Emergency Department Performance Optimization Model

Group 3

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The Problem

Assign

physicians to the
3 daily shifts

3-Day

influx of trauma
patients

Using

Statistical
Distributions
and Binary
Programming

Optimize

the ED performance
measured in speed
and/or quality

LOS

72-HR
Return

Our Approach

Objective Function

Minimize LOS

Minimize ROR

Decision Variable:

Binary

Who to staff?

When to staff?

1 **Using Statistical Distributions**

Approximate Demand

2 **Data Analysis**

Identify Constraints and Patterns

Historical Data Set of daily patient visits to ED

Jan 2014 - Jul 2016

Model Development

Objective Function

$$min\ z = \sum_{i=1}^{28} \sum_{j=1}^{3} \sum_{k=1}^{3} (Q_i D_{i,j,k} + S_i D_{i,j,k,}) \times E[X(j,k)]$$

$D_{i,j,k}$

Binary Decision Variable

Decision to Staff Physician i on Shift j of Day k

S_i

Variable (Speed),

Average LOS of Physician i

Q_i

Variable (Quality)

Average ROR of Physician i

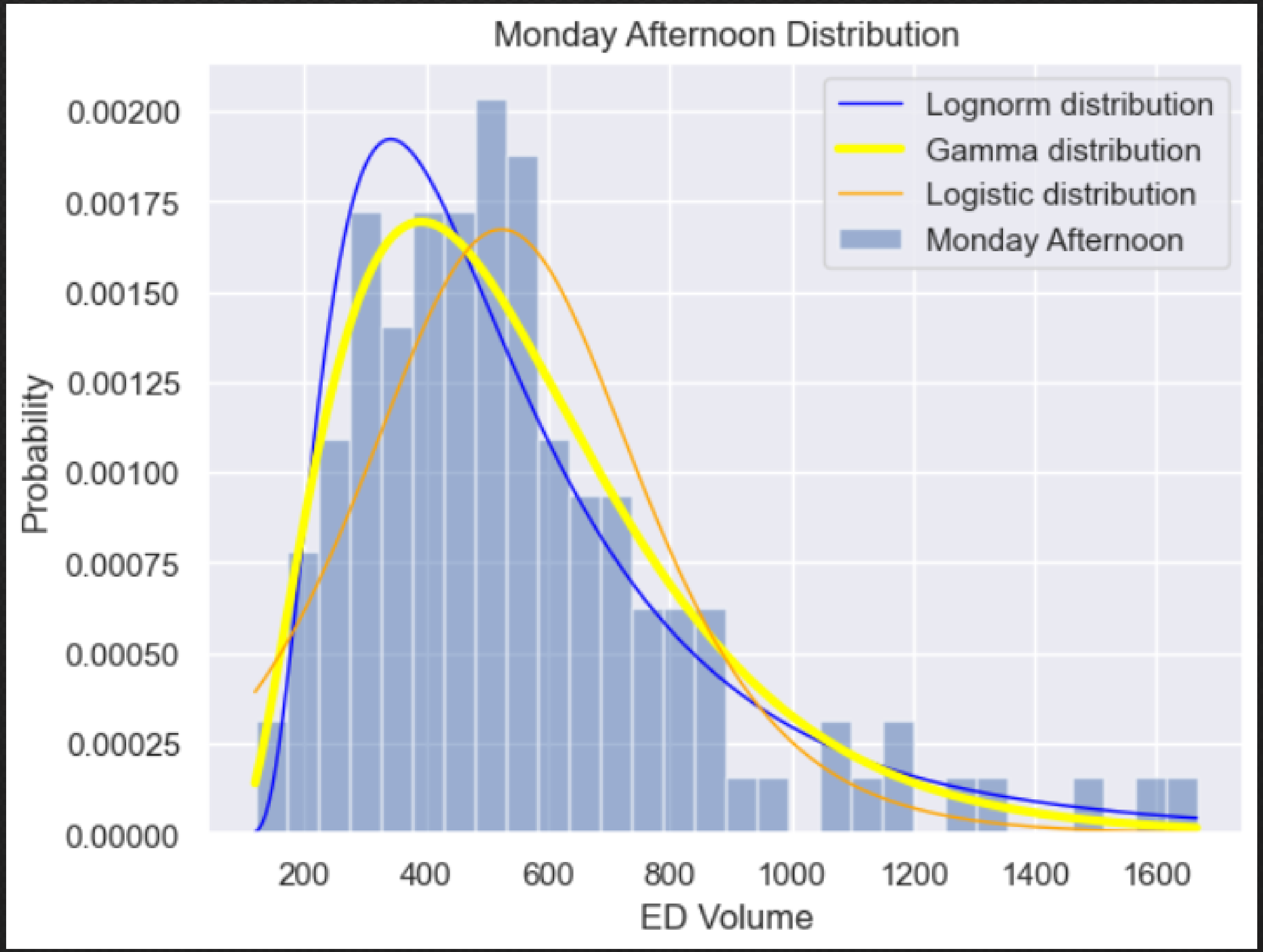
Objective Function

Demand Approximation

Sum of ED Volume of each shift per day

Fitting a statistical distribution to the histograms

$$E[X(j,k)]$$

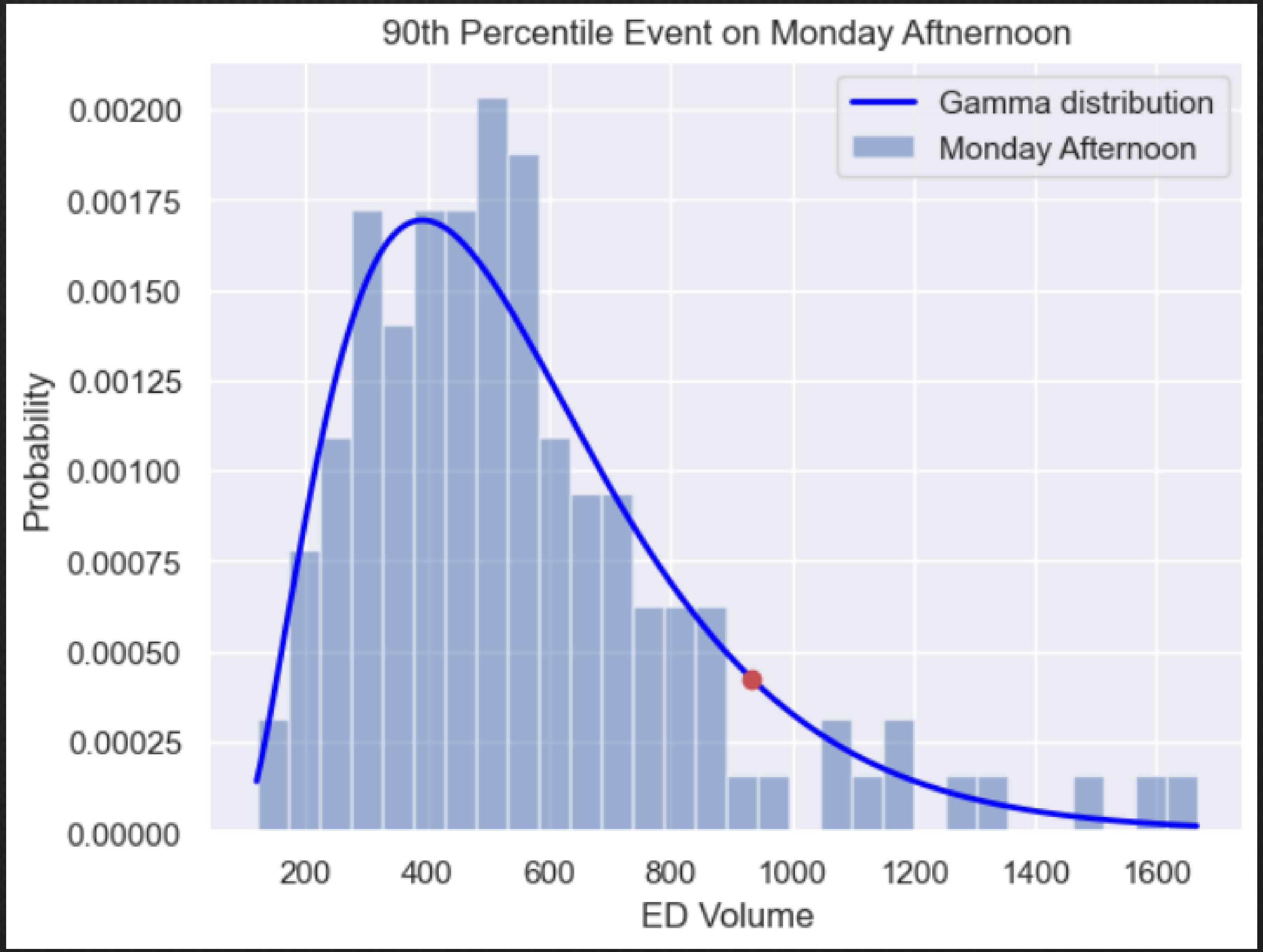


Objective Function

Tunable Parameters

Accounting for what percentile event is expected to happen

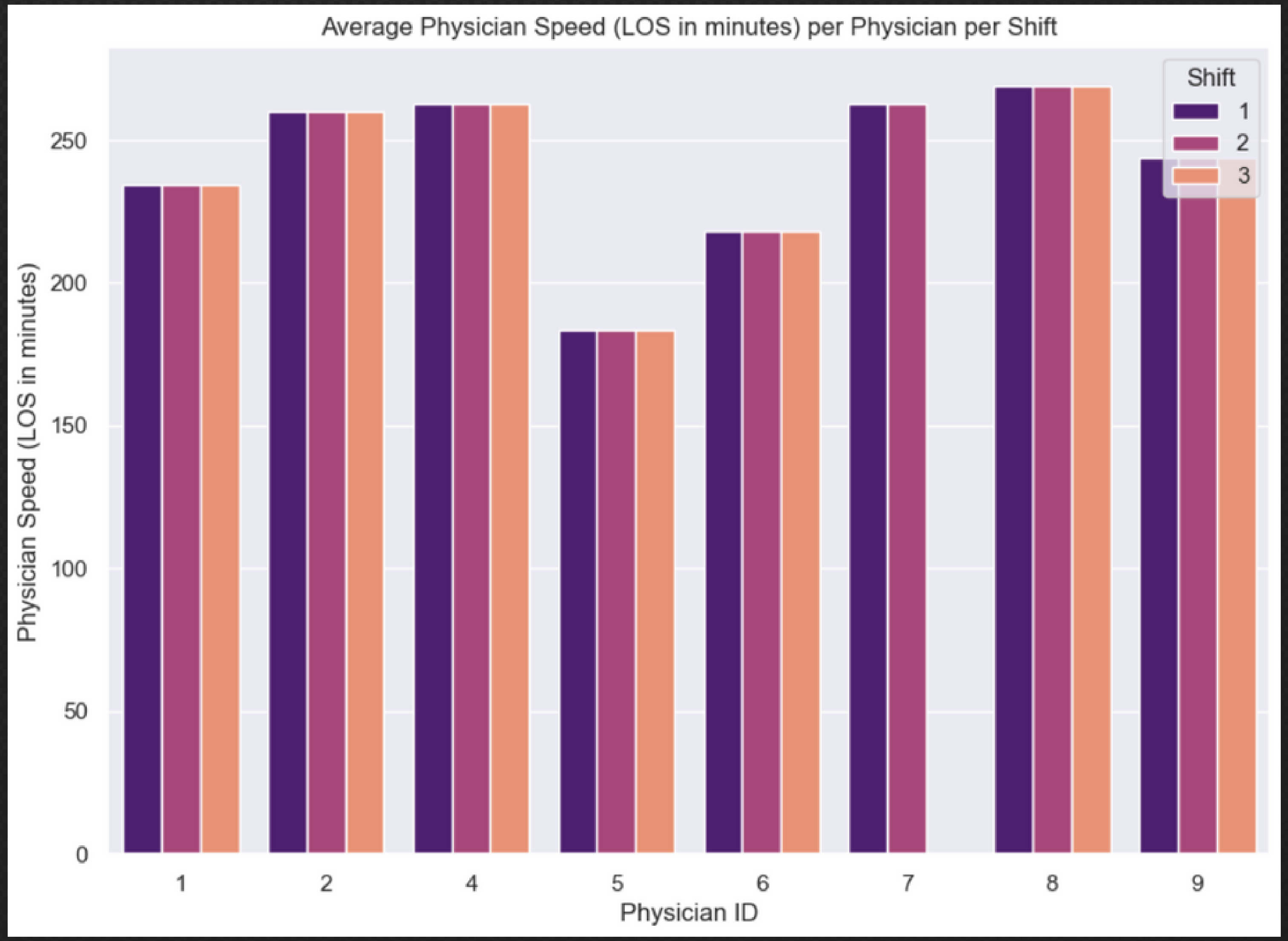
Our assumption: 90%



Objective Function

Physician Speed and Quality

Average of physician's LOS and ROR are consistent throughout different shifts and day



Constraints

1 Employment

Physicians who do not work at the ED

Physicians 3 and 20
Not in Dataset

Physicians 22 and 28
Past 6 months

$$x_{3,j,k} = 0, \forall j\ \forall k$$

$$x_{20,j,k} = 0, \forall j\ \forall k$$

$$x_{22,j,k} = 0, \forall j\ \forall k$$

$$x_{28,j,k} = 0, \forall j\ \forall k$$

2 Demand

Physicians staffed should meet Expected Demand with each physician's capacity as their Shift 1 average ED volume.

Assumed that if they could handle an amount in Shift 1, they could do the same on any shift

$$\sum_{i=1}^{28} (x_{ijk} * C_i) \geq E[X(j,k)]\ \forall j\ \forall k$$

Constraints

3 Physician-Specific

Consider day and shift preferences of physicians based on the the past 2 years.

Some do not work Mon or Tues

Some do not work Shift 2 or Shift 3

$$x_{7,2,k} = 0\ \forall k, \quad x_{7,3,k} = 0\ \forall k, \quad x_{13,3,k} = 0\ \forall k, \quad x_{16,2,k} = 0\ \forall k,$$

$$x_{16,3,k} = 0\ \forall k, \quad x_{18,2,k} = 0\ \forall k, \quad x_{18,3,k} = 0\ \forall k, \quad x_{19,2,k} = 0\ \forall k,$$

$$x_{19,3,k} = 0\ \forall k, \quad x_{21,3,k} = 0\ \forall k$$

4 Labour and Fairness

Ensures that physicians are not overworked, limiting them to 1 shift per day and no consecutive shifts.

$$\sum_{j}^{3}(x_{i,j,k}) \leq 1, \forall i\ \forall k\ , \qquad x_{i,3,k} + x_{i,1,k+1} \leq 1, \forall i,\ k = \{1, 2\}$$

Reserve physicians are limited to 1 shift in the period.

$$\sum_{j}^{3}\sum_{k}^{3}(x_{i,j,k}) \leq 1,\ i = \{7, 13, 14, 16, 18, 19\}$$

Physician 1 works Wednesdays.

$$\sum_{j}^{3}(x_{1,j,3}) \geq 1$$

Results

- 16 Unique Physicians Staffed
- 8 Physicians Not Staffed (Under Performers)
- 4 Physicians Staffed the Maximum Amount (Best Performers)

Based on 90th percentile event and stated constraints. Management should use their discretion to adjust percentile and constraints.

	Day 1			Day 2			Day 3			
Physician/ Shift	1	2	3	1	2	3	1	2	3	Count
1										1
2										0
4										3
5										2
6										2
7										1
8										0
9										0
10										2
11										1
12										0
13										0
14										1
15										3
16										1
17										3
18										0
19										1
21										0
23										0
24										1
25										3
26										1
27										1

Business Insights

1

Bridging the gap between high and low performers

4 Staffed Maximum Amount vs 8 Not Staffed

2

The tradeoff between speed and quality

Physician 18 and 19 high quality, more time.

3

Appropriate utilization of resources

Physician 17 more orders, better speed and quality

Limitations and Implications

Limitations	*Implications*
1 Speed and quality weighted equally	May not meet management ideals
2 Doesn't factor in pre-existing schedule	Physicians might decline scheduling
3 Inability to factor in social, resource and financial constraints	May result in inefficient staffing, spending, and wasted materials

Advantages of This Model

1 Having Tunable Parameters

Allows the managerial team to make adjustments according to the situation they face and make the final decision

2 Lowering ROR and LOS

Does not sacrifice speed or quality for the other and takes both into consideration

3 Based on Detailed Dataset Analysis

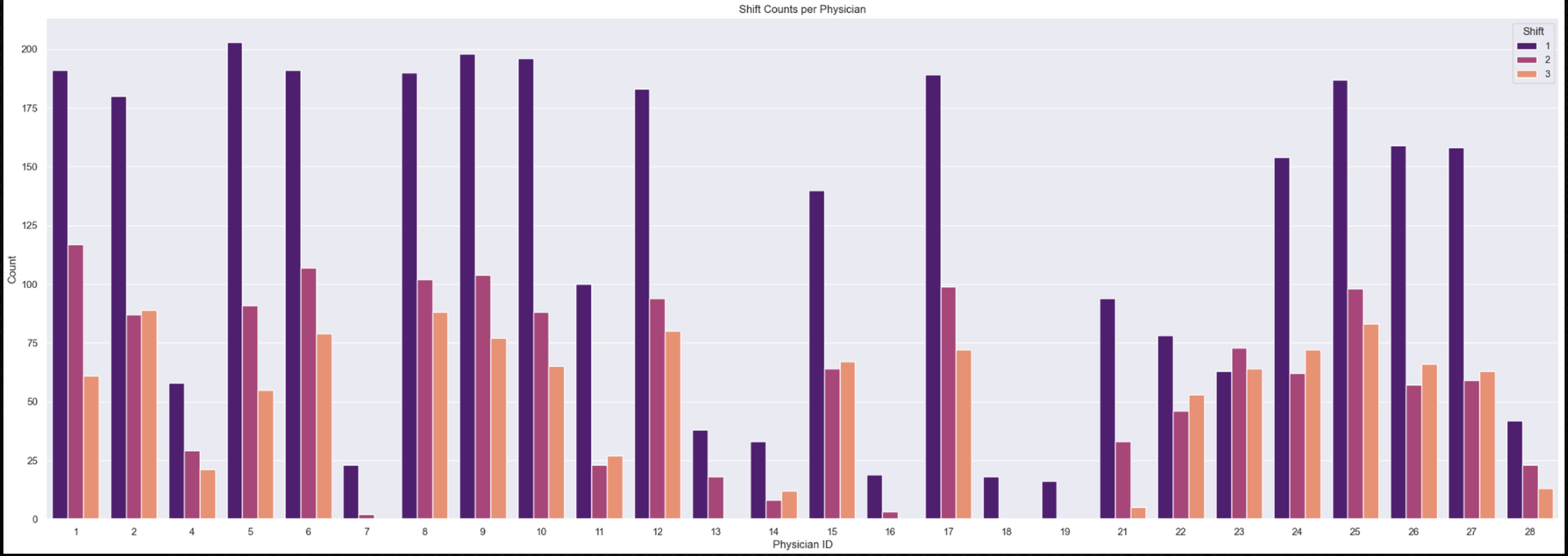
Hidden information and patterns have been extracted from the data set and incorporated into the model

Thank You

Appendix

1. Shift counts for each physician
2. Day counts for each physician
3. Capacity
4. Average ESI per shift and physician
5. Distribution types
6. Sensitivity Analysis
7. Order Counts

Shift Counts



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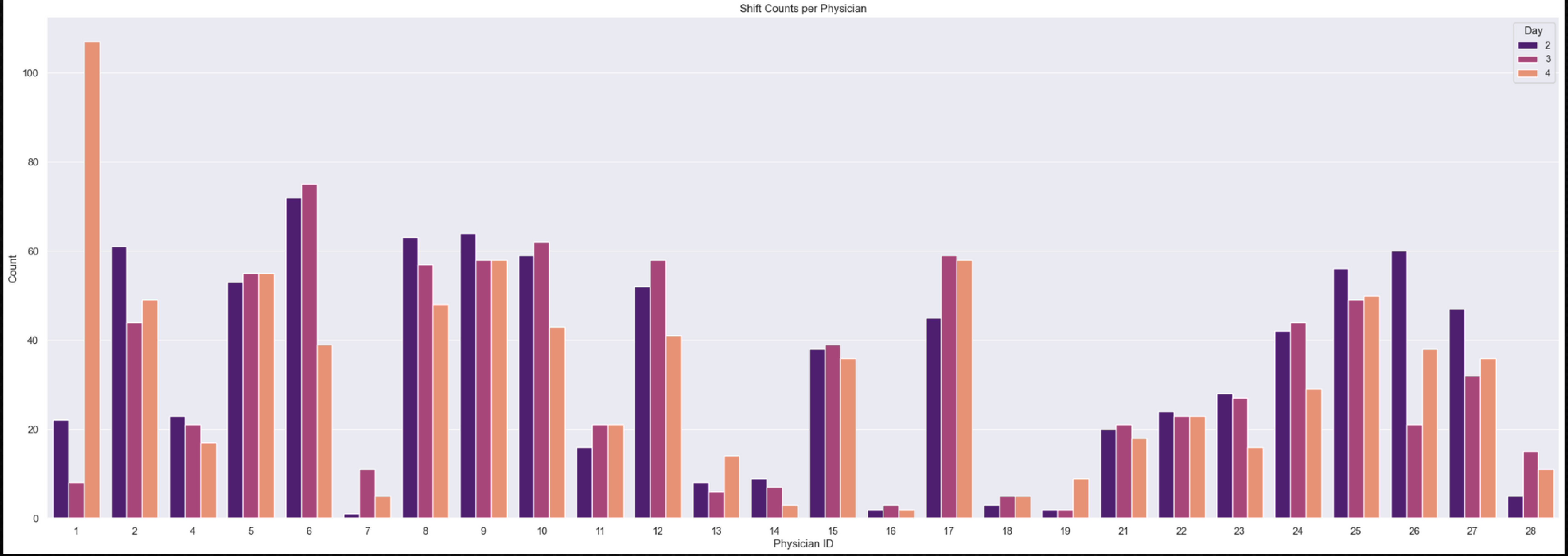
Day Counts



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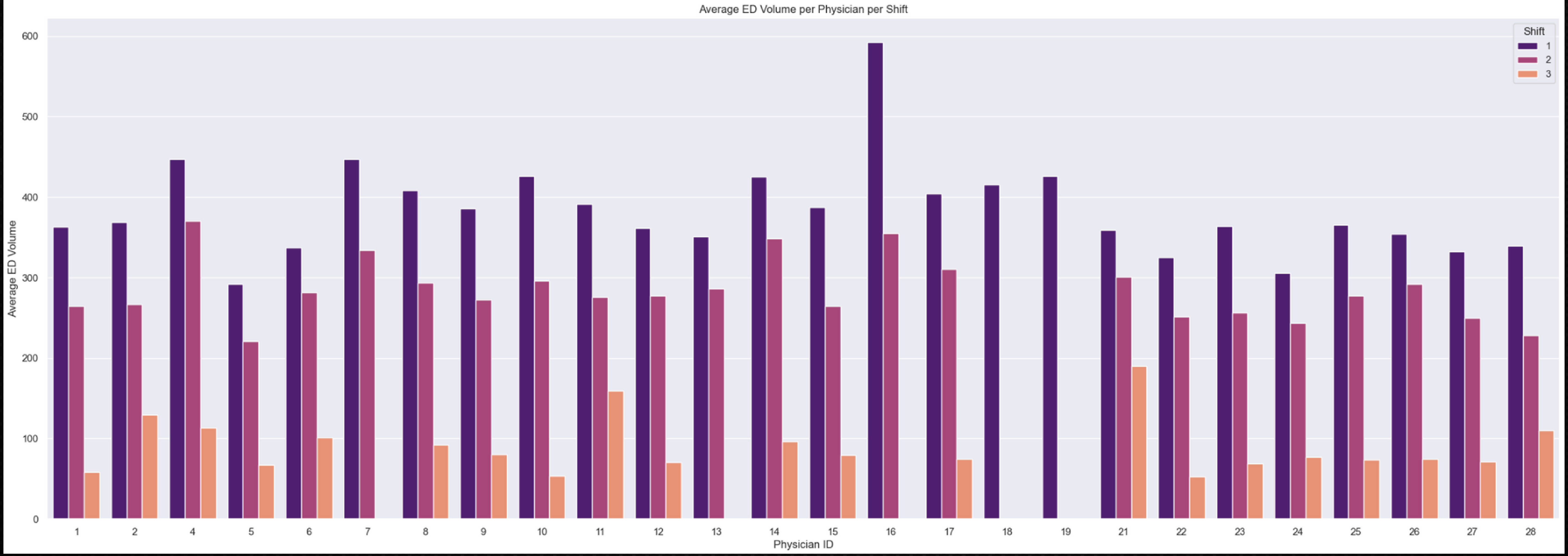
Capacity



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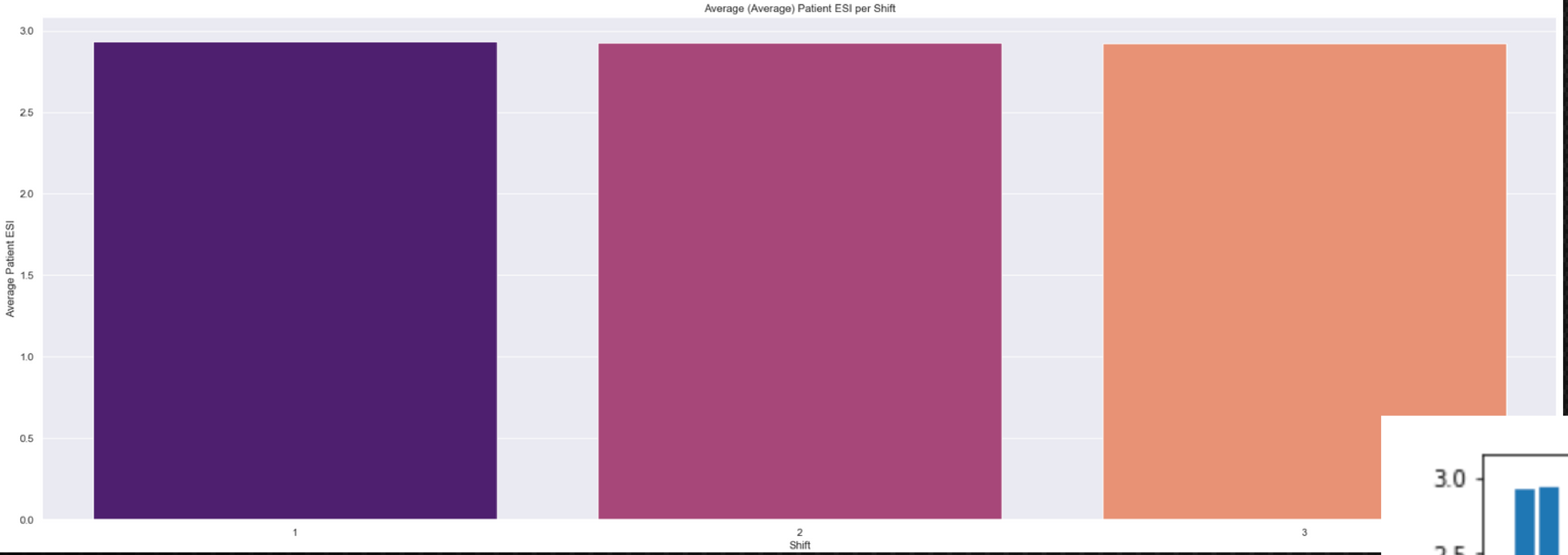
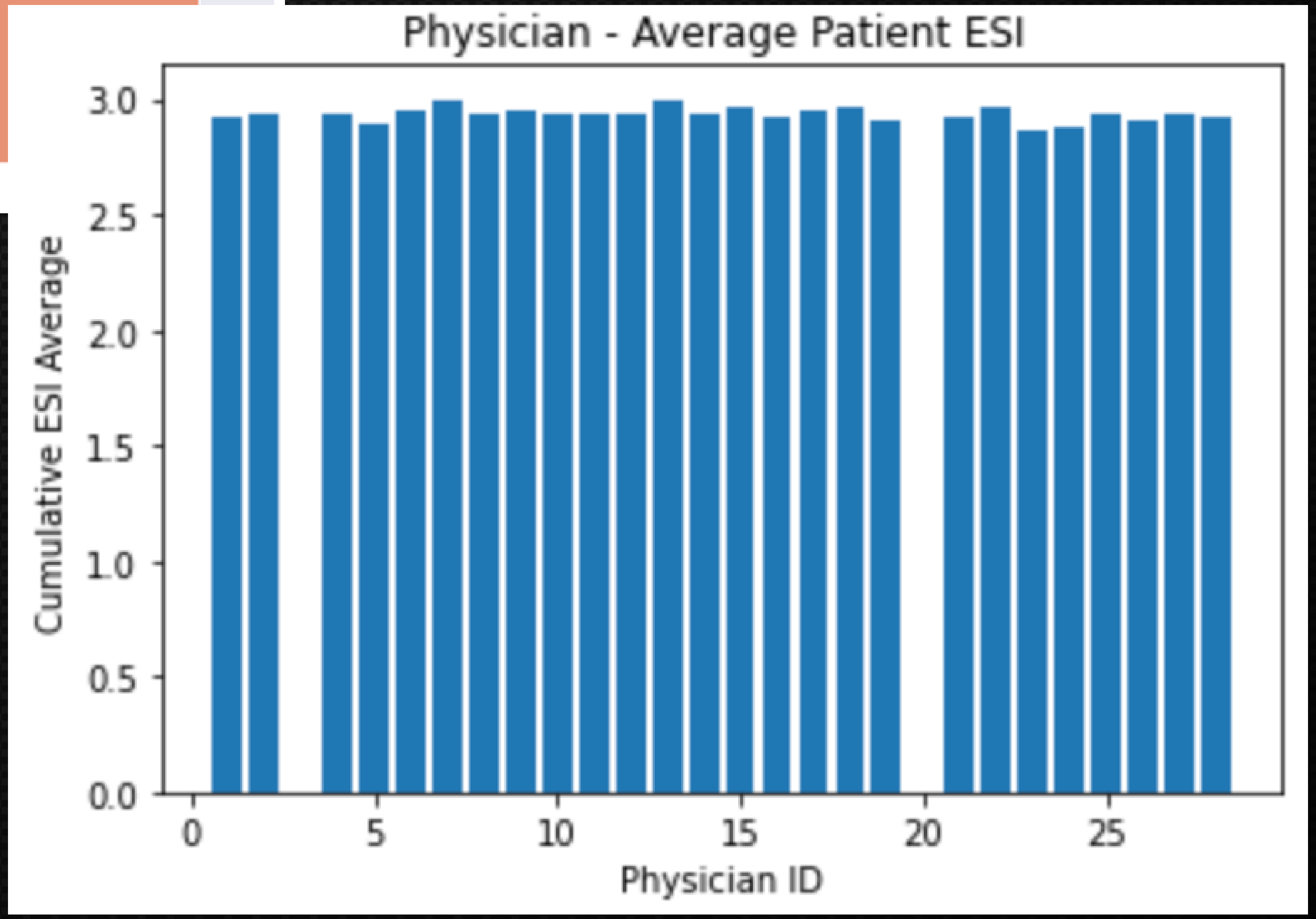
ESI



Average (Average) Patient ESI per Shift
Average Patient ESI
Shift



Physician - Average Patient ESI
Cumulative ESI Average
Physician ID

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Distributions

Distributions used for each shift-day pair			
	Day 1	Day 2	Day 3
Shift 1	Gamma	Gamma	Gamma
Shift 2	Gamma	Gamma	Logistic
Shift 3	Lognormal	Lognormal	Lognormal

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Sensitivity Analysis

Sensitivity Analysis of expected demand					
	English Definition	45th percentile	60th percentile	75th percentile	90th percentile
$E[X(1,1)]$	Monday Morning	1326	1613	1982	2615
$E[X(1,2)]$	Tuesday Morning	1174	1418	1723	2224
$E[X(1,3)]$	Wednesday Morning	994	1236	1555	2117
$E[X(2,1)]$	Monday Afternoon	472	574	706	934
$E[X(2,2)]$	Tuesday Afternoon	416	504	619	818
$E[X(2,3)]$	Wednesday Afternoon	446	527	619	764
$E[X(3,1)]$	Monday Night	46	75	132	294
$E[X(3,2)]$	Tuesday Night	47	79	139	317
$E[X(3,3)]$	Wednesday Night	45	77	142	339

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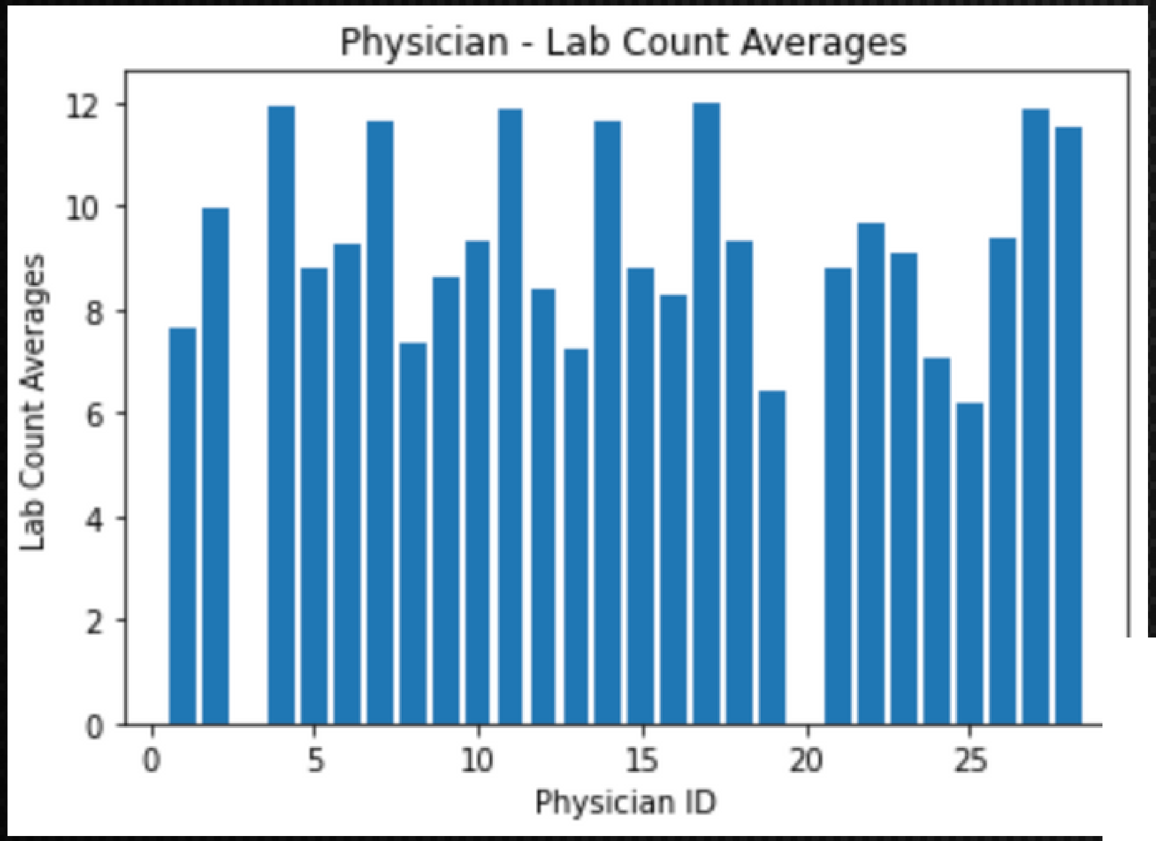
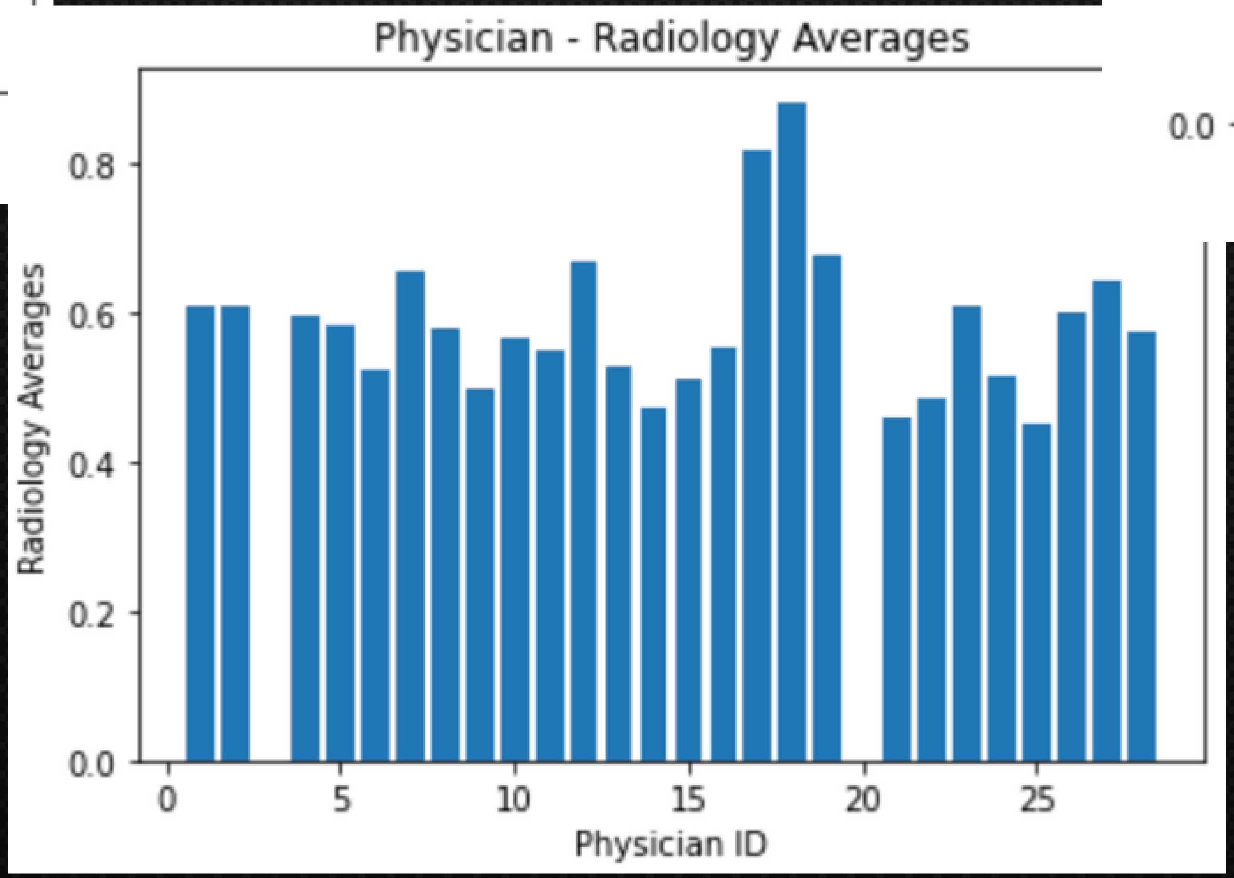
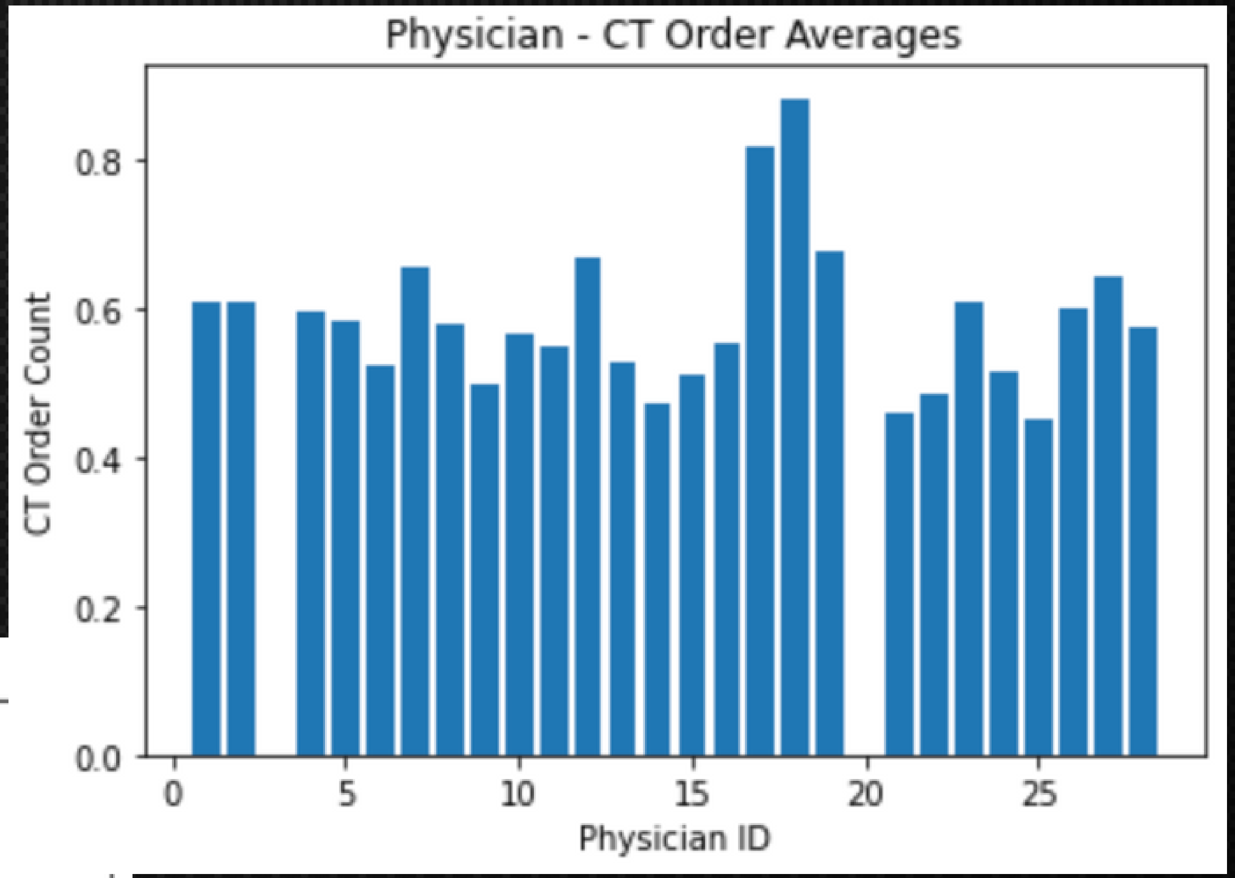
Order Counts







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