IS6611 Applied Research in Business Analytics

# IT Artefact v1 Report

GROUP 3


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# Transforming Hospital Workflow with AI -
# A Dynamic Queue System for Improved Patient Care

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## 1. Context and Motivation:

Hospitals today face significant challenges with growing patient volumes, especially in outpatient settings. The traditional first-come, first-served queue system, despite patients registering online or by phone, results in delays for patients with urgent needs and additional strain on hospital staff (Health Catalyst, 2023). These inefficiencies lead to long wait times, increased stress on staff, and potentially delayed care for critical patients.

Our AI-powered solution dynamically adjusts the patient queue in real time based on the severity of each patient's condition. The AI evaluates incoming patient data such as symptoms, vital signs, and medical history and assigns an urgency level (Critical, Moderate, Low). Admin staff can quickly update a patient's profile in case of emergencies, rerun the AI model, and reassess the patient’s queue position. This real-time adjustment helps reduce waiting times for critical patients and ensures timely intervention. Additionally, the system tracks unserved patients and identifies staffing needs, facilitating better resource allocation.

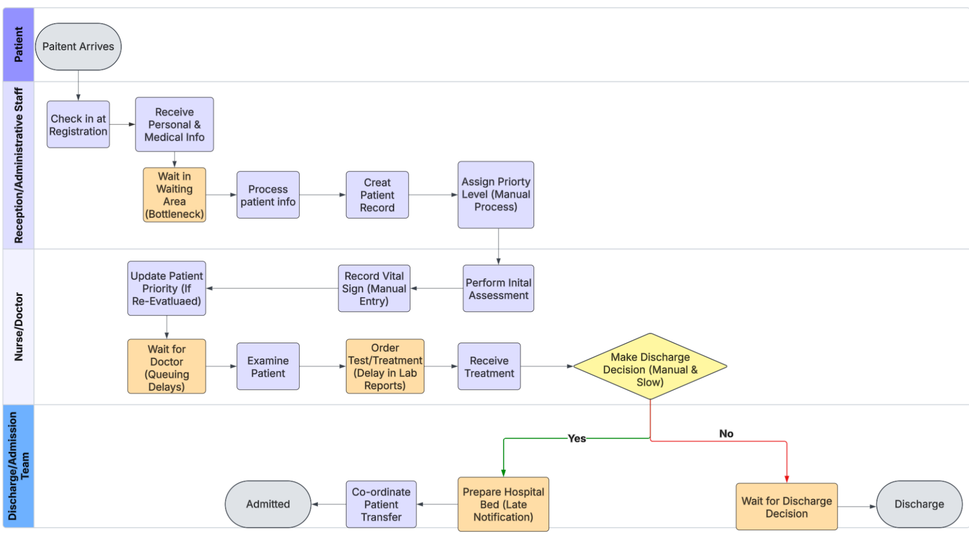
This solution aligns with **SDG 3 (Good Health and Well-being)** and **SDG 9 (Industry, Innovation, and Infrastructure)**, contributing to improved hospital efficiency, better healthcare outcomes, and reduced operational costs.

## 2. Current System [AS-IS Swimlane]

The current system relies heavily on manual processes for triaging patients. Admin staff are responsible for assigning priority levels to patients, recording vital signs, and making decisions on discharge (Smith, 2023). This reliance on human judgment results in inconsistent prioritization, particularly during peak hours. Key bottlenecks include waiting for lab results, delayed notifications regarding bed availability, and difficulty in prioritizing critical cases.

As shown in **Figure 1**, there is no automated mechanism to prioritize patients based on urgency during registration. Consequently, critical patients may experience delays in receiving timely care, leading to potentially negative outcomes. This system not only strains staff but also affects the overall efficiency of the hospital.

Figure 1: Current Hospital Queue Process



**3. Problem Exploration and Planning (Informed by Design Thinking)**

We used design thinking principles to empathize with both patients and hospital staff. Patients experience anxiety while waiting for care, regardless of the severity of their symptoms. On the administrative side, hospital staff face the challenge of balancing fairness, medical urgency, and workload during high patient volumes.

Our solution addresses the lack of an intelligent queue system. The AI algorithm analyzes patient data (symptoms, vitals, and arrival time) to dynamically prioritize patients in the queue. Admin staff can update patient details in real time, allowing the system to adjust the queue based on current conditions. This combination of AI and human control helps manage patient flow efficiently while maintaining flexibility for human oversight.

**Design Thinking Artifacts:**

We created several artifacts to ensure that all key stakeholders : admin staff, doctors, and patients are considered in the system design:

- Stakeholder Map: Identifying roles and responsibilities.
- Personas: Developed for key users like Stacey Goicoa (Admin), Pavan Madhav (Patient), and Priya Nair (Doctor).
- Customer Journey Maps: Mapping the experience of each persona to identify pain points and opportunities for improvement.
- Empathy Maps: Capturing the thoughts, feelings, and needs of each persona to ensure the system meets their expectations.

Figure 2: Stakeholder Map

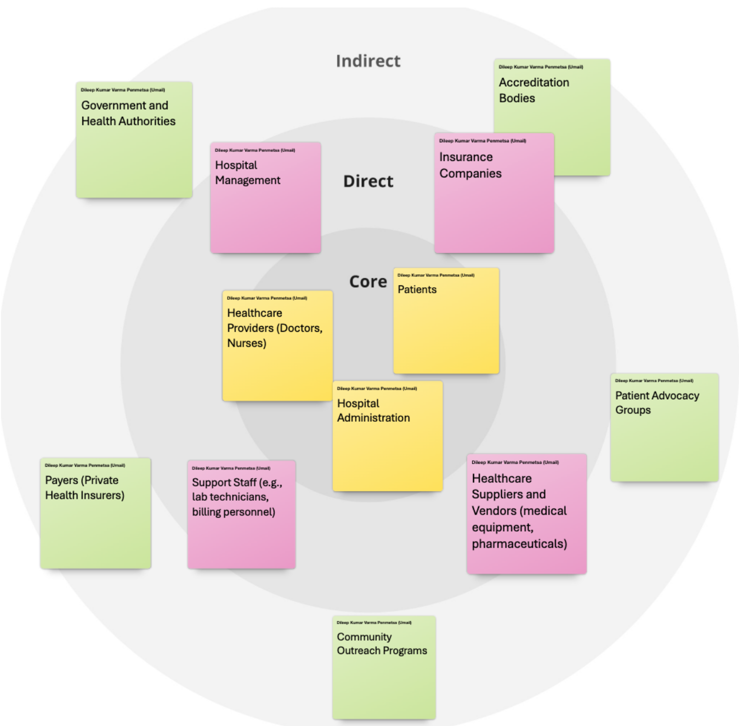


Figure 3: Persona 1- Stacey Goicoa (Admin Staff)

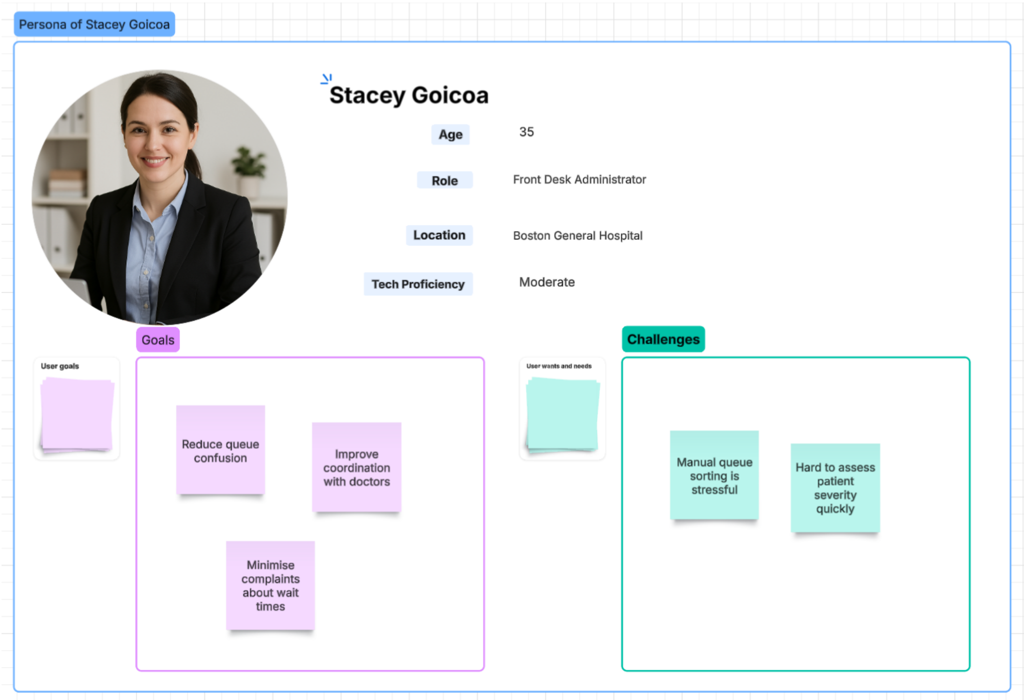



Figure 4: Persona 2- Pavan Madhav (Patient)

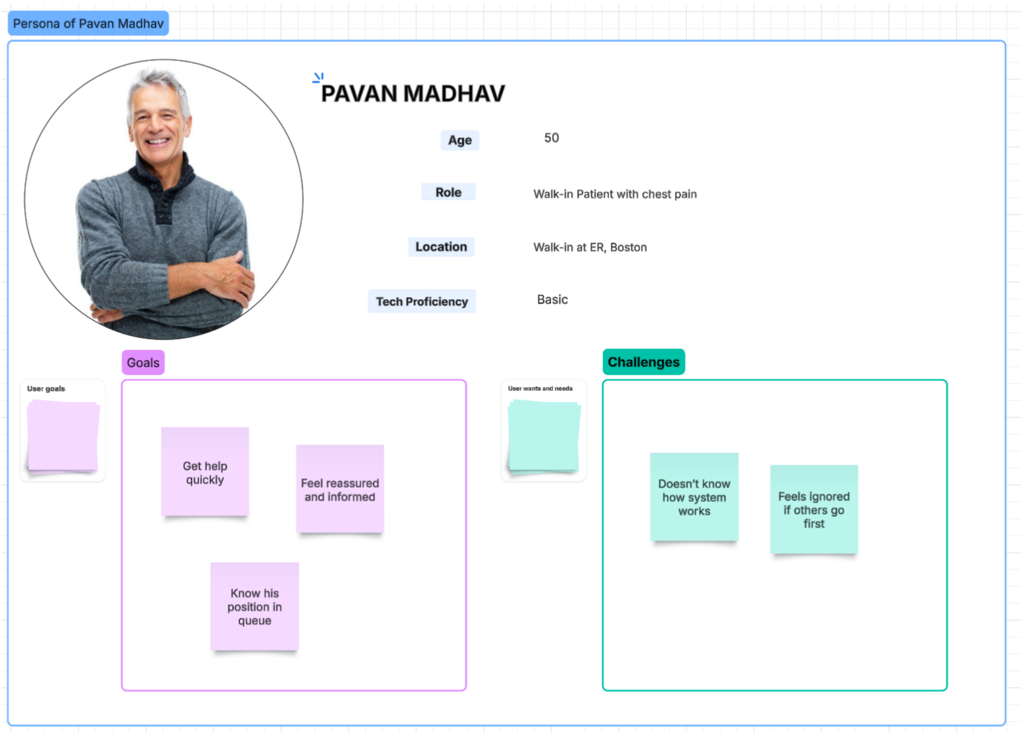
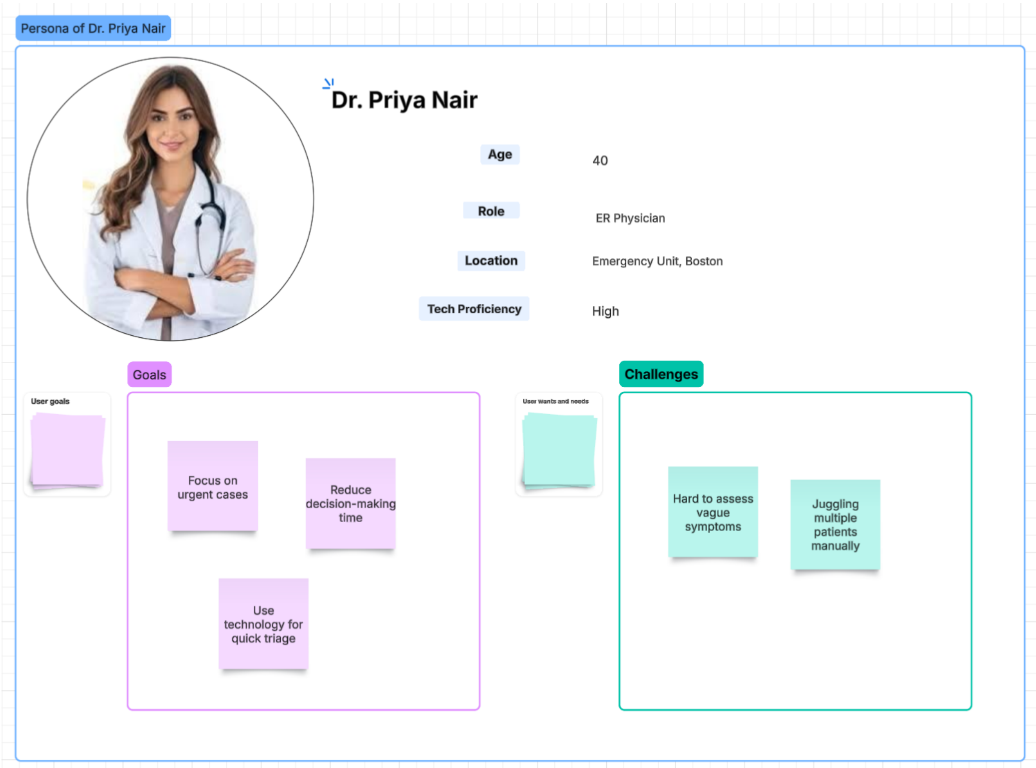


Figure 5: Persona 3- Priya Nair (Doctor)




- ## Customer Journey Maps

Figure 6: Customer Journey Map for Stacey Goicoa (Admin Staff)

| | Action | Touch Point | Emotion | Piain Point |
|---|---|---|---|---|
| Arrival | Patient registers | Front Desk System | Stressed | Unsure how urgent the patient is |
| Input | Enters patient symptoms | Admin Web App | Neutral | Time-consuming & prone to human error |
| Predict | Clicks "Predict Urgency" | Queue Interface | Curious | Needs confirmation model works |
| Adjust | Queue updates automatically | Dashboard | Relieved | Wants final control if needed |
| Monitor | Tracks live queue status | Queue Table | Satisfied | Would prefer alert system for spikes |

Figure 7: Customer Journey Map for Pavan Madhav (Patient)

| | Action | Touch Point | Emotion | Piain Point |
|---|---|---|---|---|
| Arrival | Reaches hospital, explains pain | Help desk | Anxious | Fears his case may be skipped |
| Wait | Waits in area | Queue screen | Confused | Doesn't understand queue changes |
| Notfiy | Queue adjusts due to urgency | Digital screen/phone | Curious | Seeks clarity on why he was prioritised |
| Treat | Called ahead of others | Doctor's Room | Relieved | Relieved but unsure about system logic |
| Follow Up | Sees doctor notes and status | Patient App | Empowered | Appreciates post-visit transparency |

Figure 8: Customer Journey Map for Priya Nair (Doctor)

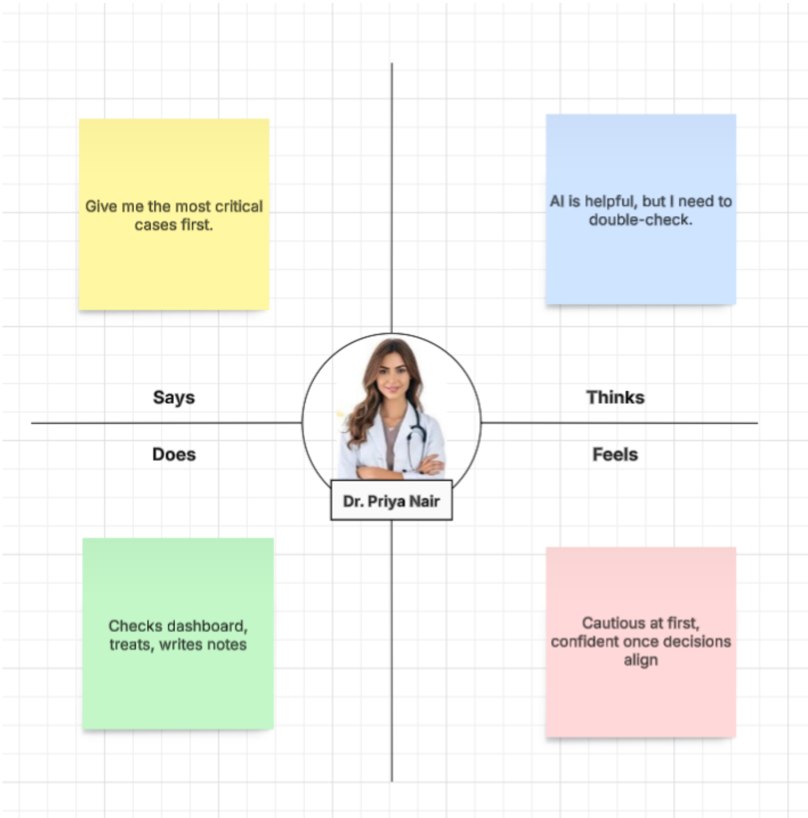
| | Action | Touch Point | Emotion | Piain Point |
|---|---|---|---|---|
| Login | Opens queue dashboard | Doctor App | Alert | Needs high-level case summaries fast |
| Review | Reads urgency + case history | Summary UI | Impressed | Relies on AI accuracy for decisions |
| Confirm | Confirms triage logic | Bedside Consult | Focused | Sometimes AI score might need override |
| Update | Enters treatment notes | EMR system | Confident | Wants smoother integration |
| Hand Off | Finalises status for admin | Doctor Dashboard | Responsible | Needs digital trail for accountability |

- **Empathy Maps** to capture what users see, feel, think, and do.

Figure 9: Empathy Map for Stacey Goicoa (Admin Staff)


Figure 10: Empathy Map for Pavan Madhav (Patient)

Figure 11: Empathy Map for Priya Nair (Doctor)




**4. Proposed System [TO-BE Swimlane (AI-Integrated System)]**

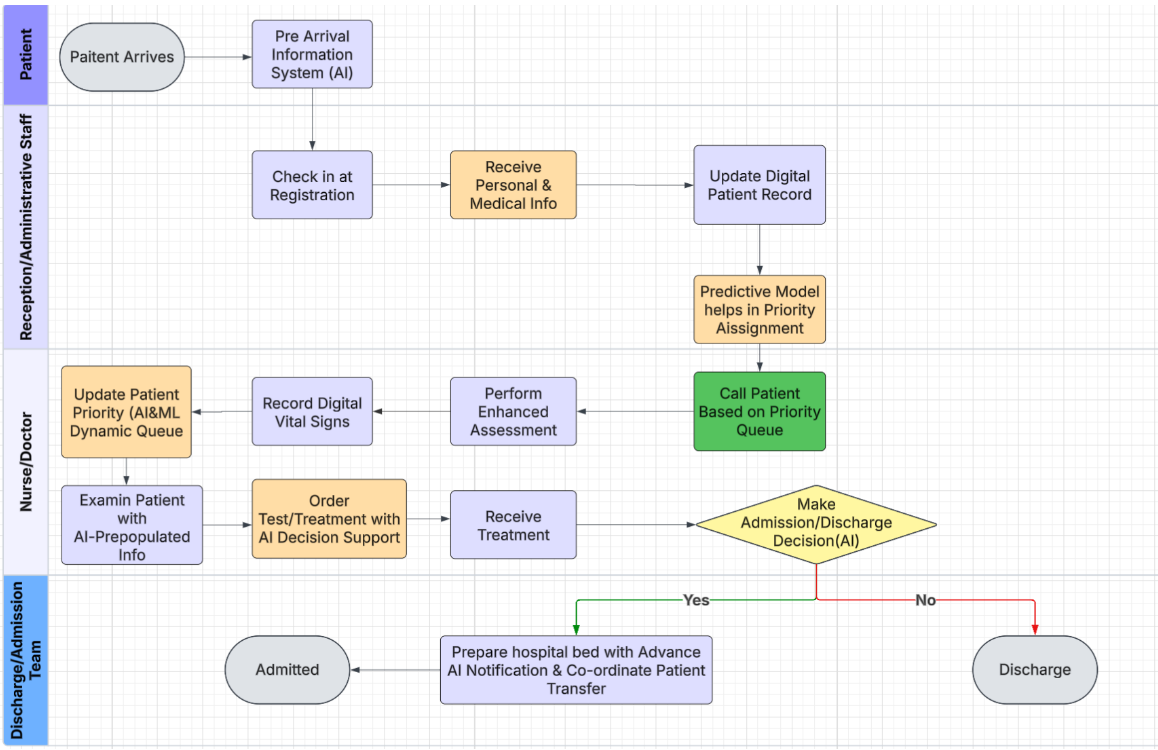
The AI-powered system dynamically adjusts the patient queue based on the severity of each patient's condition. This feature improves patient care by ensuring that critical patients are prioritized. The system evaluates symptoms, vital signs, and medical history to assign an urgency level (Critical, Moderate, Low). Admin staff can update the data and re-run the AI model to make immediate adjustments as emergencies arise.

**Key Features**:

- **Real-Time Patient Information**: The system allows patient to access visit history, prescriptions, and test results immediately.
- **AI Assistance**: The AI suggests prioritization based on urgency, helping staff make quick decisions.
- **Manual Override**: In emergencies, staff can manually update patient information and re-run the AI model.
- **Dynamic Queue View**: Patients are color-coded (🔴 Critical, 🟡 Moderate, 🟢 Low), ensuring efficient care prioritization.

These features reduce wait times for critical patients, streamline hospital operations, and help prevent staff burnout by providing real-time decision support.

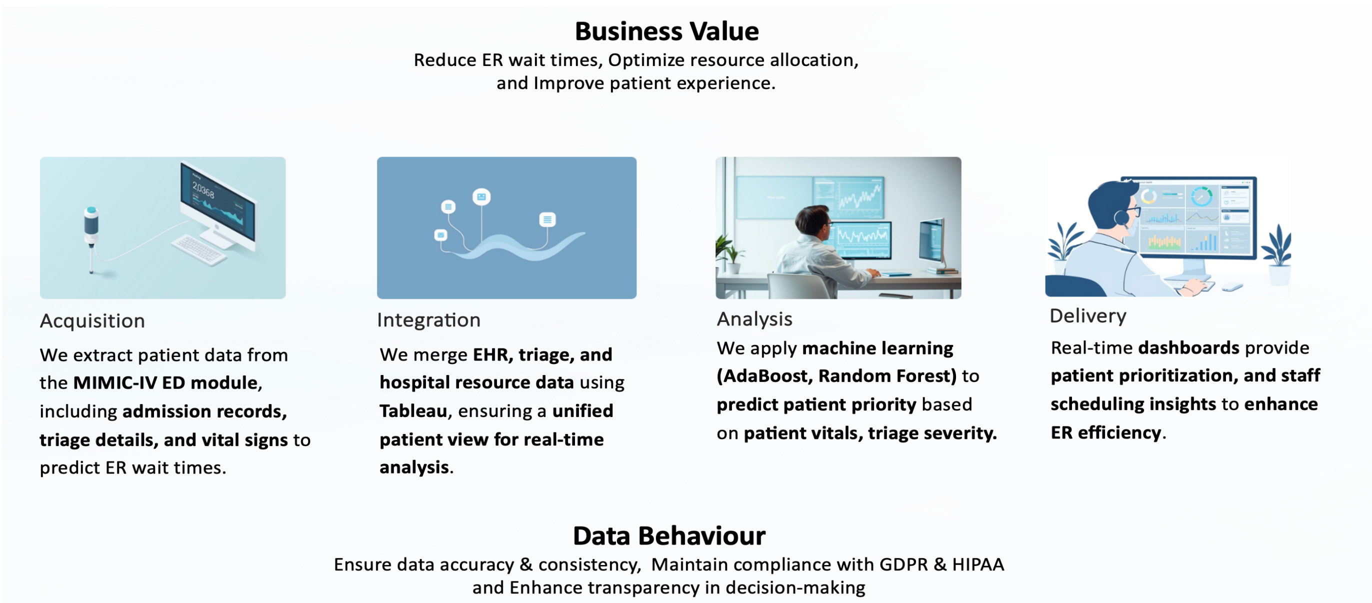
Figure 12: Proposed Queue System




## 5. Data Planning and Model Approach

We are using the **MIMIC-IV demo dataset** (Johnson et al., 2022), a comprehensive dataset of anonymized patient records, which includes demographic details, vitals, and symptoms. We apply machine learning models like **Random Forest** and **AdaBoost** to predict patient urgency. These models are ideal for handling large, complex datasets, and they provide a robust way to prioritize patients based on available data.

Figure 13: DVM



**Data Value Map (**Sammon, D. (2024):

1. **Acquisition**: Collect patient data, including symptoms, vital signs, and arrival time.
2. **Integration**: Clean and merge data from various sources (electronic health records, lab results) using SQL and data wrangling techniques.
3. **Analysis**: Apply machine learning models (Random Forest, AdaBoost) to assign urgency scores based on patient data.
4. **Delivery**: Implement the predictive engine through a simple web application (Flask-based).

**Model Evaluation**: We will evaluate model performance using metrics such as **Mean Squared Error (MSE)**, **Mean Absolute Error (MAE)**, and **$R^2$**. Additionally, **cross-validation** will be used to ensure the models generalize well to new data.

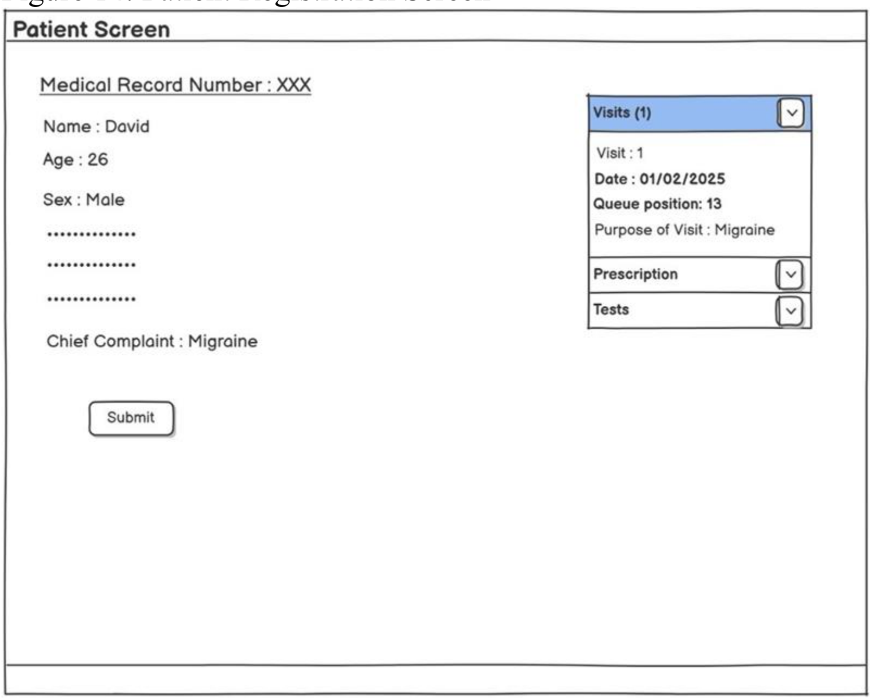
**6**. **Interface and Prototype**

We developed a **low-fidelity prototype** using **Balsamiq** to simulate the user interface. The system provides features such as real-time updates of patient data, dynamic queue management, and easy access to vital patient information.

Key Screens**:**

**6.1 Patient Registration Screen:** Allows patients to register their details and view their queue status.

Figure 14: Patient Registration Screen




**6.2 Admin Dashboard**: Enables staff to update patient details, prioritize based on severity, and adjust the queue dynamically.

**Prototypes**:

- **Before Prediction**: Admin interface without the AI prediction.
- **After Prediction**: AI-driven patient prioritization, with color-coded urgency levels.

Figure 15: Low-Fidelity Prototype of the Hospital Management System (Before Prediction)

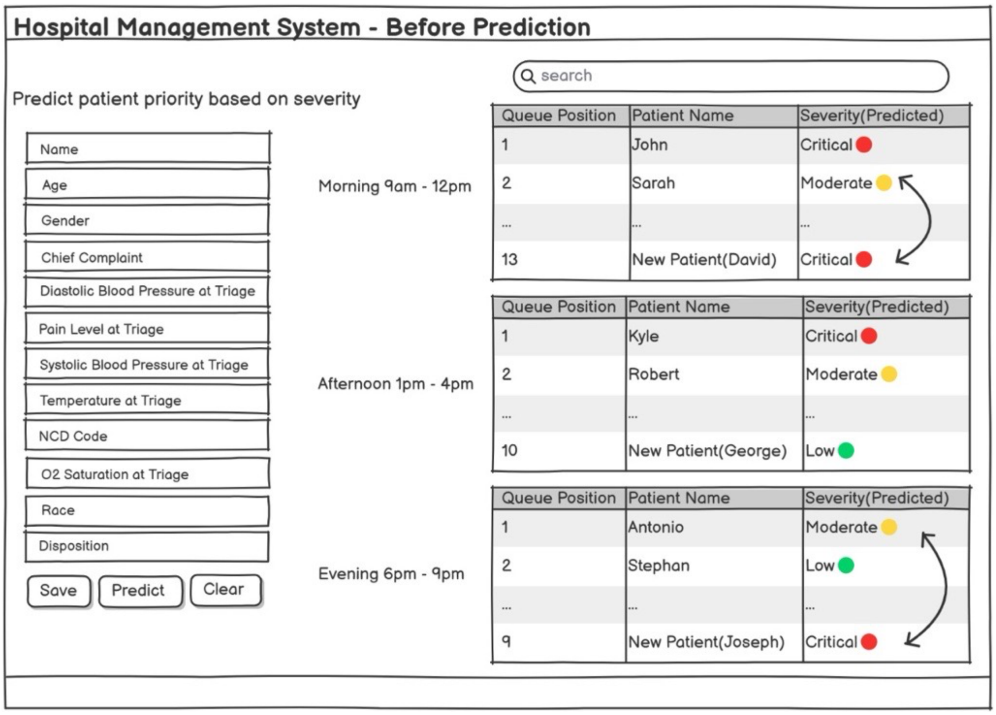
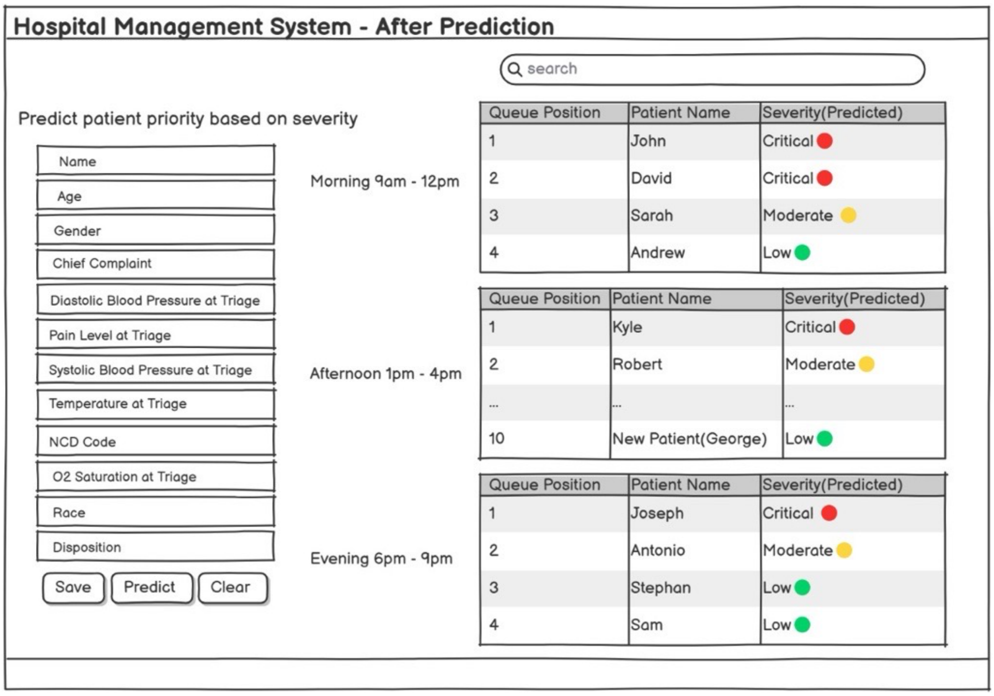
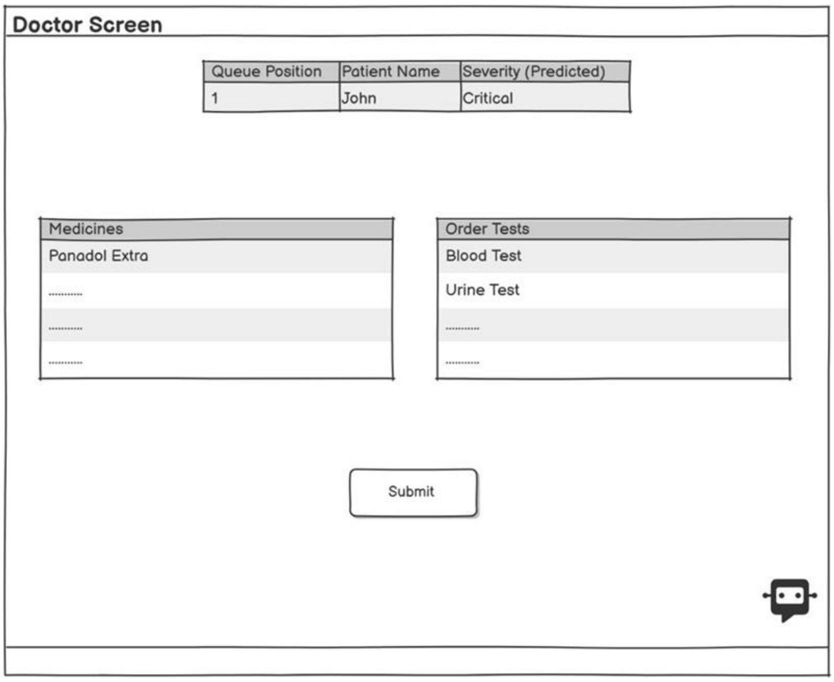



Figure 16: Low-Fidelity Prototype of the Hospital Management System (After Prediction)



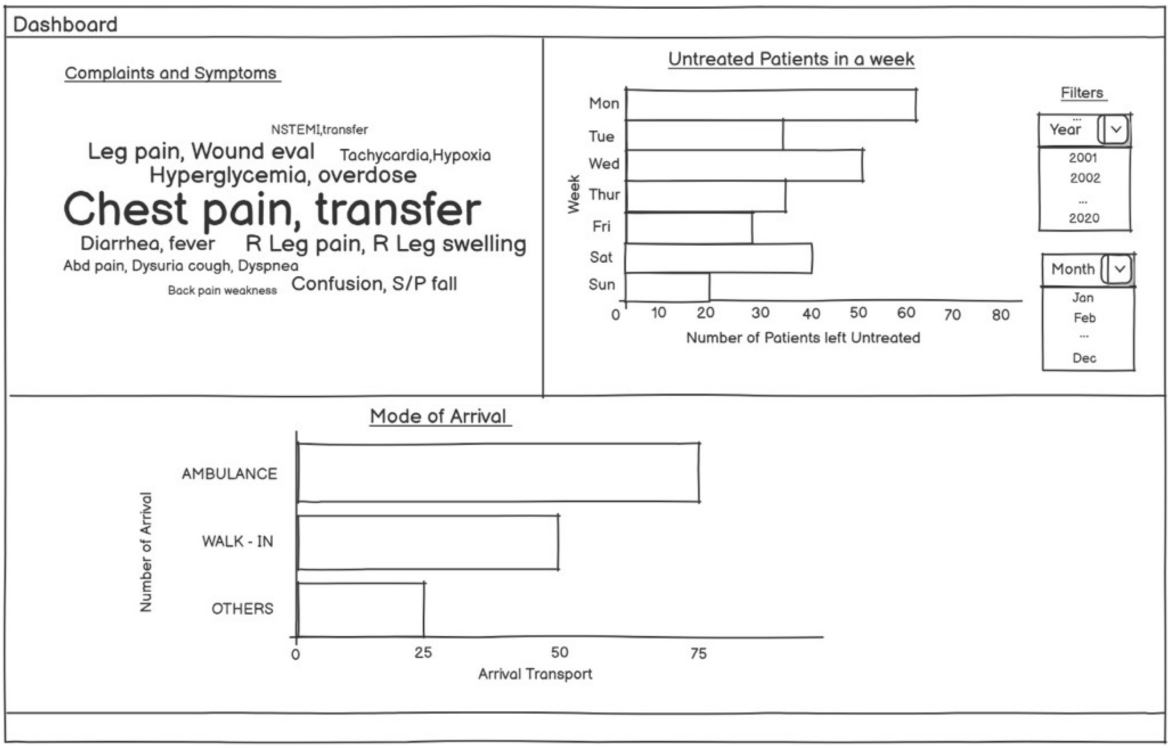
**6.3 Doctor's Interface**: Displays real-time patient data, including vital signs and AI suggestions for diagnosis and treatment.

Figure 17: Doctor Screen




**6.4 Dashboard Overview**: Provides hospital administrators with insights into patient load, staffing trends, and resource allocation needs.

Figure 18: Dashboard Overview



## 7. Value Creation and Future Path

The proposed system delivers multiple layers of value both immediate and long-term for hospital staff, management, and patients. It ensures that those in most need are seen first, while also supporting hospital administrators in understanding workload trends and planning resource allocation.

**Key Benefits**:

These benefits include reduced waiting times for critical patients, decreased staff stress due to automation, and enhanced operational visibility. Over time, hospitals can plan shifts better and anticipate surge periods, improving patient outcomes and system performance overall.

## 8. Team Collaboration and Research

Our team worked closely to develop this solution, each member contributing their expertise in different areas:

- **System Architecture**: Dileep and Nikhil focused on the architecture, ensuring it supported AI-based predictions.
- **Personas and Journey Maps**: Harshank and Aryan created detailed user personas and customer journey maps.
- **Wireframes**: Cindy and Dinesh developed the wireframes using Balsamiq, ensuring the design was intuitive and user-friendly.

Our research included case studies of healthcare systems, particularly the **Boston healthcare system**, and a review of AI applications in patient triage.

## 9. Conclusion

This AI-powered dynamic queue management system significantly improves the way hospitals handle patient flow. By prioritizing care based on real-time urgency, the system ensures that critical patients are seen first, while also optimizing staff workloads. The combination of AI predictions and manual oversight allows for flexible, responsive care that improves patient outcomes and reduces operational stress. Our next steps include expanding model accuracy, integrating a visual dashboard, and preparing for real-world testing.

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