




Dynamic adaptation to COVID-19 in a Singapore paediatric emergency department

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ABSTRACT

Singapore was one of the earliest countries affected by the coronavirus disease 2019 (COVID-19) pandemic, with more laboratory-confirmed COVID-19 cases in early February 2020 than any other country outside China. This short report is a narrative review of our tertiary paediatric emergency department (ED) perspective and experience managing the evolving outbreak situation. Logistic considerations included the segregation of the ED into physically separate high-risk, intermediate-risk and low-risk areas, with risk-adapted use of personal protective equipment (PPE) for healthcare personnel in each ED area. Workflow considerations included the progressive introduction of outpatient COVID-19 testing in the ED for enhanced surveillance; adapting the admissions process particularly for high-risk and intermediate-risk cases; and the management of unwell accompanying adult caregivers. Manpower considerations included the reorganisation of medical manpower into modular teams to mitigate the risk of hospital transmission of COVID-19. Future plans for a tiered isolation facility should include structural modifications for the permanent isolation facility such as anterooms for PPE donning/doffing; replication of key ED functions in the tent facility such as a separate resuscitation room and portable X-ray room; and refresher PPE training. Dynamic reassessment of ED workflow processes, in conjunction with the hospital and national public health response, may help in managing this novel disease entity.

The coronavirus disease 2019 (COVID-19) pandemic has met a swift public health response in Singapore,^{1,2} where the high volume of air traffic from China coinciding with travel for the annual Lunar New Year holiday, meant a high risk of outbreak spread. In early February 2020, Singapore

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had more laboratory-confirmed COVID-19 cases than any country outside China.³ On finding local cases without links to previous cases or travel to China, Singapore escalated its risk assessment and public health response level,⁴ implementing a multi-pronged surveillance and containment strategy.²

KK Women's and Children's Hospital is an 830-bed tertiary paediatric hospital in Singapore, whose emergency department (ED) serves approximately 180 000 patients annually. The evolving outbreak situation and case definitions (online supplementary Appendix 1) presented challenges for implementing logistic and workflow changes (table 1) while maintaining continuity of care. Our experience adapting to COVID-19 may have useful implications for paediatric EDs in other countries preparing for this pandemic.

LOGISTIC CONSIDERATIONS

Segregation of ED into high-risk, intermediate-risk and low-risk areas

At baseline, we screened at triage within the main ED; patients with recent travel to China were given surgical face masks and seen in the ED isolation area. Subsequently, we initiated pre-triage screening before entering the ED and segregation of patients into three risk-stratified physically separate areas (figure 1). A tent was built to increase capacity and we chose to see low-risk patients there as they represented the smallest category of patients. Floor-to-ceiling partitions were built to cordon off part of the main ED to serve low-risk patients needing procedural sedation and X-rays, ensuring that all three areas had X-ray facilities. It was necessary to distinguish between intermediate-risk and low-risk to balance exposure risks to patients and healthcare professionals with resource utilisation of personal protective equipment (PPE). In view of the novel viral pandemic with many unknowns, risk stratification was frequently updated based on the Ministry of Health (online

supplementary appendix 1) and infectious diseases team input.

- ▶ **High-risk area.** Patients/caregivers considered 'suspect' based on symptoms and travel history (online supplementary appendix 1) were housed in the existing ED isolation facility with negative-pressure resuscitation bay and private consult rooms.
- ▶ **Intermediate-risk area.** 'At-risk' patients/caregivers with fever or acute respiratory symptoms were issued surgical face masks and managed here.
- ▶ **Low-risk area** for patients with no travel or contact history, fever or acute respiratory symptoms.

Risk-adapted use of PPE for healthcare personnel

Pre-outbreak standard PPE was surgical face mask and hand hygiene (alcohol hand rub) for all clinical contacts; adding N95 face mask, gown and gloves for airborne/droplet-borne infectious cases in the isolation facility. With increasing numbers of confirmed COVID-19 cases, evidence of hospital transmission to healthcare personnel in China,⁵ and possibility of ocular transmission,⁶ enhanced PPE with N95 face masks, and subsequently eye protection, were progressively implemented (table 2). This is similar to the United States Centers for Disease Control and Prevention recommended PPE when caring for patients with known/suspected COVID-19: respirator/face mask (N95 or higher-level protection for aerosol-generating procedures), eye protection, gloves and gown.⁷ The World Health Organization has since published interim guidance on the rational use of PPE; healthcare workers involved in direct care of outpatients are recommended to use medical mask, gown, gloves and eye protection during physical examination of patients with respiratory symptoms, and PPE according to standard precautions and risk assessment for patients without respiratory symptoms.⁸

WORKFLOW CONSIDERATIONS

COVID-19 testing

During the initial outbreak, COVID-19 nasopharyngeal swabs were only performed for inpatients. Outpatient testing prior to ED discharge was progressively introduced for enhanced surveillance (table 1). The discovery of high viral loads with potential transmission from asymptomatic children⁹ highlighted the need for early identification of suspect cases. This allowed containment measures, assessment of community spread and vigilance for potential school clusters. Testing of asymptomatic paediatric contacts

Table 1 Timeline of key paediatric emergency department (ED) interventions.

Date	Intervention	Rationale
23 Jan 2020	*Mandatory admission to inpatient isolation wards for all suspect cases presenting to the ED (case definitions in online supplementary appendix 1)	Containment and isolation purposes as Singapore confirmed first imported case of COVID-19
31 Jan 2020	Enhanced personal protective equipment (PPE): N95 face mask for front-line ED staff at triage and in the resuscitation area	Increasing numbers of imported COVID-19 cases in Singapore
5 Feb 2020	<ul style="list-style-type: none"> ▶ All patients with community-acquired pneumonia requiring inpatient admission admitted to an isolation ward ▶ *All patients with recent travel to China seen in ED isolation area 	<ul style="list-style-type: none"> ▶ Local transmission reported in Singapore ▶ Significant human-to-human transmission in more than one province of China
9–10 Feb 2020	<ul style="list-style-type: none"> ▶ Pre-triage screening of all patients and caregivers ▶ Segregation of ED into high-risk, intermediate-risk and low-risk areas ▶ ED medical manpower split into modular teams ▶ Further PPE enhancement with eye protection for triage, high-risk and intermediate-risk areas 	<ul style="list-style-type: none"> ▶ Singapore's national risk assessment raised to Orange (second-highest level)⁴ ▶ Evidence of healthcare personnel in China getting infected with COVID-19⁵ ▶ Evidence of possible ocular transmission of COVID-19⁶
14 Feb 2020	*COVID-19 nasopharyngeal swab for patients with community-acquired pneumonia discharged from ED	Enhanced surveillance for COVID-19 ²
28 Feb 2020	COVID-19 nasopharyngeal swab for patients with travel history outside Singapore within last 14 days and fever/acute respiratory illness	Increasing local transmission in several countries
5 March 2020	*COVID-19 nasopharyngeal swab for asymptomatic paediatric close contacts of confirmed cases (proactively identified; brought to ED for testing)	Asymptomatic paediatric patients may have high COVID-19 viral load ⁹

*Interventions mandated at national level. All other interventions were decided at hospital level.

of positive cases was expedited by close communication between ED staff, hospital infectious diseases team and the Ministry of Health.

The workflow required a dedicated room for ED staff wearing full PPE to perform the nasopharyngeal swab, then hand-deliver the specimen to the hospital laboratory in a double bag (to prevent transmission to lab staff). Parents were advised as follows:

- ▶ The child was given medical leave of absence for 5 days, within which time they would be informed of the swab result.
- ▶ To self-isolate the child at home as a precautionary measure until the swab result was available.
- ▶ To bring the child back to ED if unwell or fever persisted.

Admissions processes

Initially, only COVID-19 suspect cases were admitted to a designated isolation ward. Subsequently, patients with

community-acquired pneumonia requiring admission were also isolated and cohorted. Patients admitted for urgent surgery who had an intercurrent illness with respiratory symptoms were cohorted and COVID-19 swab performed prior to surgery. High-risk and intermediate-risk admissions were escorted by hospital security staff and patient care assistants wearing full PPE to clear the route for patient transfer, secure elevators and disinfect the elevator immediately afterwards.

Management of adult parents/caregivers

When children requiring inpatient admission presented with an unwell accompanying adult caregiver, further considerations included: maintaining family care as a unit, keeping one designated caregiver throughout hospital admission, age of the child, clinical acuity of both child and adult, and minimising movement of confirmed cases as part of outbreak containment efforts. If an alternate caregiver was

available, the child would be admitted with the well caregiver and the sick adult sent to the National Centre for Infectious Diseases. Otherwise, the dyad was admitted and kept together in the paediatric hospital as far as possible, except in situations where the adult was acutely ill (breathless or requiring intensive care) or had chronic medical conditions requiring adult specialist input.

MANPOWER CONSIDERATIONS

Hospital transmission of COVID-19 is a significant risk to healthcare workers, with 1716 laboratory-confirmed cases in China as of 11 February 2020.⁵ To mitigate this risk, our ED medical manpower was split, with senior and junior doctors rostered into four modular teams working in 12-hour shifts to prevent cross-exposure.

FUTURE DIRECTIONS

Operationalising a tiered isolation facility has highlighted several practical considerations.

First, the permanent isolation facility of the main ED needs structural modifications, including anterooms for PPE donning/doffing and a separate isolation resuscitation area for non-pandemic infectious cases such as measles or pertussis.

Second, during an outbreak it is ideal to manage potentially infectious cases outside the main ED. The tent design should thus be modified to meet this need by replicating the following ED functions:

- ▶ PPE donning/doffing area.
- ▶ Separate room for aerosol-generating procedures.
- ▶ Separate resuscitation room.
- ▶ Separate lead shield-equipped portable X-ray room.

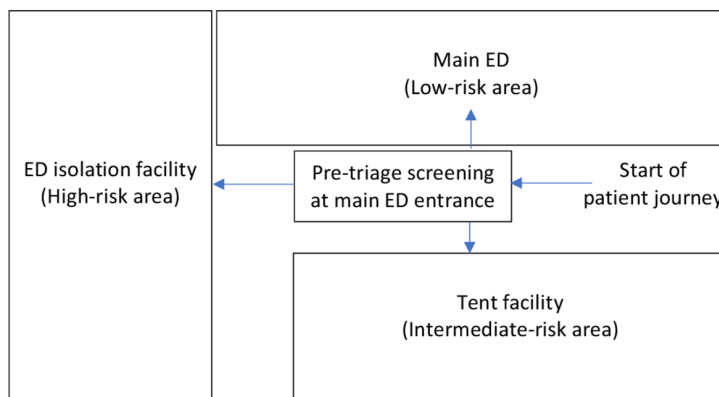


Figure 1 Initial layout of high-risk, intermediate-risk and low-risk areas of the emergency department (ED). The intermediate-risk and low-risk areas were later switched due to space constraints and patient numbers.

Table 2 Current COVID-19 personal protective equipment (PPE) guidelines in the emergency department (ED).

Area of ED/procedures	Risk-adapted PPE/precautions
Triage	N95 face mask and goggles
High-risk area	N95 face mask, goggles, gown and gloves
Intermediate-risk area	N95 face mask and goggles
Low-risk area	Surgical face mask
Aerosol-generating procedures (intubation, suctioning, performing COVID-19 nasopharyngeal swabs)	▶ Powered air-purifying respirator (PAPR) ▶ Disposable laryngoscope blades for intubation
Management of respiratory tract infections	Avoid nebulised medications

- ▶ Dedicated patient washroom (strain on nursing manpower to accompany patients to washroom with violations of clean/dirty zones).
- ▶ Onsite pharmacy for discharge medications.

Third, refresher PPE training is needed as several staff found powered air-purifying respirator usage unfamiliar or were unable to fit standard N95 face masks, despite most having received PPE training and N95 fit-testing.

As we refine our understanding of COVID-19, a high degree of active surveillance in the community and dynamic reassessment of ED workflow processes, in conjunction with the hospital and nationwide public health response, may help us better manage this ongoing pandemic and prepare for the next.

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