

# Reducing PACU Boarding by Altering the Block Schedule

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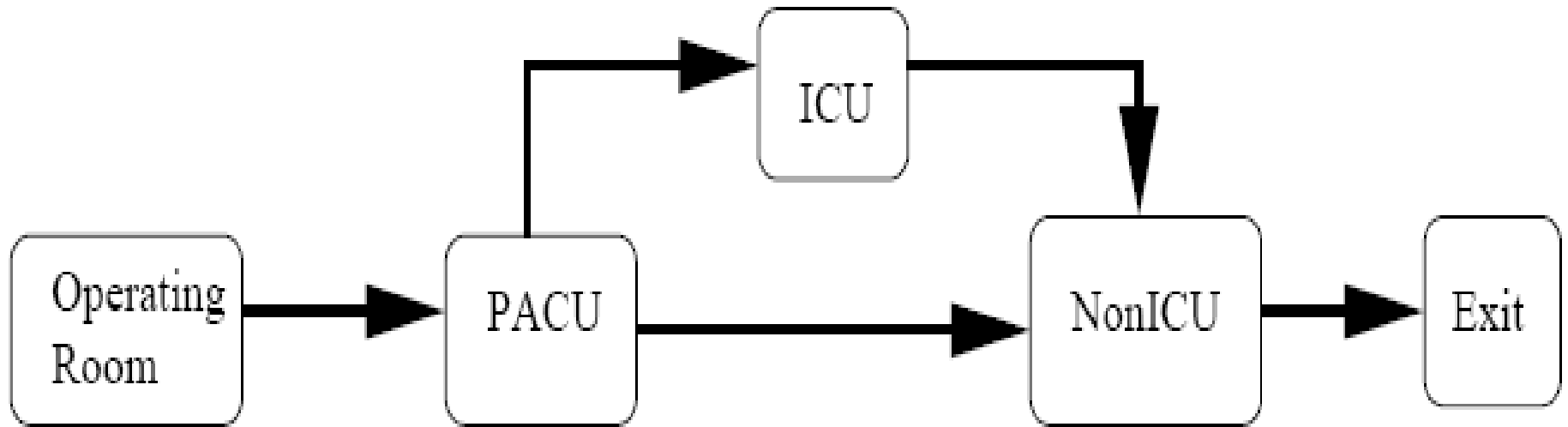
# Problem Statement

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- The current structure of the block schedule does not consider the downstream effects of inpatient census
- Because of differences in service line case volumes per block, patient acuity, and post-op LOS, the current scheduling approach creates artificial variability that impacts inpatient census
- This artificial variability contributes to spikes in the inpatient census resulting in overnight boarders in the PACU

# Patient Flow

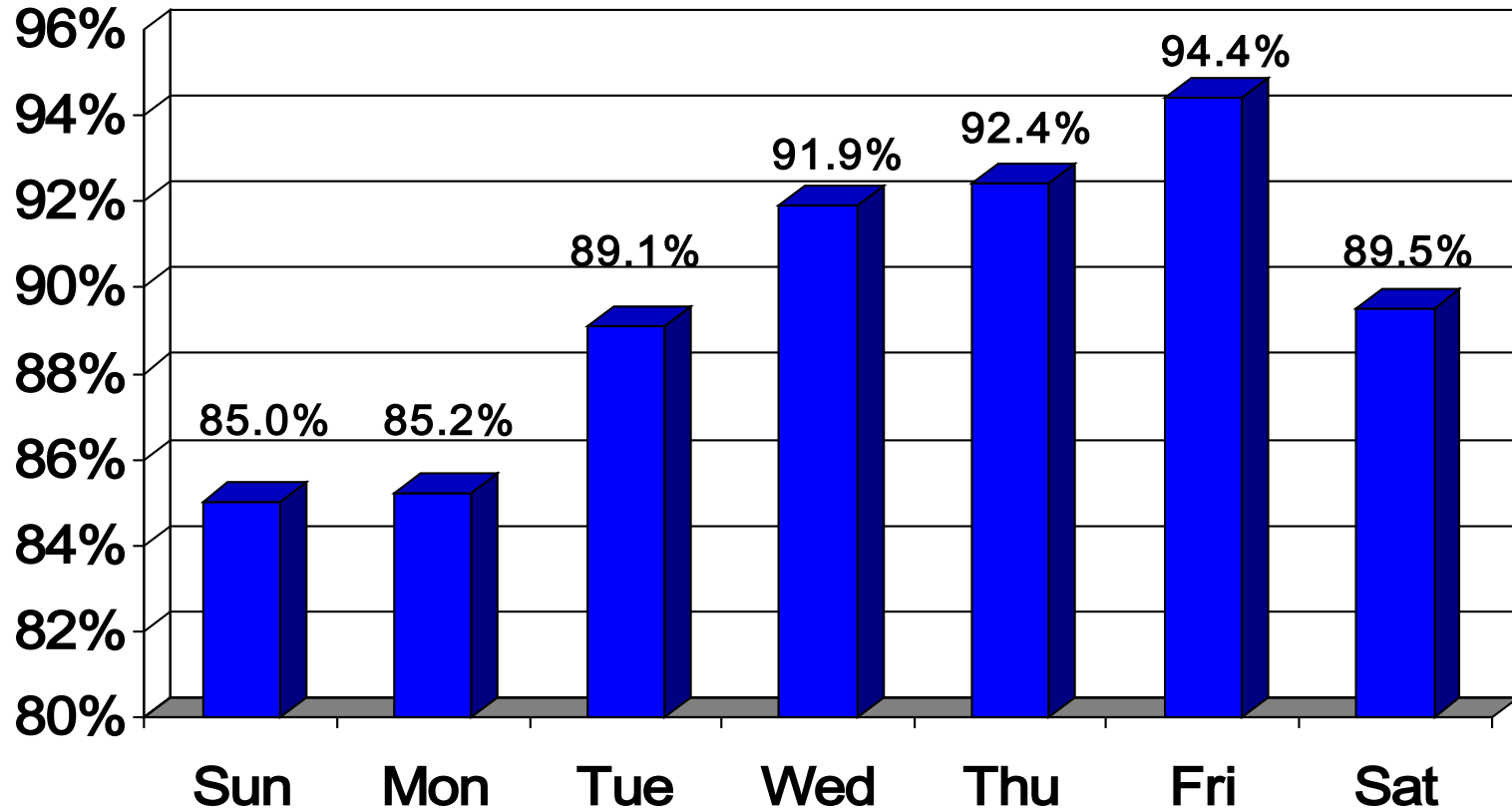
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# Surgical Staffed Bed Occupancy

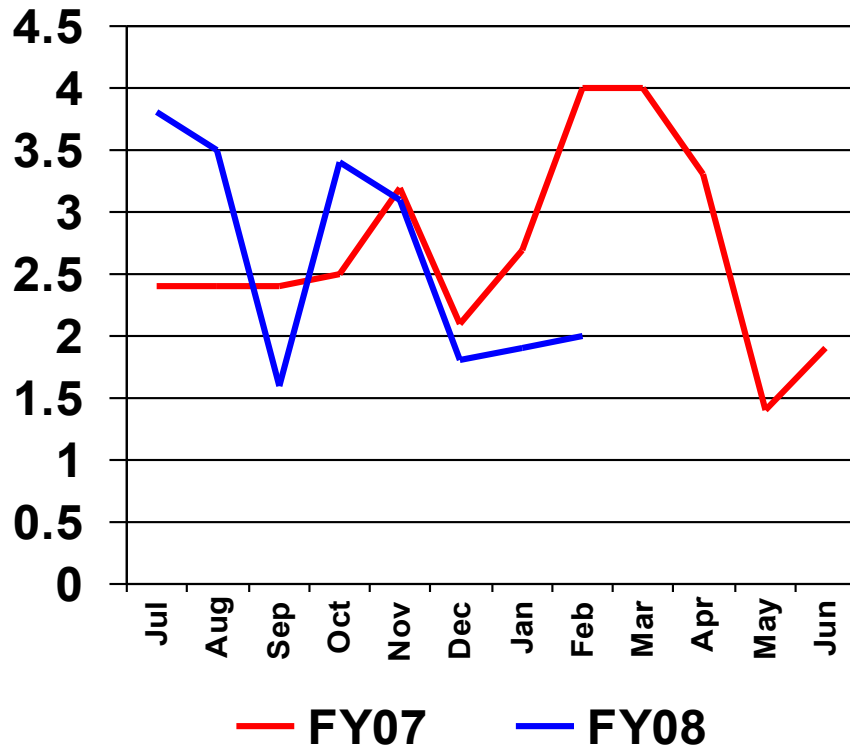
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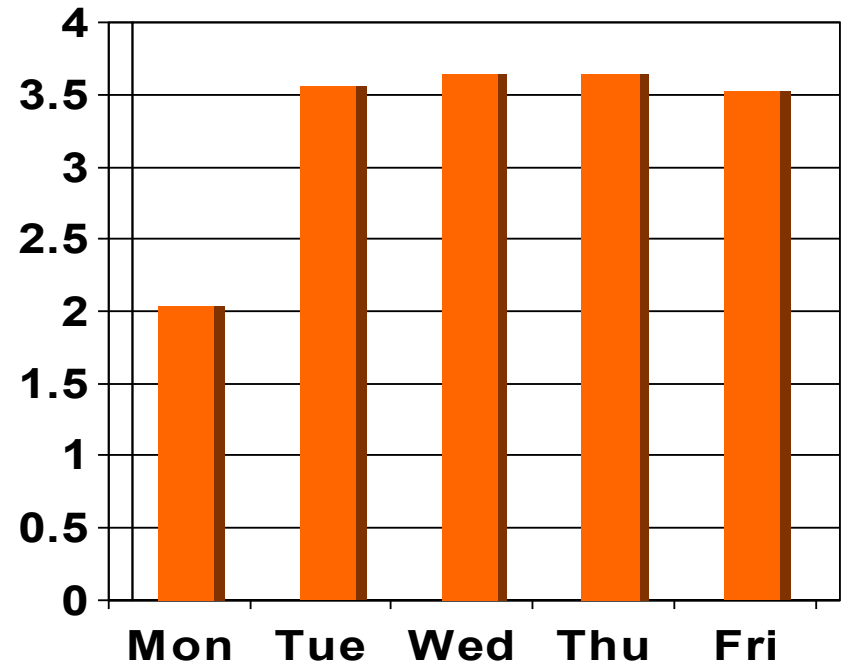


# PACU Boarders

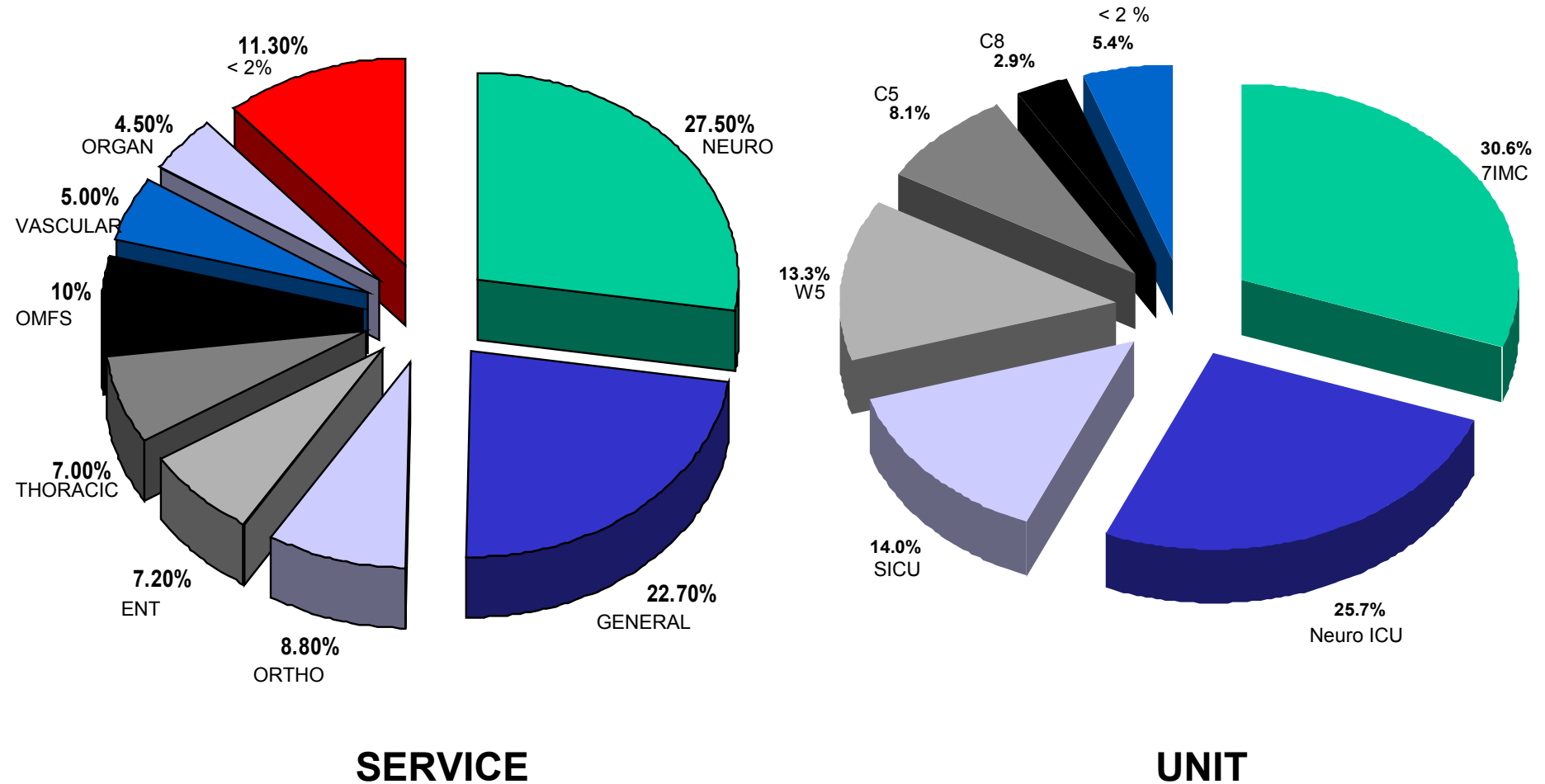
## Avg Overnight Boarders Per Day



## Avg Boarders by Day of Week



# PACU Boarder Detail



# Objective of Study

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- Understand current block allocation methodology and census variability via rigorous analysis of historic operating room and surgical inpatient volume data
- Develop a model linking the schedule to the census
- Create a load balancing schema for the surgical block schedule
- Validate model through computer simulation

# Approach

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- First, we clustered the surgical service lines by length of stay and cases per block (as measured by average case duration)
- Next, we constructed a mixed integer programming model (MIP) to match the flow of patients into the ICU with the expected discharges of patients from the ICU
- Finally, we tested different scheduling approaches using a simulation experiment



# Groupings

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- Service Lines were grouped by volume (cases performed in one room in one day) and post-operative length of stay
  - Group 1: Gynecology, Ophthalmology, and Urology (high volume, short LOS)
  - Group 2: General, Oral, Otolaryngology, Plastic, and Vascular (medium volume, medium LOS)
  - Group 3: Neurosurgery, Oncology, Organ Transplant, Orthopedics, and Thoracic (low volume, long LOS)

# Model

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- Redistribute service block time without altering total block time allocation
- Match ICU patients arrival with ICU patients departure from unit
- Cap total blocks per day and each group's blocks per day based upon current allocation

# IP Schedule

	Mon	Tue	Wed	Thu	Fri
1	Group 1 : 1	Group 1 : 1	Group 1 : 3.1	Group 1 : 5	Group 1 : 1
2	Group 2 : 5.8	Group 2 : 12			Group 2 : 2
3					
4			Group 2 : 7.1		Group 3 : 13
5					
6				Group 2 : 3.7	
7					
8	Group 3 : 9				
9					
10				Group 3 : 3	
11			Group 3 : 3		
12					
13					
14		Group 3 : 3			
15					
16					
Total	16	16	13.1	11.7	16

# Current Schedule

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	Mon	Tue	Wed	Thu	Fri
1	Group 1 : 2.3	Group 1 : 3.0	Group 1 : 1.6	Group 1 : 2.6	Group 1 : 1.6
2					
3	Group 2 : 6.9		Group 2 : 5.2		Group 2 : 7.0
4		Group 2 : 6.5		Group 2 : 5.0	
5					
6					
7					
8			Group 3 : 5.9		
9				Group 3 : 8.0	
10	Group 3 : 5.5				Group 3 : 6.2
11		Group 3 : 5.6			
12					
13					
14					
15					
16					
Total	14.7	15.1	12.7	15.6	14.8

# Rules of Thumb

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- Meet minimum daily demand
- Split Group 1 time between Wed and Thu
- Maximize Group 2 time on Tue
- Split Group 2 time between Mon, Wed, and Thu
- Split Group 3 time between Mon and Fri

# Rules of Thumb (1 of 5)

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- Meet minimum daily demand
- Based on the current block schedule certain service lines (Oto, Neuro, Ortho, Gen, Uro) receive at least one block every day of the week

	Mon	Tue	Wed	Thu	Fri	Total
Group 1	1	1	1	1	1	5
Group 2	2	2	2	2	2	10
Group 3	4	4	4	4	4	20
Total	7	7	7	7	7	35

# Rules of Thumb (2 of 5)

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- Split Group 1 time between Wed and Thu
- Wednesday and Thursday are the “heavy” days for Group 1 in the IP

	Mon	Tue	Wed	Thu	Fri	Total
Group 1	1	1	4.1	4	1	11.1
Group 2	2	2	2	2	2	10
Group 3	4	4	4	4	4	20
Total	7	7	10.1	10	7	41.1

# Rules of Thumb (3 of 5)

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- Maximize Group 2 time on Tue
- The IP puts the most blocks for Group 2 on Tuesdays

	Mon	Tue	Wed	Thu	Fri	Total
Group 1	1	1	4.1	4	1	11.1
Group 2	2	9	2	2	2	17
Group 3	4	4	4	4	4	20
Total	7	14	10.1	10	7	48.1



# Rules of Thumb (4 of 5)

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- Split Group 2 time between Mon, Wed, and Thu
- Monday, Wednesday, and Thursday had more than the minimum number of blocks in the IP

	Mon	Tue	Wed	Thu	Fri	Total
Group 1	1	1	4.1	4	1	11.1
Group 2	6	9	6	6	3.6	30.6
Group 3	4	4	4	4	4	20
Total	11	14	14.1	14	8.6	61.7

# Rules of Thumb (5 of 5)

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- Split Group 3 time between Mon and Fri
- Mon and Fri had most of the blocks for Group 3
- Wed gets an extra block because the total demand for Group 3 must be met

	Mon	Tue	Wed	Thu	Fri	Total
Group 1	1	1	4.1	4	1	11.1
Group 2	6	9	6	6	3.6	30.6
Group 3	9	4	4	4	10.2	31.2
Total	16	14	14.1	14	14.8	72.9

# Rules of Thumb Schedule

	Mon	Tue	Wed	Thu	Fri
1	Group 1 : 1	Group 1 : 1	Group 1 : 4	Group 1 : 4.1	Group 1 : 1
2	Group 2 : 6	Group 2 : 9			Group 2 : 3.6
3					
4					
5			Group 2 : 6	Group 2 : 6	
6					Group 3 : 10.2
7					
8	Group 3 : 9				
9					
10					
11		Group 3 : 4		Group 3 : 4	
12			Group 3 : 4		
13					
14					
15					
16					
Total	16	14	14	14.1	14.8

# Perturbation Schedule

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- There were concerns about totally replacing the current block schedule
- We looked into making a few swaps to the current schedule based on the rules of thumb
- Swap 1: a Grp 1 on Mon with a Grp 3 on Wed
- Swap 2: a Grp 2 on Mon with a Grp 3 on Tues
- Swap 3: 2 Grp 2 on Fri with 2 Grp 3 on Thu

# Perturbation Schedule (cont.)

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- How could this be done?
- Swap 1: a Grp 1 on Mon with a Grp 3 on Wed
  - GYN on Mon (19) with Thoracic on Wed(23)
- Swap 2: a Grp 2 on Mon with a Grp 3 on Tues
  - General on Mon with Thoracic on Tues
- Swap 3: 2 Grp 2 on Fri with 2 Grp 3 on Thu
  - General on Fri (18) with Thoracic on Thu (23)
  - Oncology on Fri (16) with Oto on Thu (16)

# Simulation Tests

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- Five schedules tested: Current, Even, MIP, Rules of Thumb, and Perturbed
- 5 week warm up period
- 10 weeks of data collection
- 10,000 runs for each schedule
- Estimated daily boarders using simple formula:  
$$\text{Boarders}_i = \text{Max}(\text{ICUCensus}_i - \text{ICUCapacity}_i, 0)$$

# Simulation Results

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	Average Boarders per Day			Census	
	5%	Mean	95%	Mean	St. Dev
Historical	3.36	4.67	6.06	30.93	11.70
Even	3.20	4.50	5.89	30.94	11.37
Perturbed	3.07	4.32	5.69	30.93	11.11
MIP	2.70	4.00	5.50	30.94	10.76
Rules	2.73	4.02	5.46	30.94	10.65

ICU Capacity = 31  
(SICU and Neuro ICU)

# Efficiency

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Schedule	Swaps	Weekly Reduction	Standard Deviation	Efficiency
Perturbed	4	2.45	11.11	0.61
Rules	16	4.55	10.65	0.28
MIP	33	4.69	10.76	0.14



# Financial Implications

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- On an annual basis, there would be  $4.69 * 50 = 234.5$  fewer boarders
- If 234.5 additional surgeries were performed, the hospital could have  $234.5 * \$15,000 = \$3,517,500$  in additional revenue

# Conclusions

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- The simulation results indicate that the Rules of Thumb schedule, IP schedule, and Perturbed schedule reduce the number of boarders and the variation in the census
- The Perturbed schedule gets about half of the total benefit with only four block exchanges