Outcomes of Patients With Coronavirus Disease 2019 Receiving Organ Support Therapies: The International Viral Infection and Respiratory Illness Universal Study Registry

OBJECTIVES: To describe the outcomes of hospitalized patients in a multicenter, international coronavirus disease 2019 registry.

DESIGN: Cross-sectional observational study including coronavirus disease 2019 patients hospitalized with laboratory-confirmed severe acute respiratory syndrome coronavirus-2 infection between February 15, 2020, and November 30, 2020, according to age and type of organ support therapies.

SETTING: About 168 hospitals in 16 countries within the Society of Critical Care Medicine's Discovery Viral Infection and Respiratory Illness University Study coronavirus disease 2019 registry.

PATIENTS: Adult hospitalized coronavirus disease 2019 patients who did and did not require various types and combinations of organ support (mechanical ventilation, renal replacement therapy, vasopressors, and extracorporeal membrane oxygenation).

INTERVENTIONS: None.

MEASUREMENTS AND MAIN RESULTS: Primary outcome was hospital mortality. Secondary outcomes were discharge home with or without assistance and hospital length of stay. Risk-adjusted variation in hospital mortality for patients receiving invasive mechanical ventilation was assessed by using multilevel models with hospitals as a random effect, adjusted for age, race/ethnicity, sex, and comorbidities. Among 20,608 patients with coronavirus disease 2019, the mean (± sd) age was 60.5 (±17), 11,1887 (54.3%) were men, 8,745 (42.4%) were admitted to the ICU, and 3,906 (19%) died in the hospital. Hospital mortality was 8.2% for patients receiving no organ support ($n = 15,001$). The most common organ support therapy was invasive mechanical ventilation ($n = 5,005$; 24.3%), with a hospital mortality of 49.8%. Mortality ranged from 40.8% among patients receiving only invasive mechanical ventilation ($n = 1,749$) to 71.6% for patients receiving invasive mechanical ventilation, vasoactive drugs, and new renal replacement therapy ($n = 655$). Mortality was 39% for patients receiving extracorporeal membrane oxygenation ($n = 389$). Rates of discharge home ranged from 73.5% for patients who did not require organ support therapies to 29.8% for patients who only received invasive mechanical ventilation, and 8.8% for invasive mechanical ventilation, vasoactive drugs, and renal replacement; 10.8% of patients older than 74 years who received invasive mechanical ventilation were discharged home. Median hospital length of stay for patients on mechanical ventilation was 17.1 days (9.7-28 d). Adjusted interhospital variation in mortality among

Juan Pablo Domecq, MD[1]

Amos Lal, MBBS[2]

Christopher R. Sheldrick, PhD[3]

Vishakha K. Kumar, MD, MBA[4]

Karen Boman[4]

Scott Bolesta, PharmD[5]

Vikas Bansal, MBBS, MPH[2]

Michael O. Harhay, PhD[6]

Michael A. Garcia, MD[7]

Margit Kaufman, MD[8]

Valerie Danesh, PhD, RN[9,10]

Sreekanth Cheruku, MD, PhD[11]

Valerie M. Banner-Goodspeed, MPH[12]

Harry L. Anderson III, MD[13]

Patrick S. Milligan, MD[14]

Joshua L. Denson, MD, MSc[15]

Catherine A. St. Hill, DVM, PharmD[16]

Kenneth W. Dodd, MD[17,18]

Greg S. Martin, MD, MSc[19]

Ognjen Gajic, MD[2]

Allan J. Walkey, MD, MSc[7]

Rahul Kashyap, MBBS, MBA[20]

patients receiving invasive mechanical ventilation was large (median odds ratio 1.69).

CONCLUSIONS: Coronavirus disease 2019 prognosis varies by age and level of organ support. Interhospital variation in mortality of mechanically ventilated patients was not explained by patient characteristics and requires further evaluation.

KEY WORDS: big data; coronavirus disease 2019; intensive care unit; organ failure; patients; severe acute respiratory syndrome coronavirus 2; Viral Infection and Respiratory Illness University Study

Coronavirus disease 2019 (COVID-19) was declared a global pandemic on March 11, 2020, and has resulted in almost 2,000,000 deaths worldwide as of January 2021 (1). The most severe forms of COVID-19 often lead to critical illness due to respiratory failure, often requiring invasive mechanical ventilation (IMV) and, potentially, multiorgan system failure (2–6). However, given that most studies of COVID-19 outcomes are single-center case series (2, 5, 7), robust clinically informative prognostic information for hospitalized patients according to types of organ supportive therapies remains unclear. Mortality of mechanically ventilated patients with COVID-19 reported in single- and multicenter studies from Italy, the United States, Germany, and the United Kingdom has ranged from 19% to 75% (8–10). The prognostic information based on the type of organ support required and the likelihood of discharge home in different age groups have not been clear for patients with COVID-19. We sought to describe patient outcomes among hospitalized patients receiving commonly used organ supportive therapies in a multicenter, international COVID-19 registry.

MATERIALS AND METHODS

Study Population, Setting, and Data Collection

In response to the COVID-19 pandemic, Discovery, the Critical Care Research Network formed by the Society of Critical Care Medicine in 2016, provided a centralized platform and resources for clinical investigators to scale up research in critical care. The initiative led to the creation of the Viral Infection and Respiratory Illness Universal Study (VIRUS) (11), which is an HIPAA compliant multinational database developed to capture deidentified clinical information as well as daily physiologic, laboratory, and treatment information collected. Individual study investigators will be able to use the pooled data for ancillary research questions.

We enrolled hospitalized patients 18 years old or older with laboratory-confirmed COVID-19 infection, at 168 (150 from the United States) academic, community, or private hospitals in 16 countries between February 15, 2020, and November 30, 2020 (**Supplemental Table 1**, http://links.lww.com/CCM/G128). Patients below 18 years old, with no recorded discharge status, and participants that did not have research authorization to access medical records were excluded. Patients were followed until hospital discharge or death whichever came first. A confirmed case of COVID-19 was defined by a positive result on a reverse-transcriptase–polymerase-chain-reaction assay. The registry was granted exempt status for human subject research by the Institutional Review Board at Mayo Clinic (20-002610). The ClinicalTrials.gov number is NCT04323787. Each study site submitted a proposal to their local review boards for approval and signed a data use agreement before being granted permission to extract and enter deidentified data into the registry.

Data Collection

We included data elements common to prior COVID-19 registry work, using the World Health Organization COVID-19 case report forms (CRFs) (12) as a starting template. Data elements for inclusion were selected to capture elements of COVID-19 diagnosis, patient demographics, chronic comorbidities, acute illness characteristics, and details of critical care interventions and outcomes. Electronic CRFs (**Supplemental Table 2**, http://links.lww.com/CCM/G129) were then constructed using Research Electronic Data Capture (13), a secure web-based software and workflow methodology for electronic collection and management of research data. Study personnel at each site collected data into CRFs by manual review of electronic or paper medical records. All diagnostic and therapeutic management decisions were performed at the discretion of the treating physician. We ensured data prioritization, integrity, and maintained bidirectional open lines of communication between the study sites

and central registry organization by having weekly remote training online meetings with clinical research coordinators/data abstractors at participating study sites globally (14). After obtaining patients' data, we performed quality checks for adherence to the study protocol and accuracy of data collection methods. Then, we reviewed missing data weekly and contacted sites with high rates of missing data points. Finally, we performed multistep data cleaning, looking for field entries out of range or proper data type, with iterations to contact sites for correction of errant data.

Outcome Measures and Exposure of Interest

Primary outcome was hospital mortality. Secondary outcomes were discharge home with or without assistance and total hospital length of stay (LOS). The outcomes are reported based on the types of organ support therapies provided. We focused on the following: no organ support therapies, need for IMV, use of vasopressors and/or inotropes (i.e., vasoactive drugs), new renal replacement therapy (RRT), and extracorporeal membrane oxygenation (ECMO).

Statistical Analysis

Continuous data were summarized as mean (sd) or median (interquartile range [IQR], 25–75%) and categorical variables as n (%).

Due to the strong association between age and prognosis for patients with COVID-19 (15), we stratified analyses of outcomes by age: 18–44 years, 45–59 years, 60–74 years, and 75 years and above. We provided hospital mortality rates by age and different types of organ supportive therapies.

Risk-adjusted variation in hospital mortality (for hospitals entering $n > 10$ patients into the registry) for patients receiving IMV was assessed by using multilevel models with hospitals as a random effect, adjusted for age, race/ethnicity, sex, and comorbidities (**Supplemental Table 3**, http://links.lww.com/CCM/G130). The variance from the random effects output was used to calculate the intraclass correlation coefficient (ICC = $V_A/[V_A+\pi^2/3]$)—an estimate of the variation explained by the hospital random effect, as well as the median odds ratio (MOR = exp $[\sqrt{(2*V_A)}*0.6745]$, the median increased odds of death that a patient would have moving from a randomly selected lower to higher risk hospital (16). Variation

in hospital mortality was calculated from the random effects output beta estimate for each hospital. In a post hoc exploratory analysis of potential factors associated with hospital variation in mortality among patients requiring mechanical ventilation, we added Sequential Organ Failure Assessment (SOFA) score quartile at ICU admission, hospital case volume of mechanically ventilated patients with COVID-19, and country (United States vs not United States) to the base model adjusted for age, race, sex, and comorbidities. Missing data were coded as missing and included in models as a missing category. Statistical analyses were performed by using SAS (Version 9.1, SAS Institute, Cary, NC). The analyses were conducted by C.R.S. and A.J.W. with input from the VIRUS registry investigators group.

RESULTS

Patient Characteristics at Baseline

Among 49,058 patients enrolled in the VIRUS registry at the time of data extraction, 20,608 met eligibility criteria and were included in the analysis (**Fig. 1**). **Table 1** demonstrates the characteristics of patients included in this study, with mean (± sd) age 60.5 (±17), 54.3% of patients men, and 50.4% White, 25.9% Black, and 5.6% Hispanic; 87% of patients had at least one comorbid condition and 42.4% required ICU admission.

Hospital Mortality and Need for Organ Support Therapies

The overall mortality in the hospitalized cohort was 19% ($n = 3,906$). The most commonly used invasive organ support therapy was IMV ($n = 5,005$, 24.3%) either alone or in combination with the other organ support therapies; 602 patients (2.9% of the total sample) required vasoactive drugs and/or RRT without IMV. The mortality rate among patients ($n = 15,001$) who did not receive organ support therapies was 8.2% ($n = 1,226$). The mortality associated with IMV was 49.8% ($n = 2,494$) and ranged from 40.8% ($n = 714$) among patients who only received mechanical ventilation to 71.6% ($n = 469$) among patients who received IMV, vasoactive drugs, and RRT (**Fig. 2**; and **Supplemental Table 4**, http://links.lww.com/CCM/G131). Mortality was 35% ($n = 136$) among patients who received ECMO. The lowest mortality less than 1% was observed among hospitalized patients younger than 45 years old who did not receive organ supportive
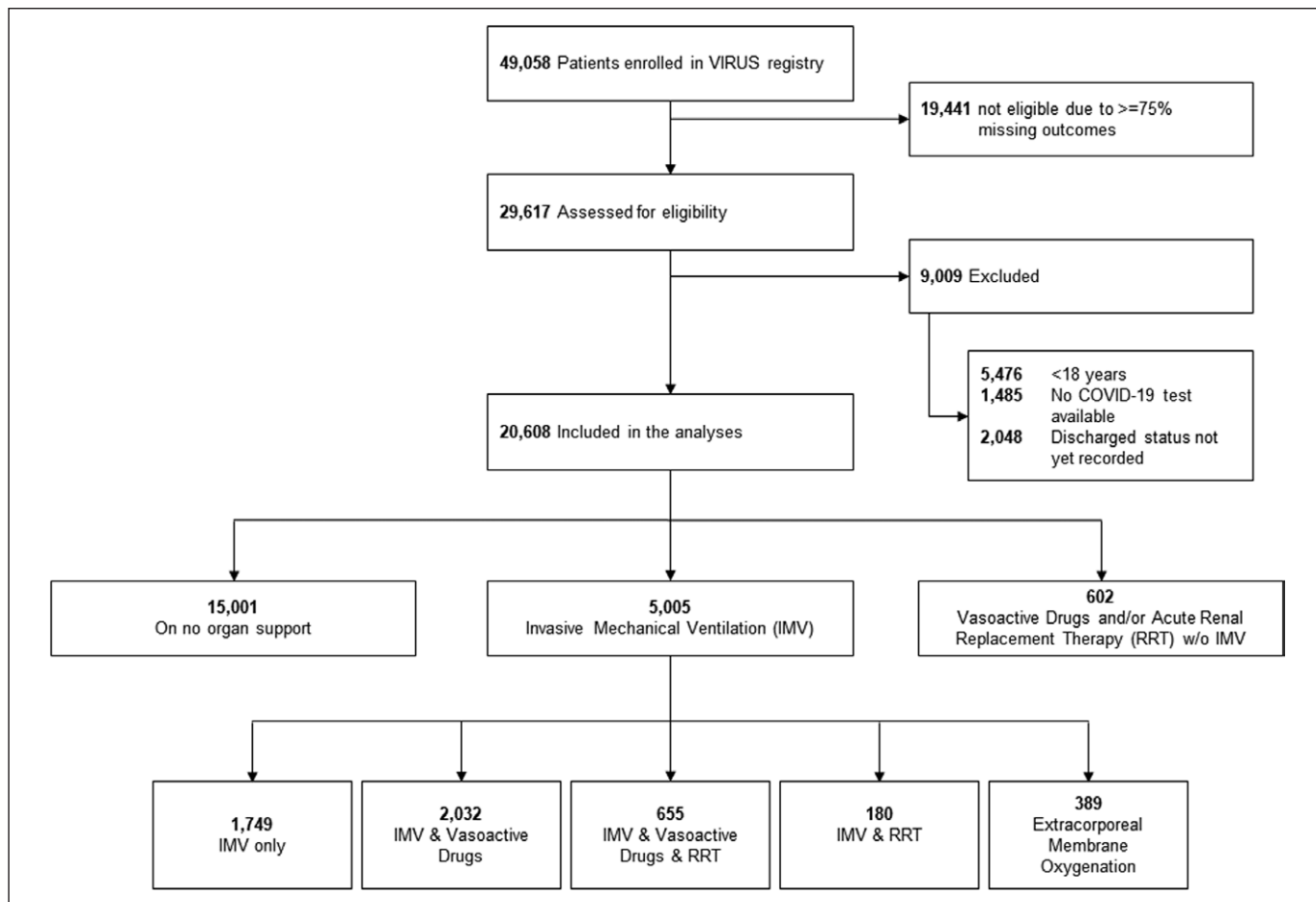
Figure 1. Included patients flowchart. COVID-19 = coronavirus disease 2019, IMV = invasive mechanical ventilation, RRT = renal replacement therapy.

therapies, and the highest mortality (78.3%; $n = 83$) was observed among patients older than 74 years receiving a combination of IMV, vasoactive drugs, and RRT.

Secondary Outcomes

The rate of discharge home (Table 2) from hospitalization with COVID-19 among patients who did not receive organ support therapies was 73.5% ($n = 8,900$). For patients who received IMV, 24.2% ($n = 1,150$) were discharged home, with a range of 29.8% ($n = 467$) for those who only received IMV to 10% (95% CI, 8–14) for those who received the combination of IMV, vasoactive drugs, and RRT, and 41.2% ($n = 152$) for those who received ECMO. There was a very small number of patients ($n = 602$) who received vasoactive drugs and/or renal replacement without IMV.

The median ICU LOS was 7 days (IQR, 4–14 d). The median hospital LOS (**Supplemental Table 5**, http://links.lww.com/CCM/G132) (IQR) ranged from

6 days (3-10 d) among patients who did not receive organ supportive therapies to 21.4 days (9.6-38 d) among patients receiving ECMO. The median duration of IMV was 8.8 days (IQR,3.3-17 d). The overall hospital LOS for patients on IMV was 17.1 days (IQR, 9.7-28 d).

Mortality Variation of Mechanically Ventilated Patients Across Hospitals

Among the 5,005 patients on IMV (**Supplemental Table 6**, http://links.lww.com/CCM/G133), we examined the variation in hospital mortality for 4,749 patients receiving IMV across 84 hospitals enrolling more than 10 patients requiring IMV, in 12 countries. Risk-adjusted hospital mortality rates for invasive mechanically ventilated patients ranged from 27.7% to 77.9% (**Fig. 3**), with an MOR of 1.69 for the adjusted effect of a higher versus lower mortality hospital of admission. An ICC of 8.5% was observed, showing that approximately 10% of the variation in mortality was

TABLE 1.

Demographic and Clinical Characteristics Among Hospitalized Patients With Coronavirus Disease 2019 Stratified According to Age

	All Adults	18–44 yr	45–59 yr	60–74 y	75+ yr
n	20,608	3,986	5,300	6,491	4,831
Male sex, n (%)	11,187 (54.3)	2,016 (50.6)	3,139 (59.2)	3,723 (57.4)	2,309 (47.8)
Not reported	253 (1.2)	45 (1.1)	66 (1.3)	73 (1.1)	69 (1.4)
Race, n (%)					
White	10,391 (50.4)	1,697 (42.6)	2,392 (45.1)	3,323 (51.2)	2,979 (61.7)
African American	5,330 (25.9)	1,001 (25.1)	1,423 (26.8)	1,804 (27.8)	1,102 (22.8)
Native American	144 (0.7)	32 (0.8)	48 (0.9)	40 (0.6)	24 (0.5)
Asian American	397 (1.9)	97 (2.4)	93 (1.8)	121 (1.9)	86 (1.8)
East Asian	247 (1.2)	33 (0.8)	60 (1.1)	68 (1)	86 (1.8)
West Asian	293 (1.4)	51 (1.3)	81 (1.5)	102 (1.6)	59 (1.2)
South Asian	911 (4.4)	330 (8.3)	296 (5.6)	238 (3.7)	47 (1)
Southeast Asian	125 (0.6)	21 (0.5)	41 (0.8)	45 (0.7)	18 (0.4)
Other	2,641 (12.8)	698 (17.5)	830 (15.7)	711 (11)	402 (8.3)
Not reported	129 (0.6)	26 (0.7)	36 (0.7)	39 (0.6)	28 (0.6)
Hispanic ethnicity, n (%)	1,160 (5.6)	222 (5.6)	321 (6.1)	381 (5.9)	236 (4.9)
Not reported	511 (2.5)	88 (2.2)	121 (2.3)	152 (2.3)	150 (3.1)
Body mass index (median, IQR)	29 (25.1–34.5)	30.4 (25.8–37.4)	30.5 (26.6–36)	29.1 (25.3–34.4)	26.4 (22.9–30.7)
Not reported	4,965 (24.1)	1,045 (26.2)	1,287 (24.3)	1,457 (22.5)	1,176 (24.3)
Documented social history, n (%)					
Current smoker	677 (3.3)	171 (4.3)	214 (4)	217 (3.3)	75 (1.6)
Former smoker	2,750 (13.3)	199 (5)	499 (9.4)	1,187 (18.3)	865 (17.9)
Alcohol use disorder	446 (2.2)	94 (2.4)	143 (2.7)	160 (2.5)	49 (1)
Substance use disorder	357 (1.7)	109 (2.7)	108 (2)	121 (1.9)	19 (0.4)
Not reported	8,363 (40.6)	1,679 (42.1)	2,079 (39.2)	2,455 (37.8)	2,150 (44.5)
Comorbid conditions, n (%)					
Hypertension	9,893 (48)	632 (15.9)	2,231 (42.1)	3,845 (59.2)	3,185 (65.9)
Diabetes	6,345 (30.8)	623 (15.6)	1,655 (31.2)	2,515 (38.7)	1,552 (32.1)
Obesity	3,623 (17.6)	815 (20.4)	1,136 (21.4)	1,207 (18.6)	465 (9.6)
Chronic kidney disease	2,467 (12)	144 (3.6)	397 (7.5)	942 (14.5)	984 (20.4)
Coronary artery disease	2,428 (11.8)	49 (1.2)	288 (5.4)	996 (15.3)	1,095 (22.7)
No comorbidities	2,645 (12.8)	1,106 (27.7)	867 (16.4)	488 (7.5)	184 (3.8)
Not reported	3,077 (14.9)	922 (23.1)	833 (15.7)	751 (11.6)	571 (11.8)

TABLE 1. (*Continued*).

Demographic and Clinical Characteristics Among Hospitalized Patients With Coronavirus Disease 2019 Stratified According to Age

	All Adults	18–44 yr	45–59 yr	60–74 yr	75+ yr
Sequential Organ Failure Assessment, median (IQR)	2 (0–5)	1 (0–3)	2 (0–4)	3 (1–6)	3 (1–6)
Not reported, *n* (%)	14,038 (68.1)	2,755 (69.1)	3,519 (66.4)	4,314 (66.5)	3,450 (71.4)
Use of steroids, *n* (%)	2,818 (13.7)	521 (13.1)	790 (14.9)	995 (15.3)	512 (10.6)
Hospital					
Length of stay, median (IQR), d	7 (4–14)	5 (2.4–9.7)	7 (3.7–14)	8.6 (4.7–16.8)	7.9 (4–14)
Not reported, *n* (%)	44 (0.2)	9 (0.2)	13 (0.3)	10 (0.2)	12 (0.3)
Discharge disposition, *n* (%)					
Home[a]	10,264 (49.8)	2,733 (68.6)	3,204 (60.5)	2,973 (45.8)	1,354 (28)
Skilled nursing facility	835 (4.1)	67 (1.7)	145 (2.7)	336 (5.2)	287 (5.9)
Assisted living	1,197 (5.8)	62 (1.6)	198 (3.7)	451 (6.9)	486 (10.1)
Other	1,156 (5.6)	160 (4)	287 (5.4)	368 (5.7)	341 (7.1)
Disposition not reported	3,250 (15.8)	781 (19.6)	884 (16.7)	880 (13.6)	705 (14.6)
Deceased	3,906 (19)	183 (4.6)	582 (11)	1,483 (22.8)	1,658 (34.3)
ICU, *n* (%)					
Admission	8,745 (42.4)	1,349 (33.8)	2,293 (43.3)	3,186 (49.1)	1,917 (39.7)
Not reported	3,567 (17.3)	698 (17.5)	847 (16)	1,015 (15.6)	1,007 (20.8)
Mortality	3,091 (35.3)	171 (12.7)	543 (23.7)	1,299 (40.8)	1,078 (56.2)
Not reported	0 (0)				
IMV, *n* (%)	4,810 (55)	584 (43.3)	1,279 (55.6)	1,944 (61)	1,003 (52)
Days on IMV, median (IQR)	8.8 (3.3–17)	8 (3–15.6)	9.4 (4–19)	9.3 (4–17.9)	7 (2–13.1)

IMV = invasive mechanical ventilation, IQR = interquartile range.

[a]Estimates different from Table 2 due to missing data.

explained by the hospitals of admission. A post hoc exploratory analysis evaluated effects of severity of acute illness (baseline SOFA Q1 vs Q4: OR, 0.74; 95% CI, 0.54–1.0), and hospital case volume of mechanically ventilated patients with COVID-19 (OR, 0.876; 95% CI, 0.763-1.006) on risk-adjusted hospital mortality among patients requiring mechanical ventilation did not substantively alter results (model ICC, 10%; MOR, 1.69). The effects of country (non United States vs United States; OR, 1.99; 95% CI, 1.26–3.14) was a likely minor contributor to mortality variation, with the United States having lower mortality than non-United States countries, though hospitals remained major contributors to variation in mortality after adjusting for country.

DISCUSSION

We report hospital mortality, discharge home rates, and LOSs for specific organ supportive therapies within a large, multinational registry of patients admitted with laboratory confirmed severe acute respiratory
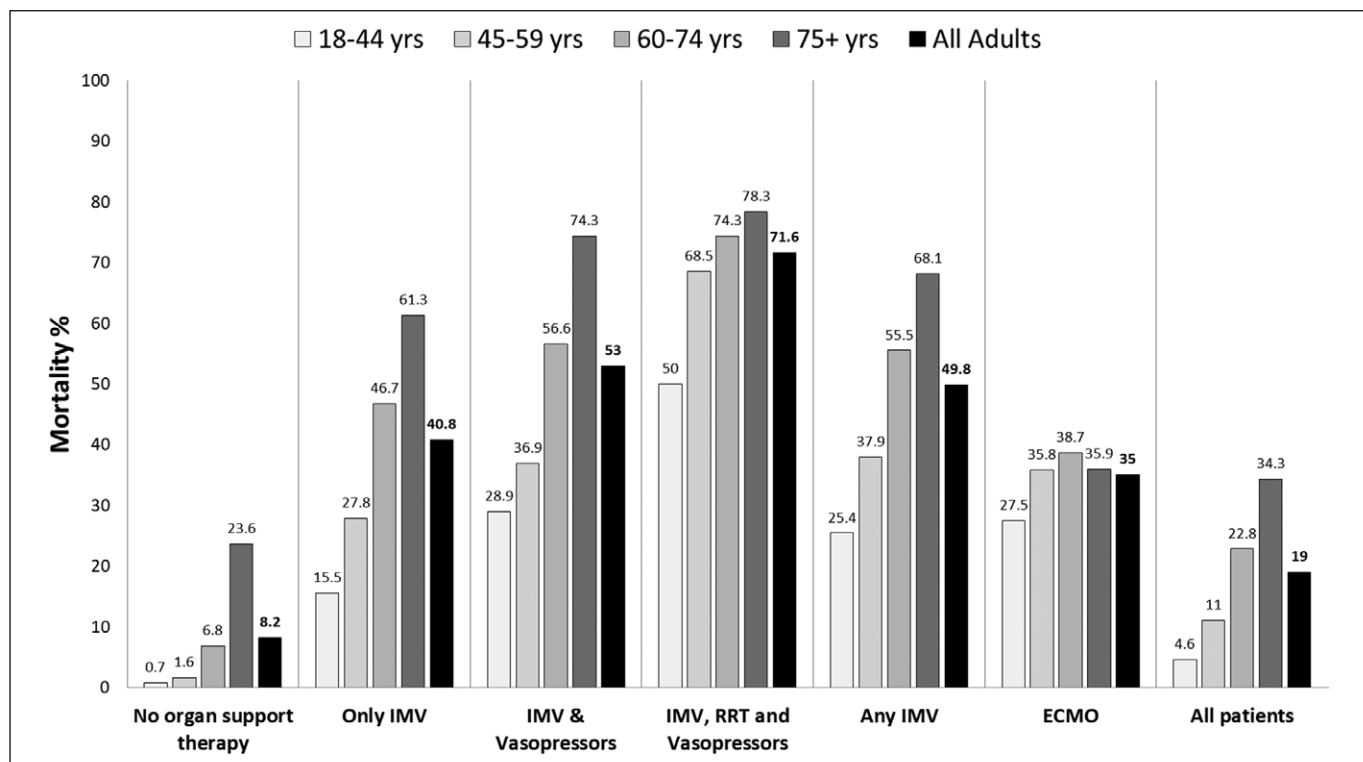
Figure 2. Mortality rate by age and type of organ support therapy. This figure shows the mortality rate by age group from the different invasive organ support therapies received in hospitalized adult patients with coronavirus disease 2019. ECMO = extracorporeal membrane oxygenation, RRT = renal replacement therapy.

syndrome coronavirus 2 (SARS-CoV-2) infection. Our findings provide novel prognostic estimates for important patient-centered outcomes of survival and probability of discharge home across a wide range of ages and types of organ supportive therapies commonly required for patients with severe COVID-19. Additionally, information presented regarding hospital LOS can assist with patient and hospital planning. Importantly, we provide data that demonstrate wide, unexplained variation in case-mix-adjusted hospital mortality rates of mechanically ventilated patients, presenting an opportunity for future studies to learn from practices at hospitals that achieved low adjusted mortality rates.

Few studies have evaluated COVID-19 outcomes across multiple centers and international hospital settings (17–19). Mortality has varied widely in reports of critically ill patients from 10 European countries (24%) (20), the United States (35.4%) (21), Italy (53.4%) (7), and China (53.8%) (22), but those reports were not stratified by types of organ support. Thus, few prior studies have evaluated outcomes among patients with COVID-19 according to a major prognostic factor: the organ support therapies required by patients

(21, 23–25). The mortality rates found in our cohort for patients receiving IMV were similar to that of the control group reported in the meta-analysis of seven randomized trials that evaluated the benefits of corticosteroids on patients with COVID-19 (26); thus, our results also provide information regarding the external validity of clinical trial results to nontrial, routine care settings.

An observational study (27) of hospital claims data of 11,721 hospitalized patients with COVID-19 in the United States with a similar mean age and comorbidities to our cohort reported a hospital mortality rate slightly higher than our overall mortality, but a substantially higher mortality rate for IMV of 70.5%. One potential reason for these differences in outcomes is that our registry enrolled countries other than the United States, some with previously reported lower mortality (28), as well as the possibility that less strained hospitals may have participated in a voluntary registry. The mortality of patients with COVID-19 receiving IMV from our cohort (47%) was similar to the mortality of patients with severe non-COVID-19 Acute Respiratory Distress Syndrome from the Large observational study to understand the Global impact

TABLE 2.
Discharged Home Rate by Age Category

Organ Support Therapy Provided[a]	All Adults (20,608)	18–44 yr (3,986)	45–59 yr (5,300)	60–74 yr (6,491)	75+ yr (4,831)
No organ support required, %	73.5 (8,900/12,108)	93.2 (2,413/2,590)	88.9 (2,728/3,067)	73.1 (2,544/3,481)	40.9 (1,215/2,970)
IMV only, %	29.8 (467/1,567)	60.3 (120/199)	39.7 (159/401)	22.3 (139/624)	14.3 (49/343)
IMV and vasopressors (no RRT), %	22.2 (445/2,007)	47.5 (103/217)	34.9 (175/502)	16.5 (132/799)	7.2 (35/489)
IMV, vasopressors, and RRT, %	8.8 (57/646)	27.1 (13/48)	11.6 (19/164)	6.4 (21/330)	3.8 (4/104)
Any IMV, %	24.2 (1,150/4,745)	50.2 (283/564)	33.3 (416/1,250)	17.8 (342/1,925)	10.8 (109/1,006)
Any extracorporeal membrane oxygenation, %	41.2 (152/369)	48.1 (37/77)	36 (54/150)	40.8 (42/103)	48.7 (19/39)
All patients, %	59.1 (10,264/17,358)	85.3 (2,733/3,205)	72.6 (3,204/4,416)	53 (2,973/5,611)	32.8 (1,354/4,126)
Disposition not reported	15.8 (3,250/20,608)	19.6 (781/3,986)	16.7 (884/5,300)	13.6 (880/6,491)	14.6 (705/4,831)

IMV = invasive mechanical ventilation, RRT = renal replacement therapy.
[a]Categories are not mutually exclusive.

of Severe Acute respiratory Failure (LUNG SAFE) observational study (46%) (29).

We identified a large interhospital variation in mortality for patients receiving IMV, unaccounted for by hospital case-mix, hospital case volume, or patient acute illness severity. Qian et al (30) using data from 5,062 patients with COVID-19 admitted in the ICU—regardless of mechanical ventilation status—found an Acute Physiology and Chronic Health Evaluation II score-adjusted large interhospital variation from hospitals in the England Surveillance System. In the context of a survey (31) of 1,132 ICU specialists showing significant variation in opinions regarding practices for patients with COVID-19, large interhospital variation in outcomes among invasive mechanically ventilated patients provides strong motivation for further studies evaluating links between hospital practice variation—as well as evaluation of ICUs strain—and outcomes.

Strengths of the study include the large, international cohort of hospitalized patients with laboratory confirmed SARS-CoV-2 infection in which complete follow-up of and standardized definitions with data quality monitoring increase data validity and avoid misrepresentation of outcome estimates. Our study includes patients admitted on or before November 30, 2020 with complete discharge status, making our cohort one of the large scale studies with most recent multinational patient data at the time of publication. Another major strength of our cohort is that it captures hospitalized patients on the wards/floors and the ICU, allowing capture of patient outcomes regardless of location within the hospital, especially as hospitals often required expansion of critical care outside of traditional ICUs and ICU admission criteria vary greatly across health systems (32). Our study focused not only on organ support therapies but also on the rates of discharge to home and length of hospital stay, which based on our clinical practice are very important patient centric outcomes for patients and their relatives during their hospitalization; this will help clinicians, patients, and family members to establish data-based expectations and communication strategies during a COVID-19-related hospital admission.

The study's results should be considered in the context of its limitations. Missing data, local differences in local hospital resources, and capabilities potentially
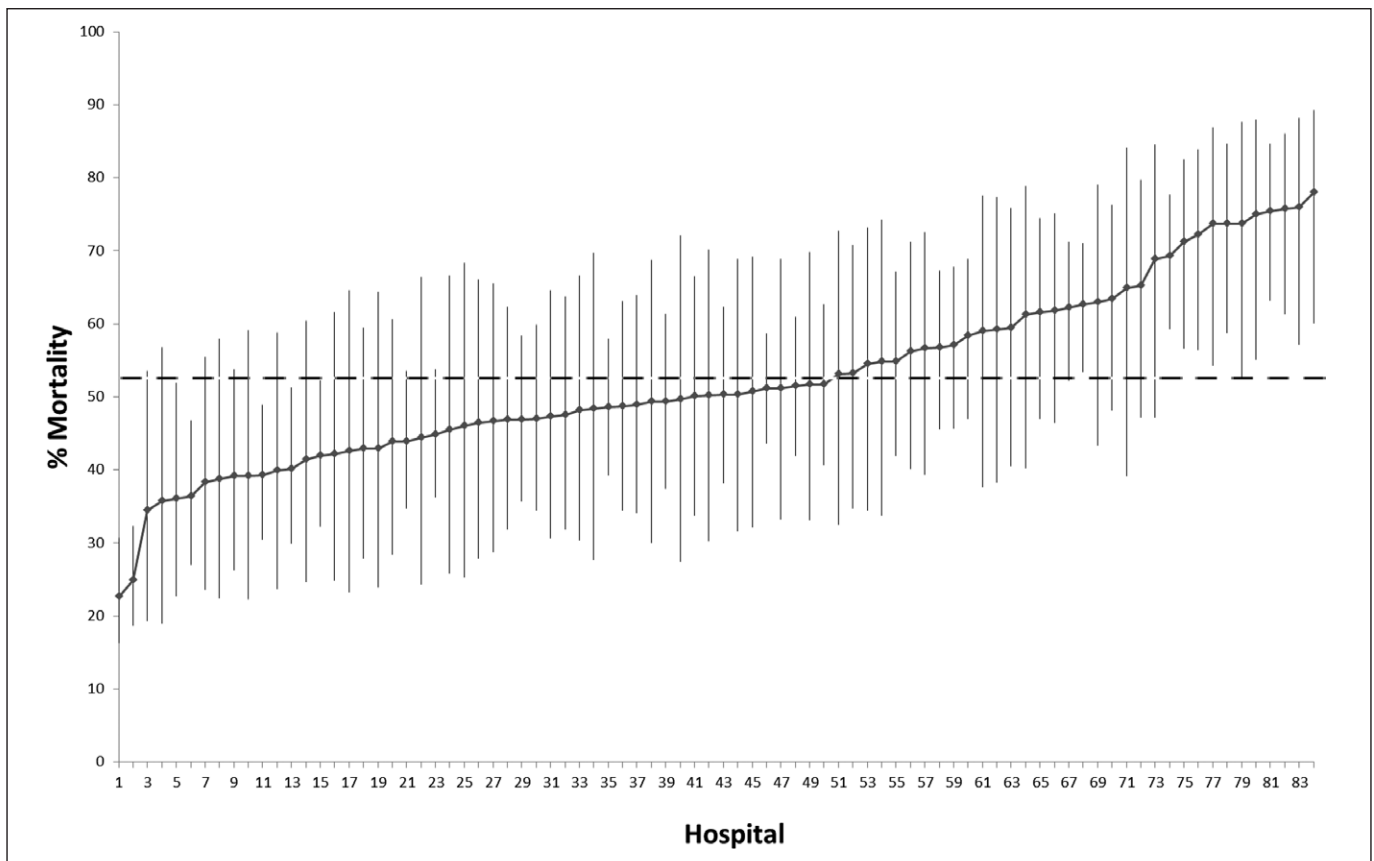
Figure 3. Mortality variation across hospitals adjusted by age, race/ethnicity, sex, and comorbidities. Risk-adjusted hospital mortality rates by comorbidities and demographics for patients on invasive mechanical ventilation from hospitals ($n = 84$) entering $n > 10$ patients into the Viral Infection and Respiratory Illness Universal Study (VIRUS) registry. *Dotted line* indicates the averaged adjusted mortality rate (52.6%) for patients invasive mechanical ventilation from hospitals entering $n > 10$ patients into the VIRUS registry.

affected the ability to use all registry patients in analyses and may bias analyses if missing data are correlated with outcomes. It is possible that patient factors such as preferences for life-sustaining treatments, and health system factors such staffing, ICU type, and resource constraints related to the surge in pandemics may influence variation in mortality across hospitals; future studies should explore further potential reasons for variation in hospital mortality (33). In the current analyses, there was no accounting for care preferences (comfort measures and do not intubate/do not resuscitate) and will be explored in the subsequent iterations of the registry through ancillary studies. Finally, we could not address specific differences in environment and resources that may have affected mortality estimates.

CONCLUSIONS

We provide novel and clinically applicable patient outcome data based on the type of organ supportive therapies within a large multinational registry. Our findings may be used to assist in prognostication of patients hospitalized with COVID-19; high interhospital mortality variation in patients receiving IMV requires further evaluation that links specific hospital structure and practices to improved outcomes.

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1   Division of Nephrology and Hypertension, Department of Internal Medicine, Mayo Clinic, Rochester, MN.

2   Division of Pulmonary and Critical Care Medicine, Department of Internal Medicine, Mayo Clinic, Rochester, MN.

3   Department of Health Law, Policy and Management, Boston University School of Public Health, Boston, MA.

4   Society of Critical Care Medicine, Mount Prospect, IL.

5   Department of Pharmacy Practice, Nesbitt School of Pharmacy, Wilkes University, Wilkes-Barre, PA.

6   Department of Biostatistics, Epidemiology, and Informatics and Palliative and Advanced Illness Research (PAIR) Center, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA.

7   Pulmonary Center, Division of Pulmonary, Allergy, Critical Care and Sleep Medicine, Department of Medicine, Evans Center of Implementation and Improvement Sciences, Boston University School of Medicine, Boston, MA.

8   Department of Anesthesiology and Critical Care Medicine, Englewood Health, Englewood, NJ.

9   Baylor Scott & White Health, Department of Nursing, Dallas, TX.

10 Department of Nursing, University of Texas School of Nursing, Austin, TX.

11 Department of Anesthesiology and Pain Management, UT Southwestern Medical Center, Dallas, TX.

12 Department of Anesthesia, Critical Care & Pain Medicine, Beth Israel Deaconess Medical Center, Boston, MA.

13 Department of Surgery, St. Joseph Mercy Ann Arbor, Ann Arbor, MI.

14 Division of Infectious Diseases, Department of Medicine, Community Health Network, Indianapolis, IN.

15 Section of Pulmonary Diseases, Critical Care, and Environmental Medicine, Department of Medicine, Tulane University School of Medicine, New Orleans, LA.

16 Department of Care Delivery Research, Allina Health, Minneapolis, MN.

17 Department of Emergency Medicine, Advocate Christ Medical Center, Oak Lawn, IL.

18 Department of Emergency Medicine, University of Illinois at Chicago, Chicago, IL.

19 Division of Pulmonary, Allergy, Critical Care and Sleep Medicine, Department of Medicine, Emory University, Atlanta, GA.

20 Department of Anesthesiology and Perioperative Medicine, Mayo Clinic, Rochester, MN.

Address requests for reprints to: Rahul Kashyap, MBBS, Department of Anesthesiology and Perioperative Medicine, Mayo Clinic, 200 First St SW, Rochester, MN. E-mail: kashyap.rahul@mayo.edu

For the Society of Critical Care Medicine Discovery Viral Infection and Respiratory Illness Universal Study (VIRUS): COVID-19 Registry Investigator Group

Members of the Society of Critical Care Medicine Discovery Viral Infection and Respiratory Illness Universal Study (VIRUS): COVID-19 Registry Investigator Group are listed in the **Appendix** *(http://links.lww.com/CCM/G127).*

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