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ORIGINAL RESEARCH

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Effectiveness, safety, and efficiency of a drive-through care model as a response to the COVID-19 testing demand in the United States

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Abstract

Objectives: Here we report the clinical performance of COVID-19 curbside screening with triage to a drive-through care pathway versus main emergency department (ED) care for ambulatory COVID-19 testing during a pandemic. Patients were evaluated from cars to prevent the demand for testing from spreading COVID-19 within the hospital.

Methods: We examined the effectiveness of curbside screening to identify patients who would be tested during evaluation, patient flow from screening to care team evaluation and testing, and safety of drive-through care as 7-day ED revisits and 14-day hospital admissions. We also compared main ED efficiency versus drive-through care using ED length of stay (EDLOS). Standardized mean differences (SMD) >0.20 identify statistical significance.

Results: Of 5931 ED patients seen, 2788 (47.0%) were walk-in patients. Of these patients, 1111 (39.8%) screened positive for potential COVID symptoms, of whom 708 (63.7%) were triaged to drive-through care (with 96.3% tested), and 403 (36.3%) triaged to the main ED (with 90.5% tested). The 1677 (60.2%) patients who screened negative were seen in the main ED, with 440 (26.2%) tested. Curbside screening sensitivity and specificity for predicting who ultimately received testing were 70.3% and 94.5%. Compared to the main ED, drive-through patients had fewer 7-day ED revisits (3.8% vs 12.5%, SMD = 0.321), fewer 14-day hospital readmissions (4.5% vs 15.6%, SMD = 0.37), and shorter EDLOS (0.56 vs 5.12 hours, SMD = 1.48).

Conclusion: Curbside screening had high sensitivity, permitting early respiratory isolation precautions for most patients tested. Low ED revisit, hospital readmissions, and

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EDLOS suggest drive-through care, with appropriate screening, is safe and efficient for future respiratory illness pandemics.

1 | INTRODUCTION

1.1 | Background

Our emergency department (ED) was the first site in Northern California's San Francisco Bay Area to have hospital-based testing available at the start of the COVID-19 pandemic.[1–3] As a result, concerned and symptomatic patients self-triaged to our ED to determine whether they were infected. Given the high contagion of COVID-19,[4,5] and in anticipation of high-volume patient arrival,[6,7] we planned a drive-through care pathway to limit transmission within the ED and hospital facility. It was accompanied by curbside screening to triage patients to drive-through versus main ED care.

1.2 | Importance

Although prior investigation had explored the mechanics of the physical layout of a drive-through testing model,[6] the real-world patient safety and operational efficacy of a screening and testing protocol were yet to be measured. We did not know before launching our care pathway and our subsequent study whether patients could safely be evaluated in this model to prevent repeat visits and hospitalizations, or whether we could effectively screen for those low-acuity patients who would be appropriate for the drive-through care pathway.

1.3 | Goals of investigation

In this investigation, we share our experience launching this intervention in the early phases of the pandemic and quality-related outcomes.[8]

2 | METHODS

2.1 | Care setting and study period

Drive-through care occurred between March 13, 2020 and April 7, 2020 from 12 p.m.–8 p.m. as an extension of our 4300-square-foot, hospital-based, multi-unit care ED. Our 6 negative-pressure ED rooms were inadequate for the anticipated volume. ED and hospital leadership identified an area within a nearby garage that was converted into a care unit. Details of the care model's development and early launch have been previously published.[8,9]

2.2 | Screening for case reporting and diagnoses

The Centers for Disease Control and Prevention (CDC) made a novel COVID-19 restriction site polymerase chain reaction (RS-PCR) test available through state public health laboratories. The results turnaround from the CDC was 7 days, requiring isolation and continued use of personal protective equipment (PPE) for prolonged periods.[10] As a result, quarantine outside of the hospital was a minimum of 7 days. On March 3, 2020, we overcame this challenge when our pathology lab started performing COVID-19 testing that produced results within 24 hours.[3]

2.3 | Intervention: Drive-through care pathway

2.3.1 | Screening and preservation of personal protective equipment

Curbside screeners were placed outside of the ED in full PPE that consisted of a gown, N95 mask, gloves, and disposable goggles.[8] Ambulatory ED patients, including those arriving in private vehicles, public transportation, or on foot to the ED were directed to the curbside screeners as the first point of contact. The screening staff asked each arriving patient if they were experiencing fever, cough, sore throat, or shortness of breath. Screening vital signs were obtained including heart rate and oxygen saturation.

2.3.2 | Inclusion/exclusion triage criteria

Drive-through care's inclusion and exclusion criteria triaged the arriving ambulatory patients into 3 care streams before they entered the ED. First, those who screened negative for a potential viral illness were directed to routine main ED entry and excluded from drive-through care. Second, those who screened positive for a potential viral illness, but who were younger than 2 years or older than 64 years, or who had cardiovascular or pulmonary comorbidities or an abnormal vital sign (heart rate <50 or >110 bpm, or oxygen saturation $<92\%$) were masked and directed to enter the ED for care. These patients were excluded from drive-through care. The third group of patients aged 2–64 years screened positive for COVID-19 concerning presentations without cardiovascular or pulmonary comorbidities and had normal screened vital signs. They were directed to the drive-through care area that was in the parking garage adjacent to the ED entrance.

The Bottom Line

For patients with suspected viral syndromes during the COVID-19 pandemic, a drive-through care pathway had 70.3% sensitivity for predicting the need for COVID testing. This pathway had a shorter emergency department length of stay compared to main ED care (34 minutes vs 5 hours). Hospital readmission rates were 4.5%, less than one third of the rate associated with main ED care.

2.3.3 | Flow of drive-through care delivery

Once a patient arrived in the drive-through care area, a nurse photographed their identification card, which was transmitted to the ED registration staff via a secure mobile phone and messaging application, Voalte (Hillrom).[11] This enabled staff to identify the patient, generate an electronic health record encounter for the visit, and remotely print identifying wristbands to the drive-through care area for a nurse to apply to the patient.

Within the garage, we maintained separate care streams for in-car and on-foot/dropped-off patients. Patients were seen by a nurse in full PPE who validated reasons for the ED visit; repeated screening for fever, cough, or shortness of breath; and obtained triage vital signs (temperature, heart rate, and respiratory rate). Oxygen saturation with a waveform was added if the patient reported a cough or shortness of breath. This information was documented in a triage note. All clinical documentation processes mirrored that of main ED care.

Physicians evaluated patients through their car windows. Physical exams were limited to focused complaints. The outcome of the physician encounter was to either discharge without testing, discharge home with testing, or retriage for a full evaluation in the ED. During this time, we did not test asymptomatic patients. For those tested, an order was placed, and the nasopharyngeal swab was obtained by a second PPE-protected nurse. We preprinted standardized discharge instructions, with test results available via an online portal, with a nurse call for positive results.[12]

2.3.4 | Transition to virtual physician evaluation

After 3 days, we noted that 2-layered screening before physician evaluation effectively restricted the drive-through patients to a low-acuity population. Physicians reported physical examinations beyond visual inspection and vital signs were not informing care or testing decision-making.[7] Consequently, in-person physician evaluation was replaced with telemedicine on March 16, 2020.

After curbside screening and nurse triage, a cart-based video conferencing device with a camera (Cisco DX80 with Jabber communication software) was wheeled to the car window. Patients who were not in a private vehicle sat in a chair next to a cart. Via a video interaction, the physician completed a history and determined if testing or retriage to the main ED was needed. We created a templated note that included prefilled text and drop-down options to ensure documentation of the encounter both (1) met the minimum requirements of a medical screening exam, and (2) supported adequate documentation for an evaluation and management for a level 3-code (99213).[13] This physician role was preferentially, but not exclusively, offered to physicians within our group who had comorbidities that put them at high risk for poor outcomes if infected with COVID-19. Specific criteria included pregnancy, immunocompromised, or age >60 years. These no-risk patient encounters were considered a form of virtual PPE.

2.3.5 | Drive-through de-implementation

We anticipated the drive-through care would be a temporary intervention to address capacity and infection control needs until evaluation and testing could be decentralized away from the hospital. We planned to de-implement the garage-based drive-through care once the daily patient volume for this care area dropped below 10 patients/day for 7 days, which occurred on April 7, 2020.

2.4 | Patient demographic and visit characteristics

Characteristics observed for each visit included age, sex, race, ethnicity, insurance, preferred language, triage acuity based on the 5-point triage nurse-assigned Emergency Severity Index (ESI; 1 is high acuity; 5 is low),[14] and presenting chief complaint.

2.5 | Outcomes

Outcomes included ED length of stay (EDLOS), ED revisit within 7 days, and hospital admissions within 14 and 30 days. Subsequent hospital admissions after the index ED visit included those occurring via the ED, direct admission, or transfer; we also examined mortality. Care location cohorts for these outcomes were based on the discharging location for the index visit because some patients, initially triaged to drive-through care, were retriaged to main ED care. For patients who revisited the ED or returned for hospital admission, we examined presenting complaints and admission diagnoses, respectively. In a post hoc analysis, we estimated comparative PPE use between a drive-through and main ED care by estimating the number of full PPE gown changes per patient encounter based on in-ED versus drive-through care COVID-19 isolation protocols.

2.6 | Data analysis

We tracked and compared drive-through versus main ED care patients who screened positive for potential COVID infection, as well as those who screened negative. We measured the effectiveness of curbside screening using diagnostic test characteristics: sensitivity, specificity, positive predictive value, negative predictive value, and total population tested. We quantified counts and frequencies for demographic and visit characteristics, COVID-testing, and positive test results. Standard mean differences (SMDs) were used to assess the differences between groups. We did not use *P* values both to avoid multiple testing and because this is an observational, descriptive study. The SMDs for continuous and binary variables were calculated as effect sizes.[15,16] For categorical variables with 3 or more groups, they were calculated as the square root of the Mahalanobis distance.[17] To interpret the SMDs, we took values 0.2 as small, 0.5 as a medium, and 0.8 as large differences between groups per Cohen guidance for comparing meaningful differences.[18,19] We extracted clinical data from our health system's clinical data warehouse, which we structured for analysis in R (version 4.0.2) and RStudio (Version 1.3.1056). Final statistical analyses were performed in IBM SPSS (version 26.0). Microsoft Excel and PowerPoint (MSOffice 365) were used to create tables and figures.

3 | RESULTS

During the 25-day period of drive-through care, 5932 patients were seen in the ED. Of these, 2788 (47%) were ambulatory patients, all of whom were screened. This 47% is a marked reduction from 2019 when 3493 ambulatory patients were seen during the same period accounting for 75% of visits. Additional comparisons to prepandemic patient volume and the distribution of ambulatory versus ambulance patients are in Table 1. Of ambulatory patients seen during the 25-day period, 1111 (39.8%) screened positive for "COVID-19 concerning presentation" (Figure 1). We triaged 708 (63.7%) to drive-through care, where 96.3% were tested. The remaining 403 (36.3%) patients with COVID concerning presentations went to the main ED directly because they did not meet the low-acuity criteria of curbside screening. A subset (417, 90.5%) of the total patients sent to the ED (461, which includes the 58 patients retriaged from the garage) were tested for COVID-19 after evaluation. Of the 1677 (60.2%) patients who screened negative, 440 (26.2%) were tested (Figure 1).

3.1 | Patient demographics

Drive-through patients were younger compared to main ED patients, with a median age of 40 years versus 49 years (SMD = 0.56). Triage acuity findings supported our early program observations that these patients were low acuity. All had scores of ESI-4 and ESI-5, except four ESI-2 patients who were advised to enter the ED for a more complete evaluation but declined (Table 1). We found small differences between a drive-through and main ED patients by gender or racial groups (Table 1), but notably, fewer drive-through patients were Black (2.8% vs 6.4% main ED) or identified as Hispanic compared to those in the main ED (16.5% vs 25.4%). Differences in insurance status were large across the two populations (SMD = 0.89), as more drive-through patients had private insurance (63.7% vs 45.1%, SMD = 0.38), and fewer had Medicare or Medicaid. The higher proportion of "other" forms of insurance among drive-through care versus main ED patients (16.2% vs 3.4%), and the marked increase over the prior year among all ambulatory patients (6.6% vs 2.6%), was largely attributed to worker's compensation-related visits for exposure testing. Worker's compensation accounted for 81.6% (99/117) and 61.4% (43/70) of "other" insurance types in the drive-through and main ED care, respectively. A total of 8.3% of drive-through patients had Spanish or another non-English language as their preferred language. This is lower than in the main ED (14.6%) but higher than the 4.6% observed among all ambulatory patients (Table 1).

3.2 | Reasons for presentation

When we examined the primary reasons for presentation, drive-through care patients' top chief complaints were cough (31.6%), sore throat (16.5%), request for COVID test (15.4%), fever (9.7%), upper respiratory infection (7.5%), and shortness of breath (7.2%). Among those seen in the main ED, top chief complaints included shortness of breath (14.4%), cough (8.7%), abdominal pain (8.0%), chest pain (7.8%), fever (7.0%), and nausea/vomiting (3.7%). The frequency hierarchy is different from the top chief complaints observed in the ED prepandemic, which included abdominal pain (11.0%), chest pain (6.5%), shortness of breath (5.8%), fall (3.6%), back pain (2.7%), and fever (2.7%) (Table 2).

3.3 | Outcomes: Effectiveness, safety, and efficiency

Curbside screening sensitivity and specificity for patients the care team tested upon evaluation were 70.3% (95% confidence interval [CI]: 67.9%–72.6%) and 94.8% (95% CI: 93.4%–95.9%), respectively. The care team tested 1043 of the 1111 ambulatory ED patients identified as having COVID-19 concerning presentations, yielding a positive predictive value of 93.9% (95% CI: 92.3%–95.2%). The care team did not test the 1237 (of 1677) patients who screened negative and entered the main ED for care, which produced a negative predictive value of 73.8% (95% CI: 71.6%–75.8%) (Table 3).

Comparing the drive-through care pathway's safety to main ED care for all ambulatory patients, we observed fewer patients returned for an ED revisit within 7 days (3.8% vs 12.5%, SMD = 0.32), and fewer were admitted to the hospital within 14 (4.5% vs 15.6%, SMD = 0.38) or 30 days (5.5% vs 21.7%, SMD = 0.48) (Table 4). Reasons for ED revisits and hospital readmissions are included in Tables 5 and 6, respectively. We observed lower mortality within 14 days among drive-through care patients (0.2% vs 5.5%, SMD = 0.33). The single mortality within drive-through care represents a hospice patient who was retriaged and advised to enter the ED, but refused preferring to only be tested and remain at home to pass with family if COVID negative (Table 3).

When evaluating the drive-through care pathway's efficiency, we found patients had notably shorter mean ED length of stay (EDLOS) of 0.56 hours compared to the overall EDLOS during this period (4.28 hours, SMD = 1.48), all main ED patients (5.12 hours, SMD = 1.48), main ED patients with COVID-19 concerning presentations upon curbside screening (4.82 hours, SMD = 1.98), low-acuity patients seen in the main ED during the drive-through period

TABLE 1 Characteristics of ambulatory patient visits in the main ED and drive-through care compared to all patients and prior year patients

	March 13–April 7, 2019		COVID Drive Through Period: March 13-April 7, 2020			
	All ED patients	All ambulatory patients	All ambulatory patients	Main ED	Drive-Through	SMD
Visits	4658	3493	2788	2080	70	
Age						**0.556**
Mean (SD)	50.42 (21.13)	48.15 (20.13)	46.55 (17.58)	48.84 (18.05)	39.84 (14.10)	
Median (IQR)			43.92 [31.82, 59.12]	47.05 [33.55, 62.39]	37.16 [29.50, 49.82]	
Gender						**0.058**
Male	2081 (44.7)	1529 (43.8)	1338 (48.0)	983 (47.3)	355 (50.1)	
Female	2577 (55.3)	1964 (56.2)	1450 (52)	1097 (52.7)	353 (49.9)	
Race (%)						**0.189**
White	1964 (42.2)	1354 (38.8)	1158 (41.5)	864 (41.5)	294 (41.5)	
Other/unknown/multiple	1551 (33.3)	1272 (36.4)	928 (33.3)	683 (32.8)	245 (34.6)	
Asian	688 (14.8)	534 (15.3)	465 (16.7)	335 (16.1)	130 (18.4)	
Black	328 (7.0)	235 (6.7)	153 (5.5)	133 (6.4)	20 (2.8)	
Pacific Islander, Native American/Hawaiian/Alaskan Native	127 (2.7)	98 (2.8)	84 (3.0)	65 (3.1)	19 (2.7)	
Ethnicity						**0.231**
Non-Hispanic	3424 (73.5)	2459 (70.4)	2111 (75.6)	1533 (73.6)	578 (81.5)	
Hispanic	1170 (25.1)	992 (28.4)	646 (23.2)	529 (25.4)	117 (6.5)	
Other	64 (1.4)	42 (1.2)	34 (1.2)	20 (1.0)	14 (2.0)	
Insurance						**0.89**
Private	1713 (36.8)	1308 (37.4)	1389 (49.8)	938 (45.1)	451 (63.7)	
Medicaid	1241 (26.6)	1045 (29.9)	587 (21.1)	522 (25.1)	65 (9.2)	
Medicare	1420 (30.5)	927 (26.5)	504 (18.1)	475 (22.8)	29 (4.1)	
Other	120 (2.6)	91 (2.6)	185 (6.6)	70 (3.4)	115 (16.2)	
Self-pay	164 (3.5)	122 (3.5)	123 (4.4)	75 (3.6)	48 (6.8)	
Emergency Severity Index (ESI) score						**2.574**
1	34 (0.7)	2 (0.1)	4 (0.1)	4 (0.2)	0 (0.0)	
2	598 (12.8)	374 (10.7)	348 (12.5)	344 (16.5)	4 (0.6)	
3	2968 (63.7)	2469 (70.7)	1431 (51.3)	1395 (67.1)	36 (5.1)	
4	597 (12.8)	546 (15.6)	813 (29.2)	255 (12.3)	558 (78.8)	
5	76 (1.6)	71 (2.0)	71 (2.5)	44 (2.1)	27 (3.8)	
None	385 (8.3)	31 (0.9)	121 (4.3)	38 (1.8)	83 (11.7)	
Language (%)						**0.258**
English	3864 (83.0)	2840 (81.3)	2425 (87.0)	1777 (85.4)	648 (91.5)	
Spanish	528 (11.3)	465 (13.3)	232 (8.3)	189 (9.1)	43 (6.1)	
Other	266 (5.5)	188 (5.3)	131 (4.6)	114 (5.0)	17 (2.2)	
Vital signs						
Oxygen saturation (mean (SD))			98.21 (1.76)	98.04 (1.83)	98.71 (1.39)	**0.414**
% below 93% oxygen saturation			18 (0.6)	17 (0.8)	1 (0.1)	0.098
Systolic blood pressure (mean (SD))			127.10 (18.24)	127.06 (18.31)	127.83 (16.75)	0.044
% above 160			84 (3.0)	81 (3.9)	3 (0.4)	0.241
% below 90			8 (0.3)	8 (0.4)	0 (0.0)	0.088

(Continues)

TABLE 1 (Continued)

	March 13–April 7, 2019		COVID Drive Through Period: March 13-April 7, 2020			
	All ED patients	All ambulatory patients	All ambulatory patients	Main ED	Drive-Through	SMD
Diastolic blood pressure (mean (SD))			77.52 (12.56)	77.50 (12.59)	77.72 (12.07)	0.018
% above 100			61 (2.2)	59 (2.8)	2 (0.3)	0.207
Heart rate (mean (SD))			79.18 (14.09)	78.81 (13.97)	80.28 (14.40)	0.103
% above 110			56 (2.0)	35 (1.7)	21 (3.0)	0.085
% below 50			12 (0.4)	11 (0.5)	1 (0.1)	0.067
Temperature (mean (SD))			98.25 (0.68)	98.19 (0.67)	98.43 (0.68)	**0.347**
% above > 100			34 (1.2)	23 (1.1)	11 (1.6)	0.039

Abbreviations: ED, emergency department; IQR, interquartile range; SD, standard deviation; SMD, standardized mean difference.

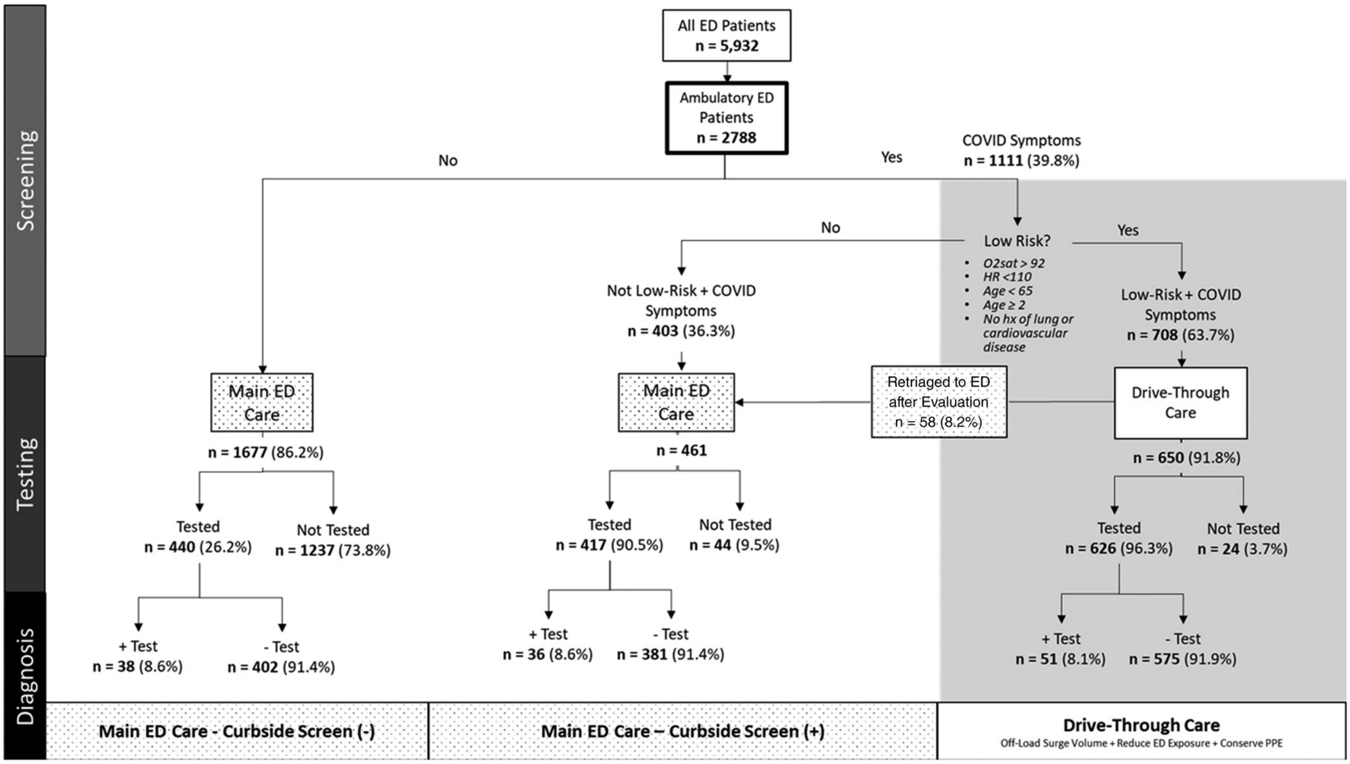

FIGURE 1 ED patient flow diagram—curbside screening to COVID-19 testing to test result during the drive-through care period: March 9–April 7, 2020. Abbreviations: ambulatory, patients arriving via private, public, or other non-ambulance transport; curbside screen, querying entering patients for symptoms of cough, fever, or shortness of breath and examining for low-risk vital sign criteria; ED, emergency department; low-risk, oxygen saturation (O2 sat) > 92%, heart rate (HR) < 110, age (< 65 years or ≥2), no history of lung or cardiovascular disease; PPE, personal protective equipment; test = COVID-19 polymerase chain reaction test.

(2.48 hours, SMD = 0.998), and low-acuity patients seen during the same dates the year before (2.92 hours, SMD = 1.09).

3.4 | COVID testing results

Curbside screening stratified ambulatory patients into threegroups. The proportion of patients tested within each group varied but was aligned with differing pretest probability for COVID-19. Only 26.2% of main ED patients who screened negative were tested, yet 90.5% of main ED patients and 93.3% of drive-through patients who screened positive were tested. However, we observed similar percentages of positive tests within the main ED patients who screened negative (8.6%), main ED care patients who screened positive (8.6%), and the drive-through care patients (8.1%), suggesting evaluating physicians made similar clinical decisions on whom to test (Figure 1).

TABLE 2 Top chief complaint for ambulatory patient visit: Main ED versus drive-through care compared to all patients and prior year

Chief complaints	March 13–April 7, 2019		COVID drive-through period: March 13–April 2020		
	All ED patients n = 4658	All ambulatory patients n = 3493	All ambulatory patients n = 2788	Main ED n = 2080	Drive-through n = 708
1	Abdominal pain (511, 11.0%)	Abdominal pain (450, 12.9%)	Cough (540, 14.5%)	Shortness of breath (400, 14.4%)	Cough (299, 31.6%)
2	Chest pain (304, 6.5%)	Chest pain (247, 7.1%)	Shortness of nreath (468, 12.6%)	Cough (241, 8.7%)	Sore throat (156, 16.5%)
3	Shortness of breath (271, 5.8%	Shortness of breath (196, 5.6%)	Fever (288, 7.7%)	Abdominal pain (222, 8.0%)	Lab test only (145, 15.4%)
4	Fall (170, 3.6%)	Fever (108, 3.1%)	Sore throat (236, 6.3%)	Chest pain (216, 7.8%)	Fever (92, 9.7%)
5	Back pain (126, 2.7%)	Back pain (106, 3.0%)	Chest pain (231, 6.2%)	Fever (196, 7.0%)	Upper respiratory infection (71, 7.5%)
6	Fever (126, 2.7%)	Headache (101, 2.9%)	Abdominal pain (222, 6.0%)	Nausea/vomiting (104, 3.7%)	Shortness of breath (68, 7.2%)
7	Cough (118, 2.5%)	Cough (88, 2.5%)	Lab test only (171, 4.6%)	Sore throat (80, 2.9%)	Headache (18, 1.9%)
8	Headache (116, 2.5%)	Nausea/vomiting (88, 2.5)	Nausea/vomiting (108, 2.9%)	Weakness (61, 2.2%)	Chest pain (15, 1.6%)
9	Nausea/vomiting (110, 2.4%)	Psychiatric complaint (74, 2.1%)	Upper respiratory infection (85, 2.3%)	Back pain (59, 2.1%)	Myalgias (14, 1.5%)
10	Weakness (105, 2.3%)	Abnormal lab (70, 2.0%)	Headache (77, 2.1%)	Headache (59, 2.1%)	General evaluation (12, 1.3%)
11	Dizziness (98, 2.1%)	Dizziness (70, 2.0%)	Weakness (71, 2.1%)	Abnormal lab (42, 1.5%)	Chills (10, 1.1%)
12	Psychiatric complaint (98, 2.1%)	Weakness (65, 1.9%)	Back pain (59, 1.6%)	Diarrhea (38, 1.4%)	Weakness (10, 1.1%)
13	Altered mental status (84, 1.8%)	Fall (62, 1.8%)	Abnormal lab (43, 1.2%)	Lab test only (35, 1.3%)	Nasal pain (9, 1.0%)
14	Abnormal lab (77, 1.7%)	Flank pain (48, 1.4%)	Diarrhea (41, 1.1%)	Dizziness (33, 1.2%)	Dizziness (5, 0.53%)
15	Motor vehicle crash (74, 1.6%)	Sore throat (48, 1.4%)	Dizziness (38, 1.0%)	Psychiatric complaint (33, 1.2%)	Nausea/vomiting (4, 0.42%)
	51.3%	**52.2%**	**72.0%**	**65.5%**	**98.4%**

Abbreviation: ED, emergency department.

TABLE 3 Accuracy of drive-through care for classifying patients at persons under investigation after evaluation

		Tested for COVID-19 after ED evaluation			
		Tested	Not tested		
Curbside COVID concerning presentation screen	Yes	1043	68	1111	**Positive predictive value = 93.9%**
	No	440	1237	1677	**Negative predictive value = 73.8%**
		1483	1305	2788	
	Sensitivity = 1043/1483 = **70.3%** (95% CI: 68.0-73.0%)			**Miss rate** = 1-sensitivity = **29.7%**	
	Specificity = 1237/1305 = **94.8%** (95% CI: 92.5-95.3%)				

Abbreviations: CI, confidence interval; ED, emergency department.

TABLE 4 Emergency department ambulatory patient outcomes during the COVID drive through care pathway period: ED revisits, hospital re-admissions, and mortality

	Overall	Main ED[a]	Drive-through[a]	SMD
(n)	2788	2138 (76.7%)	650 (23.3%)	-
ED revisits in 7 days (n,%)[b]	293 (10.5%)	263 (12.5%)	25 (3.8%)	0.321
Hospital readmissions in 14 days (n,%)	362 (13.0%)	333 (15.6%)	29 (4.5%)	0.377
Hospital admissions in 30 days (n,%)	499 (17.9%)	463 (21.7%)	36 (5.5%)	0.484
Mortality in 14 days (n,%)	118 (4.2%)	117 (5.5%)	1 (0.2%)	0.326

Abbreviations: ED, emergency department; SMD, standardized mean difference.
[a]Based on patient's discharge location (considering that 58 drive-through care patients moved to the main ED).
[b]Included planned and unplanned revisits.

TABLE 5 Reasons for ED-revisits within 7 days: Presenting chief complaints

All ED patients				Main ED patients				Drive-through care ED patients			
	Chief complaint	#	%		Chief complaint	#	%		Chief complaint	#	%
1	Abdominal pain	29	15%	1	Abdominal pain	29	16%	1	Chest pain	3	20%
2	Breathing problem/SOB	20	10%	2	Breathing problem/SOB	17	9%	2	Breathing problem/SOB	2	13%
3	Chest pain	15	8%	3	Chest pain	12	7%	3	Fever	2	13%
4	Fever	12	6%	4	Fever	10	6%	4	Cough	1	7%
5	Cough	10	5%	5	Cough	9	5%	5	Dehydration	1	7%
6	Nausea/emesis/vomiting	7	4%	6	Nausea/emesis/vomiting	7	4%	6	Dizziness	1	7%
7	Back pain	6	3%	7	Back pain	6	3%	7	Flank pain	1	7%
8	Melena	6	3%	8	Melena	6	3%	8	Headache	1	7%
9	Sore throat/throat pain	6	3%	9	Abnormal lab	5	3%	9	Nasal congestion	1	7%
10	Abnormal lab	5	3%	10	Sore throat/throat pain	5	3%	10	Other	1	7%
11	Flank pain	4	2%	11	Vascular access problem	4	2%	11	Sore throat/throat pain	1	7%
12	Vascular access problem	4	2%	12	Flank pain	3	2%			15	100%
13	Headache	3	2%	13	Multiple complaints	3	2%				
14	Multiple complaints	3	2%	14	Rash	3	2%				
15	Rash	3	2%	15	Aphagia	2	1%				
		133	68%			121	67%				

Abbreviations: ED, emergency department; SOB, shortness of breath.

4 | LIMITATIONS

Several limitations of our study should be considered when interpreting our results: Drive-through care did not include ambulance arrivals, given the general need for these patients to enter the ED through a direct handoff from the paramedic team to the ED care staff. As a result, precautions for ambulance arrivals were based on paramedic team report after completing an evaluation in transit to the ED. We observed 1 death in the low-acuity drive-through population, in a patient for whom death was expected. However, mortality data, particularly among drive-through patients who often traveled for testing and were without follow-up in our health system, were limited.

5 | DISCUSSION

The drive-through care pathway provided a safety net public health service for COVID-19 testing until other options were available. In nearly 4 weeks, 708 patients (25% of the ED ambulatory population) were shunted away from the main ED to this lower contact and more efficient care pathway. Although these patients were of low acuity, they had a higher pretest probability for COVID-19 infection. Although investing in a launch of this type for a low-acuity ED population is not generally lucrative or sustainable, our health system found the cost and coordination of equipment, electricity, wi-fi installation, and staff in the alternative care area to be far less than the management of ED and in-hospital patients contracting COVID iatrogenically. Saving

TABLE 6 Reasons for hospital admissions within 14 days: Admitting diagnoses

Main ED patients				Drive-through care ED patients			
	Chief complaint	#	%		Chief complaint	#	%
1	Cough	11	5%	1	Cough	4	31%
2	Shortness of breath	11	5%	2	Shortness of breath	2	15%
3	Abdominal pain, generalized	8	4%	3	Abdominal pain	1	8%
4	Other malaise and fatigue	7	3%	4	Acute pharyngitis	1	8%
5	Hemorrhage of gastrointestinal tract	5	2%	5	Acute upper respiratory infections	1	8%
6	Gastroparesis	4	2%	6	Aneurysm of unspecified site	1	8%
7	Alcoholic cirrhosis of liver	3	1%	7	Chest pain, unspecified	1	8%
8	Atrial fibrillation	3	1%	8	Enlargement of lymph nodes	1	8%
9	Bacteremia	3	1%	9	Other chest pain	1	8%
10	Calculus of kidney	3	1%			13	100%
11	Other general symptoms	3	1%				
12	Other specified viral infection	3	1%				
13	Preoperative examination	3	1%				
14	Abdominal pain, other specified site	2	1%				
15	Abdominal pain, epigastric	2	1%				
		71	35%				

Abbreviation: ED, emergency department

the prolonged hospital LOS and health care worker sick days that could result from accelerated spread in the ED compounded the cost benefits.

5.1 | Curbside screening effectiveness

Curbside screening offered those with COVID-19 concerning presentations the opportunity to be seen via a lower contact care pathway or enter the ED with COVID respiratory isolation precautions applied before entry.[14,20,21] Here we advance prior work by reporting on the screening performance: we observed a sensitivity of 70.3%, meaning of those tested were correctly identified before entry, which consequently empowered us to apply COVID-19 precautions and PPE before contact with physician and non-physician healthcare workers,or the ED indoor spaces. A specificity of 94.5% and negative predictive value of 73.8% reflect our screening's ability to capture the majority of patients the care team found to be at risk and tested after evaluation.

This sensitivity is high but not perfect; we had a miss rate of 28.7% (444/1677), reflecting those who screened negative but were tested upon evaluation when more information was elicited. Nevertheless, the presence of curbside screening led to the patients who entered the ED after screening negative having a lower pretest probability for COVID-19. This was evidenced by only 2.3% (38/1677) of those who screened negative having a positive test, compared with 7.8% of those who screened positive (Figure 1).

5.2 | Drive-through care safety and efficiency

Concern for safety was allayed when we observed fewer ED revisits and readmissions, as well as effective triage of a low-acuity patient subgroup to garage care. This was reflected in a single death, in a patient who was under hospice care and declined to enter the main ED. In addition, only 8.2% (58/708) of patients triaged to drive-through care were retriaged to the main ED for evaluation.

In a prior study, patients diagnosed with COVID-19 and discharged from the EDs in a multihospital system were found to have a 4% ED revisit rate, only slightly higher than the 3.8% observed in our COVID-tested population. Our admissions at 14 and 30 days after drive-through care (4.5% and 5.5%, respectively) are far lower than the overall ambulatory population (17.9%) or those seen only in the main ED (21.7%) for this time. Finally, drive-through encounters were more efficient, with an 8.6-fold shorter EDLOS than main ED patients as well as ambulatory patients seen in the prior year.

5.3 | Managing infection risk and PPE usage

During the study period, 53.2% (1483/2788) of all the ambulatory patients were tested. Curbside screening and drive-through care permitted us to stratify arriving patients into groups of varying COVID-19 risk. In addition to high screening sensitivity that allowed us to apply PPE and/or other COVID-19 precautions before contact on over 70.3% of those tested,[14,20,21] specificity of 94.5% and negative predictive value of 73.8% reflect curbside screening's ability to capture the majority of those tested.

We further reduced infection risk to ED staff by leveraging telemedicine. This enabled physicians with comorbidities to continue to practice despite pregnancy,[22,23] older age,[24] or immunocompromised conditions.[25] Besides facilitating efforts for at-risk staff to still care for ED patients, this switch eliminated the need for physicians to use physical PPE during patient evaluation. [26–28]

Finally, we further minimized PPE use because each member of the drive-through staff needed only 2 sets of PPE per shift. This was compared to main ED care, where 5 sets of PPE were used per patient with suspected COVID symptoms. Drive-through PPE use was similar to a prior study where 1 set of PPE was used for a team of 6 providers on a 6-h/day shift to see approximately 164 patients.[28] In a post hoc analysis, we estimated that drive-through care shifts had a 1:6 reduction in PPE cost per shift.

5.4 | Extensions and refinements of curbside ambulatory patient screening

With assurances of safety and efficiency, we relaunched drive-through care during 2 subsequent pandemic case incidence peaks that similarly increased testing demand: July 27–August 20, 2020, and November 23–January 19, 2021. Symptom criteria for curbside screening during these times were modified using what we learned from the top presenting chief complaints from the initial launch (Table 2).

We replicated the pathway's flow to accommodate demand during the COVID-19 omicron variant-associated surge in early 2022. At that time, 67% of the state[29] and 87% of the county[30] population were fully vaccinated, symptoms from the omicron variant were found to be milder,[31] and we observed more asymptomatic positive tests with surveillance.[32] Offices and most schools were open and strongly encouraging negative COVID test results before return. This spiked evaluation and testing demand. On December 31, 2021, the ED evaluated 437 low-acuity patients with COVID-19 concerning presentations, nearly twice the daily patient volume during the pandemic. We employed an Emergency Medical Treatment and Labor Act waiver[32,33] to move all low-acuity presentations concerning for COVID to a semi-indoor well-ventilated space adjacent to the ED entrance for nurse-only visits, which allowed better management of workforce constraints, such as physician and triage nurse staffing. With these modifications, we saw 1976 patients in the first week of 2022. This is approximately 282 patients per day, which exceeded ED patient volume of the preceding week.

6 | CONCLUSION

Drive-through care, with curbside screening, is an effective, safe, and efficient care delivery option for future respiratory illness pandemics. Curbside screening reliably triaged a low-acuity population to drive-through care and created an opportunity to apply early respiratory isolation precautions before ED entry. Drive-through care increased capacity to manage testing demand, reduced iatrogenic transmission, and preserved PPE. Drive-through patients' EDLOS was lower than other low-acuity patients, suggesting more efficient care delivery. Low ED-revisit and hospital readmission rates support a safe match between lower acuity patient need and lower acuity care delivery.

AUTHOR CONTRIBUTIONS

Shashank Ravi drafted the description of the drive-through model. Sam Shen, Karen Stuart, and Patrice Callagy co-led the team that developed the rationale and structure of the drive-through care model and contributed to the study design. Maame Yaa Yiadom drafted the outline for the manuscript; participated in the procurement of data, the study design, and analysis; and provided scientific oversight. Ian Brown led the procurement of data and participated in the study design and interpretation of results. Stefanie Sebok-Syer assisted with the study design and analysis interpretation and drafted parts of the manuscript. Anna Graber and Vandana Sundaram contributed to the study analysis plan and data analysis. All clinical operations authors created and implemented the model and reviewed, participated in substantial edits, and approved the final draft of the manuscript.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest to disclose.

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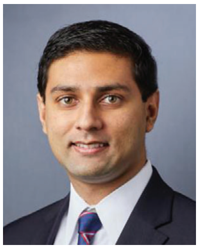

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