


Containing COVID-19 in the Emergency Department: The Role of Improved Case Detection and Segregation of Suspect Cases

Liang E. Wee, MPH^{1,2} , Tzay-Ping Fua, MRCSEd (A&E)³, Ying Y. Chua, MRCP², Andrew F. W. Ho, MMed³, Xiang Y. J. Sim, MRCP^{2,4}, Edwin P. Conceicao, BSc. (Nursing)⁴, Indumathi Venkatachalam, MPH^{2,4}, Kenneth B.-K. Tan, MCEM³, and Ban H. Tan, MRCP²

ABSTRACT

Objectives: Patients with COVID-19 may present with respiratory syndromes indistinguishable from common viruses. This poses a challenge for early detection during triage in the emergency department (ED). Over a 3-month period, our ED aimed to minimize nosocomial transmission by using broader suspect case criteria for better detection and using appropriate personal protective equipment (PPE) for health care workers (HCWs).

Methods: All ED admissions with respiratory syndromes over a 3-month period were tested for COVID-19. The sensitivity and specificity of screening criteria in detecting COVID-19 were assessed. A risk-stratified approach was adopted for PPE usage in the ED, based on high-risk “fever areas” and lower-risk zones. When a case of COVID-19 was confirmed, surveillance was conducted for potentially exposed patients and HCWs.

Results: A total of 1,841 cases presenting with respiratory syndromes required admission over the study period. Among these, 70 cases of COVID-19 were subsequently confirmed. The majority (84.2%, 59/70) were detected at ED triage because they fulfilled suspect case criteria. Of these, 34 met the official screening criteria; an additional 25 were detected by the broader internal screening criteria. Over the 12-week period, the cumulative sensitivity of internal screening criteria was 84.3% (95% confidence interval [CI] = 73.6% to 91.9%), whereas the sensitivity of the official screening criteria was 48.6% (95% CI = 36.4% to 60.8%). Given the broadened internal criteria, the preexisting ED “fever area” was insufficient and had to be expanded. However, there were no cases of nosocomial transmission from intra-ED exposure, despite extensive surveillance.

Conclusion: Frontline physicians need to be given leeway to decide on the disposition of cases based on clinical suspicion during an ongoing outbreak of COVID-19. If a broader criterion is used at ED triage, ED facilities and isolation facilities need to be readied to accommodate a surge of suspect cases. Usage of appropriate PPE is essential in minimizing nosocomial transmission.

In late December 2019, a novel pathogen, SARS-CoV-2, first emerged in mainland China.¹ Since then, an outbreak of acute respiratory disease (ARD) caused by this novel coronavirus (COVID-19) has evolved into a global pandemic, with cases of local transmission being reported soon after the detection of imported cases in affected countries.² While heightened vigilance is necessary to prevent sustained

From the ¹Singhealth Infectious Diseases Residency; and the ²Department of Infectious Diseases; the ³Department of Emergency Medicine; and the ⁴Department of Infection Prevention and Epidemiology, Singapore General Hospital, Singapore.

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Address for correspondence and reprints: Liang E. Wee; e-mail: ian.wee@mohh.com.sg.

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transmission in new locations,³ challenges exist. To contain an outbreak of COVID-19, the role of a large hospital in this effort pivots on its frontline doctors, namely, emergency department (ED) physicians, assisted by infectious diseases (ID) specialists, to ensure that potential cases of COVID-19 are identified early and isolated upon arrival. This is challenging as individuals with COVID-19 may be relatively asymptomatic in the early stages of illness and may present with atypical manifestations;⁴ early stages of COVID-19 may thus be indistinguishable from ARDs caused by common respiratory viruses. Case definitions are hence essential in guiding the ED physician with regard to triage of potential suspect cases. The role of the ED as a line of defense in ensuring that suspected COVID-19 cases are contained and isolated from arrival is crucial, given the significance of nosocomial transmission.⁵

In Singapore, a globalized Asian city-state with close travel links to mainland China, the risk of imported cases was recognized early. The local Ministry of Health (MOH) published initial suspect case criteria on January 2, 2020, that, in line with the initial case criteria published by the World Health Organization (WHO), focused on patients with pneumonia and a recent travel history to Wuhan, based on what was known about the outbreak at that time.⁶ Subsequently, suspect case criteria from both the WHO and our MOH changed to keep up with the evolution of the COVID-19 pandemic. The first imported case of COVID-19 in Singapore was reported in end-January 2020, followed by the first documented case of local transmission in early February 2020.⁷ As of end-February 2020, less than one-third of cases in Singapore were imported, and the rest were locally transmitted.⁶ Previous analyses have suggested that the surveillance system in Singapore is robust, with a high sensitivity for case detection.⁸ Here, we report our institution's ED experience during the initial outbreak of COVID-19 over a 3-month period that saw a gradual shift from imported cases to locally transmitted ones, followed by a second wave of imported cases with onward local transmission. In line with the national strategy of containment, our ED aimed to minimize the risk of nosocomial transmission by utilizing a broader set of suspect case criteria to screen all attendees with respiratory symptoms for better detection; enforcing strict segregation of patients with respiratory syndromes and/or fever from the rest of the ED, with infrastructural modifications to accommodate

the surge of patients and improve infection control; and adopting a risk-stratified approach to the usage of personal protective equipment (PPE). The impact of this strategy in case detection, resource utilization and infection control was assessed. Uniquely, the sensitivity and specificity of our suspect case criteria could be assessed, given that all admitted patients with respiratory symptoms were tested for COVID-19.

METHODS

Institutional Setting

Our institution, Singapore General Hospital is the largest public tertiary hospital in Singapore, with 1,785 beds. Our institution accounts for about a quarter of the total acute hospital beds in the public sector and about one-fifth of acute beds nationwide. Our institution's isolation ward (IW) was used to nurse confirmed and suspected cases of COVID-19. From February 5, 2020, after our institution detected the first case of local transmission, all patients presenting with respiratory symptoms without an obvious history of contact with travelers or known COVID-19 cases were admitted to designated inpatient cohorted wards ("respiratory surveillance wards" [RSWs]). In the RSW, staff wore N95 masks and eye protection and SARS-CoV-2 was tested for prior to transfer or discharge via reverse transcriptase polymerase chain reaction (rtPCR) of respiratory samples. The minimum criteria for transfer/discharge was two negative COVID-19 samples taken 24 hours apart.⁹

Broadening Case Definitions for Suspected COVID-19 Cases at ED Triage

On January 2, 2020, our local MOH issued a set of suspect case criteria for COVID-19, mandating admission and isolation for every person meeting the case criteria. The criteria closely matched those released by the WHO and U.S. Centers for Disease Control and Prevention.^{10,11} In this study, the WHO's suspect case criteria for COVID-19, with close reference to our own MOH's suspect case criteria to provide additional local context for relevance, was defined as the "official case criteria." From February 27, 2020, the WHO case criteria were broadened to include patients presenting with ARD with no alternative etiology and a history of residence in any country reporting ongoing local transmission. Thereafter our own MOH's suspect case criteria were utilized as the official case criteria, because the WHO case criteria would have

automatically included all patients with ARD presenting to our institution, given local transmission in Singapore. In our institution, however, apart from the official case criteria, a broadened set of internal screening criteria was used to improve case detection. Both the official case criteria and the internal screening criteria were used at ED triage to decide on isolation of patients presenting with either pneumonia or ARD of any severity, based on various epidemiologic risk factors; patients who had the relevant risk factors were considered as meeting case criteria. The changes in both our internal screening criteria and the official case criteria over a 3-month period are reflected in Data Supplement S1, Table S1, available as supporting information in the online version of this paper, which is available at <http://onlinelibrary.wiley.com/doi/10.1111/acem.13984/full> (for pneumonia) and Data Supplement S1, Table S2 (for ARD of any severity). Both sets of criteria underwent multiple changes during this period, reflecting the fast-evolving situation.

ED Workflow During COVID-19 Outbreak: Efforts to Protect Health Care Workers

As patients with COVID-19 may present with respiratory syndromes indistinguishable from those caused by common respiratory viruses, a risk-stratified approach was adopted for PPE usage in the ED. During the study duration, all patients presenting to the ED with respiratory syndromes or undifferentiated fever were deemed to be at higher risk and were managed in segregated areas of the ED (“fever areas”), where health care workers (HCWs) used full PPE comprising N95 masks, eye protection (face shields), and disposable gown and gloves, similar to the disposition and management of suspected COVID-19 cases. Outside of the fever areas where the bulk of patients were classified as lower risk, ED staff wore N95 masks for extended periods in areas where they might potentially come into contact with patients with respiratory symptoms, such as at all triage areas, corridors of fever areas, in the observation ward where patients with respiratory symptoms might be held while awaiting admission, and in the critical care area where patients with respiratory symptoms might need urgent resuscitation. In other low-risk areas of the ED, usage of a surgical mask was made the mandatory minimum standard. Mask usage was made mandatory throughout the ED as asymptomatic and presymptomatic patients might also potentially transmit COVID-19.¹² If masks were used for extended duration, they could only be used

up to 4 to 6 hours, with N95 masks being placed in a new and clean zip-lock bag each time the mask was removed. Masks would be changed if soiled. This was in line with local studies that did not detect contamination of PPE despite extended use of N95 masks and goggles with strict adherence to environmental and hand hygiene.¹³ Full PPE was used for any aerosol-generating procedures (e.g., intubation) throughout the whole ED, as this was deemed to be a high-risk procedure.

Criteria for Inclusion and Exclusion of COVID-19

All patients admitted via the ED and who presented with respiratory symptoms at ED triage over a 3-month period from January 1, 2020, to April 1, 2020, were tested for COVID-19 via rtPCR of respiratory samples for SARS-CoV-2. A confirmed case of COVID-19 was defined as a positive test for SARS-CoV-2 via rtPCR testing,^{10,11} while patients were considered negative for COVID-19 at the point of testing if they had two negative COVID-19 samples taken 24 hours apart.⁹ To evaluate case detection at ED triage, the sensitivity and specificity of our internal screening criteria in detecting COVID-19 were calculated and compared to the official case criteria. Whenever a case of COVID-19 was confirmed, activity mapping and contact tracing were conducted retrospectively by our hospital’s epidemiology team to determine whether any patients or staff in the ED had been exposed, and surveillance was conducted for potentially exposed patients and staff.

Ethics Approval

Because this was a descriptive study based on surveillance data collected by the hospital’s Department of Infection Prevention and Epidemiology and only aggregate data were collected without patient identifiers, ethics approval was not required under our hospital’s institutional review board guidelines.

RESULTS

Case Detection for COVID-19 Using Broader Internal Screening Criteria

From January 1, 2020, to April 1, 2020, over a 3-month period, a total of 1,841 cases presented to our ED with respiratory syndromes requiring admission or fulfilling suspect criteria for COVID-19, and all were tested for COVID-19. Among these, 70 cases tested

positive for COVID-19. Over the study period, there was a clear shift from imported cases to locally transmitted ones, followed by a successive wave of imported cases (Figure 1A). Of note, our institution picked up the first locally transmitted case in Singapore, which formed part of a cluster (Case 4, linked to Case 5, Figure 1B); these cases did not fulfill official case criteria but were detected by our internal screening criteria. The majority of COVID-19 cases (84.2%, 59/70) were detected at ED triage because they fulfilled suspect case criteria. Of these, 34 met the official screening criteria, an additional 25 were additionally picked up by the broader internal screening criteria, and 11 cases did not fulfill either set of criteria. In total, 695 patients

met internal screening criteria, and 218 met official case criteria for suspected COVID-19. Over the 3-month period, the cumulative sensitivity of internal screening criteria in detecting COVID-19 cases for isolation at ED triage was 84.3% (95% confidence interval [CI] = 73.6% to 91.9%), with a specificity of 64.8% (95% CI = 62.5% to 67.0%), whereas the sensitivity of the official screening criteria was 48.6% (95% CI = 36.4% to 60.8%), with a specificity of 89.6% (95% CI = 88.1% to 91.0%; Table 1).

Our internal screening criteria picked up the additional 25 cases through maintaining higher vigilance; the details are provided in Table 2. Of the 11 cases that did not fulfill either official or internal screening

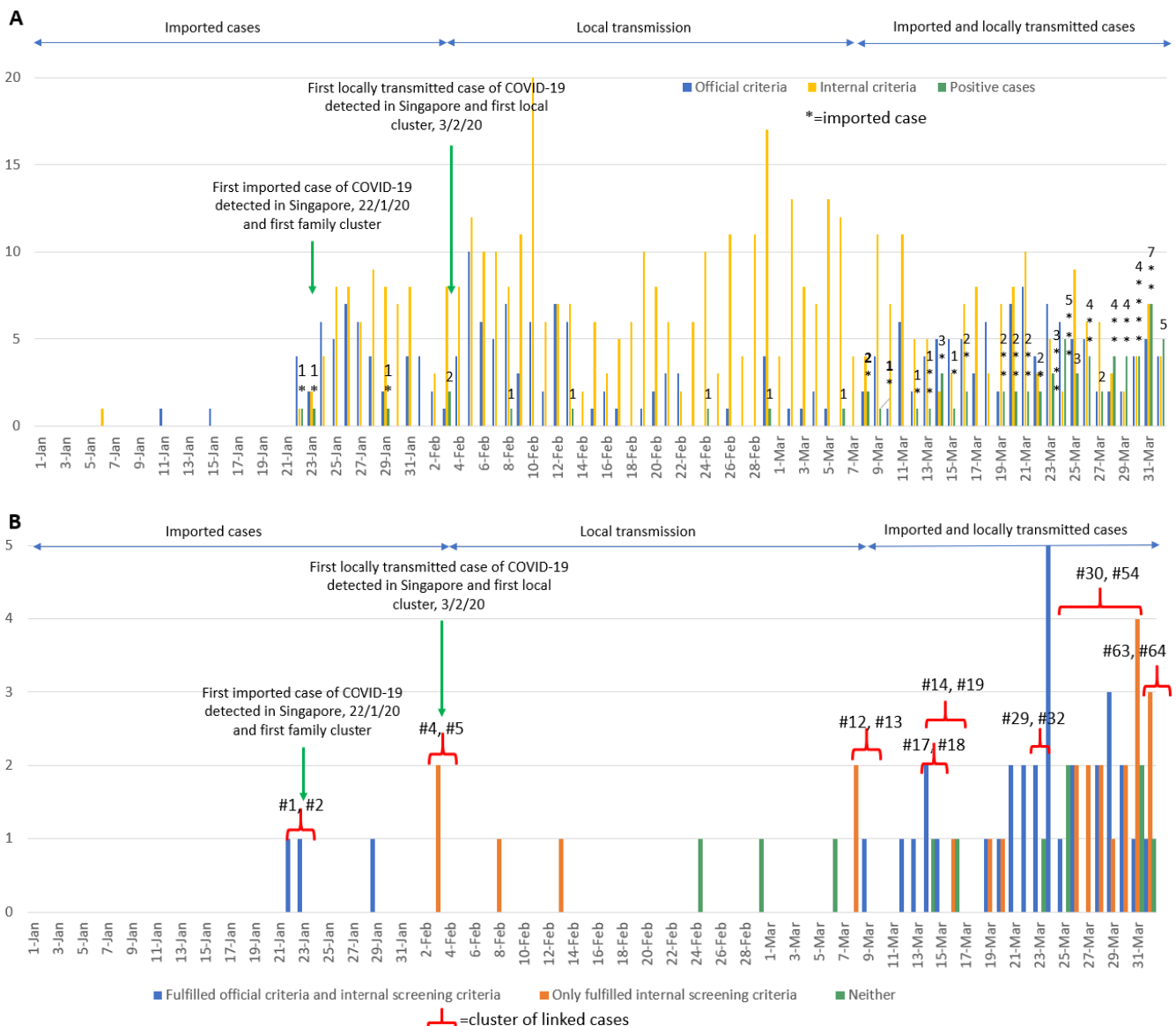


Figure 1. Epidemiologic features of suspected and confirmed cases of COVID-19 patients presenting to the ED of a Singaporean tertiary hospital over a 3-month period.

Table 1

Accuracy of Suspect Case Criteria at Triage for Deciding on Isolation for Suspected COVID-19, Among All Cases of ARD Presenting to the ED of a Singaporean Tertiary Hospital Over a 3-month Period

	Confirmed COVID-19 case	Negative COVID-19 case	Total		Confirmed COVID-19 case	Negative COVID-19 case	Total
Internal screening criteria met at ED triage for isolation as a suspect COVID-19 case*	59	636	695	Official case criteria met at ED triage for isolation as a suspect COVID-19 case†	34	184	218
Internal screening criteria not met at ED for isolation as a suspect COVID-19 case	11	1135	1146	Official case criteria not met at ED for isolation as a suspect COVID-19 case	36	1,587	1,623

*Sensitivity of internal screening criteria: 84.3% (95% CI = 73.6% to 91.9%), specificity 64.8% (95% CI = 62.5% to 67.0%), positive predictive value 8.49% (95% CI = 7.61% to 9.46%), and negative predictive value 99.1% (95% CI = 98.4% to 99.5%).

†Sensitivity of official screening criteria: 48.6% (95% CI = 36.4% to 60.8%), specificity 89.6% (95% CI = 88.1% to 91.0%), positive predictive value 15.6% (95% CI = 12.3% to 19.6%), negative predictive value 97.8% (95% CI = 97.2% to 98.2%).

Table 2

Epidemiologic and Clinical Features of COVID-19 Patients That Fulfilled Internal Screening Criteria But Not Official Criteria, Over a 3-month Period (N = 25)

Category of internal screen criteria	Component of internal screen criteria that detected case	Number of cases [§]
Epidemiology	Higher-risk occupations*	10
Clinical (symptoms)	Anosmia	8
Travel history	Recent travel to Southeast Asian countries, not on list of areas requiring heightened vigilance at the point of detection†	5
Epidemiology	Frequent or close contact during work with recent travelers or tourists (in last 14 days prior to symptom onset)‡	3
Travel history	Recent travel to European countries, not on list of areas requiring heightened vigilance at the point of detection†	3
Epidemiology	Close secondary contacts of unwell contact from large local cluster	1

*Examples of such occupations deemed higher risk included: HCWs working in higher risk areas or frontline roles (e.g., ED, IW); occupations with a higher proportion of migrant workers staying in congregate settings (e.g., cleaners, dishwashers, construction workers); occupations catering to the expatriate community (e.g., international school teachers).

†The official suspect case criteria included individuals with acute respiratory illness who had traveled to affected areas requiring heightened vigilance. These areas were selected based on the volume of travel links with Singapore and ongoing severity of local transmission and included specific Southeast Asian or European countries at different points in time. However, the internal screening criteria was broadened to include a wider range of countries, based on the higher volume of travel between Singapore and neighboring Southeast Asian countries and the severity of local transmission in European countries at that point of the outbreak.

‡The first locally transmitted case, as well as the first cluster of locally transmitted infections, were detected using this criterion. From March 23, 2020, all short-term visitors were not allowed entry into Singapore.

§Numbers add up to more than 25 cases because cases may have fulfilled more than one internal screening criteria.

criteria, all were locally transmitted cases that did not have history of travel and did not have links with a confirmed COVID-19 case or cluster.

Infrastructural Modifications in the ED During an Ongoing COVID-19 Outbreak

To accommodate the large number of patients presenting to the ED with respiratory symptoms/undifferentiated fever during an ongoing COVID-19 outbreak, the designated “fever area” was expanded by taking over the adjacent ambulatory surgery center and converting it into an expanded fever area, in which staff wore full PPE. Within the fever area, partitions 2 meters high were set up between trolleys to construct

temporary cubicles and trolleys were spaced 2 meters apart, to reduce the risk of droplet spread; partitions and trolleys were wiped down after each patient. Traffic flows for patients managed in the fever areas were separated from the rest of the ED. Subsequently, to accommodate the rising number of patients, a sheltered carpark off-site was modified into an additional fever screening area for well patients with upper respiratory tract symptoms.

Increased Inpatient Resource Utilization Arising From Broader Screening Criteria

Broadening the screening criteria tripled the number of suspect cases, resulting in increased pressure on

IW beds. If only cases who fulfilled official case criteria had been admitted to isolation, the bed occupancy rate of our IW would have remained at less than ~50% during the first 2 months of the outbreak, whereas by using our internal screening criteria, bed occupancy of the IW reached almost 100% on January 28 and again on the February 6. To accommodate this spillover and the large number of suspect COVID-19 cases requiring admission to IW, our institution converted 40 single rooms scattered throughout the hospital with attached toilets into extensions of the IW. The single rooms were used for lower-risk suspect cases, whereas negative-pressure rooms were used for patients requiring aerosol-generating procedures and for confirmed COVID-19 cases.

Impact of Improved Case Detection at ED Triage on Minimizing Nosocomial Spread

Most cases fulfilled suspect case criteria and were managed in designated fever areas within ED and admitted to the IW. Although 11 unlinked cases of COVID-19 were not detected at ED triage, because all patients presenting to the ED with respiratory syndromes or undifferentiated fever were managed similar to suspect COVID-19 cases and triaged into fever areas where full PPE was used, and patients were spaced farther apart, intra-ED exposure was minimized. Within the ED, only one case of COVID-19 was managed outside of a fever area, because the initial respiratory symptoms reported at triage were fairly mild. Because the patient stayed ≥ 12 hours in the ED, a total of 43 patients were deemed to have potentially significant unprotected exposure and required quarantine. A total of 20 staff in the ED were potentially exposed; however, because all ED staff used N95 masks, none of the staff were deemed to have significant unprotected exposure requiring quarantine. All patients and staff were followed up for 14 days post-exposure; none developed symptoms compatible with COVID-19. Swabs from the patient's room, call bell, and trolley in the ED were tested for SARS-CoV-2 (taken ≥ 24 hours post-exposure) and were all negative. The majority of the 11 cases not fulfilling suspect case criteria were triaged into the RSW where enhanced PPE was used, hence minimizing inpatient exposure. Only one case of undifferentiated fever was initially triaged to the general ward; the patient remained in the general ward for 18 hours before being shifted to an RSW where the diagnosis of COVID-19 was confirmed. To date, despite extensive

surveillance and monitoring of potentially exposed staff and patients, no documented cases of nosocomial transmission from intra-ED exposure have been identified. Given that staff in the ED managed these unlinked cases with full PPE and ED staff wore N95 masks for extended periods in areas where they might potentially come into contact with patients with respiratory symptoms, the number of staff requiring quarantine as a result of unprotected exposure was minimal and the ED was kept fully operational.

DISCUSSION

Case definitions are important in the early stages of an infectious diseases outbreak, by helping to ensure appropriate triage and isolation and by rationing testing resources, which may be scarce especially in outbreaks caused by a novel pathogen. Given close travel links between Singapore and China, with almost 300,000 visitor arrivals a day,¹⁴ our country was at higher risk of imported cases¹⁵ and our institution had maintained vigilance for potential cases of COVID-19 since the start of January 2020. While using a case definition based on travel history and contact with confirmed cases of COVID-19 is possible in the early phases of an outbreak when cases are mostly imported, during ongoing community transmission, distinguishing between cases of COVID-19 and ordinary pneumonia becomes difficult. Our institution had previously experienced an outbreak of severe acute respiratory syndrome (SARS), in 2003; and appropriate triaging, cohorting, and selective isolation was found to be an effective and practical model of intervention in cohorts exposed to a SARS outbreak.¹⁶ However, to achieve appropriate triaging, case definitions are crucial. During SARS, early studies showed low sensitivity and potential undertriage at ED, when the WHO case criteria for SARS were used for clinical assessment, in areas with established local transmission.¹⁷⁻¹⁹ Furthermore, distinguishing COVID-19 posed its own set of challenges. In SARS, fever was a predominant feature on initial presentation, and few patients were asymptomatic,²⁰ allowing for fever and severity of respiratory disease to form part of case criteria.¹⁷⁻²¹ However, it appears that fever, though common, may not occur in all patients with COVID-19 on initial presentation, and individuals may not present with severe respiratory disease. In a large study of more than 1000 patients with COVID-19, fever occurred in only 43.8% of patients on presentation

but developed in 87.9% following hospitalization.²² Thus, admission strategies adopted during SARS outbreaks that focused on isolating all patients with febrile pneumonia²³ may not be feasible in detecting all patients with COVID-19 ARD on initial presentation to hospital. Admission strategies adopted for MERS that focused on isolating and cohorting patients with significant travel history and a compatible clinical syndrome²⁴ may not be suitable during the later phases of an outbreak of COVID-19 with ongoing local transmission. While official case criteria were fairly sensitive, more than half of confirmed COVID-19 cases did not fulfil the official case definitions. The effectiveness of case definitions in practice depends on the context and the user.²⁵ The importance of early detection of COVID-19 at ED triage cannot be understated, given that a single case of COVID-19 managed without appropriate PPE can result in the quarantine of large numbers of HCWs and disrupt hospital operations during an ongoing outbreak.²⁶

As such, to improve case detection at ED triage, our institution allowed physicians on the ground more leeway in determining who to test/isolate, via the use of a broader set of internal screening criteria. This improved sensitivity and the pickup rate for COVID-19 at ED triage. Usage of a looser set of criteria and flexibility afforded to frontline staff likely enabled our institution to detect several of the country's "firsts," such as the first imported case and the first case of local transmission. While official case definitions are important to appropriately target testing, there must be room for flexibility based on the latest available information and clinical suspicion. In China, laboratory tests for COVID-19 were originally requested according to the case definitions, which included an epidemiologic link to Hubei or other confirmed cases; subsequently, a more liberal clinical testing regimen allowed clinicians to test at lower thresholds of suspicion.²⁷ Similarly, the initial cases of COVID-19 in other countries were only detected because of a higher index of suspicion by frontline clinicians, because they did not meet official case criteria.^{28,29} However, increased sensitivity comes at the expense of specificity, and a fine balance needs to be struck, because an overly broad definition will strain hospital resources, especially in institutions with limited isolation beds. Infrastructural modifications are also necessary to accommodate the increased number of suspected COVID-19 cases identified using a broader set of internal screening criteria. By partitioning the ED into

higher risk and lower-risk areas, and setting up different traffic flows, the risk of cross-infection can be mitigated.³⁰ Finally, while most COVID-19 cases presenting to our ED over a 12-week period were successfully isolated, one-fifth of cases did not have any known epidemiologic links that allowed detection based on case criteria alone. This suggests that, as community penetration deepens, likely through mildly symptomatic cases, it will be more and more difficult to use epidemiologic criteria to pick out potential cases at triage in the ED. Within the ED, managing all patients presenting with respiratory syndromes in designated fever areas and the creation of inpatient RSWs, with upgraded PPE and better bed spacing of patients, would appear to be the last line of defense against patient-to-staff transmission during an outbreak of COVID-19 with ongoing community transmission. This is essential, given that even a single patient in an overcrowded ED can ignite a nosocomial outbreak of respiratory disease caused by a novel pathogen, with devastating consequences.³¹

LIMITATIONS

The limitations of our study are as follows. The diagnostic yield of PCR testing for SARS-CoV-2 would likely be dependent on the quality and type of respiratory tract sample, and the sensitivity and specificity of the assay are unknown at present. COVID-19 cases may thus have been missed due to sampling issues with the tests available at the time. Our hospital was not the designated hospital for receiving COVID-19 suspect cases from primary care clinics and hence the majority of COVID-19 patients in Singapore were not managed here. Hence, our experience would be more relevant to the majority of health care institutions that are not designated centers for the management of COVID-19 cases, especially in countries and regions in the earlier stages of an outbreak.

CONCLUSIONS

In conclusion, during an ongoing outbreak of COVID-19 with progression from imported cases to locally transmitted ones, our ED managed to detect and appropriately isolate the majority of confirmed COVID-19 cases upon triage at the ED, over a 3-month period. Our institution's internal screening criteria had higher sensitivity in deciding on appropriate ED triage of suspect cases, compared to the published

official case criteria. However, if a broader criterion is used for the triage of suspected COVID-19 cases, ED facilities and isolation facilities need to be readied to accommodate a larger number of cases. Frontline physicians need to be given leeway to decide on the disposition of cases based on clinical suspicion and be afforded appropriate PPE. Continued vigilance at the frontline as part of an overall containment strategy may reduce the likelihood of nosocomial transmission and buy precious time for hospital preparedness during an outbreak of a novel pathogen.

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Supporting Information

The following supporting information is available in the online version of this paper available at <http://onlinelibrary.wiley.com/doi/10.1111/acem.13984/full>
Data Supplement S1. Supplemental material.