'Protecting staff and the Emergency System during COVID-19 in Singapore'

Prof. Marcus Ong
Senior Consultant, Clinician Scientist
Department of Emergency Medicine
Singapore General Hospital
Director, Health Services Research Center, Singhealth
Director, Health Services and Systems Research, Duke-NUS Medical School
Medical Director, Unit for Prehospital Emergency Care
Senior Consultant, Ministry of Health

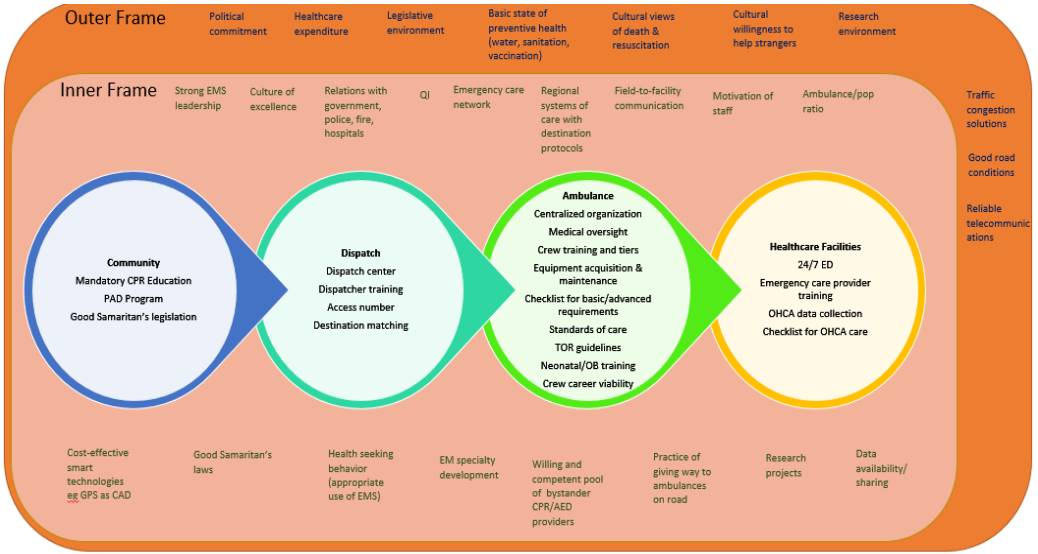
Singapore

- Area - 712 km^2
- Population - 5.4 million
- One of the most densely populated countries in the world
- International travel hub
- One of the earliest to report COVID-19 outside China

It takes a System to Save a Life

Barriers

- Geographic constraints
- Poor Infrastructure
- Cultural mindset
- Lack of public awareness
- Lack of funding
- Low Public CPR skills
- Low AED availability & skills
- Low EMS Crew/dispatcher training
- Multiple, poorly regulated independent ambulance providers
- Ambulance crew training and attrition issues
- Hospital cooperativity and communications
- Data sharing issues

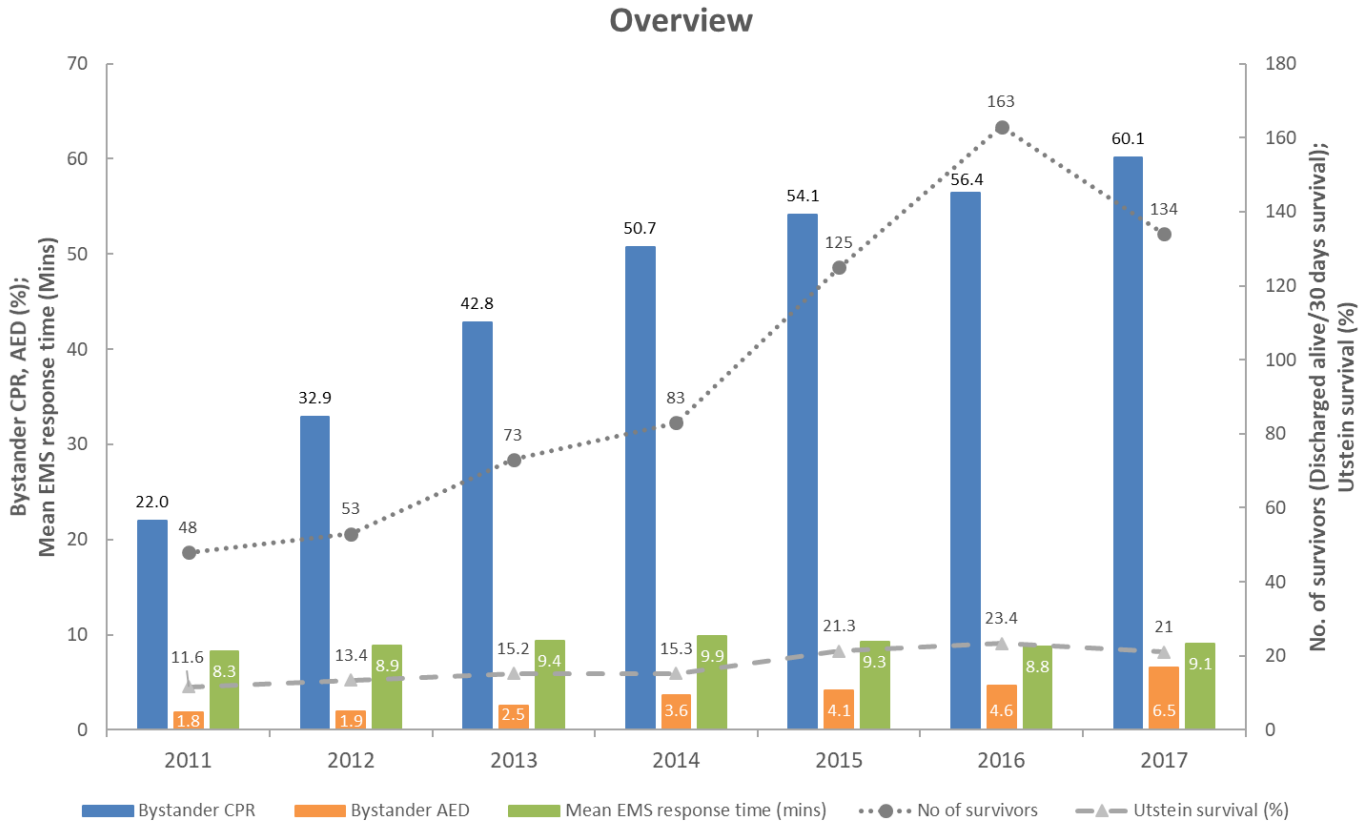


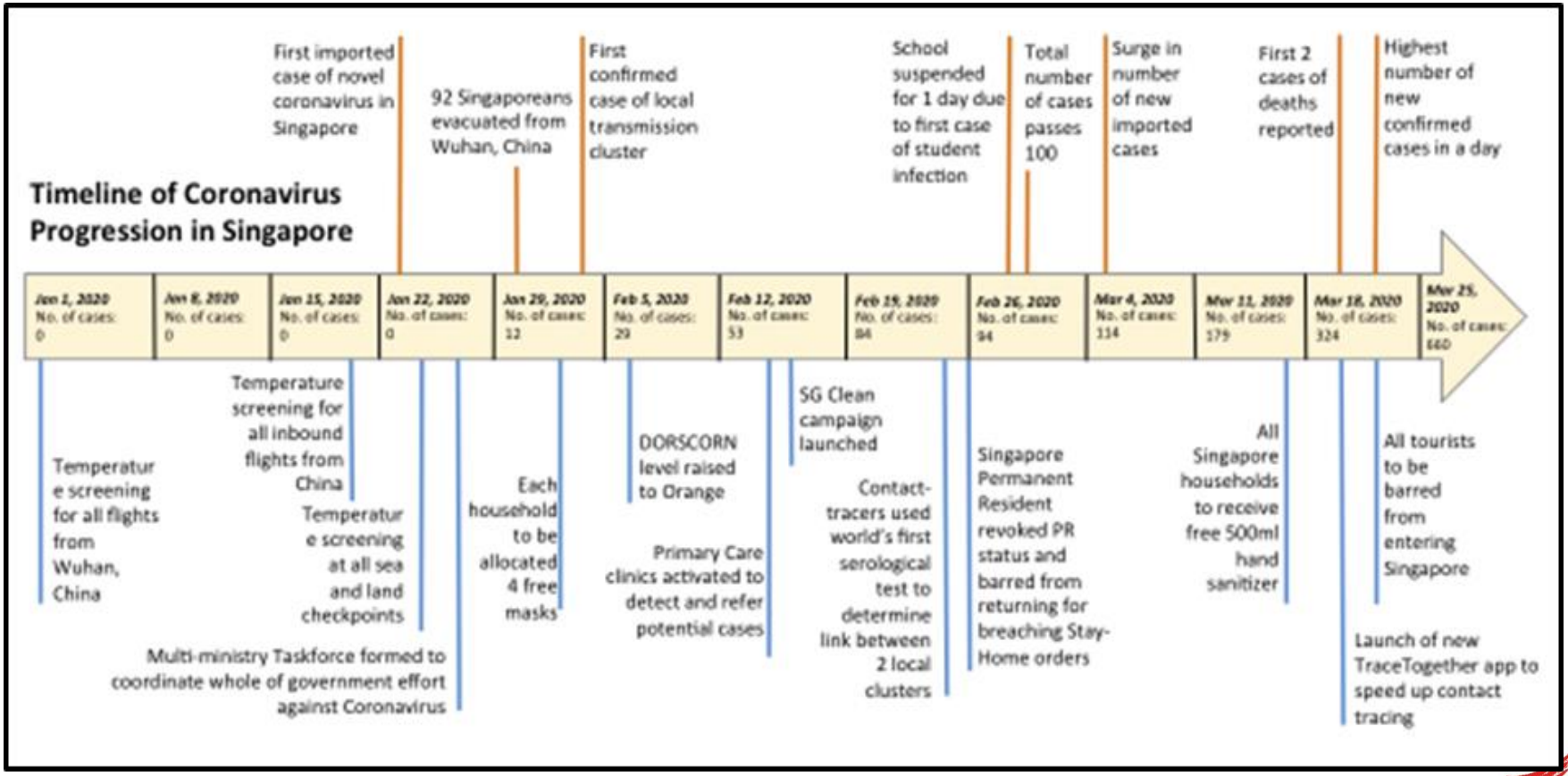
GRA 10-Steps

1. Cardiac arrest registry
2. Telephone CPR
3. High Performance EMS CPR
4. Rapid Dispatch
5. Measurement of professional resuscitation using defibrillator
6. First responder AED program
7. Smart technologies for CPR/AED
8. Mandatory training for CPR/AED
9. Accountability
10. Culture of Excellence

Bridging the gap

Improving OHCA survival in Singapore

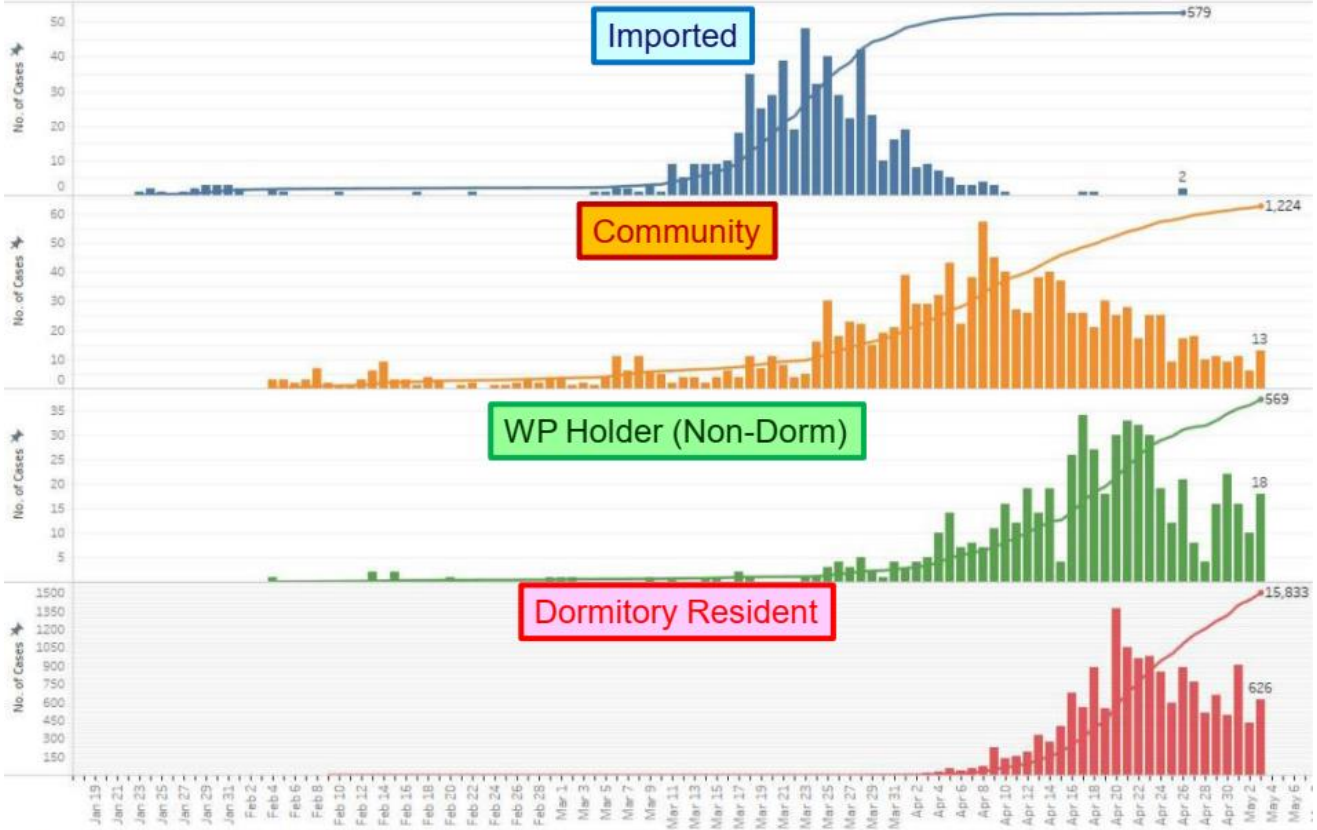



Timeline of Coronavirus Progression in Singapore
First imported case of novel coronavirus in Singapore
92 Singaporeans evacuated from Wuhan, China
First confirmed case of local transmission cluster
School suspended for 1 day due to first case of student infection
Total number of cases passes 100
Surge in number of new imported cases
First 2 cases of deaths reported
Highest number of new confirmed cases in a day
Jan 1, 2020 No. of cases: 0
Jan 8, 2020 No. of cases: 0
Jan 15, 2020 No. of cases: 0
Jan 22, 2020 No. of cases: 0
Jan 29, 2020 No. of cases: 12
Feb 5, 2020 No. of cases: 29
Feb 12, 2020 No. of cases: 53
Feb 19, 2020 No. of cases: 84
Feb 26, 2020 No. of cases: 94
Mar 4, 2020 No. of cases: 114
Mar 11, 2020 No. of cases: 179
Mar 18, 2020 No. of cases: 324
Mar 25, 2020 No. of cases: 660
Temperature screening for all flights from Wuhan, China
Temperature screening for all inbound flights from China
Temperature screening at all sea and land checkpoints
Multi-ministry Taskforce formed to coordinate whole of government effort against Coronavirus
Each household to be allocated 4 free masks
DORSCORN level raised to Orange
Primary Care clinics activated to detect and refer potential cases
SG Clean campaign launched
Contact-tracers used world's first serological test to determine link between 2 local clusters
Singapore Permanent Resident revoked PR status and barred from returning for breaching Stay-Home orders
All Singapore households to receive free 500ml hand sanitizer
All tourists to be barred from entering Singapore
Launch of new TraceTogether app to speed up contact tracing

SingHealth

Epidemic Curve of the COVID-19 Outbreak in Singapore by Press Release Date

National Centre for Infectious Diseases



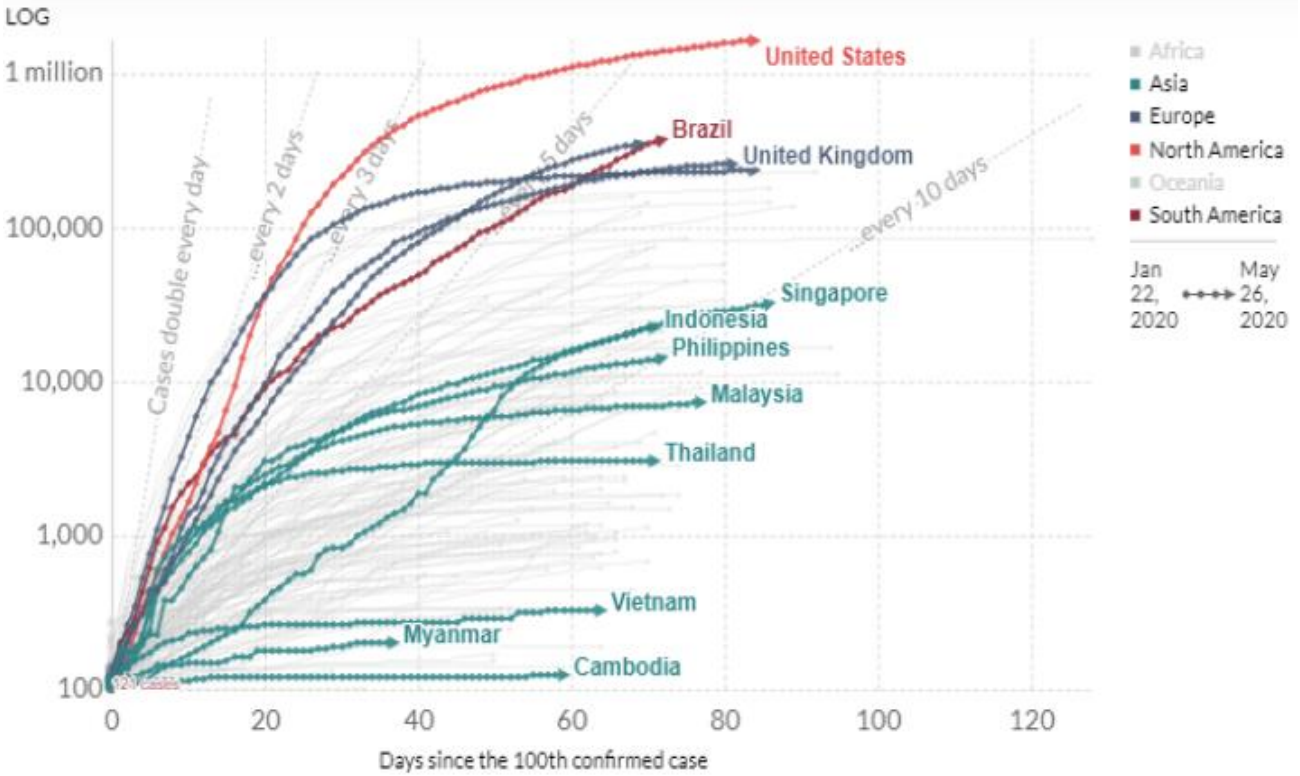
Source: MOH COVID-19 Situation Report

Updated 3 May 2020

SingHealth

Trajectory comparisons for confirmed cases

National Centre for Infectious Diseases

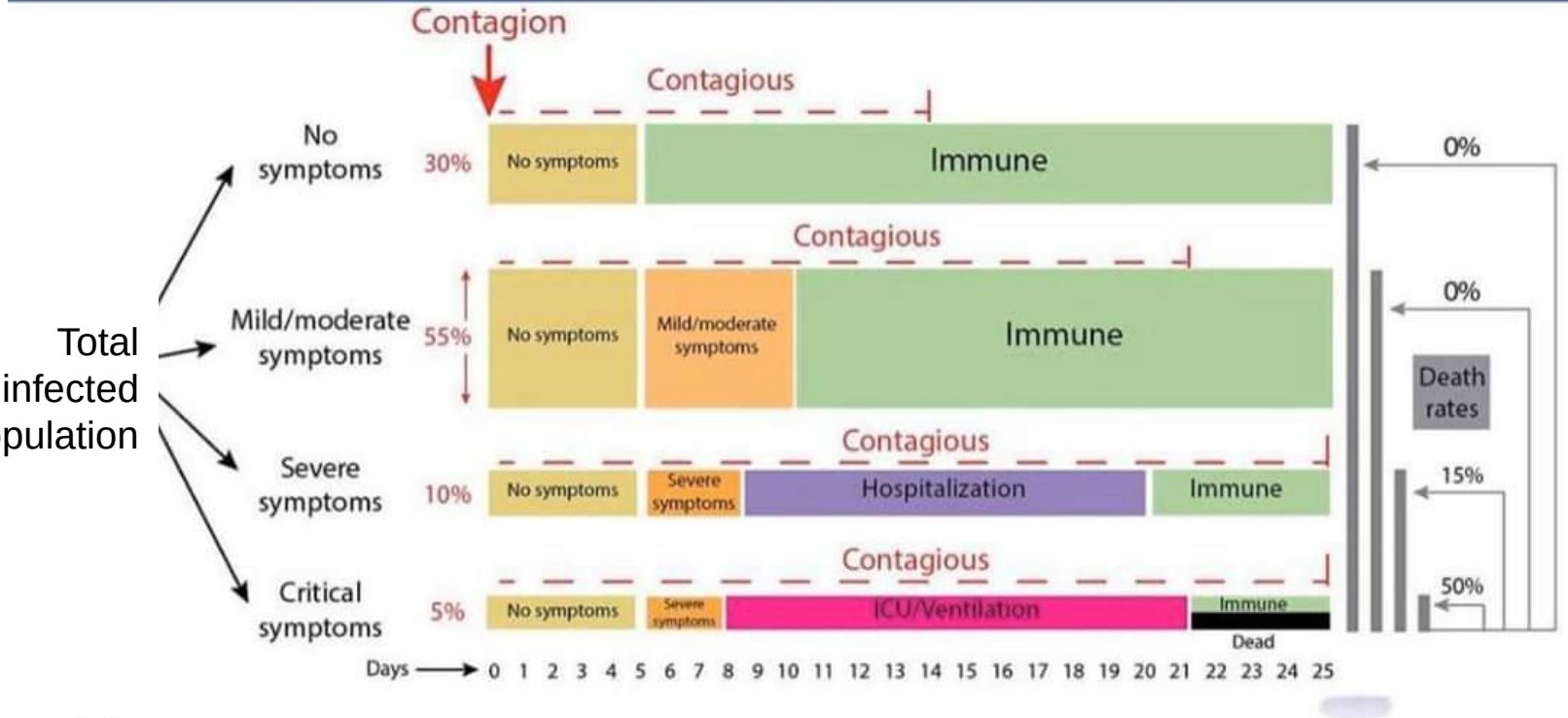


Source: European CDC – Situation Update Worldwide – Last updated 26th May, 11:00 (London time)

Graphs generated from https://ourworldindata.org/coronavirus.

Updated 26 May 2020, 1900hrs

SingHealth



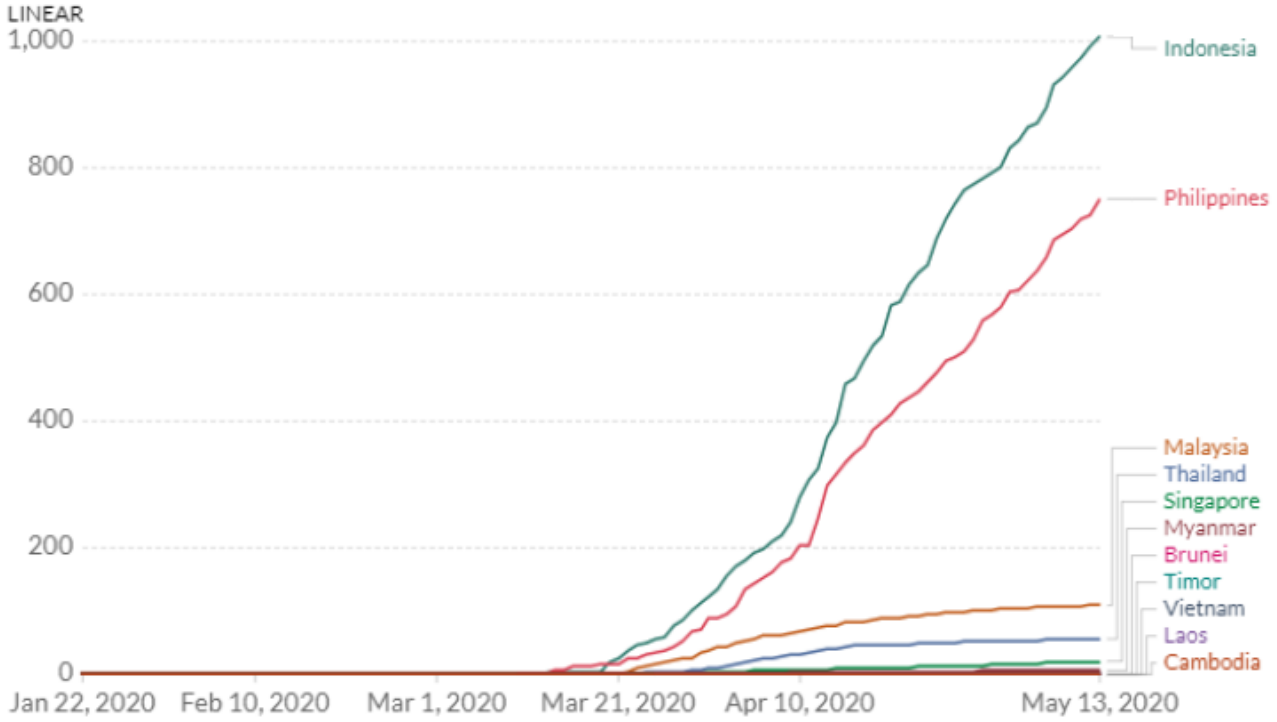
References:
1. The Incubation Period of Coronavirus Disease 2019 (COVID-19) From Publicly Reported Confirmed Cases: Estimation and Application. Lauer SA et al. Ann Intern Med. 2020 Mar 10.
2. Impact of non-pharmaceutical interventions (NPIs) to reduce COVID19 mortality and healthcare demand. Neil M Ferguson et al. Imperial College COVID-19 Response Team. 16 March 2020.
3. Viral dynamics in mild and severe cases of Covid-19. Yang Liu et al. The Lancet, March 19, 2020.

SingHealth

Southeast Asian countries:
Trends for Total Number of Deaths

Global

National Centre for Infectious Diseases



Source: European CDC – Situation Update Worldwide – Last updated 13th May, 11:15 (London time)

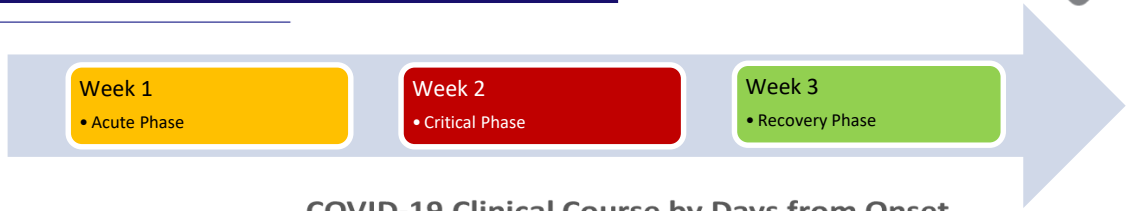
Graphs generated from https://ourworldindata.org/coronavirus.

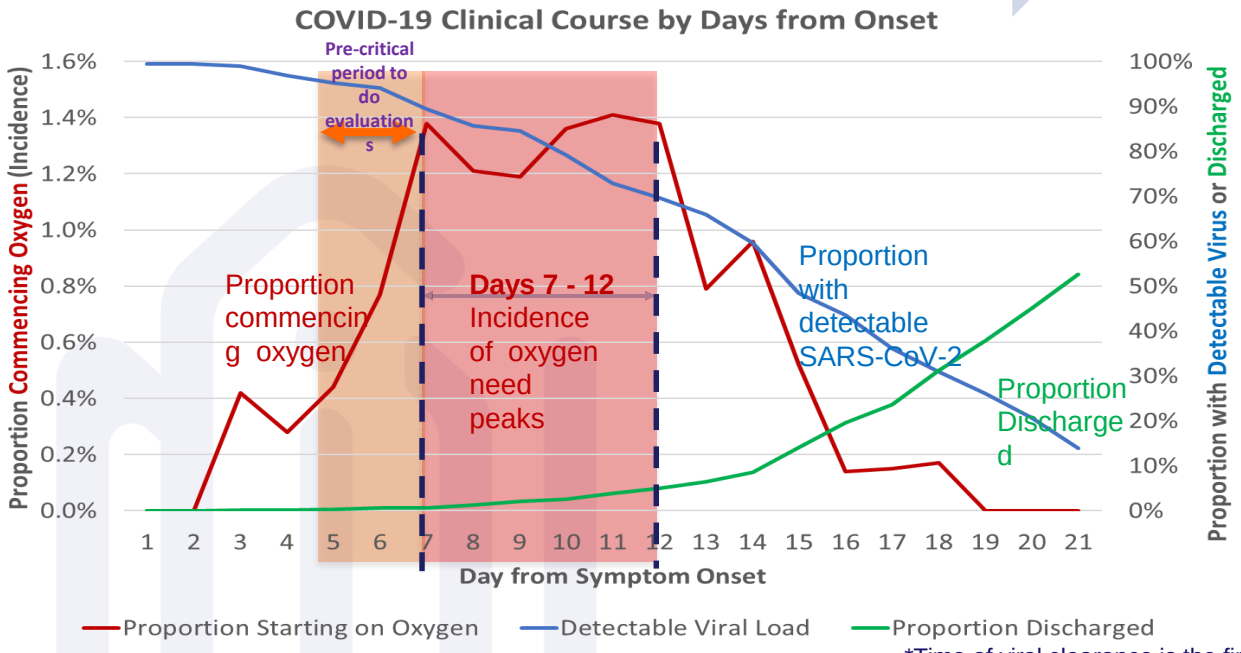
Updated 14 May 2020, 1800hrs

SingHealth

Clinical Course of COVID-19

National Centre for Infectious Diseases





*Time of viral clearance is the first of two or more consecutive negative tests

SingHealth

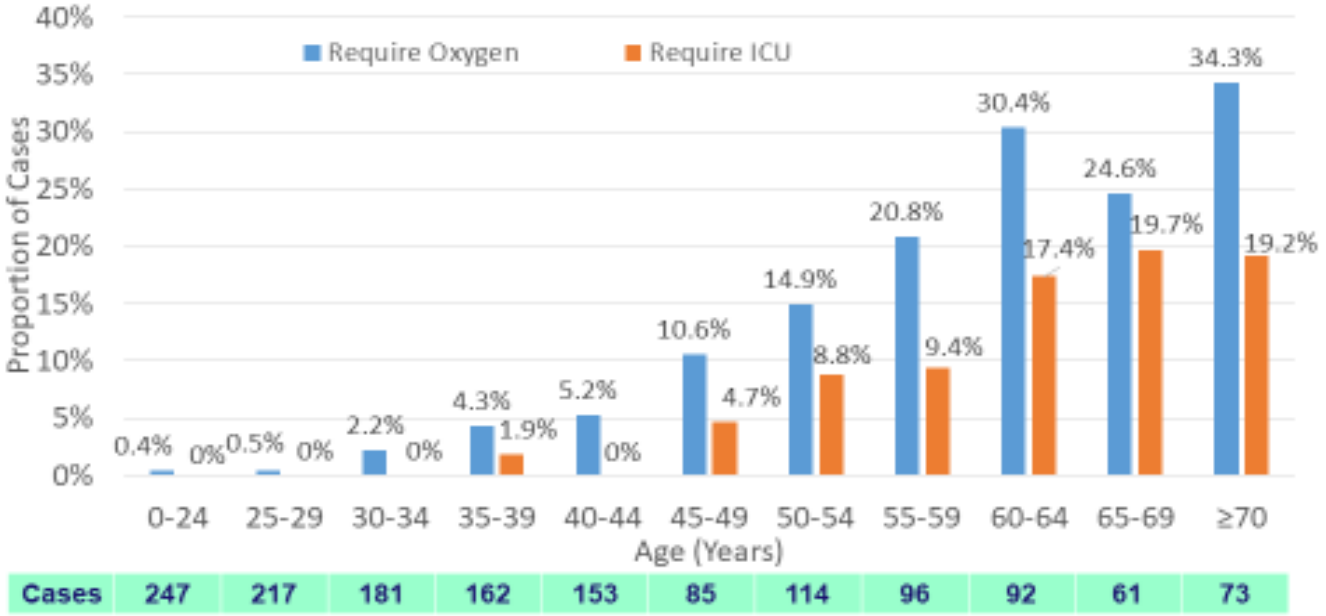
Assumption – ICU Conversion Rates Across Age Groups

COVID-19 Patients with Increased Care Needs

All hospitals

National Centre for Infectious Diseases

Oxygen and ICU Requirements by Age as of 7 Apr (N=1481)*



Cases	247	217	181	162	153	85	114	96	92	61	73

Needs increase with age

Updated 12 Apr 2020, 2200hrs

*Note: Cross-sectional data showing person who ever required ICU or supplemental O_2

SingHealth

Current outbreak in worker dormitories

Updated 3 May 2020, 2200hrs

National Centre for Infectious Diseases

Local Situation Update: Summary

Cumulative cases as of 3 May

Total	18,205 (100.0%)
Discharged	1,408 (7.7%)
Died	18 (0.1%)
Still hospitalised	1,630 (9.0%)
Isolated at CIF	15,149 (83.2%)

	Number	% distribution
Work Permit Holders (residing in dormitories)	15,833	87.0%
Work Permit Holders (residing outside dormitories)	569	3.1%
Community	1,224	6.7%
Imported	579	3.2%

	Number	% distribution
Singaporeans/PRs	1,448	8.0%
Long-Term and Work Pass Holders	16,698	91.7%
Visitors	59	0.3%

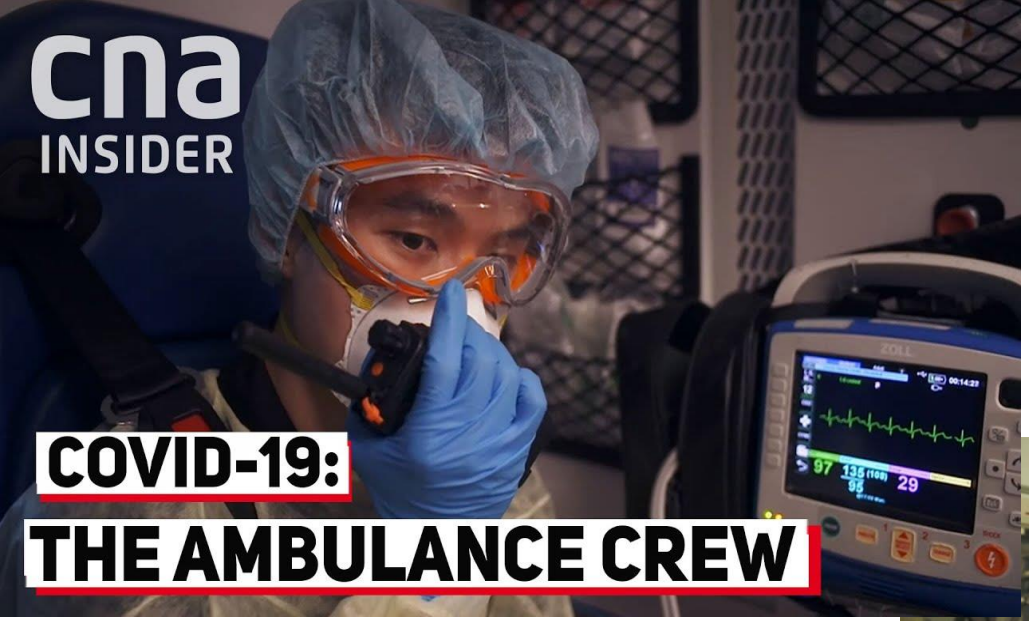
New cases from 1 to 3 May

Total	2,036 (100.0%)
Linked	1,641 (80.6%)
Pending contact tracing	395 (19.4%)
Imported	0 (0.0%)

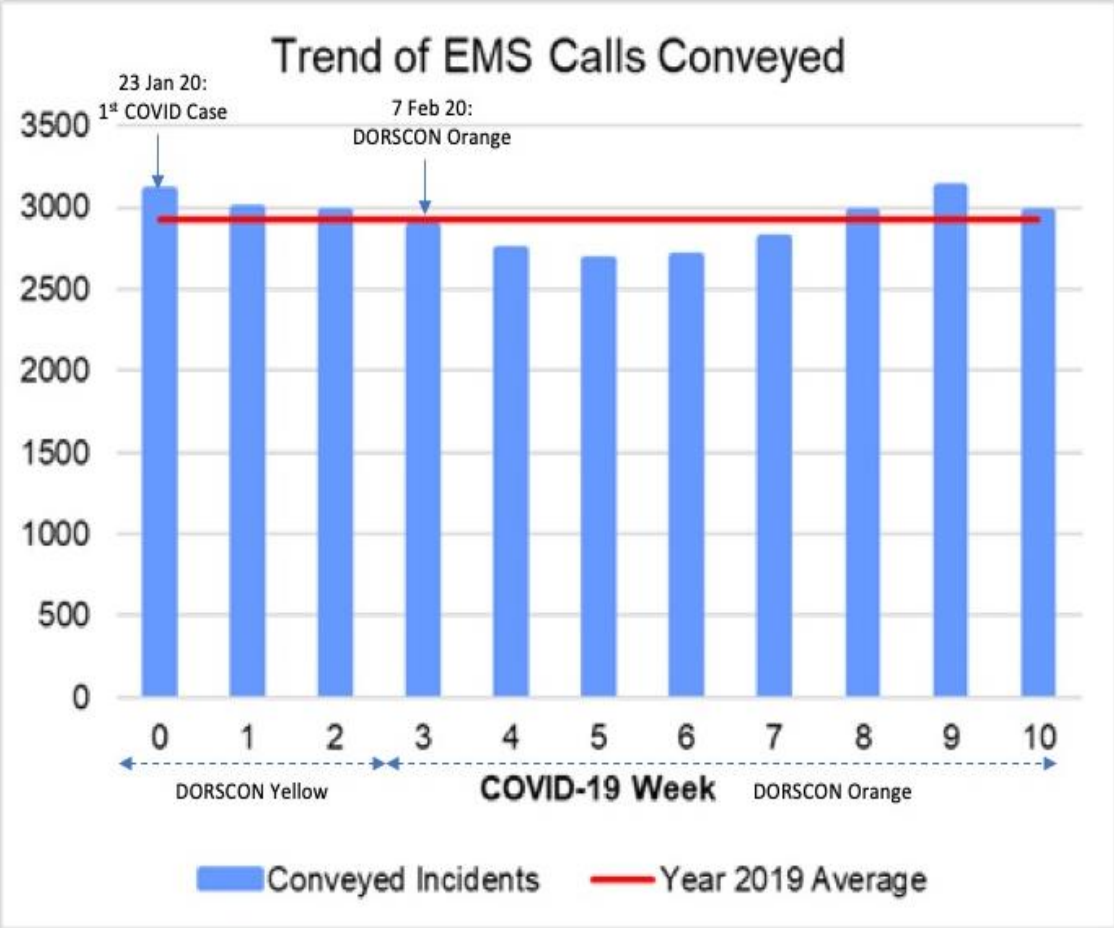
	Number	% distribution
Work Permit Holders (residing in dormitories)	1,962	96.4%
Work Permit Holders (residing outside dormitories)	44	2.2%
Community	30	1.5%
Imported	0	0.0%

	Number	% distribution
Singaporeans/PRs	19	0.9%
Long-Term and Work Pass Holders	2,017	99.1%
Visitors	0	0.0%

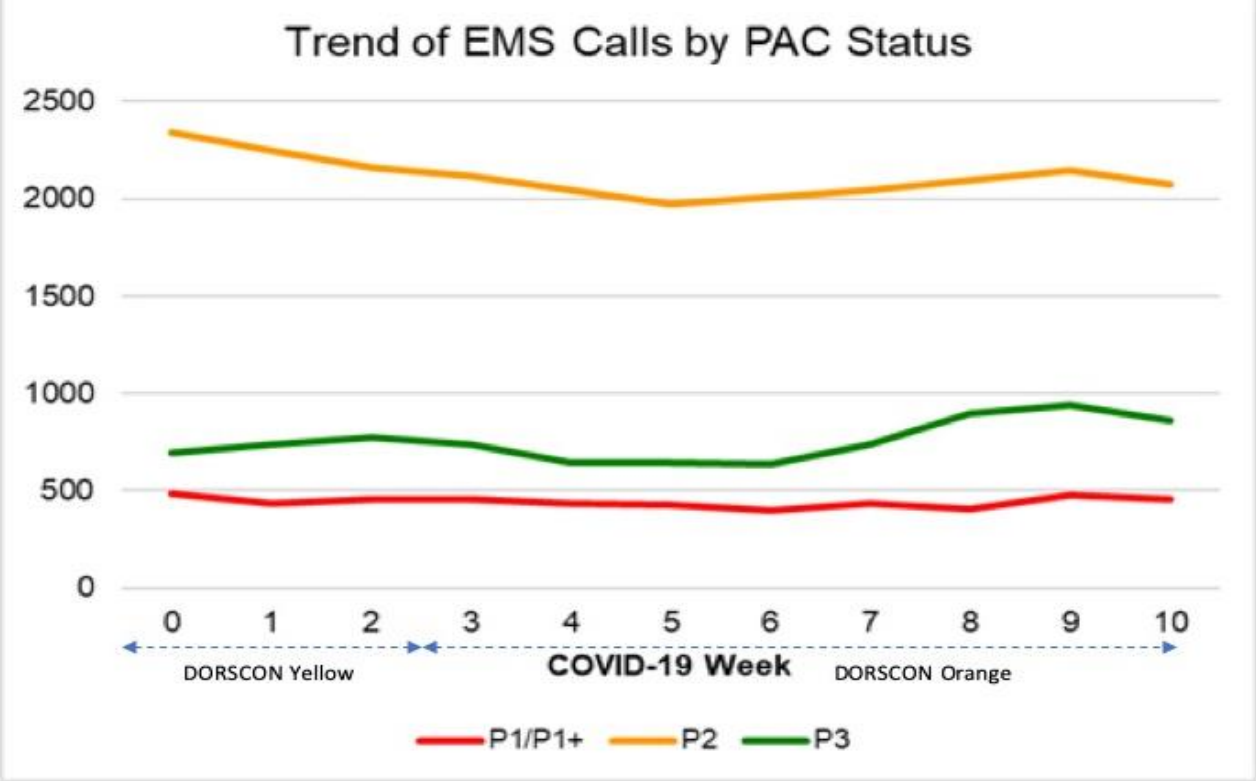
SingHealth

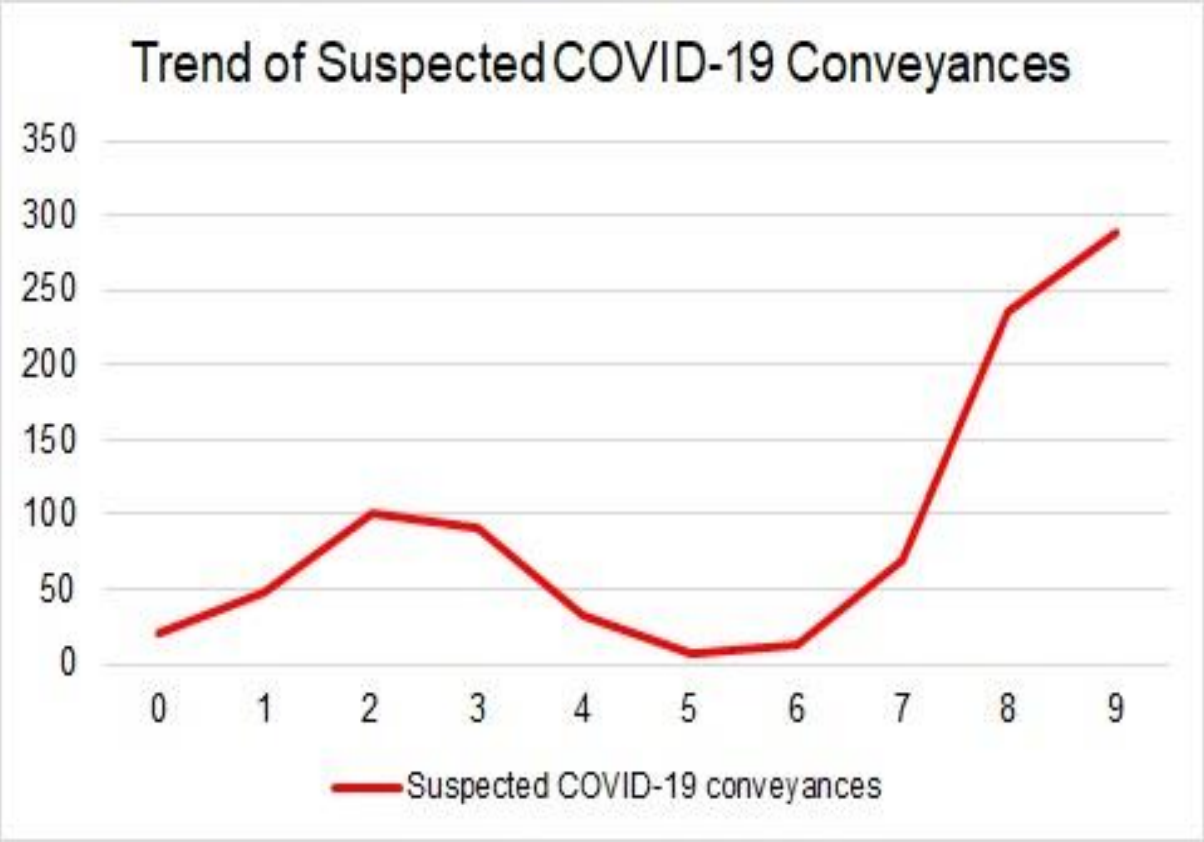


EMS and COVID-19


Trend of EMS Calls Conveyed
23 Jan 20:
1st COVID Case
7 Feb 20:
DORSCON Orange
3500
3000
2500
2000
1500
1000
500
0
0 1 2 3 4 5 6 7 8 9 10
DORSCON Yellow
COVID-19 Week
DORSCON Orange
Conveyed Incidents
Year 2019 Average

SingHealth


Trend of EMS Calls by PAC Status
2500
2000
1500
1000
500
0
0 1 2 3 4 5 6 7 8 9 10
DORSCON Yellow
COVID-19 Week
DORSCON Orange
P1/P1+
P2
P3


Trend of Suspected COVID-19 Conveyances
350
300
250
200
150
100
50
0
0
1
2
3
4
5
6
7
8
9
Suspected COVID-19 conveyances

SingHealth

BREAKING | 8,679 views | May 26, 2020, 01:36pm EDT

Nearly 300 Healthcare Workers Have Died From Coronavirus

Alexandra Sternlicht Forbes Staff
Business
I cover breaking news

TOPLINE 294 healthcare workers have died from Covid-19 after fighting it on the frontlines, according to CDC data, which the National Nurses Union says is a consequence of PPE shortages.

NEW YORK, NEW YORK – MAY 26: Medical workers wearing protective masks stand outside NYU Langone ... [+] NOAM GALAI/GETTY IMAGES

KEY FACTS

- 62,690 healthcare workers have contracted coronavirus, resulting in 294 casualties, according to new CDC data.
- There are likely more healthcare worker casualties, as only 21% of cases reported to the CDC include information that could identify the patient

21 MAY 2020 COMMENT

Lack of protective equipment preparation led to spike in frontline healthcare worker deaths

By GlobalData Healthcare

Similar trends can be seen in other hard-hit countries, such as the UK, where it has been reported that over 300 frontline healthcare workers have died of Covid-19. Cred

SingHealth

OBSERVATION: BRIEF RESEARCH REPORT

COVID-19 and the Risk to Health Care Workers: A Case Report

Background: Little is known about the effectiveness of personal protective equipment for health care workers who take care of patients infected with the novel coronavirus (SARS-CoV-2) that recently originated in China and has spread globally (1, 2).

Objective: To describe the clinical outcome of health care workers who took care of a patient with severe pneumonia before the diagnosis of COVID-19 was known.

Case Report: The patient was a middle-aged man with diabetes mellitus and hyperlipidemia who was hospitalized in February 2020 for community-acquired pneumonia. He had not traveled recently to China nor had had contact with anyone known to have COVID-19. He required supplemental oxygen on admission; the following day, he developed respiratory distress that required endotracheal intubation by the emergency airway team and mechanical ventilation in the intensive care unit (ICU). He was transferred to the ICU for intubation and had a difficult intubation that required use of a video laryngoscope and an airway bougie. He improved clinically after 3 days of mechanical ventilation and was subsequently extubated to noninvasive ventilation.

On the day that the patient was extubated, a nasopharyngeal swab was sent as part of COVID-19 surveillance, and it was positive for SARS-CoV-2 on polymerase chain reaction (PCR) assay (3). Two other swabs obtained on subsequent days tested positive for SARS-CoV-2.

On the basis of contact tracing, 41 health care workers were identified as having exposure to aerosol-generating procedures for at least 10 minutes at a distance of less than 2 meters from the patient. The aerosol-generating procedures included endotracheal intubation, extubation, noninvasive ventilation, and exposure to aerosols in an open circuit (4). All 41 health care workers were placed under home isolation for 2 weeks, with daily monitoring for cough, dyspnea, and myalgia and twice-daily temperature measurements. In addition, they had nasopharyngeal swabs scheduled on the first day of home isolation, which could have been day 1, 2, 4, or 5 after last exposure to patient, and a second swab scheduled on day 14 after their last exposure. The swabs were tested for SARS-CoV-2 by using a PCR assay. None of the exposed health care workers developed symptoms, and all PCR tests were negative (Table).

Discussion: The primary route for the spread of COVID-19 is thought to be through aerosolized droplets that are expelled during coughing, sneezing, or breathing, but there also are concerns about possible airborne transmission. In the situation we describe, 85% of health care workers were exposed during an aerosol-generating procedure exposed while wearing a surgical mask, and the remainder were wearing N95 masks. That none of the health care workers in this situation acquired infection suggests that surgical masks, hand hygiene, and other standard procedures protected them from being infected. Our observation is consistent with previous studies that have been unable to show that N95 masks were superior to surgical masks for preventing influenza infection in health care workers (5). We emphasize, however, that nearly all experts recommend that health care workers wear an N95 mask or equivalent equipment while performing an aerosol-generating procedure.

We recognize the limitations of this single case report and acknowledge that additional studies are necessary to determine how best to protect health care workers from becoming infected with SARS-CoV while they are providing care for patients with COVID-19.

Kangqi Ng, MBBS
Beng Hoong Poon, MBBS, MPH, MMed (Family Med)
Troy Hai Kiat Puar, MBBS
Jessica Li Shan Quah, MBBS
Wann Jia Loh, MBBS
Yu Jun Wong, MD
Thean Yen Tan, MBBCh
Jagadesan Raghuram, MB BCh BAO
Changi General Hospital
Singapore

Current EMS PPE Posture

Item	**Purpose**	**Length of Use before change**	**Remarks**
N95 Mask	For respiratory protection in all situations. Offers higher level of protection in aerosol-generating procedures (AGP)	Up to 6 hours	For extended wear, when not in use, to store in clear, Ziploc bag. Ziploc bag is single use and is to be changed time to prevent contamination from the inner sides of the bag. To change after transfer of each suspect/confirmed case.
Goggles	Eye protection	Re-usable	Goggles should be cleaned and dis-infected after every case. When not in use, goggles should be stored in a clear, Ziploc bag.
Level 4 Gown	Needed as transfer of patient is a high-contact activity	Per working shift	Re-using of gown is necessary to conserve resources for the long-term. Reuse of gown entails a need for cleaning of the gown between cases. To change if visibly soiled or after transfer of each suspect/confirmed case.
Gloves	Hand protection	Per trip	Single gloving is sufficient. Gloves should be disposed following each case. Thereafter, hand hygiene should be performed and hands should be allowed to dry. Use hand moisturizer 3X/day.
Removed from PPE requirements Head cover/ hair net* Shoe cover			

SingHealth

OHCA and COVID

	Jan 2020	Feb 2020	Mar 2020	Apr 2020
Total OHCA	275	228	246	230
Median age, years	71	69	70	74
Bystander CPR performed (%)	129 (46.9)	101 (44.3)	128 (52.0)	113 (49.1)
DA-CPR performed (%)	97 (75.2)	67 (66.3)	74 (57.8)	77 (68.1)
Bystander AED applied (%)	42 (15.3)	19 (8.3)	26 (10.6)	26 (11.3)
Prehospital ROSC (%)	33 (12.0)	29 (12.7)	32 (13.0)	22 (9.6)

Single-Use CPR Protection Kit for Rescuers

- FACE SHIELD – for patient
- GLOVES – for rescuer
- CPRCARD™ – for rescuer to optimize quality of CPR
- FACE MASK – to protect rescuer
- DISINFECTANT WIPES – for rescuer to use post-incident
- “Evolving concept”

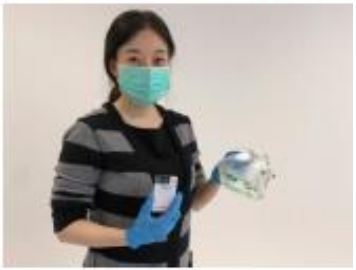
How to use the CPR Protection Kit?

Step 1: Have the kit ready

Step 2: Unpack the kit

Step 3: Put on gloves and face mask

Step 4: Bring the CPRcard and face shield to the patient



Step 5: Put the face shield on the patient

Step 6: Place CPRcard on the patient's chest as shown on card

Step 7: Give chest compressions

SingHealth

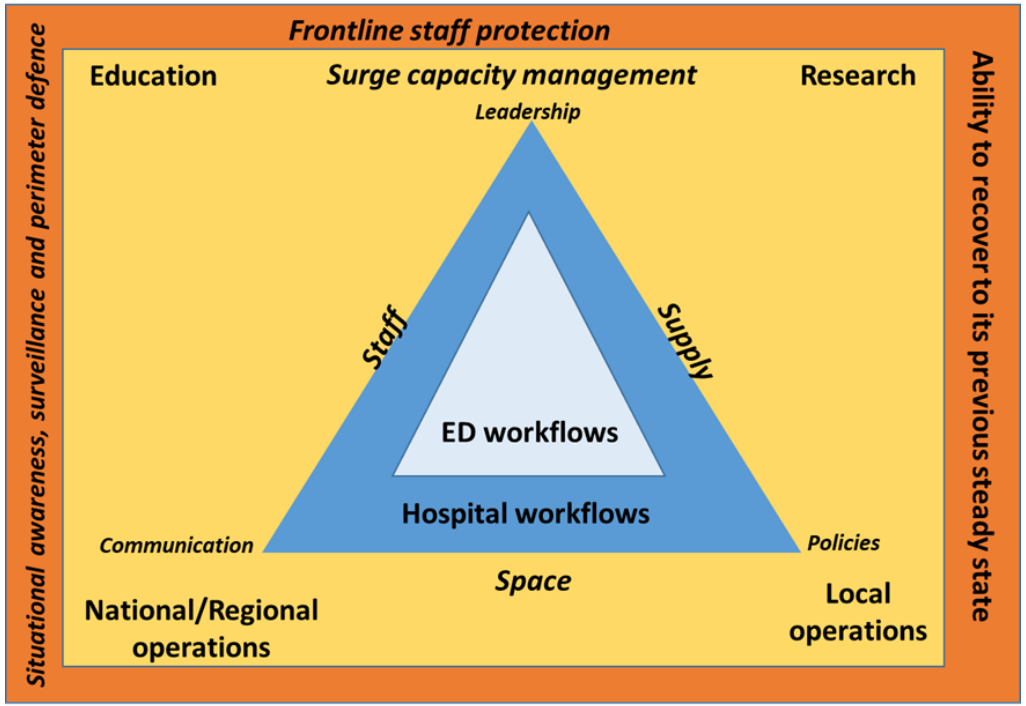
Proposed Face Shield Prototypes for Patients

Mask

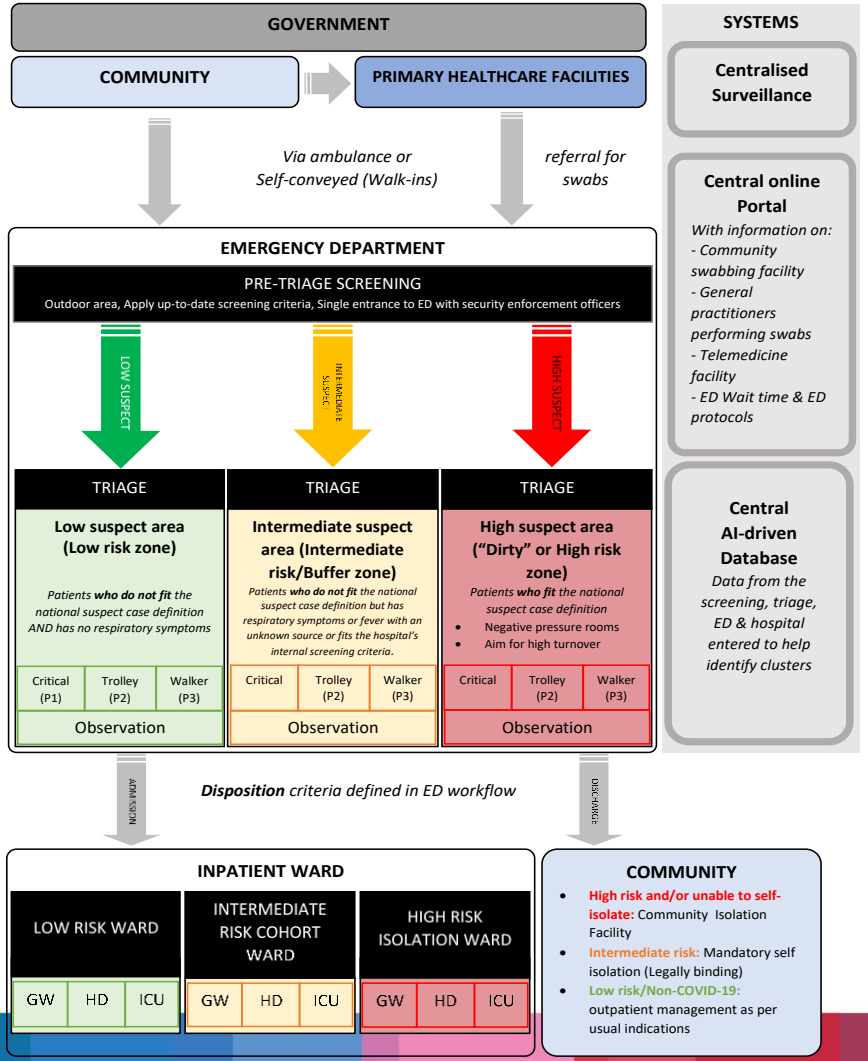
“Shower Cap”

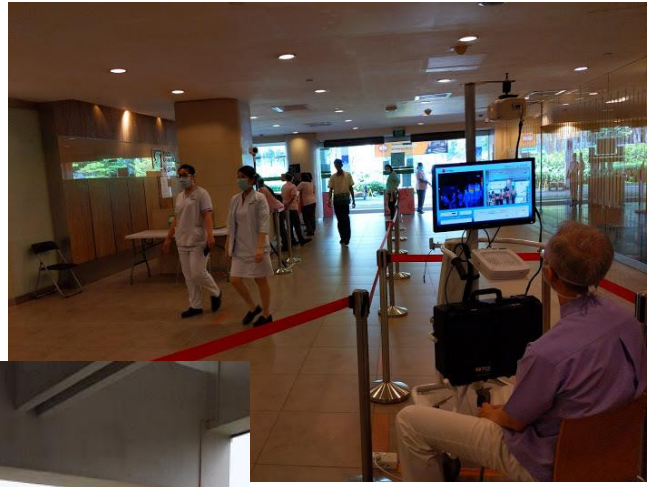
SingHealth

Conceptual framework describing relationship between state, hospital and ED in pandemic preparedness planning and response



Physical space and workflow model

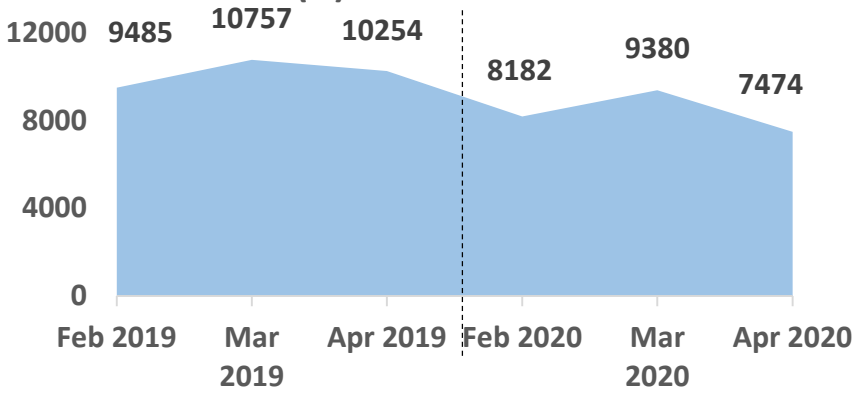




SingHealth

ED ATTENDANCE
TIME PERIOD: FEB – APR 2019 VS FEB – APR 2020

(A) Overall ED Attendance



(A) **Overall ED attendance** is **lower** in **Feb-Apr 2020** as compared to **Feb-Apr 2019.**

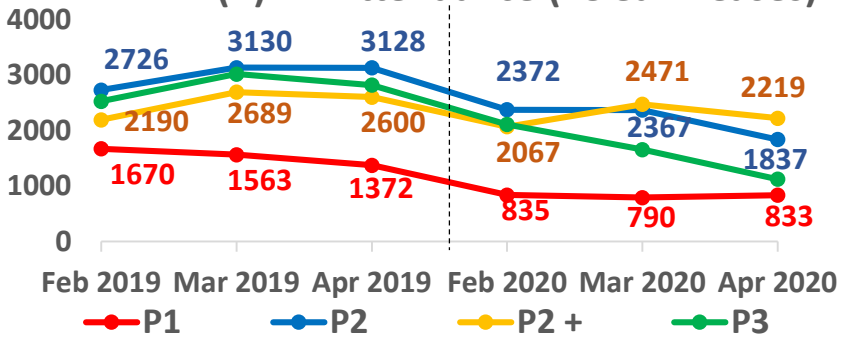
(B) **"Clean"** cases attendance are **lower** in **Feb-Apr 2020** as compared to Feb-Apr 2019, **except for P2+** (yellow line) where attendance remains, which means we are still seeing many sicker patients.

(C) **Fever** cases attendance are **higher** in **Feb-Apr 2020** as compared to Feb-Apr 2019, **especially for P3F** (green line) where attendance is about 10 times more as compared to Feb-Apr 2019.

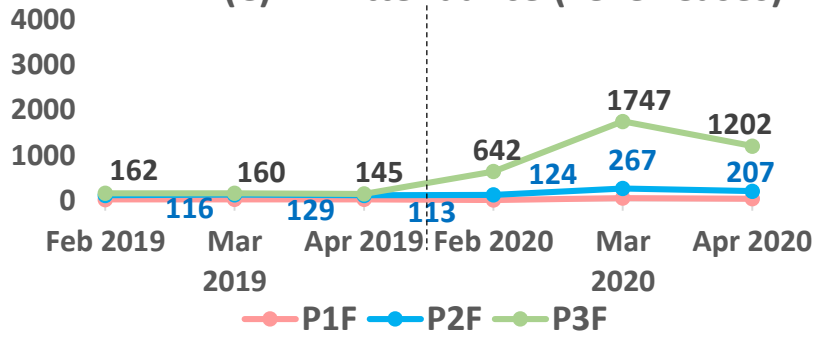
Note 1: There is a huge decrease in P1 attendance in Feb-Apr 2020 as comparison to Feb – Apr 2019.

Note 2: Decrease in P3 attendance from Feb-Apr 2020, may be due to opening of FSA on 20 Mar 2020

(B) ED Attendance ("Clean" Cases)



(C) ED Attendance (Fever Cases)



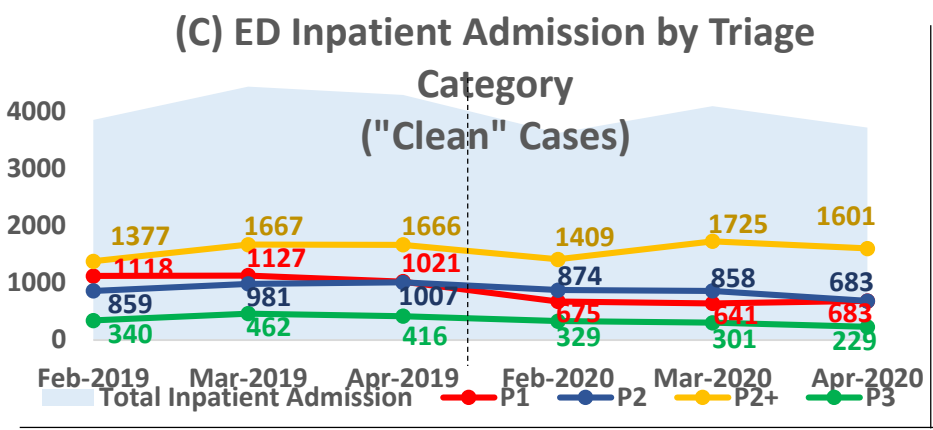
Note: P4 cases were not included in this analysis as the numbers were relatively small.

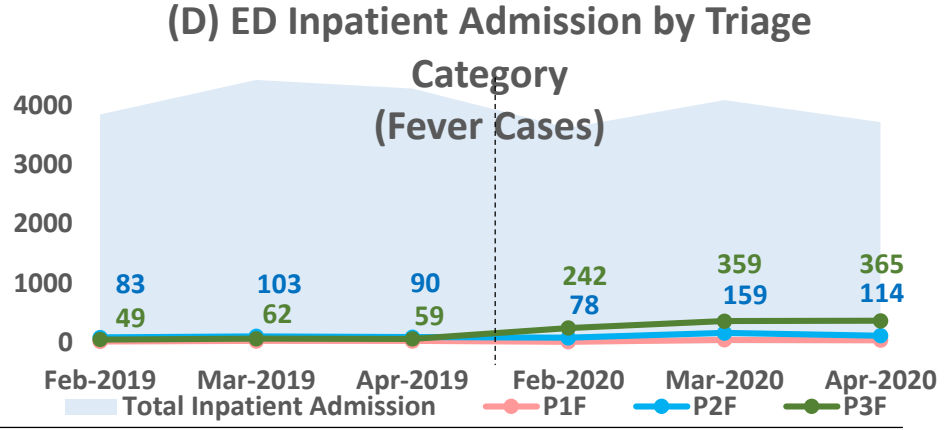
Data Source: eHIntS A&E Case Subject

SingHealth

TOP 5 ADMISSION DIAGNOSIS – TRIAGE CATEGORY

TIME PERIOD: FEB – APR 2019 VS FEB – APR 2020





P1 - Top 5 Diagnosis

	Feb-Apr 2019		Feb-Apr 2020	
1	Chest pain	214	Pneumonia	153
2	Fluid overload	202	Fluid overload	127
3	Pneumonia	136	Chest pain	100
4	Unstable angina	117	Angina	49
5	Angina	97	Stroke	42

P2+ Top 5 Diagnosis

	Feb-Apr 2019		Feb-Apr 2020	
1	Falls	168	Pneumonia	194
2	Abdominal pain	162	Falls	184
3	Pneumonia	131	Abdominal pain	173
4	Fluid overload	129	Fluid overload	172
5	Fever	127	Fever	146

P1F - Top 5 Diagnosis

	Feb-Apr 2019		Feb-Apr 2020	
1	Pneumonia	10	Pneumonia	19
2	Fluid overload	6	Fluid overload	8
3	Sepsis	5	Asthma	4
4	Giddiness	2	Chest pain	4
5	Chest pain	2	Atrial fibrillation	3

P2 - Top 5 Diagnosis

	Feb-Apr 2019		Feb-Apr 2020	
1	Abdominal pain	220	Abdominal pain	159
2	Cellulitis	123	Cellulitis	93
3	ESRF - End stage renal failure	89	ESRF - End stage renal failure	64
4	Fever	83	Fever	64
5	Chest pain	62	Chest pain	51

P3 - Top 5 Diagnosis

	Feb-Apr 2019		Feb-Apr 2020	
1	Cellulitis	90	Abscess	61
2	Abscess	74	Cellulitis	51
3	Fever	52	Fever	46
4	Pneumonia	32	Perianal abscess	21
5	Perianal abscess	30	Pneumonia	20

P2F - Top 5 Diagnosis

	Feb-Apr 2019		Feb-Apr 2020	
1	Fever	20	Pneumonia	77
2	Pneumonia	17	Fever	20
3	Sepsis	15	LRTI	19
4	Gastroenteritis	11	URTI	13
5	Cellulitis	8	Asthma	10

P3F - Top 5 Diagnosis

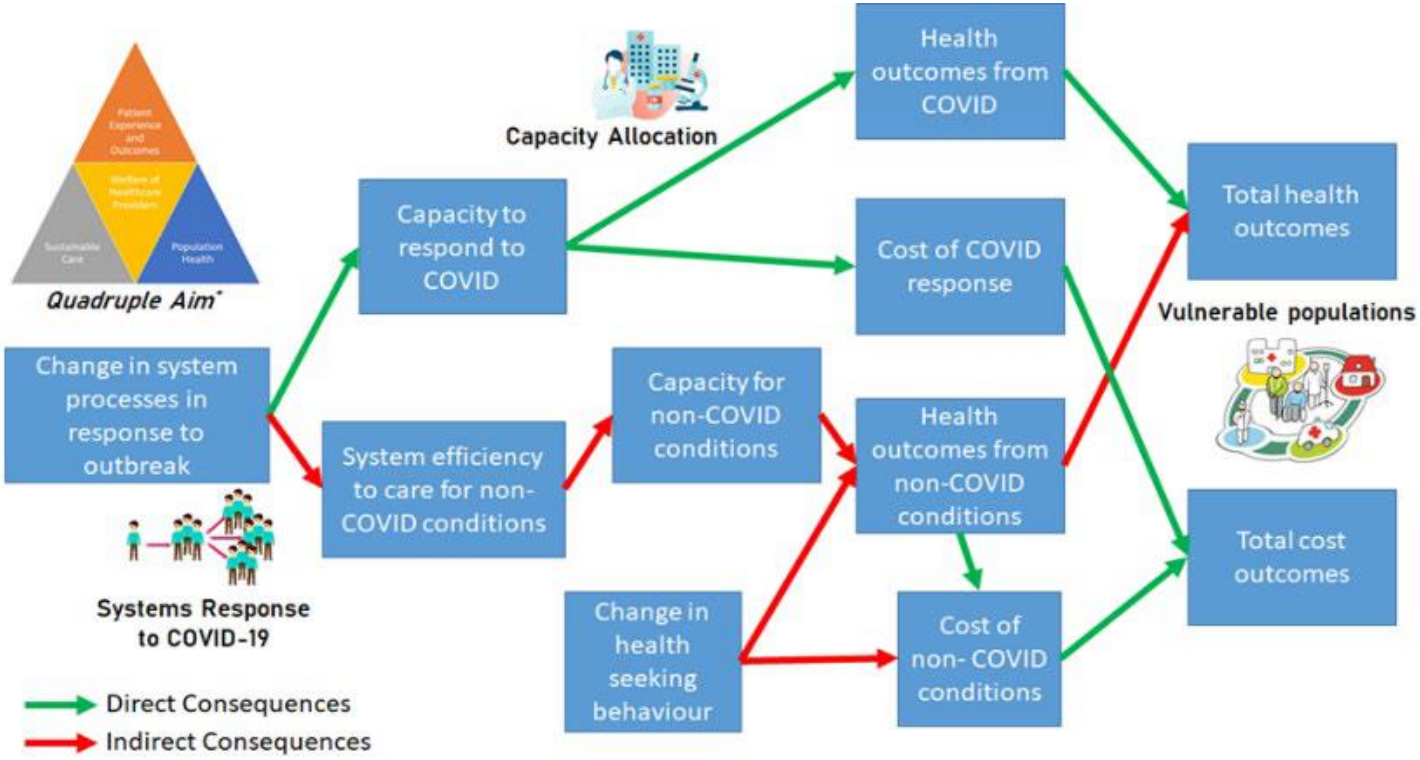
	Feb-Apr 2019		Feb-Apr 2020	
1	Haemoptysis	39	URTI	295
2	Pneumonia	11	Pneumonia	181
3	Fever	9	Fever	68
4	Bronchiectasis	6	LRTI	49
5	Herpes zoster	6	Abdominal pain	19

Note: P4 cases were not included in this analysis as the numbers were relatively small.

Data Source: eHIntS A&E Case Subject

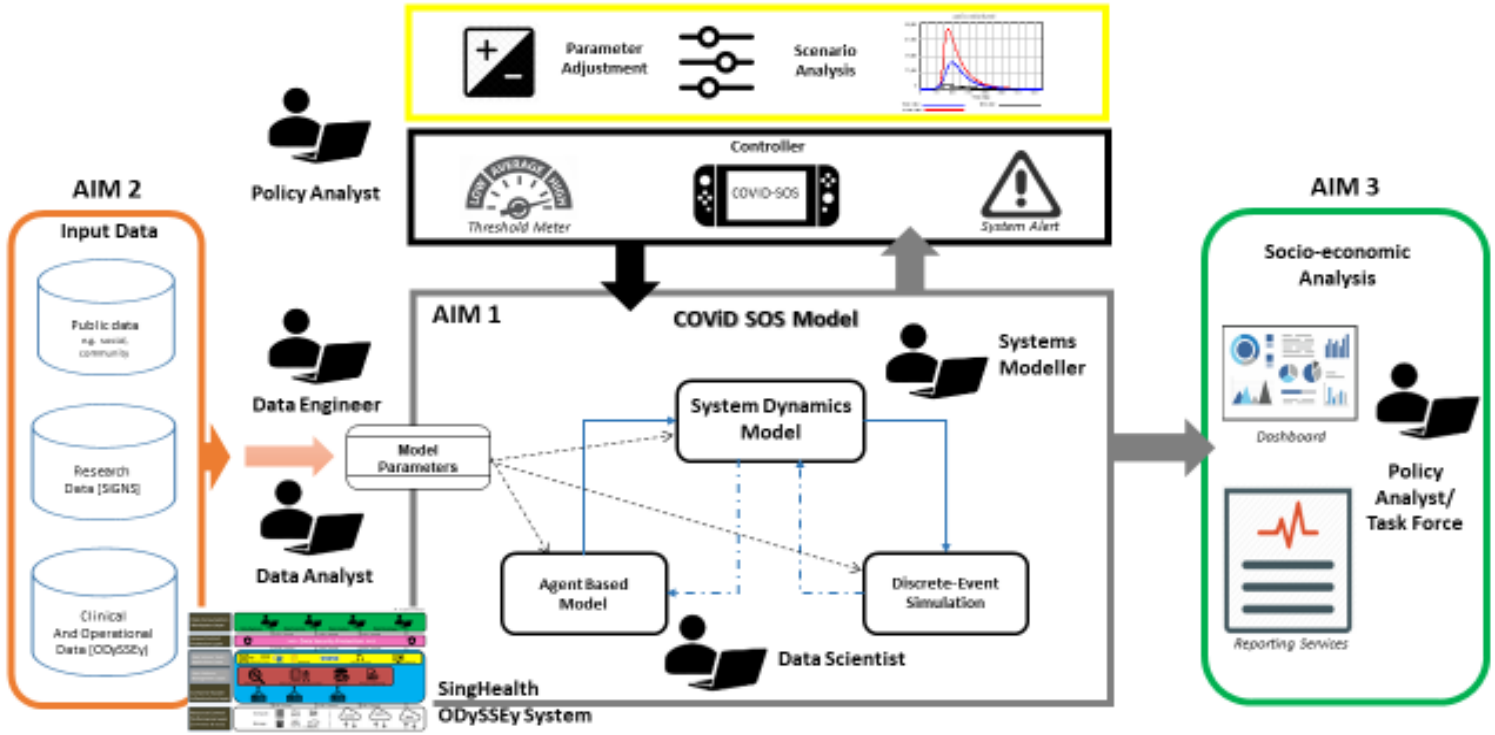
SingHealth

My health services research work: COVID-SOS – Conceptual model



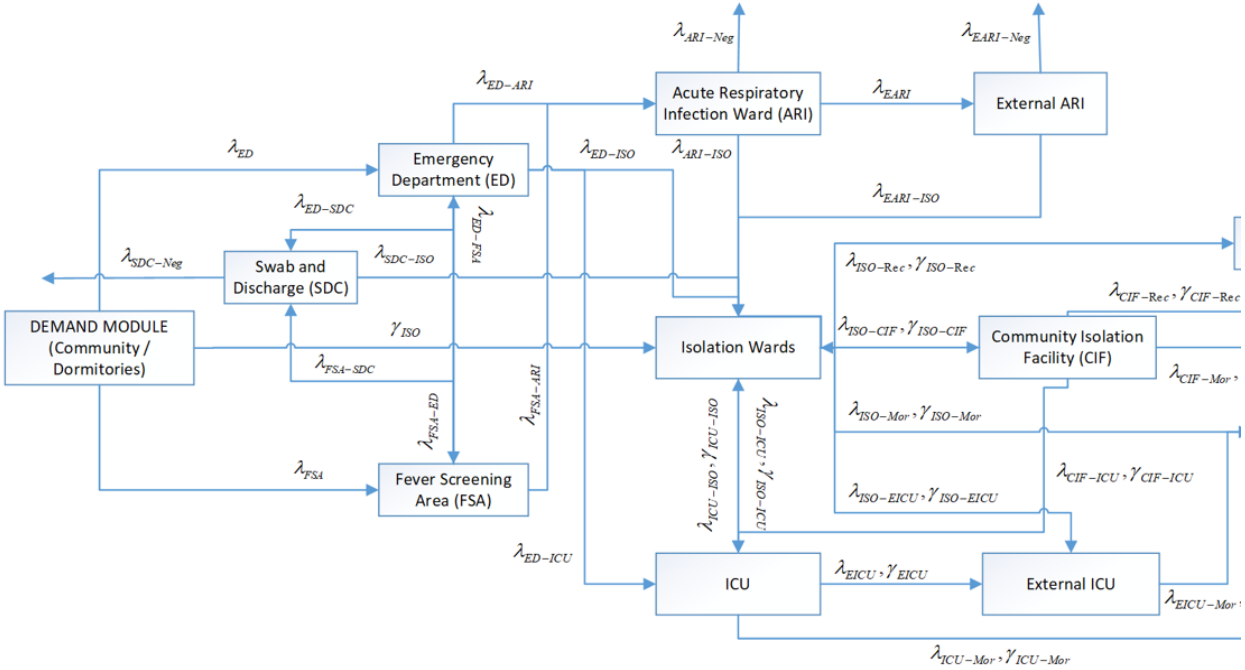
COVID-SOS – Systems Dynamic Model

AIM 1 System Architecture



SingHealth

High Level Schematic (Variant 2)



λ_i: Arrival rate of suspect cases from community to server i where $i = \{ED, FSA\}$;

γ_j: Arrival rate of suspect/confirmed cases from dormitories to server j where $j = \{ED, FSA, ISO$

Transfer rate of suspect/confirmed cases from server p to server q where

$p = \{ED, FSA, SDC, ARI, EARI, ISO, EISO, ICU, EICU, CIF\}$ and

$p = \{ED, FSA, SDC, ARI, EARI, ISO, EISO, ICU, EICU, CIF, Rec, Mor, Neg\}$, and;

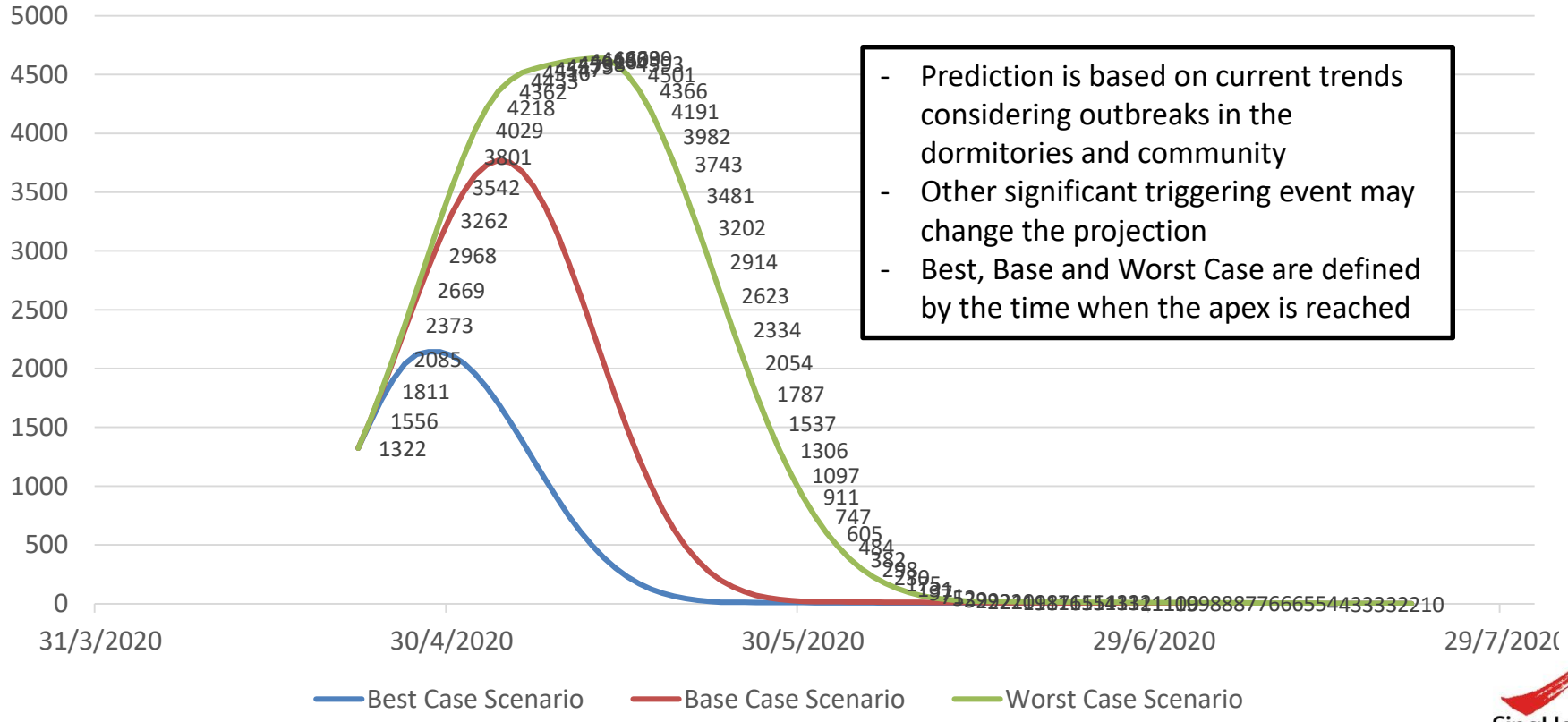
Mor: Mortality for COVID-19 cases; Rec: Recovered cases

Control Panel: SGH-COVID-19 Simulation Platform

Scenarios to be cosidered (to activate change the value from 0 to 1)	Policies to be evaluated (to activate change the value form 0 to 1 and set the corresponding parameters)	Intervention Parameters to be set	Key Performance Indicators (KPIs) to be monitored
Best Case Scenario	Intervention 1: Hospital ARI Capacity Extension	<ARI Capacity> <ARI Extended Capacity>	Total Number of ARI Beds Required
			Extra ARI Beds Required (Total - Available Capacity)
Base Case Scenario	Intervention 2: Hospital Isolation Rooms Capacity Extension	<ISO Capacity> <ISO Extended Capacity>	Total Number of Isolation Beds Required
			Extra Isolation Beds Required (Total - Available Capacity)
Worst Case Scenario	Intervention 3: External Isolation Facility to Cover Overflowed Hospital ISO Demand	<Ex-ISO Capacity>	Total Number of ICU Beds Required
	Intervention 4: Hospital ICU Capacity Extension	<ICU Capacity> <ICU Extended Capacity>	Extra ICU Beds Required (Total - Available Capacity)
	Intervention 5: Extenal ICU to Cover Overflowed Hospital ICU Demand	<Ex-ICU Capacity>	Total COVID-19 Mortality (Including overflowed Demand Mortality)
	Intervention 6: Aggressive Transfer of Stable Cases to External ISO Facility	<ISO Stable Fraction> <ALOS (ISO-Stable)>	Hospital COVID-19 Mortality

SingHealth

Projected Number of Singapore Confirmed COVID-19 New Cases (over the next 3 months)

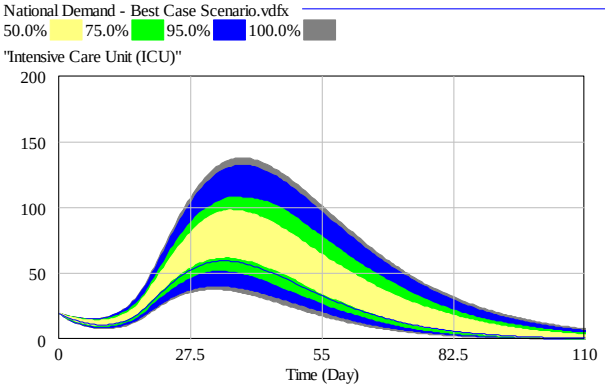


- Prediction is based on current trends considering outbreaks in the dormitories and community
- Other significant triggering event may change the projection
- Best, Base and Worst Case are defined by the time when the apex is reached

SingHealth

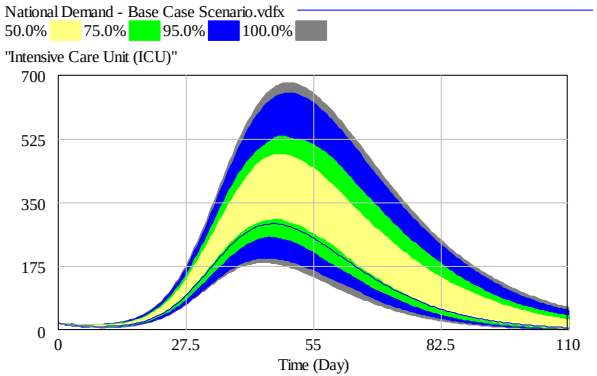
Multi-variate sensitivity analysis for required number of **National ICU beds**

1. ALOS(ICU) is uniformly distributed (7-18 days)
2. ICU Conversion Rate from Dorms is uniformly distributed (1% to 3% weighted average) (4.95% community)



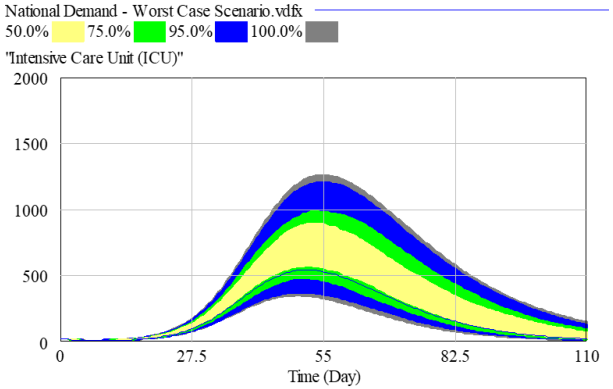
Best Case Scenario

95% CI [40, 135]



Base Case Scenario

95% CI [197, 650]



Worst Case Scenario

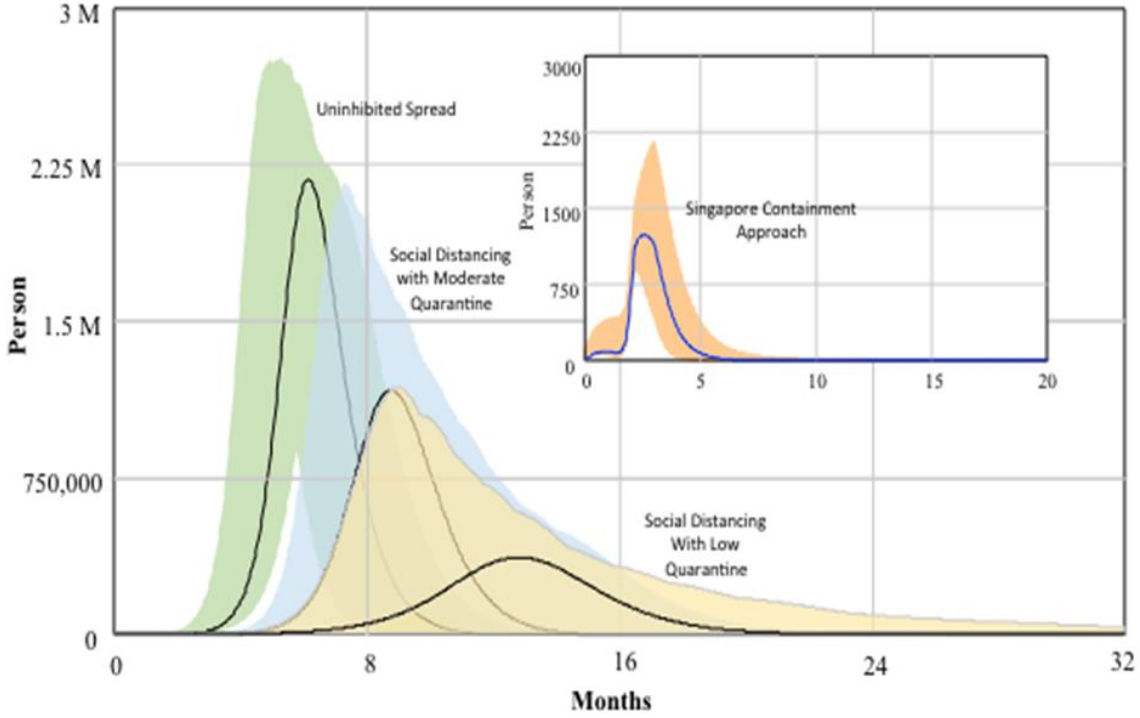
95% CI [375, 1210]

* Time=0 on 2020/05/01

Estimated National ICU Capacity:
(Baseline, Min, Max) = (352, 310, 1,200)

SingHealth

Projected total cases of COVID-19 in Singapore under current containment intervention and alternative interventions, with 100% confidence ranges

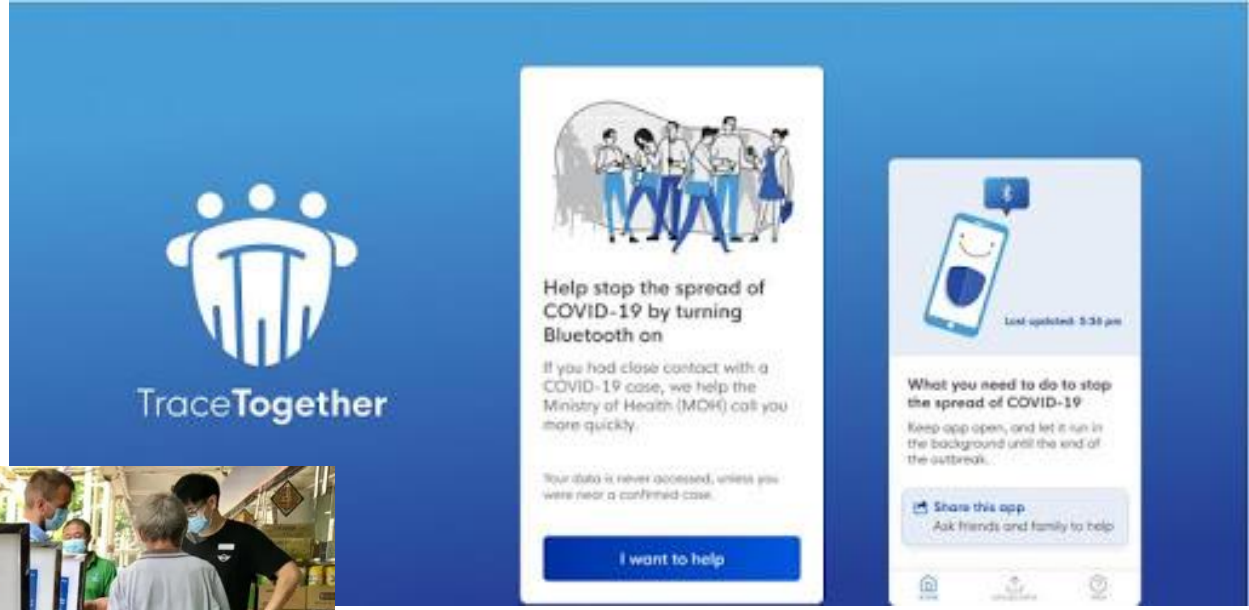


As the reference case projections are not visible on the common scale, projections for the reference case are shown on a separate scale (inset).

SingHealth

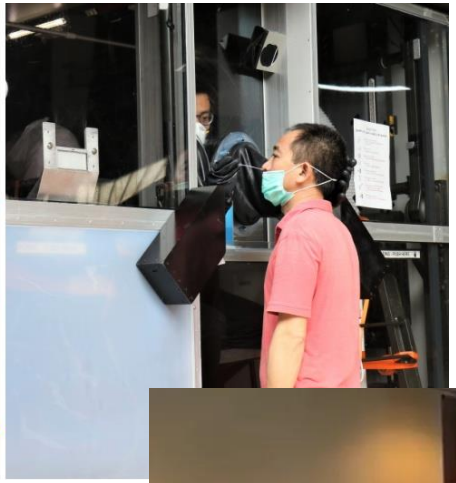
COVID-19 Apps

SafeEntry



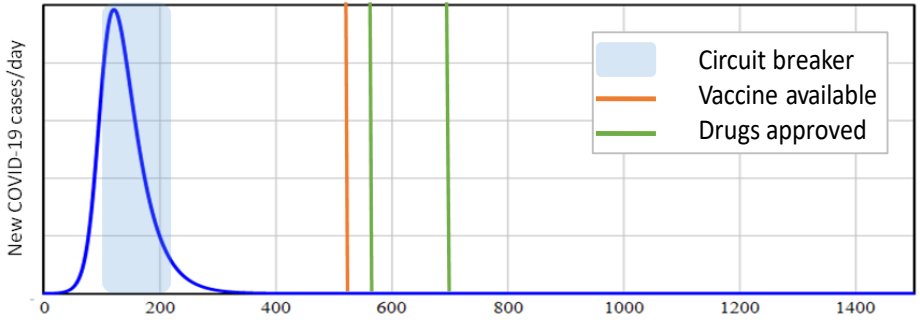
TraceTogether

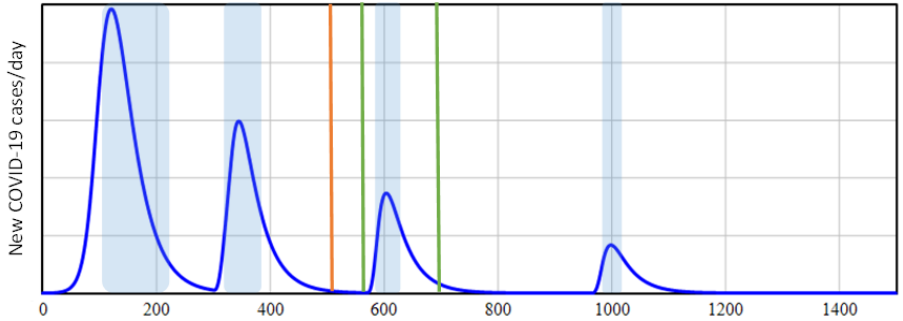
SingHealth

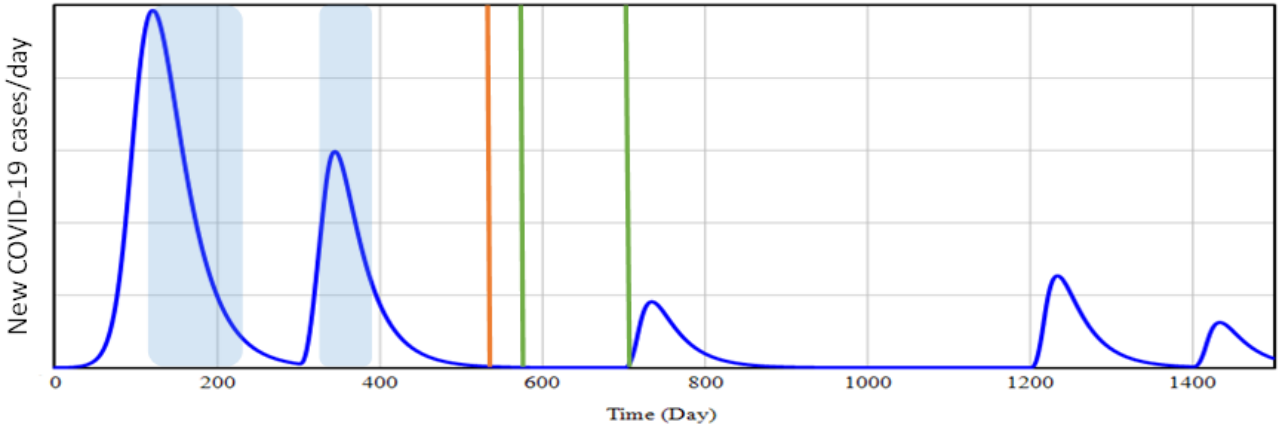


SingHealth

Three possible scenarios how COVID-19 could play out: Single wave, Repeated waves, Epidemic to Endemic

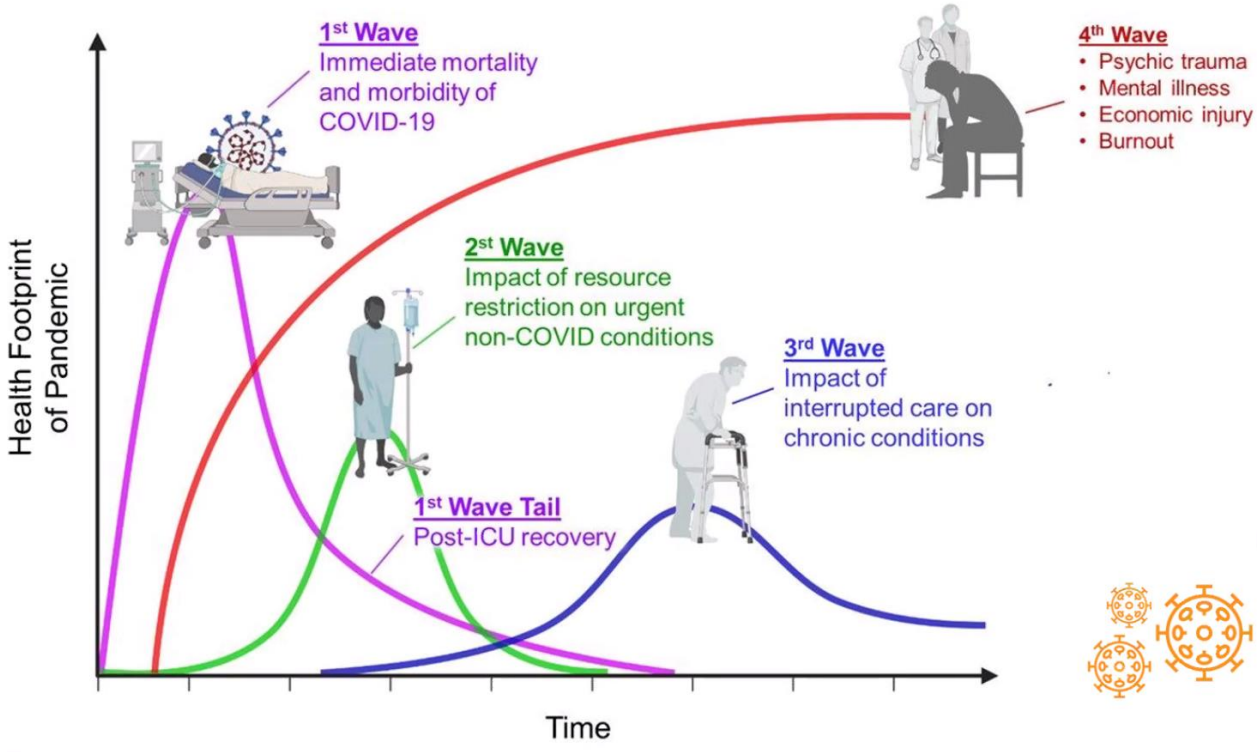






SingHealth

Next impacts in the aftermath of COVID-19



My take home lessons

- COVID-19 will be a test of : healthcare system, government response, social capital
- Preparedness matters: Pandemic plans, epidemic legislation, mobilization of resources, stockpiling of PPE and supplies
- Whole of government, whole of society response
- EMS, ED, Hospital upgraded their PPE posture early – <5 healthcare workers infected , mostly in social setting
- Key to protect the healthcare system capacity – 34,000 COVID cases, 8 in ICU, 23 deaths
- No healthcare worker should die because of their work
- This will not be quick, this will not be pretty. We will need a paradigm shift in thinking. The world has changed.