EMERGENCY DEPARTMENT SIMULATION MODELING IN SIMIO: STAFFING AND CAPACITY DECISION ANALYSIS

1. Project Background and Objective

A regional hospital in the United States faced increasing emergency room congestion, with average wait times exceeding **4 hours** during peak evening shifts. Despite efforts to hire more staff, management lacked clarity on how staffing adjustments would affect **system-wide throughput, patient length of stay (LOS), and resource utilization**.

Project Goal: Use **Simio simulation modeling** to evaluate alternative staffing strategies and predict their effects on queue times, bed occupancy, and throughput in a typical 24-hour emergency department (ED) cycle.

2. System Components and Simulation Scope

Entities:

- Patients (categorized by triage level: Critical, Moderate, Minor)

Resources:

- Triage Nurses

- ED Physicians

- Examination Beds

- Admission/Discharge Coordinators

Process Flow:

1. Arrival →

2. Registration & Triage →

3. Wait for Doctor →

4. Examination & Treatment →

5. Decision (Discharge/Admit/Transfer)

3. Modeling Environment and Parameters

Software Used: Simio RPS Edition with animation visualization enabled

Key Model Features:

- Time-based arrival pattern (triangular distribution peaking at 6 PM)

- Probabilistic branching based on triage level

- Resource constraints and scheduling (staff roster defined by shift)

Assumptions:

Variable	Distribution/Value
Arrival Rate	Triangular(1, 3, 7) per 10 minutes
Treatment Duration	Normal(45, 10) minutes
Wait Time Threshold	Max 120 min for minor cases
Number of Beds	20
Staff Shift Configurations	3 per day: Morning, Evening, Night

4. Scenarios Modeled

Scenario	Description
Base	Existing staffing (2 nurses, 3 doctors/shift)
Alt 1	Add 1 nurse to evening shift
Alt 2	Add 1 nurse + 1 doctor to peak shift only
Alt 3	Increase beds from 20 → 25

5. Key Simulation Outputs (10 replications each)

Metric	Base	Alt 1	Alt 2	Alt 3
Avg. Wait Time (min)	104.6	84.2	**61.8**	71.3
Avg. Bed Utilization (%)	97.2	92.4	89.8	75.1
Patients Left Unseen (%)	6.4	4.7	**2.3**	3.9

Throughput (patients/day)	232	251	**273**	262

Best Performing Strategy: Alt 2 – strategically increasing staff during peak hours significantly reduced wait times and increased patient throughput without over-provisioning across all shifts.

6. Visualization and Model Animation

- **Real-time animation:** Visual representation of patient queues, resource allocation, and movement through treatment stages

- **Resource dashboard:** Live tracking of nurse and doctor utilization during the simulation

- **Gantt charts:** Visualized bottlenecks and idle resource time

7. Deliverables Provided

- .spfx Simio model files with full replication setup

- Simulation control spreadsheet for adjusting shift policies and bed capacity

- Interactive report: Scenario comparison dashboard (Excel + charts)

- Executive summary and recommendation brief

- Video walkthrough (optional) to demonstrate how to run the Simio model internally

8. Strategic Decision Outcome

- The hospital implemented **targeted staffing for high-volume evening shifts** with minimal full-day hiring

- Resulted in **21% reduction in average ED wait time** within two months

- Scenario model retained by operations for quarterly scheduling reviews

9. Stakeholder Relevance

- **Healthcare Sector:** Applicable for hospital operations managers, quality assurance teams, and consultants designing throughput solutions

- **Academic Use:** Suitable for teaching simulation modeling, capacity planning, and resource scheduling in operations research and healthcare analytics curricula