OBJECTIVES: To assess 30-day mortality in coronavirus disease 2019 acute respiratory distress syndrome patients transferred from rural Appalachian hospitals.

DESIGN: Retrospective case controlled, based on consecutive patients transferred and admitted from rural hospitals to a tertiary-care ICU. The primary outcome was all-cause 30-day mortality. Kaplan-Meier method and log-rank test were used in the survival data analysis.

SETTING: Medical ICU, West Virginia University Hospital, Morgantown, WV.

PATIENTS: All adult patients admitted to the ICU for coronavirus disease 2019 disease between September 30, 2020, and December 2, 2020.

INTERVENTION: Not applicable.

MEASUREMENTS AND MAIN RESULTS: Seventy-nine consecutive coronavirus disease 2019 patients were admitted to the ICU during the defined period. Overall mortality of the cohort was 54%. Of the 79 patients, 50 were transferred from critical access hospitals/rural facilities with coronavirus disease 2019–induced acute respiratory distress syndrome. A control group consisted of 39 patients admitted to the ICU with noncoronavirus disease 2019 acute respiratory distress syndrome who were intubated and mechanically ventilated. Thirty-day mortality in patients with coronavirus disease 2019 admitted to the ICU was significantly higher than the control group (68% vs 42%) \( (p = 0.034) \). Mean Sequential Organ Failure Assessment scores were similar in both coronavirus disease 2019 acute respiratory distress syndrome group and controls. Intubation in patients 70 years old or more and mechanical ventilation for over 5 days was associated with significantly higher mortality.

CONCLUSIONS: Our data on critically ill and mechanically ventilated coronavirus disease 2019 acute respiratory distress syndrome patients transferred from critical access hospitals/rural facilities have increased mortality compared with non–coronavirus disease 2019 acute respiratory distress syndrome controls. These data suggest that lack or delay in access to tertiary care may impact coronavirus disease 2019 outcome in rural areas. Intubated patients 70 years old or more and mechanical ventilation for over 5 days may be a risk factor for increased mortality. These data may help physicians and hospital administrators in rural areas for optimal utilization of limited resources.

KEY WORDS: coronavirus disease 2019; healthcare disparities; mechanical ventilation; mortality; rural health services

Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has continued to surge throughout the world, with the World Health Organization reporting a global crude mortality rate of 2.2% (1). This is especially true throughout the United States—although initial epicenters were centered largely in high...
population-density areas, a second and larger surge involving more rural regions began in early October. By the December of 2020, rural areas accounted for more cases than the urban population centers (2).

Rural areas tend to have a more elderly population who also suffer from more comorbid health conditions that together may predispose them to worse outcomes. For example, 20% of West Virginia's population is over 65 years old and has the highest rates of cardiopulmonary disease in the United States (3). In this specific setting, healthcare resources are also more limited—rural areas frequently have fewer acute care beds, ICU beds, intensive care physicians, and critical care nurses per capita compared with other states (4). Together, this trend of increased infections, in an older, sicker population with limited healthcare infrastructure generates a higher risk for an overwhelmed system capacity.

Care practices and pharmacotherapy of critically ill patients infected with COVID-19 have varied since the onset of the pandemic. Reports of case fatality rates have also been inconsistent over this span. Early data in patients requiring mechanical ventilation showed high mortality ranging from 50% to 97% (5–7). In fact, even higher case fatality rates are reported in the first waves of disease spread within epicenters such as Wuhan and New York when compared with later hotspots (8). Meta-analyses of patients requiring ICU admission and mechanical ventilation have yielded mortality rates of 40–45% (9). One urban center reported a much lower mortality of 30.9% in patients with COVID-19 admitted to the ICU (10).

The mortality of patients with COVID-19 in rural Appalachia admitted to the tertiary care ICU is not known. Majority of patients were transferred from critical access hospitals (CAHs) and outlying rural facilities (11). CAH designation is given to rural hospitals who have 25 or fewer acute care beds, are more than 35 miles away from another hospital, and maintain an average length of stay less than 4 days (12). Factors such as reduced access to healthcare, limited resources, and expertise of CAHs/outlying rural facilities may play a role in patient outcome. These factors may compound an already vulnerable population that is older with higher comorbidities and low health literacy. We conducted a retrospective case-controlled study on consecutive patients transferred with COVID-19–induced acute respiratory distress syndrome (ARDS) from CAH/rural facility and admitted to a tertiary-care ICU at West Virginia University. We also analyzed the overall characteristics and risk factors for mortality in COVID-19 patients admitted to our tertiary-care hospital.

**MATERIALS AND METHODS**

This is a single-center retrospective case control study of patients with COVID-19 ARDS admitted to West Virginia University Hospital (WVUH) ICU requiring intubation and mechanical ventilation between September 30, 2020, and December 1, 2020. The primary outcome was 30-day mortality of COVID-19 ARDS patients transferred from CAHs/rural facilities compared with non-COVID-19 ARDS controls. All patients still on mechanical ventilation on day 30 were considered survivors. All patients admitted to the ICU for COVID-19 were diagnosed by SARS-CoV-2 polymerase chain reaction assay performed either at the WVUH or at a transferring hospital. Patient demographics, and clinical and laboratory data were obtained from the electronic medical record. Control group constituted of consecutive non-COVID ARDS patients admitted to the ICU before the onset of the pandemic. This study was approved by the WVU Institutional Review Board (No. 2101205408).

This is a retrospective study in 79 COVID-19 patients and 39 controls. The primary objective is to assess clinical outcomes of patients transferred from CAHs/rural hospitals between two cohorts, and the major endpoints include 30-day mortality. Statistical analysis was performed using SAS 9.1 (SAS Institute, Cary, NC) and R (Version 3.63, R Foundation, Vienna, Austria). With this sample size, we have more than 85% power to detect the 30-day mortality between 40% (control) and 70% (COVID-19) using a two-sample two-sided test at a significance level of 0.05. Descriptive statistical analyses were performed to summarize the data, including summary tables, proportions, medians, and means with standard deviations. Fisher exact test was used for binary and categorical variables. Wilcoxon rank test was used in the data analysis for continuous variables. Kaplan-Meier method and log-rank test were used in the survival data analysis. Hazard ratio (HR) was estimated from the Cox regression model. All statistical tests were two-sided, and \( p < 0.05 \) was considered statistically significant.

**RESULTS**

From September 2, 2020, to December 1, 2020, 79 consecutive patients with COVID-19 were admitted to the WVUH ICU (Fig. 1, Flowchart). The mean/median age of the group was 67.5 and 72, respectively, and 67% of
the patients were male. Of the 79 patients, 50 (63%) were transferred from CAHs/rural hospitals and were intubated and mechanically ventilated due to ARDS from COVID-19. The control group consisted of 38 consecutive ARDS patients (without COVID-19) also intubated and mechanically ventilated. Of the 79 patients, 53 (67%) were 65 years or older and 47 (54.4%) were 70 years or older. The mean body mass index (BMI) for the cohort was 33.5. The most common comorbidities noted were hypertension (81%), type II diabetes mellitus (52%), coronary artery disease (33%), chronic obstructive pulmonary disease (23%), and obesity (64%). A total of 70.9% of patients (n = 56) required intubation and mechanical ventilation, with an average length of time on mechanical ventilation of 9.6 days. The mean \( P_{\text{a,o}_2}/F_{\text{io}_2} \) (P/F ratio) was higher in survivors (123.3 ± 95.7) versus nonsurvivors (71.2 ± 26.2) \((p = 0.02)\) and mean Sequential Organ Failure Assessment (SOFA) scores significantly lower in survivors (6.0 ± 2.2) compared with nonsurvivors (8.4 ± 3.6) \((p = 0.003)\).

Patients who were intubated and mechanically ventilated had significantly higher mean SOFA scores (8.16 ± 3.21 vs 5.34 ± 2.49; \(p < 0.001\)). See Table 1 for baseline demographics and survival in all patients. Table 2 shows the demographic and baseline characteristics of the intubated COVID-19 ARDS patients versus controls (non-COVID-19–intubated ARDS patients) who were transferred from rural centers/CAHs.

In the primary endpoint analysis of 30-day mortality, COVID-19 patients transferred from CAH/}

![Figure 1. Flowchart showing recruitment and outcome of patients in patients with coronavirus disease 2019 (COVID-19) in ICU. ARDS = acute respiratory distress syndrome.](image-url)

### Table 1.

Baseline Demographics and Characteristics of All Coronavirus Disease 2019 Patients Admitted to ICU

| Characteristics                                      | Percent/ Mean/Median |
|------------------------------------------------------|----------------------|
| n                                                    | 79                   |
| Mean age                                             | 67.5 ± 11.6 (median = 72) |
| Female                                               | 26 (32.9)            |
| Mean body mass index                                 | 33.50 ± 8.6          |
| Transferred from other facility, \( n \) (%)          | 67 (84.8)            |
| Hypertension, \( n \) (%)                            | 64 (81.0)            |
| Diabetes, \( n \) (%)                                | 41 (51.9)            |
| Chronic obstructive pulmonary disease, \( n \) (%)    | 18 (22.8)            |
| Cancer, \( n \) (%)                                  | 6 (7.6)              |
| Current smoking, \( n \) (%)                         | 4 (5.1)              |
| Coronary artery disease, \( n \) (%)                 | 26 (32.9)            |
| Sequential Organ Failure Assessment score             | 7.34 ± 3.3           |
| Initial P/F                                           | 113 ± 75.1           |
| Worst P/F                                             | 93.4 ± 70.0          |
| Intubated, \( n \) (%)                               | 56 (70.9)            |
| Intubated > 5 d, \( n \) (%)                         | 36 (45.6)            |
| Age ≥ 70, \( n \) (%)                                | 47 (59)              |
| Mean days on ventilator                              | 6.8 ± 6.6            |
| Prone, \( n \) (%)                                   | 36 (45.6)            |
| Inhaled nitric oxide, \( n \) (%)                    | 43 (54.4)            |
| Decadron, \( n \) (%)                                | 77 (97.5)            |
| Remdesivir, \( n \) (%)                              | 46 (58.2)            |
| Convalescent plasma, \( n \) (%)                     | 11 (13.9)            |
| Tracheostomy, \( n \) (%)                            | 8 (10.1)             |
| Extracorporeal membrane oxygenation, \( n \) (%)     | 6 (7.6)              |
| Mortality, \( n \) (%)                               | 43 (54.4)            |

\[ P/F = P_{\text{a,o}_2}/F_{\text{io}_2} \]
rural facilities had a higher mortality 34/50 (68%) versus controls 13/31 (42%) \((p = 0.034)\) (Table 2). Table 3 shows characteristics of survivors compared to non-survivors. In the secondary endpoint on HR in survival analysis, the HR from the Cox proportional hazard model is 1.8 (95% CI, 0.96–3.5; \(p = 0.06\)).

Kaplan-Meier plot for survival also revealed trends toward worst survival in COVID-19 ARDS patients transferred from CAHs/rural facilities compared with non-COVID ARDS controls (Fig. 2A).

Of the total 79 consecutive COVID-19 patients admitted to the ICU during the study time period, the net mortality was 54.4%. Subset analysis of intubated patients revealed significantly higher mortality in older (≥ 70) COVID-19 ARDS patients compared with younger ARDS patients (85.3% vs 50%) \((p = 0.001)\) (Fig. 2B). Patients intubated for more than 5 days had significantly higher mortality than less than 5 days (58% vs 42%) \((p = 0.02)\).

Specific therapies targeted toward COVID-19 were as follows: remdesivir (58%), dexamethasone (97.5%), inhaled nitric oxide (54.4%), and convalescent plasma (14%). There was no statistically significant difference in the percentage of patients who received these therapies between the survivors and nonsurvivors. The only difference in therapies received between patients who received mechanical ventilation and those who were never intubated was a significantly increased use of inhaled nitric oxide in patients who were mechanically ventilated (35% vs 62%; \(p = 0.03\)).

**DISCUSSION**

We demonstrated an overall mortality rate of 54.4% in patients with COVID-19 admitted to ICU in rural Appalachia. However, critically ill COVID-19 patients with ARDS transferred from CAHs/rural facilities

| Characteristics | Controls (Non-COVID-19 ARDS) | COVID-19 ARDS | \(p\) |
|-----------------|-----------------------------|--------------|-----|
| \(n\)           | 31                          | 50           |     |
| Mean age        | 56.00 ± 13.28               | 67.96 ± 1 ± 2.02 | < 0.001 |
| Sex (female)    | 21 (68)                     | 17 (34)      | 0.006 |
| Mean body mass index | 38.37 ± 10.83         | 33.18 ± 8.17 | 0.024 |
| Diabetes, \(n\) (%) | 14 (45)                   | 29 (58)      | 0.36  |
| Hypertension, \(n\) (%) | 20 (65)                   | 37 (74)      | 0.454 |
| Chronic obstructive pulmonary disease, \(n\) (%) | 10 (32)                          | 9 (18)       | 0.18  |
| Current smoking, \(n\) (%) | 9 (29)                          | 2 (4)        | 0.002 |
| Coronary artery disease, \(n\) (%) | 7 (23)                           | 12 (24)      | 1     |
| Sequential Organ Failure Assessment score | 9.48 ± 3.15                      | 8.50 ± 3.32  | 0.155 |
| Initial P/F     | 101.48 ± 65.02              | 102.04 ± 68.27 | 0.641 |
| Worst P/F       | 68.68 ± 53.84               | 77.26 ± 55.19 | 0.012 |
| Mean days on ventilator |                      |              |     |
| Proned, \(n\) (%) | 19 (61)                     | 31 (62)      | 1    |
| Decadron, \(n\) (%) | 2 (6)                       | 50 (100)     | < 0.001 |
| Inhaled nitric oxide, \(n\) (%) | 19 (61)                     | 29 (58)      | 0.819 |
| Remdesivir, \(n\) (%) | 0 (0)                       | 27 (54)      | < 0.001 |
| Tracheostomy, \(n\) (%) | 4 (13)                      | 7 (14)       | 0.581 |
| Extracorporeal membrane oxygenation, \(n\) (%) |                  |              |     |
| Mortality       | 13 (42)                     | 34 (68)      | 0.036 |

ARDS = acute respiratory distress syndrome, COVID-19 = coronavirus disease 2019, P/F = \(\text{Pa}_{2}\)/\(\text{FiO}_{2}\).
Figure 2. 30-day mortality in coronavirus disease 2019 (COVID-19) acute respiratory distress syndrome vs controls. A, Kaplan-Meier survival curves by disease (n = 81, transfer and intubated): hazard ratio (HR) = 1.8 with 95% CI, 0.96–3.5 between control vs COVID-19, p value = 0.06. B, Kaplan-Meier survival curves by age (n = 56, intubated): HR = 3.4 with 95% CI, 1.6–7.2 between age ≥ 70 vs age < 70, p value = 0.001.

TABLE 3. Characteristics, Comorbidities, and Therapy in Survivors Versus Nonsurvivors (n = 79)

| Characteristics                                      | Survivors | Nonsurvivors | Hazard Ratio (If Applicable) | p  |
|-------------------------------------------------------|-----------|--------------|------------------------------|----|
| n                                                     | 36        | 43           |                              |    |
| Mean age                                              | 62.5      | 71.7         |                              | 0.001 |
| Female, n (%)                                         | 12 (33)   | 14 (33)      | 1.07                         | 0.999 |
| Mean body mass index                                  | 33.3      | 33.7         |                              | 0.558 |
| Diabetes, n (%)                                       | 17 (47)   | 24 (56)      | 1.23                         | 0.57 |
| Hypertension, n (%)                                   | 28 (78)   | 36 (84)      | 1.19                         | 0.57 |
| Chronic obstructive pulmonary disease, n (%)          | 9 (25)    | 9 (21)       | 0.88                         | 0.789 |
| Cancer, n (%)                                         | 4 (11)    | 2 (5)        | 0.5                          | 0.403 |
| Current smokers, n (%)                                | 3 (8)     | 1 (2)        | 0.41                         | 0.326 |
| Coronary artery disease, n (%)                        | 10 (28)   | 16 (37)      | 1.24                         | 0.473 |
| Sequential Organ Failure Assessment score             | 6.02 ± 2.21| 8.44 ± 3.62|                              | 0.003 |
| Initial P/F                                           | 135.3 ± 94.2| 96.4 ± 52.4|                              | 0.077 |
| Worst P/F                                             | 123.3 ± 95.7| 71.2 ± 26.2|                              | 0.021 |
| Intubated, n (%)                                      | 18 (50)   | 38 (88)      | 4.4                          | < 0.001 |
| Intubated > 5 d                                       | 11 (31)   | 25 (58)      | 1.88                         | 0.023 |
| Age ≥ 70                                              | 14 (39)   | 33 (72)      | 3.2                          | 0.001 |
| Days ventilated                                       | 4.7 ± 6.2 | 8.6 ± 6.5    |                              | 0.002 |
| Proned, n (%)                                         | 11 (31)   | 25 (58)      | 1.81                         | 0.023 |
| Inhaled nitric oxide, n (%)                           | 17 (47)   | 26 (60)      | 1.2                          | 0.265 |
| Decadron, n (%)                                       | 34 (94)   | 43 (100)     | N/A                          | 0.204 |
| Remdesivir, n (%)                                     | 22 (61)   | 24 (56)      | 0.94                         | 0.655 |
| Convalessent plasma, n (%)                            | 4 (11)    | 7 (16)       | 1.19                         | 0.746 |

N/A = not available, P/F = PaO₂/FiO₂.
had significantly higher mortality (68%) than non-COVID-19 ARDS controls (42%). Based on our findings, the mortality outcome seems to be most influenced by delayed access to tertiary-care facility. This may have been compounded by factors typical to rural population including aging population, higher comorbidities, and lower health literacy. Lack of ICU expertise and limited bed availability at the tertiary-care hospitals may have led to increased strain on ill-equipped CAH/rural facilities during the COVID-19 surge. This suggests that rurality and limited access to healthcare influenced outcome in critically COVID-19 patients. This is further supported by the fact that the overall 30-day ICU mortality of patients admitted with COVID-19 in rural Appalachia was higher than nationally reported (54% vs 40%) (6) or compared with an urban center (54% vs 30.9%) and appears to approach those of the earliest disease centers (8, 10). The SOFA scores were similar in both study and control groups. Of the total 79 COVID-19 patients admitted to our ICU, 67 (85%) were transferred from outlying facilities and CAHs (11).

Analysis of all the COVID-19 patients admitted to ICU during the stated time period revealed higher mortality in intubated patients (68% compared with 22%) than those who avoided mechanical ventilation. The observed mortality was highest in intubated patients 70 years old and more. Patients who were placed on mechanical ventilation are four times more likely to die.

Our preliminary data indicate that the rural population in comparison with urban centers has a disproportionately worse ICU outcome. Compared with the study performed by Auld et al (10) in urban settings, our patients are older, have higher comorbidities, and are more obese. This is consistent with existing data that rural communities are older with higher comorbidities and disabilities (13–15). Limited and delayed access to healthcare along with demographic differences unique to rural communities appears to be the most likely explanation for the poor outcome in critically ill patients with COVID-19 in rural Appalachia.

Our study has some limitations including a retrospective design and relatively small sample size. Furthermore, the study is limited to the second wave witnessed between October and November of 2021. The control group constituted patients with ARDS admitted prior to the COVID-19 pandemic as almost all ARDS patients during the pandemic were COVID-19-related. Given the lack of available resources in rural environments, it would be reasonable to hypothesize that these patients might be sicker upon their arrival in the tertiary-care ICU given a lack of available resources at their site of initial presentation. However, the same limitation was present with non-COVID control group. Additionally, both groups had similar SOFA scores suggesting similar level of organ dysfunction and illness. Despite these limitations, we believe the data provide insight into the care and outcome of critically ill COVID-19 patients in rural setup.

CONCLUSIONS

Per our review of current literature, this is the first data on mortality in critically ill COVID-19 patients admitted to the ICU in a rural setting. The data highlight the rural healthcare disparities and its potential impact on COVID-19 outcome in critically ill patients. A closer look on the resources and expertise available to handle critically ill patients in rural hospitals may be required. This is crucial in light of poor vaccination rate in rural America as reported by Centers for Disease Control and Prevention (16) and emergence of newer and more infectious variants.

The hospital decision-maker’s allocation framework may want to take into account the high mortality of older critically ill COVID-19 patients when deciding if mechanical ventilation is appropriate (17, 18). Consideration should be given to goals of life discussion and conscientious shared decision-making prior to pursuing intubation in this age group. This will become increasingly important as rural hospitals/ICUs operate at or above capacity. Prolonged intubation (more than 5 d) also appears to be a risk factor of increased mortality and may be factored in ongoing goals of care discussions and possibly help to set expectations for outcomes via time limited trials (17, 18). Further studies are needed in rural populations to combat the paucity of relevant data that may ultimately help improve outcomes for this novel and evolving pandemic—especially now that its impact is most prominent in rural America.

1 Section of Pulmonary, Critical Care and Sleep Medicine, West Virginia University, Morgantown, WV.
2 WVU Critical Care and Trauma Institute, Morgantown, WV.
3 Department of Medicine, West Virginia University, Morgantown, WV.
The authors have disclosed that they do not have any potential conflicts of interest.

This work was performed at West Virginia University Hospital, Morgantown, WV.

For information regarding this article, E-mail: sunil.sharma@hsc.wvu.edu

REFERENCES

1. World Health Organization: Coronavirus Disease (COVID-19) Weekly Epidemiological Update and Weekly Operational Update. Available at: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports/. Accessed January 10, 2021

2. Centers for Disease Control and Prevention: COVIDView: A Weekly Surveillance Summary of U.S. COVID-19 Activity. Available at: https://www.cdc.gov/coronavirus/2019-ncov/covid-data/covidview/index.html. Accessed January 10, 2021

3. Hopkins LR, Mclaury J, Lewin P, et al: West Virginia Behavioral Risk Factor Surveillance System Report 2018. WV Department of Health and Human Resources, Health Statistics Center. 2020. Available at: http://www.wvdhhr.org/bph/hsc/pubs/brfss/2018/BRFSS2018.pdf. Accessed January 29, 2021

4. KFF: State COVID-19 Data and Policy Actions - Policy Actions. Available at: https://www.kff.org/report-section/state-covid-19-data-and-policy-actions-policy-actions/#stateleveldata. Accessed January 19, 2021

5. Zhou F, Yu T, Du R, et al: Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: A retrospective cohort study. Lancet 2020; 395:1054–1062

6. Richardson S, Hirsch JS, Narasimhan M, et al; the Northwell COVID-19 Research Consortium: Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City area. JAMA 2020; 323:2052–2059

7. Arentz M, Yim E, Klafl L, et al: Characteristics and outcomes of 21 critically ill patients with COVID-19 in Washington State. JAMA 2020; 323:1612–1614

8. Lim ZJ, Subramaniam A, Ponnappa Reddy M, et al: Case fatality rates for patients with COVID-19 requiring invasive mechanical ventilation. A meta-analysis. Am J Respir Crit Care Med 2021; 203:54–66

9. Armstrong RA, Kane AD, Cook TM: Outcomes from intensive care in patients with COVID-19: A systematic review and meta-analysis of observational studies. Anaesthesia 2020; 75:1340–1349

10. Auld SC, Caridi-Scheible M, Blum JM, et al: ICU and ventilator mortality among critically ill adults with coronavirus disease 2019. Crit Care Med 2020; 48:e799–e804

11. CMS: Critical Access Hospital. Critical Access Hospital. Available at: https://www.cms.gov/Outreach-and-Education/Medicare-Learning-Network-MLN/MLNProducts/Downloads/CritAccessHospctsh.pdf. Accessed January 26, 2021

12. Critical Access Hospitals (CAHs) [online]. Rural Health Information Hub. Available at: https://www.ruralhealthinfo.org/topics/critical-access-hospitals. Accessed July 10, 2021

13. USDA ERS - The COVID-19 Pandemic and Rural America: The COVID-19 Pandemic and Rural America. Available at: https://www.ers.usda.gov/covid-19/rural-america/. Accessed January 10, 2021

14. Wolkin A, Patterson JR, Harris S, et al: Reducing public health risk during disasters: Identifying social vulnerabilities. J Homel Secur Emerg Manag 2015; 12:809–822

15. Flanagan BE, Gregory EW, Hallisey EJ, et al: A social vulnerability index for disaster management. J Homel Secur Emerg Manag 2011; 8:1–24

16. Barry V, Dasgupta S, Weller DL, et al: Patterns in COVID-19 vaccination coverage, by social vulnerability and Urbanicity - United States, December 14, 2020-May 1, 2021. MMWR Morb Mortal Wkly Rep 2021; 70:818–824

17. White DB, Luce J, Katz M, et al: A Model Hospital Policy for Allocating Scarce Critical Care Resources: Available Online Now. Department of Critical Care Medicine. Available at: https://ccm.pitt.edu/?q=content%2Fmodel-hospital-policy-allocating-scarce-critical-care-resources-available-online-now. Accessed March 25, 2020

18. White DB, Lo B: A framework for rationing ventilators and critical care beds during the COVID-19 pandemic. JAMA 2020; 323:1773–1774