Ranking elective surgery patients through prioritisation algorithms

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Supervisors: Paul Corry & James McGree

Introduction

Currently in Australia, elective surgery patients are placed on a waiting list and assigned one of three nationally defined classifications indicating the urgency of the surgery. However, this classification process can be subjective and up to the discretion of the treating health professional, leading to potential inequities in waiting time and admission order.

Research Problem

This project investigates prioritising patients through use of a mathematical formula that incorporates clinical factors and time spent on the waiting list to determine a priority score, which can then be used to rank patients.

Data Collection

Project clinicians reviewed historical cases and reassessed patients' original priority classification, as well as collecting data relating to clinical factors for that procedure. These factors were then weighted utilising multi-criteria decision-making techniques.

Hernia					
Pain	Nil (0)		On Exertion (13.1)		All the Time (26.1)
Reducibility	Easy (0)		Difficult (8.3)		Irreducible (15.4)
Risk of complications	Mild (0)		Moderate (13.1)		Severe (28.3)
Functional consequences	Nil (0)		Mild-Moderate (6.1)		Severe (19.2)
Other relevant factors	Low Priority (0)		Medium Priority (7.2)		High Priority (11)
Category	1		2		3
Maximum waiting time	14	30	42	90	365

Example booking form used to collect clinical factors data from historical cases, along with calculated relative weights

Category 1

- **Admission within 30 days**

Category 2

- **Admission within 90 days**

Category 3

- **Admission within 365 days**

Current three category system classifications

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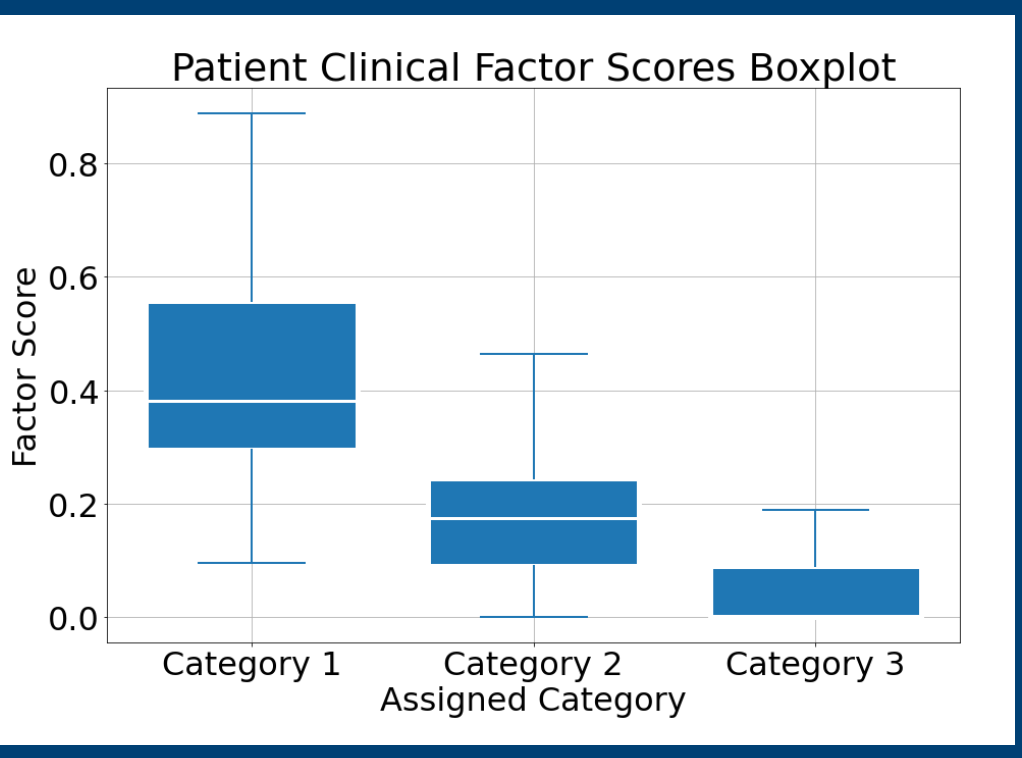
Simulation Design

A simulation was designed to model the current three category admission system versus a priority scoring system. Patient arrivals were determined from historical data and service rates calibrated so that the system remained in a steady state.



Priority Score Formulation

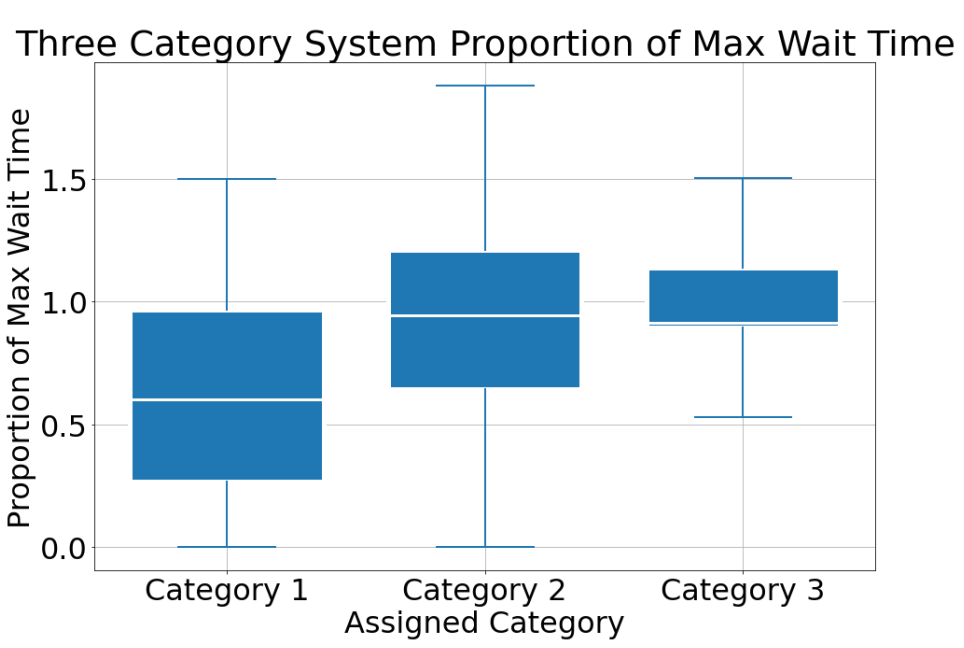
$$P = \frac{t}{M}\left[1 + F\left(\sum_{i=1}^{n} c_i\right)\right]$$

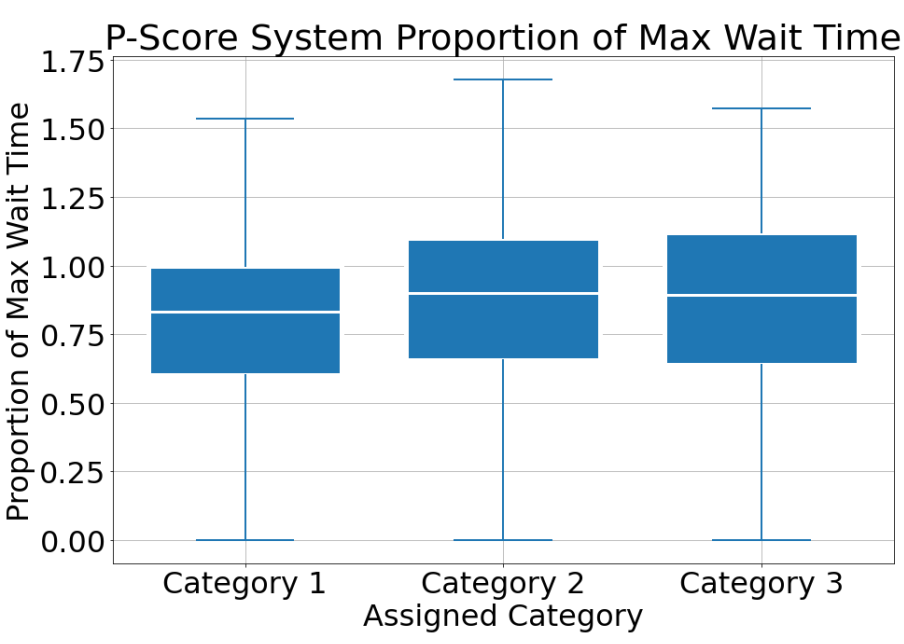
P: priority score
t: time on waiting list
M: maximum recommend waiting time
c_i: clinical factor i $(n = 5)$
$F_{\sum c_i}(x)$: empirical cumulative distribution (eCDF) function of $\sum c_i$ for patients on the waiting list

The eCDF was used as a multiplier factor depending on a patient's clinical factors. As shown in the clinical factor boxplot (left), the scores of patients in the cohort are relatively low ($\sum c_i \in [0,1]$). Hence, the eCDF calibrates the multiplier factor to ensure that an appropriate value is applied, relative to the overall patient cohort.

Results

It was found that under the P-Score system, patients on average waited approximately the same proportion of their maximum waiting time, reflecting increased equity. In the three-category system, there is a much larger spread, especially in category 1 & 2 patients. This can be attributed to the discrete category system inherently prioritising higher priority patients. The P-Score system can more fairly distribute patient waiting times, as it explicitly prioritises based on patients' proportion of maximum waiting time, while also incorporating a more granular indicator of a patient's need through their clinical factor score.





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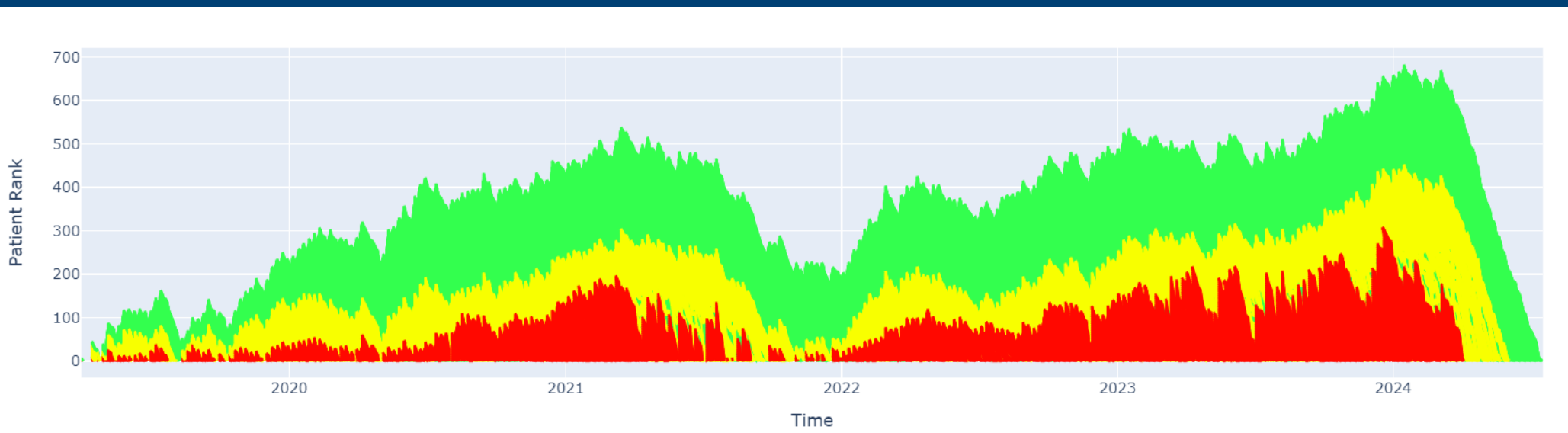
Simulation Model & Future Direction

The specific behavior of the two prioritisation techniques can be seen in the rank over time plots (below). In the three-category system, distinct blocks of patients can be seen as the simulation progresses, while in the P-Score system, patients are more blended together. This can be attributed to how the P-Score system incorporates patients' urgency classification category as well as clinical factors.

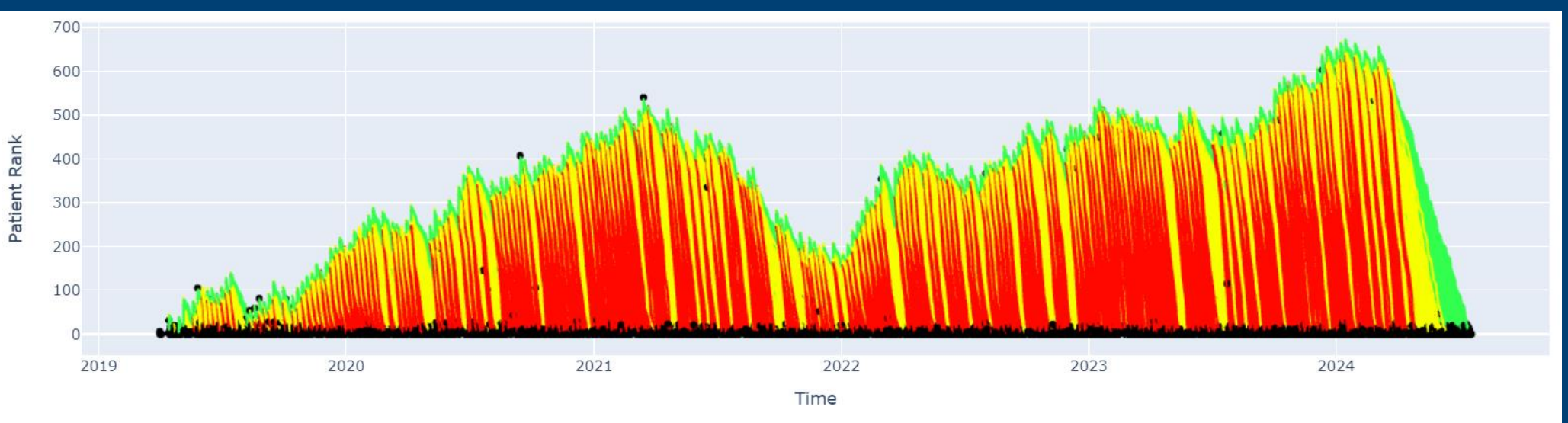
Future work on this model will focus on tuning the three-category system to better reflect the real world, while also incorporating random events such as surgery cancellations. Future work on the project will involve utilising genetic programming techniques to optimise the functional form of the prioritisation formula to maximise key performance indicators.

Three Category System – Rank Over Time

Category 1 | Category 2 | Category 3



P-Score System – Rank Over Time



P-Score System – Score Over Time