IE3100M: Systems Design Project in collaboration with National University Hospital (NUH)

Smart Notification System to Reduce Medication Errors and Patient Fall Rates

Group 11: CHAN Tiong Ley, CHEN Feng, Damien CHAN, TAN Wei Xiang (Leader)
NUS Supervisors: Professor Andrew LIM, Dr. LI QiaoHong
Industry Supervisors: Jennie Jen Chieh GOH, Caroline LEE, Jaime GOH

National University of Singapore
Department of Industrial Systems Engineering and Management

1. Background and Objectives

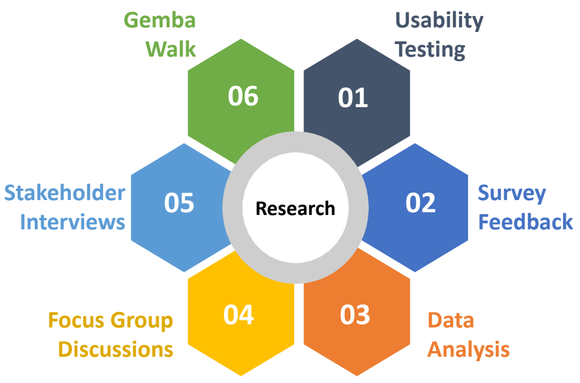
Client Background – National University Hospital (NUH)
NUH is one of the main hospitals in Singapore, with 1,239 bed capacity and serving more than 49,000 inpatients yearly. To improve the quality of their healthcare, NUH needs to reduce avoidable errors, especially medication errors and fall incidences.

In this project, NUH has two goals and one key constraint:

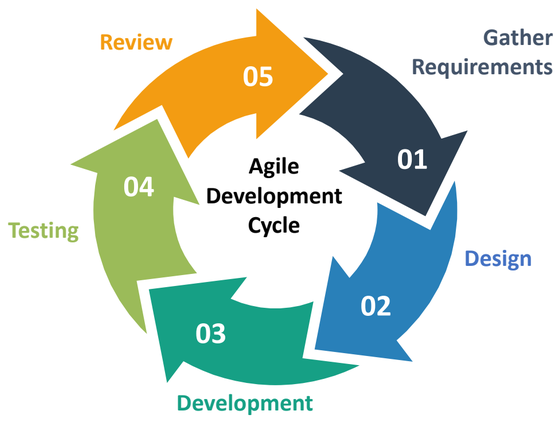
- **Goal 1** Reduce Medication Errors
- **Goal 2** Reduce Fall Incidences
- **Key Constraint** No increase in staff

2. Methodology

Research Methodology



Iterative Design and Development Process



3. Current System and Key Opportunities

Primary Research

Time Study Nurse Shadowing
A form of Gemba walk to experience in real life the nurses' jobs and record data in a quantitative manner.

Exploring Electronic Hospital Occurrence Records
Conduct data analysis to identify trends and root problems

Nurse Interviews
Gather information about nurses' experience with medication administration and fall prevention

Challenges in Current System

Medication Process

- **Heavy reliance on human memory;**
- **Lack of notifications** when new medication is ordered resulting in needless checking of the system;
- **Lack of error prevention design** in the process.

Fall Rates

- **NUH has exhausted almost all the measures** utilised by healthcare systems around the world;
- **Falls happen sporadically** and the best way to prevent them is having nurses be aware of the patients.

Key Opportunities

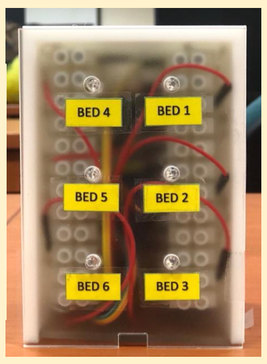
Getting Administration Times Right
Tools that assist nurses to grasp the right medication timing and frequency can greatly reduce medication errors down to 53%.

Improving Coverage
Tools that can improve ward coverage by freeing nurses can potentially reduce fall incidences down to 60%.

4. Proposed Solution: The Smart Notification System

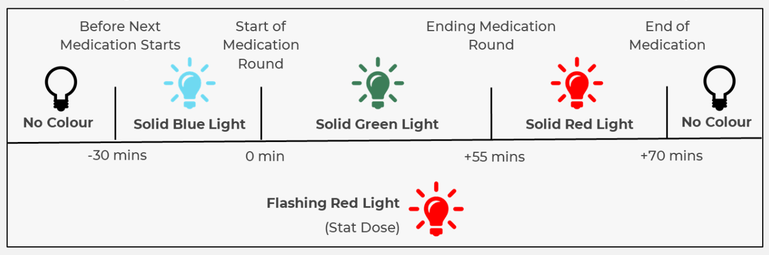
A) Smart Notification System (SNS)

The SNS is a **decision-support tool for medication administration.** It aids in the medication administration process by signalling the required medication administration actions using light.



B) Lights to Signal Nurses' Action

Different lights represent different instances of time and actions required.

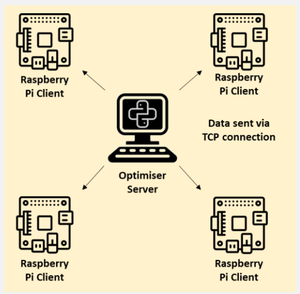


Signals and their meaning

- **No colour:** No action is required
- **Blue light:** Prepare for medication round
- **Green light:** Medication should be served now.
- **Red light:** Serve now! Before a medication error occurs
- **Flashing Red light:** This a stat dose. Serve now!

C) Realtime Updates via Server

A "server-client architecture" is built in the SNS. A computer acts as a server to send information to the Raspberry Pi. Optimised medication serve timings are streamed into each Raspberry Pi in real-time.



D) Integer Programming

The signal time optimisation is done using integer programming where the objective function aims to **minimise the number of time slots nurses need to serve medication**. The optimisation uses Python's MIP package.

E) Expected Result

Through the optimised light signals,

Administration times should be accurate as the light signals guide the medication administration process and reduce timing and frequency medication errors.

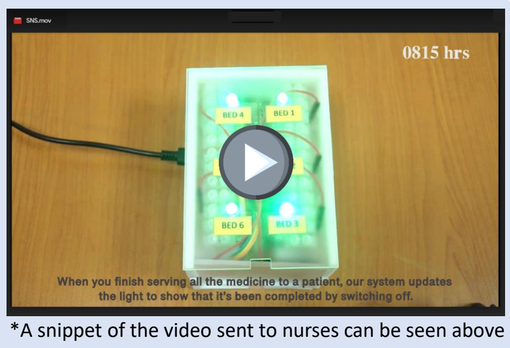
Coverage of wards is improved as the light signals are staggered between cubicles. This reduces the chances of nurses' coverage falling when nurses serve medication at the same time.

5. Results & Implementation

Validation via Survey due to COVID-19

Due to the COVID-19 pandemic, **NUH could not be accessed anymore**. Hence, a survey was given out an alternative to pilot testing.

To obtain as accurate results as possible, a video (a snippet on the right) was attached to each survey, to **ensure the SNS was thoroughly explained to the respondents.**



*A snippet of the video sent to nurses can be seen above

Outcome: Extremely Positive Response

Total Respondents: 50 Nurses (70% with more than 5 years experience)

Achieved Results:

- **92%** Want the SNS to be implemented in NUH
- **86%** Think the SNS is effective in reducing medication error
- **74%** Think the SNS is effective in reducing fall rates

Implementation and Scaling in NUH

Cloud-powered Server
When scaled, a powerful server is required to run all the necessary optimisations in NUH

Customisation of Integer Program
Wards outside of the scope of this project would entail new constraints.

6. Further Extensions

The SNS is a novel decision-support tool which incorporates electronic medical records, integer programming and electrical engineering.

The bulk of the SNS optimiser is generalisable to other healthcare institutions where the optimiser will work as long as the required patient data is available digitally. This means the SNS can be **scaled globally**. Though extensions have to be made in terms of the unique constraints each healthcare institution has.

Besides the math, work can be done to improve the user interface of the SNS hardware.

Acknowledgements

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Technical Skills Used

- System Thinking
- Integer Programming
- Data Analysis
- Human Factors Engineering
- Computer-Aided Design (CAD)
- Electrical Engineering