Tele-ICUs for COVID-19: A Look at National Prevalence and Characteristics of Hospitals Providing Teleintensive Care

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Abstract

Purpose: Amidst the COVID-19 outbreak, the use of intensive care unit telemedicine (tele-ICUs) may be one mechanism to provide patient care, particularly in rural parts of the United States. The purpose of this research was to inform hospital decision makers considering tele-ICUs, policy makers weighing immediate and longer-term funding and reimbursement decisions relative to tele-ICU care, and researchers conducting future work evaluating tele-ICUs.

Methods: We compared hospitals that reported providing tele-intensive care to those that did not, using the 2018 American Hospital Association Annual Survey (AHAAS). Differences between groups were tested using Pearson's chi-square (categorical variables) and t-tests (continuous variables) using a 0.05 probability of Type 1 error. The study sample included all US short-term, acute care hospitals that responded to the AHAAS in 2018. Our key variable of interest was whether a hospital reported having any tele-ICU capabilities in the 2018 AHAAS. Other factors evaluated were ownership, region, beds, ICU beds, outpatient visits, emergency department visits, full-time employees, and whether a hospital was rural, a critical access hospital, a major teaching hospital, or part of a health system.

Findings: Larger, not-for-profit, non-rural, non-critical access, teaching hospitals that were part of a health system, particularly in the Midwest, were more likely to have tele-ICUs. Over one-third of hospital referral regions (HRRs) had zero hospitals with tele-ICUs, 4 had all hospitals with tele-ICU, and the median percent of hospitals with tele-ICU by HRR, weighted by outpatient visits, was 11.3%.

Conclusions and Implications: We found wide variation in the prevalence of tele-ICUs across HRRs and states. Future work should continue the evaluation of tele-ICU effectiveness and, if favorable, explore the variation we identified for improved access to teleintensive care.

Key words COVID-19, pandemic, rural critical care, telehealth, tele-ICU.

The coronavirus disease 2019 (COVID-19) pandemic has overwhelmed some US health care systems, highlighting ICU bed capacity concerns, particularly in outbreak hotspots.1–6 ICU beds are essential to treat the sickest COVID-19 patients, and they are frequently the subject of bed capacity concerns.1–2 While the number of ICU beds per capita in the United States is one of the highest in the world,5,6 the
distribution of ICU beds across geographic regions in the United States is not equal.7 Amidst the COVID-19 outbreak, the use of intensive care unit telemedicine (tele-ICUs) may be important to facilitate high-quality patient care, particularly in rural parts of the United States.

Tele-ICU “is technology enabled care delivered from off-site locations that was developed to address the increasing complexity of patients and insufficient supply of intensivists.”8 Tele-ICU uses remote technology to provide direct access from teleintensivists and critical care nurses who monitor patients, biomedical devices, and electronic medical records.6–11 Tele-ICU platforms use algorithms and push-notification dashboards to provide interventional care,8,9 which has been shown to improve a variety of clinical and financial outcomes.9,12 Tele-ICU is also one mechanism to provide intensive care when on-site and on-call intensivists are unavailable or hard to recruit,5,9 such as in rural areas.13 Tele-ICU networks are often set up in a hub-and-spoke model, with a central hub hospital housing many of the resources that are virtually deployed to multiple spoke hospitals that need ICU services.

A host of factors expose rural Americans to higher risk of not having access to an ICU bed when demand is high, such as in the current COVID-19 pandemic. Rural Americans are, on average, a more vulnerable population—they are older, poorer, and have more comorbidities.13,14 Vulnerable populations are at an increased risk of having a severe COVID-19 response15 that may require intensive care. Nonmetro areas (a category under which rural hospitals are included)16 have fewer ICU beds per capita.7 Even testing for COVID-19 has been estimated to be lower in rural, relative to nonrural, parts of the country.17 Some of this rural-urban disparity may be related to the geographic dispersion of our nation. While around 17% of the US population is rural, this population lives across 97% of the vast US land mass.18 For the approximately 2,100 rural hospitals that provide local access to care to rural Americans,15 providing intensive care in a surge event can be difficult. Tele-ICUs may be one mechanism by which rural hospitals can provide intensive care to rural Americans.

A variety of telehealth modalities have been effective, access-to-care portals during previous pandemics and epidemics, such as Ebola.20 Currently, many health systems are using tele-ICUs to treat COVID-19 patients.21,22 For rural Americans, prior research has described the many potential benefits of telehealth23,24 and specifically, tele-ICUs.8,10,11,25–27 At this juncture in health care delivery, particularly in response to a second wave of COVID-19 that may now be impacting many rural areas more than the first wave, understanding the national prevalence and characteristics of hospitals providing tele-ICUs is a logical first step.

Several models and maps of national ICU capacity have been helpful to prepare for and respond to the COVID-19 pandemic.1–4,28–30 Yet, we are aware of only one paper describing any current national tele-ICU capacity.31 That paper evaluated a different sample of US hospitals; specifically, its analysis was limited to hospitals with ICUs.31 Our work differs and builds upon Jain et al’s paper in at least 3 ways: (1) we evaluate tele-ICU provision nationally among nearly all US hospitals, instead of limiting our analysis to hospitals with ICUs (eg, our sample was 4,288 hospitals; the referent article had 2,816 hospitals); (2) we describe additional characteristics, such as region, system membership, and the number of ICU beds, total outpatient visits, emergency visits, and full-time personnel; and (3) we map the provision of tele-ICU nationally, weighted by the total outpatient visits in a hospital referral region (HRR) to provide the reader with detailed information about the geographic distribution of services. By evaluating all US hospitals, we include more rural hospitals and provide a broader picture of the US tele-ICU landscape. The objective of this paper is to inform hospital decision makers considering tele-ICUs, inform policy makers weighing immediate and longer-term funding and reimbursement decisions relative to tele-ICU care, and aid fellow researchers in future work evaluating tele-ICUs.

Methods

Data Sources

We combined multiple secondary data sources from 2018 to conduct this research. Whether a hospital provided teleintensive care and the number of ICU beds came from the 2018 American Hospital Association Annual Survey (AHAAS). Other hospital-level information came from the AHAAS, CMS Hospital Cost Report Information System (HCRIS) files “cost reports,”32 the Hospital Source Area File (HSAF), and the Area Health Resources File (AHRF).

Study Design

We compared hospitals that reported providing teleintensive care to hospitals that reported not providing teleintensive care in the 2018 AHAAS. Differences between groups were tested using Pearson’s chi-square (categorical variables) and t-tests (continuous variables) using 0.05 as the probability of Type 1 error.
Study Sample
The study sample included all US short-term, acute care hospitals that responded to the AHAAS in 2018. In 2018, 4,659 short-term acute care hospitals submitted cost reports. Cost reports are a widely adopted source of hospital information because all hospitals are required to file these with CMS annually to receive Medicare reimbursement. Of those 4,659 hospitals, 371 did not respond to the AHAAS. Our final sample included 4,288 US hospitals.

Study Variables
Our key variable of interest was whether a hospital reported having any tele-ICU capabilities in the 2018 AHAAS, question 97.b. In the survey, a hospital representative must select from 4 options as to whether the hospital provides Telehealth eICU (question 97.b) as: (1) owned or provided by my hospital or subsidiary, (2) provided by my health system (in my local community), (3) provided through a formal contractual arrangement or joint venture with another provider that is not in my system (in my local community), or (4) do not provide. We categorized any response to the first 3 options as providing tele-ICU. Otherwise, a hospital was coded as not providing tele-ICU if they selected option 4 (eg, “do not provide”) or if they did not answer the question but answered other questions on the survey. For Figure 1, the provision of tele-ICU was weighted by the number of outpatient visits per HRR. To create these weights, we separated hospitals by tele-ICU status, and then by HRR. Next, we summed total outpatient visits at the HRR level. We summed total outpatient visits for hospitals with tele-ICUs by HRR and divided that by all outpatient visits provided by hospitals with and without tele-ICU by HRR. HRRs represent regional health care markets for tertiary medical care.33 Weighting by total outpatient visits per HRR proxies for potential ICU need within a health care market. Weighting by outpatient visits was chosen as the proxy for potential ICU need to account for the relatively large proportion of outpatient health services provided by most rural hospitals. In 2018, the average rural hospital billed 74% of total charges for outpatient services, compared to only 53% for nonrural hospitals.

Other factors evaluated were ownership, region, total active beds, total ICU beds, total outpatient visits, total emergency department visits, full-time employees, and whether a hospital was rural, a critical access hospital (CAH), a major teaching hospital, or part of a health system. Ownership was categorized as private for-profit, private not-for-profit, and government-owned. Region was categorized in accordance with the US Census Bureau’s 4 statistical regions. Rurality was defined according to the criteria specified by the Federal Office of Rural Health Policy and other federal programs.16 Teaching status, system membership, staffed beds and ICU beds, outpatient and emergency visits, and total full-time personnel were reported by the hospital on the AHAAS. ICU beds was the summation of 5 types of ICU beds reported on the AHAAS: medical/surgical, cardiac, neonatal, pediatric, and other.

Results
In Table 1, we present descriptive statistics of hospitals by whether or not the hospital reported any tele-ICU capabilities in 2018. The first column depicts averages for all hospitals, in the second column are averages for hospitals that did not report having a tele-ICU, the third column presents averages for hospitals with a tele-ICU, and the fourth column shows P values for statistical differences between tele-ICU and nontele-ICU hospitals. Compared to hospitals without tele-ICUs, hospitals with tele-ICUs were more likely to be not-for-profit owned (87%-56%), nonrural (69%-48%), noncritical access (86%-66%), teaching hospitals (11%-4%) that were part of a system (89%-62%) in the Midwest (36%-29%) and were generally larger, in terms of the number of hospital beds, ICU beds, outpatient and emergency visits, and full-time employees. Tele-ICU hospitals were less likely to be for-profit owned (3%-19%) and in the South region (29%-39%). Seventy-seven hospitals had a tele-ICU but no ICU beds (unreported).

In Figure 1, we display the availability of a tele-ICU as a proportion of outpatient visits by HRR. In the map, darker shading represents a higher proportion of hospitals providing tele-ICU as a proportion of total outpatient visits. The orange blocks represent the latitude/longitude location of hospitals with tele-ICU, and the black stars represent those without tele-ICU. Of the 306 HRRs, 113 had zero hospitals with tele-ICU and 4 had all hospitals with tele-ICU. The median percent of hospitals with tele-ICU by HRR, weighted by outpatient visits, was 11.3%.

In Figure 2, we show the availability of tele-ICU at hospitals by state. The median percent of all hospitals within a state providing tele-ICU was 15%. Alabama had the lowest provision, with no hospitals (0%) having tele-ICU. Utah had the highest provision, with 51% of hospitals having tele-ICU.

In Figure 3, we limit the sample to only rural hospitals and show the availability of tele-ICU at rural hospitals by state. In the map, darker shading represents a higher proportion of rural hospitals within a state providing tele-ICU as a proportion of all rural hospitals in the state. The orange blocks represent the latitude/longitude location of
Figure 1: The Prevalence of Tele-ICUs as a Proportion of Outpatient Visits, by HRR.

Source: Authors' analysis of AHAAS 2018 Survey Data.
### Table 1 Unadjusted Hospital Characteristics, by Whether a Hospital Has a Tele-ICU

| Ownership Status (%) | No Tele-ICU Provision (N = 3,582) | Tele-ICU Provision (N = 706) | P       |
|----------------------|-----------------------------------|------------------------------|---------|
|                      | Mean (Standard Deviation) or %    |                              |         |
| Not-for-Profit       | 60.68                             | 55.53                        | 86.83   |
| For-Profit           | 16.81                             | 19.43                        | 3.54    |
| Government           | 22.5                              | 25.04                        | 9.63    |
| Rural (%)            |                                   |                              |         |
| Nonrural             | 51.89                             | 48.46                        | 69.26   |
| Rural                | 48.11                             | 51.54                        | 30.74   |
| CAH Status (%)       |                                   |                              |         |
| Non-CAH, PPS         | 69.29                             | 66.05                        | 85.69   |
| CAH                  | 30.71                             | 33.95                        | 14.31   |
| Region (%)           |                                   |                              |         |
| Northeast            | 12.36                             | 11.53                        | 16.57   |
| Midwest              | 30.43                             | 29.4                         | 35.69   |
| South                | 37.34                             | 39.06                        | 28.61   |
| West                 | 19.87                             | 20.02                        | 19.12   |
| Teaching Hospital (%)|                                   |                              |         |
| Nonteaching          | 94.59                             | 95.76                        | 88.67   |
| Teaching             | 5.41                              | 4.24                         | 11.33   |
| System Membership (%)|                                   |                              |         |
| No System            | 33.62                             | 37.91                        | 11.38   |
| System Member        | 66.38                             | 62.09                        | 88.62   |
| Total Beds (Active)  | 168.69 (207.92)                   | 154.56 (188.21)              | 240.35 (277.11) |
| Total ICU Beds       | 20.74 (39.32)                     | 17.64 (35.09)                | 36.47 (53.42) |
| Total Outpatient Visits | 1.7e+05 (2.7e+05)               | 1.5e+05 (2.4e+05)            | 2.5e+05 (4.0e+05) |
| Total Emergency Visits | 3.086.28 (36.869.18)            | 29.523.66 (34.240.81)        | 45.088.17 (45.912.66) |
| Total Full-time Personnel | 963.89 (1,702.12)              | 850.92 (1,472.51)            | 1,537.06 (2,492.00) |

*p* values by t-test for continuous variables and chi² test for binary/categorical variables.

*P* < .05, **P** < .01, ***P*** < .001.

Source: Authors’ analysis of AHAAS 2018 Survey Data and Cost Report Data.

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Rural hospitals with tele-ICU, and the black stars represent rural hospitals without tele-ICU. Of the 50 states, 47 had at least 1 rural hospital (Delaware, New Jersey, Rhode Island, and the District of Columbia had no rural hospitals). Of those 47 states, 41 had at least 1 rural hospital that provided tele-ICU (Alabama, Alaska, Connecticut, Maryland, Massachusetts, and Michigan had no rural hospitals providing tele-ICU). Of those 41 states, 24 had less than 10% of all rural hospitals providing tele-ICU services (Louisiana was the lowest with 2%), and Utah had the highest rate with over 50% of all rural hospitals providing tele-ICU services.

**Discussion**

Our findings reveal 2 critical insights about tele-ICU that are relevant to hospital decision makers (eg, boards and executives), political decision makers, and future research. One, there is a wide variation in tele-ICU availability across geographic regions. And, 2, hospital factors are very strongly associated with tele-ICUs.

Our most important set of findings shows the prevalence of tele-ICU nationally by HRR (Figure 1), by state (Figure 2), and by rurality (Figure 3). Those findings showed wide variation in the provision of teleintensive care. For example, over one-third of HRRs had no tele-ICUs, while 4 had 100% of hospitals with tele-ICUs. At the state level, Utah had over 50% of hospitals with tele-ICUs, while Alabama had no hospitals with tele-ICUs. Also, the map shows geographic clustering of areas with no tele-ICUs, such as Alabama/western Tennessee and west Texas. When limited to rurality (Figure 3) at the state level, there was also wide variation in tele-ICU adoption. Six states had no tele-ICU provision among rural hospitals, and most states had less than 10% tele-ICU provision among rural hospitals, but Utah had over 50% tele-ICU provision among rural hospitals. These may be areas of focus for future tele-ICU networks.
The second most important finding is that we determined the types of hospitals with tele-ICUs. Knowing that larger, not-for-profit owned, nonrural, noncritical access, teaching hospitals that were part of a health system in the Midwest were more likely to have a tele-ICU suggests that many hospitals with tele-ICUs already have ICU capacity. Also, identifying 77 hospitals that had tele-ICU but did not have any ICU beds may highlight a use for tele-ICU in settings where higher levels of care are needed for emergency or acute medical/surgical services. One limitation of our data is that we do not know if a tele-ICU hospital is the hub, providing tele-ICU to other hospitals, or the spoke, receiving the teleintensive care from the hub. These findings remain helpful to identify what types of hospitals provide teleintensive care. Future work should build upon these findings to determine whether a hospital is the hub or the spoke provider.23,34

Taken together, our findings can benefit a variety of stakeholders. The relatively fewer rural, CAHs in the South providing teleintensive care suggest that, if tele-ICUs are an effective care delivery mechanism, there is room to improve teleintensive access in many rural areas. Consider the disparity in adoption between Utah and Alabama. Both states have a higher-than-average rural population; so, such a discrepancy merits further investigation.

COVID-19 has led to the most sweeping expansion of federal and state telehealth reimbursement in history.35–37 A multitude of parties will be evaluating those expansions for some time. For rural hospital decision makers, considering the continuation, expansion, or addition of tele-ICU, there are a host of factors to consider beyond the scope of this paper. For example, the presence of tele-ICUs does not indicate the local availability of ventilators, or medical staff. So, providing tele-ICU may suggest the availability of only some structural components necessary to deliver teleintensive services. This research sheds light on hospitals that are providing teleintensive care and may aid in decision making. For policy makers, these findings may be useful when evaluating incentives to expand tele-ICU nationally. For researchers, baseline tele-ICU knowledge from this paper may benefit future evaluations of the health and financial impact of COVID-19 and the associated reimbursement changes for many years to come.

**Conclusion**

Tele-ICUs may be important to access-to-care, particularly during times of a pandemic such as COVID-19. We identified the types of hospitals with tele-ICUs and showed the geographic prevalence of tele-ICUs by HRRs and state. We found that larger, not-for-profit, nonrural, noncritical access, teaching hospitals that were part of a health system, particularly in the Midwest, were more likely to have tele-ICUs. We also found wide variation in the prevalence of tele-ICUs across HRRs and states. Future work should continue the evaluation of tele-ICU effectiveness.
Figure 3
The Prevalence of Tele-ICU at Rural Hospitals as a Proportion of Total Rural Hospitals, by State.

Source: Authors' analysis of AHAAS 2018 Survey Data.
and, if favorable, explore the variation we identified for improved access to teleintensive care.

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