001
THORACIC	0.298	[0.088 , 0.998]	0.091

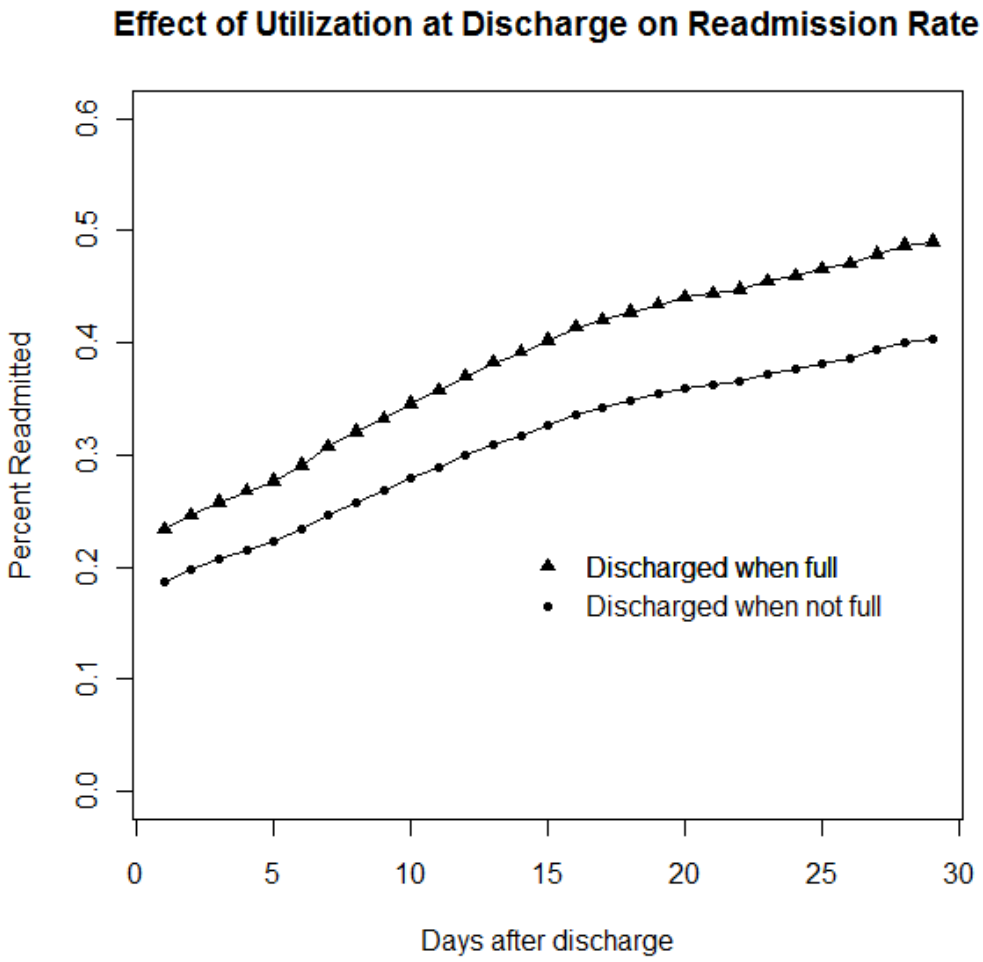
Controlling for race, age, gender, and the type of surgery, each bed in use at the time of discharge increases the odds of readmission by a factor of 1.008. The 95% confidence interval is [1.003 , 1.012].

Utilization Effect Over Time



The effect of utilization on readmission is the strongest within 72 hours, but persists up to 30 days.

Survival Analysis



Over the course of a month, patients discharged from a full hospital are much more likely to be readmitted.

Conclusions

- The discharge rate rises when utilization is high
- This corresponds to an increase in the readmission rate
- We conclude that some patients are discharged too soon when utilization is high
- Surgeons have an incentive to clear space for their surgeries