COVID-19 SURGERY RISK OF INFECTION MODEL

AY2020/2021 IE3100M Systems Design Project

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BACKGROUND

Given the highly infectious nature of the COVID-19 and the increase in the number of COVID-19 cases admitted to hospitals, it is essential for SingHealth to conduct an epidemiological study to protect its medical staff.

OBJECTIVES

The purpose of this project is to find out approaches to mitigate and reduce the risk of transmission for healthcare workers at a reasonable economic cost.

METHODOLOGY

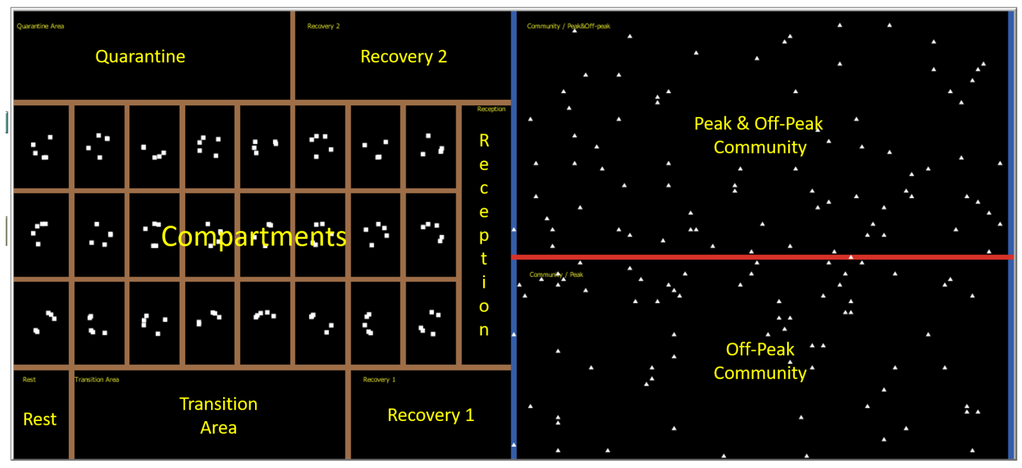
Strategies

- Social distancing in the work place.
- Rationalised PPE(Personal Protective Equipment) use.
- Compartmentalisation of care teams.
- Screening of asymptomatic patients.
- Postponement of elective surgery.

Agent-Based Simulation Model

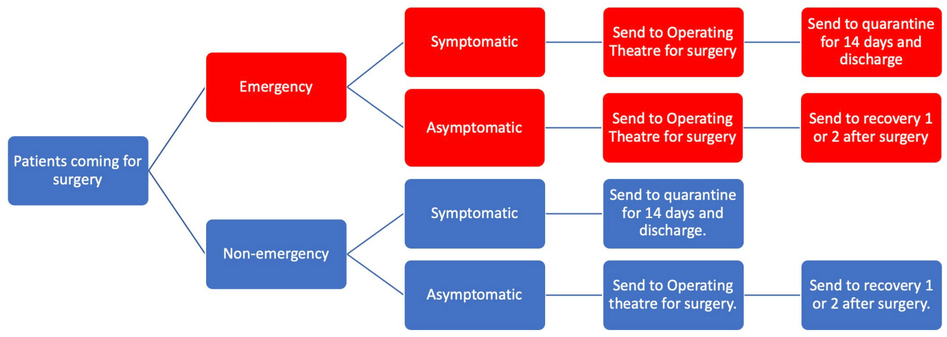
- Models individual entities as agents who interact and affect one another such as transmission of COVID-19.
- Captures the interactions between HCWs and patients.
- Incorporates probabilities of interactions between agents.
- Allows for evaluation of different scenarios and parameters levels for decision making.

BASE MODEL LAYOUT



- Community: Public area. HCWs will be sent to the Community after their working hours.
- Hospital rest area: For HCWs to rest when there are no immediate surgeries to perform.
- Compartments: Each surgery will be performed within one of the compartments where each compartment contains the patient and HCWs.
- Quarantine area: Agents will be sent to the quarantine area if the swab test returns a positive result for the COVID-19 test.

FLOW DIAGRAM



Patients who come to the hospital are differentiated by emergency patients and non-emergency patients. For emergency patients, regardless of their swab test result, they need to go through the surgery first and go to quarantine if test positive. For non-emergency patients, test-positive patients will postpone the surgery and go to quarantine for 14 days while test-negative patients will go through the surgery directly.

SENSITIVITY ANALYSIS

Best & Worst case study

By running the model for one year with 30 repetitions for each run, the team obtained the result shown in the tables. From the result, the best prevention strategy under the best case scenario is through PPE, leading to 0.28% of infected healthcare workers. On the other hand, the best prevention strategy under the worst case scenario is compartalization which leads to a 3.97% of infected healthcare workers.

Best case 1	
Constant factors	
asympto-to-sympto-probability	0.2
distancing-infection-chance	0.04
initial-infection-chance	0.05
Swab test	100
C1,C2-4	0.65 & 0.05
One precaution to be taken	
PPE	Y & Full
Compartment	N
Social distance-hospital	N
Social distance-community	N
Final Result	
% infected HCWs	0.28
% infected Patients	0.00065
No. of swabs used	5444

Worse case 1	
Constant factors	
asympto-to-sympto-probability	1.00
distancing-infection-chance	0.65
initial-infection-chance	0.50
Swab test	0.00
C1,C2-4	0.65 & 0.05
One precaution to be taken	
PPE	Y & Full
Compartment	N
Social distance-hospital	N
Social distance-community	N
Final Result	
% infected HCWs	4.39
% infected Patients	0.06158
No. of swabs used	2158

Best case 2	
Constant factors	
asympto-to-sympto-probability	0.2
distancing-infection-chance	0.04
initial-infection-chance	0.05
Swab test	100
C1,C2-4	0.65 & 0.05
One precaution to be taken	
PPE	Y & Mask
Compartment	N
Social distance-hospital	N
Social distance-community	N
Final Result	
% infected HCWs	0.74
% infected Patients	0.00063
No. of swabs used	5434

Worse case 2	
Constant factors	
asympto-to-sympto-probability	1.00
distancing-infection-chance	0.65
initial-infection-chance	0.50
Swab test	0.00
C1,C2-4	0.65 & 0.05
One precaution to be taken	
PPE	Y & Mask
Compartment	N
Social distance-hospital	N
Social distance-community	N
Final Result	
% infected HCWs	5.78
% infected Patients	0.00190
No. of swabs used	2150

Best case 3	
Constant factors	
asympto-to-sympto-probability	0.2
distancing-infection-chance	0.04
initial-infection-chance	0.05
Swab test	100
C1,C2-4	0.65 & 0.05
One precaution to be taken	
PPE	N
Compartment	Y
Social distance-hospital	N
Social distance-community	N
Final Result	
% infected HCWs	0.48
% infected Patients	0
No. of swabs used	5445

Worse case 3	
Constant factors	
asympto-to-sympto-probability	1.00
distancing-infection-chance	0.65
initial-infection-chance	0.50
Swab test	0.00
C1,C2-4	0.65 & 0.05
One precaution to be taken	
PPE	N
Compartment	Y
Social distance-hospital	N
Social distance-community	N
Final Result	
% infected HCWs	3.97
% infected Patients	0.35473
No. of swabs used	2142

Best case 4	
Constant factors	
asympto-to-sympto-probability	0.2
distancing-infection-chance	0.04
initial-infection-chance	0.05
Swab test	100
C1,C2-4	0.65 & 0.05
One precaution to be taken	
PPE	N
Compartment	N
Social distance-hospital	Y
Social distance-community	N
Final Result	
% infected HCWs	0.63
% infected Patients	0.00064
No. of swabs used	5469

Worst case 4	
Constant factors	
asympto-to-sympto-probability	1.00
distancing-infection-chance	0.65
initial-infection-chance	0.50
Swab test	0.00
C1,C2-4	0.65 & 0.05
One precaution to be taken	
PPE	N
Compartment	N
Social distance-hospital	Y
Social distance-community	N
Final Result	
% infected HCWs	6.76
% infected Patients	0.00449
No. of swabs used	2141

Best case 5	
Constant factors	
asympto-to-sympto-probability	0.2
distancing-infection-chance	0.04
initial-infection-chance	0.05
Swab test	100
C1,C2-4	0.65 & 0.05
One precaution to be taken	
PPE	N
Compartment	N
Social distance-hospital	N
Social distance-community	Y
Final Result	
% infected HCWs	0.33
% infected Patients	0
No. of swabs used	5450

Worst case 5	
Constant factors	
asympto-to-sympto-probability	1.00
distancing-infection-chance	0.65
initial-infection-chance	0.50
Swab test	0.00
C1,C2-4	0.65 & 0.05
One precaution to be taken	
PPE	N
Compartment	N
Social distance-hospital	N
Social distance-community	Y
Final Result	
% infected HCWs	7.91
% infected Patients	0.00127
No. of swabs used	2142

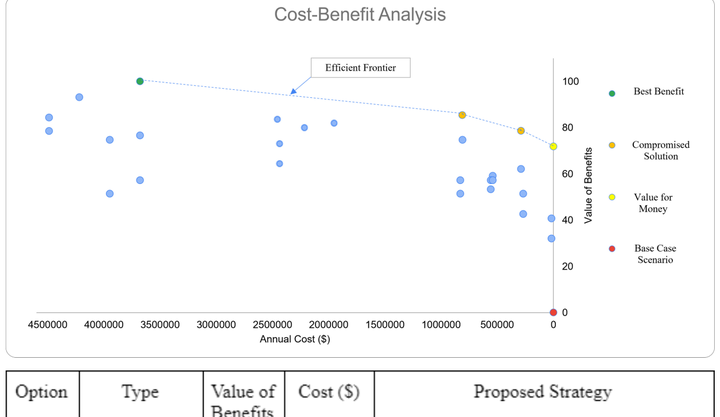
Validation with Microsimulation model

Intervention	Stochastic Microsimulations: Median Probability of HCW infection	Stochastic Microsimulations: % Reduction in Median	NetLogo Model: Median Probability of HCW infection	NetLogo Model: % Reduction in Median
Baseline	**0.21%**		**1.39%**	
20% social distancing	0.19%	-2.00%	1.20%	-0.19%
40% social distancing	0.17%	-4.00%	1.11%	-0.28%
60% social distancing	0.15%	-6.00%	1.06%	-0.33%
80% social distancing	0.13%	-8.00%	0.93%	-0.46%
100% social distancing	0.11%	-10.00%	0.81%	-0.57%
No PPE	0.21%	0.00%	1.24%	-0.15%
Baseline (Minimal PPE)	0.21%	0.00%	0.73%	-0.65%
full PPE for all	0.21%	0.00%	0.48%	-0.90%
100% compartmentalisation	-	-	1.28%	-0.11%
Swabs 20% effective	0.20%	-1.00%	1.16%	-0.22%
Swabs 40% effective	0.20%	-1.00%	0.77%	-0.62%
Swabs 60% effective	0.20%	-1.00%	0.66%	-0.73%
Swabs 80% effective	0.20%	-1.00%	0.44%	-0.95%
20% postponement	0.20%	-1.00%	1.28%	-0.11%
40% postponement	0.17%	-4.00%	0.94%	-0.44%
60% postponement	0.16%	-5.00%	0.73%	-0.66%
80% postponement	0.13%	-8.00%	0.61%	-0.78%

A model validation is performed by comparing the results from a microsimulation developed by SingHealth. The team adopted the same parameters used in the microsimulation model for a comparison with the NetLogo simulation model. When compared to the NetLogo model, SingHealth has provided their confirmation that the results from the NetLogo model have more realistic probabilities.

RECOMMENDATION

A cost-benefit analysis was performed to aid decision making. An option can be selected from the table below after taking into consideration some factors which include cost feasibility, availability of PPEs and masks as well as the desired level of risk to protect HCWs from COVID-19 infection.



Option	Type	Value of Benefits	Cost ($)	Proposed Strategy
1	Best Benefit	100	3679200	PPE, Compartmentalisation
2	Compromised Solution	85.4	810000	Compartmentalisation, Social Distancing (Community + Hospital)
3	Compromised Solution	78.6	288396	Mask, Social Distancing (Hospital)
4	Value for Money	71.8	0	Social Distancing (Community)

WHAT'S NEXT

Further study directions are proposed which might be helpful in generating more insights on this topic.

- Vaccine injection: This might be a good focus in monitoring the reduction of infection using up-to-date literature on vaccine efficacies.
- AB-shifting: Is a prevention method used to reduce human interaction and exposure among workers in the workplace. This method can be studied for healthcare worker teams.
- Extending the model to other infectious diseases: Although the current agent-based model is tailored to Singapore's COVID-19 situation, the team believes that the model is a good reference for simulating any forms of infectious diseases and generating meaningful insights.

KEY SKILLSETS

Simulation — **Design-Thinking** — **Data Analysis**