Patient Flow in UCLA Obstetrics

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Background: OB-GYN

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Obstetrics and Gynaecology (OB-GYN): Patient Flow and Capacity central to success of operations

- US Complexity: perinatal care complex, shifts between different levels of care
- Sets precedent: Perinatal care vital to long-term sustained health and reduction of chronic diseases
- Innovation: Exciting new technologies and innovations in delivery room tech – only useful if actual use and flow of delivery optimized

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- Delivers close to 4000 babies annually
- OB unit ranked in US Top 10 for Women's Healthcare

Area of Inquiry

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Obstetrics

- The obstetric unit is a good sub-system of health care to test simulation models (Cochran and Bharti 2006)
- Ronald Reagan Obstetrics Unit Patient Experience
- How does patient flow impact patient experience in obstetrics?

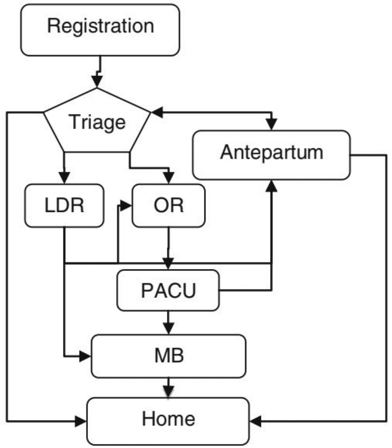

Figure 1: Illustration of Patient Flow Model in OB (Griffin et al. 2011)

Patient Flow

- Improving patient throughput by ensuring even capacity utilization, minimizing wait times for resources and care
- Topics of interest: patient classification, path-based modeling, blocking, accounting for swing rooms, time dependent arrival and departure patterns
- Why is improving patient flow in obstetrics units important?

Motivation

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Proven areas for useful change or optimization

- Unit Capacity - especially important in larger health system with multiple locations
- Managing workload with decreasing staff - fewer OB-GYNs means heavier workload for remaining, optimization essential to success and stopping burnout
- Healthy Births - Improve rates of successful healthy birth for mother and child, particularly in high-risk or lower income areas (some of which UCLA serves)

"Maternity Desert" - wave of maternity ward closings in Los Angeles

- 29 hospitals stopped delivering babies since 2021
- 17 obstetrics departments closed in LA in last decade

Current & Future Gaps

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Lack of efficient utilization across locations at UCLA Health - (from UCLA ops)

- Capacity modeling in the UCLA OB would be novel and a definite value-add
- Potential collaborators in OHIA or CTSI

ED and critical care predominant sites for capacity prediction research

- OB ward patient flow work needed, especially given prior context

Insufficient Model Performance

- Rf models predicting capacity have had lower accuracy than ideal for a decision support system within the OB context

OB Complexity

- Future modeling efforts could include dynamic, real-time simulation with time-series analysis

Problem Framework

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Cohort definition

- Labor & Delivery Patients admitted to unit 5OB in Ronald Reagan Medical Center between 01/01/2022 - 09/01/2024

Determining Scope

- Patient-level framework (long-term)
  - On-demand bed assignments based on patient characteristics

- **Time-level framework (short-term)**
  - Map hospital usage by week over the next year

Analytics & Forecasting Methods

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Analytics

- Data Visualizations on:
  - Birthing trends
  - Bed Utilization
  - Weekly Usage

Forecasting

- Defining historical usage
  - Median patients/day in a week
- Long short-term memory (LSTM) model to predict future usage
  - Optimize hyperparameters and use mean absolute error as a loss function

EDA — OB Delivery Dataset

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Fig. OB Delivery Dataframe and Dimensions

	PatientEncounterCSNID	EpisodeID	HospitalAdmissionTime	HospitalDischargeTime	LengthOfStay	IsInpatient	IsObservatic
0	2.103032e+09	5.542547e+18	2022-06-07 16:44:00	2022-06-11 13:48:00	3.836806	1.0	0
1	2.103032e+09	5.542547e+18	2022-06-07 16:44:00	2022-06-11 13:48:00	3.836806	1.0	0
2	2.103032e+09	5.542547e+18	2022-06-07 16:44:00	2022-06-11 13:48:00	3.836806	1.0	0
3	2.103032e+09	5.542547e+18	2022-06-07 16:44:00	2022-06-11 13:48:00	3.836806	1.0	0
4	2.103032e+09	5.542547e+18	2022-06-07 16:44:00	2022-06-11 13:48:00	3.836806	1.0	0

80956 rows × 36 columns

Key Data Elements

- Encounter Records
- Delivery Episodes
- Department + Bed Utilization Records
  - RR 5DR, RR PERIOPERATIVE AREA, RR 5FDU IOF, RR 5EOB, RR 7ICU
- Patient Obstetric Histories
- Temporal Attributes (i.e. dates, times, seasons)

Fig. Columns

```
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Data columns (total 36 columns):
 #   Column                  Non-Null Count  Dtype
---  ------                  --------------  -----
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 1   EpisodeID               80954 non-null  float64
 2   CheckinTime             0 non-null      float64
 3   CheckoutTime            0 non-null      float64
 4   HospitalAdmissionTime   80955 non-null  datetime64[ns]
 5   HospitalDischargeTime   80683 non-null  datetime64[ns]
 6   LengthOfStay            80645 non-null  float64
 7   IsInpatient             80955 non-null  float64
 8   IsObservation           80955 non-null  float64
 9   BedID                   43325 non-null  float64
 10  BedName                 43325 non-null  object
 11  BedInCensus             43325 non-null  float64
 12  RoomID                  66724 non-null  float64
 13  RoomName                71675 non-null  object
 14  RoomGroupName           6946 non-null   object
 15  DeliveryDate            80955 non-null  datetime64[ns]
 16  BirthDateTime           77606 non-null  datetime64[ns]
 17  LaborOnsetDateTime      47422 non-null  datetime64[ns]
 18  DeliveryMethodCode      77346 non-null  float64
 19  FirstStageLengthHours   38297 non-null  float64
 20  SecondStageLengthHours  50767 non-null  float64
 21  ThirdStageLengthHours   78475 non-null  float64
 22  NumberOfBabies          3347 non-null   float64
 23  EstimatedDateOfDelivery 3341 non-null   object
 24  DeliveryDepartmentID    77599 non-null  float64
 25  DepartmentName          80955 non-null  object
 26  IsPrimaryDeliveryUnit   80955 non-null  float64
 27  TotalLaborMinutes       46196 non-null  float64
 28  GravidaCount            3347 non-null   float64
 29  ParaCount               3347 non-null   float64
 30  PretermCount            3347 non-null   float64
 31  IsWeekend               80955 non-null  float64
 32  IsHoliday               80955 non-null  float64
 33  MonthName               80955 non-null  object
 34  QuarterNumber           80955 non-null  float64
 35  Year                    80955 non-null  float64
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EDA — Visualizations

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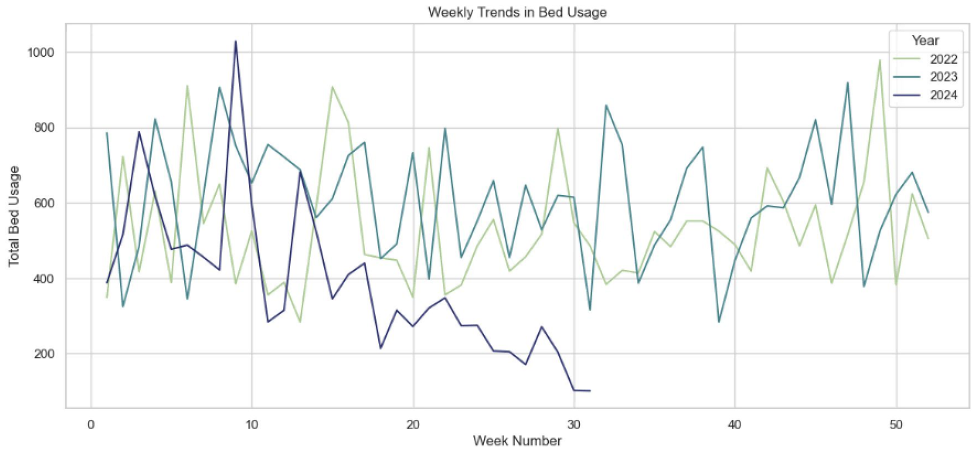
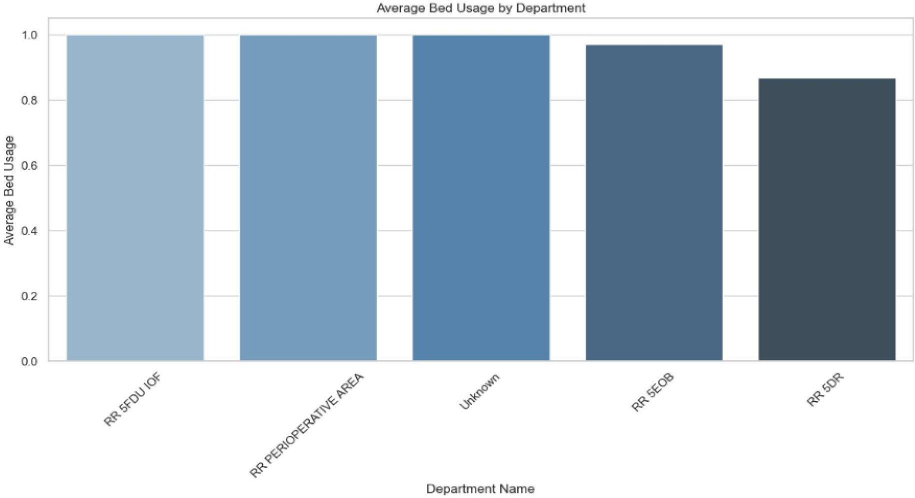


Fig. — Weekly Trends in Bed Usage by Year

Fig. — Average Bed Usage by Department



EDA — Visualizations

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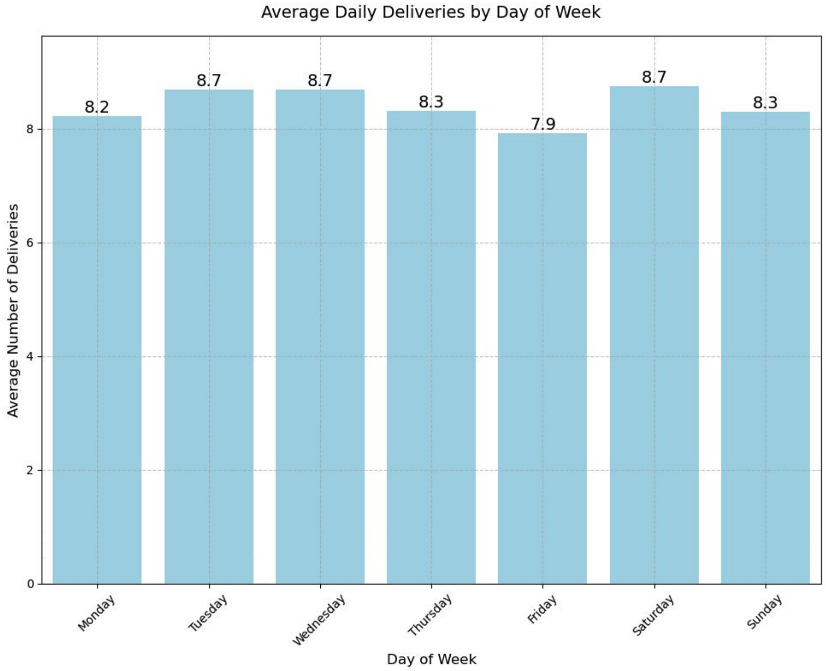
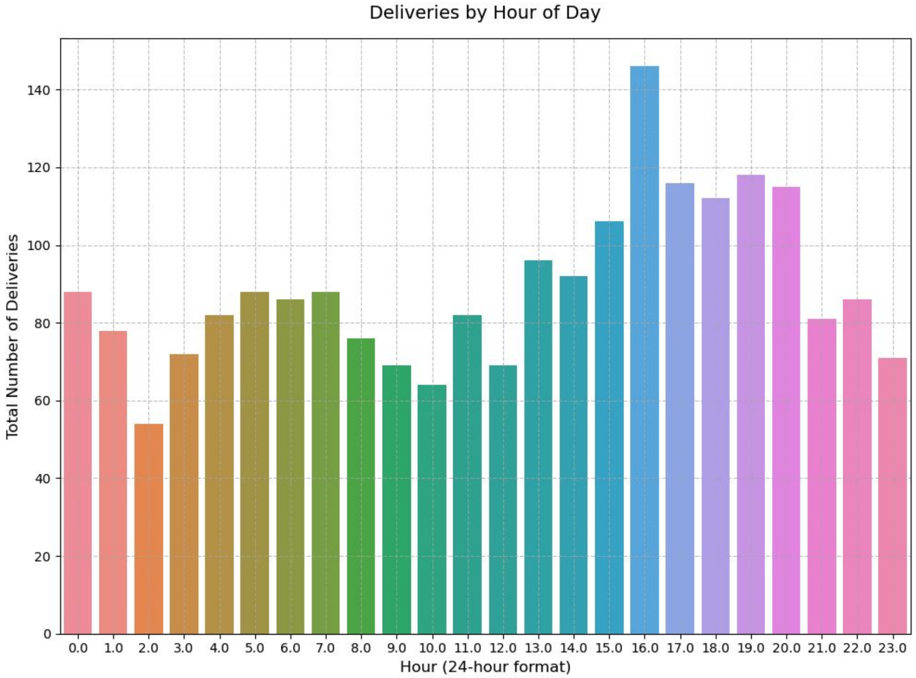


Fig. — Average Daily Deliveries by Day of Week

Fig. — Deliveries by Hour of Day



Usage Trend - Median Patients/Day

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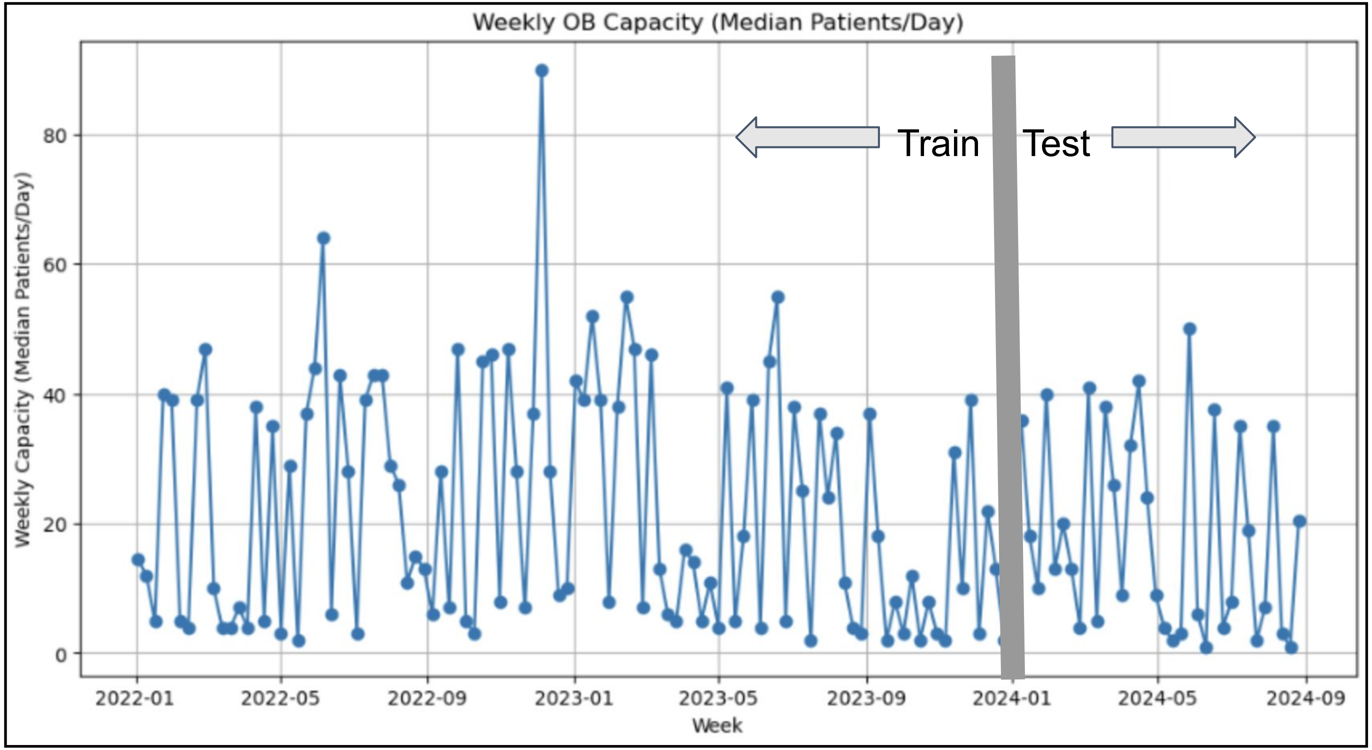
- No seasonality
- No YOY trend
- Regular fluctuations



Usage Forecasting Results

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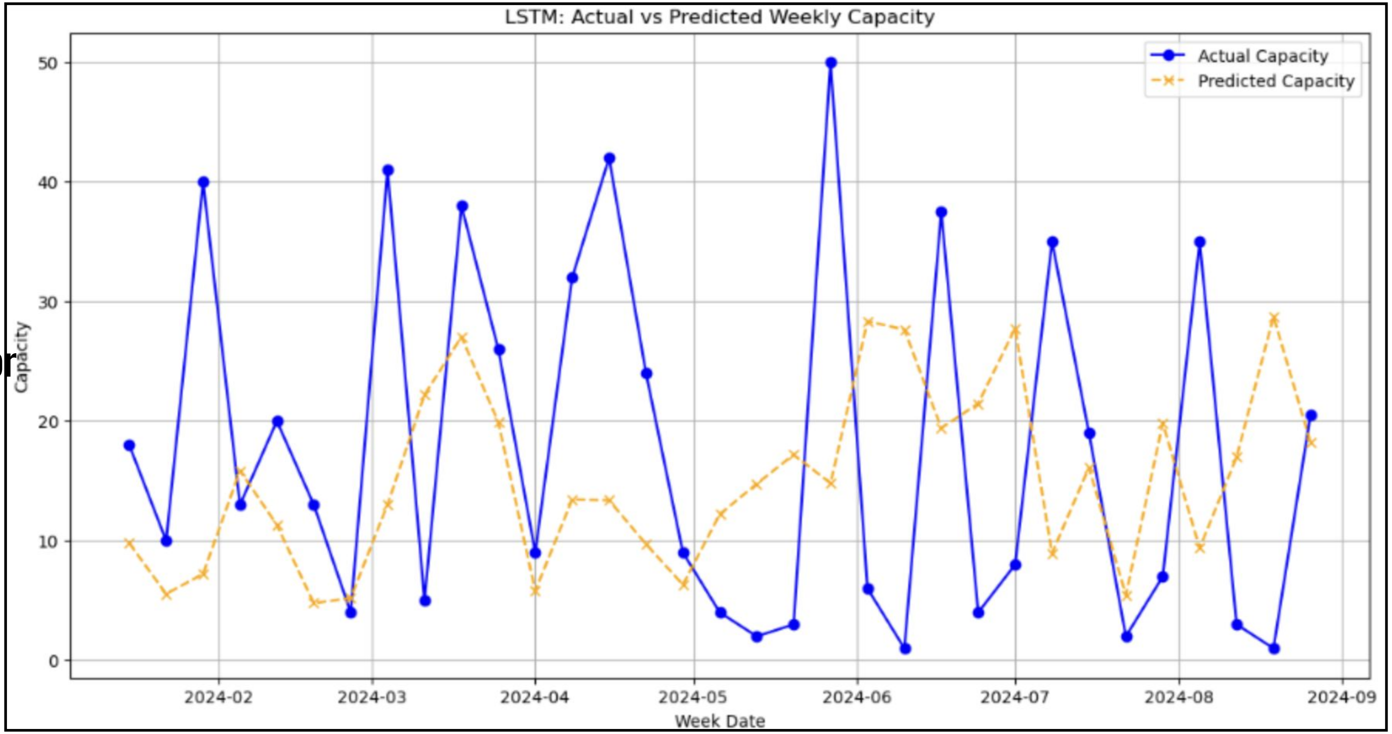

Long short-term memory (LSTM)

Test Root Mean Squared Error (RMSE): 17.69

Test Mean Absolute Error (MAE) = 14.71

Discussion

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Actionable insights

- Number of staff necessary per week
- Scheduling C-sections according to predicted capacity
- Planning to send appropriate patients to other facilities (ex: Santa Monica) during high-capacity weeks

Next Steps

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Include currently unavailable data to model capacity

- Predicted due-dates for UCLA patients
- Scheduled C-sections
- Scheduled staffing

Model Optimization

- Additional hyperparameter range exploration using GridSearchCV
- Model stacking or ensemble learning with regression-based models after additional features included (above)

Broader Implications

- Using and adapting model for other, potentially more complex departments
- Continued training for longer term prediction, increasing accuracy

Q&A