Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Short Communication

Pneumonia surveillance and its attendant clinical risk stratification for COVID-19 in low-risk patients

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ABSTRACT

Objectives: The objective of the study is to determine the prevalence of COVID-19 in the context of a secondary pneumonia surveillance program targeted at low-risk patients and to identify clinical characteristics associated with COVID-19.
Study design: This study design is a retrospective cohort study.
Methods: This study is conducted in Tan Tock Seng Hospital, a University affiliated 1600-bed public hospital in Singapore. Patients with pneumonia admitted under our Enhanced Pneumonia Surveillance (EPS) program from 7 February 2020 to 20 March 2020 were included. Relevant clinical variables were collated.
Results: Of 1295 patients admitted under our EPS program, 47 (3.6%) patients tested positive for COVID-19. The prevalence of a radiologist-reported normal chest X-ray (CXR) in the COVID-19–positive group was 62.8% compared with 6.2% in the COVID-19–negative group. In patients with a normal CXR, a low normal white blood cell (WBC) count and minimal C-reactive protein (CRP) elevation were associated with COVID-19.
Conclusions: The pick-up rate of COVID-19 in low-risk patients with pneumonia is 3.6%. However, at least 7.9% of patients who were isolated had a normal CXR. For patients with pneumonia-like illness at presentation but a normal CXR, higher WBC and CRP values may guide early deisolation. Ultimately, this informs resource allocation for both COVID-19 and non–COVID-19 clinical services.

The first case of COVID-19 in Singapore was confirmed on 23 January 2020. Our initial national strategy focused on early detection and isolation of at-risk patients to reduce the risk of community transmission.[1] Our first tier response was the creation of an unequivocal, national COVID-19 suspect case definition based on travel history to high COVID-19 prevalence countries or contact with confirmed COVID-19 patients. This case definition is frequently revised by Singapore's Ministry of Health to reflect both global and local epidemiological linkages. This definition allows prompt identification of COVID-19 suspects by primary healthcare providers as all COVID-19 suspects are to be transferred to public hospitals expediently for isolation and management.

As an additional safety net, Singapore's Ministry of Health directed all public hospitals to establish a complementary pneumonia surveillance system to identify COVID-19 cases that may be missed by the prevalent suspect case definition. This could provide an early alert on any local community transmission. With these aims in mind, our institution started the Enhanced Pneumonia Surveillance (EPS) program which enrolled all patients presenting to the emergency department with pneumonia who do not meet the prevalent COVID-19 suspect case definition. This was intended as a complementary, second tier infection control measure to pick up additional cases of COVID-19 related pneumonia which might have been otherwise missed.

Our study's aims are (1) to determine the prevalence of COVID-19 detected by the EPS program and (2) to identify clinical

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Table 1
Comparison of clinical characteristics of all patients within our Enhanced Pneumonia Surveillance (EPS) program stratified by COVID-19 status.

Variables	COVID-19 cases	Non–COVID-19 cases	*P* value
	N = 47	N = 1248	
Relevant demographic variables			
Age (years)			
Median	50	75	<0.001
IQR	32–73	61–83	
Gender			
Male	24 (51.1%)	684 (54.8%)	0.656
Female	23 (48.9%)	564 (45.2%)	
Nationality			
Singaporeans	24 (51.1%)	1118 (89.6%)	<0.001
Non-Singaporeans	23 (48.9)	130 (10.4%)	
Relevant clinical outcomes			
Length of stay (days)			
Median	9	7	0.007
IQR	7–14	4–11	
Outcome			
Death	0 (0%)	93 (7.5%)	0.052
Relevant imaging			
Chest X-ray (at presentation)			
No. of patients	43	1210	<0.001
Normal CXR	27 (62.8%)	75 (6.2%)	
Abnormal CXR	16 (37.2%)	1135 (93.8%)	
Relevant microbiological investigations			
Influenza PCR (at presentation)			
No. of patients	5	876	
Positive	0 (0%)	7 (0.8%)	NA
Negative	5 (100%)	869 (99.2%)	
Relevant haematological investigations			
No. of patients with full blood count (FBC) performed at presentation	47	1243	
White blood cells (x 10^9/L)			
<4	15 (31.9%)	40 (3.2%)	<0.001
>10	0 (0%)	489 (39.3%)	<0.001
Median	4.6	8.8	<0.001
IQR	3.9–5.5	6.7–12.1	
Lymphocytes (x 10^9/L)			
Median	1.22	1.2	1.000
IQR	0.88–1.7	0.75–1.78	
Neutrophils (x 10^9/L)			
Median	2.66	6.36	<0.001
IQR	2.15–3.70	4.47–9.48	
Haemoglobin (g/dL)			
Median	14.4	11.9	<0.001
IQR	13.2–15.0	10.4–13.3	
Platelet (x 10^9/L)			
Median	208	237	0.040
IQR	162–257	184–306	
Relevant biochemistry investigations			
Creatinine (μmol/L)			
No. of patients with creatinine performed (at presentation)	45	1238	
Median	68	92	0.040
IQR	53–83	62–123	
Urea (mmol/L)			
No. of patients with urea performed	39	1219	
Median	3.4	6.2	<0.001
IQR	2.6–4.3	4.5–10.2	
Lactate dehydrogenase (LDH) (U/L)			
No. of patients with LDH performed (at presentation)	46	131	
Median	379	488.5	<0.001
IQR	325.5–448.8	410.3–609.8	
C-reactive protein (CRP) (mg/L)			
No. of patients with CRP performed (at presentation)	46	1142	
Median	4.7	26.6	<0.001
IQR	1.8–8.3	6.3–91.6	
Procalcitonin (procal) (μg/L)			
No. of patients with procal performed (at presentation)	9	845	
<0.25	9 (100%)	308 (36.4%)	<0.001
Median	0.08	0.15	0.225
IQR	0.043–0.13	0.08–0.46	

CXR, chest X-ray; PCR, polymerase chain reaction.

characteristics associated with COVID-19, to better direct healthcare resources for the prevention and control of COVID-19.

This is a retrospective cohort study performed at Tan Tock Seng Hospital, a University affiliated 1600-bed public hospital in Singapore. All patients admitted under the EPS program from 7 February 2020 to 20 March 2020 were included. This represented Singapore's initial wave of COVID-19 infections which were predominantly imported with subsequent early community transmission. The second wave of COVID-19 infections occurred primarily in the migrant worker population who lived in dormitories and who therefore had distinct demographic characteristics and risk factors.

All patients who presented to our Emergency Department were first assessed by emergency physicians. Based on their clinical assessment, coupled with other basic investigations such as a full blood count and a chest X-ray (CXR), all patients were initially dichotomised into 2 clinical categories: pneumonia versus non-pneumonia illness. The definition of pneumonia entailed radiological evidence of consolidation in patients with suggestive respiratory or systemic symptoms. However, emergency physicians had the liberty to exercise clinical discretion and incorporate other available clinical information such as lung crepitations to make a clinical diagnosis of pneumonia, typically when radiological consolidation is thought to be equivocal. CXRs were interpreted in real-time by emergency physicians but would be eventually reported by radiologists within an hour from end of image acquisition. Therefore, any discrepancy in CXR interpretation lied solely between emergency physicians and radiologists.

COVID-19 suspect cases would be admitted directly for negative pressure, air-borne isolation, regardless whether they had upper or lower (e.g. pneumonia) respiratory tract illnesses. Non–COVID-19 suspect cases who were diagnosed with pneumonia were automatically admitted under our EPS program i.e. entry into our EPS program was decided at the Emergency Department. COVID-19 swabs were not performed in the Emergency Department for these 2 groups of patients but would be performed subsequently by the ward nurses upon arrival in the isolation rooms.

Conversely, non–COVID-19 suspect cases who presented with upper respiratory tract symptoms (e.g. cough, rhinorrhoea) but without any evidence of pneumonia were not subjected to COVID-19 swabs. This helped to ensure right siting of resources at that point in time, as the disease burden in Singapore was low, testing capabilities were limited, and isolation rooms were finite.

Patients admitted under our EPS program were preferentially admitted to designated wards with single, isolation rooms. Healthcare workers used personal protective equipment on a per single use basis. All patients were screened for COVID-19 using upper respiratory tract specimen collected by trained nurses under standard hospital protocol, with a second specimen collected 24 h later.[2] All specimens were processed via in-house qualitative real-time reverse transcription polymerase chain reaction testing. Patients were deisolated when they were clinically well with at least 2 negative COVID-19 swabs.

This study was approved by the National Healthcare Group Domain Specific Review Board (reference number 2020/00319).

Out Of 1295 patients admitted under the EPS program, 47 (3.6%) patients tested positive for COVID-19. They were also more likely to have a white blood cell (WBC) count $<4 \times 10^9$/L, as well as a lower absolute neutrophil count and C-reactive protein (CRP) value. Although only 9 patients from the COVID-19–positive group had procalcitonin values checked, all of them were <0.25 μg/L, which did not reach threshold for antibiotic treatment.[3] The prevalence of a radiologist-reported normal CXR in the COVID-19–positive group was 62.8% compared with 6.3% in the COVID-19–negative group ($P < 0.001$) [Table 1].

We examined the 102 patients (7.9%) with a radiologist-reported normal CXR in the whole cohort, stratified into COVID-19 positive and negative, respectively, as they collectively represent a subpopulation which theoretically should not have been admitted under our EPS program as the inclusion criteria necessitated CXR findings consistent with pneumonia. Non–COVID-19 patients have a significantly higher median WBC count (8.7 vs. 4.6 $\times$ 10^9/L; $P < 0.001$) and higher median CRP value (16.2 vs. 3.4 mg/L; $P < 0.002$) compared with COVID-19 patients. No COVID-19 patient had a WBC count of $>10 \times 10^9$/L, compared with 27 of 75 (36.0%) non–COVID-19 patients.

Our hospital runs a parallel, 2-tiered strategy in terms of COVID-19 testing. In our EPS Program, a secondary surveillance system, the pick-up rate of COVID-19 was only 3.6%.

We were surprised by the number of patients with normal CXR admitted in our EPS program (102/1295 or 7.9%) even though the pedantic diagnosis of pneumonia requires the presence of lung parenchymal infiltrates on CXR.[4] There are a few possible reasons for this. First, poor concordance of interpretation on lung parenchymal infiltrates on CXR between emergency department physicians and radiologists is a well-known phenomenon.[5] Second, in patients presenting with acute respiratory symptoms, emergency physicians working under the constant stress of a pandemic[6] may convince themselves that pneumonia might be present based on soft radiological signs to go down a well-defined clinical pathway,[7] thereby minimizing risk of inadvertent COVID-19 transmission.

Our EPS experience reflects real-world practicalities, whereby triage decisions have to be made swiftly and isolation of suspected COVID-19 patients cannot be continued throughout the admission. A large number of patients would need to be screened and admitted in single isolation rooms in return for an overall COVID-19 pick-up rate of 3.6%. To free up limited bed resources, we propose that patients with normal CXR, WBC $>10 \times 10^9$/L, and elevated CRP values could be considered for earlier deisolation after a single negative COVID-19 swab in the absence of additional epidemiological risks.

Our EPS program is very resource intensive but it identified COVID-19 patients that would otherwise have been missed from prevailing COVID-19 suspect criteria. Our study also provides some laboratory guidance on which low-risk patients with normal CXR may be considered for early deisolation. As many countries are cautiously emerging from the COVID-19 pandemic, our findings may help hospital administrators balance resource allocation between COVID-19 and non–COVID-19 clinical services safely.[8]

Author statements

Ethical approval

This study was approved by the National Healthcare Group Domain Specific Review Board (reference number 2020/00319).

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Competing interests

None declared.

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