Development of a Generic Inpatient Hospital Simulation Model

DALHOUSIE UNIVERSITY
FACULTY OF ENGINEERING

nova scotia health

Department of Industrial Engineering

Austen Underhill, Gavin McInnis, Lawrence Schaffer, Susim Santra

1. Problem Definition

When the PSPI team is approached by clinical or nonclinical staff regarding patient flow problems, it requires an investigation into the problem that is often time consuming and leads to specific modeling/focus on the hospital or department in the inquiry. The Project team identified the need for a generic hospital simulation model to quickly assess inpatient flow improvement initiatives within NSH hospitals and limit reworking of general inpatient flow inquiries.

2. The PSPI Team

The Project Services and Performance Improvement (PSPI) team at NSH oversees the continuous improvement of the delivery of health services within NSH's hospitals and the facilitation of projects alike.

3. Project Objective

Source: DGH Systems Planning and Design Review 2017
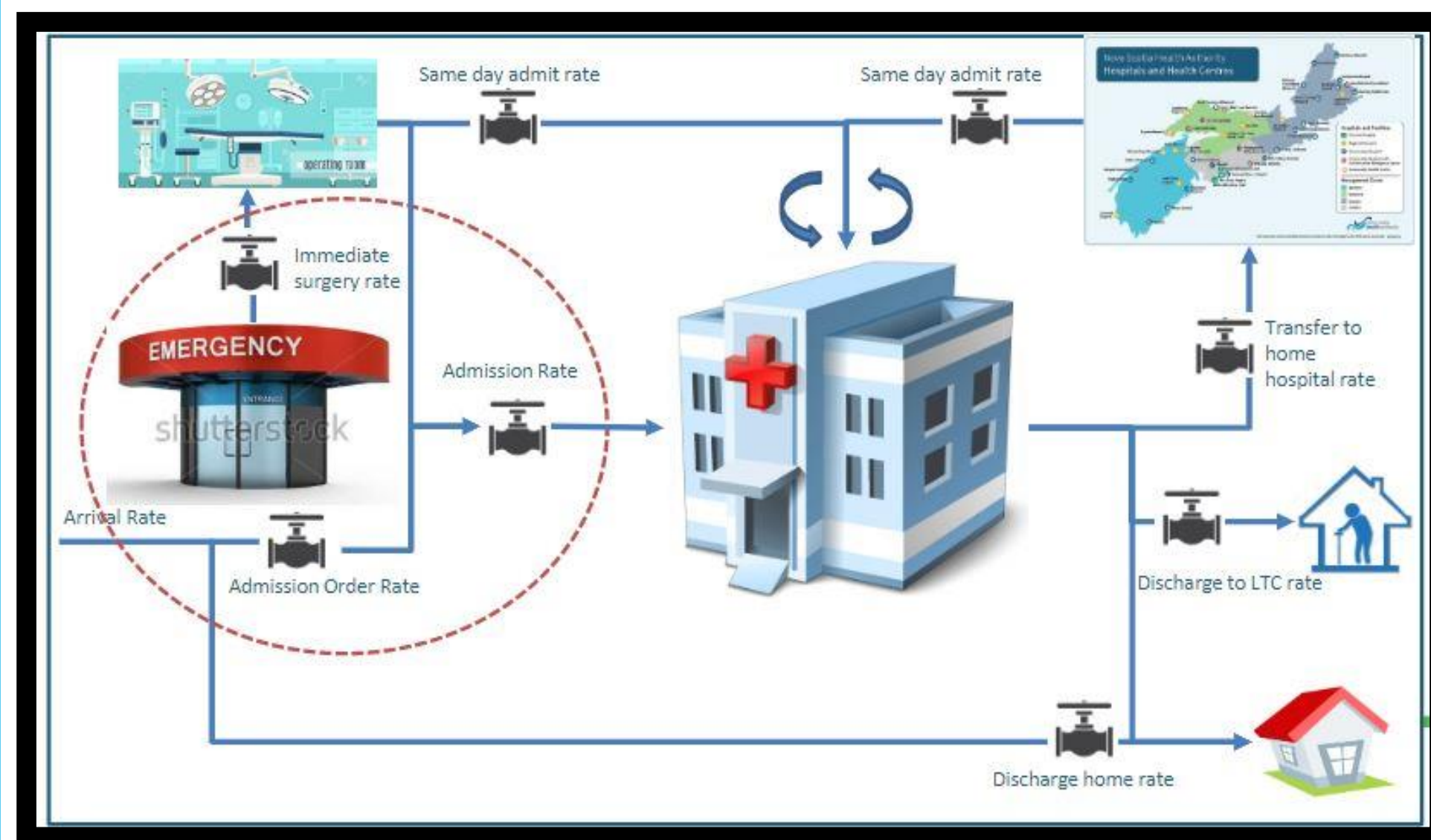
- **PROVIDE** a means for the PSPI team to quickly test inpatient flow improvement initiatives in N.S. hospitals.
  - inpatient flow pertaining to ICU, Medicine, and Surgical bed types.

- **DEVELOP** a generic inpatient flow simulation model.
  - model must be generic in nature and allow for the ability to model various hospitals under NSH's authority.

- **TEST** potential inpatient flow improvement initiatives.
  - identify areas of improvement, possible inpatient buffers, and impacts of increased capacity.

- **DOCUMENT** model functionality.
  - provide a user manual on model structure and usage for future use by the PSPI team.

4. Method & Analysis

4.1. Designing a Generic Inpatient Hospital Structure

Historical Inpatient Data Acquired for Dartmouth General Hospital (DGH) and Valley Regional Hospital (VRH)

- **Beds**: Medicine, Surgery, Intensive Care, Emergency.
- **Patients**: Direct Admits, Emergency Admits.
- **Services**: All inpatient services offered on site.
- **Length of Stay (LOS):** Determined by fitting statistical distributions to historical data.
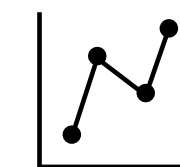 ****No Staff Modelled****
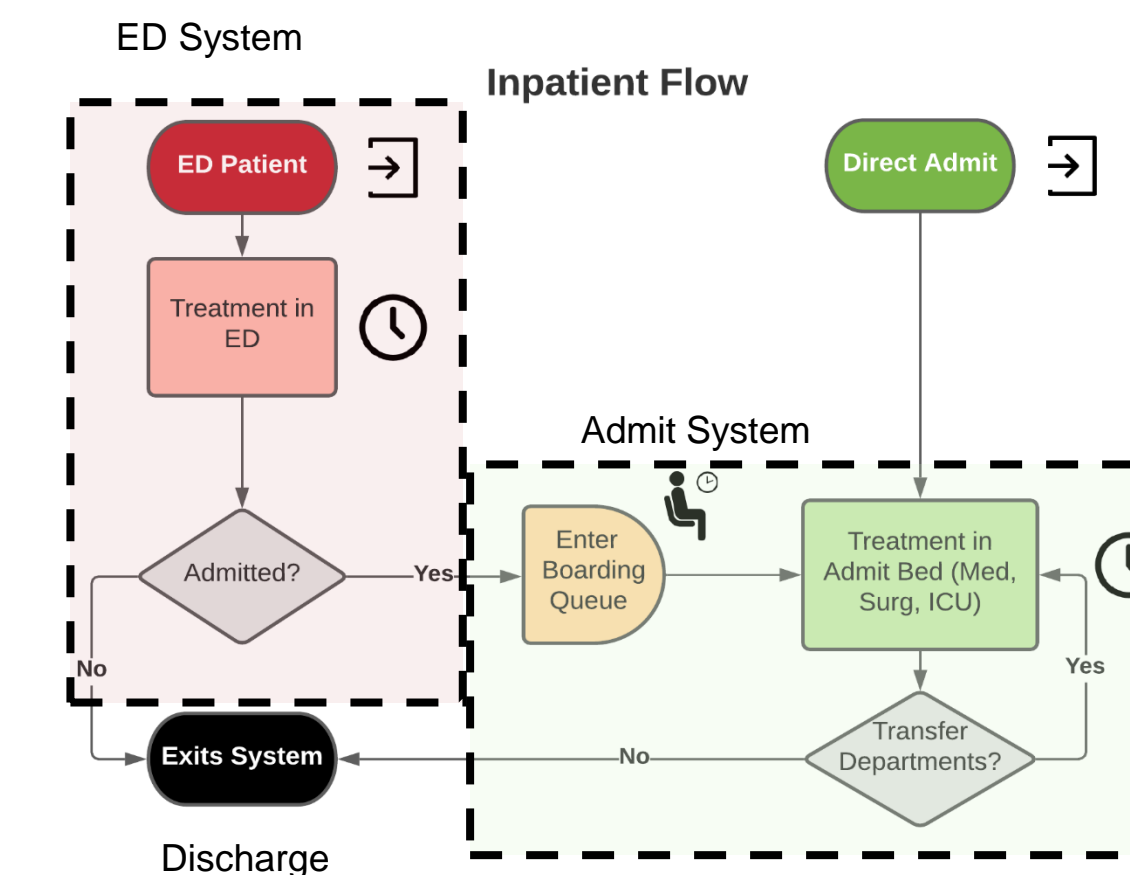
4.2. INPUT - Historical Data Analysis

Pre-COVID (2018/2019) Patient Data Used

Data Available:
- **ED Data:** Patient Arrivals/LOS Specific to the ED.
- **Census:** Number of Daily Patients in Admit System.
- **Transfer:** How Inpatients Travelled through the Hospital.
- **Surgical:** Specific Data on Surgeries and Direct Admits.

Key Metrics:
- **Arrivals:** How many patients are arriving per day (ED and Direct Admits)?
- **Destinations:** Where do patients end up after they arrive (Service dispositions)?
- **LOS:** How long is each patient staying per service?
- **Transfers:** How many patients are rotating services?
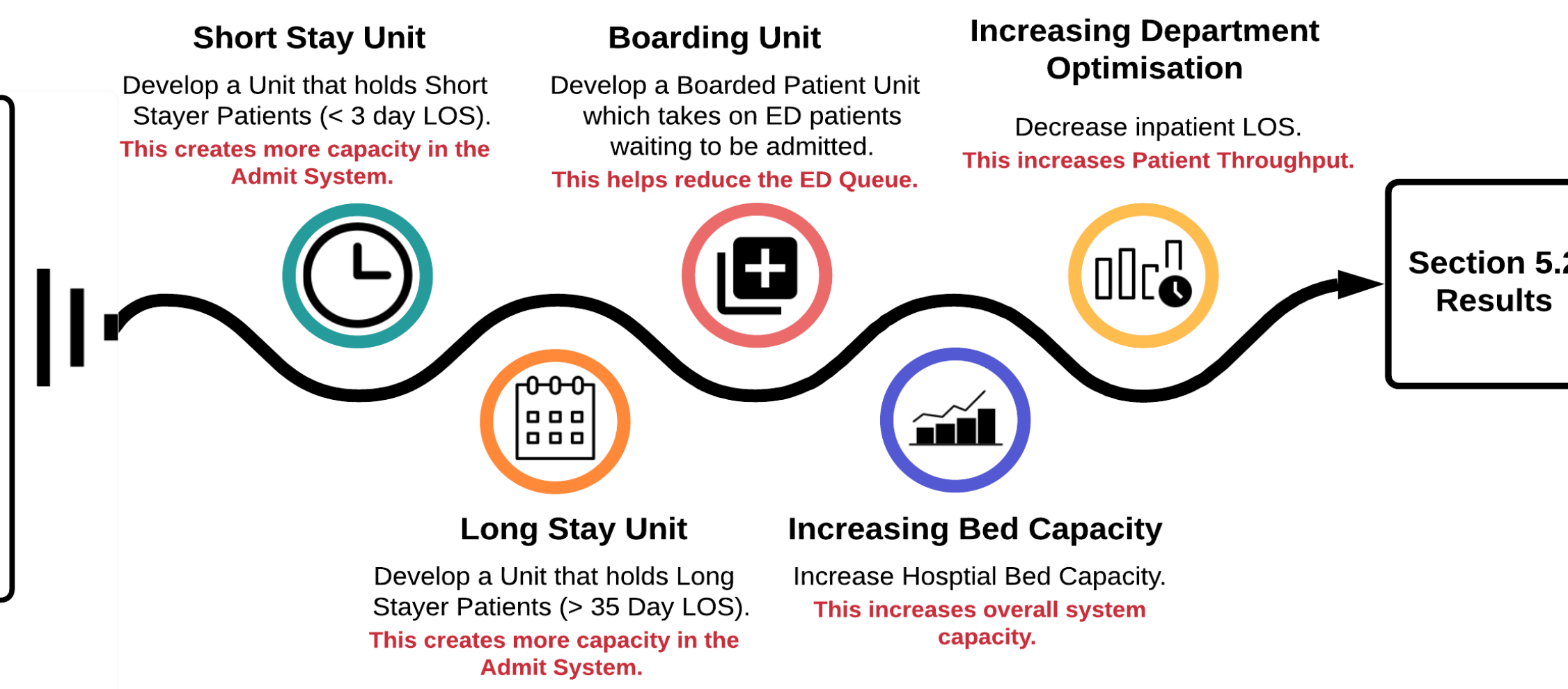
4.3. FlexSim Healthcare Model

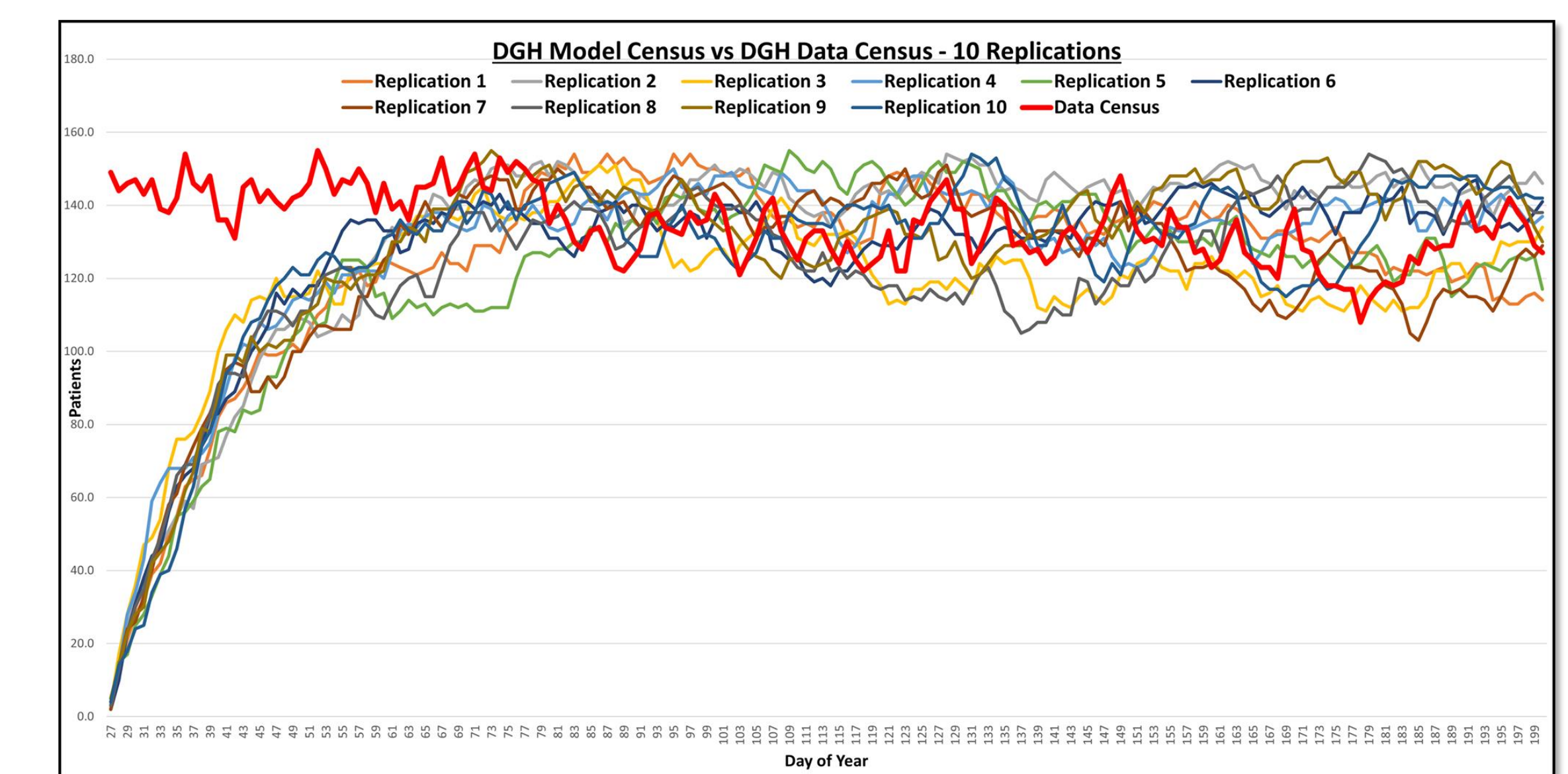### 4.4. OUTPUT - Inpatient Flow Improvement Initiatives Testing

BED DAYS — Short Stayers, Long Stayers, All Inpatients (4%, 29%, 67%)
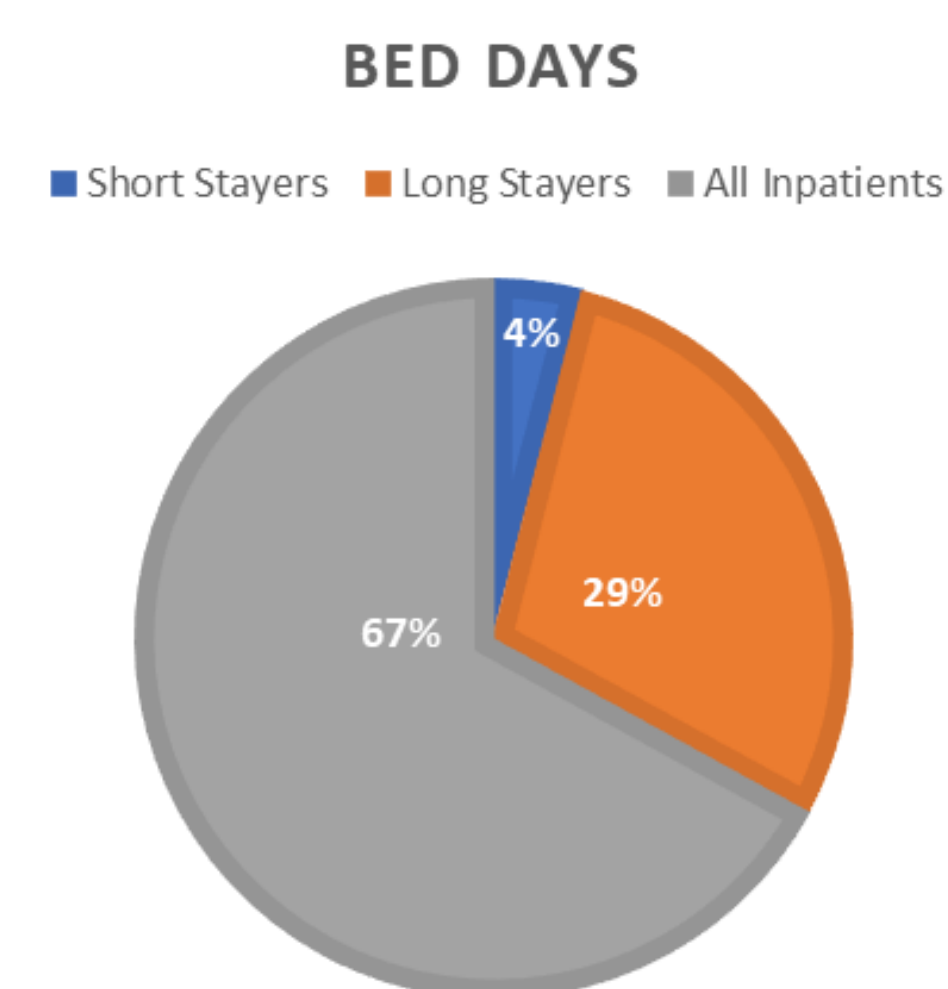
Inpatient Flow Issues
- **Long Stayers:** account for 14,794 bed days per year on average.
  - 29% of all bed days available per year.
  - These patients are generally lower acuity.
- **Short Stayers:** account for 2,081 bed days per year on average.
  - 4% of all bed days available per year.
- **Boarding Patients:** create blockages in the ED.

Short Stay Unit
Develop a Unit that holds Short Stayer Patients (< 3 day LOS). **This creates more capacity in the Admit System.**

Boarding Unit
Develop a Boarded Patient Unit which takes on ED patients waiting to be admitted. **This helps reduce the ED Queue.**

Increasing Department Optimisation
Decrease inpatient LOS. **This increases Patient Throughput.**

Long Stay Unit
Develop a Unit that holds Long Stayer Patients (> 35 Day LOS). **This creates more capacity in the Admit System.**

Increasing Bed Capacity
Increase Hospital Bed Capacity. **This increases overall system capacity.**

Section 5.2 Results

5. Results

5.1 Model Validation

DGH Model Census vs DGH Data Census - 10 Replications

^ Dartmouth General Hospital historical bed census (red) compared with 10 replications from the generic inpatient hospital simulation model.

The generic inpatient hospital simulation model was validated using two-sample t-tests assuming unequal variance for bed census and inpatient LOS.

5.2 Scenario Testing Results

Scenario (Compared to Baseline Model)	Period (Months)	Boarding Time	Boarding Patients	Inpatient LOS	90th Percentile LOS	Inpatient Throughput	Approximate Bed Days
Short Stay Unit	4	-3.65%	-13.77%	+1.30%	+1.44%	+1.16%	+144
Long Stay Unit	3	-13.46%	-55.61%	-7.38%	-31.54%	+13.84%	-651.75
Boarding Unit	3	+144%	+110%	+22.15%	+14.09%	+5.87%	+1883.75
10% Bed Capacity Increase	4	-89.49%	-37.96%	-5.19%	-3.72%	+9.39%	Not Applicable
20% Bed Capacity Increase	4	-486.20%	-214.49%	-9.55%	-5.77%	+11.66%	Not Applicable
30 % Bed Capacity Increase	4	-1266.49%	-532.70%	-10.79%	-6.72%	+12.04%	Not Applicable
10% Dept. Optimization Increase	4	-40.39%	-11.59%	-10.39%	-9.09%	+9.78%	-1201.33

6. Conclusion and Recommendations

A generic inpatient hospital simulation model was developed and successfully fit for application at Dartmouth General Hospital and Valley Regional Hospital. All required inputs for application to new hospitals were identified in a user manual for NSH employees along with explanations regarding model functionality.

The project team compared the baseline model for Dartmouth General Hospital against configurations that incorporated a short stay unit, a long stay unit, a boarding patient unit, increases in departmental optimization, and increases in bed capacity. The results presented insights for how the incorporation of these proposed inpatient flow initiatives impact inpatient flow as a whole for Dartmouth General Hospital, and provided outlook on where improvement efforts should be focused.

Recommendations

1. More detailed scenarios should be investigated by NSH, specifically with a focus on Long Stayer Patients (Above 90th percentile LOS patients).
2. Less focus should be placed on creating a boarding unit without any additions in upstream patient capacity, as it creates a push system.
3. How beds become "flexible" and change status should be investigated further and incorporated into the model logic.