AMSI VACATIONRESEARCH SCHOLARSHIPS 2020–21

Get a Thirst for Research this Summer

Optimisation of Surgical Waiting List Management

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Vacation Research Scholarships are funded jointly by

AMSI Australian Mathematical Sciences Institute

Australian Government Department of Education, Skills and Employment

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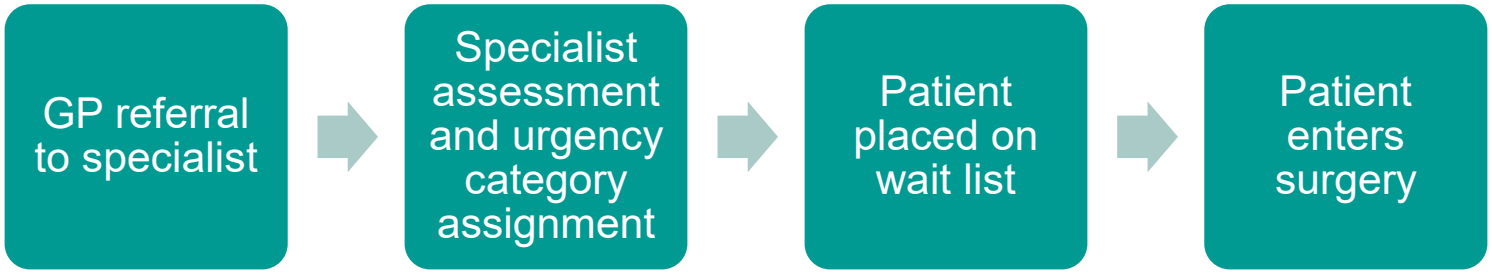
Background

- In the Australian public health system, there is often a long waiting list for patients to access elective surgeries due to high demand and the capacity of the health system.



Background

- In Australia, there are three national categories for surgery prioritisation:
  - Urgent (Category 1) – surgery recommended within 30 days of being added to the wait list
  - Semi-urgent (Category 2) – surgery recommended within 90 days of being added to the wait list
  - Non-urgent (Category 3) – surgery recommended within 365 days of being added to the wait list (Queensland Health 2015)
- This system can be a point of contention and dissatisfaction, due to the subjectivity and lack of clear guidelines in the patient classification process

Background

- **Elective surgery waiting lists continue to grow as hospitals struggle to keep up with demand** – ABC News – December 2018
- **Elective surgery wait lists blowing out, AMA warns, leaving Tasmanian patients waiting years** – ABC News – August 2019
- **Health Minister Must Act on Elective Surgery** – Tasmanian Greens – September 2020
- **COVID-19 a plague on elective surgery wait lists** – The Sydney Morning Herald – September 2020
- **Australia: Inquiry reveals chronic under funding and lengthy wait times for South-West Sydney health services** – World Socialist Web Site – January 2021

Aims

- Investigation of an alternative patient ranking system for elective surgeries
- Current prioritisation system:
  - Patients admitted to surgery based on urgency category
  - Some category 2 & 3 patients may experience extremely large wait times
- Priority score based system:
  - Use of a single waiting list, where patients are ranked according to clinical factors and time spent on waiting list
  - Clinical factors inform the priority coefficient, according to some mathematical formula, which is then multiplied by time to give a priority score
  - Patients admitted to surgery in descending order of priority score

Aims

- The key aims of this project was to:
  - Conduct a literature review of the current patient prioritisation environment in Australia and the world
  - Develop a model which represents the current three category patient prioritisation system in Australia
  - Develop a proof of concept waiting list model for a priority score system, similar to that of the work already completed in the world
  - Conduct preliminary analysis and verification of the developed model to existing work

Prior Research

- Little prior research on explicit priority score ranking models
- Large volume of work required to support such a project
  - Acceptability of waiting lists in health care
  - Individual surgeon management of patients vs nationally agreed system
  - Weightings of various clinical factors deemed to be important and relevant to elective surgery prioritisation
- Surgical Waiting List Info System (SWALIS) project
  - 2006, Italy
  - A. Testi, E. Tanfani, R. Valente
  - Web based patient priority scoring system taking into account clinical factors and time spent on waiting list.

Prior Research

- Priority scoring system (*Prioritizing surgical waiting lists* – Testi et al., 2006)
  - Use of a prioritisation formula in the general form of $P = \alpha t$
    - P is the priority score
    - α is the urgency coefficient of the patient
    - t is time spent on the waiting list in days
  - Urgency coefficient (α) determined from clinical judgment of the patient's condition according to a set of predetermined criteria with associated weightings
  - In the work of Testi et al., three clinical criteria used, where treating surgeon provides a score between 0 and 4
    - Disease progression or deterioration (r)
    - Pain or dysfunction (p)
    - Disability (d)

Prior Research

- Clinical criteria
  - Disease progression or deterioration (r)
  - Pain or dysfunction (p)
  - Disability (d)
- Priority score
  - $P = \begin{cases} 3r^2t, & r > 0 \\ (1 + 0.5p^2 + 0.5d^2)t, & r = 0 \end{cases}$
    - If there is risk of disease progression, other criteria become irrelevant, otherwise pain or dysfunction (p) and disability (d) weighted equally
- Key findings:
  - Average weighting time increased
  - Standard deviation of weighting time decreased (perhaps indicator of improved equity)

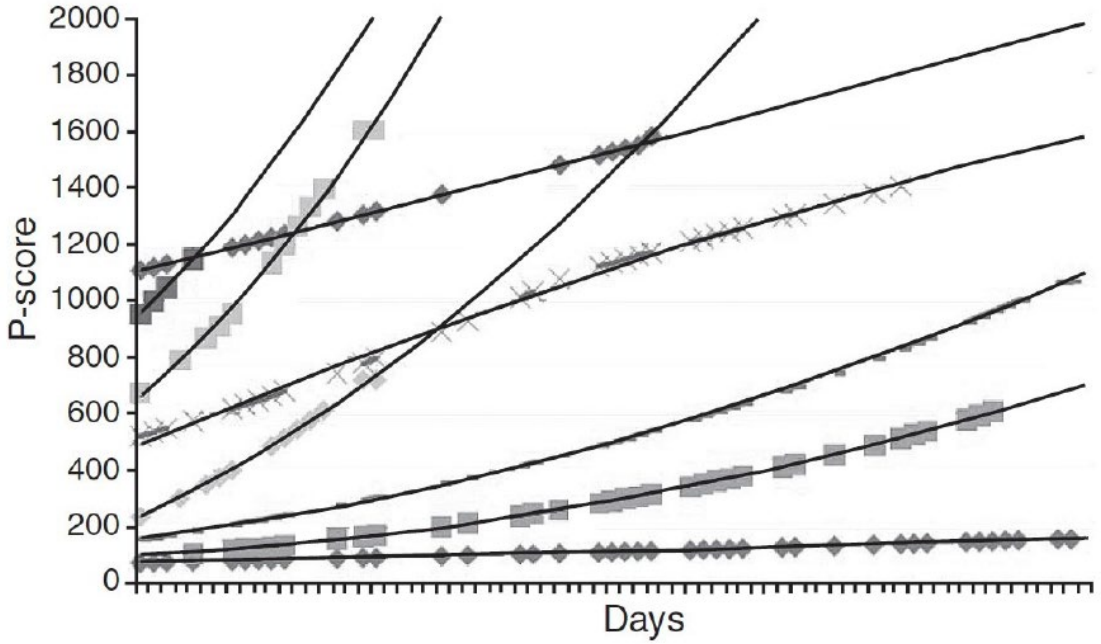
Prior Research

- Weightings of various clinical factors (*Developing a universal tool for the prioritization of patients waiting for elective surgery* - Solans-Domenech et al., 2013)

Dimension	Criteria	Weighting
Clinical-functional impairment	Disease severity	23%
	Rate of disease progression	15%
	Pain (or other main symptoms)	14%
	Difficulty in doing daily life activities	14%
Expected benefit	Probability and degree of improvement	12%
Social role	Limitations in the ability to work, study, or seek employment	9%
	Limitation to care for one's dependents (if relevant)	8%
	Being dependent with no caregiver	5%

Prior Research

- *Achieving waiting list reform: a pilot program integrating waiting time, category and patient factors* – Siddins et al., 2012
  - Similar priority system to that of Testi et al., utilising customised patient booking forms for each procedure



Model Development

- Development of a three category system and a priority score system
- Simulation model in Python
  - Discrete event simulation library SimPy
- Simulation parameters chosen arbitrarily
  - Model represents a proof of concept
  - Arbitrary units and time horizon
  - Randomly generated patient data
  - Arbitrarily chosen arrival rates, surgery and simulation length
  - Single simulation repetition
    - Not statistically rigorous

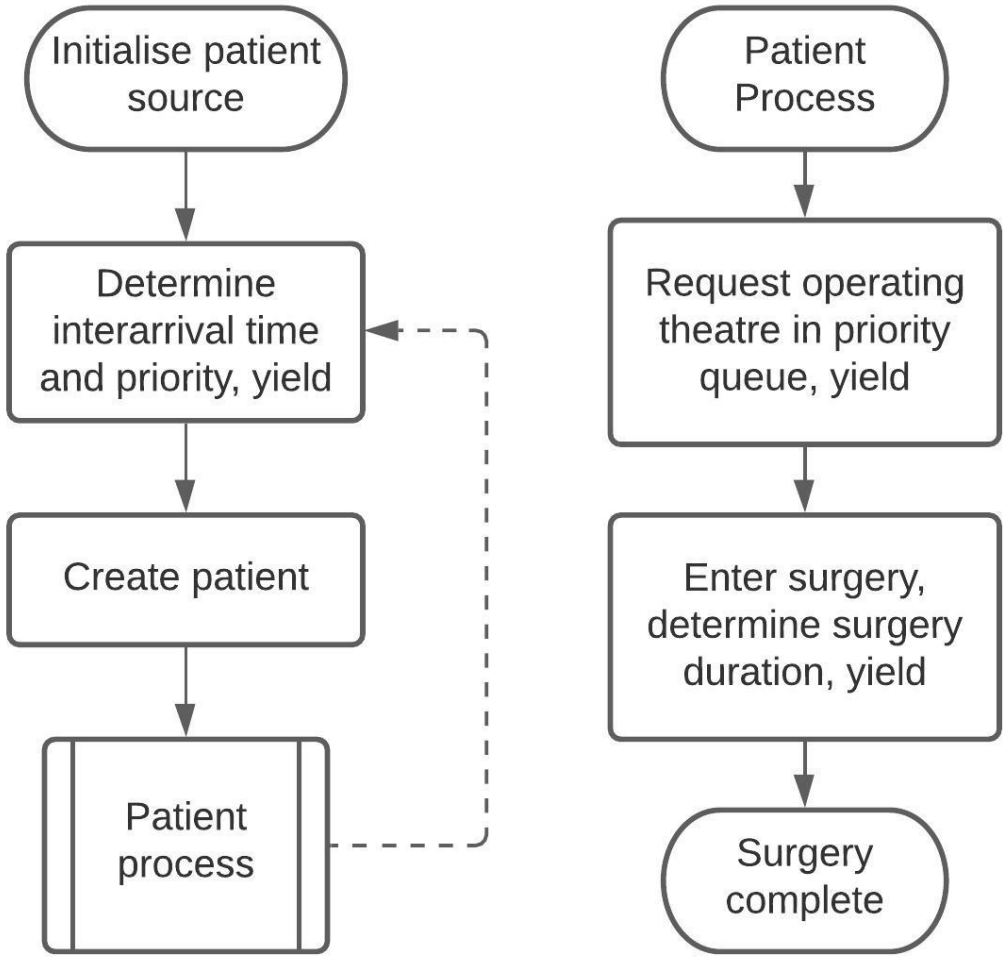
Model Development

- Simulation parameters and initial conditions
  - Note: arbitrary time units and lengths
  - Patient backlog: 20
  - Simulation length: 3000
  - Number of operating theatres: 2
  - Average patient interarrival time: 11
  - Surgery duration: 20
  - Patient data (urgency category, clinical factor scores, etc.) generated according to a uniform distribution
  - Under classical queuing theory, the proportion of time in which each server is occupied, the system utilisation parameter (ρ) is $\rho = \frac{\text{arrival rate}}{\text{service rate}} = \frac{1/11}{2 \times 1/20} = 0.\overline{90} < 1$
    - System operates under steady state conditions

Treated in turn proportion

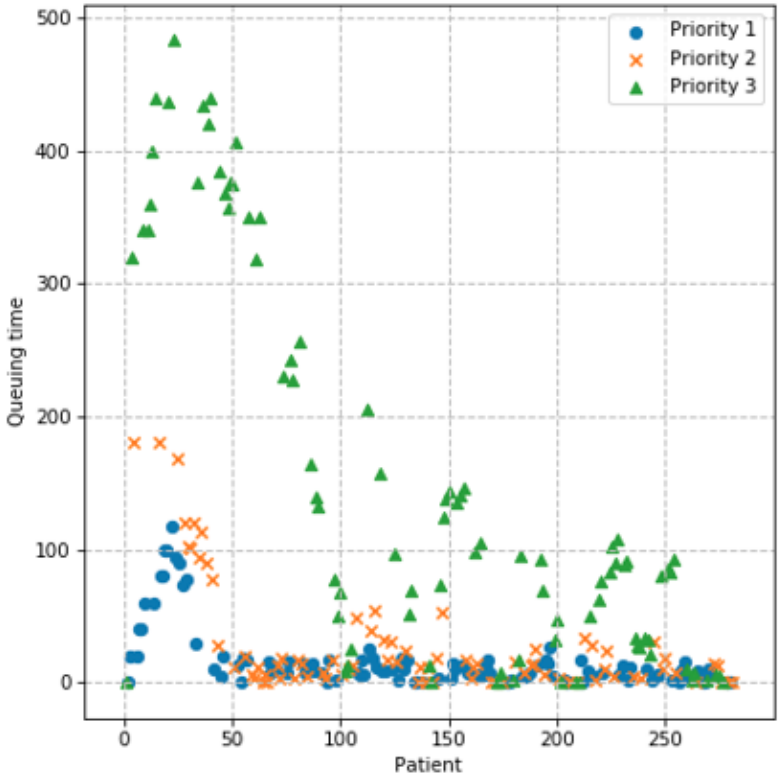
- Metric used by Queensland Health
  - *"Within each urgency category, a minimum of 60% of elective surgery patients should be treated in the same order as they are added to the waiting list"*
- Designed to minimise queue jumping while balancing clinical need
  - Essentially, a first in, first out (FIFO) queue
- Measures patients who are disadvantaged by queue jumping
  - For example, if a patient enters the waiting list as the 10^{th} patient:
    - Classified as treated in turn if they entered surgery as the 10^{th} or less patient
    - Classified as treated out of turn if entered surgery as the 11^{th} or greater patient

Three category system

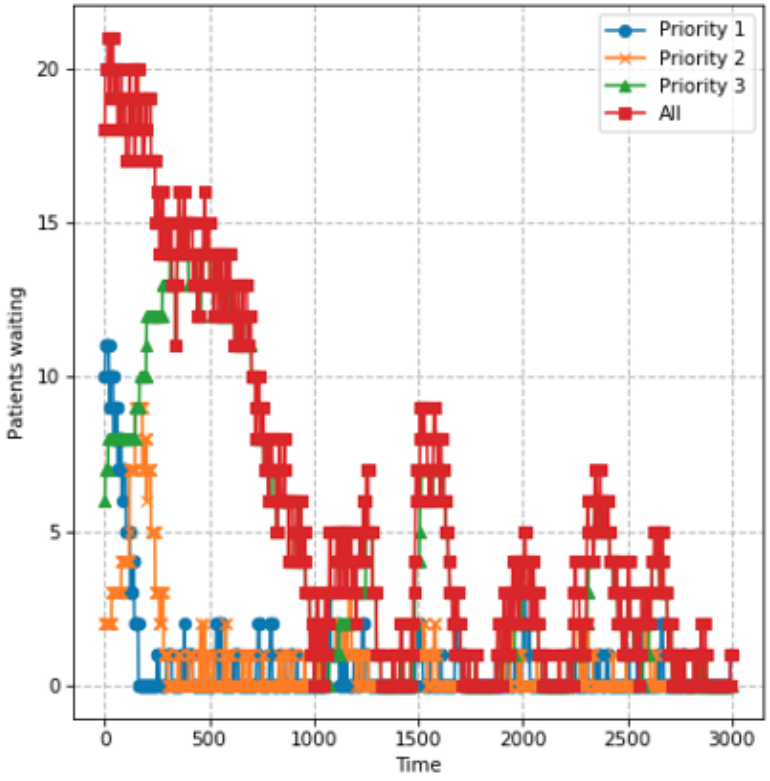


Three category system

Patient Queueing Time



Length of Queue

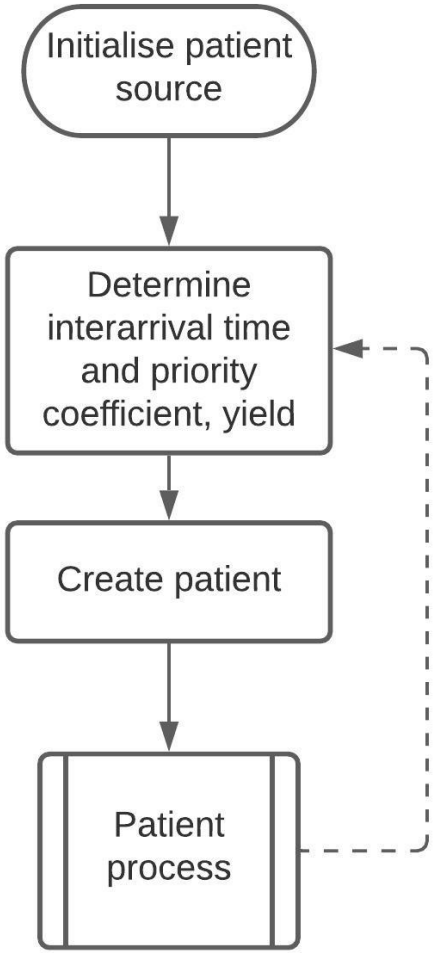


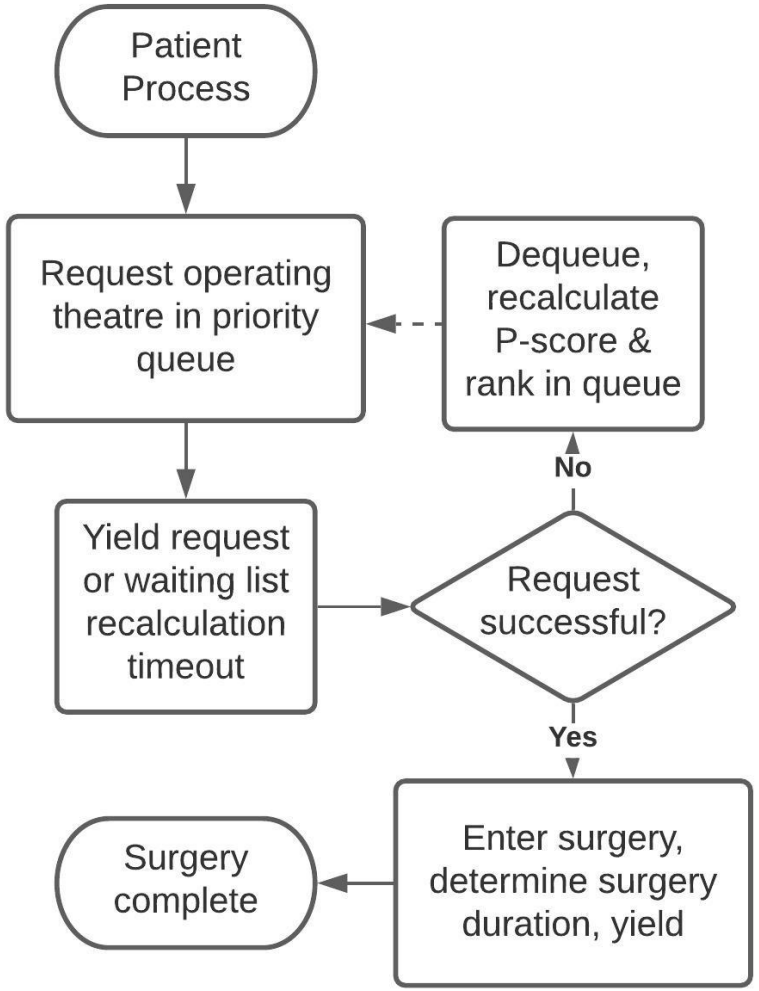
Three category system

- Average resources occupied: 1.795
  - Average system utilisation: $\frac{1.795}{2} = 0.8975$ $(\rho \approx 0.91)$
- Treat in turn proportion: 73.5%

	Time in queue		
Priority	**Mean**	**Median**	**SD**
1	16.83	8.79	24.8
2	27.1	12.1	41.35
3	145.23	90.64	146.27
Aggregated	60.99	14.17	104.45

Priority score system





Priority score system

- Weightings of various clinical factors (*Developing a universal tool for the prioritization of patients waiting for elective surgery* - Solans-Domenech et al., 2013)

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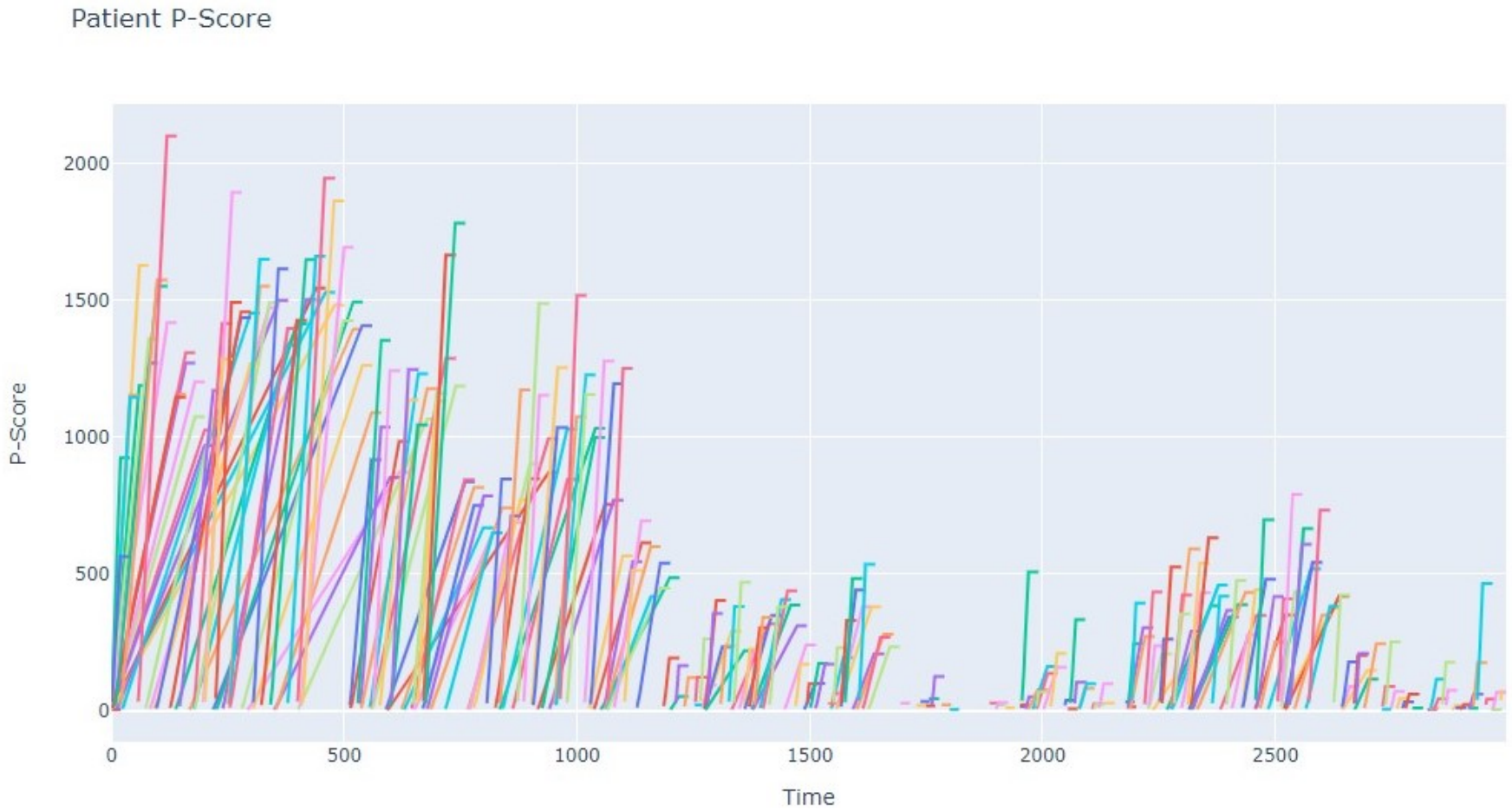
Priority score system

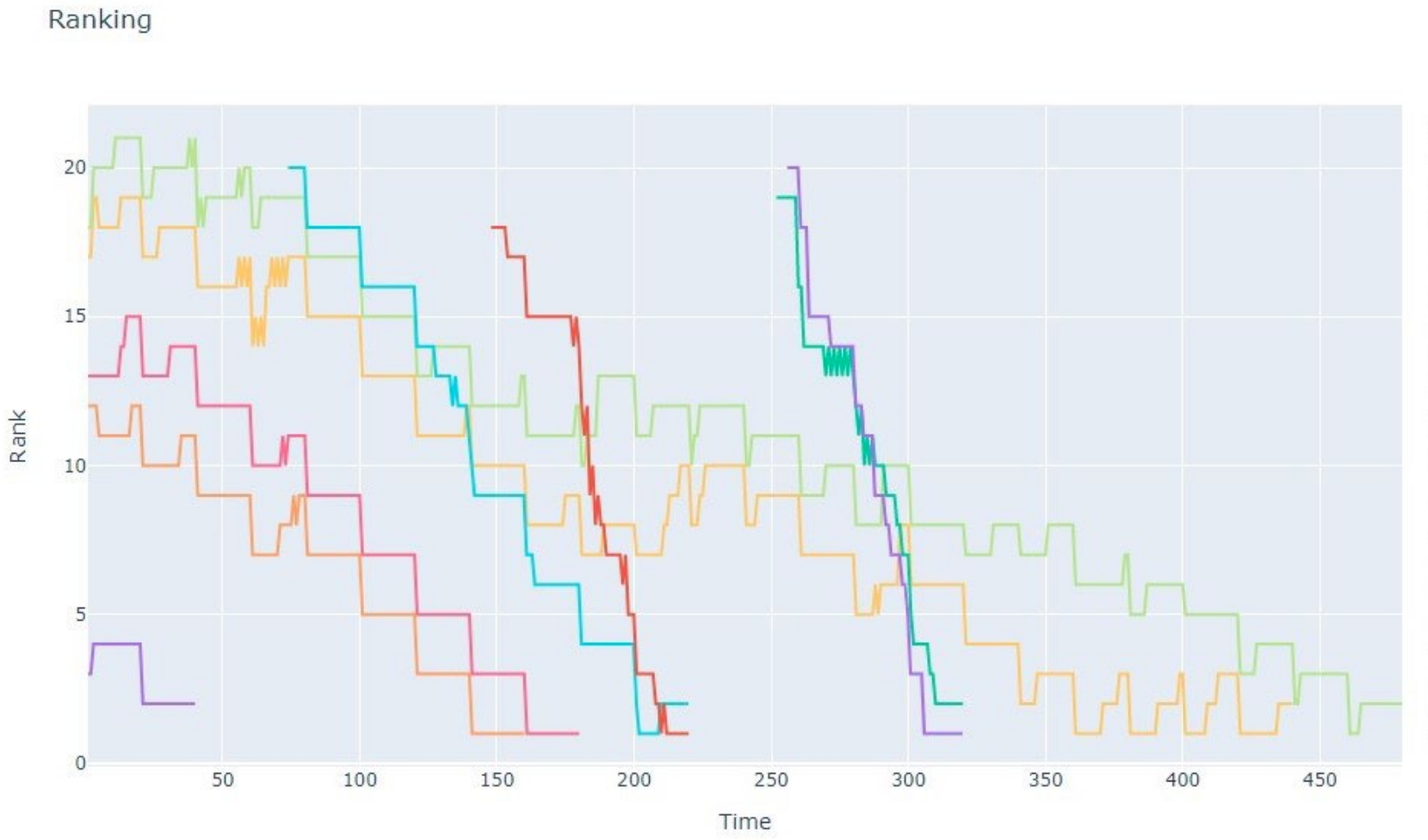
- severity (s),
- pain (p),
- rate of disease progression (r),
- difficulty in doing daily life activities (l),
- probability and degree of improvement (i),
- being dependent with no caregiver (d),
- limitation to care for one's dependents if relevant (c),
- limitations in the ability to work, study, or seek employment (w)

- $$P = \begin{cases} 3(0.6r^2 + 0.4s^2)t, & r > 2 \\ (1 + 0.23s^2 + 0.14p^2 + 0.15r^2 + 0.14l^2 + 0.12i^2 + 0.05d^2 + 0.08c^2 + 0.09w^2)t, & r \leq 2 \end{cases}$$

Priority score system



Priority score system



Priority score system

- Average resources occupied: 1.82
  - Average system utilisation: $\frac{1.82}{2} = 0.91$ $(\rho \approx 0.91)$
- Treat in turn proportion: 68.21%

	Time in queue	P-score on admission	P-score coefficient
Mean	68.82	628.94	14.79
SD	82.99	534	10.76
Median	40	438	9.58

Comparison

- Three category system vs priority score system
- Behavior of queuing time mean and standard deviation in both models similar to Testi et al. (2006)

	Time in queue			
Model	**Mean**	**SD**	**Treat in turn %**	**Average system utilisation**
Three category system	60.99	104.45	73.5%	0.8975
P-score system	68.82	82.99	68.21%	0.91

Conclusion

- Key indicators for verification against the work of Testi et al. (2006)
  - Larger average queueing time
  - Smaller queueing time standard deviation
- All results are preliminary
  - Arbitrary parameters
  - Single simulation replication
    - More replications required to obtain statistically significant evidence
- Priority scoring fundamentally changes patient ordering
  - Has the potential to revolutionise elective surgery waiting lists
    - More research would be required

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