IMPROVING CHEMOTHERAPY SCHEDULING TO OPTIMISE RESOURCE UTILISATION

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IE3100M Systems Design Project

① Company Background

- The National University Cancer Institute, Singapore (NCIS) is a national specialist centre under the National University Health System (NUHS)
- It is one of two national specialist centres in Singapore dedicated to the treatment of patients with cancer and the only public cancer centre that treats both paediatric and adult cancer in one facility.
- Their vision is a healthy community, shaping medicine, transforming care. They hope to improve the community's health by delivering quality and value healthcare through efforts in clinical care, education and research.

② Problems & Observations

The problem that NCIS is facing is the lack of an optimised process flow to maximise the use of all available resources. Given the ever increasing population of cancer patients, it is paramount that the utilisation of both treatment chairs and manpower be maximised. Through our time study, we have identified 4 main areas of improvement.

Long idle time on the chairs – due to lack of treatment nurses to administer treatment	Fluctuating workload of nurses – uneven distribution of workload throughout the day.	Appointment scheduling process was complex and time consuming – too many systems and processes that needed trained nurses to operate.	Inefficient communication channels – leading to a waste of manpower in doing admin tasks.

③ Key Objectives

1. Increase treatment chair utilisation rates
2. Achieve even workload distribution in daily operations
3. Utilise healthcare professionals for healthcare-centric tasks

This leads to an **improvement in resource utilisation**.

④ Key Skillsets

Task Analysis
When attempting to decentralise the scheduling process, we adopted a task analysis framework to better understand the key steps and information necessary in making a chemotherapy booking.

Hierarchical Task Analysis
1. Task Breakdown by Agent
2. Breakdown by Hierarchy
3. Evaluation of Individual Tasks

Mixed Integer Programming
Given the many objectives and constraints within the scheduling process, an multi variable-constraint mixed integer model was employed.

Software Engineering
Software engineering skills and concepts were used to develop solutions, which in turn bridged gaps found in the processes.

Human Factors Engineering
Concepts in Human Factors Engineering were considered, in order to create solutions that are intuitive and user-friendly.

⑥ Validation

Chemotherapy Scheduling Optimiser (CSO)

In order for the CSO to be effective, the current booking system must be assigned blocks reserved for specified treatment. In Jan 2018, the scheduling process was changed to facilitate the introduction of the optimised system with treatment blocks assigned. The change has produced results which signals the large improvement potential of the CSO. Chair utilisation improved by 8% from 82% to 90%.

Average Daily Chair Utilisation (Before / After)
- Average Utilisation per Day
- Utilisation Rate
- Linear (Maximum Utilisation per Day)

Treatment Excel Catalog (TEC)

The first version of the TEC was introduced in Feb 2018 for trial testing. Since then, two iterations of the TEC have been further introduced as updates. While the TEC has yet to allow for the decentralisation of the scheduling process, the response has been positive. The TEC appears to be feasible in bridging the information gap between the more experienced listing nurses and the less experienced clinic assistant. As we continue to monitor the usage of the TEC, we will continue to improve upon the system to eventually allow for a full decentralisation.
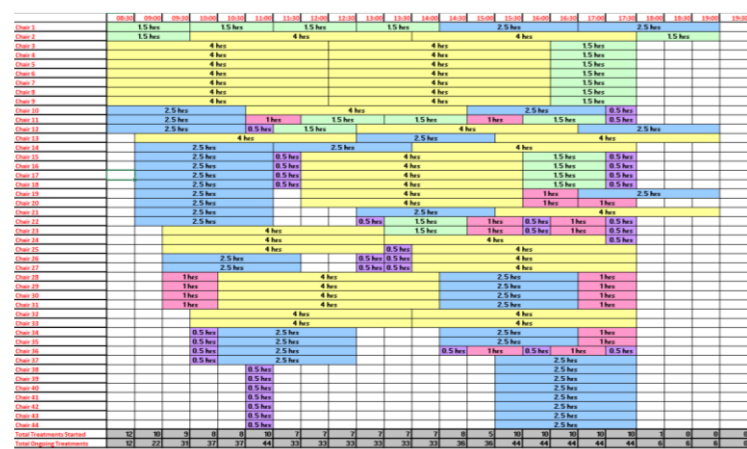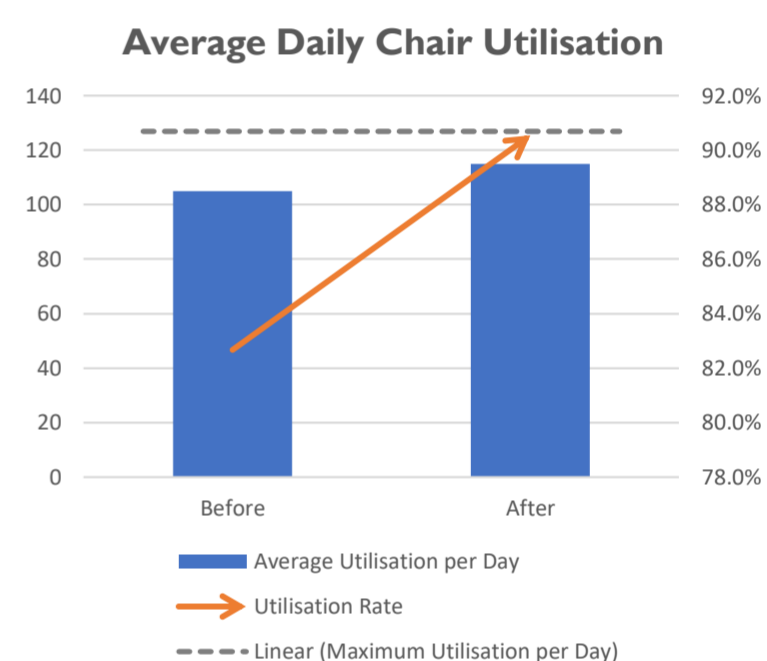
⑤ Solutions

Chemotherapy Scheduling Optimiser (CSO)

Improvement in the Planning of Treatment Schedule
Implementation of an optimal scheduling system which integrates IBM CPLEX 12.7 and Microsoft Excel
- User provides resource capacity constraints
- Software takes in constraints and generates optimal schedule
- Optimal schedule is one that maximises chair utilisation, while restricting the workload spikes for front-end staff

	1	2	3	4	5
No. of Treatments Types	5				
Length of Treatments (in Terms of Time Slot)	3	8	5	2	1
Ratio of Treatments (Sum to 1.00)	0.125	0.25	0.25	0.125	0.25
No. of Treatments Booked	510	814	925	418	898
No. of No-Shows	60	80	100	120	70
No-Show Factor	1				
Allowable Error in Ratio	0.02				
Total No. of Chairs	44				
Max Total Cases per Nurse	3				
Max Ongoing Cases per Nurse	7				
Max New Cases per Nurse	1				
Max New Cases per Time Slot	12				
No. of Time Slots	23				

	1	2	3	4	5
Manpower at each Time Slot	12.5	12.5	12.5	12.5	12.5
No. of Operating Chairs at each Time Slot	44	44	44	44	44

User Interface for Input Parameters

Optimal Treatment Schedule

Processing by CSO

Treatment Excel Catalog (TEC)

Improvement in the Execution of Treatment Bookings
We introduce the Treatment Excel Catalogue (TEC), an aggregator that helps links the untrained clinic assistants to the more complex chemotherapy treatment details.
- By reading a set of required variables, the TEC uses the input variables and a list of pre-defined variables to produce an output variable

TEC Framework

Input Variables
Default Variables
→ Output Variables

User

Administrator

3 Main Interface + 1 Settings Page
- Treatment
- Blackout Dates
- Additional Information