Development of an Automated Nurse Rostering System for the Emergency Department in the Singapore General Hospital

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Ang Boon Yew[1], Lam Shao Wei,Sean[1], Ong Eng Hock, Marcus[1,2]

2 Department of Emergency Medicine, Singapore General Hospital;
1 Health Services Research Centre, Singapore Health Services

SingHealth DUKE NUS ACADEMIC MEDICAL CENTRE

Introduction

The dynamic working environment in the emergency department **poses many challenges to creating rosters**, due to the **wide range of rules and requirements**, such as skill and gender mixes. These difficulties hamper the current manual rostering process, which requires **more than 100 nurses to be scheduled within a 2 week period**. Hence, the objective of this project is to develop an efficient system in order to **reduce the time taken and effort needed** to produce monthly rosters for nurses in the emergency department.

Staff Requirements

Skill Mix
- Triaged trained nurses
- Resuscitation trained nurses
- Overall in-charge capability

Workforce Mix
- Male vs female nurse ratio
- Senior vs junior nurse mix
- Minimum nurse to patient ratio

Schedule Requirements

Work Policies
- 2 rest days per week
- No more than 5 work days in a row
- 3 consecutive night shifts

Nurse Preferences
- Satisfy requests for shifts
- Allocate unfavorable shifts equally

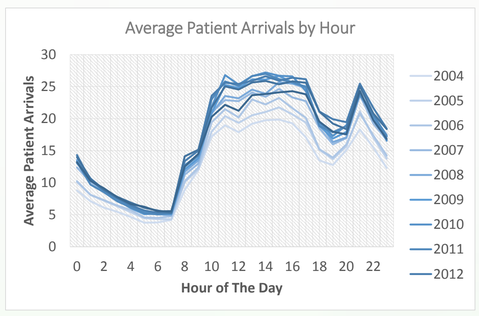
Monthly Rosters

Roster Creation
- 2 week circulating rosters
- Continuous production over rostering period
- Difficulty in enforcing all requirements

Methodology

Interviews with nurse clinicians and analysis of **patient arrival data** were conducted to determine the rostering **operational requirements.**

1
- Manpower Requirements
- Nurse Skill Mix
- 2
- 3
- 4
- Adhere to Work Policies
- Staff Welfare



Mathematical model with 4 key performance metrics was developed in order to reflect these objectives and **measure roster quality and performance.**

1. Average Nurse Patient Ratio Deviation

$$minimize \sum_{d=1}^{28} \sum_{j=1}^{3} \frac{Y_{jd}}{28}$$

2. Average Undesirable Shift Deviation

$$minimize \frac{\sum_{i=1}^{n} Z_i}{n}$$

3. Number of Approved Requests

$$maximize \sum_{i=1}^{n} \sum_{d=1}^{28} x_{ijd} p_{ijd} \; \forall \, i, d, j \in 1,4$$

4. Distribution of Non-Working Days

$$maximize \sum_{i=1}^{n} \sum_{d=1}^{28} |x_{ijd} - x_{ij(d+1)}| \; \forall \, i, d, j = 4,5,6$$

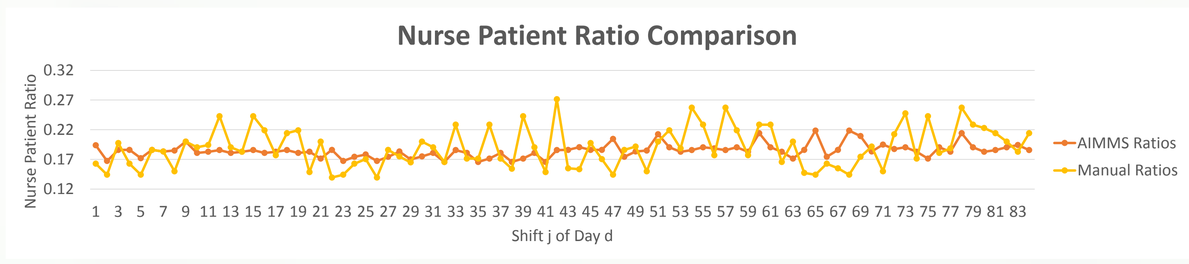
Each goal is satisfied as much as possible before moving on to the next one

Results

The rosters created through the automated system were compared with manually created rosters for similar time periods based on key performance indicators used in the mathematical model.

Key Results:

1. **Efficient allocation of manpower in response to patient demand**
2. **More equitable distribution of undesirable shifts**
3. **High number of approved requests**
4. **Reduction of long working stretches by distributing non-working days**



<30 mins
to create full rosters

Demand Sensitive
for manpower allocation

Better Patient Outcomes
with better nurse patient ratios

Shift Equity
for undesirable shifts

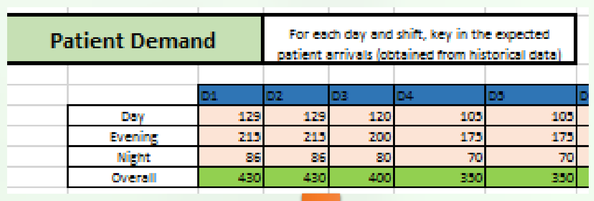
Implementation

System Development and Usage

- Automated rostering system based on a **mathematical optimization model**
- **Flexible response to changes** in patient arrival patterns and staff requirements
- Based on **Microsoft Excel** and **AIMMS (optimization software)**

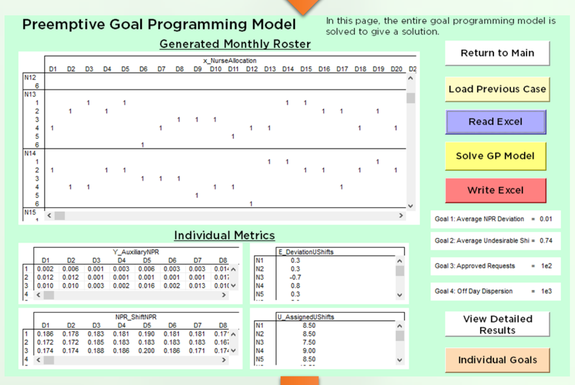
1.Input

User enters in three initial inputs for the model:
1. Expected daily patient demand
2. Nurse skill levels
3. Applied leaves and special cases



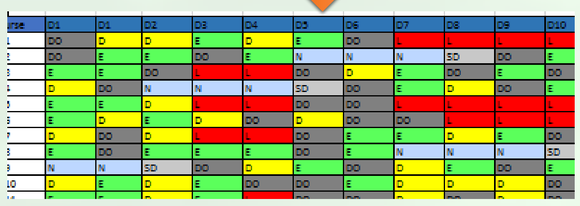
2. Optimization

Shifts are then assigned through AIMMS in order to achieve the desired objectives while adhering to the strict scheduling requirements



3. Output

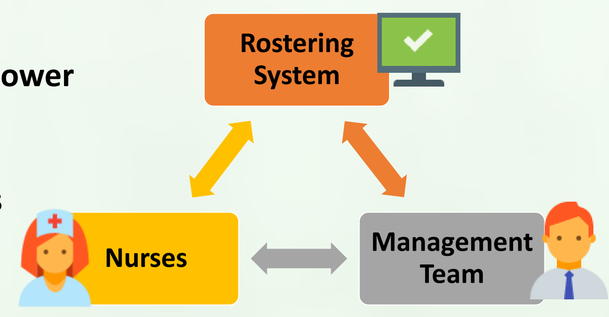
Raw solver outputs from AIMMS are translated into rosters for deployment in Excel.

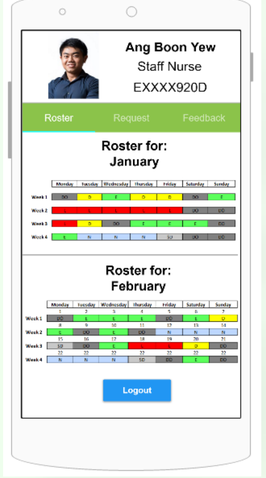


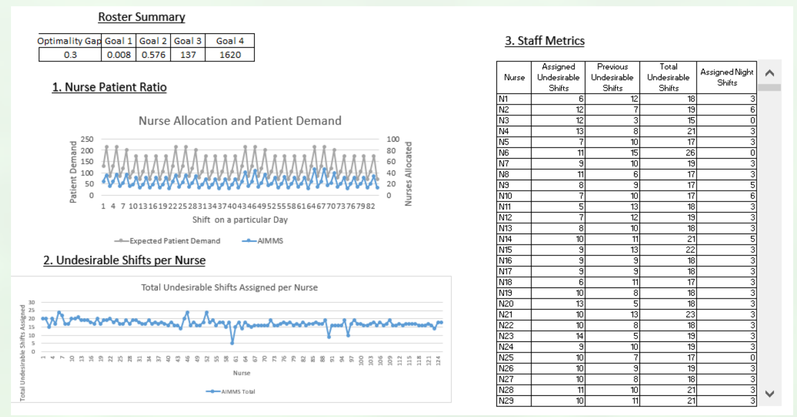
Management & Staff Support

System Integration

1. **Excel dashboards** for monitoring **manpower allocation** and **staff welfare**
2. **Mobile apps** for nurses to have **easy access to rosters** and to **make requests or feedback**







Conclusion

The automated rostering framework **reduces the time and effort needed** to create monthly rosters, **improving manpower allocation** in response to patient demand and **maximizing staff satisfaction** through more **equitable shift allocations.** It also has the potential for future modifications and extensions to be made in lieu of policy changes, demonstrating it's flexibility in use for operations.