Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Addressing ethnic disparities in imaging utilization and clinical outcomes for COVID-19

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ABSTRACT

Purpose: Racial and ethnic disparities have exacerbated during the COVID-19 pandemic as the healthcare system is overwhelmed. While Hispanics are disproportionately affected by COVID-19, little is known about ethnic disparities in the hospital settings. This study investigates imaging utilization and clinical outcomes between Hispanic and non-Hispanic COVID-19 patients in the Emergency Department (ED) and during hospitalization.
Methods: Through retrospective chart review, we included 331 symptomatic COVID-19 patients (mean age 53.2 years) at a metropolitan healthcare system from March to June 2020. Poisson regression was used to compare diagnostic imaging utilization and clinical outcomes between Hispanic and non-Hispanic patients.
Results: After adjusting for confounders, no statistically significant difference was found between Hispanic and non-Hispanic patients for the number of weekly chest X-rays. Results were categorized into four clinical outcomes: ED management (0.16 ± 0.05 vs. 0.14 ± 0.8, p:0.79); requiring inpatient management (1.31 ± 0.11 vs. 1.46 ± 0.16, p:0.43); ICU admission without invasive ventilation (1.4 ± 0.17 vs. 1.35 ± 0.26, p:0.86); and ICU admission and ventilator support (3.29 ± 0.22 vs. 3.59 ± 0.37, p:0.38). There were no statistically significant relative differences in adjusted prevalence rate between ethnic groups for all clinical outcomes ($p > 0.05$). There was a statistically significant longer adjusted length of stay (days) in non-Hispanics for two subcohorts: inpatient management (8.16 ± 0.31 vs. 9.72 ± 0.5, $p < 0.01$) and ICU admission without invasive ventilation (10.39 ± 0.57 vs. 13.45 ± 1.13, $p < 0.01$).
Conclusions: For Hispanic and non-Hispanic COVID-19 patients in the ED or hospitalized, there were no statistically significant differences in imaging utilization and clinical outcomes.

1. Introduction

Since the outbreak of Coronavirus Disease 2019 (COVID-19), many patients have been treated in the Emergency Department (ED) and other clinical settings across the United States.[1] Of all COVID-19 patients, approximately 14% have required hospitalization and 2% have required intensive care unit (ICU) treatment.[2] During initial triage, patients usually present with fever, respiratory, and/or gastrointestinal symptoms.[3–5] Hospitalized patients are typically older and with comorbidities, including cardiovascular disease, hypertension, diabetes, chronic obstructive pulmonary disease (COPD), and obesity.[6] Certain ethnic minority groups (Hispanics, Blacks, and Native Americans) are disproportionately affected by the coronavirus.[7] Although 18% of the United States population is Hispanic, 33% of the nation's COVID-19 cases occurred in the Hispanic community.[8] While social inequities (income disparity, high population density) are believed to cause ethnic disparities at the population level, once in the hospital setting, little is known about the utilization of healthcare resources at the patient level for those treated for COVID-19.[9–11] Imaging utilization is one type of healthcare resource essential to patient management in the ED or hospital. Since respiratory infection is the most common manifestation of COVID-19, chest X-ray (CXR) is the first-line imaging modality for assessing disease.[12,13] Complications from the coronavirus leading to cardiac or abdominal injury, pulmonary embolus, or stroke require more advanced imaging, such as computed tomography (CT), ultrasound (US), or magnetic resonance imaging (MRI), to manage these patients.

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To date, there have been few published works examining imaging utilization in the medical care of COVID-19 patients in the ED and hospital setting, especially among ethnic groups. Before the coronavirus pandemic, Schrager et al. found ethnic and racial differences in diagnostic imaging utilization during ED visits in the United States from 2005 to 2014.[14] Similarly, Gholamrezanezhad et al. showed race and ethnicity are linked to decreased diagnostic imaging received in the ED.[15] More recently, however, a study in a New York City healthcare system reported no disparity in image utilization in vulnerable subgroups with COVID-19 (elderly, racial/ethnic minorities, and socioeconomic underprivileged) as compared to their counterparts when given access to inpatient medical care.[16]

Since March 2020, our densely populated metropolitan city bore the brunt of the COVID-19 cases in the state, which significantly impacted the Hispanic population in our healthcare system. It is well documented that Hispanics have about 4.7 times higher hospitalization rates than non-Hispanics.[17,18] The purpose of this study is to compare medical care in terms of imaging utilization and clinical outcomes between Hispanic and non-Hispanic COVID-19 patients in the ED and hospital settings.

2. Patients and methods

Data for this study was extracted from an Institutional Review Board (IRB) approved and Health Insurance Portability and Accountability Act (HIPAA) compliant COVID-19 repository containing imaging and associated clinical data for COVID-19 positive patients. The IRB waived informed patient consent. Our healthcare system consists of an urban academic tertiary/quaternary referral center, a county Level I trauma center, and a community hospital located in the city's suburbs. These facilities service a high proportion of Hispanic individuals living in a densely populated area. Repository data elements include sociodemographic data (age, gender, race, ethnicity), travel and contact history, comorbidities, symptoms, physical examination, imaging examinations (type, date, and findings), vital signs, laboratory, and outcomes data (ED management, inpatient management (non-ICU), ICU admission without invasive ventilation, ICU admission and ventilator support, and death). Study data were collected and managed using the REDCap electronic data capture tool. This study used data from reverse transcription-polymerase chain reaction (RT-PCR) positive COVID-19 patients seen in the ED and those admitted to any of our hospitals from March 12, 2020, to June 30, 2020. Only patients with clinical symptoms consistent with COVID-19 were included in the study. Patients who were COVID-19 positive with no symptoms and admitted for unrelated medical conditions were excluded. Follow-up data for all patients were obtained through June 30, 2020.

The primary outcome was the number of imaging studies completed per week to manage COVID-19 patients in the Emergency Department (ED) or hospital settings. During the COVID pandemic, hospital guidelines and policies were set at all our facilities to reduce transmission, facilitate patient management, and effectively use available resources, including imaging. For COVID-19 patients, portable radiographs were obtained as needed. Chest CT was not used for screening but was ordered for inpatients to evaluate disease complications, such as abscesses or pulmonary embolism, as per the American College of Radiology (ACR) guidelines.[13] CT, MRI, and ultrasound were performed when indicated on an urgent basis for patient management.

The secondary outcome was a composite of clinical outcomes categorized in order of least to most critically ill patients: ED management, requiring inpatient management (non-ICU), requiring ICU admission without invasive ventilation, requiring ICU admission and ventilator support, and death. Another secondary outcome was the patient's length of stay (days) in the ED and hospital. The primary exposure of interest was self-reported ethnicity based on information available in the patient's medical records. Ethnicity was categorized as Hispanic, non-Hispanic, and unknown. The unknown category represented a small portion of the cohort and was excluded from the study.

The potential confounders associated with ethnicity or number and type of imaging studies included age and medical comorbidities. This information was collected at the time of admission from the electronic medical record and manually entered into the COVID-19 repository.

3. Statistical methods

Data distribution for the number of imaging examinations and length of stay were examined by histogram and all skewed to the right. They are typical log transformation data; therefore, the Poisson regression model with log link function was used for model fitting. The statistical test compared the log-transformed mean, and the log means were then back-transformed to the original scale for interpretation. The Poisson regression model was used to estimate the relative difference (prevalence rate ratio between Hispanic and non-Hispanic patients) for binary outcomes: death, ICU stay, and intubation status. To identify potential confounders to ethnicity, we conducted the confounder filtering using Elastic-Net. Elastic-Net was designed to combine Ridge regression and Least Absolute Shrinkage and Selection Operator (LASSO) penalties.[19] It balances having a parsimonious model with borrowing strength from correlated regressors. Elastic-Net identified important predictors from many correlated comorbidities and demographic measurements. Those predictors were used as covariates in the model with ethnicity to obtain the adjusted estimate. Model integrity was diagnosed using residual plots. Overdispersion was examined using a negative binormal model's dispersion parameter. For time to mortality and time to intubation, we have examined hazard ratio (HR) between ethnic groups using the Cox regression model. Proportional hazard (PH) assumption was assessed by the Supremum test and Schoenfeld residual plots. Benjamini and Hochberg procedure was used to correct false discovery rate from subgroup analysis. All data analyses were conducted by SAS 9.4.

4. Results

This study is based on 418 patients who tested positive for COVID-19 from March to June 2020. The following patients were excluded: 52 with no COVID-19 symptoms and admitted for other medical reasons, 15 “test only” or “phone visit only” patients, and 20 self-reported as “unknown” for ethnicity. The final sample size was 331 patients treated in the Emergency Department (ED) and/or admitted for hospitalization for COVID-19 related symptoms. The male-to-female sex distribution was 200:131. The mean age was 53.2 years, with a standard deviation of 16.7 years (Table 1). There were 247 (74.6%) Hispanic and 84 (25.4%) non-Hispanic patients. Symptoms upon initial presentation included cough, shortness of breath, fever, myalgia, chest pain, chills, fatigue, nausea, vomiting, diarrhea, throat pain, and loss of taste. One or more comorbidities were identified in 286 (86.4%) of all patients ($n = 331$), in 210 (85%) of Hispanic patients ($n = 247$), and in 76 (90.5%) of non-Hispanic patients ($n = 84$) (Table 1). Age, sex, and comorbidities have been adjusted for all statistical comparisons using LASSO.[19]

Of 331 patients, 74 (22.4%) were seen in the ED and discharged, while 257 (77.6%) patients were admitted to the hospital. Of the 257 patients admitted, 33 had previously been seen in the ED and discharged. For this study, these 33 patients were included only in a hospital sub-cohort. Among all 331 patients (Hispanic: non-Hispanic, 247:84), 74 (22.4%) were ED management (discharged home) (Hispanic: non-Hispanic, 55:19), 145 (43.8%) inpatient management (non-ICU) (Hispanic: Non-Hispanic, 107:38), 45 (13.6%) ICU admission without invasive ventilation (Hispanic: Non-Hispanic, 35:10), and 67 (20.2%) ICU admission and ventilator support (Hispanic: Non-Hispanic, 50:17) (Table 2).

We generated a list of the imaging studies obtained for all patients (Table 3). The most frequent study was chest X-ray (CXR) ($n = 1037$, 74.77%), followed by abdominal X-ray ($n = 182$, 13.12%), CT head/brain ($n = 35$, 2.52%), CT abdomen ($n = 23$, 1.66%), ultrasound abdomen ($n = 19$, 1.37%), ultrasound lower extremity venous system (n

Table 1
Demographic features of the study population.

Label	Category	Total n = 331 Mean ± SD Median (Q1 to Q3) Frequency (%)	Hispanic n = 247 Mean ± SD Median (Q1 to Q3) Frequency (%)	Non-Hispanic n = 84 Mean ± SD Median (Q1 to Q3) Fequency (%)
Age (continuous)		53.2 ± 16.7 52 (41 to 64)	50.8 ± 14.6 50 (41 to 60)	60.3 ± 20.3 61.5 (45.5 to 75)
Age	<30 years old	27 (8.16%)	18 (7.29%)	9 (10.71%)
	30–60 years	201 (60.73%)	169 (68.42%)	32 (38.1%)
	> 60 years old	103 (31.12%)	60 (24.29%)	43 (51.19%)
Sex	Male	200 (60.42%)	153 (61.94%)	47 (55.95%)
	Female	131 (39.58%)	94 (38.06%)	37 (44.05%)
Co-morbidity		286 (86.4%)	210 (85.02%)	76 (90.48%)
Immunocompromised		30 (9.06%)	18 (7.29%)	12 (14.29%)
Hypertension		129 (38.97%)	81 (32.79%)	48 (57.14%)
Chronic liver disease		14 (4.23%)	11 (4.45%)	3 (3.57%)
Dyslipidemia		67 (20.24%)	44 (17.81%)	23 (27.38%)
Pregnancy		8 (2.42%)	8 (3.24%)	0 (0%)
Thrombotic complications		7 (2.11%)	4 (1.62%)	3 (3.57%)
Stroke/CVA		10 (3.02%)	4 (1.62%)	6 (7.14%)
Neurological and psychological disorder		22 (6.65%)	8 (3.24%)	14 (16.67%)
CKD (including ESRD)		39 (11.78%)	26 (10.53%)	13 (15.48%)
Current or prior TB		9 (2.72%)	8 (3.24%)	1 (1.19%)
Obstructive sleep apnea		6 (1.81%)	3 (1.21%)	3 (3.57%)
Cardiac disease		41 (12.39%)	21 (8.5%)	20 (23.81%)
Thyroid disorder		21 (6.34%)	9 (3.64%)	12 (14.29%)
Anemia		25 (7.58%)	15 (6.07%)	10 (12.05%)
Diabetes mellitus		129 (38.97%)	105 (42.51%)	24 (28.57%)
COPD		8 (2.42%)	2 (0.81%)	6 (7.14%)
Asthma		25 (7.55%)	14 (5.67%)	11 (13.1%)
ILD		2 (0.6%)	2 (0.81%)	0 (0%)
Obesity		135 (40.79%)	110 (44.53%)	25 (29.76%)
Auto immune disease		38 (11.48%)	22 (8.91%)	16 (19.05%)

CVA: Cerebrovascular event, COPD: Chronic Obstructive Pulmonary Disease, ESRD: End Stage Renal Disease, ILD: Interstitial Lung Disease, TB: Tuberculosis, Neurological and psychological disorders: Dementia, Schizophrenia, and intracranial hemorrhage.

Table 2
Hospital setting of the studied population.

	Total n = 331	Hispanic n = 247	Non-Hispanic n = 84
ED management (discharged home)	74 (22.4%)	55 (22.3%)	19 (22.6%)
Requiring inpatient management (non-ICU)	145 (43.8%)	107 (43.3%)	38 (45.2%)
Requiring ICU admission without invasive ventilation	45 (13.6%)	35 (14.2%)	10 (11.9%)
Requiring ICU admission and ventilator support	67 (20.2%)	50 (20.2%)	17 (20.2%)

ED: Emergency department, ICU: Intensive Care Unit.

= 14, 1.01%), and CT pulmonary angiogram (n = 13, 0.94%). The rest of the studies listed in Table 3 were much less frequent. Sixty-eight patients (Hispanic: non-Hispanic, 51:17) did not receive any imaging studies. The Hispanic: non-Hispanic ratio for patients not receiving any imaging is similar to the overall cohort's ethnicity distribution. The maximum number of studies performed in one patient was 55 for a non-Hispanic patient who was in the ICU and ventilator support for seven weeks (33 chest X-rays, 15 abdominal X-rays, two hand X-rays, 2 head CTs, 1 neck CTA, 1 brain MRI, and 1CT chest/abdomen/pelvis).

We compared the number of weekly imaging studies performed between Hispanic and non-Hispanic patients. Specifically, we looked at the CXRs and all imaging studies performed per week per patient. We chose to compare imaging studies per week instead of per day because it provided an appropriate standardized ratio with a sufficient sample size accounting for different frequencies in imaging demand of the hospital and statistical outliers. Imaging studies per day would be a less reliable data point because it is more easily skewed by high daily volumes of imaging ordered for patients in the critical care setting. Weekly imaging studies provided a more accurate indication of a patient's overall

Table 3
Frequency of the employed imaging exam on the studied population.

Imaging type	Count	Percent
XR abdomen	182	13.12%
XR chest	1037	74.77%
XR fluoroscopy	2	0.14%
XR ankle, femur, fingers, hand, knee	1[a]	0.07%
CT abdomen	23	1.66%
CT angio neck	3	0.22%
CT angio pulmonary	13	0.94%
CT chest	10	0.72%
CT head/brain	35	2.52%
CT neck	3	0.22%
CT pelvis	2	0.14%
CT spine	3	0.22%
CT angio chest, angio head, angio UE, cerebral perfusion, femur, multiphase liver, sinus	1[a]	0.07%[a]
US abdomen	19	1.37%
US lower extremity venous system	14	1.01%
US retroperitoneal	2	0.14%
US upper extremity venous	5	0.36%
US chest, duplex hemodialysis access flow LUE, renal, thoracentesis	1[a]	0.07%[a]
MRI brain	7	0.50%
MRI abdomen, MRCP, pelvis, spine	1[a]	0.07%[a]
MRA head, neck	1[a]	0.07%[a]
IR gastrostomy tube placement	2	0.14%
NM hepatobiliary, myocardial perfusion	1[a]	0.07%[a]
RF speech	1	0.07%

XR: X-ray, CT: Computed Tomography, Angio: Angiogram, UE: Upper Extremity, US: Ultrasound, LUE: Left Upper Extremity, MRI: Magnetic Resonance Imaging, MRA: Magnetic Resonance Angiography, MRCP: Magnetic Resonance Cholangiopancreatography, IR: Interventional Radiology, NM: Nuclear Medicine, RF: Radiographic Fluoroscopy.

[a] One study per imaging type.

imaging requirement based on large sample size. The means are back transformed into log means for these values, and all the p values are adjusted. Age is a confounder.

There were no statistically significant differences between Hispanic and non-Hispanic patients for the weekly CXRs in four clinical outcome sub-groups: ED management (0.16 ± 0.05 vs. 0.14 ± 0.08, p:0.79), inpatient management (non-ICU) (1.31 ± 0.11 vs. 1.46 ± 0.16, p:0.43), ICU admission without invasive ventilation (1.4 ± 0.17 vs. 1.35 ± 0.26, p:0.86), and ICU admission and ventilator support (3.29 ± 0.22 vs. 3.59 ± 0.37, p:0.38), respectively. When comparing all weekly imaging studies between Hispanic and non-Hispanic patients, there were no statistically significant differences in the same four sub-groups: ED management (0.2 ± 0.06 vs. 0.14 ± 0.08, p:0.56); inpatient management (non-ICU) (1.48 ± 0.11 vs. 1.66 ± 0.17, p:0.38), ICU admission without invasive ventilation (1.62 ± 0.18 vs. 1.99 ± 0.31, p:0.28), and ICU admission and ventilator support (4.27 ± 0.24 vs. 4.89 ± 0.42, p:0.1), respectively (Table 4). We did not compare any other imaging study types since the numbers were too small for accurate analysis.

We examined the clinical outcomes between Hispanic and non-Hispanic patients. Adjusted Rate Ratios (RR) were calculated: 0.7 ± 0.19, p:0.19 for ED management; 1.1 ± 0.22, p:0.64 for requiring inpatient management (non-ICU); 1.12 ± 0.41, p:0.76 for requiring ICU admission without invasive ventilation; 1.25 ± 0.37, p:0.46 for requiring ICU admission and ventilator support; and 1.85 ± 0.72, p:0.11 for death. Similar results were found in ICU patients with adjusted RR of 2.31 ± 1.17, P:0.1 and 1.03 ± 0.32, P:0.91 for death and ventilator support, respectively. There were no statistically significant differences in clinical outcomes between Hispanic and Non-Hispanic patients (Table 5). Kaplan-Meier curves were parallel between Hispanic and non-Hispanic groups. Supremum test and Schoenfeld residual plots further confirmed promotional hazard assumption was met. As shown in Fig. 1, there was no statistically significant difference in time to death; however, in the subgroup analysis with ICU patients only, Hispanics had a trend of faster time to death after adjusting for immunocompromised, Diabetes Mellitus (DM), neurological disorder including dementia or Alzheimer's disease, age and sex with HR = 3.00 p:0.04. This statistical significance was not sustained after controlling for the false discovery rate from sub-group analyses.

When evaluating the maximum length of stay (days), there was no statistically significant difference in the mean between Hispanic and non-Hispanic patients requiring ED management (1.69 ± 0.19 vs. 1.43 ± 0.28, p:0.45) or ICU admission with ventilator support (29.66 ± 0.84 vs. 26.43 ± 1.24, p:0.04). However, there was a statistically significant difference for the patients requiring inpatient management (non-ICU) (8.16 ± 0.31 vs. 9.72 ± 0.5, $p < 0.01$) and ICU admission without invasive ventilation (10.39 ± 0.57 vs. 13.45 ± 1.13, $p < 0.01$), with a greater length of stay for non-Hispanic patients in both clinical outcomes (Table 4).

Table 4
Overall application of imaging studies per ethnicity and admission status.

Label	Category	N	Hispanic (Mean ± SE)[a]	Non-Hispanic (Mean ± SE)[a]	Adjusted p[b]
Number of chest X-rays per week per patient[c]	ED management (discharged home)	74	0.16 ± 0.05	0.14 ± 0.08	0.79
	Requiring inpatient management (non-ICU)	145	1.31 ± 0.11	1.46 ± 0.16	0.43
	Requiring ICU admission without invasive ventilation	45	1.4 ± 0.17	1.35 ± 0.26	0.86
	Requiring ICU admission and ventilator support	67	3.29 ± 0.22	3.59 ± 0.37	0.38
Number of all imaging studies per week per patient[c]	ED management (discharged home)	74	0.2 ± 0.06	0.14 ± 0.08	0.56
	Requiring inpatient management (non-ICU)	145	1.48 ± 0.11	1.66 ± 0.17	0.38
	Requiring ICU admission without invasive ventilation	45	1.62 ± 0.18	1.99 ± 0.31	0.28
	Requiring ICU admission and ventilator support	67	4.27 ± 0.24	4.89 ± 0.42	0.1
Length of stay[d]	ED management (discharged home)	74	1.69 ± 0.19	1.43 ± 0.28	0.45
	Requiring inpatient management (non-ICU)	145	8.16 ± 0.31	9.72 ± 0.5	<0.01
	Requiring ICU admission without invasive ventilation	45	10.39 ± 0.57	13.45 ± 1.13	<0.01
	Requiring ICU admission and ventilator support	67	29.66 ± 0.84	26.43 ± 1.24	0.04

ED: Emergency department, ICU: Intensive Care Unit.

[a] Point estimate was conducted at equal prevalence rate of combabilities and sex for both ethnic groups and at age 65; exponential function was used to produce back transformed adjusted prevalence rate and standard error.

[b] Adjusted p value from multi-variate Poisson regression using log transformation. Data driven covariates selection was conducted by Elastic-Net to filter the important predictor for each outcome.

[c] Adjusted by hyperlipidemia, dyslipidemia, stroke including cerebrovascular events, cardiac history, length of stay, age and sex.

[d] Adjusted by hypertension, thrombotic complications, chronic kidney disease including End Stage Renal Disease, Interstitial Lung Disease, age and sex.

5. Discussion

Ethnic minorities have been disproportionately affected by COVID-19,[17,18,20] as confirmed with our study cohort of 247 (77.6%) Hispanic and 84 (22.4%) non-Hispanic patients. Mean age was 53.2 years (standard deviation, 16.7 years) for all patients, 50.8 years (standard deviation, 14.6 years) for Hispanic patients, and 60.3 years (standard deviation, 20.3 years) for non-Hispanic patients (Table 1). Similar to CDC reports, Hispanic COVID-19 patients in this study were significantly younger than non-Hispanic patients.[18,21]

In our cohort, the most common initial presentations were cough, shortness of breath, fever, and myalgia, followed by chills, fatigue, throat pain, diarrhea, and loss of taste. These findings are consistent with well-recognized respiratory and gastrointestinal signs and symptoms in COVID-19 patients.[3–5,22] At least one underlying medical condition or comorbidity was identified in the majority 286 (86.4%) of our patients ($n = 331$).[23] Preexisting comorbidities were seen in 210 (85%) Hispanics patients ($n = 247$), and in 76 (90%) non-Hispanic patients ($n = 84$). The most frequent comorbidities were obesity, diabetes, and hypertension, with obesity (44.53%) foremost in Hispanic patients and hypertension (57.14%) in non-Hispanic patients (Table 1). Our results validate prior work and confirm obesity may play a major role in a higher incidence of COVID-19 in the Hispanic population.[23–25]

The primary outcome compared imaging utilization between Hispanic and non-Hispanic COVID-19 patients in the ED and hospital setting. Table 3 illustrates a wide range of imaging studies used to monitor these patients, reflecting the many different disease manifestations and complications associated with COVID-19.[4,26,27] As expected, with the lung being the primary organ involved, CXR was most frequently obtained in both cohorts. CXR is a critical tool in evaluating

Table 5
Clinical outcome by ethnicity.

Clinical outcome	Hispanic (Rate ± SE)[a]	Non Hispanic (Rate ± SE)[a]	Adjusted rate ratio[b]
ED management (discharged home)[c]	5.2% ± 110.7	7.5% ± 158.1	0.7 ± 0.19, P:0.19
Inpatient management (non-ICU)[d]	44.8% ± 5.4	40.7% ± 7.3	1.1 ± 0.22, P:0.64
ICU admission without invasive ventilation[e]	12.9% ± 2.9	11.6% ± 3.7	1.12 ± 0.41, P:0.76
Ventilator support among all hospitalized patients[f]	25.3% ± 4.2	20.3% ± 5.1	1.25 ± 0.37, P:0.46
Ventilator support among ICU patients only[g]	62.8% ± 10.3	60.7% ± 15.6	1.03 ± 0.32, P:0.91
Death for all hospitalized patients[h]	18.4% ± 3.7	10% ± 3.5	1.85 ± 0.72, P:0.11
Death for ICU patients[i]	30.7% ± 7.3	13.3% ± 6.3	2.31 ± 1.17, P:0.1

ED: Emergency department, ICU: Intensive Care Unit.

[a] Point estimate was conducted at equal prevalence rate of combabilities and sex for both ethnic groups and at age 65, exponential function was used to produce back transformed adjusted prevalence rate and standard error.

[b] Adjusted prevalence rate ratio and p value from multi-variate Poisson regression using log transformation. Data driven covariates selection was conducted by Elastic-Net to filter the important predictor for each outcome.

[c] Adjusted by hypertension, neurological disorder including dementia or Alzheimer's Disease or subdural hematoma or schizophrenia, chronic kidney disease including End Stage Renal Disease, cardiac history, age and sex.

[d] Adjusted by stroke including cerebrovascular events, thyroid disorder, age and sex.

[e] Adjusted by hypertension, Diabetes Mellitus, age and sex.

[f] Adjusted by stroke including cerebrovascular events, thyroid disorder, age and sex. Based on total admitted patients (non-ICU inpatients and ICU patients).

[g] Adjusted by stroke including cerebrovascular event, thyroid disorder, age and sex. Based on ICU patients only.

[h] Adjusted by immunocompromised, thrombus, stroke including cerebrovascular events, neurological disorder including dementia or Alzheimer's Disease, subdural hematoma, schizophrenia, age and sex.

[i] Adjusted by immunocompromised, Diabetes Mellitus, neurological disorder include dementia or Alzheimer's Disease, age and sex.

COVID patients, as it is ubiquitous, rapid, and portable.[28,29] Chest computed tomography (CT) is more effective than CXR in the early detection of COVID-19, with a low rate of misdiagnosing COVID-19.[30–32] However, CT is more costly, has a markedly higher radiation dose, and is not as accessible as CXR. At our institution, physicians follow the American College of Radiology (ACR) recommendations and use CXR as the first line and chest CT sparingly, mainly reserved for hospitalized patients with specific clinical indications.[13]

Our results showed no statistically significant differences in the utilization of CXRs obtained per week per patient between Hispanics and non-Hispanics in the ED and all hospital subcohorts. In addition, no statistically significant difference was found in the total number of imaging studies per week per patient in all subcohorts (Table 4). These findings are especially significant given that outside of the hospital, Hispanic patients are disproportionately affected by COVID-19.[16]

For our secondary outcome, we compared clinical outcomes for Hispanic and non-Hispanic patients, categorized from least to most critically ill as: ED management and discharge; inpatient management (non-ICU); ICU admission without invasive ventilation; ICU admission and ventilator support; and death (Table 5). Contrary to what was expected, Hispanic patients seen in the ED and/or admitted to the hospital had a similar critical illness likelihood as non-Hispanic patients. We found no statistically significant differences between Hispanic and non-Hispanic patients in all clinical outcomes and mortality. Adjusted rate ratios were calculated as 0.7 + 0.19, P:0.19 for ED management; 1.1 + 0.22, P:0.64 for inpatient management (non-ICU); 1.12 + 0.41, P:0.76 for ICU admission without invasive ventilation; 1.25 + 0.37, P:0.46 for ICU admission and ventilator support; 1.85 + 0.72, P:0.11 for death. These findings are similar to prior reports.[33,34] We did observe differences in the death outcome between the two cohorts, but our small sample size did not detect any statistically significant difference.

When evaluating the maximum length of stay by comparing the mean after log transformation, there was a statistically significant difference between Hispanic and non-Hispanic patients in the settings of ICU admission without invasive ventilation (10.39 ± 0.57 vs. 13.45 ± 1.13, $p < 0.01$) and inpatient management (non-ICU) (8.16 ± 0.31 vs. 9.72 ± 0.5, $p < 0.01$), respectively (Table 4). In these two subcohorts, non-Hispanic patients were older and had more comorbidities, which may have contributed to their longer length of stay. However, the length of stay for the most critically ill patients in the ICU requiring ventilators was longer in Hispanic than non-Hispanic patients, with a *p*-value of 0.04.

There are several limitations to this study. First, the study time-period is relatively limited during this ongoing pandemic, with rapidly evolving diagnostic and treatment guidelines. Second, while this is a single institution experience that may not accurately represent other hospital settings, our healthcare system does include a tertiary/quaternary medical center, a County hospital, and a satellite community hospital with a diverse patient population. Third, our cohort size is small and may not accurately depict the Hispanic population at large. For certain comparisons (i.e., death rate), we did observe a discrepancy with an adjusted RR of 1.85, but this was not statistically significant ($p = 0.11$). Our study is under-powered with a small effect size. Still, we are confident in concluding that there were no detectable, large differences between Hispanic and non-Hispanic populations in our data.

In our healthcare system, in a densely populated metropolitan area, which serves a large Hispanic community, we did not find a significant difference between Hispanic and non-Hispanic COVID-19 patients regarding imaging utilization or clinical outcomes in the ED or hospital setting. Our study highlights that while COVID-19 is more prevalent in the Hispanic population, once patients were evaluated in the ED or admitted to the hospital, the Hispanic patients received comparable medical care in imaging utilization with non-Hispanic patients. Moreover, there was no statistically significant difference in clinical outcomes, including mortality rate. Future work should perhaps focus on reducing the social inequities outside of the hospital (densely crowded households, limited healthcare access, and lack of health insurance), all of which contribute to higher rates of COVID-19 in the Hispanic communities.[9]

Author contributions

BD obtained IRB approval. LHL, XL, SYC, BD, DS, and MY reviewed the study documents. LHL, BD, SYC, XL, and MY provided input for all aspects. SYC and XL performed the statistical analysis. LHL, BD, and DS drafted the manuscript and references with support from XL, MY, and SYC. LHL, MY, SYC, and BD conceived the idea. The consultant and advisor was AG. All authors provided edits to the manuscript before submission.

The authors declare that they had full access to all of the data in this study. The authors take complete responsibility for the integrity of the data and the data analysis accuracy.

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Disclosures

None.

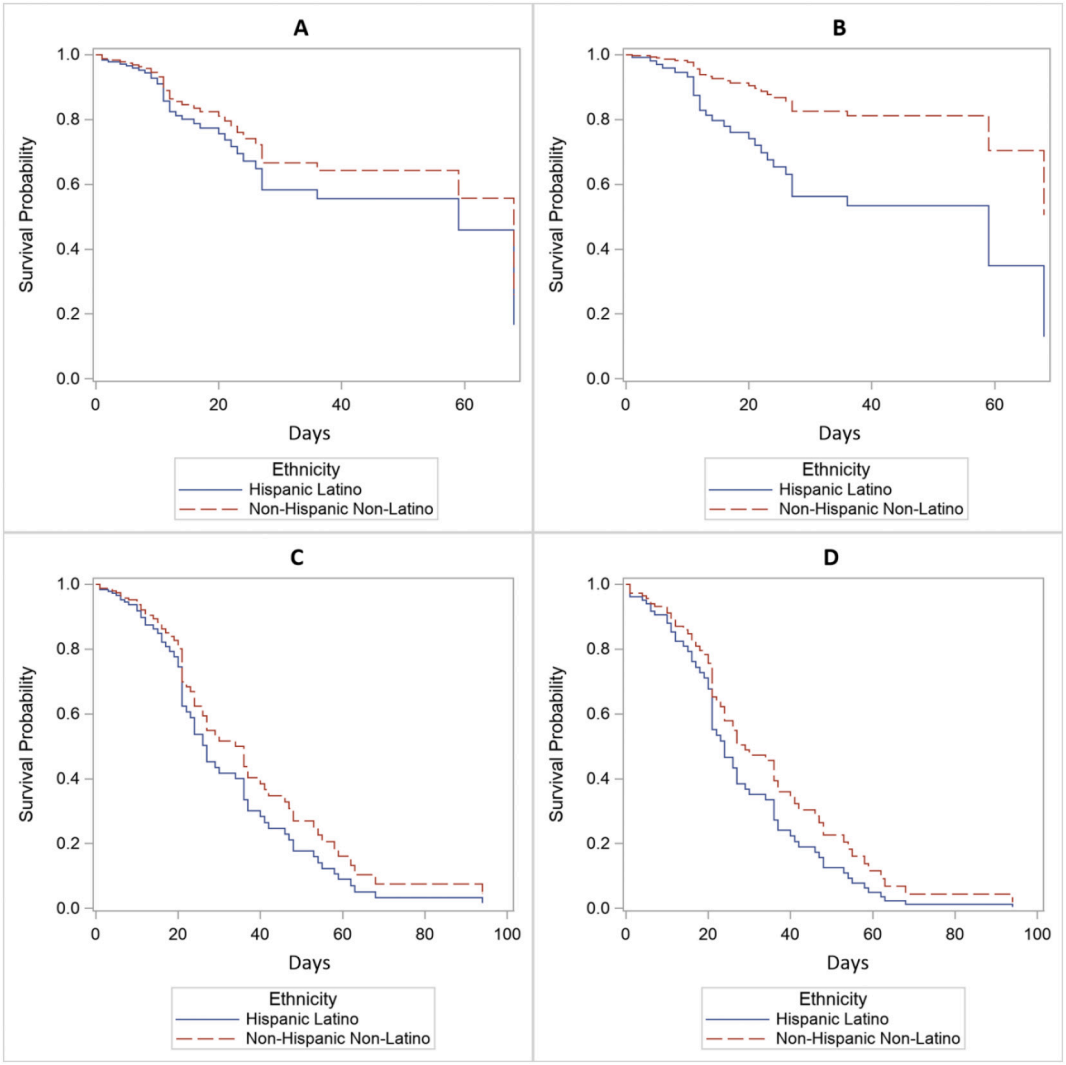

Fig. 1. Kaplan-Meier curve for death and invasive ventilation by ethnicity.
A Death free survival for all inpatients (ICU and non-ICU), HR = 1.79 $p = 0.14$, adjusted by stroke including cerebrovascular events, thyroid disorder, age and sex.
B Death free survival for ICU patients only, HR = 3.00 $p = 0.04$, adjusted by immunocompromised, Diabetes Mellitus, neurological disorder including dementia or Alzheimer's disease, age and sex.
C Ventilator support free survival for all inpatients (ICU and non-ICU), HR = 1.32 $p = 0.37$, adjusted by stroke including cerebrovascular events, thyroid disorder, age and sex.
D Ventilator support free survival for ICU patients only, HR = 1.40 $p = 0.31$, adjusted by stroke including cerebrovascular events, thyroid disorder, age and sex.

Declaration of competing interest

None.

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References

[1] Wiersinga WJ, Rhodes A, Cheng AC, et al. Pathophysiology, transmission, diagnosis, and treatment of coronavirus disease 2019 (COVID-19). JAMA 2020;324 (8):782–93.
[2] Stokes EK, Zambrano LD, Anderson KN, et al. Coronavirus Disease 2019 case surveillance – United States, January 22-May 30, 2020. MMWR Morb Mortal Wkly Rep 2020;69(24):759–65.
[3] Pan L, Mu M, Yang P, et al. Clinical characteristics of COVID-19 patients with digestive symptoms in Hubei, China: a descriptive cross-sectional, multi-center study. Am J Gastroenterol 2020;115(5):766–73.
[4] Behzad S, Aghaghazvini L, Radmard AR, Gholamrezanezhad A. Extrapulmonary manifestations of COVID-19: radiologic and clinical overview. Clin Imaging 2020; 66:35–41.
[5] Lombardi AF, Afsahi AM, Gupta A, Gholamrezanezhad A. Severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS), influenza, and COVID-19, beyond the lungs: a review article. Radiol Med 2020;26:1–9.
[6] Petrilli CM, Jones SA, Yang J, et al. Factors associated with hospital admission and critical illness among 5,279 people with coronavirus disease 2019 in New York City: prospective cohort study. BMJ 2020;369:m1966.
[7] Wadhera RK, Wadhera P, Gaba P, et al. Variation in COVID-19 hospitalizations and deaths across New York City boroughs. JAMA 2020;323(21):2192–5.
[8] Blumenthal D, Fowler EJ, Abrams M, Collins SR. Covid-19-implications for the health care system. NEJM 2020;383:1483–8.
9. Centers for Disease Control and Prevention. Health equity considerations and racial and ethnic minority groups. Available July 24, 2020, https://www.cdc.gov/coronavirus/2019-ncov/community/health-equity/race-ethnicity.html. [Accessed 21 January 2021].
[10] Joseph NP, Reid NJ, Som A, et al. Racial and ethnic disparities in disease severity on admission chest radiographs among patients with confirmed coronavirus disease 2019: a retrospective cohort study. Radiology 2020;297(3):E303–12.
[11] Alcendor D. Racial disparities-associated COVID-19 mortality among minority populations in the US. J Clin Med 2020;9(8):2442.

[12] Roshkovan L, Chatterjee N, Galperin-Aizenber M, et al. The role of imaging in the management of suspected of known COVID-19 pneumonia. A multidisciplinary perspective. Ann Am Thorac Soc 2020;17(11):1358–65.
13. American College of Radiology. ACR recommendations for the use of chest radiography and computed tomography (CT) for suspected COVID-19 infection. Available at: https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Recommendations-for-Chest-Radiography-and-CT-for-Suspected-COVID19-Infection.
[14] Schrager JD, Patzer RE, Kim JJ, et al. Racial and ethnic differences in diagnostic imaging utilization during adult Emergency Department visits in the United States, 2005–2014. J Am Coll Radiol 2019;16(8):1036–45.
[15] Shan A, Baumann G. Gholamrezanezhad A. Patient race/ethnicity and diagnostic imaging utilization in the Emergency Department: a systematic review. JACR 2021;18(6):795–808.
[16] Toy D, Mahmood SS, Rotman J, et al. Imaging utilization and outcomes in vulnerable populations during COVID-19 in New York City. Radiology 2020;2(6):e200464.
17. Centers for Disease Control and Prevention. Health disparities: race and hispanic origin. Available at: November 12, 2020, https://www.cdc.gov/nchs/nvss/vsrr/covid19/health_disparities.htm. [Accessed 21 January 2021].
18. Center for Disease Control and Prevention. Weekly updates by select demographic and geographic characteristics. Provisional death county for Coronavirus Disease 2019 (COVID-19). Available at: https://www.cdc.gov/nchs/nvss/vsrr/covid_weekly/index.htm. [Accessed 6 February 2021].
[19] Zou H. The adaptive Lasso and its oracle properties. J Am Stat Assoc 2006;101:1418–29.
[20] Sze S, Pan D, Nevill CR, et al. Ethnicity and clinical outcomes in COVID-19; a systematic review and meta-analysis. EClinical Med. 2020;29-30:100630.
[21] Podewils LJ, Burket TL, Mettenbrink C, et al. Disproportionate incidence of COVID-19 infection, hospitalizations, and deaths among persons identifying as Hispanic or Latino-Denver, Colorado March-October 2020. MMWR Morb Mortal Wkly Rep 2020;69(48):1812–6.
[22] Weng CH, Saal A, Butt WW, Chan PA. Characteristics and clinical course and outcome of COVID-19 in Hispanic/Latino patients in a community setting: a retrospective cohort study. J Med Virol 2020. https://doi.org/10.1002/jmv.26196.
[23] Richardson S, Hirsch JS, Narasimhan M, et al. Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City area. JAMA 2020;323(20):2052–9.
[24] Arasteh K. Prevalence of comorbidities and risks associated with COVID-19 among Black and Hispanic populations in New York City: an examination of the 2018 New York City community health survey. J Racial Ethn Health Disparities 2020;13:1–7.
[25] El Chaar M, King K, Lima AG. Are black and Hispanic persons disproportionately affected by COVID-19 because of higher obesity rates? Surg Obes Relat Dis 2020;16(8):1096–9.
[26] Revzin MV, Raza S, Warshawsky R, et al. Multisystem imaging manifestations of covid-19, part 1: viral pathogenesis and pulmonary and vascular system complications. Radiographics 2020;40(6):1574–99.
[27] Revzin MV, Raza S, Srivastava NC, et al. Multisystem imaging manifestations of COVID-19, part 2: from cardiac complications to pediatric manifestations. Radiographics 2020;40(7):1866–92.
[28] Akl EA, Blazic I, Yaacoub S, et al. Use of chest imaging in the diagnosis and management of COVID-19: a WHO rapid advice guide. Radiology 2020;298(2):E63-E69.
[29] Rubin GD, Ryerson CJ, Haramati LB, et al. The role of chest imaging in patient management during the COVID-19 pandemic: a multinational consensus statement from the Fleischner Society. Radiology 2020;296(1):172–80.
[30] Li Y, Xia L. Coronavirus Disease 2019 (COVID-19): role of chest CT in diagnosis and management. Am J Roentgenol 2020;214(6):1280–6.
[31] Kooraki S, Hosseiny M, Myers L, Gholamrezanezhad A. Coronavirus (COVID-19) outbreak: what the Department of Radiology should know. J Am Coll Radiol 2020;17(4):447–51. Apr.
[32] Hosseiny M, Kooraki S, Gholamrezanezhad A, Reddy S, Myers L. Radiology perspective of coronavirus disease 2019 (COVID-19): lessons from severe acute respiratory syndrome and Middle East respiratory syndrome. AJR Am J Roentgenol 2020;214(5):1078–82. May.
[33] Ogedegbe G, Ravenell J, Adhikari S, et al. Assessment of racial/ethnic disparities in hospitalization and mortality in patients with COVID-19 in New York City. JAMA Netw Open 2020;3(12):e2026881.
[34] Kabarriti R, Brodin NP, Maron MI, et al. Association of race and ethnicity with comorbidities and survival among patients with COVID-19 at an urban medical Center in New York. JAMA Netw Open 2020;3(9):e2019795.