Improving patient flow at SNEC @CGH

IE3100 Systems Design Project AY2020/2021 (Group 21)
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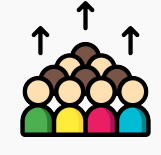**Changi General Hospital** SingHealth

Background Information

SNEC @CGH

The Singapore National Eye Clinic (SNEC) at Changi General Hospital (CGH) is a partnership between CGH and SNEC to mainly serve the eye care needs of people living in the East of Singapore. Due to the limited resources coupled with high patient flows, a more efficient patient scheduling system is required.

Problem Overview

- Patient Unsatisfactory
- Large increases in patient volume caused a significant decrease in doctor to patient ratio
- Inefficient patient notification system
- Uneven workloads between and within weekdays

Objective

Reducing overall patient turnaround time

Main objective is aimed at reducing the waiting time and thereafter the turnaround time of patient through simulation modelling.

Methodology

DATA CLEANING → DATA ANALYSIS → STATISTICAL PROOF → SIMULATION MODELLING → MODEL OPTIMISING PARAMETERS → RECOMMENDATIONS & SOLUTIONS

Key Skill Sets

Data Analysis
- Data cleaning
- Filtering & interpreting relevant data

Statistical Analysis
- Applying regressions model to data
- Hypothesis testing & ANOVA

Tools
- Python
- R Programming
- Non-linear Programming
- Amazon Web Service (AWS)

Simulation Modelling
- System validation
- Variables optimization

Data Cleaning

Patient Arrival Volume

Weekly Average Patient Arrival Volume (AM / PM)

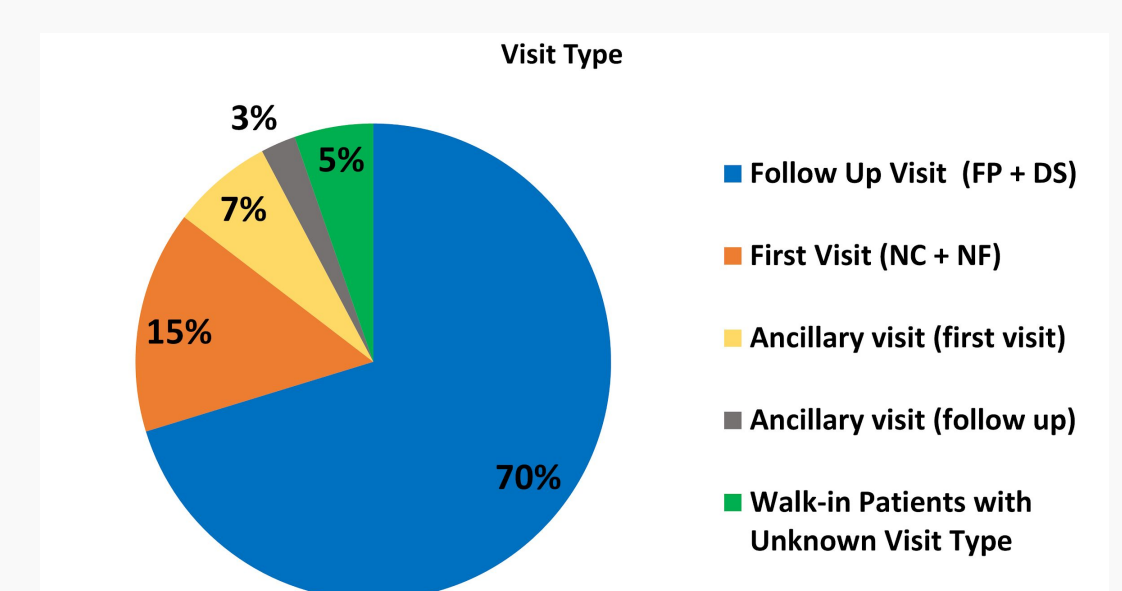|	Mon	Tues	Wed	Thur	Fri
AM	139.73	173.63	136.65	139.57	136.96
PM	93.17	180.88	108.52	108.67	107.66
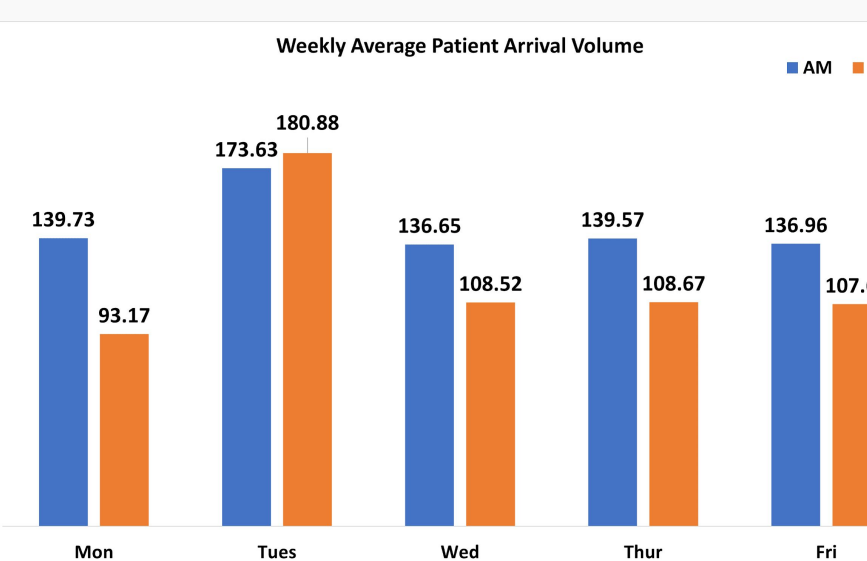
- Only full-day weekdays and AM/PM patients included
- Tuesday session has the highest volume
- AM sessions tends to have larger volumes

Visit type classification

Visit Type
- Follow Up Visit (FP + DS) — 70%
- First Visit (NC + NF) — 15%
- Ancillary visit (first visit) — 7%
- Ancillary visit (follow up) — 3%
- Walk-in Patients with Unknown Visit Type — 5%

Follow Up Visit constitutes the majority of patient volume

Data Analysis

Effect of patient visit type on consultation service time

Mean consult service time by visit types

AV	FP	FV	New Case
10.7	7.6	16.1	8.7
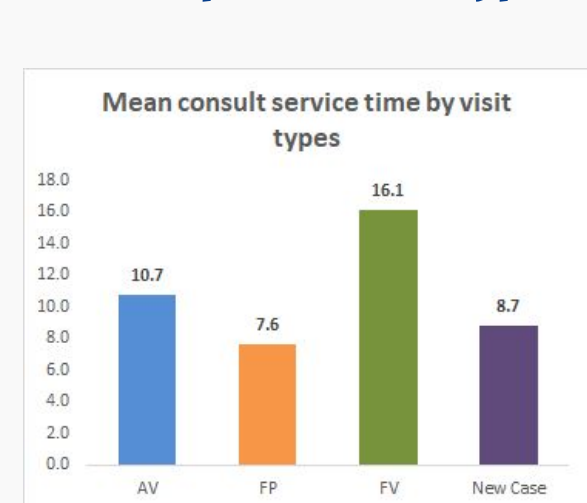
Single factor analysis of variance was done and results shows that the means of the four populations were not equal at **5%** level

Result: FV patient type has longest consultation time

Effect of uneven patient load on turnaround time
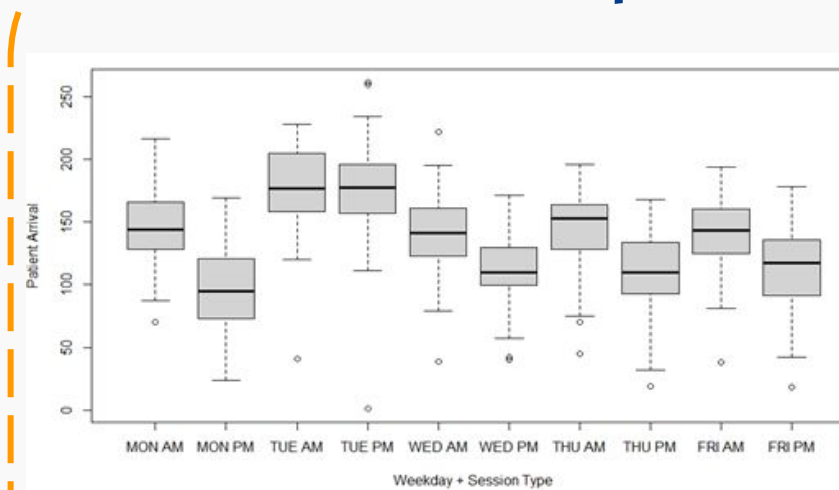
Uneven workload between weekdays and sessions across the week as shown in the graph

Two-way unbalanced ANOVA test was performed on the variables

Results: The higher, uneven workloads on **Tuesday** and **AM sessions** resulted in significantly higher turnaround time

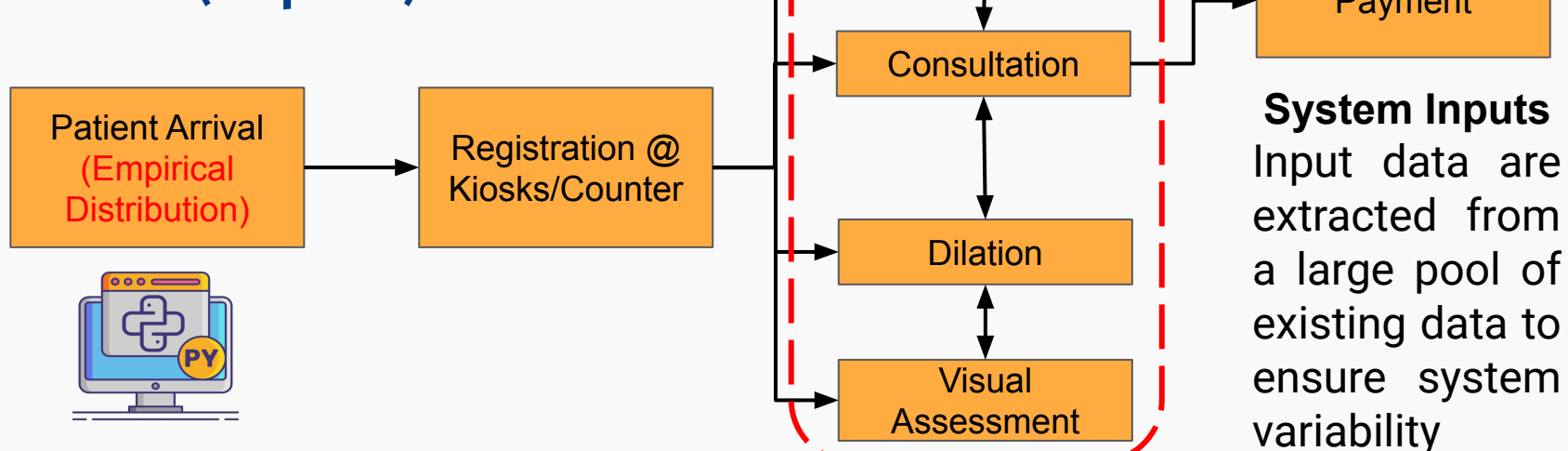### Effect of number of station(s) visited on turnaround time

- **80%** of the patients visited up to 5 stations
- **r = 0.974**, suggests a strong linear relationship
- **r^2 = 0.948**, indicates that the model is a fairly good fit for the data

Result: turnaround time ↑ proportionately to number of stations visited

Linear Regression $y = 28.433x - 0.7996$
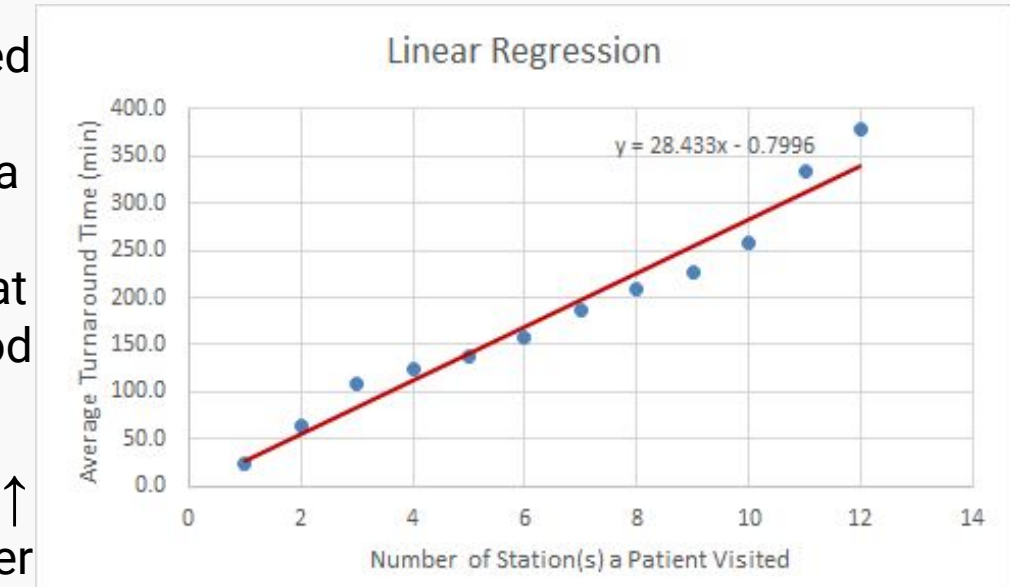
Simulation Modeling & Optimization

Overview of Simulation Model (Simplified)

Patient Arrival (Empirical Distribution) → Registration @ Kiosks/Counter → [Other Stations pathways, Consultation, Dilation, Visual Assessment] → Payment
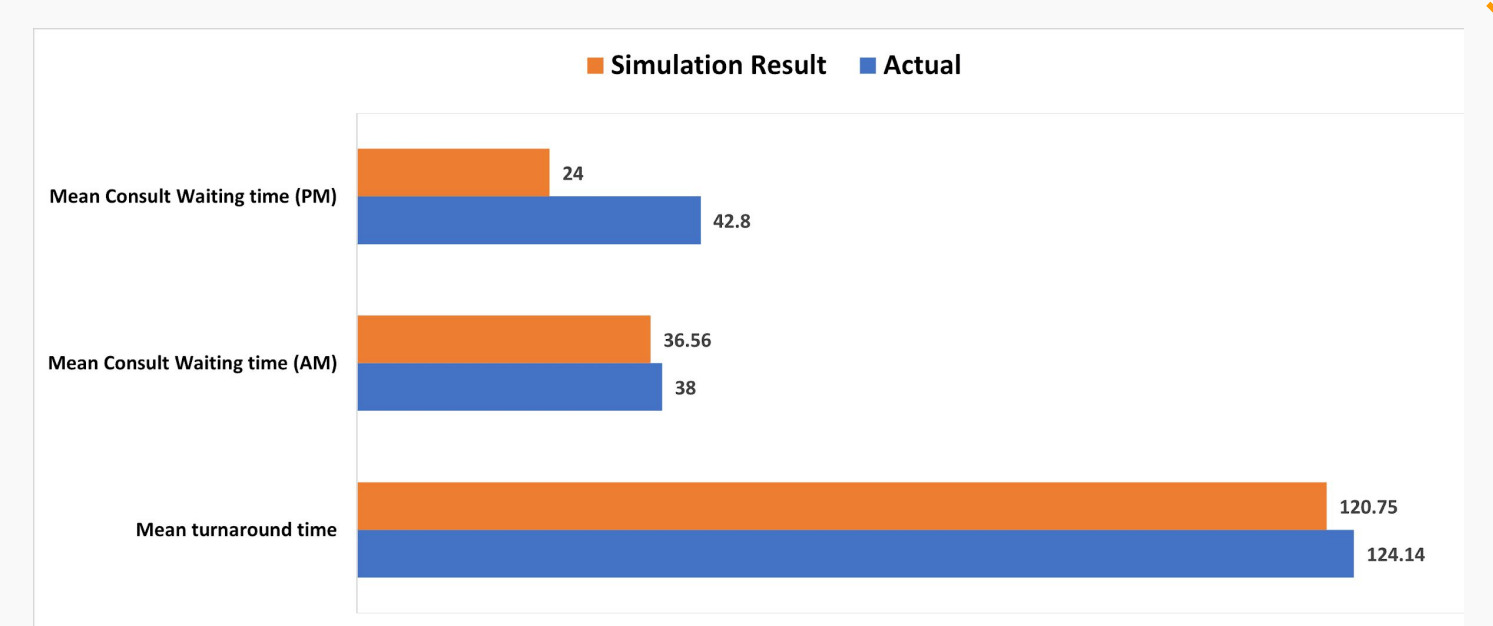
Service time empirical distribution

System Inputs
Input data are extracted from a large pool of existing data to ensure system variability

Modeling inputs and analysis

- Duration: **50** weeks
- Total number of patients
- **3287** different pathways
- Station capacity & waiting time
- Number of doctors available
- Empirical Distribution
- Validation: **t-test & f-test**
- Mean & Variance of turnaround time obtained
- Mean & Variance of consultation time obtained

(Simulation Result / Actual)

	Simulation Result	Actual
Mean Consult Waiting time (PM)	24	42.8
Mean Consult Waiting time (AM)	36.56	38
Mean turnaround time	120.75	124.14

Recommendations & Solutions

Measures to reduce turnaround time

Policy 1: Shifting loads from heavy workload days to days with less workload

Based on the current doctor's availability, one of the approach is to shift some loads from tuesday to other workdays to balance the overall turnaround time of patient across the week

Policy 2: Shifting "New Cases" patients

Statistical test performed showed that, 'New Patient' patients tend to spend longer time in the clinic

Thus rebalancing the number of 'New Case' patients across Tuesday and Wednesday gives the most optimized turnaround time

Method used

Generalized Reduced Gradient algorithm was used to find the optimal appointment schedule probability distribution which minimizes the variance of patient arrival per unit time.
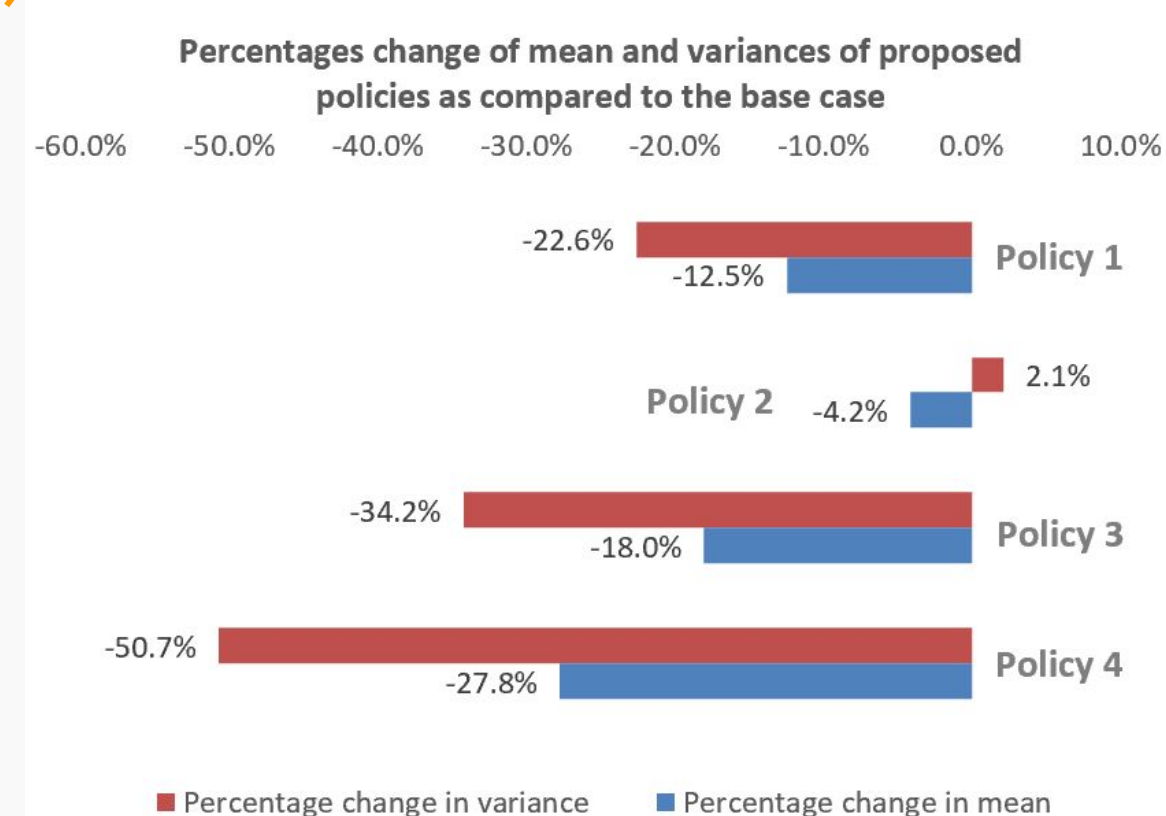
Policy 3: Balancing workload across the day I

At least 80% of the AM appointments and PM appointments are scheduled by 1000H and 1455H

Policy 4: Balancing workload across the day II

At least 80% of the AM appointments and PM appointments are scheduled by 1030H and 1530H

Solutions Evaluation

Percentages change of mean and variances of proposed policies as compared to the base case

Policy	Percentage change in variance	Percentage change in mean
Policy 1	-22.6%	-12.5%
Policy 2	2.1%	-4.2%
Policy 3	-34.2%	-18.0%
Policy 4	-50.7%	-27.8%

Policy **3** and **4** shows better results in reducing mean and variance of turnaround time

Thus it is more effective to rebalance patient workload within the day than shifting it across different days

Policy 4 was identified as the most effective solution

Recommendation: More comprehensive model could be implemented to address assumptions

Conclusion: reasonable to assume that a reduction in turnaround time could have a positive effect on a patient's satisfaction level and clinic overall performance