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Authors
Douin, David J
Ward, Michael J
Lindsell, Christopher J
et al.

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ICU Bed Utilization During the Coronavirus Disease 2019 Pandemic in a Multistate Analysis—March to June 2020

David J. Douin, MD[1]
Michael J. Ward, MD, PhD[2]
Christopher J. Lindsell, PhD[2]
Michelle P. Howell, BSN[1]
Catherine L. Hough, MD, MSc[3]
Matthew C. Exline, MD[4]
Michelle N. Gong, MD[5]
Michael S. Aboodi, MD[5]
Mark W. Tenforde, MD, PhD[6]
Leora R. Feldstein, PhD[6]
William B. Stubblefield, MD[2]
Jay S. Steingrub, MD[7]
Matthew E. Prekker, MD, MPH[8]
Samuel M. Brown, MD[9]
Ithan D. Peltan, MD, MSc[9]
Akram Khan, MD[3]
D. Clark Files, MD[10]
Kevin W. Gibbs, MD[10]
Todd W. Rice, MD, MSc[2]
Jonathan D. Casey, MD[2]
David N. Hager, MD, PhD[11]
Nida Qadir, MD[12]
Daniel J. Henning, MD[13]
Jennifer G. Wilson, MD, MS[14]
Manish M. Patel, MD[6]
Wesley H. Self, MD, MPH[2]
Adit A. Ginde, MD, MPH[1]

OBJECTIVES: Given finite ICU bed capacity, knowledge of ICU bed utilization during the coronavirus disease 2019 pandemic is critical to ensure future strategies for resource allocation and utilization. We sought to examine ICU census trends in relation to ICU bed capacity during the rapid increase in severe coronavirus disease 2019 cases early during the pandemic.

DESIGN: Observational cohort study.

SETTING: Thirteen geographically dispersed academic medical centers in the United States.

PATIENTS/SUBJECTS: We obtained daily ICU censuses from March 26 to June 30, 2020, as well as prepandemic ICU bed capacities. The primary outcome was daily census of ICU patients stratified by coronavirus disease 2019 and mechanical ventilation status in relation to ICU capacity.

INTERVENTIONS: None.

MEASUREMENTS AND MAIN RESULTS: Prepandemic overall ICU capacity ranged from 62 to 225 beds (median 109). During the study period, the median daily coronavirus disease 2019 ICU census per hospital ranged from 1 to 84 patients, and the daily ICU census exceeded overall ICU capacity for at least 1 day at five institutions. The number of critically ill patients exceeded ICU capacity for a median (interquartile range) of 17 (12–50) of 97 days at these five sites. All 13 institutions experienced decreases in their noncoronavirus disease ICU population, whereas local coronavirus disease 2019 cases increased. Coronavirus disease 2019 patients reached their greatest proportion of ICU capacity on April 12, 2020, when they accounted for 44% of ICU patients across all participating hospitals. Maximum ICU census ranged from 52% to 289% of overall ICU capacity, with three sites less than 80%, four sites 80–100%, five sites 100–128%, and one site 289%.

CONCLUSIONS: From March to June 2020, the coronavirus disease 2019 pandemic led to ICU censuses greater than ICU bed capacity at fives of 13 institutions evaluated. These findings demonstrate the short-term adaptability of U.S. healthcare institutions in redirecting limited resources to accommodate a public health emergency.

KEY WORDS: capacity; coronavirus disease 2019; intensive care unit; mechanical ventilation; resource allocation

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BACKGROUND

Novel coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) began in November 2019 has spread worldwide and has infected over 10 million people in the United States through November 10, 2020 (1–3). Patients with COVID-19 experience a heterogeneous disease course with some populations experiencing high rates of hospitalization and ICU admission (4–6). Nearly, eight in 10 hospitalized patients require supplemental oxygen and as many as one third of these patients are mechanically ventilated (5, 7, 8).

High ICU occupancy has been linked to worse patient outcomes, including mortality (9, 10). An American College of Chest Physicians (CHEST) consensus statement highlights multiple strategies for dealing with a rapid increase in patients requiring critical care, such as in a disaster or pandemic (11). They recommend all hospitals allocate resources in order to expand critical care capacity "by at least 20%" under normal circumstances and "by at least 200%" in a crisis response scenario (11). Strategies may include decreasing existing demands, such as nonurgent services over the short term (e.g., elective procedures or surgeries) or diverting new demands. Such adaptability within a hospital or healthcare system is therefore crucial to its response to a public health emergency such as COVID-19 (12).

Several regional retrospective studies from New York City (13), China (8, 14–17), Northern Italy (6), and Seattle (2) have quantified the impact a surge of COVID-19 infections can have on local ICU admissions. However, little is known about COVID-19–specific ICU bed utilization more broadly in the United States. Bed utilization may inform how hospitals across the country were able to accommodate strain from increased volumes of COVID-19 patients early during the pandemic, allocate finite resources such as ventilators, and assess pandemic preparedness. Given finite ICU bed capacity in the United States, knowledge of ICU bed utilization during the early COVID-19 pandemic with rapid escalation of critical COVID-19 cases is important for informing future resource allocation and utilization as the pandemic continues. In this retrospective observational study, we describe daily trends of ICU bed utilization by COVID-19 patients as compared to overall prepandemic ICU bed capacity at 13 large geographically dispersed academic medical centers (**Table 1**) in the United States.

METHODS

We conducted a retrospective, observational study at 13 geographically dispersed academic medical centers in the United States within the Influenza Vaccine Effectiveness in the Critically Ill (IVY) Network (18). We chose institutions based on their participation in the IVY Network, geographic diversity, and ability to provide accurate ICU census of both COVID-19 and non–COVID-19 patients. Institutional Review Boards of all participating sites determined this work to be Public Health Surveillance. We collected data in real time on ICU bed utilization via electronic health record. Our study followed the Strengthening the Reporting of Observational Studies in Epidemiology guidelines for reporting observational studies (19).

All adult patients (≥18 yr old) admitted to one of the enrolling hospitals' ICUs between March 26, 2020, and June 30, 2020 were included in this study. Each participating institution provided a daily census for ICU patients, including all patients admitted to the ICU or listed as ICU status for each day of the study period. ICU status was defined as requiring advanced therapies or support, including mechanical ventilation and vasopressor infusions, which would warrant ICU admission during normal circumstances when demand for ICU beds did not exceed ICU capacity. Patients were divided into four categories: 1) COVID-19–positive patients (i.e., with a positive molecular or antigen test) requiring mechanical ventilation, 2) COVID-19–positive patients not requiring mechanical ventilation, 3) "COVID-19–negative patients" (patients with a negative COVID-19 test or patients who did not have a COVID-19 test performed) requiring mechanical ventilation, and 4) COVID-19–negative patients not requiring mechanical ventilation.

Each participating institution also provided medical ICU (MICU) and overall ICU capacities. These values were self-reported by research personnel at each institution and reflect "prepandemic" ICU capacities. Prepandemic MICU capacities, in addition to overall ICU capacities, were included because the MICU was the preferred location for patients with severe viral pneumonia at each of the participating hospitals. We plotted the daily ICU censuses stratified by patient category on a bar graph overlaid with lines representing the reported prepandemic MICU and overall ICU capacities. We defined prepandemic capacity as the 3 months leading up to March 2020.

All of the 13 institutions were able to increase their MICU and ICU capacities to some degree. However, much of the "increase" in capacity involved the repurposing of already existing ICU beds. For example, several institutions converted their neurologic ICU and cardiac ICU into MICU beds. Accounting for increases in MICU capacity was therefore challenging as these often did not represent new ICU beds. Therefore, we decided reporting prepandemic MICU and ICU capacity was the best way to standardize capacity across all institutions.

We obtained daily COVID-19 case levels per 100,000 people over time for each county location of the 13 included institutions. These were obtained from the Harvard Global Health Institute COVID-19 Risk Level website (20). Daily case levels for all included counties were calculated based on a 7-day rolling average.

Categorical variables are reported as number and proportion. Continuous variables are reported as median and interquartile range. As a descriptive study, no inferential statistics were calculated. We display the data as stacked bar charts overlaid with line plots for prepandemic MICU capacity and overall ICU capacity. We determined the number of hospitals that had an ICU census above prepandemic ICU capacity 1 or more days during the study period, the maximum percentage of prepandemic capacity reached for these hospitals, and the number of days above prepandemic maximum ICU capacity.

RESULTS

ICU Capacities

Prepandemic MICU capacity for each hospital ranged from 16 to 60 beds. Overall ICU capacity for each hospital ranged from 62 to 225 beds (Table 1). The combined capacity for all 13 institutions was 441 MICU beds and 1,594 overall ICU beds for a median of 35 MICU beds and 109 overall ICU beds per institution.

Community Incidence

The median daily community incidence of COVID-19 cases per 100,000 residents in the county surrounding each hospital ranged from 1 to 20 (Table 1). The maximum incidence was 85 cases per 100,000 residents in Bronx County, NY, on April 9, 2020. The minimum incidence was 0.3 cases per 100,000 residents in Forsyth County, NC, on April 21, 2020.

Daily ICU Census

Daily ICU census exceeded prepandemic ICU capacity at some point during the study period at five institutions (**Figs. 1–4**): Montefiore Medical Center (maximum daily census 289% of capacity), Hennepin County Medical Center (128%), Oregon Health & Science University Hospital (120%), University of Washington Medical Center (107%), and UC Health, University of Colorado Hospital (105%). Of these five sites, Montefiore Medical Center spent the most time—all 97 days—with an ICU census over prepandemic ICU capacity (**Fig. 1)**. Three institutions did not exceed 80% of total ICU capacity during the study period (**Figs. 3** and **4**): Baystate Medical Center (79%), Intermountain Medical Center (79%), and Vanderbilt University Medical Center (52%).

The median daily and maximum ICU census of COVID-19 patients were both highest at Montefiore Medical Center with 84 and 264 patients respectively (Table 1). At the 12 remaining hospitals, median daily ICU census of COVID-19 patients ranged from one (Oregon Health & Science University Hospital) to 47 patients (Johns Hopkins Hospital). Maximum COVID-19 ICU census ranged from five (Oregon Health & Science University Hospital) to 74 patients (Ohio State University Wexner Medical Center). Figures 2–4 are stratified by the median daily ICU census of COVID-19 patients. Overall, COVID-19 patients comprised 24% (range 2–52%) of the median daily ICU census for the 97 days measured in this study (Table 1). The date at which COVID-19 patients constituted the greatest proportion of ICU capacity varied from March 28 to June 28 depending on institution.

Aggregate Census

Due to a markedly higher burden of COVID-19 cases at Montefiore Medical Center in Bronx, NY, we stratified data for Montefiore Medical Center (Fig. 1) versus non-Montefiore hospitals (**Supplemental Fig. 1**, Supplemental Digital Content 1, http://links.lww.com/CCX/A550). Cases per 100,000 patients are not

TABLE 1.
Daily ICU Censuses in Comparison With ICU Capacity

Institutions	Location	Daily Community Incidence of SARS-CoV-2 Infection per 100 k Residents, Median (IQR)	Daily ICU Census, Median (IQR)
Baystate Medical Center	Springfield, MA	15 (5–22)	32 (27–36)
Hennepin County Medical Center	Minneapolis, MN	9 (3–15)	77 (61–83)
Intermountain Medical Center	Murray, UT	7	55 (51–60)
Johns Hopkins Hospital	Baltimore, MD	12 (9–16)	99 (92–104)
Montefiore Medical Center	Bronx, NY	20 (8–58)	160 (134–270)
Ohio State University Wexner Medical Center	Columbus, OH	7 (5–8)	153 (135–165)
Oregon Health and Science	Portland, OR	2 (2–3)	62 (54–72)
Stanford University Medical Center	Palo Alto, CA	1 (1–3)	60 (54–67)
University of California at Los Angeles Medical Center	Los Angeles, CA	9 (6–13)	85 (71–92)
UC Health University of Colorado Hospital	Aurora, CO	8 (6–11)	125 (121–128)
University of Washington Medical Center	Seattle, WA	4 (3–5)	154 (145–162)
Vanderbilt University Medical Center	Nashville, TN	12 (10–14)	99 (93–104)
Wake Forest University Baptist Medical Center	Winston-Salem, NC	5 (2–14)	69 (56–85)

COVID = coronavirus disease, IQR = interquartile range.

[a]Percentages in these columns are in comparison with the total ICU bed capacity at each site.

displayed in Supplemental Figure 1 (Supplemental Digital Content 1, http://links.lww.com/CCX/A550) because local patterns of COVID-19 spread vary dramatically by region and county, making interpretation of a combined case rate challenging.

As compared to Montefiore, the aggregate ICU census of all 12 non-Montefiore hospitals did not exceed prepandemic ICU capacity at any point during the study period (Supplemental Fig. 1, Supplemental Digital Content 1, http://links.lww.com/CCX/A550). At these 12 sites, the maximum daily ICU census was achieved on June 11, 2020, when 1,208 of all ICU beds (81%) were occupied, nearly three times greater than the MICU capacity (421 beds) for these 12 institutions. However, the maximum census included both MICU and non-MICU patients. The aggregate proportion of COVID-19 patients admitted to ICUs in the subgroup of 12 non-Montefiore hospitals did not vary greatly during the study period (15-33%).

DISCUSSION

During March to June 2020, a minority of academic medical centers included in this study (5/13) reported an ICU census at least 1 day that exceeded their overall prepandemic ICU capacity. Apart from Montefiore Medical Center in New York City, no institution exceeded greater than 128% of their overall ICU capacity, and only two centers exceeded capacity for a sustained period of time of more than 17 days. Most institutions included in this study were likely able to accommodate a surge in COVID-19 patients by decreasing their traditional (coronavirus disease [COVID] negative) ICU population through various methods, such as canceling elective surgeries. Such preparedness may stem from a long-standing recognition of the potential for a sudden expansion of critical care resources under stress circumstances such as a pandemic or a disaster (11). Our findings

Daily COVID "Positive" ICU Census, Median (%)[a]	Maximum COVID "Positive" ICU Census, *n* (%)[a]	Date Maximum COVID Positive ICU Census Achieved	Medical ICU/Total ICU Bed Capacity, *n*	Maximum Proportion of Capacity Achieved, %	Days with ≥ 100% Capacity, *n* (%)
13 (21)	38 (61)	April 2	32/62	79	0 (0)
18 (24)	36 (47)	May 26	24/76	128	50 (51)
17 (19)	29 (32)	June 11	40/90	79	0 (0)
47 (39)	63 (52)	May 7	24/121	96	0 (0)
84 (79)	264 (249)	April 11	42/106	289	97 (100)
36 (18)	74 (37)	April 20	60/202	92	0 (0)
1 (1)	5 (6)	March 28	16/80	120	9 (9)
4 (4)	10 (10)	March 31	35/99	81	0 (0)
8 (7)	16 (15)	May 2	24/109	93	0 (0)
33 (25)	60 (45)	April 7	24/132	105	12 (12)
9 (5)	20 (12)	April 1	41/168	107	17 (18)
7 (3)	15 (7)	June 28	35/225	52	0 (0)
10 (8)	29 (23)	June 8	44/124	90	0 (0)

demonstrate some adaptability of U.S. healthcare institutions to accommodate an increase in critically ill patients caused by a public health emergency. However, the strain in capacity due to the disproportionate surge in hospitalized COVID-19 patients in New York City is evidence that this adaptability has limits.

Montefiore Medical Center in Bronx, NY, was a clear outlier among medical centers in this study. The New York City area experienced one of the most severe early surges of the COVID-19 pandemic in the United States, likely accounting for the differences in patient census between Montefiore and the other 12 sites (13). Faced with a massive surge of critically ill COVID-19 patients, Montefiore's adaptability was significantly strained as demonstrated by more critically ill patients receiving care in the hospital than ICU beds available.

When patient capacity is exceeded in ICUs, resources are strained. The safety of healthcare workers suffers under such conditions. Front-line healthcare personnel contracted SARS-CoV-2 at significantly higher rates than the general population, a phenomenon which was more pronounced at institutions that exceeded their ICU capacity (21). Further, healthcare workers have been dying at higher than historic rates since the start of the pandemic (22). Although ICU beds are an important component, efficient critical care requires the collective effort of multiple stakeholders. Personnel who are healthy enough to perform their jobs are arguably the most important of these stakeholders. Patient outcomes were also affected by limited resources. In-hospital mortality for non–COVID-19 patients increased significantly in April 2020 and did not return to baseline until June 2020 (23). At a certain point, no amount of adaptability is enough, and the system will be overwhelmed without extraordinary efforts requiring creative solutions by leaders and decision-makers such as expanding critical care resources

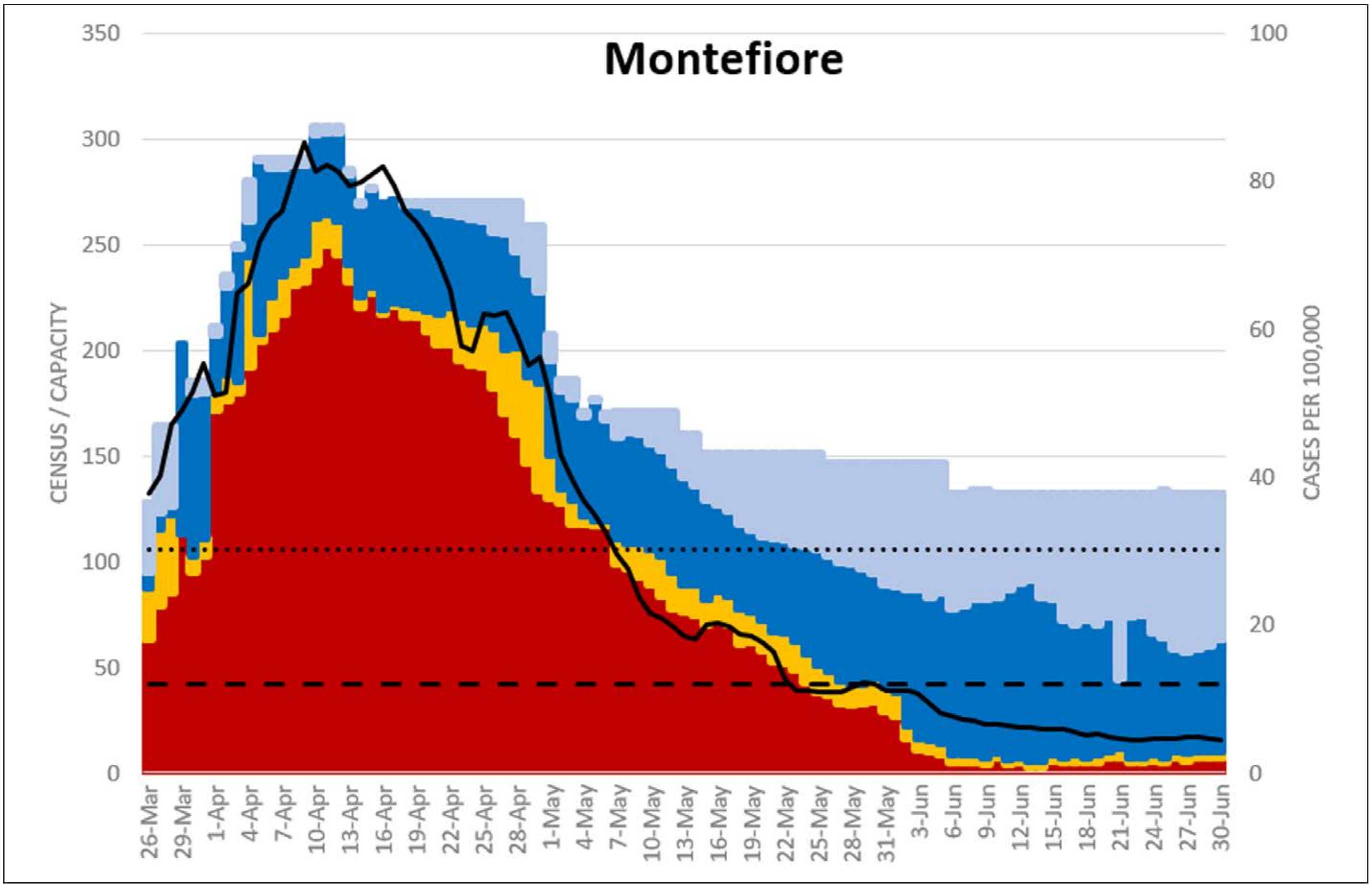

Figure 1. ICU census and capacity over time during the early coronavirus disease 2019 (COVID-19) pandemic at Montefiore Medical Center. Seven *lines* are displayed to illustrate changes in COVID-19 cases over time compared with ICU and medical ICU bed capacity and community COVID-19 case burden. These seven lines include the following: 1) counts of ICU COVID-19 patients on invasive mechanical ventilation (*red*); 2) counts of ICU COVID-19 patients not on invasive mechanical ventilation (*yellow*); 3) counts of ICU patients without COVID-19 on invasive mechanical ventilation (*dark blue*); 4) counts of ICU patients without COVID-19 not on invasive mechanical ventilation (*light blue*); 5) prepandemic capacity of medical ICU beds (medical ICU capacity; *black dashed line*); 6) prepandemic capacity of total ICU beds (total ICU capacity; *black dotted line*); 7) community cases of COVID-19 per 100,000 population in the Bronx County, NY (*solid black line*; *right-sided y*-axis). Most of the COVID-19–positive patients requiring ICU admission were intubated. Many other patients who would warrant ICU admission under nonpandemic circumstances, but were not intubated, were cared for in non-ICU settings.

beyond traditional healthcare settings and possibly equitable rationing of care (24, 25).

Large academic medical centers were likely able to rapidly increase ICU capacity during initial large increases in critical COVID-19 patients by numerous mechanisms. First, and most importantly, the nationwide postponement of elective surgical cases—employed by every hospital in our study—significantly decreased scheduled ICU admissions (26–29). Reducing elective surgeries protects patients and healthcare workers from in-hospital viral transmission (27), preserves personal protective equipment (27, 30), and frees essential workers from other areas to assist in the ICU (30). It also enables recovery areas, such as the postanesthesia care unit and operating room to be repurposed as overflow ICU beds (26, 27, 29).

Most critically ill patients with pneumonia would typically be admitted to the MICU. Under noncrisis circumstances, the cancellation of elective surgeries and a subsequent decrease in postoperative admissions should not directly affect MICU capacity. However, at each of the 13 institutions included in our study, decreased postoperative admission allowed for the repurposing of ICU beds into effective MICU or COVID-ICU beds. Any and all ICU beds must be used to accommodate a rapid surge in critically ill patients.

An estimated 4.5 million elective or nonemergent surgical procedures were cancelled in North America from mid-March to mid-May alone (27).

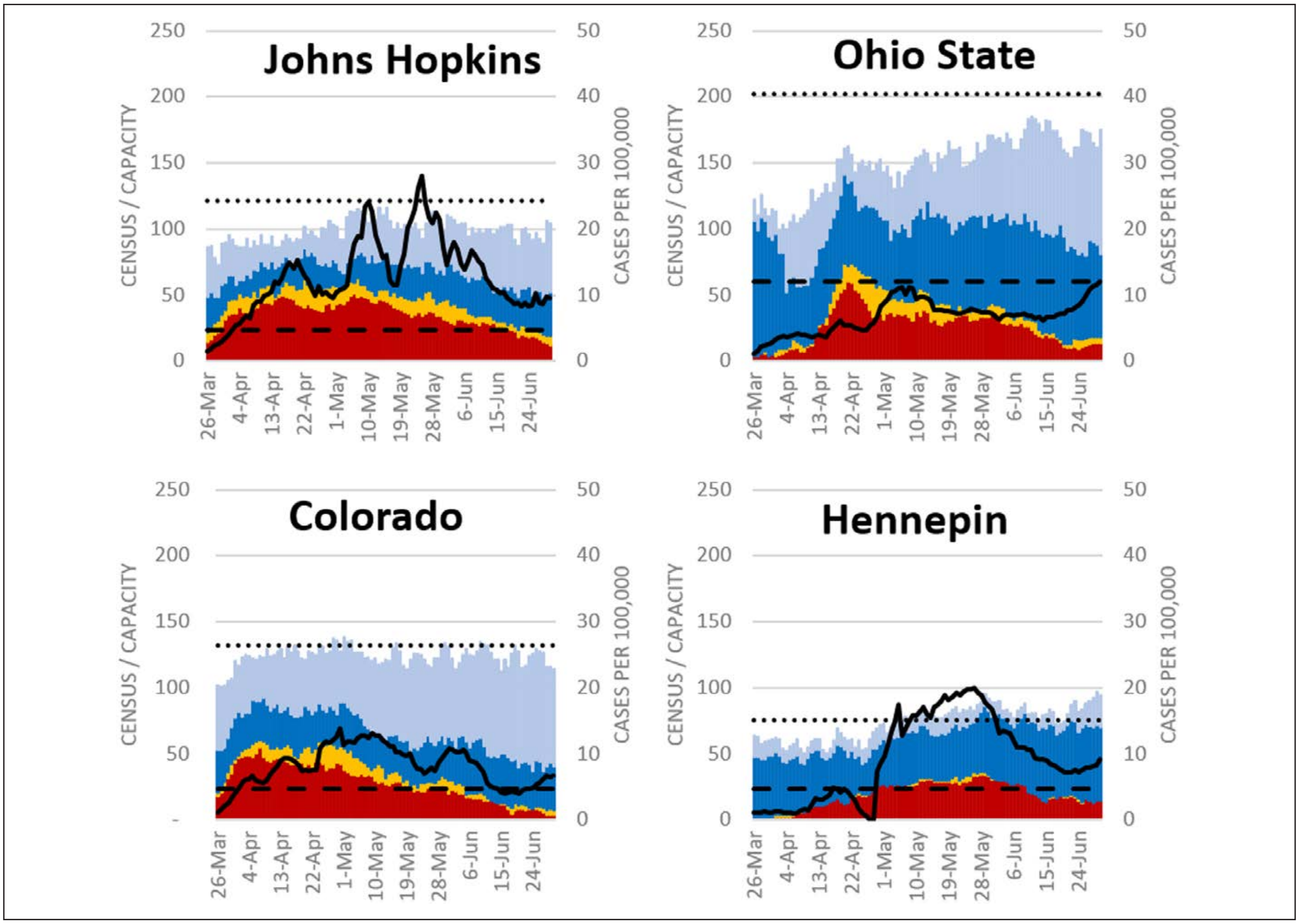

Figure 2. ICU census and capacity over time during the early coronavirus disease 2019 (COVID-19) pandemic. Each panel represents one hospital. The four hospitals with the highest median COVID-19–positive ICU census besides Montefiore Medical Center are displayed. For each hospital, seven *lines* are displayed to illustrate changes in COVID-19 cases over time compared with ICU and medical ICU bed capacity and community COVID-19 case burden. These seven *lines* include the following: 1) counts of ICU COVID-19 patients on invasive mechanical ventilation (*red*); 2) counts of ICU COVID-19 patients not on invasive mechanical ventilation (*yellow*); 3) counts of ICU patients without COVID-19 on invasive mechanical ventilation (*dark blue*); 4) counts of ICU patients without COVID-19 not on invasive mechanical ventilation (*light blue*); 5) prepandemic capacity of medical ICU beds (medical ICU capacity; *black dashed line*); 6) prepandemic capacity of total ICU beds (total ICU capacity; *black dotted line*); (7) community cases of COVID-19 per 100,000 population in the county surrounding the study hospital (*solid black line*; *right-sided y*-axis).

Approximately, 10% of patients require ICU admission following elective surgery (31). Therefore, we estimate ~450,000 ICU admissions were prevented in North America by cancelling elective surgical procedures between March and May 2020.

The cancellation of elective surgical procedures has significant costs. It has been estimated that cancellation of all elective procedures would result in an estimated \$16.3–\$17.7 billion per month in lost revenue and \$4–\$5.4 billion per month in net income loss to healthcare systems in the United States (32). Given the substantial financial impact, many hospital systems may not be able to absorb these losses repeatedly during subsequent waves of the pandemic. Further, delays in elective surgeries or procedures may potentially have adverse impact on patient outcomes (33).

A second commonly deployed mechanism to accommodate ICU strain leverages the flexibility in emergency department operations. The ability to meet the demands of rapidly expanding patient volumes is essential to the daily operations of any large emergency department (34). Such operational flexibility can also be applied to a pandemic scenario where ICU beds and critical care resources suddenly hold increased value. Emergency departments can board floor or ICU level patients, creating temporary sources of extra capacity

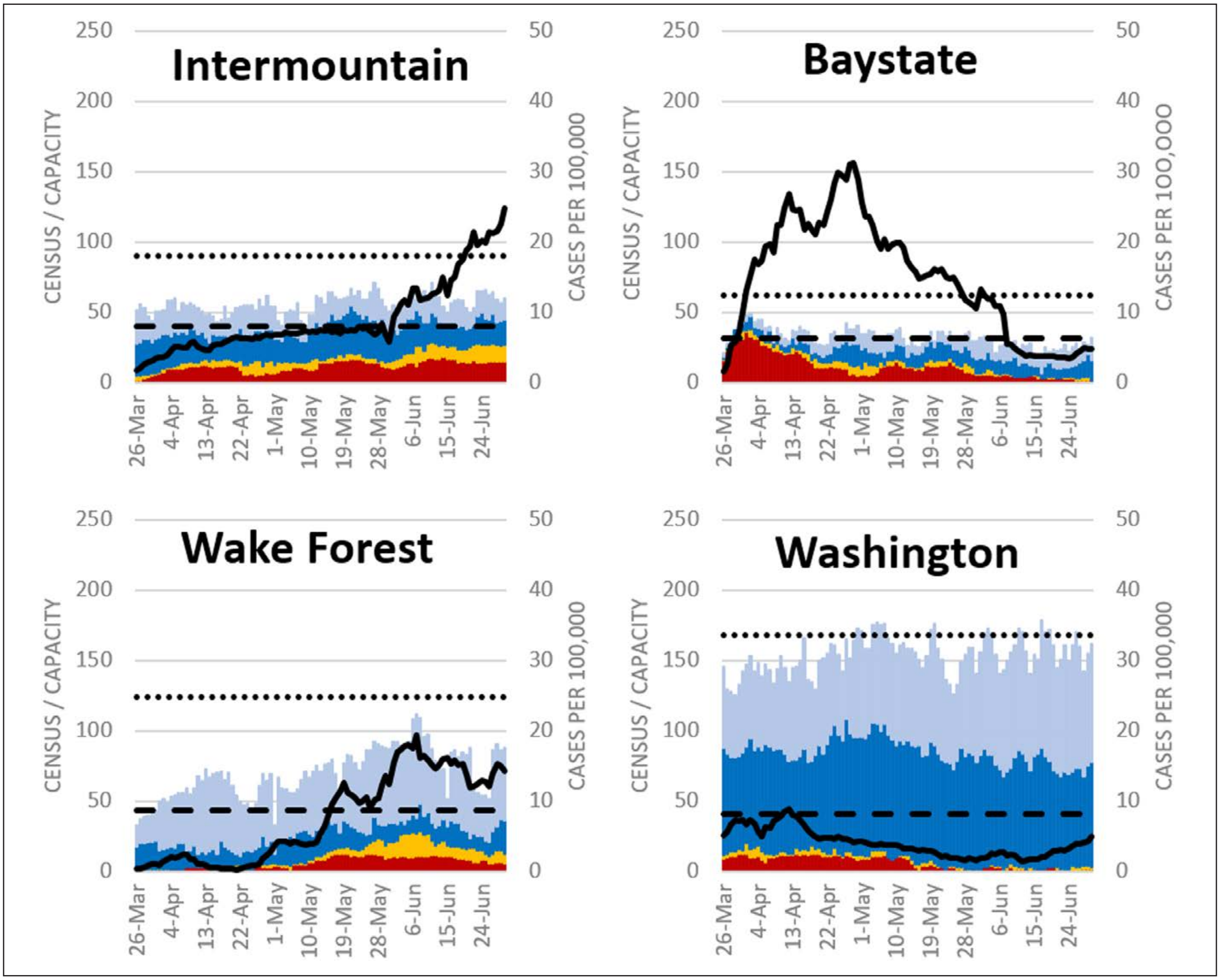

Figure 3. ICU census and capacity over time during the early coronavirus disease 2019 (COVID-19) pandemic. Each panel represents one hospital. For each hospital, seven *lines* are displayed to illustrate changes in COVID-19 cases over time compared with ICU and medical ICU bed capacity and community COVID-19 case burden. These seven lines include the following: 1) counts of ICU COVID-19 patients on invasive mechanical ventilation (*red*); 2) counts of ICU COVID-19 patients not on invasive mechanical ventilation (*yellow*); 3) counts of ICU patients without COVID-19 on invasive mechanical ventilation (*dark blue*); 4) counts of ICU patients without COVID-19 not on invasive mechanical ventilation (*light blue*); 5) prepandemic capacity of medical ICU beds (medical ICU capacity; *black dashed line*); 6) prepandemic capacity of total ICU beds (total ICU capacity; *black dotted line*); 7) community cases of COVID-19 per 100,000 population in the county surrounding the study hospital (*solid black line; right-sided y*-axis).

until hospital and ICU capacity can be relieved. Further, healthcare providers no longer working elective surgical cases or in clinics that were deemed nonessential could be reallocated to wards or ICUs to assist in the increased burden of patient care.

A third mechanism through which hospitals were likely able to accommodate ICU strain was decreased utilization of nonprocedural healthcare resources by patients. Patients sought healthcare at rates far below normal from March to May of 2020. Daily visits in the emergency department decreased by 41.5–63.5% in the United States between January and April of 2020.(35) Many patients avoided care for serious symptoms, illnesses, and injuries which would often prompt emergency services (36). Potential patients also followed stay-at-home orders or changed their behavior to make themselves less susceptible to injury or illness (36, 37). National public health messaging and uncertainty regarding COVID-19 transmission likely contributed to public avoidance of hospitals

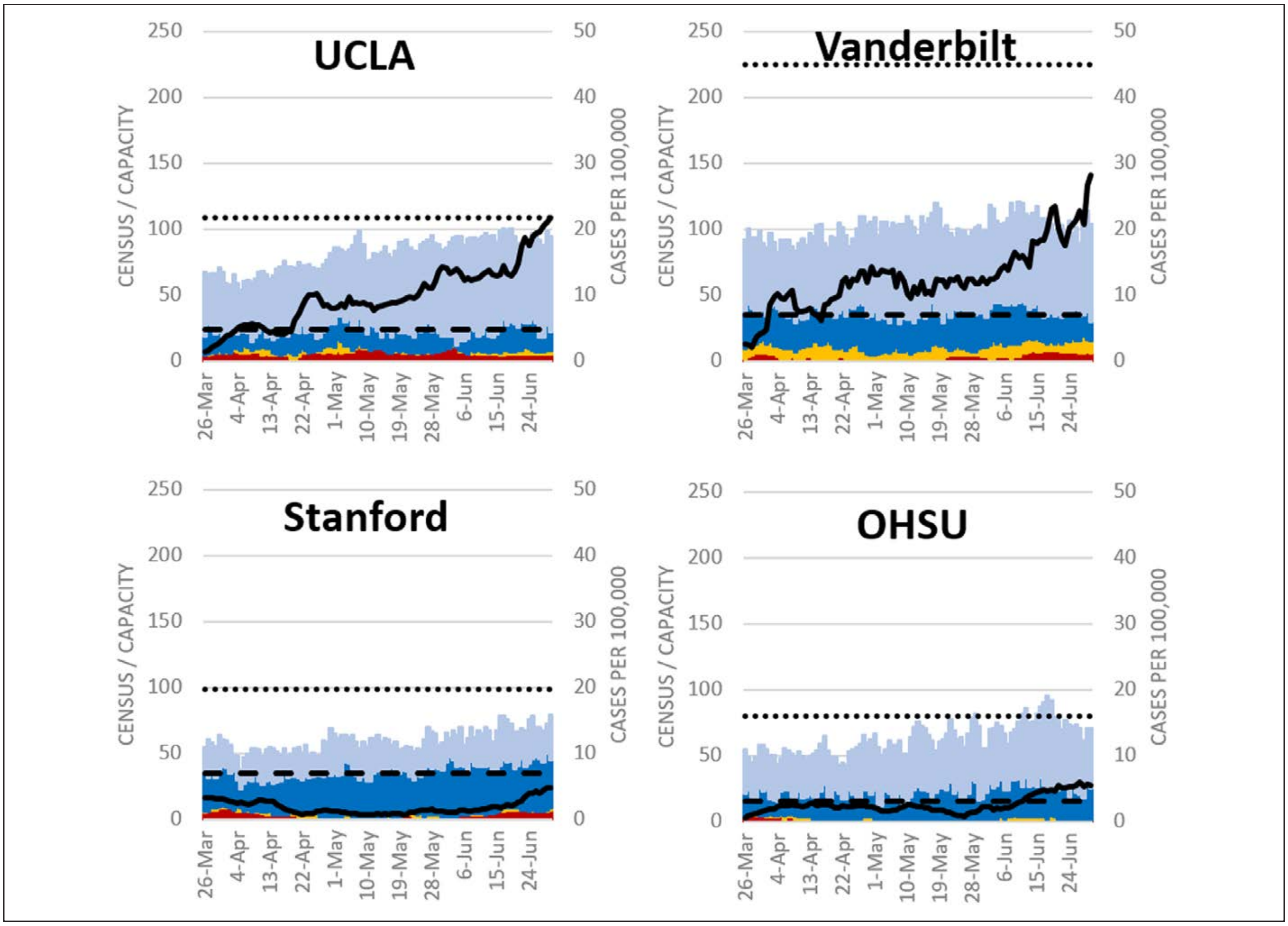

Figure 4. ICU census and capacity over time during the early coronavirus disease 2019 (COVID-19) pandemic. Each panel represents one hospital. The four hospitals with the lowest median COVID-19–positive ICU census are displayed. For each hospital, seven *lines* are displayed to illustrate changes in COVID-19 cases over time compared with ICU and medical ICU bed capacity and community COVID-19 case burden. These seven lines include the following: 1) counts of ICU COVID-19 patients on invasive mechanical ventilation (*red*); 2) counts of ICU COVID-19 patients not on invasive mechanical ventilation (*yellow*); 3) counts of ICU patients without COVID-19 on invasive mechanical ventilation (*dark blue*); 4) counts of ICU patients without COVID-19 not on invasive mechanical ventilation (*light blue*); 5) prepandemic capacity of medical ICU beds (MICU capacity; *black dashed line*); 6) prepandemic capacity of total ICU beds (total ICU capacity; *black dotted line*); 7) community cases of COVID-19 per 100,000 population in the county surrounding the study hospital (*solid black line; right-sided y*-axis). OHSU = Oregon Health & Science University, UCLA = University of California at Los Angeles.

and emergency departments and likely contributed to the lower number of COVID-negative ICU admission observed in our study (23, 36, 37). However, such delays or avoidance in care may have serious complications, as those seeking care too late with complications of their disease processes are likely to experience greater morbidity and mortality (23, 36, 37).

The changes in patient risk-taking and hospital-seeking behavior observed during the first months of the COVID-19 pandemic may not be durable. Future peaks, such as those being experienced in the fall and winter of 2020/2021, may be subject to pandemic fatigue and less public fear. If patients disregard stay-at-home orders and increase risky behavior by eschewing public health guidelines and institutions are less willing to cancel elective surgical procedures, the adaptability inherent to U.S. healthcare systems may be tested to an even greater extent. Increases in ICU capacity far exceeding those associated with the first months of the pandemic are therefore possible.

Community COVID-19 cases per 100,000 residents were associated with changes in local ICU census at some but not all institutions in our study. For example, in Bronx County, NY, and Hennepin County, MN, the

ICU censuses of COVID-19 patients at Montefiore and Hennepin County Medical Center respectively rose and fell with changes in community case rates. However, the COVID-19 censuses at University of California, Los Angeles Medical Center, and Vanderbilt University Medical Center did not seem to correlate with case rate changes in those communities. The nature of these differences is beyond the scope of our study; however, it may be due to changes in testing prevalence, admission patterns, or differing practices at other healthcare institutions in the same county.

During the early stages of the pandemic, which our data describe, there was yet to exist any national data infrastructure that could quantify or monitor COVID-19 ICU capacity across the United States. Therefore, data collection for our study required intensive, manual data collection. In the last 12 months, there has been considerable evolution, including the National COVID Cohort Collaborative (38) and the National Patient Centered Research Network COVID data model (39). Some of these more advanced efforts also obtain and make available information about disease severity and treatment. Repeating this manual data collection required for our study is unlikely to be as feasible or as fruitful as thoughtful exploration of those data sources.

Our study is subject to a number of limitations. First, although we included geographically diverse hospitals in twelve states, these centers were academic hospitals primarily in urban locations. These findings are likely not generalizable to smaller, nonacademic, and rural hospitals. Further, the interplay between academic hospitals and the resource utilization of their affiliated outlying facilities was not assessed. Although different regions of the United States are represented, cases of COVID-19 can vary dramatically even within the same geographic area. In addition, we did not include institutions from every state where large numbers of COVID-19 patients were treated. Some states experienced peaks at times after the conclusion of the study period. Further, this study is observational and descriptive only (40). We did not quantify the steps taken by each hospitals to adapt to increased ICU census demands, although it is likely that most hospitals in our study followed recommendations included in the CHEST consensus statement. Finally, we did not obtain detailed data on the critical care management received by each patient.

CONCLUSIONS

From March to June 2020, the COVID-19 pandemic led to ICU censuses greater than ICU bed capacity at five of 13 U.S. medical centers studied. Although most sites remained slightly above or less than full capacity, a New York City site, where severe COVID-19 burden was highest, substantially exceeded capacity. Some measures to increase bed capacity for COVID-19 cases included cancelling elective surgeries and borrowing beds from wards and emergency departments. These findings demonstrate the short-term adaptability of U.S. healthcare institutions in redirecting limited ICU resources away from patients without COVID-19 to accommodate the COVID-19 public health emergency. Although short-term adaptability facilitated the early response to caring for COVID-19 patients, how the displacement affected the outcomes of non-COVID patients is unknown. In future public health emergencies, health systems should plan to rapidly deploy backup processes of care for noninfected patients. Our data provide information about the range of adaptability that might be required in a future pandemic setting.

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1 *University of Colorado School of Medicine, Aurora, CO.*

2 *Vanderbilt University Medical Center, Nashville, TN.*

3 *Oregon Health & Science University School of Medicine, Portland, OR.*

4 *Ohio State University, Wexner Medical Center, Columbus, OH.*

5 *Albert Einstein College of Medicine, Bronx, NY.*

6 *CDC COVID-19 Response Team, Atlanta, GA.*

7 *Baystate Medical Center, Springfield, MA.*

8 *Hennepin County Medical Center, Minneapolis, MN.*

9 *Intermountain Medical Center and University of Utah School of Medicine, Salt Lake City, UT.*

10 *Wake Forest University Baptist Medical Center, Winston-Salem, NC.*

11 *Johns Hopkins Hospital, Baltimore, MD.*

12 *David Geffen School of Medicine at UCLA, Los Angeles, CA.*

13 *Harborview Medical Center, Seattle, WA.*

14 *Stanford Hospital Medical Center, Palo Alto, CA.*

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For information regarding this article, E-mail: david.douin@cuanschutz.edu

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