TecNav
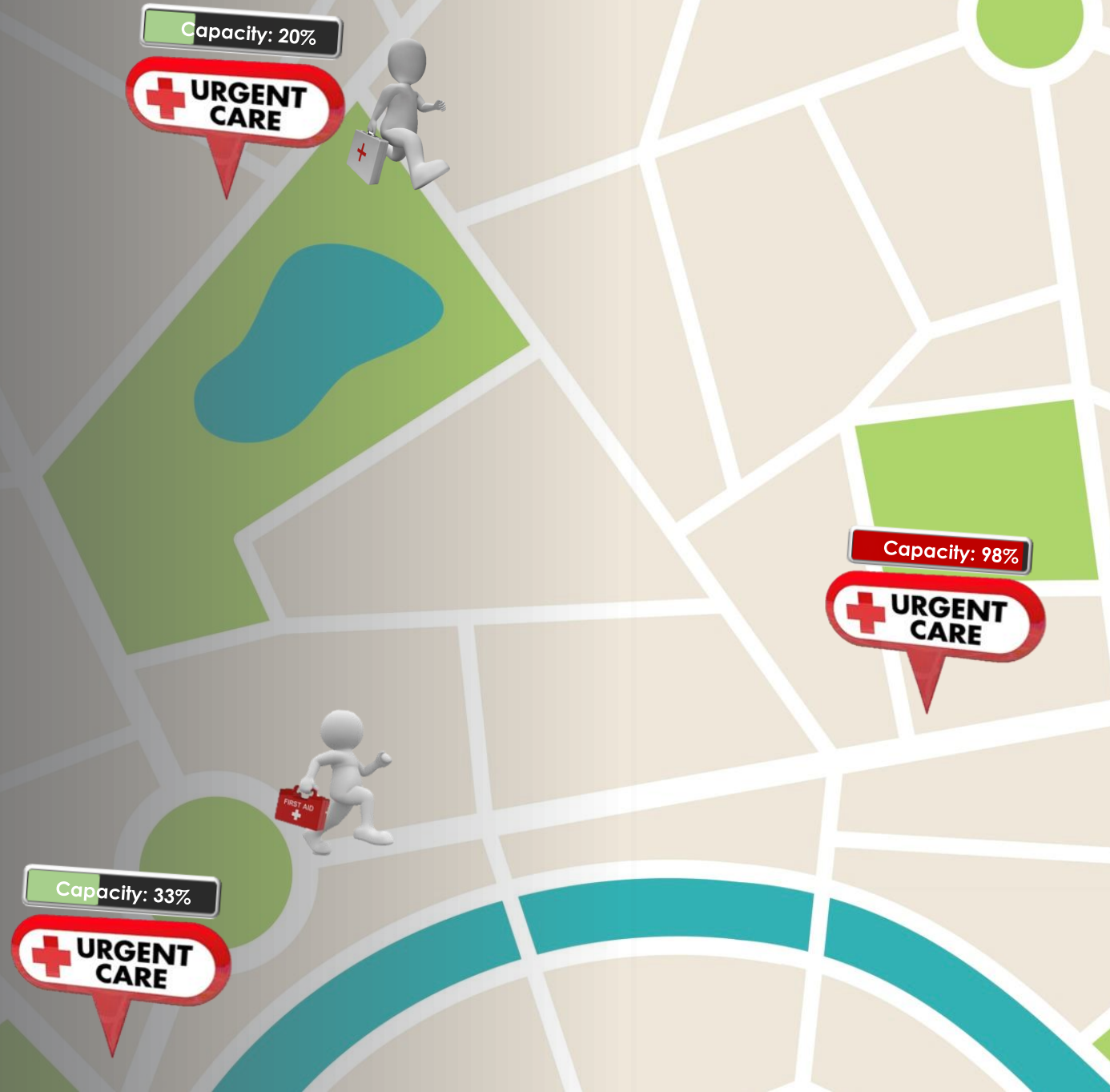
Clinic Monitoring &
Technician Navigation
Application

Tomer Danon & Romith Challa

Project Overview

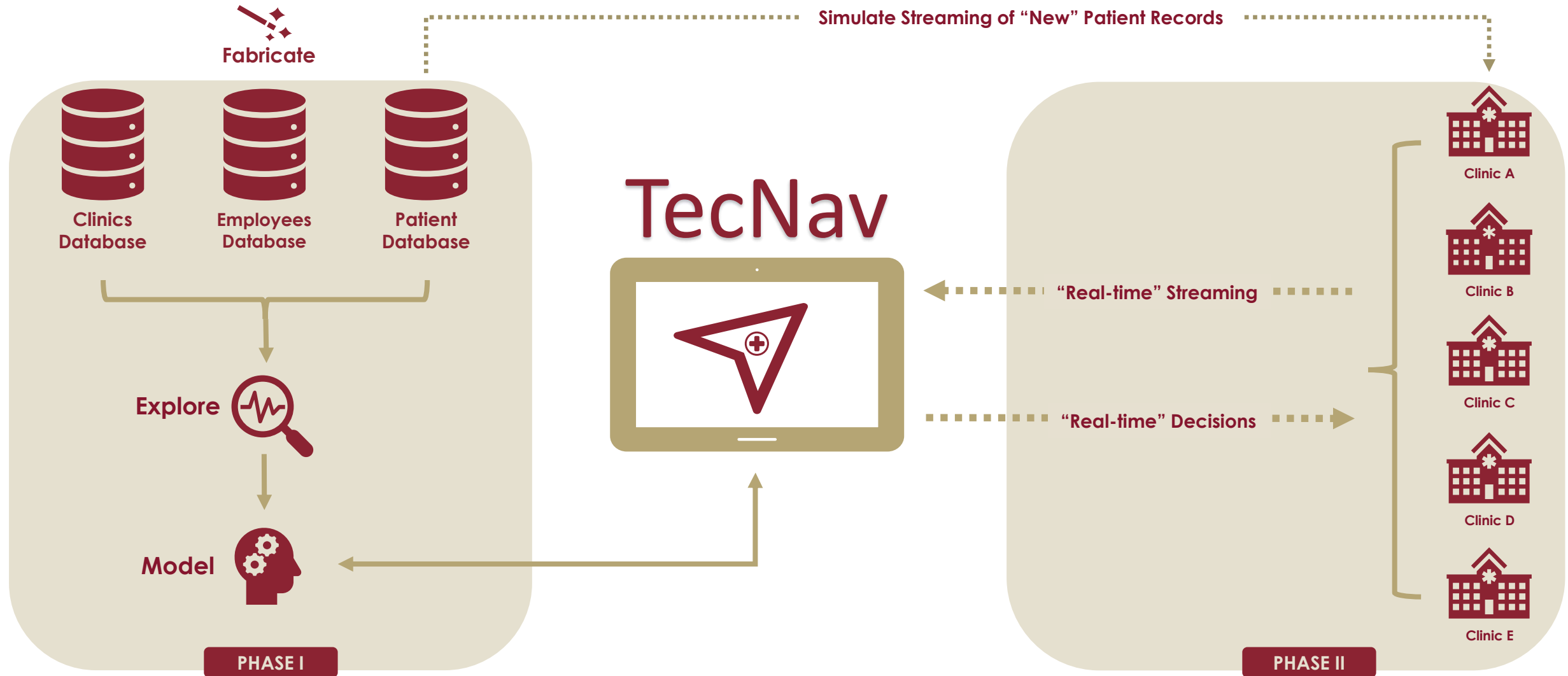| **Background**	Rapid growth of on-demand care
Challenge	Unpredictable patient traffic
Use-case	Shuffle technicians across clinics on per need basis
Pitch	Automated Real-Time ML-based Application - *TecNav*

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Project Overview

Pipeline

Data Fabrication

Overview

Data Source
- No publicly-available sources – fabricate!
- Road-Block: Patient registration logs
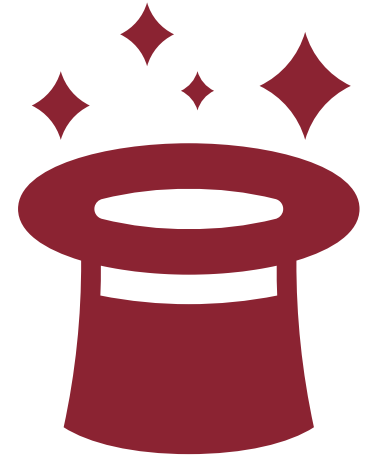
Objective
- Emulate real-world data

Challenges
- Strategize based on secondary research
- Balance between consistency across datasets, while maintaining real-world variation

Datasets
- Past patient records, clinic info, employee records, new patient logs (for streaming)

Data Fabrication

Approach

Patient Records

- IDs
- Ages
- Visit Reasons
- Names, D.O.B.

Employee Records

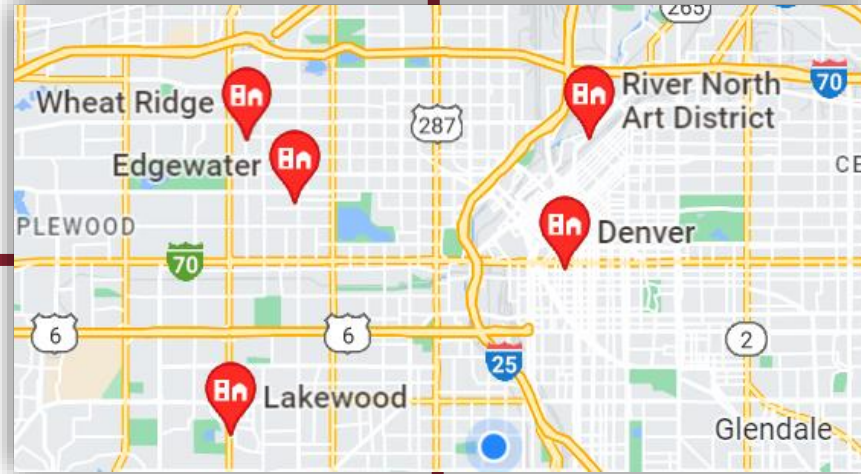- IDs
- Names
- Roles

Clinic Info

- Names / Locations
- Distances
- Capacity

Visit Records

- Severity Level
- Visit Lengths
- Check-In Times

Data Fabrication

Patient Traffic – Check-in Times

```python
# Denver-Clinic:
denver_ctime_specs = {
    'weekday_means1': [8, 8.25, 8.5, 8.75, 9],          # First weekday peak possibilities of Denver location
    'weekday_means2': [11, 11.25, 11.5, 11.75],         # Second weekday peak possibilities of Denver location
    'weekday_means3': [16, 16.25, 16.5, 16.75],         # Third weekday peak possibilities of Denver location
    'weekday_sigmas': [1.8, 1.9, 2.1, 2.2],             # Possible weekday variations (standard-deviations)
    'weekend_means1': [10.5, 11, 11.5, 12],             # First weekend peak possibilities of Denver location
    'weekend_means2': [14, 14.5, 15, 15.5],             # Second weekend peak possibilities of Denver location
    'weekend_means3': [17, 17.25, 17.5, 17.75],         # Third weekend peak possibilities of Denver location
    'weekend_sigmas': [1.8, 1.9, 2.1, 2.2]              # Possible weekend variations (standard-deviations)
}
```
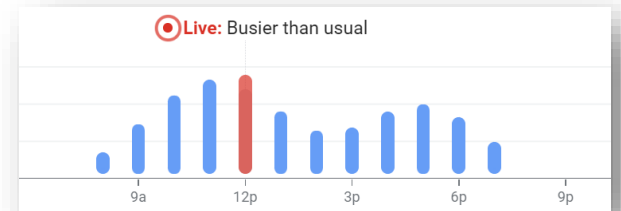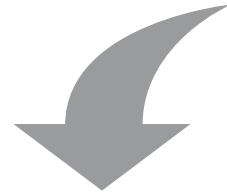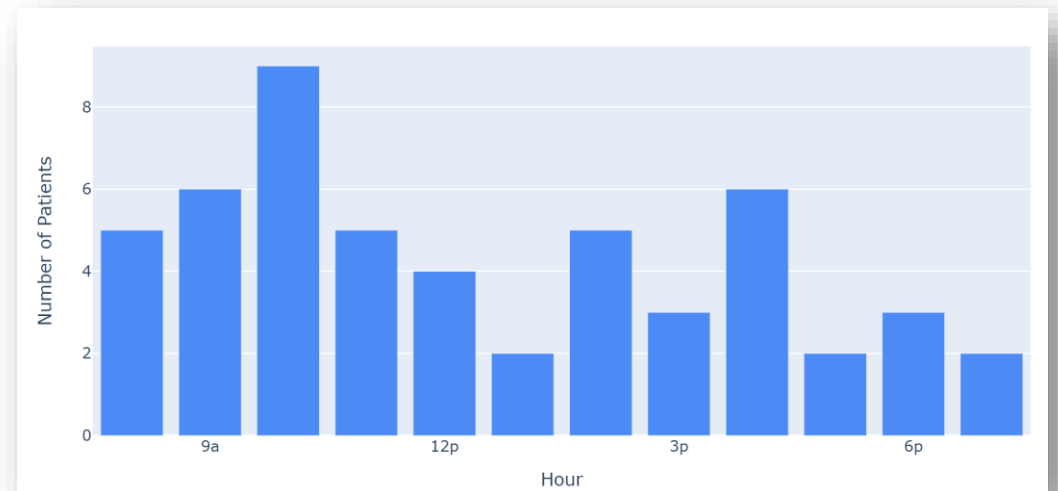

Actual Example (source: Google)

Multi-modal
- Multiple peaks

Variations
- Randomly sampled Means & SDs
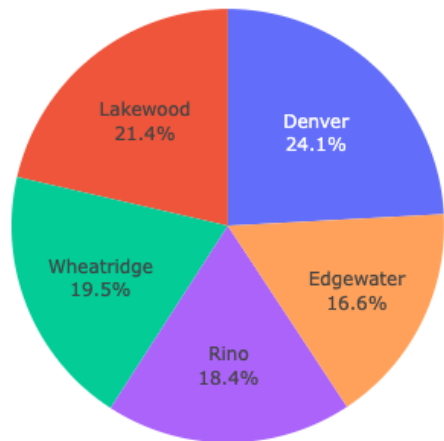- By day (weekday vs. weekend)
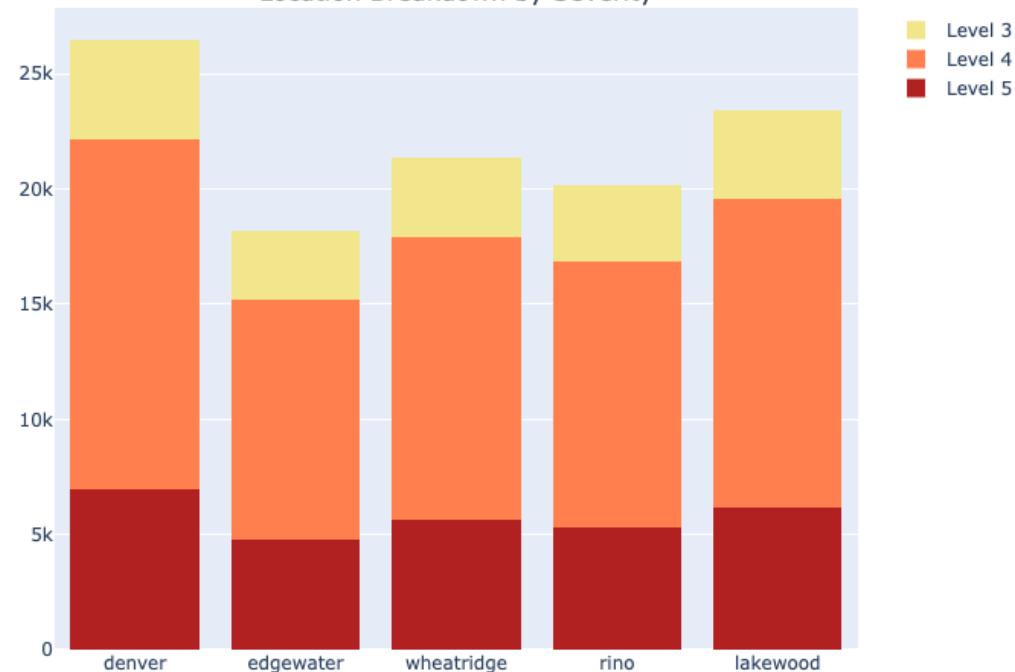- By location

Fabricated Example

Exploratory Data Analysis

Patient Traffic by Location

- Denver (most-populated) sees highest patient traffic

- Edgewater (least-populated) has smallest capacity

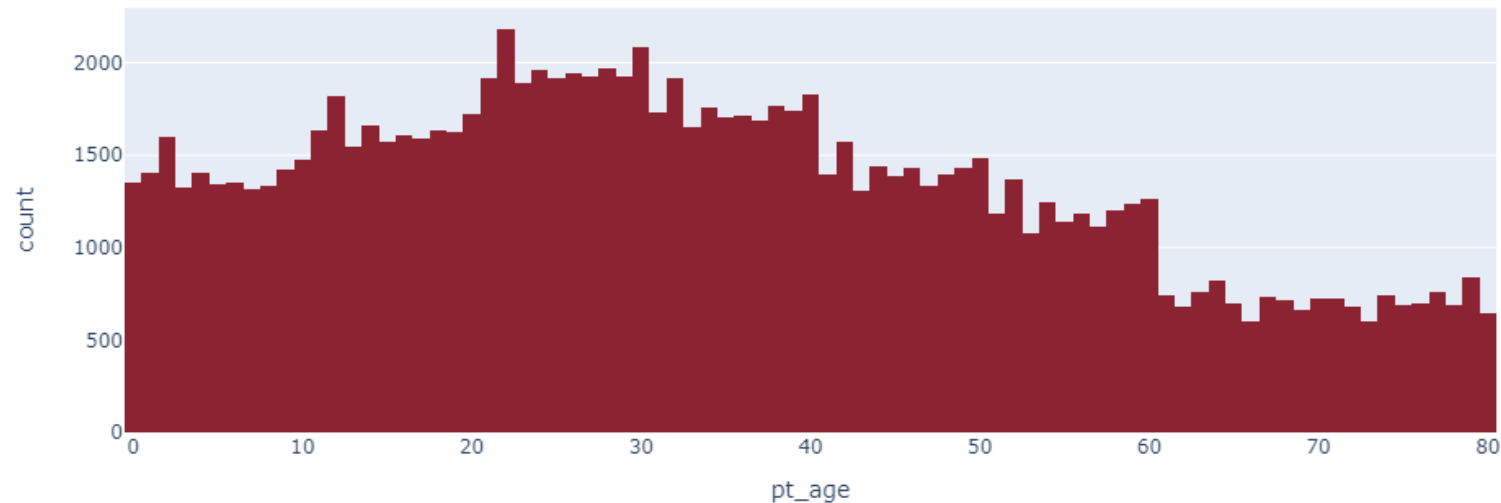- Distribution of severity levels standardized across locations

Exploratory Data Analysis

Patient Demographics

Patient Count by Age

Age-Group Breakdown

- Infant to 10: 14%
- 11 - 20: 15%
- 21 - 30: 18%
- 31 - 40: 16%
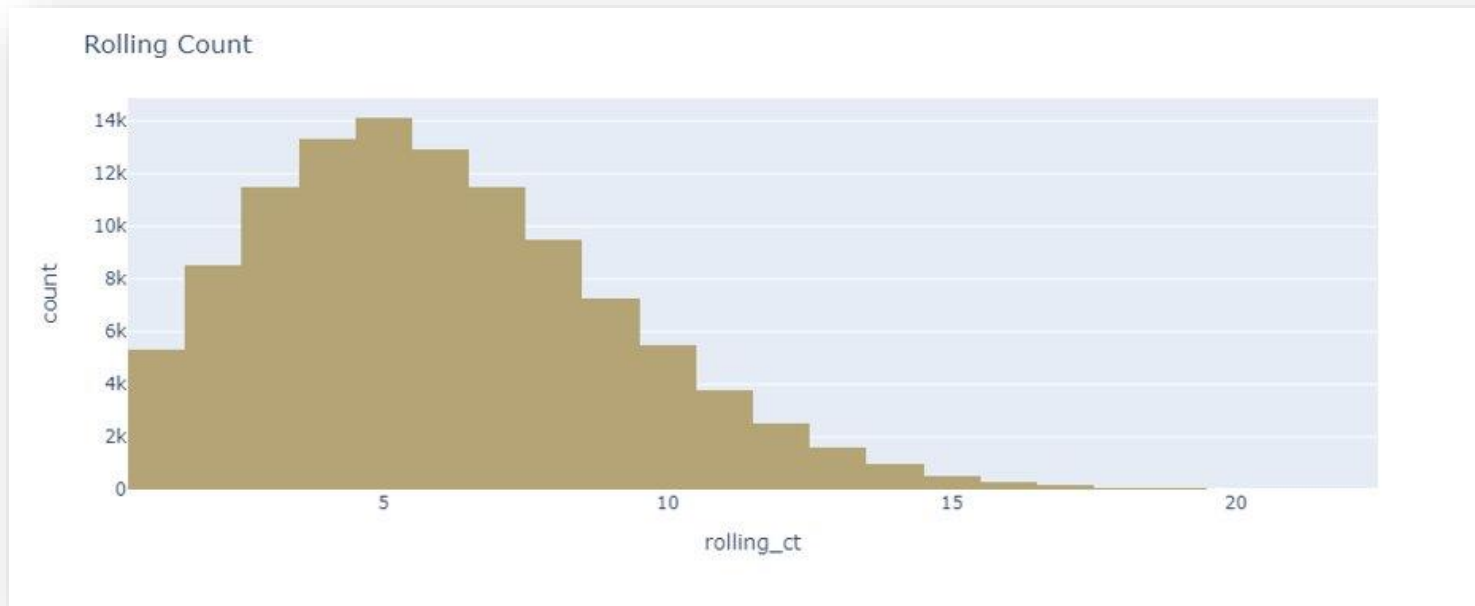- 41 - 50: 13%
- 51 - 60: 11%
- 61+: 13%

Exploratory Data Analysis

Rolling Patient Count

Based on past patient records (May 2021 – Apr 2022):

- Most common rolling count: 5-6
- Can extend up to 20
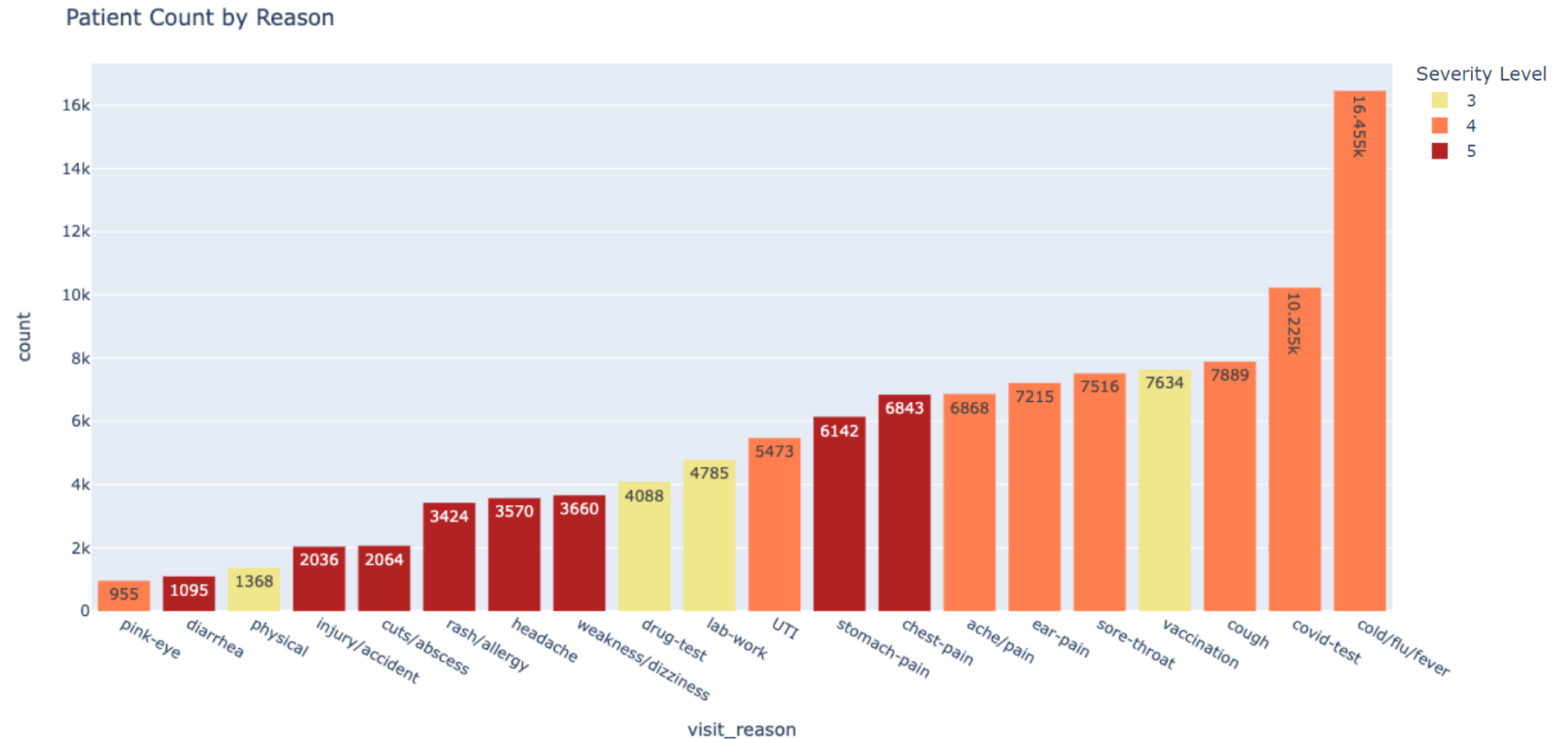- Slight variations based on clinic location

Exploratory Data Analysis

Visit Reasons

- Visit reason proportions emulate CDC's ER estimates

- Cold/Flu/Fever: most common reason for visit
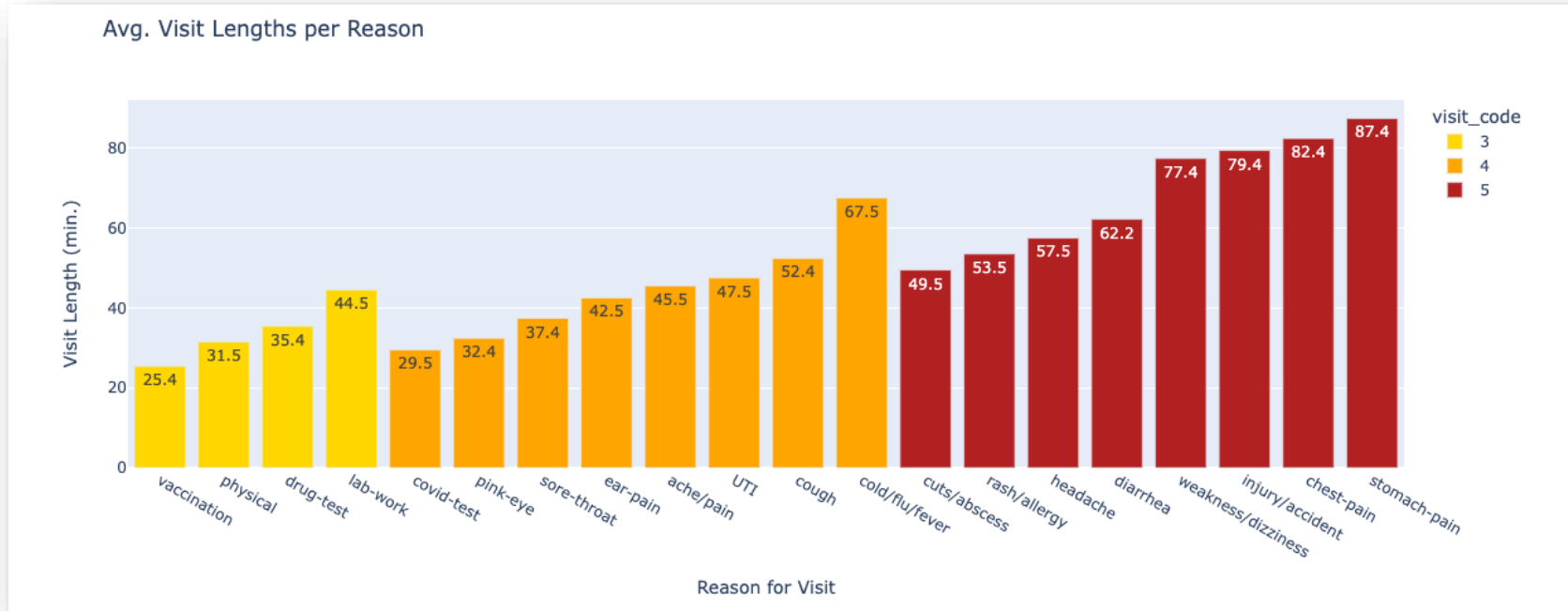
- Severity Level-4 visits are most common

Patient Count by Reason

Exploratory Data Analysis

Visit Length

- Level-3 visits ("non-urgent") have quickest visit times

- Level-5 visits have longest durations
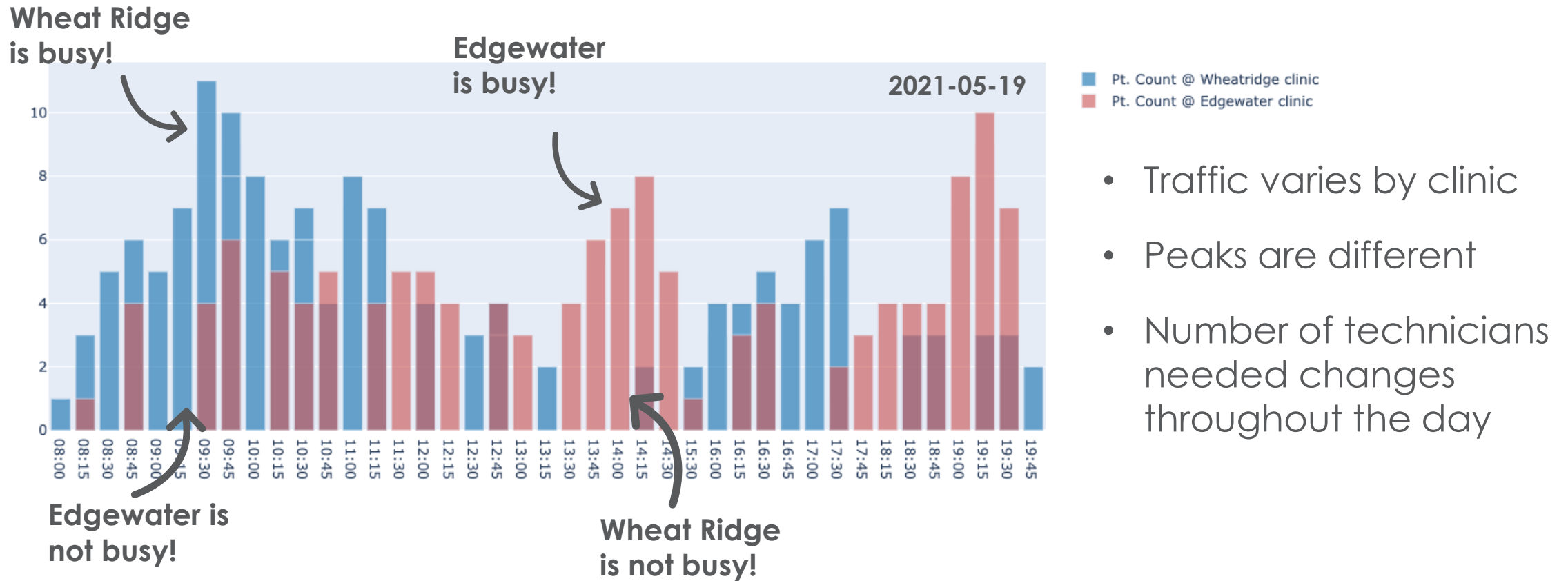 - Additional diagnostic or therapeutic measures

Exploratory Data Analysis

Patient Traffic by Location

- Traffic varies by clinic

- Peaks are different

- Number of technicians needed changes throughout the day

Exploratory Data Analysis

Scheduled Technician Count
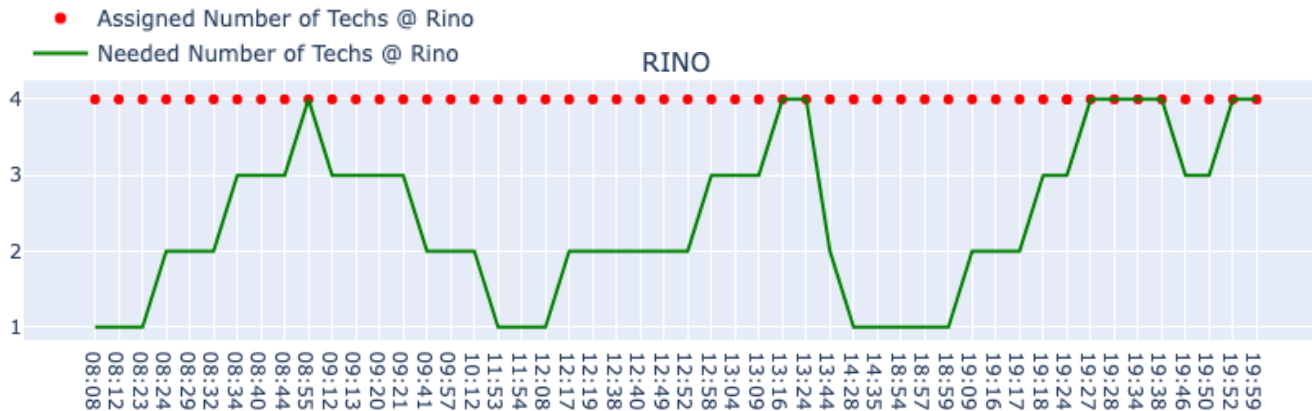
👎 Scheduling technicians based on anticipated "peak" hours leads to inefficient use of resources (red dotted line)

💡 Dynamic scheduling that adapts based on clinic's current needs can mitigate these inefficiencies

Modeling

"Is it feasible to transfer a technician?"

Model: Random Forest Regressor

Prediction: How many technicians are needed in the next hour?

Evaluation: RMSE = 0.72   (< 1 technician)

Use: Assess whether a technician can be transferred at a given time

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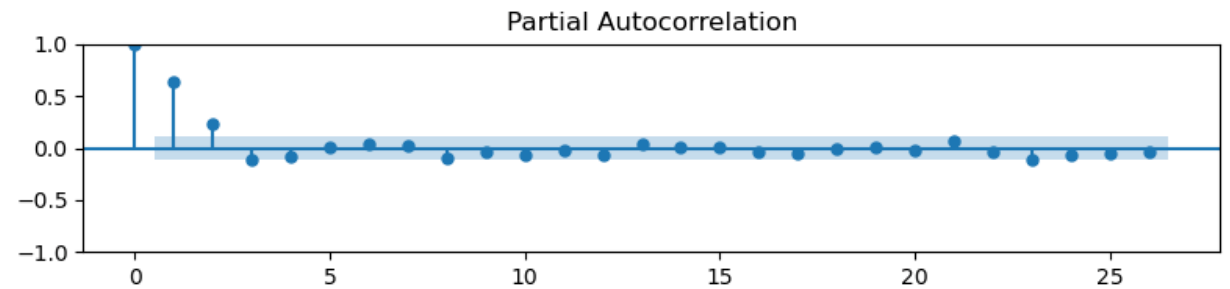
Time Series - ARIMA
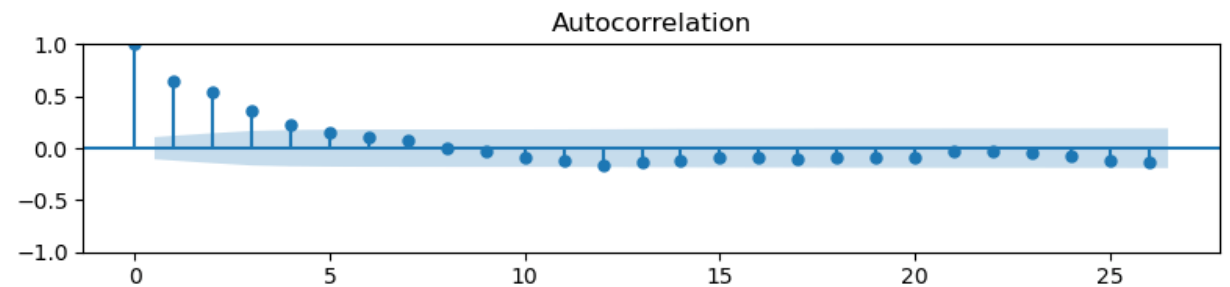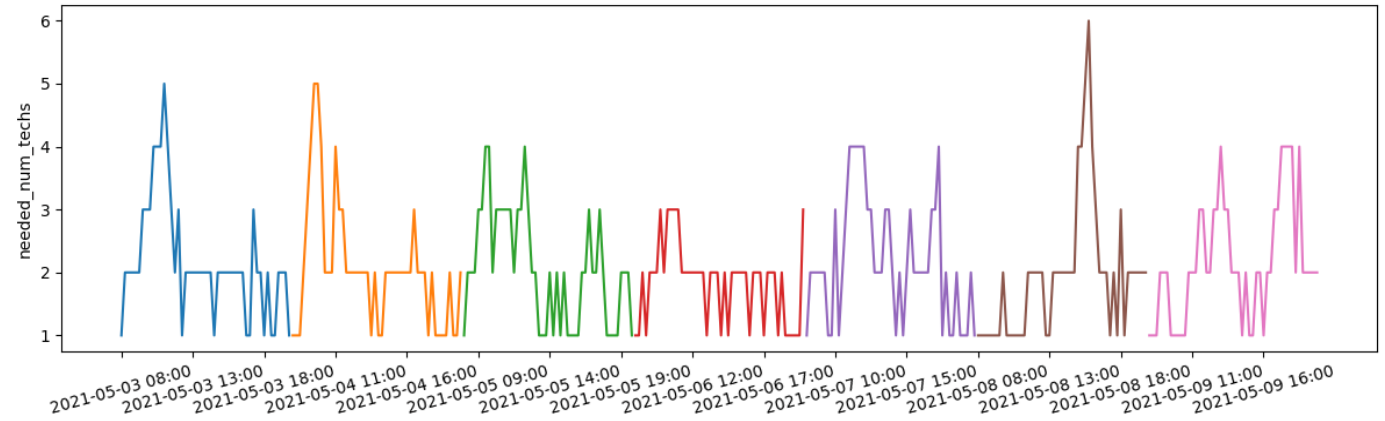
(Integrated)

AR I MA

(Autoregressive)   (Moving-Average)

Augmented Dickey-Fuller Test

```
ADF Test Statistic:  -6.393478079011247
p-value:  2.0781867199569106e-08
# of Lags Used:  2
# of Obs. Used:  333
```
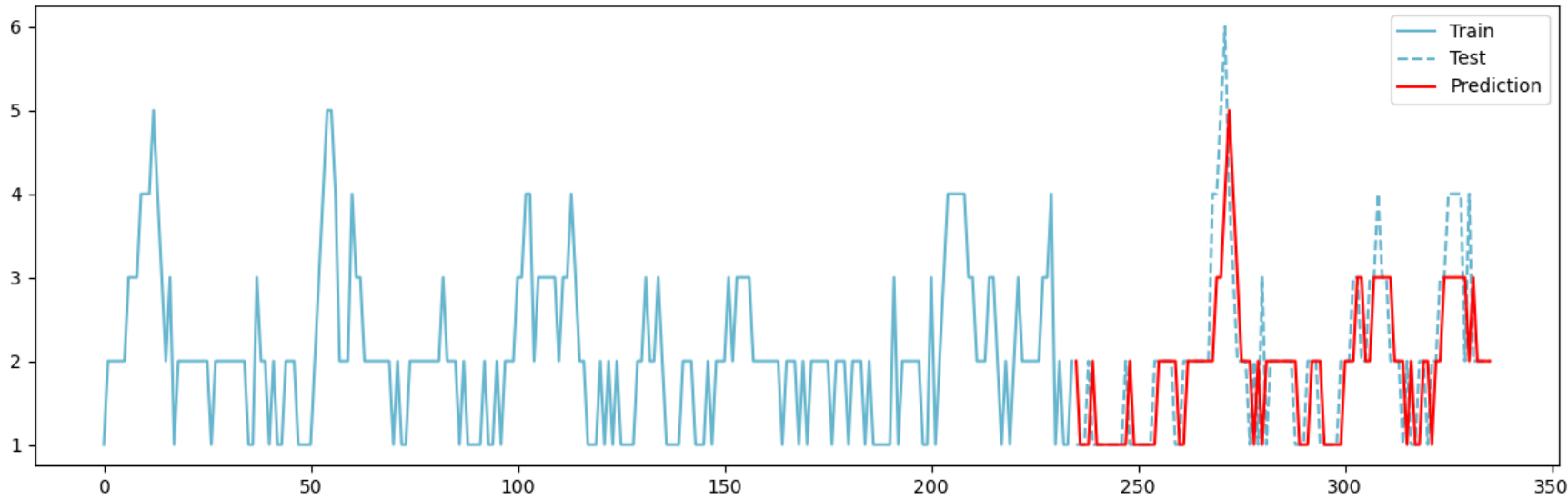
REJECT H_0!

✓ Data is **stationary!**

Autocorrelation

Partial Autocorrelation

Modeling

Time Series - ARIMA

RMSEs (05-2021):

- Denver: 0.69

- Wheat Ridge: 0.67

- Edgewater: 0.72

- RiNo: 0.65

- Lakewood: 0.67

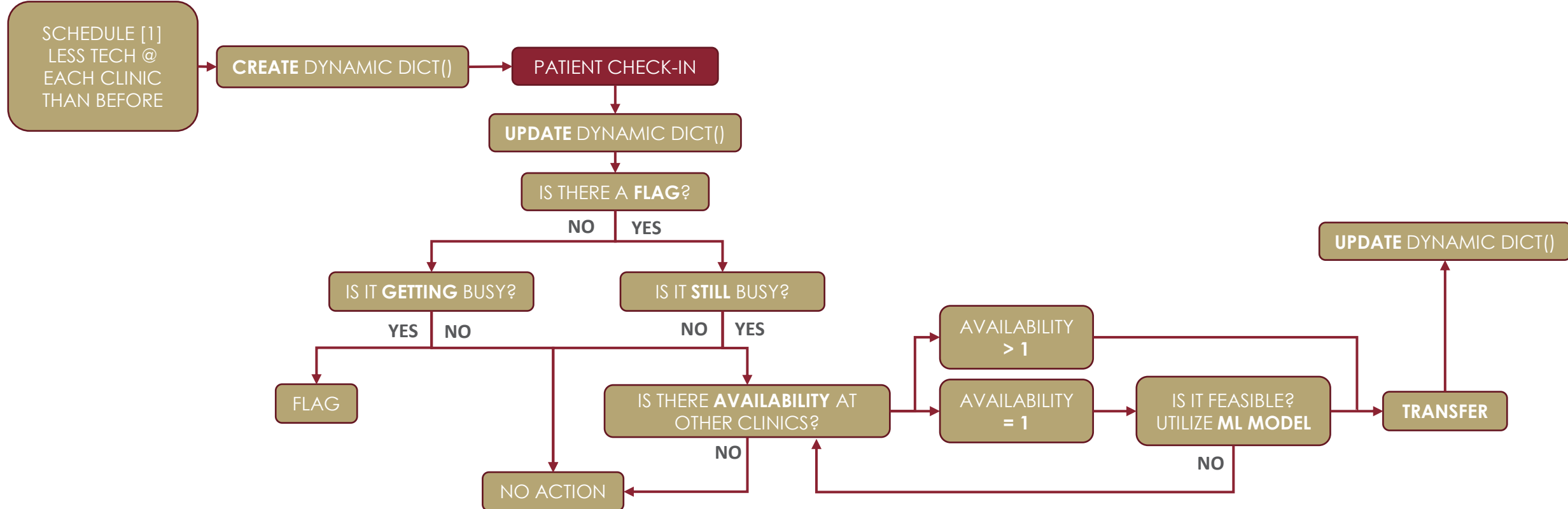**CONSIDERATIONS**: Model Performance | Time / Model Complexity | Algorithm Integration

TecNav Algorithm

Flowchart

SCHEDULE [1] LESS TECH @ EACH CLINIC THAN BEFORE → **CREATE** DYNAMIC DICT() → PATIENT CHECK-IN → **UPDATE** DYNAMIC DICT() → IS THERE A **FLAG**?

- NO → IS IT **GETTING** BUSY?
  - YES → FLAG
  - NO → NO ACTION
- YES → IS IT **STILL** BUSY?
  - NO → NO ACTION
  - YES → IS THERE **AVAILABILITY** AT OTHER CLINICS?
    - NO → NO ACTION
    - AVAILABILITY > 1 → TRANSFER
    - AVAILABILITY = 1 → IS IT FEASIBLE? UTILIZE **ML MODEL**
      - NO → IS THERE **AVAILABILITY** AT OTHER CLINICS?
      - TRANSFER → **UPDATE** DYNAMIC DICT()

Demo
Interactive Prototype of Software Application

Conclusions & Recommendations

Client Success Metrics

For our chain of 5 clinics, TecNav recommends:

- **5 less** technicians per day
  - No need for navigator

- **$91,980** savings in **yearly compensation** ($7665/month)
  - ~$21/hr (avg. Denver wage)

- **357** moves a **month**
  - Gas reimbursements: **$264**
  - Based on distances & Denver gas prices

- **Total yearly savings: $88,812***

* Minus a TecNav subscription fee ☺

Savings can be applied to:

- Expand scope of services
  - Advanced diagnostic tools
  - Imaging equipment

- Minimize cost to patients

Project Reflections

Challenges & Future Directions

Technical Challenges

- Fabrication tuning
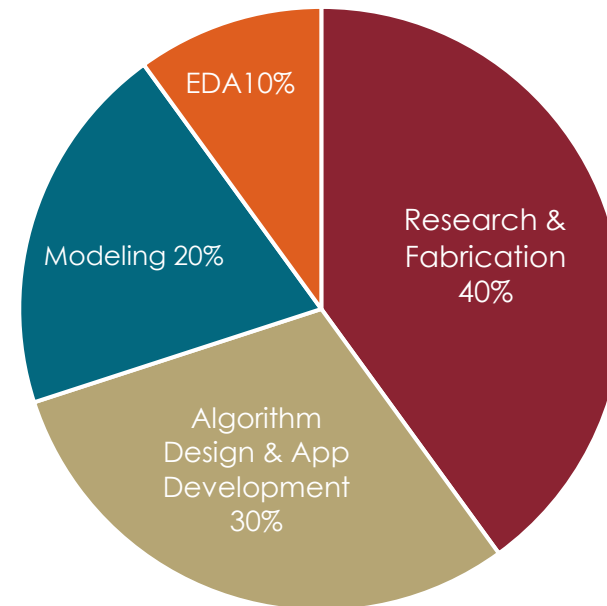- Translatable study design

Improvements

- Extra layers of sophistication
- Manual "Grid-Search"

Alternative Strategies

- Broaden applicability
- Wait-Time focus

Development Breakdown

- EDA 10%
- Modeling 20%
- Research & Fabrication 40%
- Algorithm Design & App Development 30%

Thank you!

github.com/rc-9/TecNav
github.com/RemoNona/TecNav

Tomer.Danon@du.edu

Romith.Challa@du.edu

Connect with us!