Society of Critical Care Medicine
The Intensive Care Professionals

U.S. ICU Resource Availability for COVID-19

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SCCM Ventilator Taskforce

With the onset of COVID-19,[1] and the strong possibility of large percentages of the U.S. population being admitted to the hospital and intensive care unit (ICU), the Society of Critical Care Medicine (SCCM) has updated its statistics on critical care resources available in the United States.[2] Our goal is to provide information regarding the resources both available and needed to care for a potentially overwhelming number of critically ill patients, many of whom may require mechanical ventilation.[1] In this report, we address the most current data and estimates on the number of acute care, ICU, and step-down (eg, observation, progressive) beds; ICU occupancy rates; mechanical ventilators; and staffing. We also seek to provide context to the data.

Acute care hospitals, ICU, step-down, and burn beds: The American Hospital Association (AHA) maintains a proprietary dataset of most hospitals in the United States. Data is gathered by voluntary survey. In April 2019, a study published in *Critical Care Medicine* analyzed the 2015 AHA data.[3] For this current report, we extended the analysis from that publication using the most currently available 2018 AHA data and noting minimal changes from 2015.[4] The 2018 AHA data indicate that there are 5256 AHA-registered community hospitals in the United States. Of these, 2704 (51.4%) deliver ICU services (**Figure 3**). These hospitals have 534,964 staffed (operational) acute care beds, including 96,596 ICU beds (**Table 1**), accounting for a median 16.7% of all hospital beds. The ICU beds can be categorized as adult, pediatric, or neonatal. There are 68,558 adult beds (medical-surgical 46,795, cardiac 14,445, and other ICU 7318), 5137 pediatric ICU beds, and 22,901 neonatal ICU beds. Additionally, there are 25,157 step-down beds, and 1183 burn beds. The proportion of ICU beds that are capable of negative pressure isolation is not recorded in the AHA dataset. The purpose of a negative pressure room is to confine pathogens to a single closed environment and to prevent the release of pathogens into other adjacent spaces. Negative pressure is strongly recommended with heavily communicable diseases such as COVID-19. When negative pressure rooms are not available, HEPA filters are installed in exhaust ducts leading from rooms with infected patients or patients needing isolation are cohorted together (often in separate locations) to facilitate safe and effective patient care.[5]

Acute care hospitals by core-based statistical area (CBSA): Of the 2704 U.S. hospitals with ICU services, 74% (1996) are in metropolitan areas (> 50,000 population), 17% (464) are in micropolitan areas (10,000-49,999 population), and the remaining 9% (244) are in rural areas (< 10,000 population) (**Table 2**). Concomitantly, 91% (489,337) of acute care beds and 94% (90,561) of ICU beds are in metropolitan hospitals. Only 7% (36,453) of hospital beds and 5% (4715) of ICU beds are in micropolitan areas. Two percent of acute care hospital beds and 1% of ICU beds are in rural areas.

ICU occupancy rates: We have focused on U.S. ICU, step-down, and burn beds as documented by the AHA. ICU bed utilization and occupancy rates, however, are not tracked by the AHA. Instead such data can be calculated from the Healthcare Cost Report Information System (HCRIS), a Centers for Medicare and Medicaid Services dataset composed of the Cost Reports submitted by every Medicare-certified hospital.[6] ICU occupancy rates in in acute

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care hospitals in 2010 (the most recent data available) are 66.6% in adult units, 61.6% in pediatric units and 67.7% in neonatal units.[7] ICU occupancy rates are known to be higher in larger hospitals than in smaller hospitals. For contextual purposes, the occupancy rates do not reflect temporal or seasonal variations.

Contingency and crisis beds for critically ill patients: The outbreak of COVID-19 has generated concern that critically ill patients may overwhelm existing ICU bed availability. When contingency plans are implemented and elective surgeries and procedures are cancelled, ICU beds normally used to provide perioperative support would become available to provide COVID-19 care, as would operating rooms (with ventilators) and post-anesthesia care unit beds.[8] Additional monitored hospital beds such as step-down unit beds may also be drafted into ICU service. At crisis levels, even non-monitored hospital beds may be mobilized but a significant investment of ICU-level facility infrastructure (eg oxygen, gas, power, drainage), devices (eg, mechanical ventilators, crash carts) and staff uptraining would be required. Making facility changes on this scale can take significant time and cause serious operational disruption at a time when those beds are most needed.

Beyond adjusting distribution and usage of existing hospital beds, there are a host of other options. In China, the government rapidly constructed hospitals solely for COVID-19 patients. This could be done in the United States. Local governments can also consider regionalizing or cohorting their critically ill COVID-19 patients into designated high-acuity large medical centers. The benefit of this approach is that these medical centers already have great numbers of well-equipped ICU and step-down beds and trained staff, thereby leaving the remaining hospitals to care for non-COVID-19 critically ill patients. Additionally, opening previously shuttered hospital facilities or medical wards and updating their supportive utilities (eg, power, data, air, oxygen, and suction) should be considered. Retrofitting existing nonmedical buildings (eg, hotels, dormitories) into COVID-19 care facilities has also been suggested, although this would be a very labor-intensive and expensive undertaking. These choices may be affected by a shortage of supportive medical devices and administrative and clinical staff.

The U.S. government has additional resources such as the USNS Mercy (T-AH-19) and USNS Comfort (T-AH-20), which can be deployed to assist in coastal areas. Each of these hospital ships contains 12 fully equipped operating rooms, a 1000-bed hospital facility (including 80 intensive care beds, 20 surgical recovery beds, and 280 intermediate-care [step-down] beds), digital radiologic services, medical laboratory, pharmacy, optometry laboratory, CT capability, and two oxygen-producing plants. Each ship is equipped with a helicopter deck capable of landing large military helicopters. The ships have side ports to take on patients at sea. Their crew comprises 71 civilians and up to 1200 Navy medical and communications personnel when operating at full capacity.[9]

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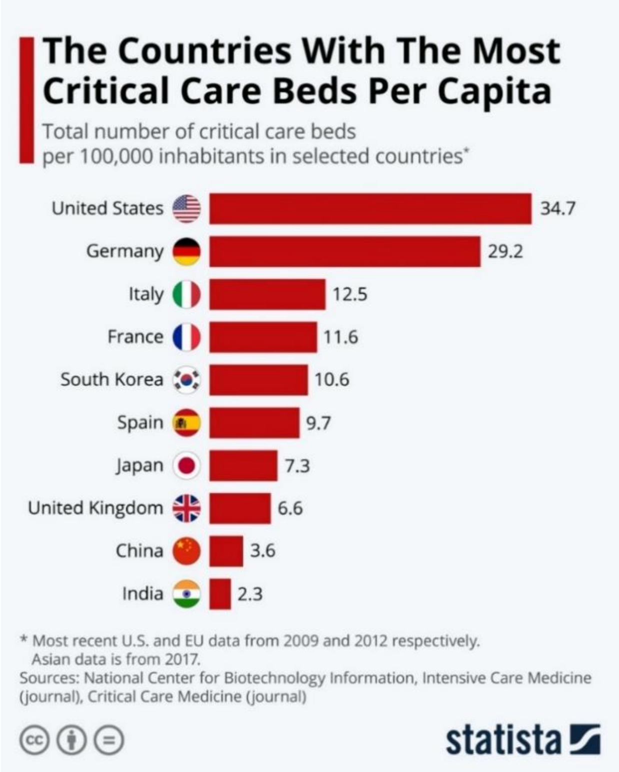
Comparison of U.S. critical care beds to other countries. The United States has a significant number of critical care beds per capita as compared to other countries (**Figure 1**).

Figure 1. Countries With the Most Critical Care Beds per Capita



Mechanical ventilators: Reports from ICUs worldwide suggest that the most common reason for COVID-19 patient admission to the ICU is severe hypoxic respiratory failure requiring mechanical ventilation.

Supply of mechanical ventilators in U.S. acute care hospitals: Based on a 2009 survey of AHA hospitals, U.S. acute care hospitals are estimated to own approximately 62,000 full-featured mechanical ventilators.[10,11] Approximately 46% of these can be used to ventilate pediatric and neonatal patients. Additionally, some hospitals keep older models for emergency purposes. Older models, which are not full featured but may provide basic functions, add an additional 98,738 ventilators to the U.S. supply.[10] The older devices include 22,976 noninvasive ventilators, 32,668 automatic resuscitators, and 8567 continuous positive airway pressure units.

Centers for Disease Control and Prevention Strategic National Stockpile (SNS) and other ventilator sources: The SNS has an estimated 12,700 ventilators for emergency deployment, according to recent public announcements from National Institutes of Health officials.[12] These devices are also not full featured but offer basic ventilatory modes. In simulation testing they performed very well despite long-term storage.[13] Accessing the SNS requires hospital administrators to request that state health officials ask for access to this equipment. SNS can deliver ventilators within 24-36 hours of the federal decision to deploy them. States may have their own ventilator stockpiles as well.[14] Respiratory therapy departments also rent ventilators from local companies to meet either baseline and/or seasonal demand, further expanding their supply. Additionally, many modern anesthesia machines are capable of ventilating patients and can be used to increase hospitals' surge capacity.

The addition of older hospital ventilators, SNS ventilators, and anesthesia machines increases the absolute number of ventilators to possibly above 200,000 units nationally. Many of the additional and older ventilators, however, may not be capable of sustained use or of adequately supporting patients with severe acute respiratory failure. Also, supplies for these ventilators may be unavailable due to interruptions in the international supply chain. Alternatively, ventilator manufacturers could be encouraged to rapidly produce modern full-featured ventilators to allow experienced clinicians to use supplemental ventilators that are familiar to them and can be readily incorporated into the hospital ventilator fleet and informatics systems. An analysis of the literature suggests, however, that U.S. hospitals could absorb a maximum of 26,000 to 56,000 additional ventilators at the peak of a national pandemic, as safe use of ventilators requires trained personnel.[15]

Estimates of hospitalized patients requiring critical care and mechanical ventilation: The U.S. Department of Health and Human Services estimated in 2005 that 865,000 U.S. residents would be hospitalized during a moderate pandemic (as in the 1957 and 1968 influenza pandemics) and 9.9 million during a severe pandemic (as in the 1918 influenza pandemic).[16] A recent AHA webinar on COVID-19 projected that 30% (96 million) of the U.S. population will test positive, with 5% (4.8 million) being hospitalized. Of the hospitalized patients, 40% (1.9 million) would be admitted to the ICU, and 50% of the ICU admissions (960,000) would require ventilatory support.[17] Such projections, however, are gross estimates. Some assumptions underlying these projections are uncertain, and the pacing of a large outbreak would influence whether ICU resources in isolated locations or nationally are severely taxed over many months or quickly overwhelmed over a shorter period. Additionally, COVID-19 patients may remain mechanically ventilated for indeterminate periods of time, with some developing prolonged or chronic critical illness requiring the extended use of ICU beds, ventilators, supplies, and trained clinicians.

Staffing to care for critically ill patients: As large numbers of critically ill patients are admitted to ICU, step-down, and other expansion beds, it must be determined who will care for them. Having an adequate supply of beds and equipment is not enough. Based on AHA 2015 data, there are 28,808 intensivists who are privileged to deliver care in the ICUs of U.S. acute care hospitals. Intensivists are physicians with training in one of several primary specialties (eg, internal medicine, anesthesiology, emergency medicine, surgery, pediatrics) and additional specialized critical care training. However, 48% of acute care hospitals have no intensivists on their staffs.[3] Based on the demands of the critically ill COVID-19 patient, the intensivist deficit will be strongly felt. Additionally, there are an estimated 34,000 critical care advanced practice providers (APPs) available to care for critically ill patients.[18] Other physicians with hospital privileges, especially those with previous exposure to critical care training or overlapping skill sets, may be pressed into service as outpatient clinics and elective surgery are suspended. All other ICU staff (eg, APPs, nurses, pharmacists, respiratory therapists) will also be in short supply. Without these key members of the ICU team, high-quality critical care cannot be adequately delivered. Moreover, an indeterminate number of experienced ICU staff may become ill, further straining the system as need and capacity surge.

At forecasted crisis levels, we estimate that the projected shortages of intensivists, critical care APPs and nurses, and respiratory therapists trained in mechanical ventilation would limit care of critically ill ventilated patients.[15] Therefore, priority should focus not only on increasing the numbers of mechanical ventilators, but on growing the number of trained professionals, for both the near and long term, who will be needed to both mechanically ventilate patients with COVID-19 and to care for other critically ill patients who will require ICU care.

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Augmenting critical care staffing: SCCM encourages hospitals to adopt a tiered staffing strategy in pandemic situations such as COVID-19 **(Figure 2)**. Hospitals with telemedicine capacity may also use the technology to connect with expert resources at other locations.

Figure 2. Tiered Staffing Strategy for Pandemic

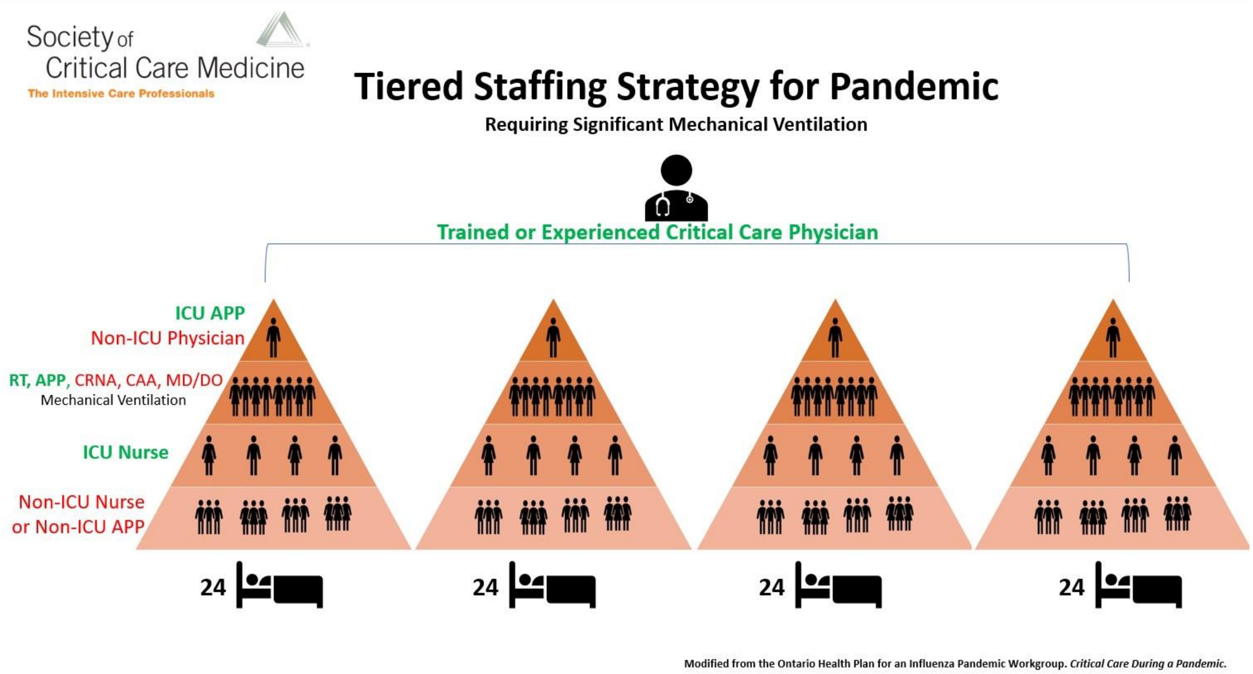

Figure 2 Note: *In the crisis model presented here, a physician who is trained or experienced in critical care and who regularly manages ICU patients, oversees the care of four groups of 24 patients each. A non-ICU physician (eg, anesthesiologist, pulmonologist, hospitalist), who ideally has some ICU training but who does not regularly perform ICU care, is inserted at the top of each triangle. This non-ICU physician extends the trained or experienced critical care physician's knowledge, while working alongside APPs who regularly care for ICU patients. Similarly, to augment the ability to mechanically ventilate more patients, experienced ICU respiratory therapists and APPs are amplified by adding clinicians such as physicians (either MD or DO), nurse-anesthetists, and certified anesthesiologist assistants who are experienced in managing patients' ventilation needs*

The model above, originally developed by the Ontario Health Plan for an Influenza Pandemic, was adapted for SCCM's Fundamental Disaster Management program as an effective strategy to incorporate non-ICU-trained staff of all disciplines (physicians, nurses, APPs, and others [in red] to greatly augment the trained and experienced ICU staff [in green]). While pharmacists, dietitians, rehabilitation specialists, and other professionals are also key members of the ICU team, this model speaks to staff needed to address a pandemic requiring a dramatic increase in need for mechanical ventilation. As elective procedures are curtailed, experienced perioperative clinical staff (eg, anesthesiologists, certified registered nurse anesthetists, operating room and post-anesthesia care unit

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nurses) may be available to support critical care services in hospitals with and without intensivists. The operating room and perioperative teams may be especially valuable if operating rooms or post-anesthesia care unit beds are converted to ICU beds, or if operating room ventilators are moved to other venues to supplement the limited supply of mechanical ventilators. While this model focuses specifically on hospitals with intensivists, 48% of U.S. hospitals have no intensivists.[3] In these hospitals, the critical care team may be directed by anesthesiologists, pulmonologists, hospitalists, or others with experience caring for critically ill patients. This model recommends adding staff dedicated to the management of multiple ventilators, while other staff (experienced and additive) support the patient overall. While the ratios shown in the figure depict generally accepted models of critical care staffing augmentation, each hospital will need to adjust to its own demands for critical care while using its available supply of personnel. While the level of care may not be the same as in the typical ICU in non-crisis times, having care directed by trained and experienced intensivists or others with critical care clinical experience is an effective way to maximize care for large numbers of critically ill patients. SCCM offers free online training resources (sccm.org/covid19) to help these non-typical ICU staff as they prepare to care for critically ill patients during a pandemic crisis.

Resources may be overwhelmed: Hospitals and their critical care organizations must include in their pandemic resource planning an ethical and legal approach to triage and resource allocation that would be activated only if the pandemic is perceived to be overwhelming the hospital's surge capacity strategies.[8,19,20] It is crucial that all staff have full access to the pandemic resource plan and know in advance who will help guide difficult decisions if the plan is activated. Topics that must be considered are the potential for unfair allocation of treatment, use of experimental interventions, and the conduct of medical research at times of healthcare crisis. SCCM provides guidance in its Ethics of Outbreaks Position Statement.[21]

Interconnectedness: It should be apparent to the reader that all hospital and ICU resources discussed in this report are interconnected and cannot work independently. Each of the three domains, ICU beds, ventilators, and critical care staff, are an essential component of the resources to manage a COVID-19 pandemic. For example, if a hospital has mechanical ventilators but not appropriate staff to operate them, the ventilators are not useful for patient care. Simply adding more of one resource element without considering the interconnectedness of the healthcare system's many assets is unwise and potentially unsafe in planning for or managing a pandemic such as COVID-19.

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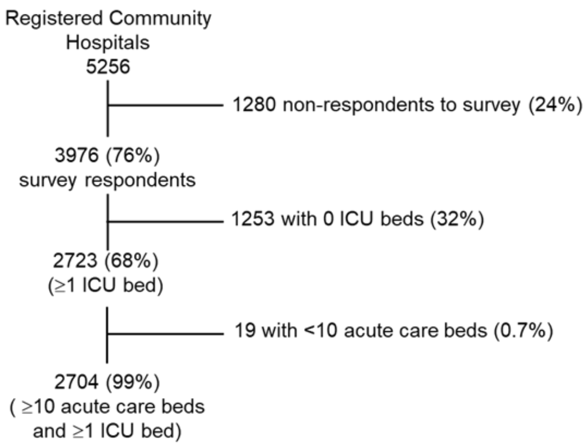
Figure 3. AHA 2018 Data



In 2018, there were 5256 AHA-registered community hospitals. Of these, 3976 (76%) responded to the AHA survey. Of these, 2704 met our criteria for acute care hospitals that deliver critical care services. Only a minority of Department of Veterans Affairs and Department of Defense hospitals participate in the AHA survey; none were included in this report because they were not classified as community hospitals by the AHA.

Table 1. Acute Care Hospitals (2018 AHA Data)

	Hospitals Combined (n = 2704)
Aggregate across all hospitals, n (%)	
Number of acute care hospital beds[a]	534,964
Number of ICU beds	96,596
Number of ICU units[b]	5039
Number of ICU beds by unit type[a]	
Medical-surgical	46,795
Cardiac	14,445
Other	7318
Pediatric	5137
Neonatal	22,901
Number of burn beds[c]	1183
Number of other special care (observation, step-down, or progressive) beds[c]	25,157

a. Acute care hospital beds include general medical and surgical adult, pediatric, obstetric, neonatal intermediate, ICU, step-down, and burn beds. Rehabilitation, alcohol/drug abuse or dependency, psychiatric, skilled nursing facility, intermediate nursing, and other long-term beds are excluded.
b. Units refers to the number of hospitals reporting more than one bed per ICU type. Each hospital can have a maximum of five AHA-designated ICU types.

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c. Burn and other special care beds (observation, step-down, progressive) are not commonly counted in the ICU bed totals.

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Table 2. Acute Care Hospitals and Beds by Core-Based Statistical Area (AHA 2018 Data)

	Hospitals Combined (n = 2704)
Number of hospitals by location, n (%):[a]	
Metropolitan	1996 (74%)
Micropolitan	464 (17%)
Rural	244 (9%)
Aggregate across all hospitals, n (%)	
Number of hospital beds by location:	
Metropolitan	489,337 (91%)
Micropolitan	36,453 (7%)
Rural	9174 (2%)
Number of ICU beds by location:	
Metropolitan	90,561 (94%)
Micropolitan	4715 (5%)
Rural	1320 (1%)

a. Metropolitan areas: > 50,000 population, micropolitan areas: 10,000-49,999 population, rural areas: < 10,000 population.

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