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Brief communication

## Characteristics and outcomes of Hispanic/Latinx patients with coronavirus disease 19 (COVID-19) requiring hospitalization in Rhode Island: a retrospective cohort study

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## ABSTRACT

**Objective:** Explore potential racial/ethnic differences, describe general clinical characteristic, and severe outcomes (intensive care unit [ICU] admission, mechanical ventilation [intubation], and death) between Hispanic/Latinx (hereafter: Hispanics or Latinx community) and non-Hispanic patients hospitalized with COVID-19.

**Methods:** Retrospective cohort of 326 patients hospitalized with COVID-19 through April 19, 2020. Sociodemographic and hospital course data were collected and analyzed. A multivariate logistic regression analysis was implemented to examine associations.

**Results:** Compared with non-Hispanic Whites (NHW), Hispanics were younger (53 years, median age) and had higher rates of Medicaid and less commercial/HMO/PPO coverage ( $P < .001$ ). Similarly, in the age sub-grouped multivariate analysis for outcomes, Hispanics  $\geq 65$ -year-old were 2.66 times more likely to be admitted to ICU (95% CI: 1.07–6.61;  $P = .03$ ), and 3.67 times more likely to get intubated (95% CI: 1.29–10.36;  $P = .01$ ).

**Conclusions:** Hospitalized Hispanic patients of  $\geq 65$ -year-old with COVID-19 were more likely to have higher risk of more severe outcomes (ICU admission and intubation) compared with NHW. Hispanic patient's social determinants of health and underlying medical conditions may explain the heightened risk for severe outcomes. Further studies are necessary to more accurately identify and address health disparities in Hispanics and other vulnerable populations amidst COVID-19 and future pandemics.

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**Abbreviations:** CDC, Centers for Disease Control; CI, Confidence Interval; COVID-19, Coronavirus Disease 2019; HMO, Health Maintenance Organization; ICU, Intensive Care Unit; NHAA, Non-Hispanic African American; NHW, Non-Hispanic White; OR, Odds Ratio; PPO, Preferred Provider Organization; SES, Socioeconomic status; WHO, World Health Organization.

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## Introduction

The COVID-19 pandemic has disproportionately affected ethnic minorities around the world [1]. In the U.S., the risk of COVID-19 infections, related hospitalizations, and deaths is higher among vulnerable populations and people of color including the Hispanic and African American communities [2–4]. In Rhode Island (RI), Hispanics and African Americans comprise 16% and 8.5% of the population, respectively. Yet, these communities overwhelmingly over-represent the proportion of COVID-19 cases (Hispanics 46% and African Americans 12%) and the rate of hospitalizations (Hispanics:

**Table 1**  
Clinical and demographic characteristics of Hispanics/Latinx, non-Hispanic African Americans, and non-Hispanic White patients with COVID-19 requiring hospitalization.

	Total	HL	NHAA	NHW	P value
Total	N = 326 (100%)	N = 126 (39%)	N = 55 (17%)	N = 145 (44%)	
Age (median)	61	53.5	63	67	<.001
Age IQR	(49.00–74.00)	(44.00–66.00)	(54.00–70.00)	(56.00–77.00)	
Gender					.31
Female	144 (44.2%)	49 (38.9%)	26 (47.3%)	69 (47.6%)	
Male	182 (55.8%)	77 (61.1%)	29 (52.7%)	76 (52.4%)	
Coverage					<.001
Commercial/HMO/PP0	64 (19.6%)	18 (14.3%)	14 (25.5%)	32 (22.1%)	
Medicaid	93 (28.5%)	59 (46.8%)	14 (25.5%)	20 (13.8%)	
Medicare	161 (49.4%)	45 (35.7%)	25 (45.5%)	91 (62.8%)	
Self-pay	8 (2.5%)	4 (3.2%)	2 (3.6%)	2 (1.4%)	
Comorbidities					
Cardiac/Pulmonary					
Congestive heart failure	30 (9.2%)	7 (5.6%)	5 (9.1%)	18 (12.4%)	.15
Cardiac arrhythmias	63 (19.3%)	7 (5.6%)	10 (18.2%)	46 (31.7%)	<.001
Valvular disease	15 (4.6%)	2 (1.6%)	1 (1.8%)	12 (8.3%)	.02
Peripheral vascular disorders	20 (6.1%)	5 (4.0%)	3 (5.5%)	12 (8.3%)	.33
Hypertension	148 (45.4%)	47 (37.3%)	30 (54.5%)	71 (49.0%)	.05
Pulmonary circulation disorders	12 (3.7%)	4 (3.2%)	1 (1.8%)	7 (4.8%)	.56
Chronic pulmonary disease	48 (14.7%)	18 (14.3%)	7 (12.7%)	23 (15.9%)	.84
Endocrine					
Obesity	130 (39.9%)	44 (34.9%)	24 (43.6%)	62 (42.8%)	.35
Diabetes	109 (33.4%)	45 (35.7%)	21 (38.2%)	43 (29.7%)	.41
Hypothyroidism	22 (6.7%)	4 (3.2%)	1 (1.8%)	17 (11.7%)	.006
Renal failure	35 (10.7%)	3 (2.4%)	13 (23.6%)	19 (13.1%)	<.01
Liver disease	11 (3.4%)	5 (4.0%)	3 (5.5%)	3 (2.1%)	.44
Hematologic/Malignancy/Immunodeficiencies					
Lymphoma	4 (1.2%)	2 (1.6%)	0 (0.0%)	2 (1.4%)	.66
Metastatic cancer	3 (0.9%)	1 (0.8%)	1 (1.8%)	1 (0.7%)	.74
Solid tumor without metastasis	20 (6.1%)	5 (4.0%)	4 (7.3%)	11 (7.6%)	.43
Coagulopathy	21 (6.4%)	13 (10.3%)	2 (3.6%)	6 (4.1%)	.08
AIDS/HIV	4 (1.2%)	1 (0.8%)	2 (3.6%)	1 (0.7%)	.20
Rheumatologic					
Rheumatoid arthritis/collagen vascular disease	6 (1.8%)	2 (1.6%)	1 (1.8%)	3 (2.1%)	.96
Psychiatric disorders					
Alcohol abuse	18 (5.5%)	5 (4.0%)	5 (9.1%)	8 (5.5%)	.38
Drug abuse	17 (5.2%)	2 (1.6%)	3 (5.5%)	12 (8.3%)	.05
Psychoses	14 (4.3%)	4 (3.2%)	6 (10.9%)	4 (2.8%)	.03
Depression	45 (13.8%)	13 (10.3%)	5 (9.1%)	27 (18.6%)	.08
E-vW score					.02
0	79 (24.2%)	44 (34.9%)	9 (16.4%)	26 (17.9%)	
<0	72 (22.1%)	26 (20.6%)	11 (20.0%)	35 (24.1%)	
1–4	50 (15.3%)	14 (11.1%)	12 (21.8%)	24 (16.6%)	
>=5	125 (38.3%)	42 (33.3%)	23 (41.8%)	60 (41.4%)	
Outcomes					
ICU	104 (31.9%)	34 (27.0%)	20 (36.4%)	50 (34.5%)	.31
Ventilator	60 (18.4%)	24 (19.0%)	11 (20.0%)	25 (17.2%)	.88
Death	57 (17.5%)	16 (12.7%)	9 (16.4%)	32 (22.1%)	.12

E-vW score = Weighted Elixhauser-van Walraven comorbidity score; HL = Hispanic/Latinx; NHAA = Non-Hispanic African American; NHW = Non-Hispanic White.  
Continuous values: median (IQR); categorical values: N (%).  
Mann-Whitney-Wilcoxon and chi-squared tests used to calculate p-values (≤.05 considered statistically significant).

100, African Americans: 106, and Whites: 33, per 100,000 people) [5].

Historically, the Latinx community has faced several social and health inequities [6,7] which may have contributed to a higher degree of COVID-19-associated illness and higher number of deaths [8]. Despite emerging data highlighting the health impact of COVID-19 cases on Hispanics across the United States [9], hospitalization data among Hispanics with COVID-19 remains sparse. Thus, studying this particular group is crucial for the identification of risk factors that may contribute to such disparities and burden of disease. This study aims to describe the clinical characteristics and outcomes of hospitalized Hispanic patients with confirmed COVID-19, and to compare with non-Hispanic Whites (NHW), and non-Hispanic African Americans (NHAA) at one of the largest, non-profit healthcare systems in RI.

## Methods

### Study design and patient selection

The study was a retrospective chart review approved by the Institutional Review Board of Rhode Island Hospital. We included all consecutive adult (≥18-year-old) patients with confirmed SARS-CoV-2 infection by RT-PCR (reverse transcriptase-polymerase chain reaction assay) admitted to our hospitals between February 17th and April 19th, 2020. We categorized patients based on their race/ethnicity including Hispanics, NHAA, and NHW. Other racial groups (e.g., Asian, Pacific Islander) and those with missing race/ethnicity data in the medical record were excluded. A consent waiver was also obtained for the purposes of this study.

**Table 2**  
Logistic regression analysis: association between race/ethnicity and outcomes in hospitalized patients with COVID-19.

	ICU		Intubation		Death	
	OR [95% CI]	P-value	OR [95% CI]	P value	OR [95% CI]	P value
<i>Race/Ethnicity</i>						
HL	0.94 [0.53–1.67]	.84	1.32 [0.67–2.60]	.42	1 [0.46–2.16]	1
NHAA	1.2 [0.61–2.36]	.59	1.27 [0.56–2.83]	.57	0.88 [0.35–2.19]	.79
Age*	1.01 [0.98–1.03]	.37	1 [0.98–1.03]	.74	1.06 [1.03–1.10]	<.001*
<i>Gender</i>						
Male	1.42 [0.86–2.32]	.17	1.81 [0.99–3.29]	.05*	0.94 [0.49–1.78]	.84
<i>Coverage</i>						
Medicaid	0.59 [0.27–1.26]	.18	0.62 [0.25–1.47]	.28	2.02 [0.48–8.39]	.33
Medicare	1.02 [0.49–2.12]	.95	0.87 [0.37–2.03]	.74	2.14 [0.56–8.07]	.26
Self-pay	0.75 [0.13–4.14]	.74	0.55 [0.06–4.95]	.59	3.38 [0.28–40.47]	.34
E-vW score*	1.04 [1.00–1.07]	.04*	1.02 [0.98–1.06]	.28	1.04 [0.99–1.08]	.06

CI = confidence intervals; E-vW score = Weighted Elixhauser-van Walraven comorbidity score; HL = Hispanic/Latinx; NHAA = Non-Hispanic African American; OR = odds ratio.

Reference variables (not shown): for racial/ethnic group: non-Hispanic White; for healthcare coverage (coverage): Commercial/HMO/PPO. Logistic regression.

\* P values ≤.05 considered statistically significant.

**Data collection**

Data were obtained from the integrated electronic health records (EHR) via two independent extractors. The data included demographics (age, gender, self-reported race/ethnicity, and insurance status), medical comorbidities, psychosocial factors. The comorbidities were extracted based on the definitions of the Elixhauser-van Walraven comorbidity index [10]. We obtained data on COVID-19 associated hospitalization outcomes such as need for ICU admission, need for mechanical ventilation (intubation), and death.

**Study outcomes**

Our primary outcome was to describe and look for possible differences in the general and clinical characteristics and outcomes among hospitalized Hispanic, NHAA, and NHW patients with COVID-19. Our secondary outcome was to evaluate if age, gender, healthcare coverage, and Elixhauser-van Walraven comorbidity score (E-vW score) contribute to higher risk for worse clinical outcomes among these ethnic groups.

**Statistical analysis**

We represented continuous measurements as medians with interquartile range (IQRs) and compared them using the Mann-Whitney-Wilcoxon test. For categorical data, we used a Pearson’s chi-squared test to compare the difference in population proportions between different sub-groups. We examined differences in patient characteristics and co-morbidities of admitted patients by race/ethnicity.

We performed a multivariate logistic regression analysis to examine the association between race/ethnicity and the outcomes of ICU admission, need for intubation and death, while adjusting for age, gender, healthcare insurance and comorbidities (E-vW score). To further examine if there were differences between race/ethnicity and outcomes by age group, we sub-grouped by age (<65 and ≥65-year-old) and repeated the same analysis in each age group. We used NHW as a reference racial/ethnic group, so the odds ratios were compared to NHW. For our analyses, 95% confidence intervals and P values are shown. A P value of ≤.05 was defined as statistically significant. All analyses were performed using Stata v15.1 (Stata Corporation, College Station, TX).

**Results**

Of the initial 339 patients admitted to our healthcare system with confirmed COVID-19, 326 (96.2%) patients were included and 13 (3.8%) were excluded based on missing data on, or being from a different race/ethnicity. Of the included patients, Hispanic patients comprised 39% (n = 136). Among the non-Hispanics, NHAA comprised 17% (n = 55), and NHW 44% (n = 145). In Table 1 we present the characteristics of the patients included in this analysis. The overall median age was 61 years (IQR:49–74); Hispanics were nearly 10 years younger (P < .001) median age of 53.5 years (IQR:44–66) compared with NHAA (63 years, IQR:54–70) and NHW (67 years, IQR:56–77).

The most common comorbid conditions among Hispanic and non-Hispanics were hypertension 45.4% (n = 148), obesity 39.9% (n = 130), and diabetes 33.4% (n = 109). Notably, non-Hispanics had higher rates of hypertension and renal disease compared with Hispanics. Among non-Hispanics, NHAA had a higher burden of renal disease (23.6% [n = 13] vs. 13.1% [n = 19], P < .001) and hypertension (54.5% [n = 30] vs. 49% [n = 71], P = .05) compared with NHW. Cardiac arrhythmias and valvular disease were more common in NHW compared with NHAA and Hispanics (31.7% [n = 46] vs. 18.2% [n = 10] and 5.6% [n = 7], P < .001). No significant differences were found in the presence of diabetes mellitus, chronic pulmonary disease, immunosuppression, or obesity between Hispanics and non-Hispanics. The weighted E-vW comorbidity index demonstrated a lower severity score among Hispanics compared with non-Hispanics (P = .02). In terms of clinical outcomes, 104 (31.9%) of all COVID-19 hospitalized patients required ICU care, of these, 34 (27%) were HL, 20 (36.4%) NHAA, and 50 (34.5%) NHW. Of the 60 (18.4%) patients who required intubation, 24 (19%) were HL, 11(20%) NHAA, and 25 (17.2%) NHW. A total of 57 (17.5%) patients died: 16 (12%) HL, 9 (16.4%) NHAA, and 32 (22.1%) NHW.

In regard to insurance coverage, Hispanics had the highest rate of Medicaid coverage 46.8% (n = 59), and the lowest rates of commercial/HMO/PPO 19.6% (n = 18) and Medicare 37.5% (n = 45) coverage when compared with NHAA and NHW (P < .001). The percentage of Hispanic patients with Medicaid was almost 3-times as high compared to that of NHW (46.8% [n = 59] vs. 13.8% [n = 20]) and almost 2-times greater compared to NHAA (46.8% [n = 59] vs. 25.5% [n = 14]).

For our secondary outcome, we present the logistic regression analysis (Table 2). We found that age was associated with a higher

risk of death (OR: 1.06, 95% CI: 1.03–1.10;  $P < .001$ ) and that having a higher E-vW score was associated with a slight increased risk of ICU admission (OR: 1.04, 95% CI: 1.00–1.07;  $P = .04$ ). Although not statistically significant, the ORs for race/ethnicity (using NHW as reference group) and outcomes were as follows: for those requiring ICU: HL (OR: 0.94, 95% CI: 0.53–1.67;  $P = .84$ ) and NHAA (OR: 1.2, 95% CI: 0.61–2.36;  $P = .59$ ); for those requiring intubation: HL (OR: 1.32, 95% CI: 0.67–2.60;  $P = .42$ ) and NHAA (OR: 1.27, 95% CI: 0.56–2.83;  $P = .57$ ); and for those who died: HL (OR: 1, 95% CI: 0.46–2.16;  $P = 1$ ) and NHAA (OR: 0.88, 95% CI: 0.35–2.19;  $P = .79$ ). However, when analyzing race/ethnicity and outcomes by age groups  $<65$  and  $\geq 65$ -year-old (Table 3), we found that Hispanic patients  $\geq 65$ -year-old were 2.66 times more likely to need ICU admission (OR: 2.66, 95% CI: 1.07–6.61;  $P = .03$  [unadjusted OR: 2.08, 95% CI: 0.94–4.64;  $P = .07$ ]) and 3.66 times more likely to get intubated (OR: 3.66, 95% CI: 1.29–10.36;  $P = .01$  [unadjusted OR: 3.73, 95% CI: 1.46–9.53;  $P = .01$ ]) compared with NHW. This analysis also showed that Hispanics  $<65$ -year-old were less likely to die (OR: 0.09, 95% CI: 0.01–0.83;  $P = .03$  [unadjusted OR: 0.11, 95% CI: 0.01–0.88;  $P = .04$ ]) compared with NHW.

**Discussion**

The impact of COVID-19 in the US has dismantled many vulnerabilities in the Hispanic population allowing for an increased risk of infection and need for hospitalization among these communities. Our study mimics the disproportionate high rate of COVID-19 cases and hospitalizations among Hispanics in the state of RI [5]. However, the proportion of COVID-19 hospitalizations among Hispanics in our study was higher compared with the COVID-19-Associated Hospitalization Surveillance Network (COVID-NET) where Hispanics comprise only 20% of the hospitalizations [11]. These findings might be related to the high rates of community transmission among densely populated Hispanic neighborhoods in RI, and shadowed by the astonishing COVID-19 disease burden and outcomes in NHAA, as seen in other states [12,13].

Interestingly, compared with non-Hispanics, Hispanic patients were significantly younger and had less comorbid conditions. This age differences may be explained by the fact that the Hispanic population in RI is predominantly younger (median age: 25.8 years) compared with NHW (median age: 44 years) [14]. Other studies have also found high COVID-19 associated hospitalization and infection rates among younger ethnic minorities [15], however, the reasons for these age disparities remain unknown. A possible explanation to the higher disease prevalence may be the increased viral burden leading to higher rate of transmission among Latinx communities living in confined environments. Moreover, at least a quarter of Hispanics work in key service occupations [16], factory warehouses, and other environments, where adhering to the local CDC and WHO social distancing recommendations could be challenging.

Many Latinx community members' low insurance rates, immigrant status, and language barriers have resulted in limited access to and lower quality of medical care [17], leading to delay, underdiagnosis, and substandard management of medical comorbidities. Notably, young Hispanics in our cohort had higher Medicaid coverage and lower commercial/HMO/PPO coverage rates compared with NHW, which may be indicators of poverty level and/or socioeconomic status (SES) [18,19]. Disparities in the structural, socioeconomic factors, and living conditions of Hispanic/Latinx communities may contribute to increasing the risk of acquisition and transmission of infections such as COVID-19 and other pandemics [20].

Although overall we did not find racial/ethnic difference in outcomes, in the sub-group analysis we did find that Hispanics of  $\geq 65$ -year-old had higher risk for ICU admission and need for

**Table 3** Logistic regression analysis: association between race/ethnicity and outcomes by age group ( $<65$  and  $\geq 65$ -year-old) in hospitalized patients with COVID-19

Outcome:	ICU		Intubation		Death	
	$<65$ OR [95% CI]; P value	$\geq 65$ OR [95% CI]; P value	$<65$ OR [95% CI]; P value	$\geq 65$ OR [95% CI]; P value	$<65$ OR [95% CI]; P value	$\geq 65$ OR [95% CI]; P value
<b>Race/Ethnicity</b>						
HL adjusted	0.46 [0.20 - 1.04]; .06	2.66 [1.07 - 6.61]; .03*	0.56 [0.21 - 1.48]; .24	3.66 [1.29 - 10.36]; .01*	0.09 [0.01 - 0.83]; .03*	1.55 [0.62 - 3.91]; .34
HL unadjusted	0.36 [0.17 - 0.74]; .01*	2.08 [0.94 - 4.64]; .07	0.48 [0.20 - 1.14]; .10	3.73 [1.46 - 9.53]; .01*	0.11 [0.01 - 0.88]; .04*	1.28 [0.57 - 2.87]; .55
NHAA adjusted	0.99 [0.40 - 2.44]; .99	1.25 [0.44 - 3.54]; .67	1.17 [0.42 - 3.24]; .75	0.86 [0.19 - 3.77]; .84	0.71 [0.15 - 3.39]; .67	0.76 [0.25 - 2.31]; .63
NHAA unadjusted	0.99 [0.42 - 2.33]; .98	1.19 [0.44 - 3.22]; .731	1.19 [0.45 - 3.18]; .72	1.01 [0.25 - 4.05]; .99	0.91 [0.22 - 3.78]; .90	0.74 [0.26 - 2.11]; .57
Age	1.02 [0.99 - 1.06]; .08	0.97 [0.93 - 1.02]; .37	1.02 [0.98 - 1.06]; .25	0.93 [0.87 - 1.00]; .05	1.03 [0.96 - 1.11]; .36	1.04 [0.99 - 1.09]; .06
<b>Gender</b>						
Male	1.02 [0.99 - 1.06]; .08	1.08 [0.51 - 2.27]; .83	2.1 [0.91 - 5.25]; .07	1.37 [0.54 - 3.42]; .49	0.71 [0.18 - 2.76]; .62	0.99 [0.47 - 2.09]; .47
<b>Coverage</b>						
Medicaid	0.64 [0.27 - 1.50]; .31	5.96 [0.31 - 111.65]; .23	0.78 [0.30 - 2.06]; .62	3.31 [0.13 - 81.53]; .46	7.29 [0.78 - 67.79]; .08	2.03 [0.13 - 29.97]; .60
Medicare	1.15 [0.45 - 2.94]; .76	6.93 [0.73 - 65.04]; .09	0.93 [0.31 - 2.79]; .90	4.08 [0.41 - 40.24]; .22	4.2 [0.38 - 45.96]; .23	1.27 [0.20 - 1.82]; .79
Self-pay	0.61 [0.06 - 5.83]; .67	6.72 [0.18 - 238.57]; .29	1 - empty	8.1 [0.20 - 325.95]; .26	1 - empty	4.03 [0.14 - 111.42]; .41
E-vW score	1.02 [0.97 - 1.07]; .33	1.04 [0.99 - 1.10]; .06	1.00 [0.95 - 1.06]; .75	1.03 [0.97 - 1.10]; .25	1.06 [0.99 - 1.15]; .79	1.01 [0.96 - 1.07]; .46

CI = confidence intervals; E-vW score = Weighted Elixhauser-van Walraven comorbidity score

; HL = Hispanic/Latinx; NHAA = Non-Hispanic African American;

OR = odds ratio.

The words "adjusted" and "unadjusted" refer to the odds ratios for each variable.

Logistic regression.

Reference variables (not shown): for racial/ethnic group: non-Hispanic White; for healthcare coverage (coverage): Commercial/HMO/PPO.

\* P values  $\leq .05$  considered statistically significant.

intubation compared to NHW. This could suggest that older Hispanic patients may have higher burden of uncontrolled/untreated or non-diagnosed medical conditions, which may be exacerbated by their social determinants of health and limited access to access to medical care, increasing their risk for worse COVID-19-associated complications. Similar findings were reported in a study in Georgia, where no association between outcomes and race in hospitalized patients was seen despite a disproportionate rate of hospitalization among Black individuals compared with non-Hispanic Whites [21]. In our series, we did not find a significant difference between race/ethnicity and hospital outcomes in young (<65-year-old) Hispanics when compared with non-Hispanics with COVID-19, indicating that in-hospital outcomes might be similar in this age group. Our study did find an association between older age and higher risk of death, which is consistent with CDC data and other studies [22,23].

The retrospective nature of our review utilizing self-reported race/ethnicity data is one of or limitations especially since some patients self-identify as both, Hispanic and Black/AA. Our data is limited to the beginning of the COVID-19 epidemic curve in RI, which may have led to an overestimation of outcomes since initial management suggested early elective intubation and admission to the ICU. We did not collect data on severity of comorbid conditions, duration of respiratory symptoms, or administration of therapeutic interventions against SARS-CoV-2 (e.g., remdesivir and convalescent plasma) which may have also had an effect in outcomes. Finally, we used insurance coverage as a guide to determine SES, which may not fully reflect our patient's SES.

## Conclusions

Hispanic patients who are 65-years old or older with COVID-19 infection and requiring hospitalization have a higher risk for severe outcomes, specifically need for intubation and ICU level of care, compared with non-Hispanic Whites. The risk for more severe outcomes among Hispanics may not solely be explained by their comorbidities, but possibly also by a result of their social determinants of health and the severity of their underlying medical conditions. Further investigations are necessary to more accurately identify potential risk factors that could be contributing to the significant disproportion in the heightened risk of acquisition, need for hospitalization, and worse outcomes in Hispanics with COVID-19. Identifying and addressing these disparities in Hispanics and other racial/ethnic minorities may positively impact prevention, testing, and education efforts crucial to control and prevent complications in future pandemics.

## Credit Author Statement

**Raul Macias Gil:** Conceptualization, Methodology, Validation, Investigation, Writing – Original Draft, Review & Editing. **Eleftherios Mylonakis:** Conceptualization, Methodology, Validation, Writing – Review & Editing, Supervision. **Francine Touzard-Romo:** Conceptualization, Methodology, Investigation, Validation, Writing– Review & Editing. **Martha C Sanchez:** Conceptualization, Investigation, Writing – Review & Editing. **Aakriti Pandita:** Conceptualization, Investigation, Resources. **Markos Kalligeros:** Conceptualization, Validation, Investigation, Resources, Writing – Review & Editing. **Evangelia K Mylona:** Validation, Methodology, Software, Formal analysis. **Fadi Shehadeh:** Validation, Methodology, Software, Formal analysis, Writing – Review & Editing.

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