

Responding to COVID-19 Through Interhospital Resource Coordination: A Mixed-Methods Evaluation

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Objectives: The COVID-19 pandemic stressed hospital operations, requiring rapid innovations to address rise in demand and specialized COVID-19 services while maintaining access to hospital-based care and facilitating expertise. We aimed to describe a novel hospital system approach to managing the COVID-19 pandemic, including multihospital coordination capability and transfer of COVID-19 patients to a single, dedicated hospital.

Methods: We included patients who tested positive for SARS-CoV-2 by polymerase chain reaction admitted to a 12-hospital network including a dedicated COVID-19 hospital. Our primary outcome was adherence to local guidelines, including admission risk stratification, anticoagulation, and dexamethasone treatment assessed by differences-in-differences analysis after guideline dissemination. We evaluated outcomes and health care worker satisfaction. Finally, we assessed barriers to safe transfer including transfer across different electronic health record systems.

Results: During the study, the system admitted a total of 1209 patients. Of these, 56.3% underwent transfer, supported by a physician-led System Operations Center. Patients who were transferred were older ($P = 0.001$) and had similar risk-adjusted mortality rates. Guideline adherence after dissemination was higher among patients who underwent transfer: admission risk stratification ($P < 0.001$), anticoagulation ($P < 0.001$), and dexamethasone administration ($P = 0.003$). Transfer across electronic health record systems was a perceived barrier to safety and reduced quality. Providers positively viewed our transfer approach.

Conclusions: With standardized communication, interhospital transfers can be a safe and effective method of cohorting COVID-19 patients, are well received by health care providers, and have the potential to improve care quality.

Key Words: COVID-19, interhospital transfer, care quality

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Widespread community transmission and the associated rise in hospitalizations related to COVID-19 have strained hospital and health systems in several unique ways.^{1–4} First, it has

forced hospitals, which usually operate at high capacity, to adapt to unexpected demand in hospital and intensive care unit (ICU) beds. Second, all movements of COVID-19 patients in health care systems—even locally within a hospital for imaging and other studies or interventions—require meticulous vigilance and management of potential transmission risks and efficient utilization of personal protective equipment. Finally, as a novel, incompletely understood illness, the structure of care delivery requires significant adaptability, which permits near real-time implementation of ongoing, rapid updates in clinical practice.

Health care delivery systems have taken multiple steps to improve care delivery under duress of exponential spread of COVID-19. For example, the rapid expansion of telemedicine and other remote care delivery approaches permitted the delivery of high-quality patient care while minimizing health care worker and patient exposure.^{5,6} Geographical cohorting has been recommended to minimize nosocomial transmission and rapidly develop internal expertise.^{7,8} Finally, international approaches included “pop-up” dedicated COVID-19 hospitals expanding capacity and separating patients with general medical illness from those with COVID-19.^{9,10}

Ideally, geographic cohorting involves treating inpatients with COVID-19 in a physically separate location or hospital.¹¹ Cohorting allows using dedicated personnel and space to manage common medical conditions that warrant hospital care while limiting nosocomial transmission to other inpatients who may be at high risk.¹² Moreover, broadly communicating that approach has the added benefit of ensuring patients who need hospitalization for other medical reasons feel safe to seek care and be hospitalized.^{13–15}

Such a systematic approach to COVID-19 in the United States has been largely hampered by the miscellany of responses and needed capabilities. First, variations in-state public health responses relative to population density and timing have resulted in widely different growth curves and hospital demand.^{16–19} Second, highly fragmented delivery systems for hospital-based care and testing availability lead to challenges in resource coordination and patient

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allocation.²⁰ Finally, lack of interoperability between electronic health record (EHR) systems and the need to have a regional or broader view of hospital beds, staff, and other resources further limit the ability to coordinate patient care outside the bounds of individual health care systems.^{21–25}

Identification of patients with severe COVID-19 occurs most often during an inpatient hospitalization, especially because testing turnaround time often means patients are hospitalized for a period of time before diagnosis. Thus, the strategy of cohorting positive patients at a separate location requires interhospital transfers, which carry additional risk. Risks include treatment delays, miscommunication, and diagnostic error.^{26–28} In addition, these risks propagate when transfers occur across different EHR systems.²⁶ Standard best practices for managing transfers have not been established, and hospital practices vary widely.²⁷

Taken together, creating a separate hospital dedicated to COVID-19 has many potential benefits. However, this approach must overcome the obstacles of fragmented EHR systems, coordinating patient movement across hospitals while accounting for dynamic changes in each hospital capacity, and managing communication at the front lines. This study describes our integrated academic hospital system early experience in developing and managing a dedicated coordinated COVID-19 hospital. We tested the hypothesis that with standardized communication via a dedicated triaging physician, the interhospital transfer can be a safe and effective mechanism to cohort COVID-19 patients and potentially improve the quality of care.

METHODS

Setting

This study describes the coordination of a 12-hospital health system in the upper Midwest that includes multiple community hospitals and a single large academic tertiary referral center. Hospitals and clinics currently use 2 different instances of the same EHR system because of a recent merger. In preparation for COVID-19, a 108-bed long-term acute care hospital (LTACH) was retrofitted to become a fully functioning COVID-19 hospital. Before COVID-19, the LTACH housed up to 50 patients including up to 18 chronically vented patients with a full range of ICU capabilities. The existing patients were transferred to 1 of 3 locations, and an additional 35 beds were refitted to be fully ICU capable. Inpatient, critical care, and subspecialty services with adequate nursing ratios and support staff were recruited from the LTACH staff and within the system.²⁹ Staffing occurred fully with an opt-in basis by staff throughout the system. Patients were only transferred with consent and using the transport service that was part of the health system.

Patients

Patients were older than 18 years, had a positive SARS-CoV-2 polymerase chain reaction test result from a nasopharyngeal swab within 21 days of a hospital admission, or tested positive during the index hospitalization. Patients without full admission (i.e., observation hospital stays) were excluded from analysis. Admissions between March 22, 2020, and September 14, 2020, were included in the study.

Transfer Management

Patient transfers were coordinated through a centralized Systems Operations Center that maintains real-time hospital capacity information and coordinates patient flow throughout the health system. Transfer communication was facilitated by a dedicated triage physician, housed at the Systems Operations Center. The triage

physician was responsible for coordinating system-wide general internal medicine transfers, regardless of COVID-19 status. Beyond facilitation of transfers, the triage physician was responsible for ensuring transfer documentation was complete, communication was free of errors, and the appropriate safety approaches such as isolation and pretransfer medical management were in place. The primary focus of the triage physician was medical patients; however, they would also assist in multidisciplinary management of subspecialty cases and potential ICU transfers. The triage physician was supported by patient access specialists who provided up-to-date bed availability, arranged transport, and facilitated nurse-to-nurse hand-off. Transfers of COVID-19 patients to the cohorting hospital occurred only after patients tested positive by nasopharyngeal or oropharyngeal reverse transcription polymerase chain reaction for COVID-19, were stable for transport, and were anticipated to require at least 48 hours of hospital care. Patients who were pregnant or required highly specialized or complex subspecialty care (e.g., inpatient psychiatric, bone marrow transplant patient, solid-organ transplant patients), who were not stable for transport, or who would likely require extracorporeal membrane oxygenation were not recommended to undergo transfer. The triage physician had the benefit of real-time capacity information including available beds, ICU beds, ventilators, and pending admissions provided by Qventus (Qventus Inc, Los Altos, CA).

Measures

Our primary exposure was whether or not the patient underwent an interhospital transfer to the dedicated COVID-19 hospital. We compared age, demographics, chronic comorbidities, hospital and ICU utilization, readmissions, and outcomes. Comorbidities were extracted from International *Classification of Diseases, Tenth Revision* codes in the year before admission relying on Elixhauser.³⁰ We then performed a prespecified subpopulation analysis to determine whether the lack of EHR interoperability impacted transfer patterns, hospital utilization, or outcomes. We additionally present cumulated volume of admissions, transfers, and discharge against statewide data. For risk stratification, we relied on the 4C score.³¹

In addition, we explored reasons patients were not transferred. Initial categories were developed through a manual chart review of 40 randomly selected charts and then codified using objective measures: admissions before opening of dedicated COVID-19 hospital, short length of stay (<3 days), high acuity (intubated before transfer), and other (refused transfer consent, delayed COVID-19 diagnosis, uncertain).

Finally, we surveyed the providers involved in caring for COVID-19 patients. An anonymous electronic survey was conducted by e-mail of all clinicians involved in the triage and care of COVID-19 patients across the system. Questions focused on domains of patient safety, efficiency of care, and provider satisfaction based on a 5-point modified Likert scale.

Outcomes

The primary outcome was quality of care delivery. We defined this as adherence to an institutional COVID-19 protocol that was available to all providers caring for COVID-19 patients or patients under investigation for COVID-19. Because of rapidly changing updates, particularly early in the course, we focused on 3 broad categories of recommendations. (1) Risk stratification via laboratory results within the first 48 hours of diagnosis: we included D-dimer, C-reactive protein (CRP), and lymphocyte count. (2) Anticoagulation: we dichotomized patients by receiving any or no anticoagulation, as guidelines were specific regarding the importance of prophylaxis at a minimum, and higher dosing for high-risk patients was considered investigational during part of the study. In

general, however, a more aggressive approach to anticoagulation in COVID-19 patients was encouraged compared with our standard medical practice. (3) Corticosteroids for severely ill patients and patients requiring oxygen supplementation: secondary measures included length of stay, ICU days, ventilator days, and unadjusted and adjusted all-cause mortality.

Statistics

We display continuous variables as median and interquartile range for skewed variables; otherwise, mean and SD are presented. Binary or categorical variables are shown as a count and percentage. An ordinal variable was generated related to survey responses as measured by Likert scale, with 0 being strongly disagree and 4 being strongly agree. Mean and SD for each group (patient versus provider and nursing staff) are displayed, with responses greater than 2 indicating more positive and less than 2 indicating more negative. Between-group comparisons were performed by *t* test, Mann-Whitney test, or χ^2 test as indicated. We used differences-in-differences (DiD) analysis to determine whether transfer to a dedicated hospital was associated with higher adherence rates. In this case, the “shock” was the system-wide recommendations of best practices. Transfers to the dedicated hospital were compared before and after the initial distribution of guidelines: risk stratification (May 2020), anticoagulation (May 2020), and steroids (July 2020). Adjusted all-cause mortality was assessed by multivariate logistic regression model including whether the patient underwent transfer and components of the 4C score (race, sex, vitals, laboratory results including blood urea nitrogen [BUN] and comorbidity sum). Similar results were achieved when adjusting for the calculated 4C score alone. We performed a sensitivity analysis excluding all patients who were discharged in less than 3 days to ensure our results were not confounded by patients only admitted a short period of time, where discharge planning likely coincided with diagnosis. All statistical analyses were performed using STATA version 16 (StataCorp, College Station, Texas).

RESULTS

During the study period, the system admitted a total of 1209 COVID-19–positive patients. Of these, 680 (56.3%) underwent transfer to a dedicated COVID-19 hospital (Table 1). On average, patients who underwent transfer were older (mean, 64.2 versus 54.8 years; $P = 0.001$) and more likely to be white (48.4% versus 39.2%, $P = 0.002$). Sex and English-speaking rates were similar between groups. Transferred patients had higher rates of chronic comorbidities including chronic obstructive pulmonary disease (30.4% versus 21.6%, $P = 0.01$), hypertension (72.5% versus 53.2%, $P < 0.001$), congestive heart failure (26.5% versus 18.8%, $P < 0.001$), diabetes (44.0% versus 31.4% $P < 0.001$), and higher total Elixhauser comorbidity sum (6 versus 4, $P < 0.001$). They were also less likely to have a body mass index (BMI) $< 30 \text{ kg/m}^2$ (51.0% versus 60.2%, $P = 0.001$), had a higher probability of a CRP > 100 (58.7% versus 24.2%, $P < 0.001$), and were more likely to have a respiratory rate (RR) greater than 30 (52.1% versus 31.1%, $P < 0.001$). Overall 4C Mortality Score was higher among patients who were transferred than in those who were not (12 versus 7, $P < 0.001$).

Of patients who were discharged, patients who underwent interhospital transfer had longer length of stay, higher ICU utilization (32.3% versus 12.5%, $P < 0.001$), and higher rates of mechanical ventilation (23.2% versus 9.2%, $P < 0.001$). Unadjusted inpatient mortality and 30-day all-cause mortality were higher among transferred patients (13.2% versus 6.6%, $P = 0.003$; Table 2). When excluding patients who were admitted for less than 3 days, mortality rates were similar between patients who were and were not transferred

(17.8% versus 18.9%, $P = 0.450$). When adjusting for age, sex, number of comorbidities, RR, SpO₂, CRP, and BUN, inpatient and all-cause mortality rates were similar between those who were transferred and those who were not (Table 2).

We then evaluated why patients were not transferred among the subset of 528 patients who were discharged without being transferred. A small number of patients (2.7%) were admitted with COVID-19 before opening of the dedicated hospital, 45.9% of patients were admitted for less than 3 days, and 37.5% of patients were too unstable for transfer. Other categories (18.0%) included patient refusing consent for transfer, COVID-19 diagnosis made close to discharge, or transfer not initiated by the provider. Age, race, sex, and comorbidities were similar across all groups (Supplemental Table 1, <http://links.lww.com/JPS/A416>).

We evaluated the quality of COVID-19–specific care administered during the patient’s hospital stay. We compared rates adherence to health system guidelines along the domains of risk stratification via CRP, D-dimer, and lymphocyte count, administration of anticoagulation, and dexamethasone administration (Fig. 1). Patients who were transferred experienced higher adherence rates

TABLE 1. Patient Demographics, Comorbidities, and Outcomes Stratified by Whether They Underwent Interhospital Transfer

	Other Hospitals	Dedicated Hospital	<i>P</i>
n	528	680	
Age, mean (SD), y	54.8 (39.6)	64.2 (23.9)	0.001
Male, n (%)			
White, n (%)	208 (39.4)	329 (48.4)	0.002
Black, n (%)	135 (25.6)	98 (14.4)	<0.001
Asian, n (%)	65 (12.3)	113 (16.6)	0.036
Hispanic, n (%)	54 (10.2)	66 (9.7)	0.764
Other, n (%)	66 (12.5)	75 (10.9)	0.384
Non-English speaking, n (%)	193 (36.6)	237 (34.8)	0.54
COPD, n (%)	114 (21.6)	207 (30.4)	0.001
Hypertension, n (%)	281 (53.2)	493 (72.5)	<0.001
CHF, n (%)	99 (18.8)	179 (26.3)	0.002
Diabetes, n (%)	166 (31.4)	299 (44.0)	<0.001
CKD, n (%)	111 (21.0)	236 (34.7)	<0.001
Elixhauser comorbidity sum, median (IQR)	4 (6)	7 (6)	<0.001
4C score, median (IQR)	7 (8)	12 (5)	<0.001
BMI $< 30 \text{ kg/m}^2$, n (%)	318 (60.2)	347 (51.0)	0.001
BMI $30\text{--}40 \text{ kg/m}^2$, n (%)	148 (28.0)	233 (34.3)	0.021
BMI $40\text{--}50 \text{ kg/m}^2$, n (%)	45 (8.5)	94 (13.8)	0.004
CRP < 50 , n (%)	103 (19.5)	131 (19.3)	0.916
CRP $50\text{--}99$, n (%)	47 (8.9)	125 (18.4)	<0.001
CRP > 100 , n (%)	68 (12.9)	259 (38.1)	<0.001
CRP missing, n (%)	310 (58.7)	165 (24.2)	<0.001
D-Dimer < 5 , n (%)	217 (41.0)	311 (58.9)	<0.001
D-dimer > 5 , n (%)	23 (4.4)	43 (6.3)	0.136
D_Dimer_Missing, n (%)	288 (54.5)	146 (21.5)	<0.001
RR < 20 , n (%)	110 (20.8)	29 (4.3)	<0.001
RR $20\text{--}30$, n (%)	249 (47.2)	286 (42.1)	0.07
RR > 30 , n (%)	164 (31.1)	354 (52.1)	<0.001
SpO ₂ $> 92\%$, n (%)	273 (51.7)	146 (21.5)	<0.001
SpO ₂ $< 92\%$, n (%)	244 (46.2)	524 (77.0)	<0.001

TABLE 2. Hospital Utilization, Treatment, and Outcomes of Patients Who Underwent Interhospital Transfer to a Dedicated COVID-19 Hospital

	Other Hospitals	Dedicated Hospital	P
n	528	680	
LOS <3 d, n (%)	288 (54.5)	47 (6.9)	<0.001
LOS 3–7 d, n (%)	132 (25.0)	211 (32.0)	<0.001
LOS 7–14 d, n (%)	66 (12.5)	204 (30.0)	<0.001
LOS > 14 d, n (%)	43 (8.0)	218 (32.1)	<0.001
General medical floor, n (%)	413 (78.2)	310 (45.6)	<0.001
ICU without intubation, n (%)	66 (12.5)	213 (32.3)	<0.001
Mechanical ventilation, n (%)	49 (9.2)	157 (23.1)	<0.001
ICU days, n (%)*	1.8 (8.13)	6.9 (11.8)	<0.001
Ventilator days, n (%)†	7.5 (12.0)	12 (16.6)	<0.001
Remdesivir, n (%)	57 (10.8)	292 (43.0)	<0.001
Glucocorticoid, n (%)	30 (5.6)	245 (36.0)	<0.001
Any anticoagulation, n (%)	296 (56.1)	638 (93.8)	<0.001
Prophylactic anticoagulation, n (%)	93 (17.6)	271 (39.8)	<0.001
Above prophylactic anticoagulation, n (%)	203 (38.4)	367 (53.9)	<0.001
Inpatient mortality, n (%)	35 (6.6)	90 (13.2)	<0.001
30-d all-cause mortality, n (%)	37 (7.0)	95 (14.0)	<0.001
30-d readmission, n (%)	29 (5.5)	37 (5.4)	0.969
Adjusted 30-d all-cause mortality, n (%)‡	1.0 (Reference)	0.77 (0.48–1.22)	0.265

*Of patients admitted to the ICU.

†Of patients who were mechanically ventilated.

‡Adjusted for age, sex, number of comorbidities, RR, SpO₂, CRP, and BUN.

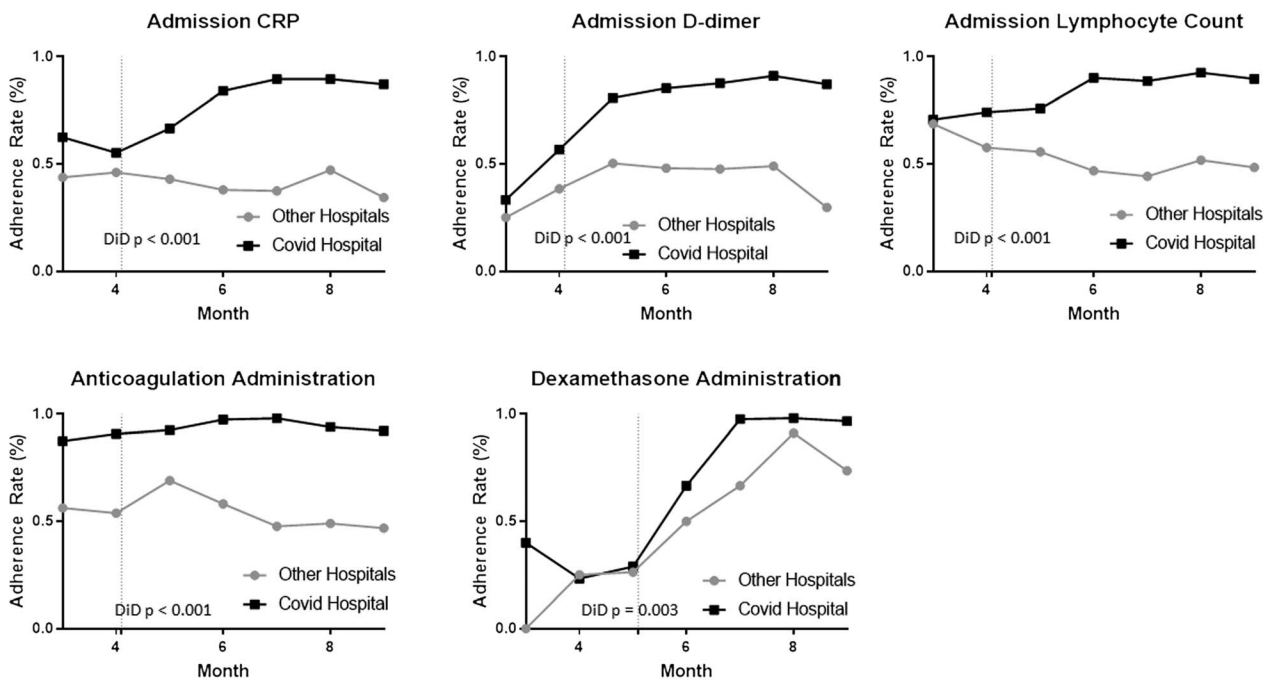


FIGURE 1. Trends in guideline adherence rates showed patients transferred to a dedicated hospital observed higher adherence rates to risk stratification (CRP, D-dimer, lymphocyte count), anticoagulation administration within 48 hours of diagnosis, and corticosteroid administration.

following guideline release: risk stratification (DiD, $P < 0.001$), anticoagulation (DiD, $P < 0.001$), and corticosteroids (DiD, $P = 0.002$). Findings were robust to excluding patients who were discharged within 3 days of admission (Supplemental Fig. 1, <http://links.lww.com/JPS/A416>).

Of patients who were transferred to a dedicated COVID-19 hospital, 43.7% were transferred from a hospital where EHR systems were seamlessly integrated compared with 56.3%, which originated from hospitals on a separate EHR system that used Epic care-everywhere to share patient information or providers accessing 2 instances of Epic simultaneously (Table 3). Patients transferred from hospitals within the same EHR system were more racially diverse ($P < 0.001$). Length of stay, ICU utilization, and ventilator use were similar between groups. Unadjusted and adjusted mortality rates were observed to be lower when transferred from hospitals with seamless EHR integration, but these differences were not statistically significant. Of patients not transferred because of potential instability, fewer examples occurred at hospitals from the same EHR as the dedicated COVID-19 hospital (27.8% versus a total of 48.4%, $P = 0.001$).

Guideline adherence rates were higher when patients were transferred among patients within the same EHR system: risk stratification (63.4% versus 72.4%, $P = 0.014$), anticoagulation (91.6% versus 96.6%, $P = 0.007$), and corticosteroids (74.8% versus 80.9%, $P = 0.011$) despite the availability of Epic care-everywhere. We compared trends in guideline adherence by EHR integration and whether they underwent transfer. Improved adherence among risk stratification (DiD, $P < 0.001$), anticoagulation ($P < 0.001$), and dexamethasone (DiD, $P < 0.001$) was observed among patients who underwent transfer. No significant differences in care quality were observed in patients who did not undergo transfer.

We further evaluated the transfer process for equity, as it was observed that patients who underwent transfer were more likely to be White. On presentation, White patients were older (66.0

versus 53.9 years, $P < 0.001$), had higher rates of chronic comorbidities associated with worse COVID-19 outcomes, and had a higher 4C score compared with non-White patients (Supplemental Table 2, <http://links.lww.com/JPS/A416>). When adjusting for severity by 4C score, transfer rates were similar across races (Supplemental Figs. 1, 2, <http://links.lww.com/JPS/A416>).

We evaluated clinician attitudes regarding the overall process of transfer and impact on patient care (Table 4). Of the 47 providers asked, we received 25 (53.2%) respondents. Overall, sentiment was encouraging with more positive statements than negative. Clinicians generally agreed that cohorting patients reduced the potential of nosocomial transmission (Likert, 3.28 [0.48]), and improved care (Likert, 2.71 [0.95]). They also support statements that a dedicated triage physician reduced cognitive burden (Likert, 3.45 [0.95]) and improved safety through documentation (Likert, 3.43 [0.79]). In addition, clinicians highlighted the fact that the lack of EHR interoperability was potentially problematic, with a majority indicating it was a barrier to efficient transfer (Likert, 3.52 [0.73]) and made the transfer less safe (Likert, 3.0 [1.3]). However, providers agreed that having a dedicated triage officer reduced uncertainty (Likert, 3.25 [0.71]).

DISCUSSION

In many areas worldwide, broad community transmission of COVID-19, which preceded many social distancing policies, has resulted in substantial strain of hospital capacity, requiring rapid innovations under duress. By contrast, our state initiated social distancing guidelines and stay-in-place orders relatively early, resulting in public health changes that preceded broad community spread.^{32,33} As such, our hospital system was able to innovate on cohorting strategies, virtual health, surge planning, and standardize medical care before the influx of patients.

In this study, we describe outcomes of a novel approach to geographical cohorting of COVID-19 patients: transferring to a dedicated

TABLE 3. Comparison of Patient Demographics, Hospital Utilization, Treatment Adherence, and Outcomes Between Patients of Patients Who Undergo Transfer Across Hospitals With 2 Separate EHR Systems Compared Against the Same

	Across EHR	Same EHR	P
Total n	383	297	
Age, mean (SD), y	64.2 (17.3)	63.8 (16.9)	0.375
Male, n (%)	206 (53.7)	153 (51.5)	0.556
White, n (%)	211 (55.1)	118 (39.7)	<0.001
Black, n (%)	75 (17.6)	23 (7.7)	<0.001
Asian, n (%)	27 (7.0)	86 (29.0)	<0.001
Hispanic, n (%)	43 (11.2)	23 (7.7)	0.128
Other, n (%)	27 (7.0)	47 (15.8)	<0.001
Non-English speaking, n (%)	97 (25.3)	140 (47.1)	<0.001
Inpatient days, n (%)	9.0 (11.3)	9.5 (10.2)	0.914
ICU days, n (%)	6.6 (13.7)	6.9 (11.6)	0.602
Ventilator days, n (%)	11.8 (16.3)	12.6 (17.6)	0.867
Readmission, n (%)	23 (6.0)	14 (4.7)	0.462
30-d all-cause mortality, n (%)	62 (16.2)	33 (11.1)	0.058
Adjusted 30-d all-cause mortality, n (%)	1.0 (Reference)	0.60 (0.36–1.02)	0.062
D-dimer adherence, n (%)	310 (80.9)	256 (86.2)	0.016
CRP adherence, n (%)	288 (75.2)	246 (82.8)	0.361
Lymphocyte count adherence, n (%)	285 (74.4)	230 (77.4)	0.069
Total laboratory adherence, n (%)	243 (63.4)	215 (72.4)	0.014
Anticoagulation, n (%)	351 (91.6)	287 (96.6)	0.007
Corticosteroids, n (%)	98 (74.8)	89 (80.9)	0.011

TABLE 4. Administered Questions and Modified Likert Responses by Clinicians and Staff Caring for COVID-19 Patients

	Mean	SD
Cohorting hospitalized COVID-19 patients in a single hospital likely reduces risk of nosocomial transmission of the disease	3.28	0.48
Cohorting hospitalized COVID-19 patients in a single hospital improves the care of patients with COVID-19	3.28	0.75
Facilitation of interhospital transfer of COVID-19 patients by a dedicated patient flow officer made the transfer safer	2.71	0.95
Facilitation of interhospital transfer of COVID-19 patients by a dedicated triage officer reduces the cognitive burden of caring for these patients	3.45	0.95
Documentation of a standardized transfer note made the transfer more safe	3.43	0.79
Communication errors are common among transfers of COVID-19 patients	2.28	0.72
Transfers of COVID-19 patients are occurring efficiently	3	1.09
Transfers of COVID-19 patients are occurring unnecessarily	1.6	0.87
Lack of shared information between 2 EHR systems is a barrier to efficient transfer of COVID-19 patients	3.52	0.73
Lack of shared information between 2 EHR systems made the transfer of COVID-19 patients less safe	3	1.3
Having a dedicated physician located at the systems operations center has improved its effectiveness	3.45	0.7
Having a dedicated physician located at the systems operations center helped reduce uncertainty associated with patient transfers	3.25	0.71
Having a dedicated physician located at the systems operations center helped prevent potential conflicts	3.29	0.83
Having real-time capacity information assists in the care and movement of patients impacted by COVID-19	2.95	0.64

COVID-19 hospital and using a system approach to the transfer process based upon awareness system-wide resources. This contrasts with other field hospitals that were generally designed to care for non-COVID-19 medically ill. Overall, we found that transfer of patients to a dedicated hospital was safe and associated with improved care quality. Clinicians were positive about the approach, agreeing that it likely reduced the risk of nosocomial transmission and improved care delivery.

However, to successfully operate a dedicated hospital, safe transfer of COVID-19 patients needs to be facilitated. In the literature, outcomes associated with hospitalized interfacility transfers are mixed, with some studies showing benefit and others showing potential harm. Studies suggested that interfacility transfer for geocohorting of patients is associated with improved outcomes in other disease processes such as trauma and acute respiratory distress syndrome.^{34,35} However, risks of interhospital transfers include higher rates of delayed care, miscommunication, error, and mortality.^{36–38} In addition, it has been suggested that interhospital transfers may exacerbate some racial and economic health disparities.^{39,40}

We observed significant racial differences between patients who were transferred and those who were not, with non-White patients being overall less likely to be transferred. On further exploration, we found that non-White patients admitted were younger with fewer comorbidities and lower severity. When evaluating for reasons a patient was not transferred or adjusting for severity, racial differences were not observed. Although our observation that minorities hospitalized with COVID were younger with lower rates of comorbidities seems to run counter to well-established racial disparities exacerbated by the pandemic, this is due to the lack of inclusion of outpatients who tested positive. A majority of patients admitted with COVID-19 were non-White, well above the regional demographic rate, highlighting the existing disparity.

Acknowledging and developing a plan to mitigate the potential risk of increased rates of delayed care, miscommunication, error, and mortality is critical when developing a multihospital cohorting plan. To overcome these obstacles, a triage physician and dedicated transfer staff led and coordinated a centralized command center to facilitate transfer. The system triage physician had access to real-time capacity information for sending and receiving sites, and direct access to each EHR, and facilitated a structured hand-off with structured documentation following best practices and ensuring patients met the criteria for ongoing hospitalization.

As such, patients who underwent transfer were sicker, and had higher rates of ICU utilization, longer length of stay, and higher unadjusted mortality. Overall, clinicians agreed that a centrally located triage officer and approach improved communication and safety, and reduced cognitive burden. Overall, our study suggests that interhospital transfer of COVID-19 patients can be done safely provided effective communication is prioritized.

We overcame one important barrier to safe transfer: lack of EHR interoperability. With a dedicated triage officer able to overcome limitations by simultaneously viewing both EHR instances, we observed no significant differences in mortality or length of stay. We did note, however, that guideline adherence was higher among patients transferred within the same EHR system. These data suggest that lack of interoperability remains a barrier to efficient care of patients undergoing transfer. These findings were supported by clinician surveys.

Taken together, we show that with adequate structural changes, risks of interhospital transfers can be mitigated, allowing for centralization of care, improved delivery, and reducing the risk of nosocomial transmission to other admitted patients. Although COVID-19 has exposed U.S. health care as a muddle of health care places, as opposed to an integrated system, we show the benefit a multihospital organization presents through being able to innovate delivery and covered nearly 10% of all patients admitted with COVID-19 in the state.

As an observational study of a single system, this study has several limitations. First, we cannot show objectively that transfers to a dedicated hospital improve outcomes. Patients who were not transferred were widely heterogeneous, and as such, comparison is challenging. Similarly, although we show adherence to local guidelines improved, this study was not designed to show an improvement in outcomes. Our study highlights the difficulty in observing treatment effects in this population as risk stratification is inherently tied to process of care.

Second, our statistical approach, DiD analysis, carries potential pitfalls. They generally require parallel trends before the exogenous shock, which is difficult to establish given the short timeline before dissemination of guidelines. We evaluated other approaches including propensity matching; however, differences in missing rates (due to adherence) resulted in a poor balance and possibly biased evaluation. In addition, some observed differences seemed to be related to a decreased adherence rates among the population, which was not transferred, perhaps due to provider unfamiliarity with the guidelines or fatigue.

Third, this study captures early stages of care in a state with the benefit of preparation. Innovations such as development of dedicated hospital for COVID-19 require time, organizational flexibility, and adequate community testing to predict capacity needs. These necessities are not available in all regions or health care systems and may not be financially sustainable in the long run. During the study period, we did not observe the degree of capacity strain experienced in other systems.

Although we investigated provider attitudes of interhospital transfers and found general positivity, this does not necessarily translate into improvements in patient experience. Recent studies have found discordance in expectations between patients and providers when patients are transferred. This is particularly true given already observed racial and economic disparities in COVID-19-affected regions. Evaluation of the impact of interhospital transfers on perceived care is an important next step.

To conclude, we describe a 12-hospital coordinated response to COVID-19, allowing transfer of positive patients to a dedicated hospital for the purposes of centralizing care, improving quality, and reducing potential transmission. Through a dedicated triage officer and standardized communication, we show that this process can be safe and is associated with higher-quality care and high provider satisfaction.

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