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Should COVID-19 symptoms be used to cohort patients in the emergency department? A retrospective analysis

Polly E. Bijur, PhD [a], Benjamin W. Friedman, MD [b,*], Sarah W. Baron, MD [c], Abhiram Ramasahayam, MS [b], Rebecca Nerenberg, MD [b], Shellyann Sharpe, MD [d], D. Yitzchak Goldstein, MD [b], David Esses, MD [b]

[a] Albert Einstein College of Medicine, Department of Emergency Medicine, Rose F. Kennedy Center, 1410 Pelham Parkway South, Bronx, NY 10461, USA
[b] Montefiore Medical Center, Department of Emergency Medicine, 111 East 210th Street, Bronx, NY 10467, USA
[c] Montefiore Medical Center, Department of Medicine, Division of Hospital Medicine, 111 East 210th Street, Bronx, NY 10467, USA
[d] Jacobi Medical Center, 1400 Pelham Parkway South, Bronx, NY 10461, USA

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ABSTRACT

Objective: To determine how cohorting patients based on presenting complaints affects risk of nosocomial infection in crowded Emergency Departments (EDs) under conditions of high and low prevalence of COVID-19.
Methods: This was a retrospective analysis of presenting complaints and PCR tests collected during the COVID-19 epidemic from 4 EDs from a large hospital system in Bronx County, NY, from May 1, 2020 to April 30, 2021. Sensitivity, specificity, positive and negative predictive value (PPV, NPV) were calculated for a symptom screen based on the CDC list of COVID-19 symptoms: fever/chills, shortness of breath/dyspnea, cough, muscle or body ache, fatigue, headache, loss of taste or smell, sore throat, nasal congestion/runny nose, nausea, vomiting, and diarrhea. PPV was calculated for varying values of prevalence.
Results: There were 80,078 visits with PCR tests. The sensitivity of the symptom screen was 64.7% (95% CI: 63.6, 65.8), specificity 65.4% (65.1, 65.8). PPV was 16.8% (16.5, 17.0) and NPV was 94.5% (94.4, 94.7) when the observed prevalence of COVID-19 in the ED over the year was 9.7%. The PPV of fever/chills, cough, body and muscle aches and nasal congestion/runny nose were each approximately 25% across the year, while diarrhea, nausea, vomiting and headache were less predictive, (PPV 4.7%–9.6%) The combinations of fever/chills, cough, muscle/body aches, and shortness of breath had PPVs of 40–50%. The PPV of the screen varied from 3.7% (3.6, 3.8) at 2% prevalence of COVID-19 to 44.3% (44.0, 44.7) at 30% prevalence.
Conclusion: The proportion of patients with a chief complaint of COVID-19 symptoms and confirmed COVID-19 infection was exceeded by the proportion without actual infection. This was true when prevalence in the ED was as high as 30%. Cohorting of patients based on the CDC's list of COVID-19 symptoms will expose many patients who do not have COVID-19 to risk of nosocomially acquired COVID-19. EDs should not use the CDC list of COVID-19 symptoms as the only strategy to minimize exposure.

1. Introduction

In March 2020, COVID-19 surged in New York City, presenting numerous challenges for Emergency Departments (EDs) [1]. Once the initial spike had passed, a continuing challenge has been how to minimize nosocomial spread of COVID-19 in crowded urban EDs given the limited physical space and resources to provide isolation. Although interventions such as masking can reduce the spread of COVID-19 [2], this intervention is often not practical among a population of ED patients with acute illness particularly those with respiratory symptoms. Similarly, crowded EDs with space constraints, may not be able to maintain an appropriate level of physical distance between patients [3]. Rapid antigen testing, while not perfect, can mitigate risk. However, rapid testing is not feasible in many EDs that lack the space and personnel for this strategy.

Cohorting patients is a basic component of infection control [4]. This strategy entails grouping patients with similar infectious disease characteristics and confining their care to a designated area separate from other patients. In an attempt to decrease nosocomial spread of COVID-19, we implemented a system of cohorting patients with presenting complaints defined by the CDC as symptoms of COVID-19 [5]. Patients

* Corresponding author at: Montefiore Medical Center, Department of Emergency Medicine, 111 East 210th Street, Bronx, NY, USA.
E-mail addresses: polly.bijur@einsteinmed.edu (P.E. Bijur), befriedm@montefiore.org (B.W. Friedman), sarbaron@montefiore.org (S.W. Baron), aramasahay@montefiore.org (A. Ramasahayam), rnerenbe@montefiore.org (R. Nerenberg), shellyann.sharpe@nychhc.org (S. Sharpe), dogoldst@montefiore.org (D.Y. Goldstein), desses@montefiore.org (D. Esses).

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who were positive on the symptom screen were bedded together. Thus, patients who are positive on the symptom screen but are ultimately found to be negative on PCR are at higher risk of nosocomial infection than if they are bedded with the general ED population.

Our goal was to determine how presenting complaints correspond to eventual diagnosis of COVID-19 in an effort to better understand how cohorting patients based on these complaints may affect risk of nosocomial infection in crowded EDs under conditions of high and low prevalence of COVID-19.

2. Methodology

2.1. Design

This is a retrospective analysis of data collected during the COVID-19 epidemic. We analyzed data from visits by patients 18 years of age or greater between May 1, 2020 and April 30, 2021. Because all data were de-identified, this study was granted an exemption by the Internal Review Board of the Albert Einstein College of Medicine.

2.2. Setting and patients

The data were collected from 4 hospital-based EDs of the Montefiore Medical System in Bronx County, NY. Together, these EDs have nearly 250,000 visits annually. The local population is mixed socio-demographically, with a large medically under-served and immigrant community. The US Census Bureau provides intercensal estimates of demographic characteristics of all US states and counties. In the period from 2010 to 2019, 45% of Bronx residents were estimated to be Black or African American, 45% white, 4% mixed race, 6% other. Of the white residents, 91% were estimated to be Latino or Hispanic. Thirty-five percent were foreign born and 26% met the criteria for living in poverty [6].

All visits during which patients 18 years and older received a polymerase chain reaction (PCR) test for COVID-19 were included in the analysis. All admitted patients were tested for COVID-19 via PCR assays. Testing of those not admitted was at the discretion of the treating providers.

2.3. Measures

COVID-19 status was determined using the Cepheid Xpert Xpress, Hologic Panther Fusion, Abbott Alinity m SARS-CoV-2 RT-PCR assays, or the Qiagen Qiastat Dx Respiratory SARS-CoV-2 RT-PCR panel. In case of conflicting test results, positive results were used rather than negative.

We developed a symptom screen based on the presenting complaints included in the CDC COVID-19 list of symptoms [5]: 1) fever or chills, 2) shortness of breath or dyspnea, 3) cough, 4) muscle or body aches, 5) fatigue, 6) headache, 7) loss of taste or smell, 8) sore throat, 9) nasal congestion or runny nose, 10) nausea or vomiting, and 11) diarrhea. If the visit record included one or more of these symptoms it was considered positive on the symptom screen. For comparison we also developed a more focused symptom screen based on fever or chills, cough, muscle or body aches, and nasal congestion.

The number of COVID-19 positive cases and number tested by month were accessed from publicly recorded data from Bronx County, NY [7].

2.4. Data collection

Presenting complaints were abstracted from the electronic medical record (EMR)(Epic, Verona, Wisconsin). The complaints are based on data recorded by the triage nurse. In our hospital system, triage nurses must have a registered nurse degree, a minimum of one year of general nursing experience and one additional year of ED experience. All triage nurses undergo triage training which consists of both classroom-based didactics and supervised practical training.

Multiple chief complaints are documented in the EMR. If the patient reported multiple complaints, each one was included as a separate variable. Multiple visits to the ED by the same patient were included as separate ED visits.

2.5. Data analysis

We calculated the sensitivity and specificity of the CDC-based symptom screen to detect the positive and negative PCR test results. The positive and negative predictive values (PPV and NPV) of the symptom screen were calculated at the observed prevalence of COVID-19 in the entire 12 months of the study.

As the PPV and NPV vary with prevalence of COVID-19 in the ED, we calculated them at 6 levels of prevalence of COVID-19 in the ED: 2%, 5%, 10%, 15%, 20% and 30% [8]. This calculation assumed the same sensitivity and specificity as in the observed data. The number of false positive and false negatives for each value of prevalence were also calculated.

The percent of patients positive and negative on the symptom screen who were COVID-19 positive and the percent of all ED visits in which patients were COVID-19 positive were plotted by month. In addition, the percent of rapid tests that were positive for COVID-19 in Bronx County, calculated from publicly available data [7], were plotted by month.

The unit of analysis was patient visit. We used SPSS version 27 (Armonk, NY) for all analyses.

3. Results

There were 80,078 visits by patients 18 years and older between May 1, 2020 and April 30, 2021 during which PCR tests were administered.

The sensitivity of the symptom screen was 64.7% (95%CI: 63.6, 65.8) and the specificity was 65.4% (95%CI: 65.1, 65.8). Of the 30,032 patients who screened positive, 5031 had positive PCR tests, 16.8% (95%CI: 16.5, 17.0), and 25,001, 83.2% (95% CI: 82.8, 83.7) were negative on the PCR test (Table 1). Thus, a large majority of patients with symptoms compatible with COVID-19 had negative PCR tests. The negative predictive value of the symptom screen was high, 94.5% (95%CI: 94.4, 94.7). This meant that 5.5% of patients who screened negative had positive PCR tests.

Table 2 shows that, as expected, the PPV increases as the prevalence increases and NPV decreases. The number of false positives, those exposed to COVID-19 if bedded with all who screen positive, is greatest when the prevalence of COVID-19 is lowest and decreases as prevalence increases although the number of false positives continue to be larger than the number of true positives, even at a prevalence of 30%.

The predictive values of each of the symptoms that make up the symptom screen vary (Table 3). Fever, cough, generalized body or muscle aches, and URI/nasal congestion were most strongly predictive of

Table 1
Test characteristics of the CDC-based symptom screen.

Symptom Screen	COVID-19 Positive	COVID-19 Negative	Total
Positive	5,031 (TP)	25,001 (FP)	30,032
Negative	2,744 (FN)	47,302 (TN)	50,046
Total	7,775	72,303	80,078

Test Characteristic	Statistic	(95% CI)
Sensitivity	64.7%	(63.6, 65.8)
Specificity	65.4%	(65.1, 65.8)
Prevalence	9.7%	(9.5, 9.9)
Positive Predictive value	16.8%	(16.5, 17.0)
Negative Predictive value	94.5%	(94.4, 94.7)
LR+	1.9	(1.8, 1.91)
LR-	0.5	(0.5, 0.6)

TP – true positive; FP – false positive; FN – false negative; TN – true negative.
LR+ — Positive likelihood ratio; LR- – Negative likelihood ratio; CI – confidence interval.

Table 2
Positive and negative predictive value of CDC-based symptom screen and number of false positives and false negatives by prevalence of COVID-19 in ED*.

Prevalence of COVID-19	Positive Predictive Value % (95% CI)	False Positives N	Negative Predictive Value % (95% CI)	False Negatives N
2%	3.7 (3.6, 3.8)	27,440	98.9 (98.9, 98.9)	560
5%	9.0 (8.8, 9.1)	26,600	97.2 (97.2, 97.3)	1,400
10%	17.2 (16.9, 17.5)	25,200	94.3 (94.2, 94.5)	2,800
20%	31.7 (31.4, 32.3)	22,400	88.1 (87.7, 88.4)	5,600
30%	44.3 (44.0, 44.7)	19,600	81.2 (81.0, 81.5)	8,400

N – total number of patients, CI – confidence interval.
* Assumptions: 80,000 patient visits, sensitivity = 65%, specificity = 65%.

COVID-19 when they were the only presenting symptom. The combinations of cough, fever, and generalized body or muscle aches had positive predictive values of nearly 50%. Shortness of breath/dyspnea as a single symptom had a low positive predictive value, 13.8% (95%CI: 13.1, 14.5). When combined with fever and other additional COVID-19 symptoms, its predictive value increased to 50.8% (95%CI: 45.2, 56.5).

Several of the symptoms in the screen had low PPVs, notably, nausea, vomiting, diarrhea, headache and sore throat. Including these symptoms in the symptom screen reduced the PPV of the screen, but increased its sensitivity. Use of the 4-item symptom screen that included generalized muscle aches, cough, fever/chills, and URI/nasal congestion, the PPV increased to 27.1% (95%CI: 26.4, 27.9). Substituting the 4-item screen for the CDC-based symptom screen reduced sensitivity from 64.7% to 34.5% (95%CI: 33.5, 35.6%) while the specificity rose from 65.4% to 90.0% (95% CI: 89.8, 90.2%).

The PPV of common presenting complaints that were not part of the CDC-based symptom screen varied substantially. (Table 4) The one PPV that was of the same magnitude as fever, cough and generalized muscle aches was visit to the ED for a COVID-19 test.

Fig. 1 shows the percent of visits in which patients who screened positive on the symptom scale and had COVID-19 plotted by month, as well as that percent for patients who screened negative and the percent of all ED visits in which a test was performed. The positivity rates of COVID-19, the number of tests that were COVID-19 positive divided by the number of tests performed in Bronx County, are also shown. When the positivity rate was low, in the summer of 2020, the percent with positive COVID-19 was similar in symptomatic and asymptomatic patients. In January and February 2021, when the positivity rates in the community were high, the percent of COVID-19 in all ED patients was high. The percent of patients who were symptomatic and not symptomatic on the symptom scale diverged substantially when the positivity rates in the community were high.

Table 4
Positive predictive value of selected complaints in asymptomatic patients.

	Positive Predictive Value		
	n/N	%	(95% CI)
ED visit for COVID-19 test	411/1853	22.2	(20.3, 24.2)
Syncope	106/1222	8.7	(7.1, 10.3)
Dizzy	126/2153	5.9	(4.9, 6.8)
Chest pain	349/6276	5.6	(5.0, 6.1)
Abdominal Pain	363/7694	4.7	(4.2, 5.2)
Altered mental status	112/1859	6.0	(4.9, 7.1)
Injury/specific musculoskeletal pain	306/7812	3.9	(3.5, 4.3)
Psychiatric complaints	45/1060	4.2	(3.0, 5.5)

n - number of patients with the symptom who were COVID-19 positive; N - total number of patients with the symptom; CI – confidence interval.

4. Limitations

We did not measure the incidence of nosocomial infections in patients who were positive on the symptom screen but did not have a positive PCR test in the ED. Over the year period of the study, there were 25,000 of these patients. In January and February, the months with the highest prevalence of COVID-19, approximately 500 patients would need to be contacted and tested each week to assess COVID-19 status. This was beyond our resources and likely to be beyond the resources of many EDs. Thus, we could only infer risk of nosocomial

Table 3
Positive predictive value of individual and multiple COVID-19 symptoms.

	Positive Predictive Value		
	n/N	%	(95% CI)
One COVID19 symptom			
Generalized Muscle Ache	223/923	24.2	(21.4, 26.9)
Cough	485/1928	25.2	(23.2, 27.1)
Fever or chills	554/2573	21.5	(19.9, 23.1)
URI or nasal congestion	65/266	24.4	(19.3, 29.6)
Fatigue	134/795	16.9	(14.2, 19.5)
Shortness of breath or dyspnea	1322/9570	13.8	(13.1, 14.5)
Headache	223/2312	9.6	(8.4, 10.8)
Sore throat	101/992	10.2	(8.3, 12.1)
Diarrhea	129/1404	9.2	(7.7, 10.7)
Nausea or vomiting	150/3169	4.7	(4.0, 5.5)
Two COVID-19 symptoms			
Cough + body or muscle ache	34/72	47.2	(35.7, 58.8)
Cough + fever	171/344	49.7	(44.4, 55.0)
Cough + Shortness of breath or dyspnea	196/963	20.4	(17.8, 22.9)
Fever + Shortness of breath or dyspnea	108/319	33.9	(28.7, 39.0)
Fever + body or muscle ache	60/146	41.1	(33.1, 49.1)
Body or muscle ache + Shortness of breath or dyspnea	34/111	30.6	(22.1, 39.2)
Three or more COVID-19 symptoms that include:			
Cough + shortness of breath or dyspnea	167/414	40.3	(35.6, 45.1)
Cough + body or muscle ache	113/222	50.9	(44.3, 57.5)
Cough + fever	218/416	52.4	(47.6, 57.2)
Fever + shortness of breath or dyspnea	152/299	50.8	(45.2, 56.5)
Fever + body or muscle ache	109/233	46.8	(40.4, 53.2)
Body or muscle ache + shortness of breath or dyspnea	63/150	42.0	(34.1, 49.9)

n - number of patients with the symptom who were COVID-19 positive; N - total number of patients with the symptom; CI – confidence interval.

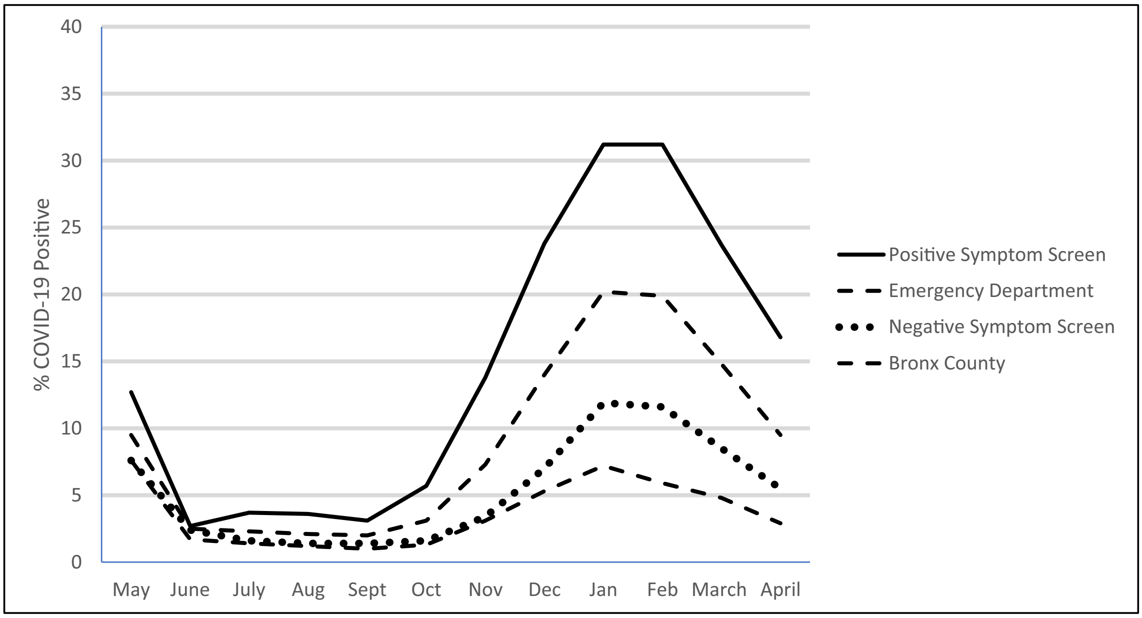

Fig. 1. Percent COVID-19 positive by month, May 1, 2020 to April 30, 2021 and Group: patients with positive symptom screens; patients with negative symptom screens; all patients in Emergency Department with COVID-19 PCR tests; persons who received Bronx County COVID-19 antigen tests.

infection from the proportion of patients who had symptoms of COVID-19 but negative PCR tests when bedded with those who had positive PCR tests, not actual acquisition.

All patients who presented to the ED did not receive PCR tests. The decision to request a PCR assay for patients, other than those being admitted, was left to the individual practitioner. It is likely that presence of symptoms would have prompted PCR testing. However almost two-thirds of these tests were ordered on patients without symptoms of COVID-19 identified by the CDC as can be seen in Table 1. Part of this is explained by our hospital policy requiring all admitted patients to have COVID-19 PCR assays prior to admission.

We did not have a sufficient number of patients who presented with a chief complaint of loss of taste or smell and so are unable to generate positive predictive values for these complaints.

The results of these analyses are most relevant to EDs that are crowded and lack resources in terms of space and personnel.

5. Discussion

In this retrospective analysis of data from an early COVID-19 epicenter, we found that the majority of patients with a chief complaint on the CDC list of COVID-19 symptoms did not have actual COVID-19 infection. This was true at times of high prevalence of COVID-19, but even more so when the community prevalence of COVID-19 was low. During the summer of 2020, when the local prevalence of COVID-19 was 2% or lower, the proportion of patients who had one or more COVID-19 symptoms but were ultimately negative on PCR testing was 97%. Even during January and February of 2021, a period of peak prevalence in our community, 70% of patients with one or more symptom on the CDC list, had negative PCR testing. Thus, cohorting patients based on the CDC symptom list would expose a large proportion of patients without COVID-19 to additional risk of nosocomial infection.

As can be seen in the figure, as the percent of patients in the ED and percent of all tests in the community that were COVID-19 positive increased, the risk of being exposed to patients with confirmed COVID-19 diverges in the symptomatic and asymptomatic groups. Without cohorting, in January and February 2021, the risk of being bedded near a positive patient was about 20%, the overall prevalence in the ED. With cohorting, that risk increased to about 30% for symptomatic patients and decreased to 10% for asymptomatic patients.

The positive predictive values of each symptom on the CDC list of symptoms varied substantially. Patients with fever/chills, cough, generalized muscle aches and URI/nasal congestion had the highest PPVs (between 21% and 25%). Patients with two or more concurrent symptoms, notably cough and fever/chills or muscle aches had a risk of COVID-19 that approached 50%. In contrast, the proportion of patients with nausea and vomiting who had positive COVID-19 tests was no higher than patients without any of the CDC symptoms, approximately 5%. These are high frequency symptoms that could easily overwhelm the ability to separate symptomatic from asymptomatic patients due to space limitations, without decreasing the risk of nosocomial spread. Thus, cohorting these patients is neither protective, nor easily achieved.

The PPV of presentation to the ED for COVID-19 testing by asymptomatic patients was similar to that of fever/chills, cough, muscle aches and URI/nasal congestion. This may be due to COVID-19 exposure particularly in households [9] or work environments [10] that prompted the visit to the ED for a COVID-19 test. If a symptom list is used to identify patients at higher than usual risk of COVID-19, inclusion of request for COVID-19 testing should be considered a high risk chief complaint.

Several groups have proposed distinguishing COVID-19 positive from negatives based on a combination of symptoms and other clinical parameters [1,11]. Bonadio et al. [1], used symptoms, oxygen saturation and a chest radiograph to identify patients with COVID-19. The inclusion of the radiograph is problematic in busy EDs due to the time required to obtain and interpret images. Kline et al. [11], developed a prediction score based on symptoms, demographic characteristics, and report of household contact with an infected person. A score of zero on this screen was associated with a sensitivity of 95% and specificity of 20%. This results in a high rate of false positives, a low PPV and an increased risk of nosocomial infection if all patients with this constellation of signs and symptoms are cohorted.

Ideally, all patients with symptoms highly predictive of COVID-19 would be isolated. Barring that, patients need to be masked and spatially separated. However, even this is not feasible in all EDs, many of which had significant space limitations and insufficient isolation rooms even before the pandemic. Further, acuity of illness is high enough that some patients cannot be masked effectively because of the need to provide supplemental oxygen, patient disorientation or discomfort. In patients with shortness of breath, covering the face with a mask may worsen symptoms by increasing the work of breathing. These conditions are indeed present in many high-volume EDs throughout the US.

Another consideration for decisions about where to place symptomatic patients is the differential risk of transmitting COVID-19 dependent on the specific symptom(s). Patients with secretions such as those coughing or sneezing are presumably more likely to transmit COVID-19 than other patients. Length of time since symptom onset also affects risk of transmission. SARS-CoV-2 titers in the upper respiratory tract peak in the first week of illness [12]. Also, anticipated throughput time should be considered, as risk of hospital acquired COVID-19 is likely to be associated with length of exposure.

A possible solution to the quandary of where to place patients in overcrowded EDs is rapid bedside testing for all patients who have any chief complaint on the CDC's list of COVID-19 symptoms. The sensitivity of antigen tests is estimated to be approximately 80% in symptomatic patients, with specificity of 98% [13]. For high-volume, under-resourced EDs using a positive CDC symptom screen as a criterion for testing would rapidly overwhelm rapid testing capacity. This strategy would be least effective for nausea and vomiting that are high frequency, low risk conditions. The best solution for an institution seeking to implement this strategy is to first ascertain its rapid testing capability and prioritize symptoms using evidence of the likelihood of disease given the symptom and the frequency of the symptom. Lower volume EDs with high capacity for testing might indeed be able to perform a rapid test on all patients with any of the symptoms on the CDC list. Higher volume EDs with less capacity for testing might only be able to perform a rapid test for patients who present with a combination of symptoms which, as mentioned above, increases the positivity rate to as high as 40 to 50%. This decreases the burden placed on staff while maintaining testing of the groups at highest risk of nosocomial infections. Patients who test positive can then be placed in an area that is separate from those who have symptoms consistent with COVID-19 but negative results while waiting for PCR testing and results.

Given the space limitations in EDs, what are other possible solutions? Many hospitals used tents during high volume phases of the pandemic. Tents can be used to treat lower acuity, Emergency Severity Index (ESI) level 4 and 5 patients presenting with COVID-like illnesses. Use of tents both reduces overcrowding in the ED and can result in decreased transmission of COVID-19 by keeping some of the higher risk, low acuity patients out of the department. It also may be a solution for those patients presenting specifically for a COVID-19 test. It is the middle and high acuity levels ESI 1, 2 and 3 patients who present a particular challenge. Due to their acuity, treatment in a tent or other nonconventional area may not be possible due to treatment and workup requirements, e.g., oxygen, cardiac monitoring, diagnostic x-rays and advanced imaging. In our department, it is in these areas where the most overcrowding and challenges occur.

Another strategy is to separate patients with highest risk of acquiring disease from those with lower risk. This would entail separating older patients and those with high-risk features, including immunosuppressed conditions, pulmonary co-morbidities, and obesity from patients with lower risk of acquiring disease, rather than cohorting patients with symptoms of COVID-19.

These strategies may be applied to other highly contagious airborne illnesses. On-going, timely assessment of the sensitivity and specificity and accompanying PPV and NPV of the current cohorting strategy is important to inform where to place patients to reduce the possibility of nosocomial infection among the general and cohorted populations.

In conclusion, cohorting patients based on the CDC's list of COVID-19 symptoms will expose many patients who do not have COVID-19 to risk of nosocomially acquired COVID-19. EDs should not use the CDC list of COVID-19 symptoms as the only strategy to minimize exposure.

Credit authorship contribution statement

Polly E. Bijur: Writing – review & editing, Writing – original draft, Visualization, Formal analysis, Conceptualization. **Benjamin W. Friedman:** Writing – review & editing, Writing – original draft. **Sarah W. Baron:** Writing – review & editing, Conceptualization. **Abhiram Ramasahayam:** Formal analysis. **Rebecca Nerenberg:** Writing – review & editing. **Shellyann Sharpe:** Writing – review & editing. **D. Yitzchak Goldstein:** Writing – review & editing, Methodology. **David Esses:** Writing – review & editing, Writing – original draft, Conceptualization.

Declaration of Competing Interest

There are no competing interests.

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References

[1] Bonadio W, Jackson K, Gottlieb L, Legome E. Utility of an emergency department clinical protocol for early identification of coronavirus infection. West J Emerg Med. 2021;22:587–91. https://doi.org/10.5811/westjem.2020.12.49470.

[2] Chu DK, Akl EA, Duda S, Solo K, Yaacoub S, Schünemann HJ, et al. Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis. Lancet. 2020;395:1973–87. https://doi.org/10.1016/S0140-6736(20)31142-9.

[3] Hoot NR, Aronsky DJ. Systematic review of emergency department crowding: causes, effects, and solutions. Ann Emerg Med. 2008;52:126–36. https://doi.org/10.1016/j.annemergmed.2008.03.014.

[4] Centers for Disease Control. Guideline for isolation precautions: Preventing transmission of infectious agents in healthcare settings. https://www.cdc.gov/infectioncontrol/guidelines/isolation/prevention.html; 2007. [accessed 11 November 2021].

[5] Centers for Disease Control. Symptoms of COVID-19. https://www.cdc.gov/coronavirus/2019-ncov/symptoms-testing/symptoms.html; 2021. [accessed 1 November 2021].

[6] US Census Bureau. Quickfacts: Bronx County, New York, United States. https://www.census.gov/quickfacts/fact/table/bronxcountynewyork/PST045219; 2019. [accessed 4 October 2021].

[7] New York State Statewide COVID-19 Testing. https://health.data.ny.gov/Health/New-York-State-Statewide-COVID-19-Testing/xdss-u53e; 2021. [accessed 1 December 2021].

[8] Altman DG, Bland JM. Statistics notes: diagnostic tests 2: predictive values. BMJ. 1994;309:102. https://doi.org/10.1136/bmj.309.6947.102.

[9] Lewis NM, Chu VT, Ye D, Conners EE, Gharpure R, Laws RL, et al. Household transmission of severe acute respiratory syndrome coronavirus-2 in the United States. Clin Infect Dis. 2021;73:1805–13. https://doi.org/10.1093/cid/ciaa1166.

[10] Michaels D, Wagner GR. Occupational safety and health administration (OSHA) and worker safety during the COVID-19 pandemic. Jama. 2020;324:1389–90. https://doi.org/10.1001/jama.2020.16343.

[11] Kline JA, Camargo CA, Courtney DM, Kabrhel C, Nordenholz KE, Aufderheide T, et al. Clinical prediction rule for SARS-CoV-2 infection from 116 US emergency departments 2-22-2021. PLoS One. 2021;16:e0248438. https://doi.org/10.1371/journal.pone.0248438.

[12] Cevik M, Tate M, Lloyd O, Maraolo AE, Schafers J, Ho AJ. SARS-CoV-2, SARS-CoV, and MERS-CoV viral load dynamics, duration of viral shedding, and infectiousness: a systematic review and meta-analysis. Lancet Microbe. 2020;2. https://doi.org/10.1016/S2666-5247(20)30172-5. E286–7.

[13] Pray IW, Ford L, Cole D. Performance of an antigen-based test for asymptomatic and symptomatic SARS-CoV-2 testing at two university campuses—Wisconsin, September–October 2020. MMWR Morb Mortal Wkly Rep. 2021;69:1642–7. https://doi.org/10.15585/mmwr.mm695152a3.