

BMJ Open Clinical, behavioural and social factors associated with racial disparities in COVID-19 patients from an integrated healthcare system in Georgia: a retrospective cohort study

Felipe Lobelo ^{1,2}, Alan Bienvenida,¹ Serena Leung,¹ Armand Mbanja,¹ Elizabeth Leslie,¹ Kate Koplan,¹ Sangmin Ryan Shin¹

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¹The Southeast Permanente Medical Group, Kaiser Permanente Georgia, Atlanta, Georgia, USA

²Global Health Department, Rollins School of Public Health, Atlanta, Georgia, USA

Correspondence to

Dr Felipe Lobelo;
felipe.lobelo@kp.org

ABSTRACT

Objectives To identify sociodemographic, clinical and behavioural drivers of racial disparities and their association with clinical outcomes among Kaiser Permanente Georgia (KPGA) members with COVID-19.

Design Retrospective cohort of patients with COVID-19 seen from 3 March to 29 October 2020. We described the distribution of underlying comorbidities, quality of care metrics, demographic and social determinants of health (SDOH) indicators across race groups. We also described clinical outcomes in hospitalised patients including length of stay, intensive care unit (ICU) admission, readmission and mortality. We performed multivariable analyses for hospitalisation risk among all patients with COVID-19 and stratified by race and sex.

Setting KPGA, an integrated healthcare system.

Participants 5712 patients who all had laboratory-confirmed COVID-19. Of them, 57.8% were female, 58.4% black, 29.5% white, 8.5% Hispanic and 3.6% Asian.

Results Black patients had the highest proportions of living in neighborhoods under the federal poverty line (12.4%) and in more deprived locations (neighbourhood deprivation index=0.4). Overall, 14.4% (n=827) of this cohort was hospitalised. Asian patients had the highest rates of ICU admission (53.1%) and mechanical ventilation (21.9%). Among all patients, Hispanics (adjusted 1.60, 95% CI (1.08, 2.37)), blacks (1.43 (1.13, 1.83)), age in years (1.03 (1.02, 1.04)) and living in a zip code with high unemployment (1.08 (1.03, 1.13)) were associated with higher odds of hospitalisation. COVID-19 patients with chronic obstructive pulmonary disease (2.59 (1.67, 4.02)), chronic heart failure (1.79 (1.31, 2.45)), immunocompromised (1.77 (1.16, 2.70)), with glycated haemoglobin >8% (1.68 (1.19, 2.38)), depression (1.60 (1.24, 2.06)), hypertension (1.5 (1.21, 1.87)) and physical inactivity (1.25 (1.03, 1.51)) had higher odds of hospitalisation.

Conclusions Black and Hispanic KPGA patients were at higher odds of hospitalisation, but not mortality, compared with other race groups. Beyond previously reported sociodemographics and comorbidities, factors such as quality of care, lifestyle behaviours and SDOH indicators should be considered when designing and

Strengths and limitations of this study

- In the USA and across the world, racial and ethnic minorities have shouldered a disproportionate burden of COVID-19 infection, but data on the various clinical and social drivers of these disparities are limited.
- As a limitation, the target population in this analysis included only Kaiser Permanente Georgia patients that have insurance and ready access to healthcare services.
- To our knowledge, this is the first COVID-19 retrospective cohort study to incorporate multiple individual and community-level social determinants of health indicators, pre-pandemic lifestyle behaviours and comorbidity management metrics as drivers of COVID-19 racial disparities.

implementing interventions to reduce COVID-19 racial disparities.

INTRODUCTION

As of 15 November 2020, the USA had over 10.5 million cases and 250 000 deaths due to COVID-19.¹ This accounts for 20% of the cases and deaths reported worldwide, despite the USA having about 4% of the global population. It has been widely reported that racial/ethnic minorities, particularly those living in large and diverse urban centres, shoulder a disproportionate burden of the COVID-19 infection risk and associated adverse health outcomes.²⁻⁶

Earlier descriptive studies from patients admitted during March/April 2020 in Georgia showed an over-representation of COVID-19 hospitalisations and death rates among black populations.^{7 8} Subsequent reports from two large healthcare systems in Louisiana and California, and from the

Veterans Affairs health system⁹ also found racial disparities in COVID-19 outcomes and clinical risk factors for hospitalisation. These reports also theorised that chronic disease control, health behaviours, social and other factors may contribute to such disparities.^{3 5 7 8} However, limited availability of quality of care history and social determinants of health (SDOH) metrics in most medical health records has precluded a more comprehensive analysis of potential drivers of these racial disparities.

The US Census Bureau reports the racial/ethnic demographic distribution of Georgia as 57.8% white, 31.9% black, 4.1% Asian, 0.4% American Indian/Alaska Native, 2.7% two or more races and 3% some other race with 9.8% Hispanics (irrespective of race).¹⁰ As of 20 November, the Georgia Department of Public Health (DPH) reported 399 410 confirmed cases of COVID-19 with the following categorisation by race/ethnicity: 37% white, 27.5% black, 12.5% Hispanic, 1.9% Asian, 2.6% other race (American Indian/Alaska Native, Native Hawaiian/Pacific Islander) and 18.5% unknown or no data.¹¹ This over-representation of black and Hispanic populations in terms of COVID-19 burden has also been observed in other US areas.^{4 6 9 12–15} Kaiser Permanente Georgia (KPGA) is a regional integrated healthcare system serving over 300 000 patients in 32 counties located in the Atlanta Metropolitan Area and Northeast Georgia. As of April 2020, KPGA membership is 43% black, 30% white, 5% Asian, 4% Hispanic and 18% unknown/other, which mirrors that of the Atlanta Metropolitan Area.¹⁶

This study had two objectives. First, to determine if racial disparities exist among KPGA patients with COVID-19, with respect to demographic and SDOH, pre-pandemic comorbidities/underlying conditions, quality of care metrics and lifestyle behaviours as well as COVID-19-related clinical outcomes (hospitalisation, intensive care unit (ICU) admission, length of stay, mechanical ventilation, readmission and mortality). Second, to explore the roles of these clinical, behavioural and SDOH factors as potential drivers of racial disparities for COVID-19 hospitalisation.

METHODS

We performed a retrospective review of KPGA patients seen with COVID-19-related symptoms between 3 March and 29 October 2020. Patients were screened according to the US Centers for Disease Control and Prevention (CDC) and Georgia DPH guidelines.^{17 18} Patients who met the criteria were tested for SARS-CoV-2 by PCR. For this analysis, we included any KPGA member with a documented diagnosis and/or laboratory-confirmed COVID-19 PCR test in their Electronic Health Record (EHR) which also integrates tests performed in facilities outside of our healthcare system. At the start of the epidemic, KPGA prioritised testing among symptomatic healthcare workers and symptomatic KPGA patients requiring hospital admission. In mid-April, testing was progressively expanded to high-risk symptomatic patients

(based on clinical criteria (>65 years, immunocompromise, chronic obstructive pulmonary disease (COPD), moderate-to-severe asthma, serious heart condition, body mass index (BMI)>40, diabetes, chronic kidney disease (CKD), liver disease, pregnancy) and symptomatic patients with public health implications (healthcare workers, first responders, jail and elder care employees, etc). Tests were offered in the following manner. After in-person or telemedicine evaluation, patients were tested, if recommended, via drive-thru and/or tents at one of four KPGA facilities located across metro Atlanta.

Patient demographics

We characterised patients with COVID-19 by age, sex, self-reported race/ethnicity, insurance type and area of residence. Race/ethnicity was categorised in our ER as African-American/Black (hereinafter referred to as 'black'), non-Hispanic white ('white'), Hispanic/Latino ('Hispanic'), Asian/Pacific Islander ('Asian'), 'unknown', 'declined to report' and 'Other', which included American Indian/Alaska Native. For purposes of this analysis, we excluded patients with COVID-19 seen during the study period in the 'Other' (n=13), 'unknown' (n=636) and 'declined to report' (n=95) categories, given the large heterogeneity of these groups and/or low sample size.

We obtained patient's location of residence and zip code from the EHR and categorised it into four different regions of metro Atlanta: Northeast, Northwest, Southeast and Southwest. Residence location was also linked to the Neighbourhood Deprivation Index (NDI), a composite SDOH measure including income, education, employment and housing quality.^{19 20} The higher the NDI value, the higher the level of deprivation in the neighbourhood.^{19 20} We also used ESRI Business Analyst data, a comprehensive demographic and lifestyle database that provides data to help interpolate patient's socioeconomic status.²¹ Specifically, we linked patients' places of residency with ESRI's zip code level classifications of median household income, occupation (frontline, healthcare and other) and educational attainment. We used these data to cross-reference median household income with the government-defined poverty line.²²

Patient and public involvement

Given the nature of this study, it was not appropriate or possible to involve patients or the public in the design, or conduct, or reporting or dissemination plans of our research.

Comorbidities and quality of care (past 12 months)

Existing comorbidities and clinical care of patients were obtained from the latest clinical visit dating back up to 12 months from the first COVID-19 encounter. Comorbidities were reported as classified by the International Statistical Classification of Diseases and Related Health Problems codes (ICD-10).²³ The Deyo-Charlson Comorbidity Index (CCI) was used as a continuous measure of

total comorbidity burden.²⁴ The CCI is a weighted index developed to predict risk of death within 1 year of hospitalisation for patients with 17 specific common comorbidities. Each condition is assigned a weight from 1 to 6, based on the estimated 1-year mortality HR and the weights summed to produce the CCI. A score of zero indicates no comorbidities, whereas the higher the score, the more comorbidity burden resulting in higher predicted mortality or resource utilisation.

We used pharmacy dispensing data to compile the frequency of outpatient medications used by patients. We used established clinical thresholds recommended by the National Committee for Quality Assurance as markers for adequate blood pressure (<140/90 mm Hg) and (glycated haemoglobin (HbA1c)<8% and <9%) blood glucose control.²⁵

Exercise Vital Sign (EVS) data were collected and exercise minutes averaged from encounters in the 12 months prior to the first COVID related visit date. Patient's physical activity levels were classified as inactive, insufficiently active and sufficiently active for those self-reporting ≤10, 11–149 and ≥150 min of exercise/week, respectively. The EVS has been previously validated²⁶ and is considered a clinically relevant screening tool for physical activity behaviours in healthcare settings.^{27 28}

Clinical outcomes

All patients with COVID-19 who were hospitalised at KPGA affiliated (2 core and 43 non-core) hospitals were characterised by hospital length of stay (LOS), intensive care unit (ICU) LOS, invasive mechanical ventilation initiation and duration, hospital discharge, 30-day and 60-day readmission, currently hospitalised and deceased. Hospital LOS consisted of the entire time spent in hospital from admission (including emergency department) to discharge (including death). Instances of admission and discharge on the same date were defined as LOS of 1 day. Mechanical ventilation data were compiled using ICD-10 code flagging instances and length of emergency endotracheal intubation during hospital stay. Readmissions were defined as instances of subsequent admission to a hospital within the KPGA health system due to COVID-19 complications or any other cause, 30 and 60 days after index discharge. We conducted manual record reviews to distinguish between encounters of readmission and patient transfers from a hospital to another non-KPGA-affiliated medical facility.

Statistical analysis

We report numbers (percentages) for binary and categorical variables and means (SD) for continuous variables. χ^2 tests, analyses of variance (ANOVAs) and two sample t-tests were used to determine significant differences between groups. For two sample t-tests with statistically unequal variances, the Satterthwaite adjustment method was applied and reported.

Multivariable logistic regression was used to explore factors associated with having a COVID-19-related

hospitalisation in seven different models: all COVID-19 patients, stratified by race/ethnicity (black, white, Hispanic, Asian) and by sex. All multivariable logistic regression models included age, sex and race/ethnicity as independent variables and hospitalisation as the dependent variable. All additional independent variables were assessed using a bivariate analysis, either χ^2 or two sample t-test, and only the variables showing evidence of a statistically significant ($\alpha=0.05$) relationship with the dependent variable were considered for entry into the models. A stepwise selection method was used for final independent variable selection with effect entry at significance levels of 0.05 and adjusted via the Student-Newman-Keuls post hoc test for differences in means. All data analysis was conducted using SAS V.9.4 software. All data relevant to the study are included in the manuscript.

RESULTS

Demographic characteristics and SDOH

Within the study period, we screened 52166 patients, tested 42421 (81.3%) and 5721 (15.2% of tested) patients were confirmed with COVID-19. The mean age of COVID-19-positive patients was 44.8 (15.7) years old (table 1). A higher proportion of black patients resided in neighbourhoods with a high proportion of households under the federal poverty level (13.95%), with unfavourable NDI (0.37), and with the highest mean percentage of frontline (35.6%) and healthcare workers (7.4%) compared with other race groups (table 1). The highest overall percentage of the patients with COVID-19 resided in the Northeast Metro Atlanta area (36.5%) (table 1). However, different areas of metro Atlanta showed varying prevalence of patients with COVID-19 when stratified by race/ethnicity. A higher proportion of black patients lived in the southern areas of metro Atlanta which visibly correlates with higher NDI neighbourhoods (figure 1).

Comorbidities and quality of care

Black patients had the highest rates of obesity (9%), hypertension (34.7%), asthma (11.3%) and HIV (1.9%), all $p<0.0001$ (table 2). White patients presented with the highest rates of congestive heart failure (CHF; 7.2%), coronary artery disease (CAD; 7.4%), arrhythmia (5%), chronic obstructive pulmonary disease (COPD; 4.6%), depression (15.5%) (all $p<0.0001$) and overall CCI scores (2.1 (1.7)), $p=0.0014$ (table 2). Asian patients had the highest rate of diabetes (18%; $p=0.0022$) (table 2). Compared with other race/ethnicity groups, black patients had the highest proportion of patients with uncontrolled blood pressure (BP) as defined by BP >140/90 mm Hg (30.1%) and the lowest self-reported mean (SD) weekly exercise minutes (75.3 (113.4); $p<0.0001$) (table 2).

Hospitalisation and other clinical outcomes

Overall, 827 patients with COVID-19 were hospitalised with 896 hospital stays, a mean age of 57.3 (SD (15.8)) and an average length of stay of 7.9 (9.2) days

**Table 1** Sociodemographic characteristics of KPGA patients with COVID-19 seen from 3 March to 29 October 2020

KPGA members by race, N (%)						
	All N=5721 (100%)	Black n=3339 (58.4%)	White n=1689 (29.5%)	Hispanic n=487 (8.5%)	Asian n=206 (3.6%)	P value
Age, mean (SD), years	44.8 (15.7)	43.9 (15.1)	47.1 (17.8)	41.9 (14)	45.8 (15.8)	<0.0001
Age range, years						
18–49	3414 (59.7)	2106 (63.1)	865 (51.21)	328 (67.4)	115 (55.8)	<0.0001
50–64	1686 (29.5)	931 (27.9)	549 (32.5)	140 (28.8)	66 (32)	
65 and above	621 (10.9)	302 (9)	275 (16.3)	19 (3.9)	25 (12.1)	
Gender						<0.0001
Male	2416 (42.2)	1270 (38)	820 (48.5)	226 (46.4)	100 (48.5)	
Female	3304 (57.8)	2068 (62)	869 (51.5)	261 (53.6)	106 (51.5)	
Insurance						
Commercial	4626 (80.9)	2675 (80.1)	1343 (79.5)	435 (89.3)	173 (84)	<0.0001
Medicare	567 (9.9)	291 (8.7)	245 (14.5)	14 (2.9)	17 (8.3)	
Medicaid	6 (0.1)	4 (0.1)	0 (0)	2 (0.4)	0 (0)	
Self-pay	326 (5.7)	237 (7.1)	59 (3.5)	17 (3.5)	13 (6.3)	
Other*	196 (3.4)	132 (4)	42 (2.5)	19 (3.9)	3 (1.5)	
Median household income, N (%)†						
25k–50k	1079 (19.4)	855 (25.6)	115 (6.8)	78 (16)	31 (15)	<0.0001
50k–75k	2746 (49.3)	1814 (54.3)	639 (37.8)	225 (46.2)	68 (33)	
75k–100k	1478 (26.5)	512 (15.3)	734 (43.5)	155 (31.8)	77 (37.4)	
100k+	272 (4.9)	58 (1.7)	170 (10.1)	19 (3.9)	25 (12.1)	
Households under poverty level, %‡	12.36	13.95	9.85	11.96	10.37	<0.0001
Residential region (%)§						
Northeast	2090 (36.5)	1085 (32.5)	626 (37.1)	274 (56.3)	105 (51)	<0.0001
Northwest	969 (16.9)	341 (10.2)	492 (29.1)	102 (20.9)	34 (16.5)	
Southeast	1116 (19.5)	854 (25.6)	192 (11.4)	35 (7.2)	35 (17)	
Southwest	1179 (20.6)	822 (24.6)	280 (16.6)	53 (10.9)	24 (11.7)	
Neighbourhood Deprivation Index¶	0.07	0.37	−0.4	0.03	−0.27	<0.0001
Occupation, mean %**						
Frontline workers	33.6	35.6	30.2	35.4	31.2	<0.0001
Healthcare workers	7.2	7.4	7	6.5	6.6	
Other workers	59.2	57	62.7	58.1	62.1	
Education, mean %††						
Some high school	6.6	7.2	5.8	7	5.8	<0.0001
High school	22.3	24	20.2	21.4	19.9	
Associates degree	8.4	8.6	8.1	8.2	8.4	
Some college	20.8	21.8	19.7	19.4	19.1	
Bachelors	21.8	19.5	24.8	22.1	24.9	
Graduate	12.6	11.5	14.2	12.3	14.4	

*Other insurances include military Health Maintenance Organisation (HMO) or Preferred Provider Organisation (PPO).

†Based on ESRI Business Analyst dataset showing median household income by zip code and then linked to individual patients based on their recorded residence.

‡Poverty line was defined by the federal poverty level.

§The Atlanta metro area was divided up by county in four subregions. Northwest: Cobb, Cherokee, Paulding, Bartow, Pickens, Polk, Troup, Habersham. Northeast: DeKalb, Gwinnett, Forsyth, Hall, Barrow, Jackson, Butts, Gilmer, Pike, Gordon, Jasper, Monroe. Southwest: Fulton, Douglas, Fayette, Coweta, Carroll, Meriwether, Heard, Dawson, Madison, Lumpkin. Southeast: Clayton, Henry, Rockdale, Walton, Clarke, Spalding, Oconee, Muscogee, Brooks, Town.

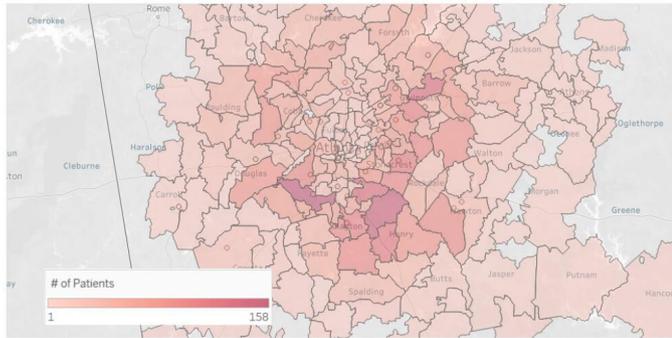
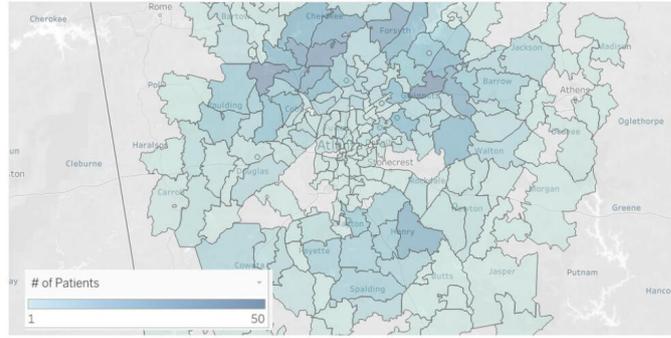
¶The Neighbourhood Deprivation Index (NDI) is a composite measure of social and economic factors such as income, education, employment and housing quality that reflect neighbourhood deprivation. The higher the index value, the higher the level of deprivation in the neighbourhood.

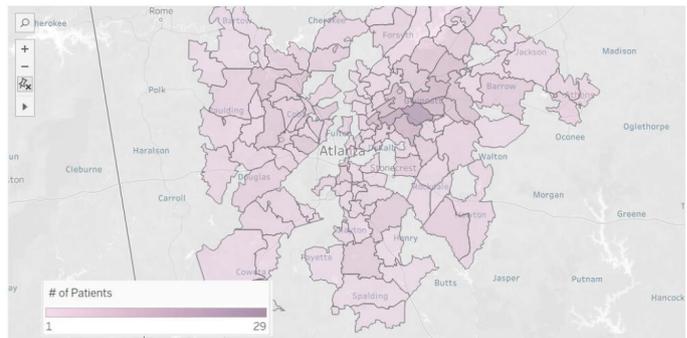
**Based on ESRI Business Analyst data. Occupation Breakdown: Frontline workers included community/social services, protective services, food preparation/serving-related services, building/grounds cleaning/maintenance services, construction/extraction services, installation/maintenance/repair services, production services and transportation/material moving services. Healthcare workers included healthcare practitioners/technicians and healthcare support staff. Other workers included personal care/service workers, sales and sales-related workers, office/administrative support workers, farming/fishing/forestry workers, management/business/financial workers, computer/mathematical service workers, architecture/engineering workers, life/physical/social science workers, community/social service workers, legal workers, education/training/library workers and arts/design/entertainment/sports/media workers.

††Based on ESRI Business Analyst data. It is expressed in mean percentage and provides the counts of individual education attainment and occupation by category within each zip code (denominator).

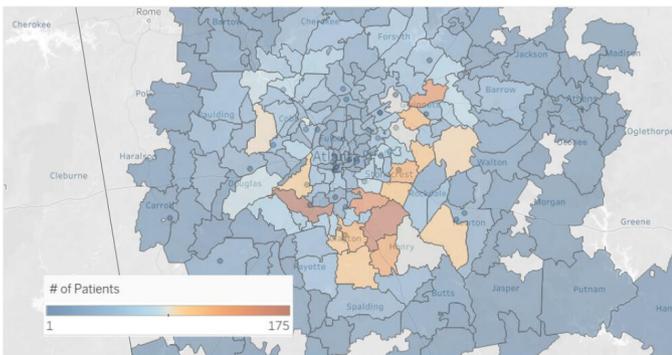
KPGA, Kaiser Permanente Georgia.

Kaiser Permanente Georgia's COVID19 Cases By Race/Ethnicity

 A. Map of Kaiser Permanente Georgia's COVID19 Cases of Race/Ethnicity **Black** in Metro Atlanta Area

 B. Map of Kaiser Permanente Georgia's COVID19 Cases Race/Ethnicity **White** in Metro Atlanta Area

 C. Map of Kaiser Permanente Georgia's COVID19 Cases Race/Ethnicity **Asian** in Metro Atlanta Area

 D. Map of Kaiser Permanente Georgia's COVID19 Cases Race/Ethnicity **Hispanic** in Metro Atlanta Area


E. Map of Kaiser Permanente Georgia's COVID19 Cases All Race/Ethnicities in Metro Atlanta Area



F. Map of Metro Atlanta Neighbourhood Deprivation Index (NDI)

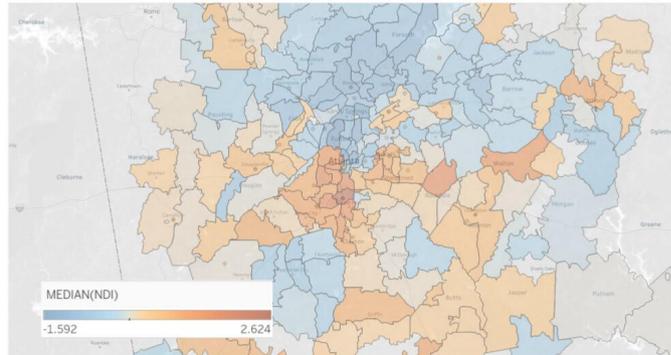


Figure 1 Map of Metro Atlanta Region's COVID-19 cases by race/ethnicity. (A) Map of COVID-19 cases: race black. (B) Map of COVID-19 cases: race white. (C) Map of COVID-19 cases: race Asian. (D) Map of COVID-19 cases: race Hispanic. (E) Map of COVID-19 cases: all races. (F) Map of Metro Atlanta Neighbourhood Deprivation Index (NDI).

(table 3). Of those hospitalised, 66% were admitted at our two core hospitals and 34% at non-core hospitals.

Compared with black and white patients, Asian patients had longer average hospital LOS (14.5 (17.1) vs 7.9 (9.1), $p=0.0002$, and 7.2 (7.9), $p<0.0001$), ICU admission (53.1% vs 27.7%, $p=0.0021$, and 27.6%, $p=0.0031$) and invasive mechanical ventilation (21.9% vs 9.2%, $p=0.0191$, and 5.8%, $p<0.0001$), respectively (table 3). Asian patients also had a longer average hospital LOS than Hispanic patients (14.5 (17.1) vs 6.9 (7.3), $p=0.0064$). No significant differences in the rates of readmission or mortality were found between racial groups (table 3).

Male patients had longer average hospital LOS (8.6 (10.0) vs 7.3 (8.3), $p=0.03$) and higher rates of ICU

admission (32.2% vs 25.8%; $p=0.03$) compared with female patients (table 3). Compared with patients aged 18–49 years, older patients aged 50–64 and 65+ had longer average hospital LOS (6.6 (8.2) vs 8.5 (9.9), $p=0.0084$, and 8.5 (9.2), $p=0.0092$), higher rates of ICU admission (21.8% vs 34.8%, $p<0.0001$, and 29.0%, $p=0.0265$), invasive mechanical ventilation (4.4% vs 10.9%, $p=0.0004$, and 9.9%, $p=0.0033$) and death (2.2% vs 8.1%, $p=0.001$, 21.1%, $p<0.0001$) (table 3). Of the 96 deceased patients in our cohort, 70% died during the COVID-19 index hospitalisation (table 3). Other patients died after discharge to hospice (10.3%), assisted/skilled nursing facility or long-term assisted care (9.3%), home (7.3%) or other hospital (3.1%).

Table 2 Comorbidities, outpatient medication, quality of care and exercise metrics of KPGA patients with COVID-19, by race/ethnicity

	All (N=5721)	Black (n=3339)	White (n=1689)	Hispanic (n=487)	Asian (n=206)	P value
Comorbidities, N (%)						
HTN	1816 (31.7)	1160 (34.7)* **	507 (30)†	87 (17.9)†††	62 (30.1)	<0.0001
Diabetes	898 (15.7)	570 (17.1)* **	229 (13.6)	62 (12.7)	37 (18)	0.0022
Obesity (BMI >30)	439 (7.7)	300 (9)* ***	102 (6)††	32 (6.6)†††	5 (2.4)	<0.0001
Hyperlipidaemia	1262 (22.1)	667 (20)* ***	453 (26.8)	82 (16.8)†††	60 (29.1)	<0.0001
CAD	285 (5)	135 (4)*	125 (7.4)†	13 (2.7)†††	12 (5.8)	<0.0001
CHF	320 (5.6)	187 (5.6)* **	121 (7.2)† ††	6 (1.2)	6 (2.9)	<0.0001
Asthma	574 (10)	377 (11.3)* ***	148 (8.8)	35 (7.2)	14 (6.8)	0.0013
COPD	153 (2.7)	64 (1.9)*	78 (4.6)†	5 (1)	6 (2.9)	<0.0001
Arrhythmia	172 (3)	79 (2.4)* **	85 (5)†	3 (0.6)†††	5 (2.4)	<0.0001
ESRD‡	4 (0.1)	3 (0.1)	1 (0.1)	0 (0)	0 (0)	0.8726
HIV	65 (1.1)	54 (1.6)* **	9 (0.5)	1 (0.2)	1 (0.5)	0.0007
Depression	633 (11.1)	318 (9.5)*	262 (15.5)† ††	39 (8)	14 (6.8)	<0.0001
CKD§	100 (1.8)	62 (1.9)**	31 (1.8)	3 (0.6)	4 (1.9)	0.2632
Cancer	93 (1.6)	55 (1.7)	33 (2)†	3 (0.6)	2 (1)	0.1867
2+ comorbidities¶	1823 (31.9)	1095 (32.8)***	570 (33.7)†	90 (18.5)†††	68 (33)	<0.0001
3+ comorbidities¶	966 (16.9)	560 (16.8)* ***	333 (19.7)†	41 (8.4)†††	32 (15.5)	<0.0001
Charlson Comorbidity Index, mean (SD)‡‡	1.9 (1.4)* **	1.9 (1.5)	2.1 (1.7)†	1.5 (1.1)	1.67 (1.2)	0.0014
Outpatient medication, N (%)						
Antirheumatic	17 (0.3)	8 (0.2)	7 (0.4)	2 (0.4)	0 (0)	0.5696
Antihypertensive	1059 (18.5)	632 (18.9)**	329 (19.5)†	62 (12.7)	36 (17.5)	0.0062
Antiasthmatic	890 (15.6)	533 (16)	274 (16.2)	57 (11.7)	26 (12.6)	0.3283
Antihyperlipidaemic	1034 (18.1)	543 (16.3)* ***	371 (22)†	65 (13.4)†††	55 (26.7)	<0.0001
Corticosteroids	1244 (21.7)	726 (21.7)*	388 (23)†	89 (18.3)	41 (19.9)	0.1478
Cough/cold medication	788 (13.8)	459 (13.8)	249 (14.7)	56 (11.5)	24 (11.7)	0.2367
Antimalarial	31 (0.5)	22 (0.7)*	4 (0.2)	4 (0.8)	1 (0.5)	0.2139
Quality of care metrics§§						
Blood pressure >140/90¶¶	501 (27.6)	349 (30.1)**	118 (23.3)†	21 (24.1)†††	13 (21)	<0.0001
Diabetes uncontrolled (A1C>8)¶¶	286 (31.8)	195 (34.2)	65 (28.4)	18 (29)	8 (21.6)	0.1976
Average exercise minutes, mean (SD)‡‡‡	79.9 (114)	75.3 (113.4)*	91 (128.1)	76.7 (115.6)	87.5 (99.7)	0.0034
EVS category, N (%)§§§						
Inactive	1648 (28.8)	998 (29.9)	460 (27.2)	136 (27.9)	54 (26.2)	0.0044
Insufficient	1336 (23.4)	814 (24.4%)*	359 (21.3)	107 (22)	56 (27.2)	
Sufficient	785 (13.7)	432 (12.9)*	265 (15.7)†	57 (11.7)	31 (15.1)	
No information	1952 (34.1)	1095 (32.8)* **	605 (35.8)	187 (38.4)	65 (31.6)	

Significance levels: *Black vs white; **Black vs Hispanic; ***Black vs Asian; †White vs Hispanic; ††White vs Asian; †††Hispanic vs Asian, significant difference at $p < 0.05$.

‡ESRD classified based on diagnosis reported by the 10th revision of the International Statistical Classification of Diseases and Related Health Problems code (ICD-10) in patient's medical history.

§CKD classified based on diagnosis reported by the ICD-10 code in patient's medical history.

¶Comorbidities here are medical diagnoses included in medical history as ICD-10 codes. These include, but are not limited to, those presented in the table.

‡‡Charlson Comorbidity Index predicts the 10-year mortality of a patient based on age and comorbidities. Scores are summed to provide a total predictive score. The lowest score of 0 corresponds to a 98% estimated 10-year survival rate (Charlson *et al* 1987).

§§Assessed at the most recent clinical encounter within the last 12 months.

¶¶Blood pressure control was evaluated only among patients with hypertension ($n=1816$) and glucose control among patients with diabetes ($n=898$).

‡‡‡Average exercise was collected from self-reported data.

§§§EVS is based on patient-reported weekly exercise minutes. We used three categories: inactive for patients who reported less than 10 min/week; insufficiently active for patients who reported 11–149 min/week; and sufficiently active for patients who reported 150 or more min/week.

BMI, body mass index; CAD, coronary artery disease; CHF, congestive heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; ESRD, end-stage renal disease; EVS, exercise as a vital sign; HbA1c, glycated haemoglobin; HTN, hypertension; KPGA, Kaiser Permanente Georgia.

Table 3 Clinical outcomes of hospitalised KPGA patients with COVID-19 by race/ethnicity, sex and age groups

	Race/Ethnicity				Sex		Age group (years)				
	N (%)				N (%)		N (%)				
	Total	Black	White	Hispanic	Asian	Female	Male	Total	18-49	50-64	65+
Hospitalisation characteristics	N=896†	556 (62.0%)	257 (28.7%)	51 (5.7%)	32 (3.6%)	458 (51.1%)	438 (48.9%)	271 (30.3%)	322 (35.9%)	303 (33.8%)	303 (33.8%)
Mean age, years (SD)‡	57.3 (15.7)	55.4 (15.1)	62.7 (16.1)	51.2 (12.4)	55.9 (15.4)	56.4 (16.4)	58.1 (14.8)	n/a	n/a	n/a	n/a
Healthcare utilisation											
Mean hospital LOS, days (SD)	7.9 (9.2)	7.9 (9.1)	7.2 (7.9)	6.9 (7.3)	14.5 (17.1)	7.3 (8.3)	8.6 (10.0)	6.6 (8.2)	8.5 (9.9)	8.5 (9.9)	8.5 (9.2)
Admitted to ICU††	259 (28.9%)	154 (27.7%)	71 (27.6%)	17 (33.3%)	17 (53.1%)	118 (25.8%)	141 (32.2%)	59 (21.8%)	112 (34.8%)	88 (29.0%)	88 (29.0%)
Mean ICU LOS, days (SD)	10.0 (10.5)	10.1 (9.3)	8.1 (9.0)	8.7 (9.6)	17.8 (20.4)	9.1 (9.8)	10.7 (11.0)	9.0 (9.0)	9.7 (10.3)	11 (11.7)	11 (11.7)
Mechanical ventilation††	77 (8.6%)	51 (9.2%)	15 (5.8%)	4 (7.8%)	7 (21.9%)	36 (7.9%)	41 (9.4%)	12 (4.4%)	35 (10.9%)	30 (9.9%)	30 (9.9%)
Mean ventilator duration, days (SD)	14.5 (11.4)	13.4 (9.0)	12.9 (10.6)	16 (9.1)	24.7 (22.5)	14.4 (10.8)	14.6 (12.0)	13.6 (9.1)	12.6 (10.7)	17.0 (12.7)	17.0 (12.7)
Outcomes											
Discharged alive††	798 (89.1%)	502 (90.3%)	222 (86.4%)	46 (90.2%)	28 (87.5%)	417 (91%)	381 (87.0%)	265 (97.8%)	294 (91.3%)	239 (78.9%)	239 (78.9%)
Still hospitalised††	2 (0.2%)	1 (0.2%)	1 (0.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (0.5%)	0 (0.0%)	2 (0.6%)	0 (0.0%)	0 (0.0%)
30-day readmission††	75 (8.4%)	44 (7.9%)	25 (9.7%)	4 (7.8%)	2 (6.3%)	38 (8.3%)	37 (8.4%)	22 (8.1%)	23 (7.1%)	30 (9.9%)	30 (9.9%)
60-day readmission††	85 (9.5%)	49 (8.8%)	30 (11.7%)	4 (7.8%)	2 (6.3%)	44 (9.6%)	41 (9.4%)	25 (9.2%)	25 (7.8%)	35 (11.6%)	35 (11.6%)
Deceased††	96 (10.7%)	53 (9.5%)	34 (13.2%)	5 (9.8%)	4 (12.5%)	41 (9.0%)	55 (12.6%)	6 (2.2%)	26 (8.1%)	64 (21.1%)	64 (21.1%)

Significance tests (categorical: χ^2 test of significance; continuous: ANOVA test of significance, two sample t-test of means).

Significance levels * $p \leq 0.05$, ** $p \leq 0.001$.

†n=896 includes patients at level of hospital stay. Thus, participants who were readmitted, or transferred, are accounted for more than once.

‡Mean age represents all unique hospitalised patients n=827.

§Across race groups, ° Black vs Asian; °° White vs Asian; °°° Hispanic vs Asian; ΔAcross sex; ΔΔMen vs women.

¶Across age groups; ∆Age 18-49 vs 50-64; ∆∆Age 50-64 vs 65+; ∆∆∆Age 50-64 vs 65+.

††In this table, column percentages are provided for categorical variables and rounded to the nearest tenth.

ANOVA, analysis of variance; ICU, intensive care unit; KPGA, Kaiser Permanente Georgia; n/a, not applicable.

Multivariable analysis and factors associated with hospitalisation

Overall model

Sociodemographic factors including increasing age (adjusted OR (aOR) 1.02, 95% CI (1.03, 1.04)), black race (aOR 1.43 (1.13, 1.83)), Hispanic race (aOR 1.60 (1.08, 2.37)), living in a zip code with high rates of unemployment (aOR 1.08 (1.03, 1.13)) and having Medicare insurance (aOR 1.52 (1.12, 2.06)) were associated with increased odds of hospitalisation for COVID-19 (table 4). Female sex was associated with lower odds of hospitalisation (aOR 0.74, 95% CI (0.61, 0.90)) (table 4).

Comorbidities, quality of care and lifestyle factors associated with increased odds of hospitalisation included patients with COPD (aOR 2.59 (1.67, 4.02)), CHF (aOR 1.79 (1.31, 2.45)), immunocompromised (aOR 1.77 (1.16, 2.70)), with HbA1c>8% (aOR 1.68 (1.19, 2.38)), depression (aOR 1.60 (1.24, 2.06)), hypertension (aOR 1.5 (1.21, 1.87)) and higher comorbidity scores (aOR 1.19 (1.11, 1.28)) (table 4). Additionally, self-reported physical inactivity was associated with higher odds of hospitalisation (aOR 1.25 (1.03, 1.51)) (table 4).

Race stratification

Increasing age was associated with increased odds of hospitalisation across all race groups (table 4).

Among black patients, living in a zip code with high rates of unemployment (aOR 1.09 (1.03, 1.16)) and having Medicare insurance (aOR 1.92 (1.29, 2.88)) were associated with higher hospitalisation odds. Clinically, those with a history of COPD (aOR 2.53 (1.24, 5.16)), CHF (aOR 2.19 (1.47, 3.27)) and hypertension (aOR 1.74 (1.30, 2.32)), as well as those with higher CCI (aOR 1.21 (1.11, 1.33)), a recent (past 12 months) uncontrolled HbA1c>8% (aOR 1.74 (1.13, 2.66)) or a cough/cold medication prescription (aOR 1.37 (1.02, 1.84)), had higher odds of hospitalisation (table 4).

Among white patients, residence in northeast Atlanta (aOR 0.64 (0.43, 0.95)) was protective for COVID-19 hospitalisation. White patients with a history of being immunocompromised (aOR 2.54 (1.14, 5.67)), with COPD (aOR 2.49 (1.38, 4.49)), depression (aOR 2.13 (1.42, 3.21)), arrhythmia (aOR 1.89 (1.05, 3.42)) and recent BP measurement >140/90 (aOR 2.17 (1.31, 3.57)), as well as those with higher CCI (aOR 1.26 (1.12, 1.42)) had increased odds of hospitalisation (table 4).

Among Hispanic patients, a recent uncontrolled HbA1c (>8%) measurement was associated with higher odds of hospitalisation (aOR 5.95 (2.24, 15.78)) (table 4). Being a female was protective for hospitalisation with aOR 0.39 (0.20, 0.76) (table 4).

Among Asian patients, being a female (aOR 0.38 (0.15, 0.96)) and residing in a high-income zip code (aOR 0.24 (0.08, 0.78)) were protective against hospitalisation for COVID-19 (table 4).

Sex stratification

Increasing age was associated with increased odds of hospitalisation in all sex-stratified models (table 4).

Among male patients, residing in a high unemployment zip code was associated with increased odds of hospitalisation (aOR 1.11 (1.04, 1.19)) (table 4). A recent uncontrolled HbA1c>9% (aOR 2.01 (1.11, 3.62)), history of depression (aOR 1.73 (1.11, 2.69)), hypertension (aOR 1.58 (1.15, 2.17)), recent antiasthmatic prescription (aOR 1.51 (1.06, 2.15)) and a higher CCI (aOR 1.34 (1.23, 1.47)) were clinical factors associated with higher hospitalisation odds (table 4).

Among female patients, sociodemographic factors associated with increased odds of hospitalisation included being black (aOR 1.46 (1.06, 2.02)) and living in a high unemployment zip code (aOR 1.09 (1.02, 1.17)) (table 4). Clinical factors significantly associated with increased odds of hospitalisation were a history of COPD (aOR 4.34 (2.42, 7.77)), CHF (aOR 2.62 (1.67, 4.12)), immunocompromise (aOR 2.41 (1.22, 4.74)), depression (aOR 1.52 (1.11, 2.09)), uncontrolled HbA1c>8% (aOR 1.76 (1.07, 2.90)), hypertension (aOR 1.38 (1.01, 1.88)), self-reported physical inactivity (aOR 1.45 (1.12, 1.89)) and a higher CCI (aOR 1.12 (1.01, 1.24)) (table 4).

DISCUSSION

This study reports an over-representation of black and Hispanic populations among the cohort of laboratory-confirmed COVID-19 patients seen in an integrated care system serving the Southeast region of the USA. In comparison to the KPGA membership by race/ethnicity (43% black, 30% white, 5% Asian, 4% Hispanic, 18% other/unknown), a higher proportion of black and Hispanic patients were diagnosed with COVID-19 (58.4% and 8.5%, respectively) and required hospitalisation (62% and 5.7%, respectively). White and Asian KPGA patients were not over-represented in terms of COVID-19 diagnosis (29.5% and 3.6%, respectively) or hospitalisation (28.7% and 3.6%, respectively). Although Asian patients showed significantly higher rates of disease severity (LOS, ICU admission, mechanical ventilation), we found no racial disparities in readmission or mortality rates.

Our findings are comparable to previous reports but with some important exceptions. Earlier studies have reported similar clinical outcomes between black and non-black hospitalised COVID-19 patients in Georgia^{7 8} and some previous reports have also showed no differences in clinical outcomes between racial/ethnic groups.^{9 15} Asian patients have also been shown to present with a higher cardiorespiratory severity (aOR 1.48)¹³ and be at 1.3 times increased risk of hospitalisation compared with white patients.¹⁵ National data from the CDC from August 2020 indicate that black and Hispanic patients were 4.6 and 4.7 times more likely than whites to be hospitalised for COVID-19.¹⁵ Other studies from academic or integrated healthcare systems have shown that after adjustment for age, sex, comorbidities and income, black patients had

Table 4 Multivariable logistic regression model ORs for hospitalisation among all KPGA COVID-19 patients and by race/ethnicity and sex

	Race/Ethnicity				Sex		
	All COVID-19 n=5721 (100%)	Black n=3339 (58.4%)	White n=1689 (29.5%)	Hispanic n=487 (8.5%)	Asian n=206 (3.6%)	Female n=3304 (57.8%)	Male n=2417 (42.2%)
Population							
Total sample size, n (%)							
Variables OR (95% CI)							
Demographics							
Race black	1.43* (1.13, 1.83)	n/a	n/a	n/a	n/a	1.46* (1.06, 2.02)	
Race Hispanic	1.60* (1.08, 2.37)	n/a	n/a	n/a	n/a		
Race Asian	1.43 (0.90, 2.28)	n/a	n/a	n/a	n/a		
Age	1.03** (1.02, 1.04)	1.02** (1.01, 1.04)	1.05** (1.03, 1.06)	1.05** (1.02, 1.07)	1.06** (1.03, 1.10)	1.04** (1.03, 1.05)	1.04** (1.03, 1.05)
Female sex	0.74* (0.61, 0.90)	0.85 (0.68, 1.6)	0.75 (0.54, 1.05)	0.39* (0.20, 0.76)	0.38* (0.15, 0.96)	n/a	n/a
Social determinants							
Medicare insurance†	1.52* (1.12, 2.06)	1.92* (1.29, 2.88)					
High unemployment zip code‡	1.08* (1.03, 1.13)	1.09* (1.03, 1.16)				1.09* (1.02, 1.17)	1.11** (1.04, 1.19)
NE county area§			0.64* (0.43, 0.95)				
High income zip code¶					0.24* (0.08, 0.78)		
Comorbidities††							
COPD	2.59** (1.67, 4.02)	2.53* (1.24, 5.16)	2.49* (1.38, 4.49)			4.34** (2.42, 7.77)	
CHF	1.79** (1.31, 2.45)	2.19** (1.47, 3.27)				2.62** (1.67, 4.12)	
Immunocompromised	1.77* (1.16, 2.70)		2.54* (1.14, 5.67)			2.41* (1.22, 4.74)	
Depression	1.60** (1.24, 2.06)		2.13** (1.42, 3.21)			1.52* (1.11, 2.09)	1.73* (1.11, 2.69)
Hypertension	1.50** (1.21, 1.87)	1.74** (1.30, 2.32)				1.38* (1.01, 1.88)	1.58* (1.15, 2.17)
Charlson Comorbidity Index‡‡	1.19** (1.11, 1.28)	1.21** (1.11, 1.33)	1.26** (1.12, 1.42)			1.12* (1.01, 1.24)	1.34** (1.23, 1.47)
Arrhythmia			1.89* (1.05, 3.42)				
Quality of care metrics§§							
Uncontrolled HbA1c>8%	1.68* (1.19, 2.38)	1.74* (1.13, 2.66)		5.95** (2.24, 15.78)		1.76* (1.07, 2.90)	2.01* (1.11, 3.62)
Uncontrolled HbA1c>9%							
Blood pressure >140/90			2.17* (1.31, 3.57)				
Antiasthmatic medication							1.51* (1.06, 2.15)
Cough/Cold medication		1.37* (1.02, 1.84)					
Lifestyle behaviours§§§							
Physically inactive¶¶¶	1.25* (1.03, 1.51)					1.45* (1.12, 1.89)	

†Not available as an independent variable for stratified models. Significance levels: *p<0.05, **p<0.001.

‡Represents Medicare population (aged 65+ and people with disabilities).

§Based on ESRI Business Analyst dataset showing employment and income breakdown by zip code and then linked to individual patients based on their recorded residence.

¶NE county area includes Dekalb, Gwinnett, Forsyth, Hall, Barrow, Jackson, Butts, Gilmer, Pike, Gordon, Jasper, Monroe counties.

††Based on diagnosis reported by the 10th revision of the International Statistical Classification of Diseases and Related Health Problems code (ICD-10) in patient's medical history.

‡‡Charlson Comorbidity Index predicts the 10-year mortality of a patient based on age and comorbidities. Scores are summed to provide a total predictive score. The lowest score of 0 corresponds to a 98% estimated 10-year survival rate (Charlson *et al* 1987).

§§Assessed at the most recent clinical encounter within the last 12 months.

¶¶Physically inactive defined as self-reported weekly exercise <10min.

¶¶¶CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; HbA1c, glycated haemoglobin; KPGA, Kaiser Permanente Georgia; NE, Northeast.

between 1.72 and 2.7 times and Hispanics 1.5 times the odds of hospitalisation compared with white patients.^{3 29 30}

Compared with white patients, a higher percentage of black and Hispanic patients with COVID-19 were female, younger and more likely to reside in zip codes with a higher proportion of median household incomes below \$75 000. Furthermore, black and Hispanic patients also resided at a higher proportion in neighbourhoods with the highest rate of households below the federal poverty level (14% and 12%), with a higher NDI (0.37 and 0.03), and the highest percentage of frontline workers (35.6% and 35.4%) compared with other racial groups. This and other SDOH factors have been associated with an increased risk of exposure to and infection with COVID-19 infection and underscore how systemic racism and inequities play a role in health disparities, a situation that has been magnified by the COVID-19 pandemic in the USA.

In addition to SDOH factors, comorbidities have been associated with more severe COVID-19 disease. The prevalence of comorbidities in the USA is inequitably distributed across race groups with minority populations shouldering a heavier burden of disease. Black patients had significantly higher prevalence of obesity, hypertension, asthma and HIV, all associated with increased disease severity in our analysis, as has been reported in previous studies.⁴ In our cohort, Asian patients had the highest diabetes prevalence. White patients were older, with higher CCI scores compared with black patients, and had a significantly higher prevalence of underlying conditions, such as hyperlipidaemia, CAD, CHF, COPD, arrhythmia and depression. Although there is a high prevalence of obesity, diabetes and other chronic diseases in the overall US population, particularly in the Southeast,^{31–33} our study and other reports suggest that different comorbidity phenotypes may influence COVID-19 disease severity across racial groups.¹³

Similar to previous studies, our multivariable analysis revealed that females were significantly (aOR 0.74) less likely to be hospitalised, while racial minorities (black, Hispanic) increasing age and chronic comorbidities were predominant factors associated with higher odds of hospitalisation.^{7 8} Medicare insurance type was a significant correlate of hospitalisation, a finding that was expected given the age of the population that has access to this insurance option. The median age for Medicare beneficiaries at KPGA was 71.8 vs 41.8 years for those with other types of insurance.

Interestingly, a recent uncontrolled blood glucose measurement (HbA1c>8%) was an independent risk factor for hospitalisation among all patients (aOR 1.68), black (aOR 1.74) and particularly Hispanic patients (aOR 5.95). Furthermore, poor BP control (>140/90 mm Hg) was a predictive factor for hospitalisation (aOR 2.17) among white patients. Overall, these findings suggest that presence of, and poorly controlled comorbidities, increase risk of hospitalisation for COVID-19 and that improving clinical management of underlying cardiometabolic diseases could help ameliorate hospitalisation

rates. As the pandemic waves progresses over time, particular emphasis on implementing evidence-based strategies to reduce well-established racial disparities in diabetes and hypertension management^{25 34} should be reinforced. Approaches that leverage novel avenues of care including telemedicine and patient-generated actionable data, as well as sustainable linkages with community resources, are recommended.^{34 35} Moreover, identifying the drivers of poorly controlled comorbidities in minority populations, particularly diabetes among Hispanic patients, may be particularly impactful given the high prevalence of both diabetes and COVID-19 risk of infection and hospitalisation among this group.

In addition to demographic factors and underlying comorbidity burden and management, our analyses also accounted for the potential role of additional SDOH, including indicators of education, economic stability, health insurance type, neighbourhood and physical environment as well as pre-pandemic lifestyle behaviours. Of these metrics, we found that residence in zip codes with a high proportion of unemployment was a consistent factor associated with increased hospitalisation risk for all patients (aOR 1.08) and specifically black patients (aOR 1.09), although with a smaller effect than other factors. In contrast, residence in zip codes with a high proportion of high-income individuals (aOR 0.24) and living in the Northeast area of metro Atlanta (0.64) were powerful protective factors against hospitalisation among white and Asian patients, respectively. Northeast Atlanta counties have consistently higher levels of median income, quality housing, green space, better safety and education and have a lower prevalence of obesity compared with the southern regions of KPGA's catchment area.^{36 37} This is another reflection of how systemic factors perpetuate racial inequities and influence the risk of adverse health outcomes.

Furthermore, self-reported physical inactivity—engaging in less than 10 min of moderate to vigorous exercise/week—increased by 25% the odds of hospitalisation among patients in our cohort. The effect estimate of physical inactivity was even more pronounced for female patients (aOR 1.45). Several biological mechanisms may explain this novel association. Physical inactivity is a consistent risk factor for a plethora of chronic diseases shown to also increase COVID-19 severity.³⁸ Increased inactivity and sedentary time and related comorbidities are also associated with an increased low-grade chronic inflammatory state,³⁹ which may contribute to the known increased systemic inflammatory effects of COVID-19. In addition to being a modulator of inflammation, regular moderate exercise is also an important immunomodulator, particularly of the virus-fighting cytotoxic immune response.⁴⁰ This is reinforced by epidemiological studies showing a link between moderate-to-vigorous regular exercise and a lower risk of upper respiratory tract viral infections—including influenza and pneumonia—as well as improved vaccine responses.⁴¹ Although previous reports have shown that self-reported exercise is a predictor of clinical outcomes,²⁸ it is noteworthy that physical inactivity remained a significant

correlate of hospitalisation risk in our study population, after adjusting for traditional risk factors such as age, BMI, comorbidity burden and therapeutic management. This reinforces the clinical value of promoting fitness and an active lifestyle, preferably outdoors, to reduce the risk of infection and disease severity of a novel infectious agent such as SARS-COV-2.⁴²

This study has some limitations. The study population included only KPGA patients that have access to insurance and, therefore, ready access to healthcare services. However, our analysis showed a diverse socioeconomic background of KPGA patients underscoring the role of various SDOH in relation to COVID-19 risk of infection and hospitalisation. We excluded ‘Other’ (n=13) and the ‘declined to report’ (n=95) race/ethnicity categories from our analyses. Despite the robustness of KPGA’s EHR data collection procedures and additional manual chart abstractions, we could not obtain data for an additional 636 patients with ‘unknown’ race/ethnicity and thus this group was also excluded from the analyses given their large heterogeneity and the difficulty to interpret findings or establish comparisons. In total, these groups constituted about 11% of patients with COVID-19 seen at KPGA during the study period, a smaller proportion than the unknown race/ethnicity category in the Georgia DPH (18.5%). Finally, despite having some SDOH indicators in our member’s EHR, we also included neighbourhood level data to extrapolate additional SDOH metrics. Well-established US studies examining COVID-19 racial disparities have included some, but not all, of the SDOH metrics we were able to include in our analyses.^{3 5 9 29} Ongoing investigation of the drivers in COVID-19 racial disparities will benefit from including more individual level SDOH data. Despite these limitations, by integrating underlying chronic disease management history, outpatient information, hospitalisation, clinical outcomes and post-discharge follow-up data, this study provides one of the most comprehensive assessments of patients with COVID-19 in relation to racial/ethnic disparities.

To our knowledge, this investigation is the first COVID-19 retrospective cohort to include a multivariate analysis on multiple measures of SDOH and pre-pandemic comorbidity management. Our study suggests that, within our sample of KPGA patients with ready access to insurance and high quality of care in an integrated healthcare system, black and Hispanic patients were still being disproportionately affected by COVID-19 infection and risk of hospitalisation. However, we found no significant differences in clinical outcomes such as readmission or mortality across race/ethnicity groups. These outcomes are not very frequent, therefore these findings need to be corroborated on a larger sample size. Location of residence, a proxy for the overall community context of our patients, appears to be a factor strongly associated with increased hospitalisation risk among black patients. The SDOH have shown to contribute to a more unfavourable baseline health status and therefore can indirectly impact COVID-19 risk of hospitalisation and severity.⁶ In

addition to age, sex, location of residence and presence of comorbidities, pre-pandemic self-reported exercise levels and underlying blood pressure and glucose control may also significantly impact hospitalisation risk in different race groups. Therefore, as interventions designed to reduce COVID-19 disparities and the systemic effects of racism⁴³ are implemented, we recommend that in addition to well-known clinical and quality of care variables, individual and community-level social factors and lifestyle health behaviours be considered by clinicians, healthcare systems⁴⁴ and public health stakeholders.

Twitter Felipe Lobelo @felipelobelo

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ORCID iD

Felipe Lobelo <http://orcid.org/0000-0003-4185-7193>

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