SHORT REPORT

Social Determinants of Health Correlating with Mechanical Ventilation of COVID-19 Patients: A Multi-Center Observational Study

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Importance: Several studies have relayed the disproportionate impact of COVID-19 on marginalized communities; however, few have specifically examined the association between social determinants of health and mechanical ventilation (MV).

Objective: To determine which demographics impact MV rates among COVID-19 patients.

Design: This observational study included COVID-19 patient data from eight hospitals' electronic medical records (EMR) between February 25, 2020, to December 31, 2020. Associations between demographic data and MV rates were evaluated using uni- and multivariate analyses.

Setting: Multicenter (eight hospitals), largest health system in Southeast Michigan.

Participants: Inpatients with a positive RT-PCR for SARS-CoV-2 on nasopharyngeal swab. Exclusion criteria were missing demographic data or non-permanent Michigan residents.

Exposure: Patients were divided into two groups: MV and non-MV.

Main Outcome and Measures: The primary outcome was MV rate per demographic. A multivariate model then predicted the odds of MV per demographic descriptor. Hypotheses were formulated prior to data collection.

Results: Among 11,304 COVID-19 inpatients investigated, 1621 (14.34%) were MV, and 49.96% were male with a mean age of 63.37 years (17.79). Significant social determinants for MV included Black race (40.19% MV vs 31.31% non-MV, p<0.01), poverty (14.60% vs. 13.21%, p<0.01), and disability (12.65% vs 9.14%; p<0.01). Black race (AOR 1.61 (CI 1.41–1.83; p<0.01)), median income (AOR 0.99 (CI 0.99–0.99; p<0.01)), disability (AOR 1.55 (CI 1.26, 1.90; p<0.01)), and non-English-speaking status (AOR 1.26 (CI 1.05, 1.53)) had significantly higher odds of MV.

Conclusions and Relevance: Black race, low socioeconomic status, disability, and non-English-speaking status were significant risk factors for MV from COVID-19. An urgent need remains for a pandemic response program that strategizes care for marginalized communities.

Keywords: COVID-19, disparities, mechanical ventilation, race, socioeconomic

Plain Language Summary

Social determinants of health are associated with an increased risk of COVID-19 morbidity and mortality.[1–3] In this retrospective observational study, we further illustrate how low socioeconomic status, Black race, disability, and non-English-speaking status were associated with an increased rate of mechanical ventilation from COVID-19. These demographic descriptors can be used to help stratify COVID-19 risk and treatment by health-care providers in the emergency room (ER) and inpatient setting.

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Introduction

Background/Rationale

The COVID-19 pandemic has illuminated the disparities within our healthcare system. Obesity, diabetes, race, and poverty have emerged as risk factors for the hospitalization of COVID-19 patients.[1,2] For instance, Black and Hispanic patients are more likely to test positive for COVID-19[3]. However, findings related to mechanical ventilation (MV) of COVID-19 patients have not been well-defined.[4] Recent studies suggest race[5] and poverty[2] are associated with increased risk for ICU admission from COVID-19, though other studies find this correlation to be inconsistent.[1] MV of COVID-19 patients is associated with a high mortality rate,[6] so identifying demographic risk factors for MV will help stratify and optimize treatment for patients at risk.

Objectives

Our study aims to identify social determinants of health that predispose COVID-19 patients to MV within a multicenter Michigan hospital system.

Methods

Study Design

We conducted a retrospective observational study at the largest healthcare system (eight hospitals) in southeast Michigan from February 25, 2020, to December 31, 2020. The study was approved under expedited review by the Beaumont Health Institutional Review Board (IRB), #2020-209. Patient consent was waived as the study design was retrospective. Data confidentiality and compliance with the Declaration of Helsinki was maintained. We included all inpatients who were diagnosed with SARS-CoV2 infection by a positive RT-PCR on nasopharyngeal swab. Patients for whom any demographic data were missing or who were not permanent Michigan residents were excluded from analysis. Zip code level data from the United States Census Bureau such as rate of unemployment/use of public transportation/percentage of food stamp use were used as proxies for economic and employment status as individual-level data was not available from the electronic medical record (EMR). The zip code level data was eventually matched with the individual patient level data. Examined variables include age, ethnicity, marital status, education level, employment, zip code, primary language, disabilities, type of insurance, body mass index (BMI), and established primary care provider

(PCP). Univariate and multivariate analyses were run using SAS 9.4 software to determine any MV correlates. P values of less than 0.05 were considered statistically significant.

Results

Participants

A total of 11,304 patient records were admitted with a diagnosis of COVID-19. Of these, 1621 (14.34%) were MV.

Descriptive Data

Of the total sample population, 58.8% identified as White or Caucasian, 32.6% as Black or African American, 10% as Arab or Middle Eastern, and 3.1% as Hispanic or Latino. Males represented 49.96% of the sample. Patients with disabilities comprised 9.7% of the sample population.

Outcome Data

Table 1 illustrates the characteristics of the study participants, grouped by need for MV. The mean age in years for patients who were MV was 65.73 (SD 13.73), and for those who were not MV 63.4 (SD 18.33). On average, patients requiring MV were older (p<0.01) and had a significantly higher BMI (33.27 versus 31.12; p<0.01). Males had 47% greater odds of MV than females (OR 1.47, p<0.01). Black patients had 47% greater odds of MV than White patients (OR 1.47, p<0.01). Disabled patients had 73% greater odds of MV than full-time working patients (OR 1.73, p=0.001). Patients with Medicare had 25% greater odds of MV than patients with private insurance (OR 1.25, p<0.01), and those without a PCP had 14% greater odds of MV than patients with a PCP (OR 1.14, p=0.03). Patients needing MV were identified as living in zip codes associated with higher unemployment rates (p<0.01), public transportation to work (p<0.01), working in service professions (p<0.01), lower median income (p<0.01), and poverty (p<0.01).

Main Results

Table 2 illustrates a multivariate model to predict MV. For each additional year of age, odds of MV increased by 2% (p<0.01). For each decrease of $1000 in median income in a ZIP code, the adjusted odds of MV increased by 1% (p<0.01). Male gender (AOR 1.43, p<0.01), Black race (AOR 1.61, p<0.01), low median income (AOR 0.99, p<0.01), non-English

Table 1 Descriptive Variables, Stratified by MV

	Total	MV (N = 1621)	Non-MV (N = 9683)	p-value
Age of Patient (Years) (n = 11,304)				
Mean (Standard Deviation)	63.77 (17.79)	65.73 (13.73)	63.40 (18.33)	< 0.0001
Body Mass Index (BMI) (n = 10,916)				
Mean (Standard Deviation)	31.43 (8.75)	33.27 (9.05)	31.12 (8.51)	< 0.0001
Unemployment Rate of ZIP Code (%) (n = 11,212)				
Mean (Standard Deviation)	7.44% (4.78%)	8.00% (4.92%)	7.35% (4.76%)	< 0.0001
Percent of ZIP Code Taking Public Transportation to Work (%) (n = 11,212)				
Mean (Standard Deviation)	1.80% (2.72%)	2.06% (2.93%)	1.76% (2.68%)	0.0001
Percent of ZIP Code Working in White Collar Profession (%) (n = 11,212)				
Mean (Standard Deviation)	35.69% (13.87%)	34.24% (13.23%)	35.92% (13.96%)	< 0.0001
Percent of ZIP Code Working in Service Profession (%) (n = 11,212)				
Mean (Standard Deviation)	18.41% (5.59%)	18.99% (5.57%)	18.31% (5.59%)	< 0.0001
Median Income of ZIP Code ($) (n = 11,211)				
Mean (Standard Deviation)	$60,704.80 ($25,539)	$57,068.40 ($23,179.14)	$61,311.67 ($25,871.93)	< 0.0001
Percent of ZIP Code on Food Stamps/SNAP* (%) (n = 11,211)				
Mean (Standard Deviation)	17.31% (13.27%)	18.87% (13.48%)	17.06% (13.23%)	< 0.0001
Poverty Rate of ZIP Code (%) (n = 11,211)				
Mean (Standard Deviation)	13.41% (10.82%)	14.60% (10.97%)	13.21% (10.79%)	< 0.0001
Biological Sex of Patient (n = 11,304)				
Female	5657 (50.04%)	678 (41.85%)	4970 (51.38%)	< 0.0001
Male	5647 (49.96%)	942 (58.15%)	4703 (48.62%)	
Race of Patient (n = 11,304)				
American Indian or Alaska Native	34 (0.30%)	5 (0.31%)	29 (0.30%)	< 0.0001
Asian	230 (2.03%)	32 (1.98%)	198 (2.05%)	
Black or African American	3684 (32.59%)	651 (40.19%)	3029 (31.31%)	
Native American or Pacific Islander	5 (0.04%	1 (0.06%)	4 (0.04%)	
Other	699 (6.18%)	84 (5.19%)	613 (6.34%)	
White or Caucasian	6646 (58.79%)	846 (52.22%)	5795 (59.91%)	
Unknown	6 (0.05%)	1 (0.06%)	5 (0.05%)	
Ethnicity of Patient (n = 11,304)				
Arabic or Middle Eastern	1139 (10.08%)	157 (9.69%)	982 (10.15%)	0.7024
Hispanic or Latino	351 (3.11%)	59 (3.64%)	292 (3.02%)	
Not Hispanic or Latino	9273 (82.03%)	1329 (82.04%)	7936 (82.04%)	
Other	440 (3.89%)	60 (3.70%)	377 (3.90%)	
Unknown	101 (0.89%	15 (0.93%)	86 (0.89%)	
Marital Status (n = 11,304)				
Divorced	1114 (9.85%)	179 (11.05%)	933 (9.65%)	< 0.0001
Married	5199 (45.99%)	761 (46.98%)	4437 (45.87%)	
Separated	124 (1.10%)	14 (0.86%)	110 (1.14%)	
Single	2967 (26.25%)	445 (27.47%)	2522 (26.07%)	
Widowed	1746 (15.45%)	189 (11.67%)	1550 (16.02%)	
Unknown	154 (1.36%)	32 (1.98%)	121 (1.25%)	
English Language Speaker (n = 11,304)				
Yes	10,082 (89.19%)	1426 (88.02%)	8645 (89.37%)	0.1061
No	1222 (10.81%)	194 (11.98%)	1028 (10.63%)	

(*Continued*)

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Table 1 (Continued).

	Total	MV (N = 1621)	Non-MV (N = 9683)	p-value
Employment Status (n = 11,239)				
Disabled	1089 (9.68%)	205 (12.65%)	884 (9.14%)	< 0.0001
Full Time	2536 (22.56%)	300 (18.52%)	2236 (23.12%)	
Homemaker	104 (0.92%)	15 (0.93%)	89 (0.92%)	
Not Employed	2382 (21.19%)	321 (19.81%)	2061 (21.31%)	
Part Time	331 (2.95%)	35 (2.16%)	296 (3.06%)	
Retired	4279 (38.07%)	648 (40.00%)	3631 (37.54%)	
Self Employed	191 (1.70%)	25 (1.54%)	166 (1.72%)	
Student	17 (0.151%)	0 (0.00%)	17 (0.18%)	
Unknown	310 (2.76%)	71 (4.38%)	293 (3.03%)	
Primary Payer (n = 11,304)				
Private Insurance	6005 (53.12%)	793 (48.95%)	5210 (53.86%)	0.0005
Uninsured	132 (1.17%)	12 (0.74%)	120 (1.24%)	
Medicaid	382 (3.38%)	56 (3.46%)	326 (3.37%)	
Medicare	4760 (42.11)	757 (46.73%)	3994 (41.29%)	
Tricare/VA	25 (0.22%)	2 (0.12%)	23 (0.24%)	
Has Primary Care Physician (PCP) (n = 11,304)				
Yes	8526 (75.42%)	1188 (73.33%)	7329 (75.77%)	0.0352
No	2778 (24.58%)	432 (26.67%)	2344 (24.23%)	

Abbreviation: SNAP, Supplemental Nutrition Assistance Program.

speakers (AOR 1.26, p=0.015), and disability (AOR 1.55, p<0.01) correlated with higher odds of mechanical MV.

Discussion
Key Results

Our results suggest that several demographic factors are associated with an increased risk of MV in COVID-19 patients. Beginning with socioeconomic status, MV patients were more likely to live in zip codes with higher rates of unemployment, poverty, public transportation, food stamp use, and essential service jobs. COVID-19 burden has been similarly observed in regions scoring high on the Distressed Communities Index, including Detroit.[7,8] Zhang et al further demonstrated that NYC neighborhoods with disadvantaged social conditions (low socioeconomic status, non-white, elderly) had higher mortality rates from COVID-19.[9] Under conditions of crowded living, public transport, and frontline work, transmission is more likely.[9] Financial insecurity and lack of insurance may also delay seeking medical care until advanced stages of infection.[10] Accordingly, we were surprised to find that patients under the "Not employed" category did not have a higher risk of MV. This could be a limitation of the EMR if employment history is not updated.

In terms of race, we found that Black patients were at 47% greater odds of being MV than White patients. In Michigan, Black residents constitute 14.1% of the population,[11] 7% of COVID-19 cases, yet 20.1% of COVID-19 deaths as of May 26, 2021.[12] Similar observations between Black race and COVID-19 burden have been found after controlling for pre-existing comorbidities.[10] It is possible that Black patients delay seeking medical attention as quickly as their White counterparts.[10] Distrust in medical providers or financial barriers as previously discussed may play a role.[10] Black Americans also comprise a disproportionate percentage of frontline jobs where risk of exposure is high, including nursing homes or skilled care facilities, courier services, and urban transportation.[13]

Patients with disabilities were also more likely to be MV from COVID-19. Intellectual and developmental disability (IDD) has previously been shown to be at greater risk for COVID-19 infection, however these results may be confounded by population density as samples resided in group homes or urban settings where transmission is greater.[14] More research to illuminate morbidity/mortality outcomes in disabled patients with COVID-19 is needed. Our results are limited as "disability" in the EMR does not delineate physical, intellectual, or professional definition.

In the univariate analysis, no significant difference was found between MV and non-MV patients regarding non-English speaking status (p=0.1061). However, when

Table 2 Multivariate Model to Predict MV

	AOR (95% CI)	P-value
Age of Patient	1.02 (1.01, 1.02)	< 0.0001
Percent of ZIP Code Working in Service Industry	0.98 (0.96, 0.99)	0.0107
Median Income of ZIP Code ($1000 USD)	0.99 (0.99, 0.99)	< 0.0001
Biological Sex of Patient		
Male	1.43 (1.28, 1.60)	< 0.0001
Female	Reference Group	
Race of Patient		
American Indian or Alaska Native	1.24 (0.49, 3.17)	0.6505
Asian	1.25 (0.85, 1.84)	0.2529
Black or African American	1.61 (1.41, 1.83)	< 0.0001
Native American or Pacific Islander	3.28 (0.43, 25.1)	0.2527
Other	0.86 (0.67, 1.11)	0.2560
Unknown	1.32 (0.17, 10.2)	0.7898
White or Caucasian	Reference Group	
Marital Status		
Divorced	1.05 (0.87, 1.26)	0.6256
Separated	0.69 (0.39, 1.21)	0.1927
Single	1.02 (0.89, 1.18)	0.7519
Unknown	1.33 (0.87, 2.02)	0.1894
Widowed	0.61 (0.51, 0.74)	< 0.0001
Married	Reference Group	
English Speaker		
No	1.26 (1.05, 1.53)	0.0150
Yes	Reference Group	
Employment Status		
Disabled	1.55 (1.26, 1.90)	< 0.0001
Homemaker	1.50 (0.85, 2.66)	0.1639
Not Employed	1.13 (0.94, 1.35)	0.1858
Part Time	1.03 (0.71, 1.50)	0.8596
Retired	1.07 (0.89, 1.28)	0.4861
Self Employed	1.08 (0.70, 1.68)	0.7324
Student	0.33 (0.22, 6.00)	0.4527
Unknown	1.52 (1.12, 2.05)	0.0070
Full Time	Reference Group	

adjusted for all other variables in the multivariate analysis, the odds of intubation were significantly increased in non-English speaking patients (p=0.015). Indeed, language barriers, even with the help of translation services, have been associated with less frequent COVID-19 testing and thus higher burden of infection.[15]

Application of the aforementioned findings could be considered when stratifying patient risk in an emergency room or inpatient setting. Prognostic calculators, such as COVID-Nolab,[16] help predict patient outcomes in resource limited settings where diagnostic labs are delayed or unavailable, and adding a demographic component to these calculations could improve their accuracy. Social determinants of health, particularly elderly and socioeconomically vulnerable patients, have even been associated with COVID-19 subphenotypes that yield higher mortality rates.[17] Our findings further support the need for health policy to protect these more vulnerable communities.[17]

Our study focuses on a southeast Michigan population with a primarily urban and suburban demographic, though results can be generalized to the population as similar findings have been observed nationally and internationally. Limitations of this study include retrospective nature as well as potential inaccuracies and missing data in the medical record.

Conclusion

Health-care disparities have negatively impacted patient outcomes during the COVID-19 pandemic. Our study shows how Black race, low socioeconomic status, non-English-speaking status, and disability were all predictors for MV from COVID-19. These demographic predictors should help health providers stratify patient risk and disposition in the ER or inpatient setting. What remains is an urgent need to create a pandemic response program that strategizes prevention and care for communities historically oppressed by structural inequalities.

Data Sharing Statement

The data used to support the findings of this study are available from the corresponding author upon request.

Ethics Approval

The study was approved by the Beaumont Health Institutional Review Board. The study was approved under expedited review and the patient consent was waived as the study design was retrospective. Data confidentiality and compliance with the Declaration of Helsinki were maintained.

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Disclosure

The authors have no conflicts of interest regarding the publication of this paper.

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