Singapore from the Frontlines

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Singapore was hit quite badly by the 2003 SARS outbreak

Probable cases of SARS by country and territory, 1 November 2002 – 31 July 2003

<table>
<thead>
<tr>
<th>Country or region</th>
<th>Cases</th>
<th>Deaths</th>
<th>Fatality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mainland China</td>
<td>5,327</td>
<td>349</td>
<td>6.6</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>1,755</td>
<td>299</td>
<td>17.0</td>
</tr>
<tr>
<td>Taiwan</td>
<td>346</td>
<td>73</td>
<td>21.1</td>
</tr>
<tr>
<td>Canada</td>
<td>251</td>
<td>44</td>
<td>17.5</td>
</tr>
<tr>
<td>Singapore</td>
<td>238</td>
<td>33</td>
<td>13.9</td>
</tr>
<tr>
<td>Vietnam</td>
<td>63</td>
<td>5</td>
<td>7.9</td>
</tr>
<tr>
<td>Total excluding Mainland China</td>
<td>2,769</td>
<td>454</td>
<td>16.4</td>
</tr>
<tr>
<td>Total (29 territories)</td>
<td>8,096</td>
<td>811</td>
<td>9.6</td>
</tr>
</tbody>
</table>

Singapore also had 5 deaths among healthcare workers

Painful Lesson:

- Due to its exposed location as trade and travel hub, SG is extremely vulnerable to imported infections!
Since 2003, Singapore kept doing pandemic planning: Our hospital’s Emerging Infectious Diseases Pages

Page from 2015

(when MERS, Ebola and Flu A H7N9 were around)
Screening Procedures from 2015

### Novel Coronavirus (MERS)
- SOUTH KOREA
- MIDDLE EAST
  The Arabian Peninsula & neighbouring countries in the Middle East includes:
  - Jordan
  - Kuwait
  - Lebanon
  - Oman
  - Qatar
  - Saudi Arabia
  - United Arab Emirates (UAE)
  - Yemen

### Influenza A (H7N9)
- CHINA
  The affected municipalities / provinces in China includes:
  - Anhui
  - Beijing
  - Fujian
  - Guangdong
  - Guizhou
  - Guangxi
  - Hebei
  - Henan
  - Hunan
  - Jiangxi
  - Jiangsu
  - Jilin
  - Shandong
  - Shanghai
  - Xinjiang
  - Zhejiang

### Ebola
- Refer to Appendix 2B for Enhanced Ebola PPE matrix
  * If patient is a 'Suspect' case -
    - Send to TTSH
  * If patient is an 'At-Risk (Low Risk / High Risk)' case -
    - Admit to Ward 46 (negative pressure with isolation room), or
    - Delivery Suite Room 1-4 (when in labour).
  For all other scenarios, discuss with ID physician

### MERS-CoV & H7N9
If patient has (1 or 2) +3
- Staff must don Full PPE. Patient to wear surgical mask.
- Admit patient to the ward with negative pressure room.

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1st screen | 2nd Screen
|-----------------|-----------------|
Screening staff | Ward staff

<table>
<thead>
<tr>
<th>MERS-CoV</th>
<th>H7N9</th>
<th>Ebola</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Korea &amp; Middle-East (last 14 days)</td>
<td>China (last 10 days)</td>
<td>Africa (last 21 days)</td>
</tr>
</tbody>
</table>

1) Travel history or resident of country (refer Appendix 1)
2) Close contact with confirmed or suspect case
3) Symptoms
   - Yes
   - No

Tick if any of symptoms present
- Fever or cough or SOB
- Vomiting,
  - Diarrhoea,
  - Headache,
  - Abdominal pain,
  - Sore throat,
  - Rash,
  - Red eyes,
  - Bleeding,
  - (mucous membranes/ venipuncture sites)
Exercise “Sparrowhawk” (I and II)

- Mock patient with serious infection arrives at the hospital
- Role-play
- Conducted for Ebola 2015 – Enhanced PPE with respirators
- For “Respiratory X” disease – Full PPE with N95 mask, eye protection, gowns, gloves
Singapore National Centre for Infectious Diseases (NCID)

- Purpose-built medical facility within the public healthcare system
- 17 wards, 330 beds, 2 ICUs
- High-level isolation ward capable of handling Ebola, Marburg, anthrax
- Research and diagnostic facilities
- National Public Health Laboratory (NPHL)
- Formally opened on 7 Sept. 2019 (just in time)

Images: Wikipedia (top), NCID (bottom)
KK Women’s and Children’s Hospital (KKH)

- 830-bed pediatric & OB/Gyn hospital
- Tertiary-level academic teaching hospital for National University of Singapore (NUS) and Duke-NUS
- My workplace -- I am a clinical microbiologist at the hospital’s Department of Pathology & Laboratory Medicine
- Relatively small microbiology section

Images: Unabiz (top), Google Maps, User KSY (bottom)
Wuhan “Exodus”

- Wuhan Lockdown 23 Jan 2020
- About 5 million people left Wuhan
- Chinese New Year 25-26 Jan 2020
- Biggest yearly travel period

• Travel inside China
• Travel to Thailand, Singapore, Bali, Hong Kong, Taiwan, Japan, S. Korea (--> “First Wave”)
Early PCR Assays (Jan 2020)

- Drosten Group, Charité, Berlin, Germany
- School of Public Health, University of Hong Kong, Hong (Leo Poon, Daniel Chu and Malik Peiris)
- China CDC (National Institute for Viral Disease Control and Prevention)
- Department of Medical Sciences, Ministry of Public Health, Thailand
- National Institute of Infectious Diseases, Tokyo, Japan
Singapore confirms first case of Wuhan virus

Employees at Singapore’s National Centre for Infectious Diseases putting on protective gear before carrying out testing for the novel coronavirus.

SINGAPORE: Singapore on Thursday (Jan 23) announced a confirmed case of the Wuhan virus, a new coronavirus that has sickened hundreds of people and killed at least 17.

In a media briefing on Thursday evening, the Ministry of Health said the patient is a 66-year-old Chinese man. The Wuhan resident, who arrived in Singapore with his family on Jan 20, flew from Guangzhou via China Southern flight CZ351.

He is currently in isolation at the Singapore General Hospital and is in stable condition.

► READ: Wuhan virus – Number of confirmed cases in China exceeds 570
► READ: Wuhan virus – What we know about the fatalities
► READ: "Verge of tears" – Residents of virus-hit Wuhan call for support amid food shortage worries
Adoption of Testing in Singapore

National Public Health Laboratory (NPHL)
- Designed own PCR (N gene, ORF1ab gene); JAMA 2020

Singapore General Hospital (SGH) Dept. Molecular Pathology
- Adopted German assay late Jan.

Other Hospital Labs (public & private)
- Received panels of coded samples from NPHL; when all correct, approval for testing by Ministry of Health (MOH)

We at KKH
- PCR testing approved 11 Feb.

Subsequently
- Commercial PCR kits became available
  - TIB Molbiol Berlin, Germany
  - Fortitude Kit, A*Star Singapore
  - Roche cobas 6800 or 8800
- Ramping up test capacity (~500/day in our small lab)
- Some bigger labs 1500-2000 per day
- Serology (Abbott IgG) started at KKH 22 May
- Singapore (pop. 6.6 m) aims at test capacity 40,000 PCRs per day
Biosafety of Testing

- Needed to design lab protocols
  1. Microbiology & Mol. Micro. Lab
  2. Other Clinical Laboratories
     a. “Respiratory type” specimens (higher risk)
     b. “Non-respiratory” specimens (lower risk)
- COVID suspect specimens double-bagged and labeled
- For (a): Biosafety cabinets (BSCs), goggles, N95 masks, gowns, gloves for specimen processing
- Pregnant women & staff on immunosuppressant medication exempted

Photos: M. Maiwald

Our “Hunting Trophy Wall”
Early COVID-19 Timeline in SG

Timeline until 7 Feb

- Chinese nationals visiting from Wuhan, then Singaporeans returning from Wuhan
- Start of local transmission in Singapore
- DORSCON level raised to ORANGE on 7 Feb

Timeline until 2 Apr

- "1st Wave": Imported cases from China
- "2nd Wave": Early local clusters and local transmission
- "3rd Wave": Returning Singaporeans and SG residents from overseas

Image: Channel NewsAsia & Ministry of Health

Image: Ministry of Health Situation Reports
PPE Measures at the Hospital

Triage

• **Counter Staff:** surg. mask (ext. use); **Clin. Staff:** N95 mask (ext.)

Patient Care

• **Suspected/confirmed pats.:** N95 mask + goggles (ext. use) + gown + gloves (single use)
• **Non-suspect patients:** surg. mask (ext. use)

Aerosol-generating Procedures

• **Suspected/confirmed pats.:** N95 + goggles (or PAPR) + gown + gloves (all single use)
• **Other pats.:** N95 mask + goggles (ext. use) + gown + gloves (single use)

Environmental Cleaning

• N95 mask + goggles (ext. use) + gown + gloves (single use)

Admin. Staff, Patients, Visitors

• Surgical mask (ext. use); or cloth mask

Notes

• Ext. use = extended use for one shift
  (N95 mask in new zip-lock bag or plastic lunch box when temporarily removed)
Other Measures during DORSCON Orange

Hospital Staff
- All staff to take temperature 2 x daily and record on staff intranet
- Anyone with fever, flu-like sympt., sore throat, runny nose MUST report to staff clinic, get COVID-19 tested and placed on 5 d mandatory home quarantine (10 k fines for breach)

Leave
- All leave outside SG is disallowed, including conferences
- Staff arriving from other countries must serve 14 d Stay-Home Notice (SHN)

Meetings, Education, Research
- Inter-hospital movement of HCWs restricted, incl. resident rostering
- Meetings & education via teleconferencing (Zoom, WebEx)
- Research is restricted; guidelines issued

Patients, Visitors
- Visitor access registration & control; only 1 visitor per patient
- Elective procedures & clinic visits restricted
- Isolation wards for suspect/confirmed pats.; discharge when PCR neg. on 2 consec. days
## Patient Categories & Indications for Testing

<table>
<thead>
<tr>
<th></th>
<th>Before 26 March</th>
<th>From 26 March</th>
<th>From 8 May</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Suspect/Confirmed Case fulfilling MOH criteria</td>
<td>Meet MOH’s suspect case definition</td>
<td>Meet MOH’s suspect case definition</td>
</tr>
<tr>
<td>2.</td>
<td>Enhanced Surveillance for Community-Acq. Pneumonia (inpat. &amp; outpatient)</td>
<td>Pneumonia surveillance (inpatient or outpatient)</td>
<td>Other clinical, e.g. fever, ARI, atypical symptoms</td>
</tr>
<tr>
<td>3.</td>
<td>ARI/ Other Conditions fulfilling KKH At-risk criteria (includes travel history/</td>
<td>Other clinical conditions, e.g. fever, ARI, atypical</td>
<td>Surveillance of confirmed case</td>
</tr>
<tr>
<td></td>
<td>pre-surgery/ etc)</td>
<td>symptoms</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>N/A</td>
<td>Surveillance of confirmed case</td>
<td>Other reasons not clinically indicated, e.g. patient’s request (chargeable)</td>
</tr>
<tr>
<td>5.</td>
<td>Pats. not fulfilling MOH criteria or KKH at-risk criteria (chargeable)</td>
<td>Other reasons not clinically indicated (chargeable)</td>
<td>N/A</td>
</tr>
</tbody>
</table>

- Patient Categories evolved during the pandemic
- MOH = Ministry of Health; ARI = Acute Respiratory Infection; KKH = KK Women’s and Children’s Hospital
Case of Paucisymptomatic Child

- 6 mo/old infant admitted for testing & isolation b/c mother was infected
- Asymptomatic except mild fever 38.5°C
- Low Ct value 13.7
  ≈ 6 billion virus copies per NP swab
- NP samples pos. up to day 16
- Child likely highly infectious

- Our lab’s lowest recorded Ct value: 9.7 (in an adult)
  ≈ 100 billion virus copies per NP swab
Environment of Infected Child

- 6 mo/old infant with high viral load
- Paucisymptomatic
- In isolation room
- Sampled & tested: Bed, Cot Rail, Table (+)
  HCW’s face shield, N95 mask, gown (-)

- Infected but well infants with no resp. symptoms can easily contaminate environment
- Child likely highly infectious

Background: Severe acute respiratory syndrome-coronavirus 2 (SARS-CoV-2) is suspected to be spread from an infected person to a susceptible host primarily via droplet and possibly direct contact (1). The roles of transmission by indirect contact (fomites) or by long-range airborne route are uncertain. Currently, there are no data on the risk for transmission from infants or young children with coronavirus disease 2019 (COVID-19) who may be asymptomatic or pauci-symptomatic.

Buccal swabs vs. NP swabs

- 11 infected children; 6 asympt., 5 symptomatic
- Symptomatic all had mild illness
- Buccal swabs are less invasive, easier
- Buccal & NP collected same day, same session
- 2/11 children had neg. buccal swabs (82% sens.)
- Buccal swab Ct values avg. 10.7 higher than NP (P<0.001; factor 1000) --> not a good specimen

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was detected from at least 1 buccal specimen in 9 of 11 coronavirus disease 2019 (COVID-19)–infected children (81.8%). Viral loads in buccal specimens were substantially lower than those in nasopharyngeal specimens. Buccal swabs are not as good as COVID-19 screening specimens in children.

Keywords: COVID-19; buccal; saliva; SARS-CoV-2; viral load.
Public Health Measures

Singapore has been exemplary in contact tracing, isolating and identifying clusters

Classical Contact Tracing

1. Positive virus case
   Contact tracing starts

2. Interview
   To determine who the person has been in contact with

3. Verify information
   Calling contacts, checking receipts, police may get involved

4. ‘Close contacts’ identified
   People thought most at risk of infection

5. Quarantine
   Close contacts with no symptoms quarantined for 14 days
   Close contacts with symptoms isolated and tested

6. Monitoring
   Contacts at moderate risk put under phone surveillance for 14 days

Smartphone App TraceTogether

- **Centralised**
  - Phone provides own anonymised ID plus codes gathered from other phones to centralised database
  - Computer server uses database to do contact matching and risk analysis, plus sends alerts

- **Decentralised**
  - Phone provides own anonymised ID only to centralised database
  - Phone downloads database, does contact matching and risk analysis, plus sends alerts

**TraceTogether Token**

1. Users carry around the TraceTogether Token with them. It will be a small device that they can slip into a bag or their pocket.

2. The token exchanges short-distance Bluetooth signals with other nearby tokens or handsets with the TraceTogether app. The interaction is logged in the devices.

3. All logs will be encrypted. Logs older than 25 days will be automatically erased.

4. If the user becomes infected with Covid-19, the device will need to be physically handed over to the authorities to extract the data needed to do contact tracing.

Source: Straits Times and MOH

Source: BBC and MOH

Source: BBC News
Coronavirus Jokes

"It is over. You may come out again".

German Chancellor Merkel

In order not to be associated with Coronavirus, Mexican beer brand renamed in “Ebola”

Source: Tagesschau.de
A Turn of Events

- Until late March, SG did extremely well
- Cases were under control with aggressive isolation and contact tracing efforts
- Shops, schools were open, public life unaffected

Then, cases emerged at Foreign-Worker Dormitories (from 30 March)

- SG has ~300,000 low-income foreign workers, mostly in construction (e.g. India, Bangladesh, Myanmar)
- Housed in cramped conditions, e.g. 15-20 people in one bedroom
- Virus got foothold, spread like ‘wildfire’
- All dormitories quarantined (Armed Forces involved)
- Comprehensive testing and relocation strategy to Government Quarantine Facilities (GQFs)

Photos: Channel NewsAsia from AFP, Reuters, MINDEF
Subsequent Timeline in SG

Timeline until 17 Apr

- 7 Apr: Start of “Circuit Breaker”, i.e. SG lockdown
  - School closures, only essential businesses open
  - Public mask wearing, social distancing
- From 2 Jun: Reopening in phases

Timeline until 11 Jul

- “4th Wave”
- --> 3 distinct epi curves

Imported Cases

Community Cases

Dorm Residents

All Cases

Image: Ministry of Health Situation Reports

Image: Channel NewsAsia & Ministry of Health
Coping with Increased Testing

• To cope with increasing test demand, MOH set up Testing Operations Centre (TOC)
• TOC would allocate cases from dorms and Government Quarantine Facilities (GQFs) across all public and private labs

Testing in high-prevalence settings is difficult!
• Many samples with low-level or borderline amplification curves (stages of infection)
• Extensive re-testing with confirmatory assays is necessary!

Typical amplification plot of a real-time PCR run

- Pos. Control
- Clearly pos.
- Note: the earlier and higher the curve rises, the more virus there is

Re-run on different PCR assay (primer system) necessary!
Measures for the General Public

Before April 2020

• Relatively normal situation; public life not much affected

• Some panic-buying after DORSCON Orange 7 Feb; quickly subsided

From 7 Apr: “Circuit Breaker”

• School closures, only essential businesses open, public mask wearing (cloth or surg.)

• Only takeout at restaurants, gatherings restricted (only families), no gyms

• No religious gatherings, travel restrictions, working from home

• Public accepted these measures well, but economic conseq. & hardship

• Access control/recording in public places & shopping centers

Reopening in Phases from 2 June

• "Safe Reopening" (phase 1), "Safe Transition" (phase 2) and "Safe Nation" (phase 3)
Conclusions and Outlook

• Singapore generally managed the crisis very well – benefitted from preparedness
• As of 2 July, 44,000 cases, 26 deaths – remarkably low death rate
• Outbreak in the foreign workers’ dormitories constituted a lapse of attention to this vulnerable part of the population – resulted in rapid spread; majority of SG’s cases

On the Ground

• Work on the ground was challenging
• So far no major PPE shortages – stockpiled before the pandemic
• Temporary lab reagent shortages – overcome with centralized procurement & alternatives

Capacity Building & Maintaining

• Completion of NCID (long planned) in 2019 was fortuitous
• Our lab was underresourced & understaffed – improved & rec’d help from hospital leaders
• Capability of Lab-Developed Tests (LDTs) “saved” us in the lab
• Maintaining clinical & lab capacity, staffing & skill sets essential for outbreak response

Future

• Unclear how pandemic will progress – unlikely relief before vaccine (2021?) availability