Association between state ICU bed utilization and income-based equality rankings during the 2020 COVID-19 surge

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Introduction

The Coronavirus 2019 (COVID-19) pandemic has strained the capacity of healthcare systems across the United States, most notably hospital and ICU bed availability. According to the National Institute of Health (NIH) COVID-19 Treatment Guidelines, COVID-19-infected patients are first sorted into different treatment groups based on their disease severity: 1) not hospitalized, mild to moderate COVID-19; 2) hospitalized but does not require supplemental oxygen; 3) hospitalized and requires supplemental oxygen; 4) hospitalized and requires oxygen delivery through a high-flow device or noninvasive ventilation; and 5) hospitalized and requires invasive mechanical ventilation or ECMO (1).

Critically ill patients (groups 4 and 5) with the following clinical features are commonly assigned to ICU level of care: respiratory failure, shock, multiple organ dysfunction or failure, dyspnea, a respiratory rate of ≥ 30 breaths per min, oxygen saturation ≤93%, partial pressure of arterial oxygen to fraction of inspired oxygen [PaO2/FiO2] ratio <300 mm Hg, and an increase in lung infiltrates >50% within 24–48 hours. Once stabilized, these patients are then transferred to the medical floor or to other inpatient rooms throughout the hospital (2).

Since the beginning of the COVID-19 pandemic in March of 2020, it has become evident that certain parts of the world have been impacted more significantly than others. Specifically, it has been shown that low- and middle-income countries have been impacted more severely than their more developed counterparts, and it has been speculated that this may be due to a scarcity of medical resources in these locations (3). Furthermore, it has been shown that an increased percentage of hospital bed occupancy, when controlling for patient demographics, comorbidities, and severity of illness, was associated with an increased 30-day-hospital mortality of patients with COVID-19 (4).

According to the CDC, the 2020 winter peak of COVID-19 was much more severe when compared to the summer wave. This is particularly detrimental given a vaccination against COVID-19 was not available at that time (5). States were reportedly better prepared regarding hospital resource quantity after the 2020 summer wave, and very few medications being available at the time to treat COVID-19 infection, it rendered hospital-based supportive care the main approach to assisting severely ill COVID-19 patients. According to an analysis by the University of Minnesota Hospitalization Tracking project, surges of COIV-19 cases across the nation led to significant crowding in large metropolitan hospitals, which tested occupancy limits and overwhelmed hospital staff. In certain metro areas areas, 40-60% of ICU patients suffered from COVID-19 and were in a critically ill state (6).

We believe these ideas are not only relevant but can be extrapolated and applied to the state-wise disparities that are commonly observed in the United States. Therefore, we concluded that the aforementioned observation may hold true when examining COVID-19 related hospital bed utilization based upon the income-based status of each state. We utilized the income-based equality ranking as a reference point when comparing COVID-19 hospital bed utilization between states (https://www.usnews.com/news/best-states/rankings/opportunity/equality). Our goal was to assess the utilization of hospital beds between states based on upper, middle, and lower income-based equality rankings. We hypothesized that there are differences in the utilization of ICU beds between the three income-based equality groups.

Methods

State-aggregated data of Covid-19-related hospital beds (or cases)/utilizations on Nov 29, 2020 were downloaded from Healthdata.gov. The state hospital data above were adjusted to values per 10K residents with the 2019 population data from the Census Bureau (www.census.gov). The fifty states were then grouped according to the income-based equality ranking. (https://www.usnews.com/news/best-states/rankings/opportunity/equality): The upper rank group (ranking 1-17), middle rank group (ranking 18-33) and low rank group (ranking 34-50). The mean values of the population-adjusted metrics of hospital bed and Covid-19 infection were compared among the three groups with one-way Anova, followed by pairwise comparisons using the Tukey HSD (honestly significant difference) procedure for multiple comparison adjustment. P-value <0.05 is statistically significant. Log transformation was applied to the percent-based utilization data for better normal approximation.

Results

We conducted a cross-sectional study comparing different population-adjusted metrics of hospital bed and Covid-19 infection among the upper rank (1-17), middle rank (18-33), and low rank (34-50) states based on income equality ratings. We utilized ANOVA testing to compare the means of the three different groups. We discovered that there was a statistically significant difference in the means between the upper, middle, and low rank groups in 1) inpatient beds used during Covid-19 (inpatient_beds_used_covid_10k, $p<0.05$), 2) the total number of adults hospitalized with confirmed and suspected Covid-19 infection (total_adult_patients_hospitalized_confirmed_and_suspected_covid_10k, $p<0.05$), 3) the percentage of all inpatients with Covid-19 infection (percent_of_inpatients_with_covid, $p<0.05$), 4) the number of inpatient beds utilized for Covid-19 patients (inpatient_bed_covid_utilization, $p<0.01$), and 5) the number of adult beds utilized for Covid-19 infected patients (adult_icu_bed_covid_utilization, $p<0.05$)

Furthermore, utilizing the Tukey HSD (honestly significant difference) procedure to adjust for multiple comparison analysis, there were statistically significant differences between the means of the middle (18-33) and low rank (34-50) state groups regarding inpatient beds used during Covid-19 (inpatient_beds_used_covid_10k, $p<0.05$), the total number of adults hospitalized with confirmed and suspected Covid-19 infection(total_adult_patients_hospitalized_confirmed_and_suspected_covid_10k, $p<0.05$), the percentage of all inpatients with Covid-19 infection (percent_of_inpatients_with_covid, $p<0.05$), the number of inpatient beds utilized for Covid-19 patients (inpatient_bed_covid_utilization, $p<0.01$), and the number of adult beds utilized for Covid-19 infected patients (adult_icu_bed_covid_utilization, $p<0.05$).

Lastly, utilizing the Tukey HSD (honestly significant difference) procedure to adjust for multiple comparison, there was also a statistically significant difference between the means of the upper and low rank state groups with regards to the percentage of all inpatients with Covid-19 infection (percent_of_inpatients_with_covid, $p<0.05$) and the number of inpatient beds utilized for Covid-19 patients (inpatient_bed_covid_utilization, $p<0.05$).

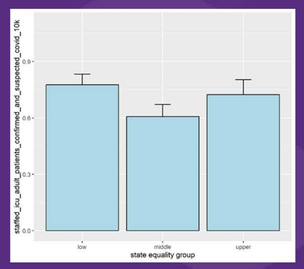

Figure 1. There is a statistically significant difference in the means among the three groups for inpatient beds used for Covid-19. The middle and the low-ranking groups have significantly different means.

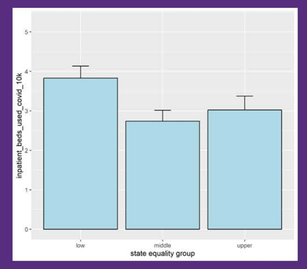

Figure 2. There is a statistically significant difference in the means of inpatient_beds_used_covid_10k among the three groups. The middle and the low-ranking groups have significantly different means.

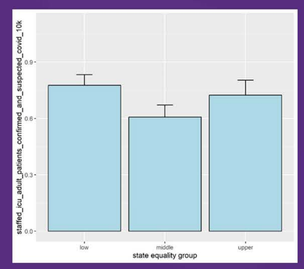

Figure 3. There is a statistically significant difference in the means of staffed_icu_adult_patients_confirmed_and_suspected_with_covid among the three groups. The middle and upper ranking groups have significantly different means from the low-ranking group.

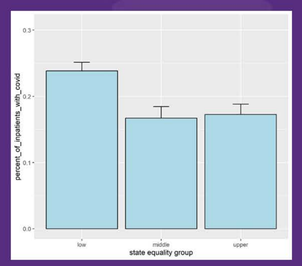

Figure 4. There is a statistically significant difference in the means of percent_of_inpatients_with_covid among the three groups. The middle and upper ranking groups have significantly different means from the low-ranking group.

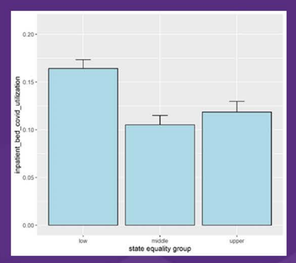

Figure 5. There is a statistically significant difference in the means of inpatient_bed_covid_utilization among the three groups. The middle and the low-ranking groups have significantly different means.

Conclusion

States with less income-based disparities (higher equality rankings), had significantly better outcomes regarding COVID-19 based on the data from November 29th, 2020.

When comparing the upper, middle, and lower rank groups, the states in the upper rank group were reporting fewer inpatient hospitalizations due to COVID-19, less beds utilized inpatient, and less adult patients with inpatient hospitalizations due to confirmed or suspected COVID-19.

Interestingly, when comparing the middle group and the upper group of states, the differences in means for these reports were lower than when comparing the lower group with the middle group.

There can be many reasons for the correlation, one of them that stands out to us as medical students who do hospital-based rotations in different regions with different populations, is the allocation of resources.

Income based equality rankings are one of the factors in the evaluation of the opportunities that a state provides to its population. The states with the lower rankings have higher disparities in their population, and their allocation of resources will in turn be different than a state with a higher ranking with lower disparities in their population.

The measure of equality includes

- the ratio of men to women in the workforce
- gaps between their median incomes
- unemployment differences in people with disabilities and those without
- comparisons between non-Hispanic whites and other racial groups regarding educational achievement, income, and employment

Therefore, while this data shows the equality rankings have a correlation with the hospitalizations due to COVID-19 during the 2020 year, it is unclear if different aspects of the equality measure are bearing more weight than others, or if some factors are bearing no weight at all.

While the data was from 2020, the pandemic did not end. The addition of vaccines, stricter mask mandates, more accessible testing, and different quarantine laws among states changed the rate of COVID-19 spread across the nation.

Further studies will need to be done on the specific factors impacting the measure of equality vs the same outcomes regarding COVID-19

Further studies should include how income-based disparities correlated with inpatient bed utilizations from COVID-19 in the years 2021 and 2022 after the addition of more resources

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