# Determining the Optimal Number of Treatment Facilities for SGH Department of Emergency Medicine

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## Problem Description

The Singapore General Hospital (SGH) Department of Emergency Medicine (DEM) is a 24-hour one-stop centre for managing major and minor emergencies such as trauma, strokes and toxic ingestions. The centre has been facing problems with overcrowding in recent years due to increasing demand for emergency services. With patient attendances more than doubling since its inception, patient load has severely outgrown existing infrastructure capacity. Inadequate space resulted in insufficient facilities, leading to congestions and long waiting times at the department. This compromises patient treatment, safety and privacy. Due to Singapore's rapidly ageing population, demand for DEM services is expected to rise further, thus prompting SGH's initiative to expand its current DEM facilities. The Systems Design Project (SDP) team was tasked to use simulation to determine the optimal number of facilities to meet current and future workload, with the aim of improving service quality and patient satisfaction.

**Objectives**: To determine the optimal number of key facilities (screening stations, triage stations, registration counters, P1 resuscitation bays, P2 critical care cubicles, P3 consultation rooms and beds in emergency observation wards) in order to
- Meet current workload and projected workload in 2030
- Meet the following waiting time KPIs for different patient types (classified by acuity level)

| Patient Type | Acuity Level | Waiting Time Targets |
|---|---|---|
| P1 patients | High | ASAP |
| P2 patients | Moderate | <= 20 min |
| P3 patients | Low | <= 60 min |

## System Analysis

Through observations at DEM and interviews with staff, a process map was developed to consolidate and define a common understanding.
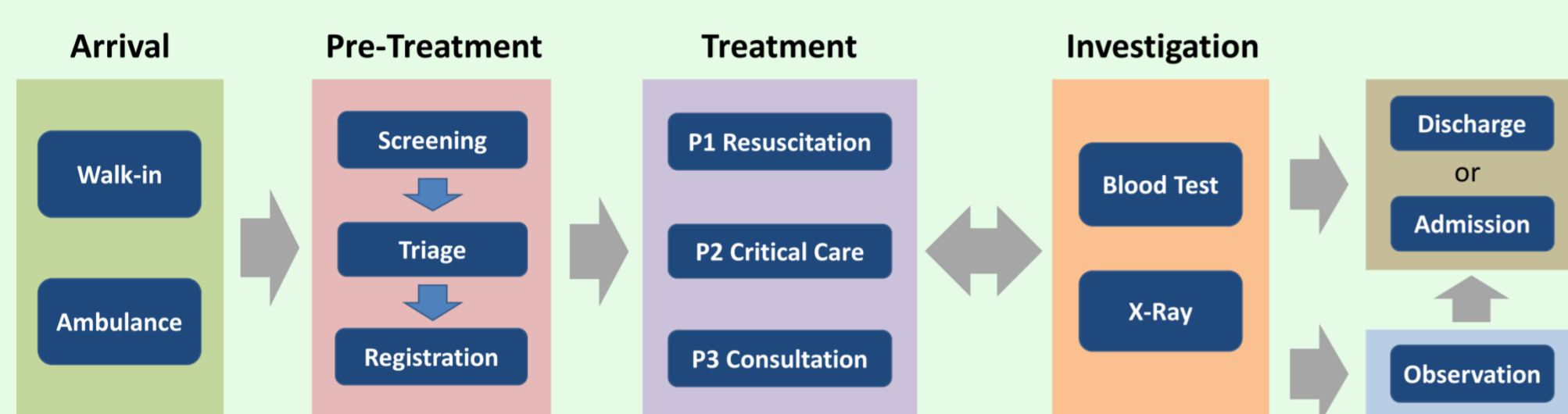


Currently, DEM sees an average of 428 patients a day in the following proportions of P1, P2, P3 patients: 16.8%, 30.2%, 53.0%.

**System Bottlenecks Identified:**
1. Insufficient capacity in P1, P2, P3 treatment areas
2. Non-adherence to standard procedures due to insufficient space e.g. lodgers

A cause and effect analysis using the Ishikawa diagram helped identify the factors that contributed to long waiting times at the DEM.
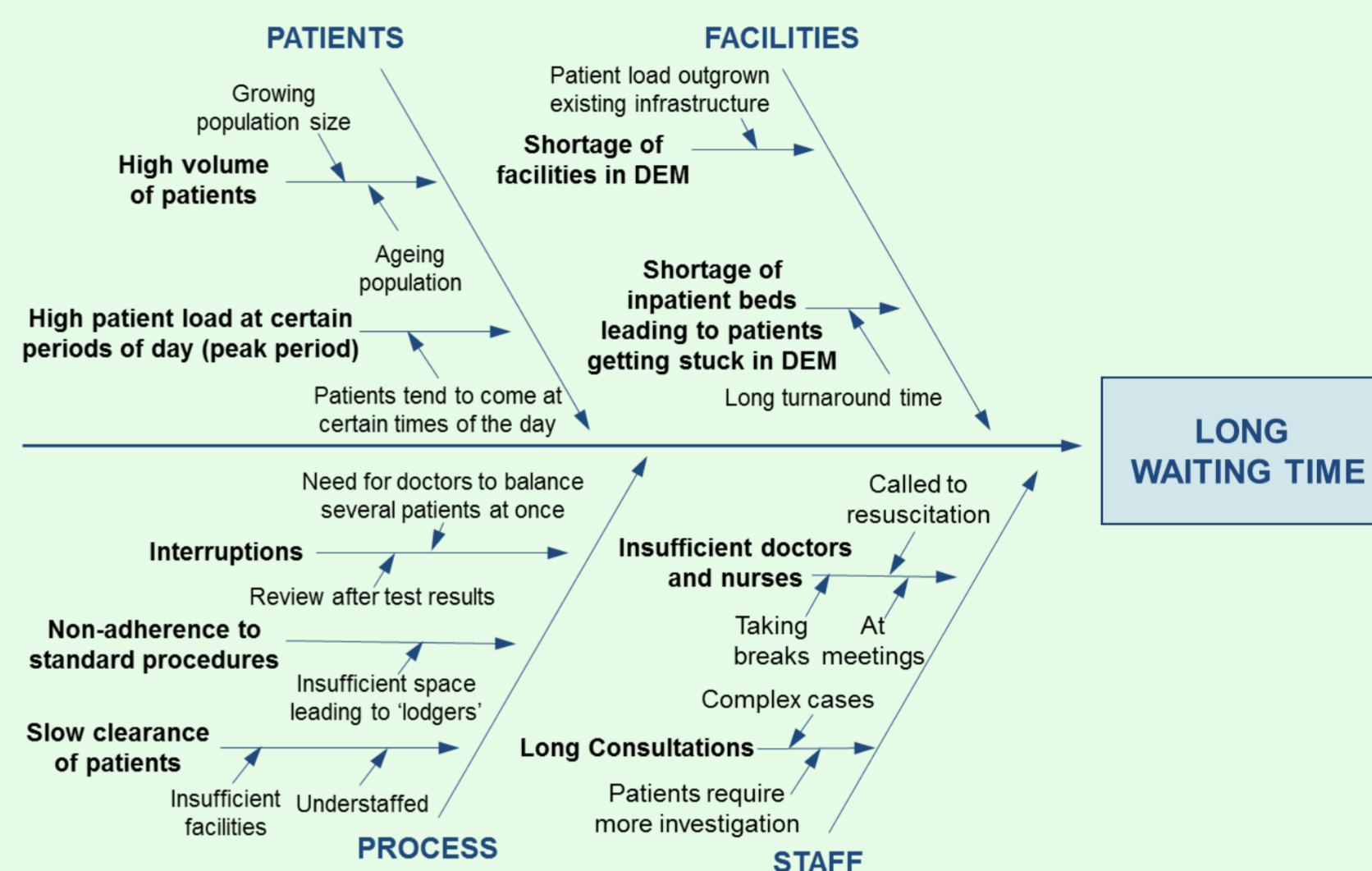


## Data Analysis

System data was analysed to obtain key information in problem formulation; accuracy of the data was assessed via on-site observations and data collection.

### A) Determining System Features
Different arrival patterns were found across 3 distinct time periods: 9am-5pm, 5pm-11pm, 11pm-9am; thus modeling in these various periods were differentiated for better model accuracy.
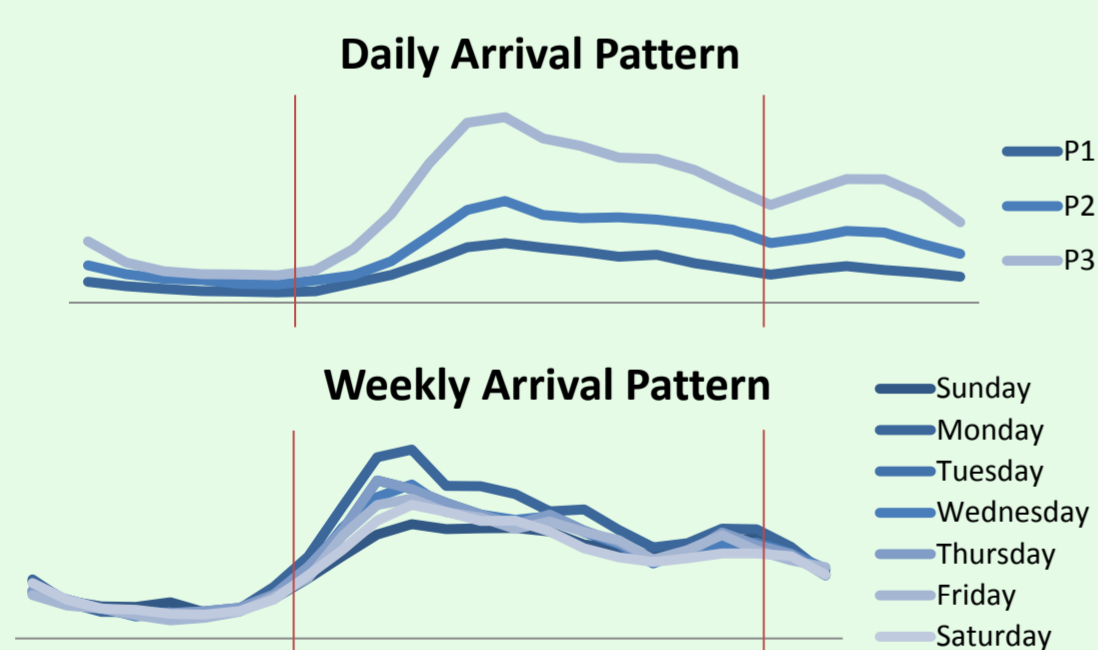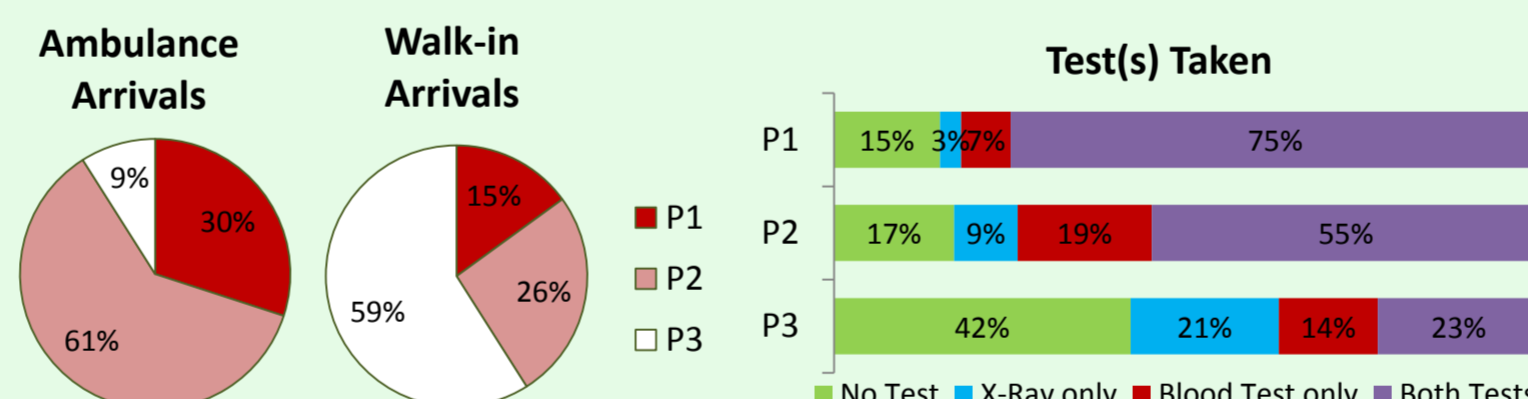


### B) Identifying Model Characteristics
Service time distributions for relevant stations were derived and goodness-of-fit tests performed to ensure accuracy.

**E.g. Blood Test Processing**
Lognormal Distribution
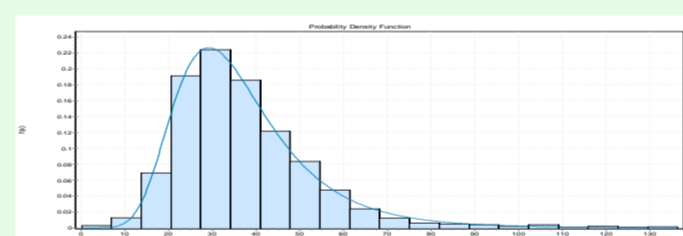
Relevant proportions were extracted for various stations to allow for more precise modeling through differentiation.
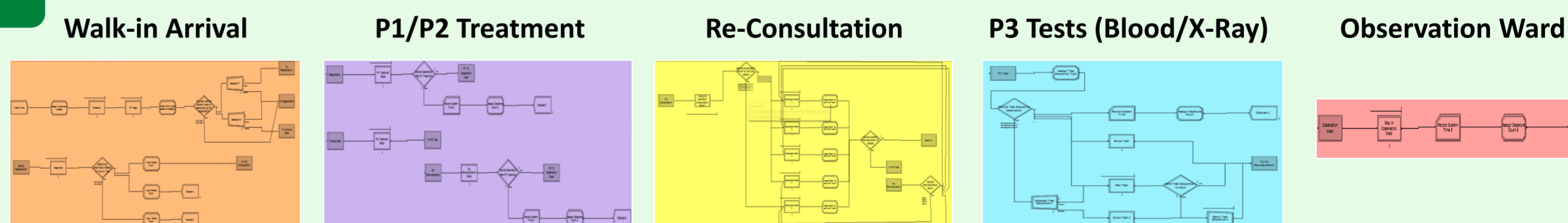


### C) Projecting Future Workload
Future patient load was projected given the factors:
1. Increasing population size
2. Increasing proportion of elderly in population

| Patient Type | Current 2013 Workload | Projected 2030 Workload |
|---|---|---|
| P1 | 24,206 | 32,464 |
| P2 | 49,440 | 66,307 |
| P3 | 82,744 | 110,974 |
| Total | 156,389 | 209,746 |

*Source: Data from SGH

## Simulation Model

An ARENA simulation model consisting of various subsystems was built to capture the features of the DEM processes.

**Walk-in Arrival** | **P1/P2 Treatment** | **Re-Consultation** | **P3 Tests (Blood/X-Ray)** | **Observation Ward**



## Results and Recommendations

### Sensitivity Analysis
Sensitivity Analysis was conducted to determine the optimal number of facilities for each facility as shown in the charts below.
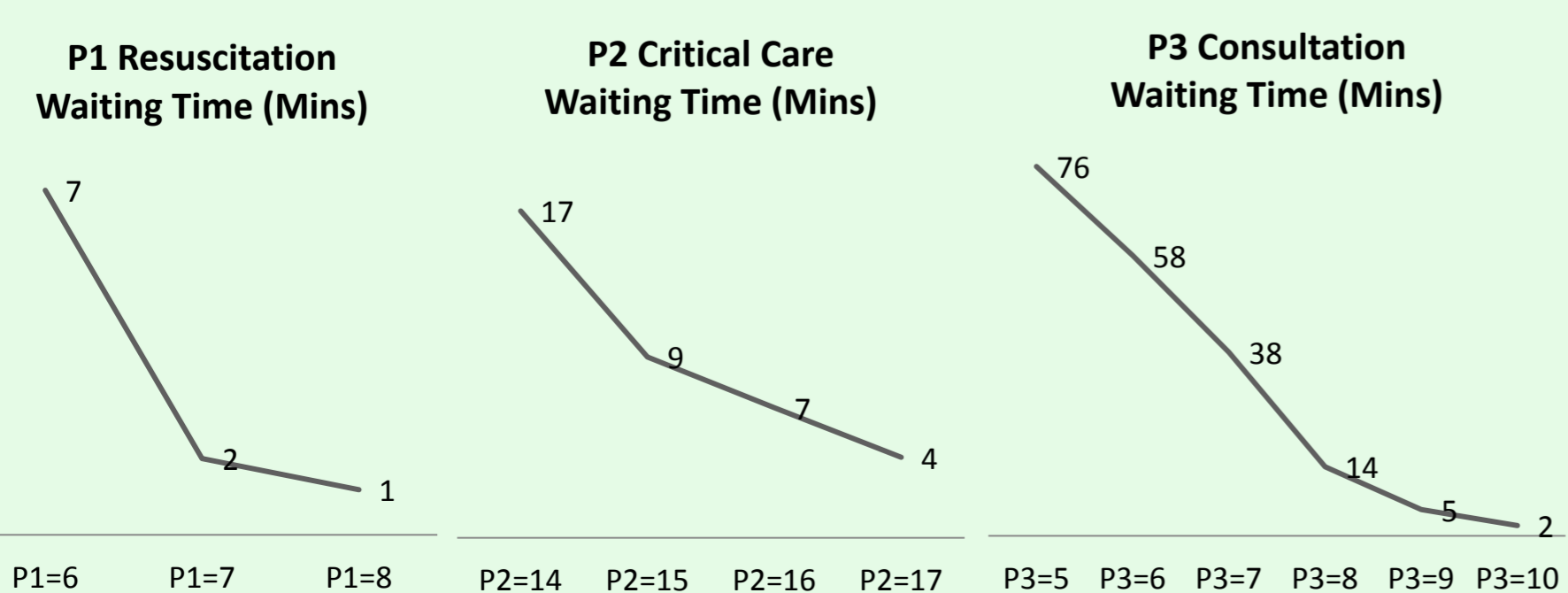


### Recommended Changes
Based on the preceding analysis, the following expansions are recommended to meet the current patient load. Similar analysis was conducted to determine optimal capacity for projected future patient load in 2030.

| Resources | Number of Facilities | | |
|---|---|---|---|
| | Current | Current Optimal | Future Optimal |
| P1 Resuscitation | 6 | 8 | 10 |
| P2 Critical Care | 14 | 16 | 18 |
| P3 Consultation | 5 | 8 | 10 |
| Screening | 2 | 2 | 3 |

The number of registration, triage stations and observation wards had minimal impact on patient waiting times. The capacity of these facilities can be kept constant as they are sufficient for current and projected patient load.

### Waiting Time Improvements
With the proposed changes, waiting times can be expected to decrease by:

**P1: 4 mins (57%) P2: 22 mins (79%) P3: 59 mins (78%)**

with the current patient load, adequately satisfying the DEM's performance targets.