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Innovative Implemented Tools for Outpatient Clinic Scheduling

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Abstract. Every year there are approximately three million new specialist clinic appointments at local hospital networks in Victoria. CSIRO, in collaboration with Austin Health, have developed two algorithms to assist with waitlist management in their outpatient specialist clinics. This study describes the implementation of these algorithms in software tools developed to support their use and trial in the clinical setting at Austin Health. We discuss the system design and development of both these software tools. We also review the implemented workflow of the tools and discuss how these tools seek to improve current systems.

Keywords. Specialist clinic, template planning tool, next available appointment

1. Introduction

Health is the second largest area of government expenditure and is now Australia's largest employer. In Australia, specialist outpatient clinics, run by public hospitals, provide a health service to patients who are waiting to be assessed by a medical/surgical specialist [1]. Across Australia, in the year 2020-21, there were 46.8 million non-admitted patient care service events provided in public hospitals, with demand increasing from the previous year by 23% [2]. The growing demand for healthcare services is creating pressure on the sustainability of the government-funded healthcare system. To be sustainable, we need to deliver healthcare services efficiently.

Austin is a public teaching hospital in Melbourne that is administered by Austin Health. The Specialist Clinics department in Austin Health facilitates over 265,000 appointments per annum, across 57 Medical/Surgical specialities, 5 geographical locations (across 2 separate campuses) and approximately 1,500 different clinics to manage the complexities of running a tertiary referral centre with state-wide service obligations. The Specialist Clinics department is made up of 85 EFT of staff (clerical and nursing) who manage the variation in different units daily.

Currently, many units have high volume waiting lists causing appointment delays in some specialities, with patients sometimes experiencing >18-month delay for an appointment. Also, one of the Department of Health and Human Services (DHHS) Key Performance Indicators for Victorian hospitals is "90% of Urgent appointments seen within 30 days". However, the magnitude of the intervention involved is variable given the demand of some units from a community referral base and Austin Health's current performance for Urgent appointments seen within 30 days is <50%. Whilst there has been considerable training and education in queue management theory/ capacity

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management principles, and various other efforts to increase efficiencies, compliance with DHHS KPIs remains challenging. These delays can lead to clinical risk for patients due to worsening conditions, staff stress and longer waiting times for patients due to re-scheduling required.

Recently, we developed two solutions, a "Next Available Appointment" (NAA) and a "Template Planning Tool" (TPT) to support improved clinic scheduling and management. The TPT uses a collection of models and the current waitlist to provide a prediction capability for specialist clinic waitlist management. It also provides the ability for an end user to investigate "what if" scenarios up to two years into the future by varying key model parameters. This tool comprehensively captures the flow of patients to accurately capture the real demand met by clinicians. The NAA tool provides a method to predict a suitable date for a patient's next appointment on/after a date requested by the clinician. This tool provides informed decision-making capability to determine, in real-time, the next available appointment at the time a specialist makes a booking for a patient.

This paper describes the subsequent co-design and development of implementations of both these tools for a trial at Austin Health.

2. Methods

The implemented system (as shown in **Figure 1** for the TPT tool) was designed in a modular way with three main layers:

- Pre-processing step where data is gathered, cleaned and collated
- Modelling step using Monte Carlo simulations
- User interface where a user can enter configurable parameters

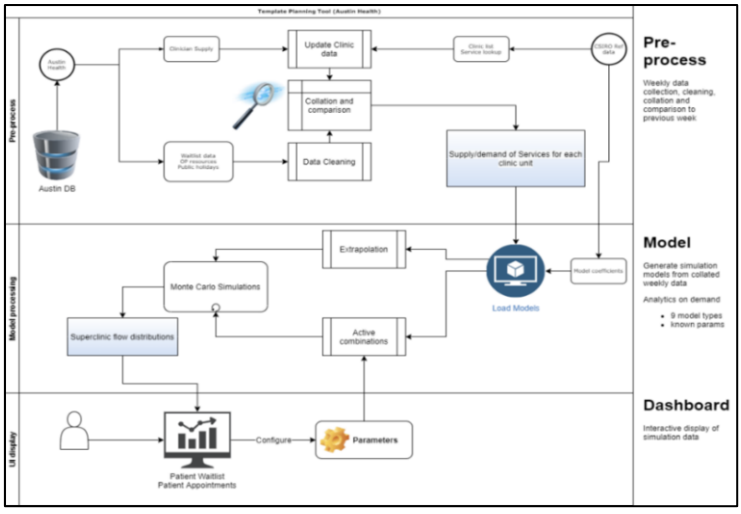

Figure 1. System design of the TPT tool.

The system was designed to be run in standalone mode on a virtual machine (VM) using Docker containers **(Figure 2)**. There are three components of the system which manage the user interaction, the running of the simulation and the display of results:

- A **User Interface** (UI) has been developed in Vue (i.e., an open-source JavaScript framework used for building front-end user interfaces) and provides a user management system. A user can self-register allowing them access to the tool. The user has the option of running either tool. The user can then select the required services and clinicians and, for the TPT tool, adjust a range of "what-if" parameters. For NAA tool, results are displayed immediately, however, a downloadable report is generated for a TPT one.
- A backend server has been developed in NodeJs Express which is a web application framework that provides a **REST API** (i.e., an interface that two computer systems use to exchange information securely over the internet) for communication between the UI, the database, and the simulation processes. Data, e.g., registered users, dropdown lists, request parameters and responses, is managed in a local SQLite database.
- For **Simulation Processing**, simulation code has been developed in R and is managed in a Docker container which runs an R API server. Requests for simulations are passed to the R API server and trigger the R code. TPT Simulation results are presented in a PDF report which is uploaded to the database and made accessible to the user via the UI. The NAA results are displayed directly to the user in near-real time.

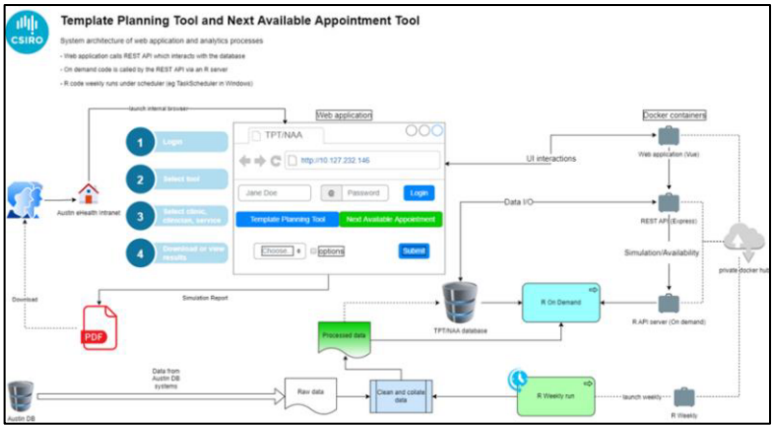

Figure 2. System structure of web application of implemented tools.

3. Results

Both NAA and TPT solutions have been implemented in the outpatient specialist clinic setting of the Austin health system. For the NAA tool, clinicians specify the unit, appointment type, and care provider and then select the timeframe in weeks or months. Then, they specify the recommended review period for the patient and run the tool. The NAA tool, using these inputs and the simulated queuing, shows the availability of a spot for a potential appointment. If the next appointment can be accommodated in the given timeframe, NAA confirms the availability, otherwise displays the timeframe is not available and provides the next available timeframe **(Figure 3)**. In either scenario, a feedback form is provided for the user to report the action they will likely take after

running the tool. This form helps to understand how the timeframe predicted by the tool affects the decision of clinicians for the next appointment.

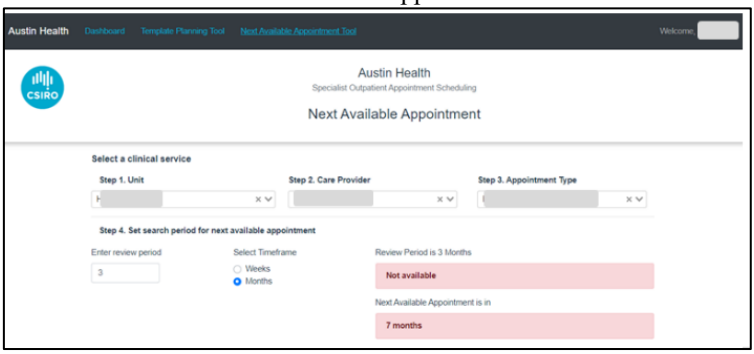

Figure 3. Screenshot of NAA displaying the next available appointment.

For the TPT tool, after the user selects the clinic, appointment type, and care provider, they can examine different scenarios by varying key model parameters such as changing the ratio of weekly discharge or the inflow of patients **(Figure 4)**. Also, the tool allows them to investigate the effect of overbooked appointments on the clinic flow.

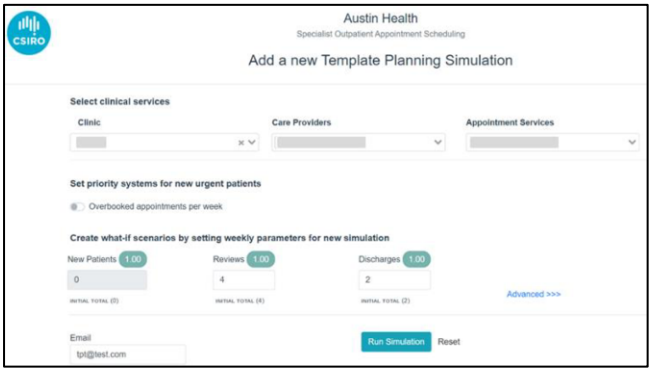

Figure 4. Screenshot of TPT features.

The output of the simulation is given in the form of plots and tables which summarise analytics representing the main measures of the selected clinic two years into the future **(Figure 5)**. The output includes 4 plots which are representing the simulated/predicted values for the next two years, on a weekly basis (i.e., 104 values each). The upper-left panel shows the weekly number of registrations to the waitlist. In this plot, the distribution of registration sources, either new or review, is also presented. The upper-right panel shows the weekly number of appointments. The lower-left panel shows analogous results for the weekly waitlist net change. That is the difference between the number added to the waitlist and the number removed from the waitlist, for each week. The lower-right panel shows the number of post-appointment discharges, defined as the number of appointments with no later scheduled appointments or waitlist registrations. Post-appointment discharges have been included as an indication of clinician-initiated discharges, as opposed to "administrative" discharges (e.g., referral expiry, automated waitlist clean-up). The plots are summarized in the upper table. The analytical results for each waitlist priority (review, routine, urgent) are shown in the lower table. This table

shows the total records for the next two years for each priority and the percentage of overdue appointments.

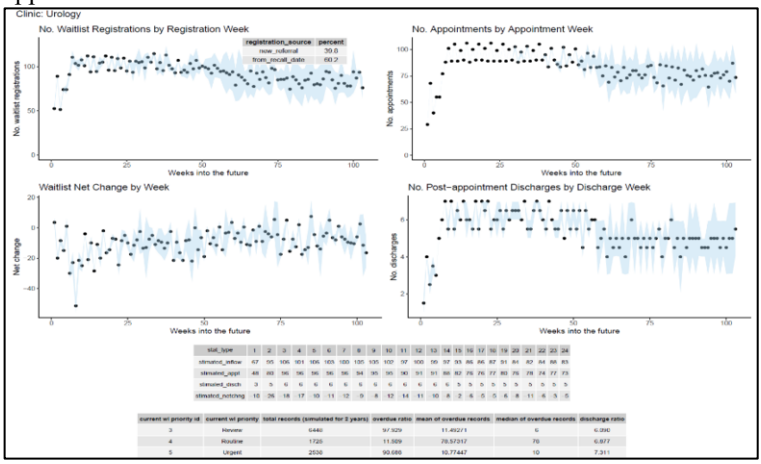

Figure 5. Screenshot of TPT output.

4. Discussion

The main aim of this study was to present the recently implemented tools in the outpatient specialist clinic setting of the Austin health system. The NAA tool provides informed decision-making capability to determine, in real-time, the next available appointment at the time a specialist makes a booking for a patient. TPT can simulate patient flow 2 years into the future based on user-selected parameters to support clinic management. The implemented solutions are transferable to other health jurisdictions to manage specialist clinic waitlist demand and improve performance against key performance metrics. Outputs from these solutions lay the foundation for evidence-based discussions with hospital decision-makers for improving access to timely care in outpatient specialist clinics.

5. Conclusions

The Next Available Appointment (NAA) and Template Planning Tool (TPT) are web-based software applications that provide visual prompts using validity algorithm/s to provide clinicians with upfront information about the ability to manage the risk associated with delays and provide additional insight for planning and scheduling of outpatient appointments at Austin Health, whilst continuing to improve the patient experience.

References

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