Analyzing Emergency Department (ED) Wait Times to Improve Patient Flow

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Abstract

We analyze Emergency Department (ED) wait times using a synthetic hospital dataset prepared in the style of Kaggle. Data was cleaned in Python and organized for analysis. Exploratory analysis shows an average wait around the mid-30 minutes, with the 90th percentile near 60 minutes. Demographics (age, gender, race) have minimal impact, while temporal patterns (hour of day and weekday-hour pockets) drive most variation. The report summarizes the dataset, cleaning steps, analysis, and actionable recommendations for staffing alignment, fast-track pathways, and better bed turnover coordination.

Keywords — Emergency Department, Patient Flow, Healthcare Analytics, Wait Time Analysis, EDA

I. Introduction

Emergency Departments handle unpredictable demand. Long waits increase clinical risk and lower satisfaction. Our objective is to measure waiting, find when and where delays occur, and suggest practical fixes using a clean, analysis-ready dataset that mirrors real hospital operations.

II. Methodology

Dataset — Synthetic ED records similar to Kaggle releases, with admission timestamp, demographics, department referral, admission flag, wait time, and satisfaction. Cleaning — Parsed datetimes, extracted calendar features, standardized categories, coerced numerics, and validated ranges. SQL — Modular scripts for cleaning, feature engineering, aggregates, KPIs, and monitoring. EDA — Interrogated distributions, temporal patterns, and department-level summaries using your plots.

Table I. Dataset Summary

Metric	Value
Rows	9,216
Columns	14
Overall missing (%)	4.2%
Unique departments	7
Gender values	F, M, NC

Table II. Wait Time Statistics (minutes)

Statistic	Value
Min	10.0
Median	35.0
Mean	35.3
90th percentile	56.0
Max	60.0

Table III. Average Wait by Department (Top 7)

Department	Avg Wait (min)
Neurology	36.8
Physiotherapy	36.6
Gastroenterology	35.8
Cardiology	35.4
Orthopedics	35.0
General Practice	34.9
Renal	34.7

III. Exploratory Data Analysis

Age Distribution of Patients

The age profile is broadly balanced across working-age and older adults. This suggests case mix stability with respect to age.

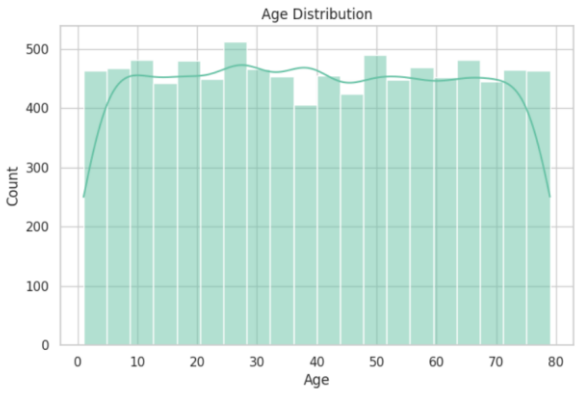

Fig. 1. Age Distribution of Patients

Gender Distribution of Patients

Male and female volumes are comparable. Gender alone does not explain systematic wait differences.

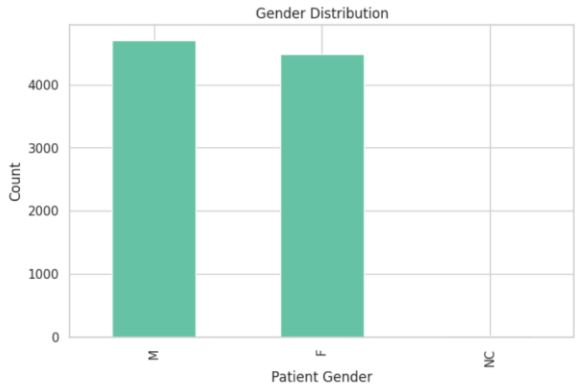

Fig. 2. Gender Distribution of Patients

Top Races in the Dataset

Race composition reflects the service population. Later checks should ensure equitable waits across groups.

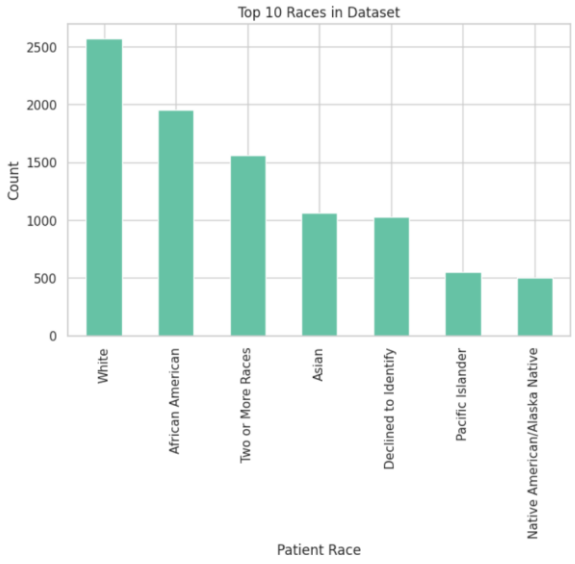

Fig. 3. Top Races in the Dataset

Department Referrals

General Practice and Orthopedics dominate volumes. These units are prime targets for throughput tuning during peaks.

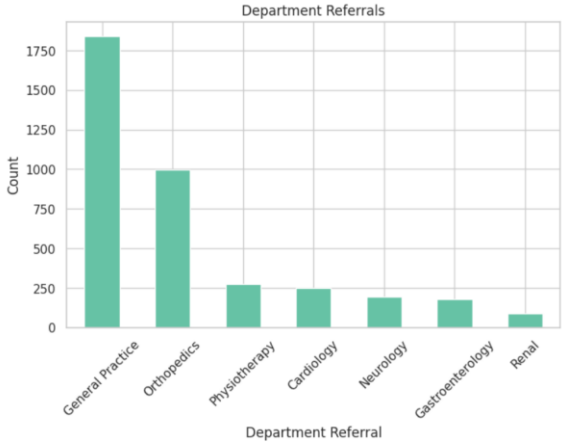

Fig. 4. Department Referrals

Patient Satisfaction Distribution

Satisfaction clusters mid-scale. Protecting patients from long right-tail waits is key to preventing low scores.

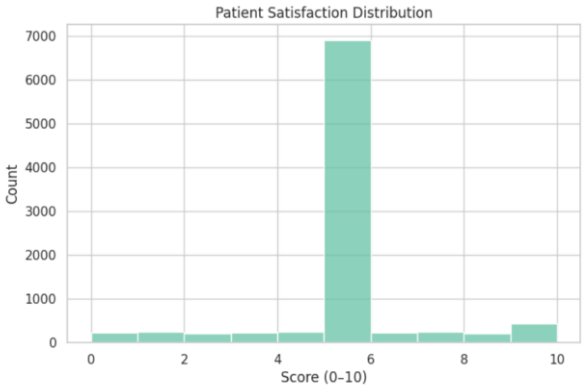

Fig. 5. Patient Satisfaction Distribution

Distribution of ED Wait Times

Waits center in the mid-30s with a noticeable right tail toward 60 minutes. The 90th percentile defines an operational SLA boundary.

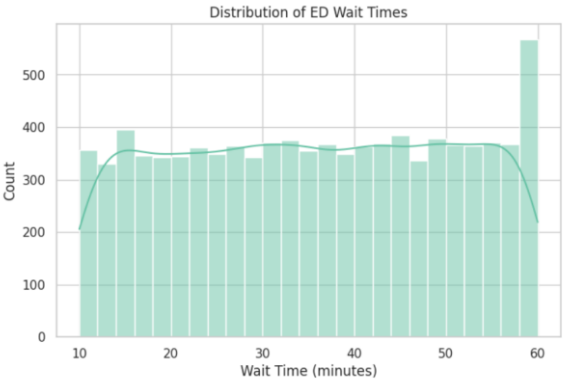

Fig. 6. Distribution of ED Wait Times

Wait Time by Gender

Medians and spreads are similar across genders, indicating no gender-specific queueing effect.

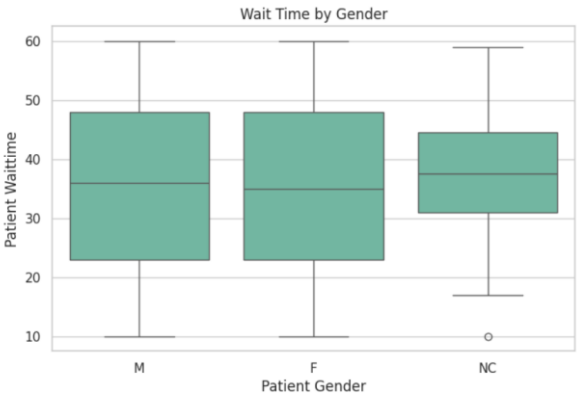

Fig. 7. Wait Time by Gender

Wait Time by Admission (0=No, 1=Yes)

Admitted and non-admitted patients have comparable medians. Boarding delays require inpatient data to diagnose.

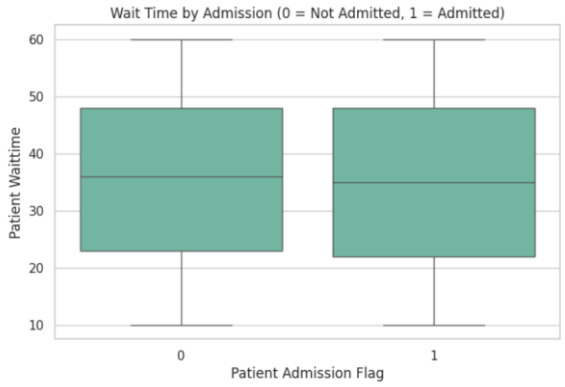

Fig. 8. Wait Time by Admission (0=No, 1=Yes)

Wait Time by Age Group

Child, Adult, Middle-Aged, and Senior cohorts show similar medians. No age-driven prioritization effect is obvious.

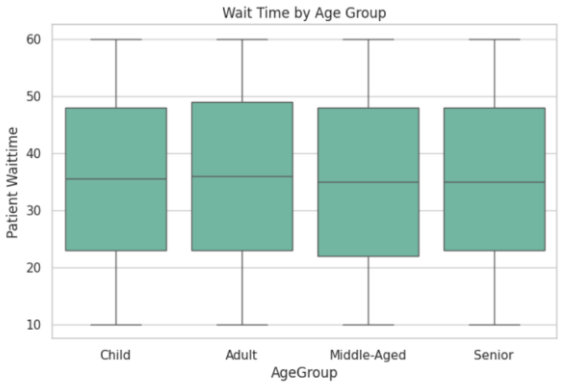

Fig. 9. Wait Time by Age Group

Average Wait by Department

Departments exhibit tightly clustered averages around the mid-30s, pointing to system-level (not unit-specific) constraints.

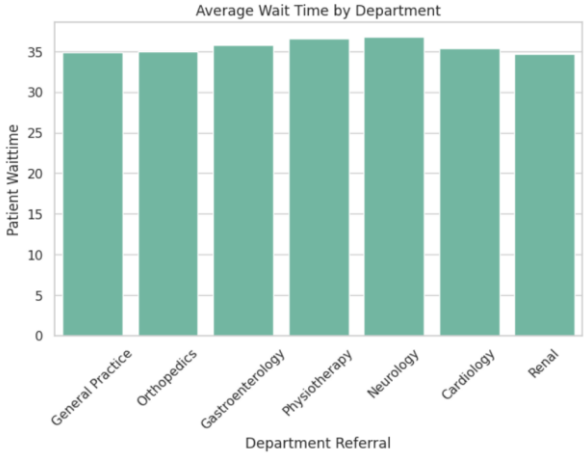

Fig. 10. Average Wait by Department

Average Wait by Weekday

Daily averages are fairly flat Monday through Sunday. Staffing levels are broadly aligned day-to-day.

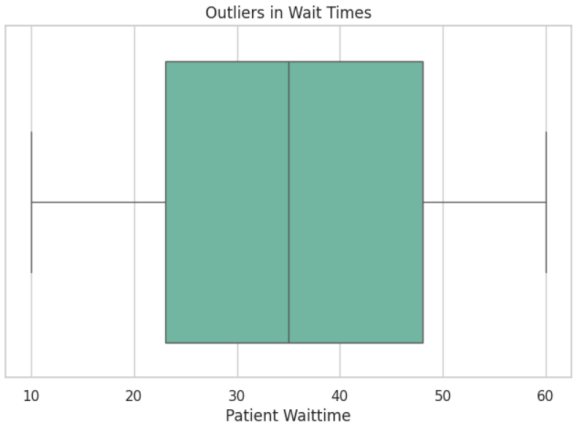

Fig. 11. Average Wait by Weekday

Average Wait by Hour of Day

A diurnal pattern appears, with higher averages at certain hours. Shifts should start before the rising edge of these peaks.

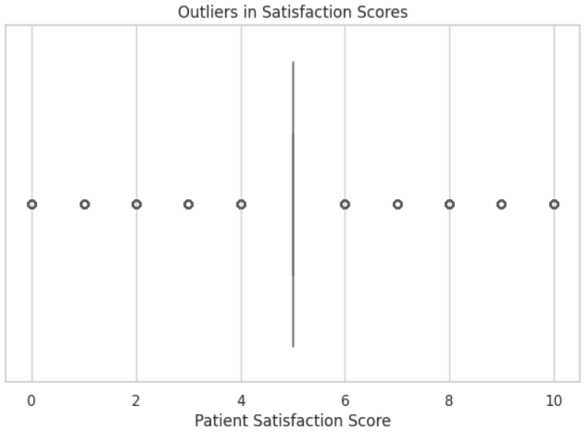

Fig. 12. Average Wait by Hour of Day

Heatmap of Average Wait (Weekday x Hour)

Hot cells identify day-hour pockets of congestion. These windows should trigger surge staffing or fast-track activation.

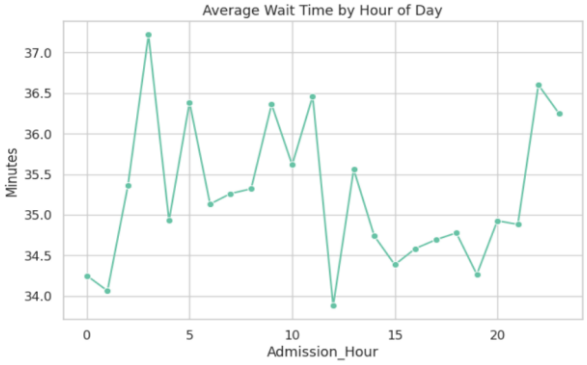

Fig. 13. Heatmap of Average Wait (Weekday x Hour)

Correlation Matrix (Numeric Features)

Pairwise correlations are near zero, consistent with multi-factor drivers rather than a single numeric predictor.

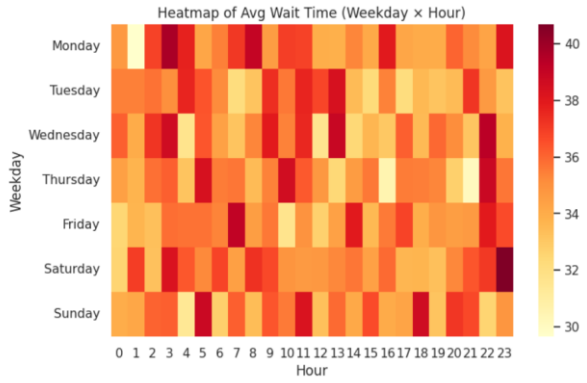

Fig. 14. Correlation Matrix (Numeric Features)

Outliers in Wait Times

Whiskers span roughly 10–60 minutes; extremes signal episodic congestion. Set alerts on rolling average breaches.

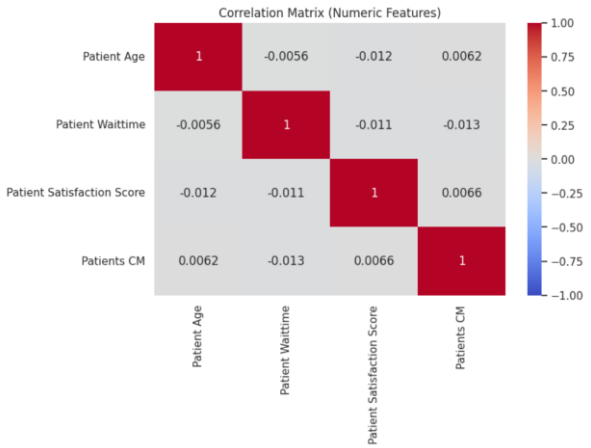

Fig. 15. Outliers in Wait Times

Outliers in Satisfaction Scores

Satisfaction centers near 5–6 with wide outliers. Proactive communication at 30 and 60 minutes can offset low scores.

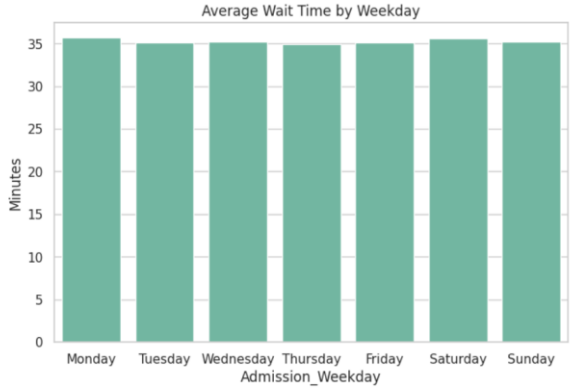

Fig. 16. Outliers in Satisfaction Scores

IV. Results and Discussion

Demographics have limited explanatory power: age and gender medians are similar. The most actionable signal is temporal: hour-of-day and weekday-hour pockets show consistent surges. Departments are tightly clustered, suggesting system-level throughput constraints rather than one problematic unit. Therefore, targeted staffing around peaks and fast-track activation are expected to reduce the 90th percentile of wait times.

V. Recommendations

1) Shift optimization: start provider shifts before peak hours to blunt the rising queue. 2) Fast-track non-urgent patients during peak windows. 3) Bed turnover coordination with inpatient units when rolling average wait exceeds threshold. 4) Transparent expectation management: display expected wait and schedule nurse check-ins at 30 and 60 minutes. 5) Continuous monitoring: automate alerts for day-hour hotspots and right-tail breaches.

VI. Conclusion

ED waits in this dataset cluster around the mid-30 minutes with a notable right tail near 60 minutes. Temporal demand spikes, not demographics, dominate the variation. Practical operational changes focused on peak coverage, streaming of low-acuity patients, and bed coordination should materially improve patient flow and satisfaction.