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Clinical, Behavioral and Social Factors Associated with Racial Disparities in Hospitalized and Ambulatory COVID-19 Patients from an Integrated Health Care System in Georgia

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ABSTRACT

Introduction: Racial and ethnic minorities have shouldered a disproportioned burden of coronavirus disease 2019 (COVID-19) infection, but data on the various drivers of these disparities is limited.

Methods: Case series of consecutive KPGA members with confirmed COVID-19 seen at Kaiser Permanente Georgia (KPGA) from March 3 to May 12, 2020. Multivariable analyses for hospitalization risk were performed among laboratory-confirmed COVID-19 patients and on 3489 persons under investigation (PUI) with suspected infection. Models included COVID-19 treatment and outcomes, underlying comorbidities and quality of care management metrics, socio-demographic and other individual and community-level social determinants of health (SDOH) indicators.

Results: Of 448 KPGA COVID-19 positive members, 68,3% were non-Hispanic Black (n=306), 18% non-Hispanic White (n=81) and 13,7% Other race (n=61). Median age was 54 [IQR 43-63) years. Overall, 224 patients were hospitalized, median age 60 (50-69) years. Black race was a significant hospitalization risk factor in the Confirmed + PUI, female and male models (ORs from 1.98 to 2.19). Obesity was associated with higher hospitalization odds in the confirmed, confirmed + PUI, Black and male models (ORs from 1.78 to 2.77). Those with adequate chronic disease management (diabetes, hypertension, hyperlipidemia) had 48% to 35% lower odds of hospitalization in the confirmed + PUI and Black models. Self-reported physical inactivity was associated with 50% higher hospitalization odds in the Black and Female models. Residence in Northeast Atlanta was associated with lower hospitalization odds in the Confirmed + PUI, White and female models (ORs from 0.22 to 0.64)

Conclusions: Non-Hispanic Black KPGA members had twice the risk of hospitalization compared to other race groups. We found no significant differences in clinical outcomes or mortality across race/ethnicity groups. Beyond well-known physiologic and clinical factors, individual and community-level SDOH indicators and health behaviors must be considered as interventions designed to reduce COVID-19 racial disparities are implemented.

ARTICLE SUMMARY: STRENGHTS AND LIMITATIONS OF THIS STUDY

- Racial and ethnic minorities have shouldered a disproportioned burden of coronavirus disease 2019 (COVID-19) infection to date in the United States and across the world, but data on the various clinical and social drivers of these disparities is limited.
- In this retrospective cohort study of 448 consecutive patients with confirmed Coronavirus disease 2019, Black members had a higher risk of infection and hospitalization but no significant differences in mortality across race groups. In addition to age, sex and presence of comorbidities, pre-pandemic self-reported exercise, control of underlying chronic diseases, and location of residence were significantly associated with hospitalization risk by race groups
- As a limitation, the target population in this analysis included only KPGA members that by definition have insurance and ready access to health care services
- 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. Clinical, behavioral and social factors should be considered as interventions designed to reduce COVID-19 disparities are implemented

Data sharing statement: All data relevant to the study are included in the article. No additional data is available.

MANUSCRIPT TEXT

Introduction

As of July 2020, despite having 4.25% of the global population, the United States (US) has contributed a quarter of the more than 10 million cases and 500,000 deaths recorded globally due to coronavirus disease 2019 (COVID-19).(1) In the US — the current epicenter of the pandemic — it has been widely reported that Black/African Americans (AA) and other racial/ethnic minorities, particularly those living in large and diverse urban centers, shoulder a disproportionate burden of 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 hospitalizations and death rates among the Black/AA population.(7, 8) Subsequent reports from two large health care systems in Louisiana and California, and from the Veterans Affairs health system(9) also found racial disparities in COVID-19 outcomes and clinical risk factors for hospitalization. These reports also theorized that chronic disease control, health behaviors, 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 metrics in most medical health records has precluded a comprehensive, broader analyses of potential drivers of these racial disparities.

The U.S. Census Bureau reports the racial/ethnic demographic distribution of Georgia as 58.3% White alone, 31.6% Black/AA, 9.7% Latino or Hispanic, and 4.1% Asian.(10) As of May 12th, the Georgia Department of Public Health (DPH) reported confirmed COVID-19 cases by race/ethnicity as 35.1% Black/AA, 30% white, 10.1% Hispanic or Latino and 1.4% Asian(11). This overrepresentation of Black/AA and other minority populations has been observed in other

Georgia counties.(11) Kaiser Permanente Georgia (KPGA) is a regional integrated health care system serving over 300,000 members in 32 counties located in the Atlanta Metropolitan Area and the Northeast region of the state. As of April 2020, KPGA membership is 43% Black/AA, 30% White, 5% Asian, 4% Hispanic or Latino (18% Unknown/other), which more closely resembles metro Atlanta than overall Georgia.(12) In this study, we conducted a descriptive analysis of KPGA members with suspected and laboratory-confirmed COVID-19. KPGA's robust electronic health record (EHR) data enabled analyses throughout the continuum of care including pre-pandemic underlying disease control, COVID-19 outpatient/inpatient management and post-discharge, with a particular focus on racial/ethnic comparisons. In addition, we conducted multivariable analyses for hospitalization risk based on demographics, comorbidities, quality of care metrics, lifestyle behaviors and other available individual and community-level social determinants of health indicators.

Methods

For this retrospective cohort study, we performed an EHR review of KPGA members seen with COVID-19 related symptoms between March 3, 2020 and May 12, 2020. 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. Patients were screened according to the Centers for Disease Control (CDC) and Georgia DPH guidelines.(13, 14) Patients who met criteria were tested for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) by polymerase chain reaction (PCR). Due to limits on the testing capacity in Georgia during this period, patients with symptoms or exposures consistent with SARS-CoV-2 were categorized as having been tested or as a person under investigation (PUI). Patients who received tests were further categorized as confirmed or ruled-out. At the start of the epidemic in our region, KPGA prioritized testing among symptomatic health care workers and/or with relevant exposures and symptomatic KPGA members requiring hospital admission. After April 22, testing was progressively expanded to include clinical dispositions dependent on test results (pre-operative clearance, dialysis pending, skilled nurse facility or hospice placement), 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 (non-KPGA healthcare workers, first responders, jail and elder care employees, etc.)

Patient Demographics

We characterized confirmed SARS-CoV-2 and PUI patients by age, sex, self-reported race/ethnicity, insurance type, and area of residence. Race/ethnicity was categorized as non-Hispanic Black/AA (confirmed n=306; 68,3%), non-Hispanic White (n=81; 18%), and Other (n=61; 13,7%), which included Hispanic or Latino (n=16), Asian (n=15), Native American (n=1) and unknown/declined to report (n=29).

We obtained patient's location of residence from the EHR and categorized it into four different regions of metro Atlanta: Northeast, Northwest, Southeast, and Southwest. Residence location was also linked to the neighborhood deprivation index (NDI), a composite SDOH measure including income, education, employment and housing quality.(15, 16) The higher the NDI value, the higher the level of deprivation in the neighborhood.(15, 16) We also utilized ESRI® Business Analyst data, a comprehensive demographic and lifestyle database which provides data to help interpolate patient's socioeconomic status(17). Specifically, we linked patients' places of residency with ESRI's® zip code level classifications of median household income, occupation, and educational attainment. We used this data to cross-reference median household income with the government-defined poverty line.(18)

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

Existing comorbidities of SARS-CoV-2 confirmed patients were obtained from the patient's EHR as classified by the International Statistical Classification of Diseases and Related Health Problems codes (ICD-10)(19). The Charlson Comorbidity Index (CCI) was used as a continuous measure of total comorbidity burden.(20) We used pharmacy dispensing data to compile the frequency of outpatient medications used by patients.

We used Healthcare Effectiveness Data and Information Set (HEDIS)(21) as a marker of hypertension (blood pressure reading lower than <140/90mm Hg) and diabetes control (glycated hemoglobin HbA1c < 8%) within a minimum rolling 12-month period.

Using KPGA's Exercise Vital Sign (EVS) data, patient's physical activity levels were classified as inactive, insufficiently active, and sufficiently active for those self-reporting ≤10 minutes, 11-149 minutes, and ≥150 minutes of exercise/week, respectively. The EVS has been previously validated(22) and is considered a clinically relevant screening tool for physical activity behaviors in the health care setting(23, 24).

Clinical Outcomes

Hospitalized patients with confirmed COVID-19 were characterized by hospital length of stay (LOS), ICU LOS, invasive mechanical ventilation initiation and length of use, hospital discharge, readmission, currently hospitalized (n=20; 8.9%), and deceased. Instances of admission and discharge on the same date were defined as LOS of one day. Mechanical ventilation data was compiled using an ICD-10 code flagging instances of emergency endotracheal intubation during hospital stay. Once identified, a manual chart review was conducted for each eligible patient to calculate the length of mechanical ventilation, from intubation to extubation or death. Readmissions were defined as instances of subsequent admission within 30 days to a hospital after recent discharge. We conducted manual record reviews to distinguish between encounters of readmission and patient transfers from a hospital to another medical facility.

Statistical Analysis

We report numbers (percentages) for binary and categorical variables and medians (interquartile ranges, IQR) for continuous variables. Chi-square tests 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 method was applied and reported.

Multivariable logistic regression was used to explore factors associated with having a COVID-19 related hospitalization in seven different models: COVID-19 confirmed cases only, confirmed cases plus PUIs, and confirmed cases plus PUIs stratified by race/ethnicity (Black/AA, White, Other) and by sex (Male and Female). All multivariable logistic regression models included age, gender and race/ethnicity as independent variables and hospitalization as

184 the dependent variable. All additional independent variables were assessed using a bivariate
185 analysis, either chi-squared or two sample t-test, and only the variables showing evidence of a
186 statistically significant (α=0.05) relationship with the dependent variable were considered for
187 entry into the models. A subset of the dependent variables was considered for the confirmed
188 cases model due to the reduced sample size of the population. Stepwise selection method was
189 used for final dependent variable selection with effect entry and effect remain significance levels
190 of 0.05. All data analysis was conducted using SAS 9.4 software.

191 The KPGA institutional review board approved this study with a waiver of informed consent. All
192 data relevant to the study are included in the article. No additional data is available.

193

194 **Results**

195 *Epidemiologic Characteristics*

196 Within the study period we screened 6,568 patients, tested 2,920 (44.5%) and 448 (15.3%
197 of tested) patients were positive for SARS-CoV-2. The median age of confirmed positive
198 patients was 54 [IQR, 43-63] years old. Black/AA patients resided in neighborhoods with the
199 highest rate under the federal poverty level (14.2%), unfavorable NDI (0.45), and the highest
200 mean percentage of frontline (35.7%) and healthcare workers (7.5%). (Table 1). The highest
201 percentage of the KPGA members with confirmed SARS-COV-2 resided in the Northeast Metro
202 Atlanta area (31.5%). However, different areas of metro Atlanta showed varying prevalence of
203 KPGA members with confirmed SARS-COV-2 when stratified by race/ethnicity. More
204 Black/AA and Other race patients lived in the Southern areas of metro Atlanta which visible
205 correlates with more socially deprived neighborhoods. (Figure)

206

Clinical Characteristics

Black/AA patients had higher rates of obesity (67.3%), hypertension (54.9%), and 2 or more comorbidities (66.3%). White patients presented with higher rates of hyperlipidemia (50.6%), congestive heart failure (CHF; 24.7%), coronary artery disease (CAD; 13.6%), arrhythmia (13.8%), CKD (11.1%) and overall CCI Scores (3.2 [2.2]) (all $p<0.001$) (Table 2).

Compared to other race/ethnicity groups, White patients had the highest rate of diabetes control (14.8%) but Black/AA patients had higher rates of blood pressure control (27.5%) as measured by HEDIS measures. Black/AA patients self-reported the least mean [SD] average weekly exercise minutes in all race/ethnicity groups (61.9 [88.1]; $p<0.001$). The prevalence of physical inactivity was higher for both Black/AA and White females compared to Other race females (38.7% vs. 41.5% vs 7.4%; all $p<0.001$, respectively).

Clinical Outcomes of Hospitalization

Overall, 224 patients with laboratory confirmed COVID-19 were hospitalized with 248 hospital stays, a median age of 60 (50-69) and a median length of stay of 6 (3-11.3) days. (Exhibit 3) There were no significant differences between Black/AA and White patients in ICU admission, ICU LOS, invasive mechanical ventilation and death (8.1% vs. 14.6%). Black/AA females were hospitalized on average 2.4 days longer than white females (95% CI 0.11 to 4.6; $p \leq 0.05$). White females had higher 30-day readmission rates than Black/AA females (17.9% vs. 4%; $p \leq 0.05$). Other race females showed significantly higher rates of invasive mechanical ventilation compared to Black/AA and White females (50% vs. 17% vs 10.7%, $p \leq 0.05$; respectively) (Table 3).

Multivariable Analysis and Factors Associated with Hospitalization

Increasing age was a significant risk factor in all models and females had lower hospitalization odds in the confirmed, confirmed + PUI, Black/AA and Other race models (ORs ranging from 0.33 to 0.51) (Table 4). Black/AA race was a significant factor in the Confirmed + PUI, female and male models (ORs ranging from 1.98 to 2.19). Obesity was associated with higher hospitalization odds in the confirmed, confirmed +PUI, Black/AA and male models (ORs ranging from 1.78 to 2.77). Every point increase in the CCI Index showed increased hospitalization odds in the White model (OR 1.35 95% CI 1.15 to 1.59; $p<0.001$) while patients with 2 or more Comorbidities had higher hospitalization odds in the Female model (OR 2.38 95% CI 1.43 to 3.94; $p<0.001$). Cardio-metabolic disease management and control metrics (diabetes, hypertension, hyperlipidemia) were associated with lower odds of hospitalization ranging from 48% to 35% in the confirmed + PUI and Black/AA models.

Self-reported physical inactivity was associated with 50% higher hospitalization odds in the Black/AA and Female models. Residence in the Northeast region of Atlanta was associated with lower hospitalization odds in the Confirmed + PUI, White and female models (ORs ranging from 0.22 to 0.64)

Discussion

This study shows an over-representation of Black/AA populations and other minorities in both the outpatient and inpatient phases of care for COVID-19 in an integrated care system, similar to previous reports (4, 6-9) Although a higher number of Black/AA KPGA members with COVID-19 were hospitalized (69.8%) than other races, there were no significant differences between racial/ethnic groups in ICU admission and duration, invasive ventilation and duration, 30-day readmissions, and mortality. However, further stratification by sex showed Black/AA females were hospitalized on average 2.4 days longer than white females, white females had higher 30-day readmission rates than Black/AA females (17.9% vs. 4%; $p \leq 0.05$) and Other race females had higher rates of invasive mechanical ventilation compared to both Black/AA and White females (50% vs. 17% vs 10.7%, $p \leq 0.05$; respectively). Previous studies reported similar clinical outcomes between Black/AA and non-Black hospitalized COVID-19 patients in Georgia(7, 8) and some but not all previous report have also showed no difference in clinical outcomes between racial/ethnic groups.(9)

Compared to White KPGA members, a higher percentage of Black/AA members with COVID-19 were female, younger, and more likely to reside in neighborhoods with median household income less than $75,000. Furthermore, Black/AA patients also reside at a higher proportion in neighborhoods with the highest rate of households below the federal poverty level (14.2%), positive neighborhood deprivation index (0.45), and the highest percentage of frontline (35.7%) and healthcare workers (7.5%) compared to other racial groups. All of these factors were associated with an increased risk of COVID-19 infection in our findings. In addition, Black/AA patients had the highest prevalence of obesity, hypertension, and presence of 2 or more comorbidities, all associated with increased disease severity in our analysis, as was found in previous reports.(4) However, we found the comorbidity burden was somewhat different by race, with White patients in our sample being on average older and showing higher CCI scores compared to Black/AA patients, and a different mix of specific underlying conditions (hyperlipidemia, CAD, CHF, arrythmia, CKD). Although there is a high prevalence of obesity, diabetes and other chronic diseases in the US population,(25-27) these findings suggest that a different comorbidity profile may influence COVID-19 disease severity across racial groups.

Similar to previous reports, our multivariable analysis revealed males were consistently more likely to be hospitalized while increasing age, obesity and hypertension were predominant factors associated with higher odds of hospitalization in all models.(7, 8) Black/AA race, diabetes, COPD, CHF, and CKD were also significant factors in different models. Of note, in the confirmed + PUIs model we detected a significant protective effect of outpatient hypertension and lipid management. Furthermore, Black/AA patients with adequate HEDIS blood pressure and diabetes control were significantly less likely to be hospitalized. Overall, these findings confirm that although the presence of various comorbidities is associated with COVID-19 admission, emphasis on providing adequate clinical management of baseline cardio-metabolic diseases could help ameliorate hospitalization rates. As the pandemic progresses over time, enhanced measures to ensure high quality of care for patients with multiple comorbidities should be reinforced, including those that leverage novel avenues of care including telemedicine and patient-generated actionable data, as well as sustainable linkages with community resources.(28, 29)

Beyond demographic and underlying comorbidity burden and management, our analyses also took into account the potential role of additional SDOH, including indicators of education, economic stability, neighborhood and physical environment and lifestyle behaviors. Of these metrics, we found that residence in the Northeast area of metro Atlanta was one of the most powerful protective factors for hospitalization in the Confirmed + PUI model, particularly for White and female KPGA members. Counties in the NE region have consistently higher levels of safety, quality housing, green space, education and income and have a lower prevalence of obesity compared to the southern regions of KPGA's catchment area(30, 31).

Furthermore, self-reported physical inactivity — engaging in less than 10 minutes of moderate to vigorous exercise/week — increased by 50% the odds of hospitalization among Black/AA and female populations. Several biologic 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.(32) Increased inactivity and sedentary time and related comorbidities are also associated with an increased low-grade chronic inflammatory state,(33) which may contribute to the known increased systemic inflammatory effects of SARS-COV-2. In addition to being a modulator of inflammation, regular moderate exercise is also an important immunomodulator, particularly of the virus-fighting cytotoxic immune response.(34) This is reinforced by epidemiologic 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.(35) Although previous reports have shown that self-reported exercise is a predictor of clinical outcomes(24), it is noteworthy that physical inactivity remained a significant correlate of hospitalization risk in our study population, after adjusting for traditional "hard" 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.(36)

This study has some limitations. Limited testing availability in the early stages of the pandemic — globally and in Georgia — led to prioritizing those with the most symptomatic and severe disease requiring admission, as well as testing healthcare workers to prevent further nosocomial infection. For this reason, we included in our analysis not only laboratory-confirmed but also persons under investigation seeking care with COVID-like symptoms. However, we acknowledge that not all PUIs would necessarily have SARS-COV-2. The target population in this analysis included only KPGA members that by definition have insurance and ready access to health care services. However, our analysis showed a diverse socioeconomic background of KPGA members. Merging racial/ethnic groups with low sample sizes into a combined "Other" race category was necessary for statistical power reasons but limits the interpretation of findings for this group. Finally, despite having some SDOH indicators in our member's EHR, we also included neighborhood level data to extrapolate additional SDOH metrics. Ongoing investigation of drivers in COVID-19 disparities will benefit from more individual level SDOH data. Despite these limitations, by integrating underlying chronic disease management history, outpatient information, hospitalization, clinical outcomes and post-discharge follow-up data, this study provides a comprehensive longitudinal assessment of COVID-19 patients 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 members with ready access to insurance and high quality of care within an integrated health system, Black/AA members were still being disproportionately affected by COVID-19 risk of infection and hospitalization. However, we found no significant differences in clinical outcomes such as ICU length of stay or mortality across race/ethnicity groups. Location of residence, a proxy for the overall community context of our patients, appears to be a factor strongly associated with increased infection risk among Black/AA and other minorities. SDOH have also shown to contribute to a more unfavorable baseline health status and therefore, can indirectly impact COVID-19 risk of hospitalization and severity.(6) In addition to age, sex, location of residence and presence of comorbidities, pre-pandemic self-reported exercise levels and underlying cardio-metabolic disease control may also significantly impact hospitalization risk in different race groups. Therefore, beyond well-known physiologic and clinical factors, individual and community-level social factors and health behaviors must be considered by clinicians, health care systems(37) and public health stakeholders (6) as interventions designed to reduce COVID-19 disparities and the systemic effects of racism(38) are implemented.

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Author Contributions: Drs Lobelo and Shin had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Concept and design: Shin, Lobelo, Koplan

Acquisition, analysis, or interpretation of data: Lobelo, Bienvenida, Leung, Mbanya, Leslie, Shin

Drafting of the manuscript: Lobelo, Shin, Bienvenida, Leung, Mbanya, Leslie

Critical revision of the manuscript for important intellectual content: Lobelo, Koplan, Shin

Statistical analysis: Leung, Leslie

Administrative, technical, or material support: Lobelo, Koplan, Shin

Supervision: Lobelo, Koplan, Shin

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Table 1: Socio-economic and demographic characteristics of KPGA members with confirmed SARS-COV-2 seen from March 3 to May 12, 2020

	Patients Stratified by Race [a] No. (%)				
	All (N= 448)	**Black/AA (n= 306)**	**White (n= 81)**	**Other (n= 61)**	**p-value**
Age, median [IQR], years	54 [43-63]	54 [43-62]	58 [49-73]	51 [37-61]	<.001
Age range, years					<.001
18-49	169 (37.7)	116 (37.9)	23 (28.4)	30 (49.2)	
50-64	177 (39.5)	132 (43.1)	24 (29.6)	21 (34.4)	
65 and above	102 (22.8)	58 (19.0)	34 (42.0)	10 (16.4)	
Gender					<.001
Male	176 (39.3)	102 (33.3)	40 (49.4)	34 (55.7)	
Female	272 (60.7)	204 (66.7)	41 (50.6)	27 (44.3)	
Insurance					
Commercial	282 (62.9)	194 (63.4)	43 (53.1)	45 (73.8)	0.11
Medicare	94 (21)	61 (19.9)	26 (32.1)	7 (11.5)	
Self-pay	44 (9.8)	31 (10.1)	7 (8.6)	6 (9.8)	
Other [b]	28 (6.3)	20 (6.6)	5 (6.2)	3 (4.9)	
Median Household Income [c] No.	**439**	**299**	**80**	**60**	
25k-50k	95 (21.6)	74 (24.7)	9 (11.3)	12 (20)	<.001
50k-75k	230 (52.4)	178 (59.5)	27 (33.8)	25 (41.7)	
75k-100k	88 (20)	43 (14.4)	29 (36.3)	16 (26.7)	
100k+	26 (5.9)	4 (1.3)	15 (18.8)	7 (11.7)	
Households Under Poverty Level, % [d]	13.1	14.2	10.0	12.0	<.001
Residential Region, No. (%) [e]	**308**	**208**	**51**	**49**	
Northeast	97 (31.5)	55 (26.4)	15 (29.4)	27 (55.1)	<.001
Northwest	46 (14.9)	23 (11.1)	19 (37.3)	4 (8.2)	
Southeast	84 (27.3)	65 (31.3)	6 (11.8)	13 (26.5)	
Southwest	81 (26.3)	65 (31.3)	11 (21.6)	5 (10.2)	
Neighborhood Deprivation Index [f]	0.21	0.45	-0.48	-0.07	<.001
Occupation [g], mean % [h]					
Frontline Workers	34.4	35.7	29.6	34.3	<.001
Healthcare Workers	7.3	7.5	6.9	6.8	<.001
Other Workers	58.3	56.8	63.5	58.9	<.001
Education, mean % [h]					
Some High School	6.8	7.2	5.5	6.5	<.001
High School	22.9	24.4	18.9	20.9	<.001
Associates Degree	8.4	8.6	7.8	8.3	<.001
Some College	21	22	18.7	19.3	<.001
Bachelors	21.1	19.2	26.3	23.4	<.001
Graduate	12.4	11.4	15.6	13.4	<.001

Abbreviations: IQR, Interquartile Range; COVID-19, Coronavirus Disease 2019; KPGA, Kaiser Permanente Georgia; AA, African American.
[a] Other is defined as all other racial/ethnic groups (Asian, Hispanic/Latino), Unknown, and those who declined to report their race.
[b] Other Insurances include military Health Maintenance Organization (HMO) or Preferred Provider Organization (PPO).
[c] Based on ESRI® Business Analyst dataset showing median household income by zip code and then linked to individual patients based on their recorded residence.[19]
[d] Poverty line was defined by the Federal poverty level [18]
[e] The Atlanta metro area was divided up by county in four sub-regions

- 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.

[f] The Neighborhood Deprivation Index (NDI) is a composite measure of social and economic factors such as income, education, employment and housing quality that reflect neighborhood deprivation.[13,14] The higher the index value, the higher the level of deprivation in the neighborhood.
[g] Based on ESRI® Business Analyst data.[16] 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.

[h] 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).[19]

Table 2: Comorbidities, outpatient medication, history of disease control, & exercise frequency of KPGA members with confirmed SARS-COV-2 by race & sex

		Race/Ethnicity [a]								
	All	**Black/AA No. (%)**			**White No. (%)**			**Other No. (%)**		
		Total	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**
	(N=448)	(n=306)	(n=102)	(n=204)	(n=81)	(n=40)	(n=41)	(n=61)	(n=34)	(n=27)
Comorbidities										
Hypertension	226 (50.5)	168 (54.9) *ɫ, *°°	61 (59.8) *ʃʃ	107(52.5) *εε	37(45.7) *ɫ	21 (52.5)	16 (39)	21 (34.4) *ɫ, *°°	13 (38.2) *ʃʃ	8 (29.6) *εε
Diabetes	116 (25.9)	86 (28.1) *°°	40 (39.2) §, *ʃʃ	46 (22.5) §	21(25.9)	14 (35) *ʃʃʃ	7 (17.1)	9 (14.8) *°°	5 (14.7) *ʃʃ, *ʃʃʃ	4 (14.8)
Obesity (BMI>30)	273 (60.9)	207 (67.3) **ɫ, *°, *°°	70(68.6) *ʃʃ	137(67.2) *ε	39(48.1) **ɫ, *°	21 (52.5)	18 (43.9) *ε	28 (45.9) **ɫ, *°°	15 (44.1) *ʃʃ	13 (48.1)
Hyperlipidemia	150 (33.5)	95 (31) **ɫ, *°	41 (40.2) §, *ʃ	54 (52.9) §, *ε	41(50.6) **ɫ, *°, *°°°	23 (57.5) *ʃ, *ʃʃʃ	18 (43.9) *ε, *εεε	14 (23) **ɫ, *°°°	9 (26.5) *ʃʃʃ	5 (18.5) *εεε
CAD	34 (7.6)	19 (6.2) *°	11 (10.8) §	8 (3.9) §, *ε	11(13.6) *°	6 (15)	5 (12.2) *ε	4 (6.6)	3 (8.8)	1 (3.7)
CHF	61 (13.6)	38 (12.4) *ɫ, *°	17 (16.7) *ʃʃ	21 (10.3) *ε	20(24.7) *ɫ, *°, *°°°	10 (25)	10 (24.4) *ε	3 (4.9) *ɫ, *°°°	1 (2.9) *ʃʃ	2 (7.4)
Asthma	47 (10.5)	37 (11.8) *ɫ, *°	10 (9.8)	26 (12.7)	2(2.5) *ɫ, *°, *°°°	1 (2.5) *ʃʃʃ	1 (2.4) *εεε	9 (14.8) *ɫ, *°°°	2 (5.9) ¶, *ʃʃʃ	7 (25.9) ¶, *εεε
COPD	28 (6.3)	13 (4.2) *ɫ, **°	5 (4.9)	8 (3.9) **ε	12(14.8) *ɫ, **°	2 (5) #	10 (24.4) #, **ε	3 (4.9) *ɫ	1 (2.9)	2 (7.4)
Arrhythmia	29 (6.6)	16 (5.3) *ɫ, *°	7 (6.9) *ʃ	9 (4.4)	11(13.8) *ɫ, *°, *°°°	8 (20) *ʃ, *ʃʃʃ	3 (7.3)	2 (3.4) *ɫ, *°°°	1 (2.9) *ʃʃʃ	1 (3.7)
ESRD [b]	1 (0.2)	1 (0.3)	1 (1)	0 (0)	0(0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
HIV	6 (1.3)	5 (1.6)	4 (3.9) §	1 (0.5) §	1(1.2)	1 (2.5)	0 (0)	0 (0)	0 (0)	0 (0)
Depression	69 (15.4)	45 (14.7)	5 (4.9) §	40 (19.6) §	15(18.5)	3 (7.5) #	12 (29.3) #	9 (14.8)	5 (14.7)	4 (14.8)
CKD [c]	25 (5.6)	15 (4.9) *ɫ, *°	6 (5.9)	9 (4.4) *ε	9(11.1) *ɫ, *°, *°°°	3 (7.5)	6 (14.6) *ε	1 (1.6) *ɫ, *°°°	0 (0)	1 (3.7)
Cancer	15 (3.4)	12 (4)	7 (6.9)	5 (2.5)	2(2.5)	0 (0)	2 (4.9)	1 (1.6)	1 (2.9)	0 (0)
2+ Comorbidities [d]	281 (62.7)	203 (66.3) *ɫ, *°°	72 (70.6) *ʃʃ	131(64.2)	50(61.7) *ɫ	26 (65)	24 (58.5)	28 (45.9) *ɫ, *°°	15 (44.1) *ʃʃ	13 (48.2)
3+ Comorbidities [d]	179 (40)	124 (40.5)	48 (47.1)	76 (37.3)	38(46.9) *°°°	20 (50)	18 (43.9)	17 (27.9) *°°°	11 (32.3)	6 (22.2)
CCI, mean [SD] [e]	2.4 [1.8]	2.3 [1.6]	2.7 [1.8]	2.1 [1.5]	3.2[2.2]	3 [1.8]	3.4 [2.5]	1.5 [1]	1.6 [1.0]	1.36 [1.1]

	**ɫ, *°, *°°		*ε	**ɫ, *°, **°°°	*∫∫∫	*ε, *εεε	**ɫ, *°°, **°°°	*∫∫∫	*εεε

Table 2: Comorbidities, outpatient medication, history of disease control, & exercise frequency of KPGA members with confirmed SARS-COV-2 by race & sex

		Race/Ethnicity [a]								
	All	**Black/AA No. (%)**			**White No. (%)**			**Other No. (%)**		
		Total	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**
	(N=448)	(n=306)	(n=102)	(n=204)	(n=81)	(n=40)	(n=41)	(n=61)	(n=34)	(n=27)
Outpatient Medication, No. (%)										
Anti-Rheumatic	2 (0.4)	1 (0.3)	1 (1)	0 (0) *εε	0(0)	0 (0)	0 (0)	1 (1.6)	0 (0)	1 (3.7) *εε
Anti-Hypertensive	129 (28.8)	91 (29.7)	34 (33.3)	57 (27.9)	24(29.6)	15 (37.5)	9 (22)	14 (23)	7 (20.6)	7 (25.9)
Anti-Asthmatic	103 (23)	72 (23.5)	27 (26.5)	45 (22.1) *εε	17(21)	9 (22.5)	8 (19.5) *εεε	14 (23)	4 (11.8) ¶	10 (37) ¶, *εε, *εεε
Anti-Hyperlipidemic	125 (27.9)	81 (26.5)	40 (39.2)	41 (20.1)	29(35.8)	17 (42.5)	12 (29.3)	15 (24.6)	9 (26.5)	6 (22.2)
Corticosteroids	151 (33.7)	112 (36.6)	37 (36.3)	75 (36.8)	22(27.2)	9 (22.5)	13 (31.7)	17 (27.9)	7 (20.6)	10 (37)
Anti-malarial	6 (1.3)	4 (1.3)	0 (0)	4 (2)	1(1.2)	0 (0)	1 (2.4)	1 (1.6)	0 (0)	1 (3.7)
HEDIS Measures [f]										
Blood Pressure Control [g]	113 (25.2)	84 (27.5) *°	35 (34.3)	49 (24)	18(22.2) *°, *°°°	11 (27.5)	7 (17.1)	11 (18) *°°°	5 (14.7)	6 (22.2)
Diabetes Control HbA1c < 8% [h]	55 (12.3)	37 (12.1) *ɫ, *°	14 (13.7) *∫	23 (11.3)	12(14.8) *ɫ, *°	7 (17.5) *∫	5 (12.2)	6 (9.8) *ɫ	3 (8.8)	3 (11.1)
Weekly Exercise, mean [SD], mins [i]										
	70.1 [101.8]	61.9 [88.1] *ɫ, *°°	86.7 [104.5]	49.5 [76.1] *εε	75.7 [118.5] *ɫ	76.4 [97.74]	75.? [136.2]	108.4 [134.9] *ɫ, *°°	98.4 [126.8]	123 [148.9] *εε
Exercise Vital Sign Category, No. (%) [j]										
Inactive	151 (33.7)	106 (34.6) **ɫ, *°°	27 (26.5)	79 (38.7) *εε	32(39.5) **ɫ, *°°°	15 (37.5)	17 (41.5) *εεε	13 (21.3) **ɫ, *°°, *°°°	11 (32.3)	2 (7.4) *εε, *εεε
Insufficiently Active	144 (32.1)	103 (33.7) **ɫ	34 (33.3)	69 (33.8)	23(28.4) **ɫ	11 (27.5)	12 (29.3)	18 (29.5) **ɫ	7 (20.6)	11 (40.8)
Sufficiently Active	64 (14.3)	37 (12.1) **ɫ	21 (20.6)	16 (7.8) *ε	16(19.8) **ɫ	8 (20)	8 (19.5) *ε	11 (18) **ɫ	7 (20.6)	4 (14.8)
No information	89 (19.9)	60 (19.6) **ɫ,*°°	20 (19.6)	40 (19.7) *εε	10(12.3) **ɫ, *°°°	6 (15)	4 (9.7) *εεε	19 (31.2) **ɫ, *°°, *°°°	9 (26.5)	10 (37) *εε, *εεε

Abbreviations: AA, African American; HbA1c, Glycated Hemoglobin; BMI, Body Mass Index; CAD, Coronary Artery Disease; CCI, Charlson Comorbidity Index; CHF, Congestive Heart Failure; CKD, Chronic Kidney Disease; COPD, Chronic Obstructive Pulmonary Disease; ESRD, End Stage Renal Disease;

Significance Levels * P ≤ 0.05, ** P ≤ 0.001

Significance Tests

ⱡ Across Race Groups
° Black/AA vs. White, °° Black/AA vs. Other, °°° White vs. Other
§ Black/AA Male vs. Black/AA Female
# White Male vs. White Female
¶ Other Male vs. Other Female
ᵋ Black/AA Female vs. White Female, ᵋᵋ Black/AA Female vs. Other Female, ᵋᵋᵋ White Female vs Other Female
ʃ Black/AA Male vs. White Male, ʃʃ Black/AA Male vs. Other Male, ʃʃʃ White Male vs. Other Male

[a] Other Race is defined as all other racial/ethnic groups (Asian, Hispanic/Latino), Unknown, and those who declined to report their race.
[b] ESRD classified based on ICD-10 in patient's medical history.[20]
[c] CKD classified based on diagnosis reported by the ICD-10 code in patient's medical history.[20]
[d] Comorbidities are medical diagnoses included in medical history as ICD-10 codes. These include but are not limited to those presented in the table.
[e] Charlson Comorbidity Index. The lowest score of 0 corresponds to a 98% estimated 10-year survival rate.[21]
[f] Healthcare Effectiveness Data and Information Set (HEDIS), is a performance improvement tool used by healthcare organizations in the United States.[22] For this study, this tool was used to identify the proportion of COVID-19 confirmed patients with their chronic disease successfully controlled. Of note, the total number of people with diabetes (n=116) included in this analysis is larger than the total number of diabetics reported by HEDIS measure (n=55). This discrepancy is also observed when comparing total number of people with hypertension in this analysis (n=226) with total number of hypertensive patients reported by HEDIS measure (n=116). Explanations for these differences in sample size are related to lack of continuous membership enrollment and the likelihood of no interactions with patient within the last year. These reasons could explain the lack of documentation of HEDIS disease control.
[g] HEDIS measure for blood pressure control (<140/90mm HG) for KPGA members with a 12-month rolling enrollment.[22]
[h] HEDIS measure for diabetes control based on a HbA1C < 8% for KPGA members with a 12-month rolling enrollment.[22]
[i] Average exercise was collected from self-reported data during a clinical encounter in the last year.
[j] Exercise Vital Sign is based on patient reported weekly exercise minutes. Three categories are coded: Inactive (< 10 mins/week), insufficiently active (11-149 minutes/week) and sufficiently active (150 or more mins/week)[24]

Table 3: Clinical outcomes of hospitalized KPGA members with confirmed COVID-19 by race & age groups

		Race/Ethnicity [b] No. (%)									Age group (years) No. (%)		
	All No. (%)	Black/AA			White			Other					
		Total	Male	Female	Total	Male	Female	Total	Male	Female	18-49	50-64	65+
Hospitalization Characteristics	N = 248 [c]	n=173	n=79	n=94	n=48	n=20	n=28	n=27	n=17	n=10	n=62	n=97	n=89
Age of Hospitalized Patients, median (IQR) [d], years	60 (50.0-69.0)	59 (49.5-66.0)	59 (49.5-66.0)	59 (49.5-66.0)	67 (54.0-75.5)	66.5 (52.5-74.5)	68 (55.5-77.0)	60.5 (39.5-65.5)	62 (37.0-66.0)	52 (41.0-60.0)	n/a	n/a	n/a
Hospital Length of Stay, median (IQR), days	6 (3.0-11.3)	6 (3.0-11.0)	7 (3.0-12.0)	6 (3.0-11.0) *ε	6 (2.8-10.3)	7.5 (3.0-14.5)	4 (2.0-8.5)	5 (2.0 - 17.0)	4 (2.0-14.0)	12 (2.0-20)	5 (3.0-8.0) *¶,	6 (3.0-12.0) *¶, *◊◊	6 (3.0-14.0) *¶,*◊
Admitted to ICU	104 (41.9)	69 (39.9)	33 (41.8)	36 (38.3)	19 (39.6)	9 (45.0)	10 (35.7)	16 (59.3)	9 (52.9)	7 (70.0)	20 (32.3)	44 (45.4)	40 (44.9)
ICU Length of Stay, median (IQR), days	7 (2.0-13.0)	6 (2.0-13.3)	6 (3.0-14.0)	7 (1.0-13.0)	8 (1.0-10.5)	10 (8.0-13.0)	5.5 (1.0-8.0)	9 (4.0-18.0)	8.5 (2.0-18.5)	9 (5.0-19.0)	4 (1.0-16.0)	6 (3.0-12.0)	9 (3.5-16.0)
Invasive Mechanical Ventilation	47 (19.0)	32 (18.5)	16 (20.3)	16 (17.0)	6 (12.5)	3 (15.0)	3 (10.7)	9 (33.3) *°°°	4 (23.5)	5 (50.0) *εε, *εεε	5 (8.1)	20 (20.6)	22 (24.7)
Ventilator duration, median (IQR), days	13 (8.0-16.5)	13 (8.0-15.5)	11.5 (6.0-15.5)	13 (9.5-16.0)	10.5 (6.0-16.0)	13 (4.0-24.0)	8 (6.0-16.0)	11 (8.0-14.0)	12.5 (9.5-16.5)	9 (8.0-14.0)	14 (13.0-15.0) *¶	10.5 (6.5-13.0) *¶	15.0 (8.0-19.0) *¶,*◊◊◊
Outcomes													
Discharged alive	206 (83.0)	149 (86.1)	65 (82.3)	84 (89.4)	37 (77.1)	16 (80.0)	21 (75.0)	20 (74.1)	12 (70.6)	8 (80.0)	60 (96.8) **¶	86 (88.7) **¶	60 (67.4) **¶
Still Hospitalized	20 (8.1)	10 (5.8) *ǂ	6 (7.6)	4 (4.3)	4 (8.3) *ǂ	1 (5.0)	3 (10.7)	6 (22.2) *ǂ	5 (29.4) *ʃ, *ʃʃʃ	1 (10.0)	2 (3.2)	7 (7.2)	11 (12.4)
30-day Readmission Rate	13 (5.2)	7 (4.0)	4 (5.1)	3 (3.2)	5 (10.4)	0 (0.0)	5 (17.9) *ε	1 (3.7)	1 (5.9)	0 (0.0)	2 (3.2)	2 (2.1)	6 (6.7)
Deceased	22 (8.9)	14 (8.1)	8 (10.1)	6 (6.4)	7 (14.6)	3 (15.0)	4 (14.3)	1 (3.7)	0 (0.0)	1 (10.0)	0 (0.0) **¶	4 (4.1) **¶	18 (20.2) **¶

Abbreviations: ICU, Intensive Care Unit; IQR, interquartile range; n/a = not applicable; AA, African American

[a] Significance Levels * P ≤ 0.05, ** P ≤ 0.001; Significance Tests (Categorical: Chi-Squared Test of Significance, Continuous: ANOVA Test of Significance, Two-Sample T-Test of Means)

[b] Other is defined as all other racial/ethnic groups (Asian, Hispanic/Latino), Unknown, and those who declined to report their race.

[c] N=248 includes patients at level of hospital stay. Thus, participants who were readmitted, or transferred, are accounted for more than once.

[d] Median age represents all unique hospitalized patients n=224 (Black n=160, White n=40, Other n=24); [e] In this table, column percentages are provided for categorical variables.

ǂ Across Race Groups, ° Other vs. Black, °°° White vs. Other, ¶Across Age Groups, ◊Age 18-49 vs. 50-64, ◊◊ Age 18-49 vs. 65+, ◊◊◊ Age 50-64 vs. 65+

ε Black/AA Female vs. White Female, εε Black/AA Female vs. Other Female, εεε White Female vs Other Female; ʃ Black/AA Male vs. Other Male, ʃʃʃ White Male vs. Other Male

Table 4: Multivariable logistic regression model odds ratios for hospitalization by COVID-19 status, Rrce, and sex

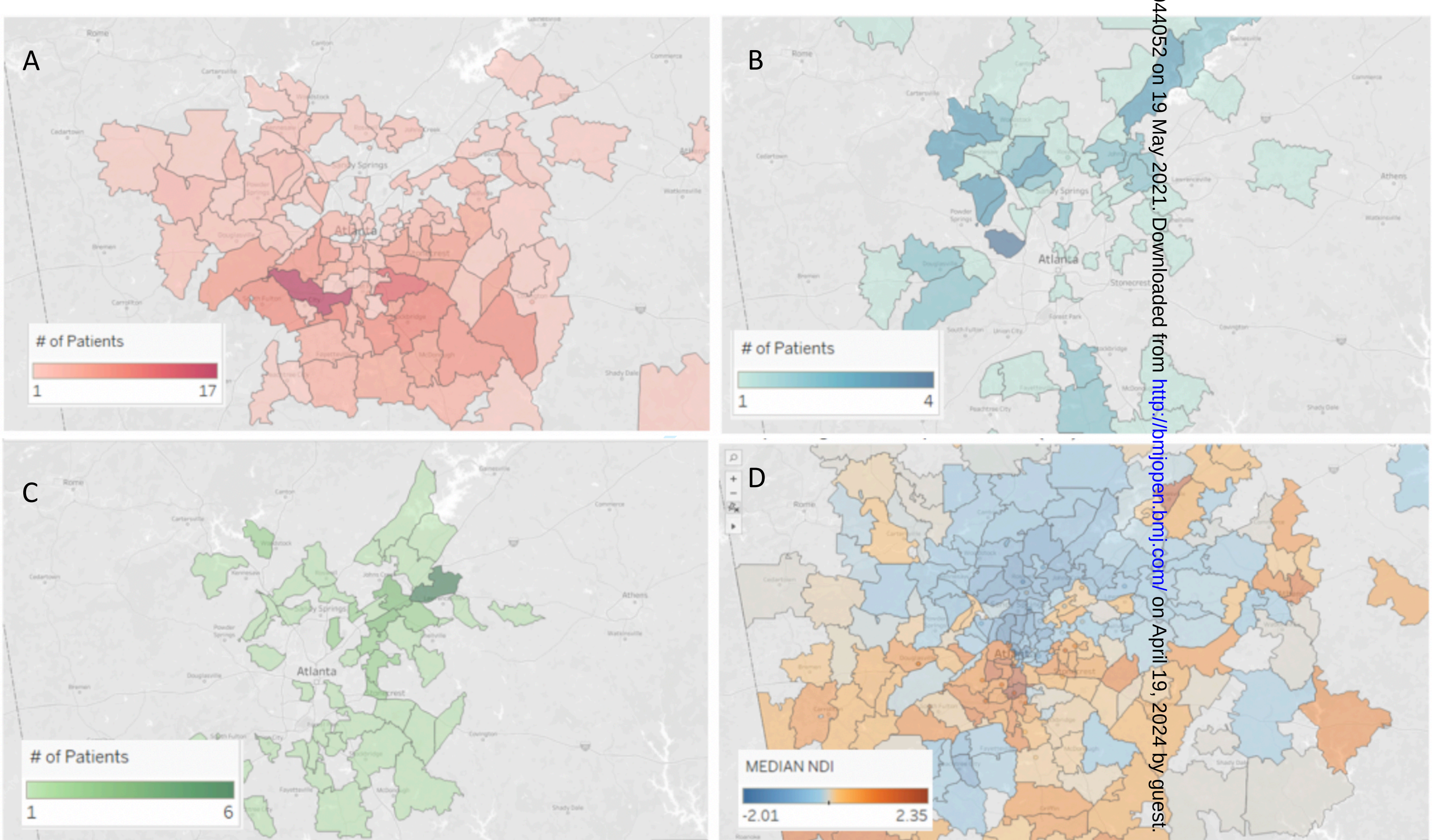
	SARS-COV-2 Status		**Race/Ethnicity Groups**			**Sex Groups**	
Sample Population	**Confirmed**	**Confirmed & PUI**	**Black/AA**	**White**	**Other [a]**	**Female**	**Male**
Total sample size	**n=448**	**n=3,937**	**n=2,156**	**n=981**	**n=800**	**n=2,536**	**n=1,401**
Variables, OR (95% CI)							
Age	1.03**(1.02,1.05)	1.05**(1.04,1.06)	1.04**(1.03,1.06)	1.05**(1.02,1.08)	1.06**(1.03,1.09)	1.04**(1.03,1.06)	1.06**(1.05,1.08)
Race: Black		1.98**(1.44,2.72)	n/a [b]	n/a [b]	n/a [b]	2.19**(1.40,3.42)	2.03*(1.31,3.13)
Female	0.42**(0.27,0.65)	0.51**(0.38,0.68)	0.52**(0.37,0.73)		0.33*(0.14,0.77)	n/a [c]	n/a [c]
Obesity (BMI ≥30)	1.87*(1.19,2.93)	1.80**(1.31,2.47)	1.78*(1.21,2.64)				2.77**(1.78,4.32)
CCI [d]				1.35**(1.15,1.59)			
CHF [e]		1.83*(1.19,2.80)	1.99*(1.20,3.31)			2.65**(1.54,4.52)	
Hypertension [e]	2.09*(1.33,3.29)	1.76*(1.21,2.55)	2.02*(1.26,3.21)				
CKD [e]	11.04*(1.39,87.60)						
Diabetes [e]		1.76*(1.23,2.51)	2.00*(1.27,3.13)				
Physically Inactive [f]			1.50*(1.05,2.13)			1.49*(1.00,2.20)	
COPD [e]	5.37*(1.45,19.81)	1.72*(1.02,2.90)					
2+ Comorbidities [g]						2.38**(1.43,3.94)	
Antihypertensive		0.65*(0.46,0.94)					
Antihyperlipidemic		0.65*(0.45,0.95)					
HEDIS [h] BP Control [i]			0.62*(0.41,0.94)				
HEDIS [h] Diabetes Control [j]			0.52*(0.29,0.93)				
NE County Residence [k]		0.64*(0.47,0.89)		0.22*(0.07,0.66)		0.61*(0.38,0.95)	

Abbreviations: OR, Odds Ratio; CI, Confidence Interval; PUI, Persons Under Investigation; n/a, not applicable; BMI, Body Mass Index; AA, African American; CCI, Charlson Comorbidity Index; CHF, Congestive Heart Failure; CKD, Chronic Kidney Disease; COPD, Chronic Obstructive Pulmonary Disease; HEDIS, Healthcare Effectiveness Data and Information Set; BP: blood pressure
Significance Levels * P ≤ 0.05, ** P ≤ 0.001

Odds Ratios (OR) represent yes vs no for all variables except Age (per year) and Charlson Comorbidity Index (per point)
[a] Other is defined as all other racial/ethnic groups (Asian, Hispanic/Latino), Unknown, and those who declined to state race
[b] Race Black/AA is not available as independent variable for race stratified models
[c] Gender Female not available as an independent variable for the gender stratified models
[d] Charlson Comorbidity Index [21]
[e] CHF, Hypertension, CKD, Diabetes, and COPD classified based on ICD-10 diagnosis in member's electronic medical record[20]
[f] Physically Inactive defined as self-reported exercise < 10 minutes/week.[24]
[g] Comorbidities here are medical diagnoses included in medical history as ICD-10 codes.[20]
[h] HEDIS is a performance improvement tool used by healthcare organizations in the United States.[22] For this study, this tool was used to identify the proportion of members with their chronic conditions successfully controlled
[i] HEDIS measure for blood pressure control (<140/90mm HG) for KPGA members with a 12-month rolling enrollment.[22]
[j] HEDIS measure for diabetes control based on a glycated hemoglobin HbA1c < 8% for KPGA members with a 12-month rolling enrollment.[22]

[k] NE County Area of Residence, extracted from member's electronic medical record, includes Dekalb, Gwinnett, Forsyth, Hall, Barrow, Jackson, Butts, Gilmer, Pike, Gordon, Jasper, Monroe counties

Figure 1.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STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Manuscript Page #	Recommendation
Title and abstract	1,2	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	4	Explain the scientific background and rationale for the investigation being reported
Objectives	5	State specific objectives, including any prespecified hypotheses
Methods		
Study design	5	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	5,6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed
Variables	7,8	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	7,8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	8	Describe any efforts to address potential sources of bias
Study size	6,7	Explain how the study size was arrived at
Quantitative variables	7,8	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	8	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, explain how loss to follow-up was addressed
		(*e*) Describe any sensitivity analyses
Results		
Participants	9	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	9,10	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) Summarise follow-up time (eg, average and total amount)
Outcome data	10	Report numbers of outcome events or summary measures over time
Main results	10,11	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear

		which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	9-11	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	11,12	Summarise key results with reference to study objectives
Limitations	14,15	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	14-16	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	14-16	Discuss the generalisability (external validity) of the study results
Other information		
Funding	16	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

Clinical, Behavioral and Social Factors Associated with Racial Disparities in Hospitalized and Ambulatory COVID-19 Patients from an Integrated Health Care System in Georgia: A Retrospective Cohort Study

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Clinical, Behavioral and Social Factors Associated with Racial Disparities in Hospitalized and Ambulatory COVID-19 Patients from an Integrated Health Care System in Georgia: A Retrospective Cohort Study

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ABSTRACT

Objectives: To explore drivers of racial disparities in relation to coronavirus disease 2019 (COVID-19) in outpatient and inpatient settings

Design: Retrospective cohort of patients with laboratory-confirmed COVID-19 seen from March 3rd to October 29th, 2020. Analyses included underlying comorbidities, quality of care metrics, demographic and social determinants of health (SDOH) indicators. Multivariable analyses for hospitalization risk were performed among COVID-19 patients overall and by race and sex.

Setting: Kaiser Permanente Georgia, an integrated health care system in the Southeast United States.

Results: Of 5,712 patients with COVID-19, 57.8% were female, 58.4% Black, 29.5% White, 8.5% Hispanic and 3.6% Asian. Overall, 14.4% (n=827) of this cohort was hospitalized. Demographic and SDOH factors associated with higher hospitalization odds among all patients included: race Hispanic (adjusted OR 1.60, 95% CI [1.08, 2.37]), race Black (1.43 [1.13, 1.83]) and age in years (1.03 [1.02, 1.04]) while female sex was protective (0.74 [0.61, 0.90]). Living in a zip-code with high unemployment was associated with higher hospitalization odds in the All-patients (1.08 [1.03, 1.13]) and Black models (1.09 [1.03, 1.16]), while residence in northeast Atlanta (0.64 [0.43, 0.95]) and in zip-codes with high incomes (0.24 [0.08, 0.78]) associated with lower hospitalization odds among White and Asian patients, respectively. 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 hemoglobin >8% (1.68

[1.19, 2.38)], depression (1.60 [1.24, 2.06]), hypertension (1.5 [1.21,1.87]) and self-reported physical inactivity 1.25 ([1,03, 1.51]) had higher odds of hospitalization.

Conclusions: Black and Hispanic KPGA patients were at higher odds of hospitalization, but not mortality, compared to other race groups. Beyond previously reported socio-demographics and comorbidities, we recommend considering quality of care and lifestyle behaviors as well as individual and community-level SDOH indicators when designing and implementing interventions to reduce COVID-19 racial disparities.

ARTICLE SUMMARY: STRENGHTS AND LIMITATIONS OF THIS STUDY

- In the United States 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 is limited.
- In this retrospective cohort study of 5,721 consecutive patients with confirmed COVID-19, Black and Hispanic patients had a higher risk of infection and hospitalization but no significant differences in mortality across race groups. In addition to age, sex and presence of comorbidities, pre-pandemic self-reported exercise, control of underlying chronic diseases, and location of residence were significantly associated with hospitalization risk by race groupings
- As a limitation, the target population in this analysis included only KPGA patients that have insurance and ready access to health care services
- To our knowledge, this is the first COVID-19 retrospective cohort study to incorporate multiple measures of SDOH, pre-pandemic lifestyle behaviors and comorbidity management as drivers of COVID-19 racial disparities

Data sharing statement: All data relevant to the study are included in the article. No additional data is available.

MANUSCRIPT TEXT

Introduction

As of November 15th 2020, the United States (U.S) had over 10.5 million cases and 250,000 deaths due to coronavirus disease 2019 (COVID-19).[1] This accounts for 20% of the cases and deaths reported worldwide, despite the U.S having about 4% of the global population. It has been widely reported that racial/ethnic minorities, particularly those living in large and diverse urban centers, 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 hospitalizations and death rates among Black populations.[7 8] Subsequent reports from two large health care systems in Louisiana and California, and from the Veterans Affairs health system[9] also found racial disparities in COVID-19 outcomes and clinical risk factors for hospitalization. These reports also theorized that chronic disease control, health behaviors, 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 analyses of potential drivers of these racial disparities.

The U.S. Census Bureau reports the racial/ethnic demographic distribution of Georgia as 58.3% White, 31.6% Black, 9.7% Hispanic, and 4.1% Asian.[10] As of November 20th, the Georgia Department of Public Health (DPH) reported 399,410 confirmed COVID-19 with the following categorization 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 overrepresentation of Black and Hispanic populations in terms of COVID-19 burden has also been observed in other U.S areas.[4 6 9 12-15] Kaiser Permanente Georgia (KPGA) is a regional integrated health care 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 amongst KPGA patients with COVID-19, with respect to demographic and SDOH, pre-pandemic comorbidities/ underlying conditions, quality of care metrics and lifestyle behaviors and COVID-19 related clinical outcomes. Second, to explore the roles of these clinical, behavioral and social factors as potential drivers of racial disparities for COVID-19 hospitalization.

Methods

We performed a retrospective review of KPGA patients seen with COVID-19 related symptoms between March 3rd and October 29th of 2020. Patients were screened according to the U.S. Centers for Disease Control and Prevention (CDC) and Georgia DPH guidelines.[17 18] Patients who met criteria were tested for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) by polymerase chain reaction (PCR). For this analysis, we only included patients with laboratory-confirmed COVID-19. At the start of the epidemic, KPGA prioritized testing among symptomatic health care 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 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 characterized COVID-19 patients by age, sex, self-reported race/ethnicity, insurance type, and area of residence. Race/ethnicity was categorized in our EHR 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 analyses, we excluded COVID-19 patients 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 categorized it into four different regions of metro Atlanta: Northeast, Northwest, Southeast, and Southwest. Residence location was also linked to the neighborhood 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 neighborhood.[19 20] We also utilized ESRI® Business Analyst data, a comprehensive demographic and lifestyle database which 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 this 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 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 hospitalization for patients with 17 specific common comorbidities. Each condition is assigned a weight from 1 to 6, based on the estimated 1-year mortality hazard ratio 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 utilization.

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 (<140/90mmHg) and (glycated hemoglobin (HbA1c <8% and <9%) blood glucose control. [25]

Exercise Vital Sign (EVS) data was collected from the latest encounter. Patient's physical activity levels were classified as inactive, insufficiently active, and sufficiently active for those self-reporting ≤10 minutes, 11-149 minutes, and ≥150 minutes of exercise/week, respectively. The EVS has been previously validated [26] and is considered a clinically relevant screening tool for physical activity behaviors in health care settings [27,28].

Clinical Outcomes

All patients with COVID-19 who were hospitalized at KPGA affiliated (2 core and 43 non-core) hospitals, were characterized by hospital length of stay (LOS), intensive care unit (ICU) LOS, invasive mechanical ventilation initiation and duration , hospital discharge, 30 and 60-day readmission, currently hospitalized , and deceased. Instances of admission and discharge on the same date were defined as LOS of one day. Mechanical ventilation data was compiled using an 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. Chi-square tests, 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 method was applied and reported.

Multivariable logistic regression was used to explore factors associated with having a COVID-19 related hospitalization 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 hospitalization as the dependent variable. All additional independent variables were assessed using a bivariate analysis, either chi-squared or two sample t-test, and only the variables showing evidence of a statistically significant (α=0.05) relationship with the dependent variable were considered for entry into the models. Stepwise selection method was used for final independent variable selection with effect entry and effect remain significance levels of 0.05. All data analysis was conducted using SAS 9.4 software. The KPGA institutional review board approved this study with a waiver of informed consent. All data relevant to the study are included in the manuscript.

Results

Demographic Characteristics and SDOH

Within the study period, we screened 52,166 patients, tested 42,421 (81.3%) and 5,721 (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. Black patients resided in neighborhoods with the highest rate under the federal poverty level (13.95%), unfavorable NDI (0.37), and the highest mean percentage of frontline (35.6%) and healthcare workers (7.4%). (Table 1). The highest percentage of the patients with COVID-19 resided in the Northeast Metro Atlanta area (36.5%). However, different areas of metro Atlanta showed varying prevalence of COVID-19 patients 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 neighborhoods. (Figure 1)

Comorbidities and Quality of Care

Black patients had the highest rates of obesity (9%), hypertension (34.7%), Asthma (11.3%) and human immunodeficiency virus (HIV; (1.9%) all p<0.001. 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). Compared to other race/ethnicity groups, Black patients had the lowest rate of blood pressure control (69.9%) and the lowest self-reported mean [SD] weekly exercise minutes (75.3 [113.4]; p<0.001).

Hospitalization and Other Clinical Outcomes

Overall, 827 patients with COVID-19 were hospitalized 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 3). Of those hospitalized, 66% were admitted at our two core Hospitals and 44% at non-core hospitals. Compare to all other race/ethnicity groups, Asian patients had longer average hospital LOS (14.5 [17.1]), ICU admission (53.1%) and invasive mechanical ventilation (21.9%) (all p<0.05). No significant differences in the rates of re-admission or mortality were found between race/ethnic groups.

Male patients had longer average hospital LOS's (8.6 [10.0] vs. 7.3 [8.3], p<0.05), and higher rates of ICU admission (32.2% vs. 25.8%; p<0.05) compared to female patients.

Compared to patients aged 18 to 49 years, older patients aged 50 to 64, and 65+ had longer average hospital LOS (6.6 [8,2] vs. 8.5 [9.9] and 8.5 SD [9.2]; p<0.05), higher rates of ICU admission (21.8% vs. 34.8% and 29.0%; p<0.05), invasive mechanical ventilation (4.4% vs. 10.9% and 9.9%; p<0.05) and death (2.2% vs. 8.1%, 21.1%; p<0.001). Of the 96 deceased patients in our cohort, 70% died during the COVID-19 index hospitalization. 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%)

Multivariable Analysis and Factors Associated with Hospitalization

Overall, increasing age was a significant risk factor for hospitalization in all models. Female sex was associated with lower odds of hospitalization in the All-patients (adjusted OR 0.74, 95% CI [0.61,0.90]), Asian (0.38, [0.15,0.96)]) and Hispanic models (0.39, [0.20, 0.76]), respectively (Table 4). Race Black (1.43 [1.13,1.83]) and race Hispanic (1.60 [1.08, 2.37]) were associated with increased odds of hospitalization in the All-patients model. Within the female model, race Black was associated (1.46 [1.06,2.02]) with increased odds of hospitalization.

Regarding comorbidities and quality of care, COVID-19 patients with COPD (2.59 [1.67, 4.02]), CHF (1.79 [1.31,2.45]), immunocompromised (1.77 [1.16, 2.70]), with HbA1c >8% (1.68 [1.19, 2.38]), depression (1.60 [1.24, 2.06]), hypertension (1.5 [1.21,1.87]) and higher comorbidity scores (1.19 [1.11,1.28]) had increased odds of hospitalization. Additionally, self-reported physical inactivity was associated with higher odds of hospitalization in the All-patients (1.25 [1,03, 1.51]) and female models (1.45 [1.12, 1.89])

Among Black patients, those with a history of COPD (2.53 [1.24, 5.16]), CHF (2.19 [1.47, 3.27]) and hypertension (1.74 [1.30, 2.32]) as well as those with higher CCI (1.21 [1.11, 1.33]), a recent (past 12 months) uncontrolled HbA1c >8% (1.74 [1.13, 2.66]) or a cough/cold medication prescription (1.37 [1.02, 1.84]) had higher odds of hospitalization.

Among White patients, those with a history of being immunocompromised (2.54 [1.14, 5.67]), with COPD (2.49 [1.38, 4,49]), depression (2.13 [1.42, 3.21]) and arrythmia (1.89 [1.05, 3.42]) as well as those with higher CCI (1.26 [1.12, 1.42]) had increased odds of hospitalization, whereas a recent blood pressure <140/90 measurement was a protective factor (0.46 [0.28, 0.76]).

Among Hispanic patients, a recent uncontrolled HbA1c(>8%) measurement was associated with higher odds of hospitalization (5.95 [2.24, 15.78]).

Among females, clinical factors significantly associated with increased odds of hospitalization were a history of COPD, CHF, immunocompromise, depression, uncontrolled HbA1c >8%, hypertension, self-reported physical inactivity and a higher CCI (adjusted ORs ranging from 4.34 to 1.12 in descending order). Among males, a recent uncontrolled HbA1c >9%, history of depression, hypertension, recent anti-asthmatic prescription and a higher CCI, were clinical factors associated with higher hospitalization odds (adjusted ORs ranging from 2.01 to 1.34, in descending order).

Finally, regarding SDOH factors, living in a zip code with high rates of unemployment (1.08 [1.03, 1.13]) and having Medicare insurance (1.52 [1.12, 2.06]), were associated with higher hospitalization odds among All-patients, as well as for Black patients. Conversely, residence in northeast Atlanta (0.64 [0.43, 0.95]) and in high-income zip codes (0.24 [0.08, 0.78]) were associated with lower hospitalization odds among White and Asian patients respectively.

Discussion

This study reports an over-representation of Black and Hispanic populations in both the outpatient and inpatient phases of care for COVID-19 in an integrated care system serving the Southeast region of the United States. 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 hospitalization (62% and 5.7%, respectively). White and Asian KPGA patients where not overrepresented in terms of COVID-19 diagnosis (29.5% and 3.6%, respectively) or hospitalization (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 re-admission 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 hospitalized 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 1.3x times increased risk of hospitalization compared to White patients.[15] National data from the CDC from August 2020 indicates that, Black and Hispanic patients were 4.6 and 4.7 times more likely than Whites to be hospitalized for COVID-19.[15] Other studies from academic or integrated health care systems have shown that, after adjustment for age, sex, comorbidities, and income, Black patients had between 1.72 and 2.7 times and Hispanics 1.5 times the odds of hospitalization compared to White patients.[3 29 30] In comparison in our cohort, adjustment for socio-demographics, comorbidities, pre-pandemic quality of care and lifestyle behaviors did attenuate but not fully eliminate racial disparities, with Black and Hispanic patients showing 1.43 and 1.60 higher odds of hospitalization compared to White patients. Of note, when examining the concordance (c) statistics of the different variables included in the All-patients model, clinical risk factors/quality of care predicted 0.66 of the hospitalization outcomes, comorbidities predicted 0.75 and demographics/SDOH a c-statistic of 0.76. Furthermore, the combination of these three groups of predictor variables reached a discriminatory ability of 0.79 for hospitalization. These findings underscore the importance of considering SDOH's in addition to demographic and clinical risk factors to better discriminate risk of severe COVID-19 health outcomes.

Compared to 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 reside at a higher proportion in neighborhoods with the highest rate of households below the federal poverty level (14 and 12%), high neighborhood deprivation index (0.37 and 0.03), and the highest percentage of frontline workers (35.6 and 35.4%%) compared to 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 plays a role in health disparities, a situation that has been magnified by the COVID-19 pandemic in the U.S.

In addition, 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] However, we found the comorbidity burden was somewhat different by race. In our cohort, Asian patients had the highest diabetes prevalence. White patients were older, with higher CCI scores compared to Black patients, and had a significantly higher prevalence of underlying conditions, such as hyperlipidemia, CAD, CHF, COPD, arrythmia, and depression. Although there is a high prevalence of obesity, diabetes and other chronic diseases in the overall U.S 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 females were significantly (aOR 0.74) less likely to be hospitalized while race (Black, Hispanic) increasing age and chronic comorbidities were predominant factors associated with higher odds of hospitalization [7 8]. Medicare insurance type was a significant correlate of hospitalization, a finding that was expected given 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 hospitalization among All-patients (aOR 1.68), Black (aOR 1.74) and particularly Hispanic patients (aOR 5.95). Conversely adequate blood pressure control (<140/90 mmHg) was a strong protective factor against hospitalization (aOR 0.46) among White patients. Overall, these findings suggest that presence of, and poorly controlled comorbidities, increase risk of hospitalization for COVID-19 and that improving clinical management of underlying cardio-metabolic diseases could help ameliorate hospitalization 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]

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, neighborhood and physical environment as well as pre-pandemic lifestyle behaviors. Of these metrics, we found that residence in zip codes with a high proportion of unemployment was a consistent factor associated with increased hospitalization risk for All patients (aOR 1.08) and specifically Black patients (aOR 1.09). 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 hospitalization 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 to 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 minutes of moderate to vigorous exercise/week — increased by 25% the odds of hospitalization among patients in our cohort. The effect estimate of physical inactivity was even more pronounced for female patients (aOR 1.45). Several biologic 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 epidemiologic 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 hospitalization risk in our study population, after adjusting for traditional risk factors such as age, body mass index, 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 health care services. However, our analysis showed a diverse socio-economic background of KPGA patients underscoring the role of various SDOH in relation to COVID-19 risk of infection and hospitalization. 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 groups 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 the COVID-19 patients 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 neighborhood level data to extrapolate additional SDOH metrics. Well established U.S 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, hospitalization, clinical outcomes and post-discharge follow-up data, this study provides one of the most comprehensive longitudinal assessments of COVID-19 patients 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 health care system, Black and Hispanic patients were still being disproportionately affected by COVID-19 risk of infection and hospitalization. However, we found no significant differences in clinical outcomes such as re-admission or mortality across race/ethnicity groups. Location of residence, a proxy for the overall community context of our patients, appears to be a factor strongly associated with increased infection risk among Black patients. The SDOH have shown to contribute to a more unfavorable baseline health status and therefore, can indirectly impact COVID-19 risk of hospitalization 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 hospitalization risk in different race groups. Therefore, as interventions designed to reduce COVID-19 disparities and the systemic effects of racism [43] are implemented, we recommend that in addition to well-known clinical variables, individual and community-level social factors and lifestyle health behaviors be considered by clinicians, health care systems [44] and public health stakeholders.

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Figure 1 Legend. Map of Metro Atlanta Region's COVID19 Cases by Race/ethnicity

A. Map of COVID19 Cases: Race Black

B. Map of COVID19 Cases: Race White

C. Map of COVID19 Cases: Race Asian

D. Map of COVID19 Cases: Race Hispanic

E. Map of COVID19 Cases: All Races

F. Map of Metro Atlanta Neighborhood Deprivation Index

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Table 1: Socio-demographic characteristics of KPGA patients with COVID-19 seen from March 3 to October 29th, 2020

	KPGA members by Race No. (%)					
	All N=5,721 (100%)	**Black n=3,339 (58,4%)**	**White n=1,689 (29,5%)**	**Hispanic n=487 (8.5%)**	**Asian n=206 (3.6%)**	**p-value**
Age, mean [SD], y	44.8 [15.7]	43.9 [15.1]	47.1 [17.8]	41.9 [14]	45.8 [15.8]	<.0001
Age range, y						
18-49	3414 (59.7)	2106 (63.1)	865 (51.21)	328 (67.4)	115 (55.8)	
50-64	1686 (29.5)	931 (27.9)	549 (32.5)	140 (28.8)	66 (32)	<.0001
65 and above	621 (10.9)	302 (9)	275 (16.3)	19 (3.9)	25 (12.1)	
Gender						
Male	2416 (42.2)	1270 (38)	820 (48.5)	226(46.4)	100(48.5)	<.0001
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)	
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)	<.0001
Self-pay	326 (5.7)	237 (7.1)	59 (3.5)	17 (3.5)	13 (6.3)	
Other [a]	196 (3.4)	132 (4)	42 (2.5)	19 (3.9)	3 (1.5)	
Median Household Income[b] No. (%)						
25k-50k	1079 (19.4)	855 (25.6)	115 (6.8)	78 (16)	31 (15)	
50k-75k	2746 (49.3)	1814 (54.3)	639 (37.8)	225 (46.2)	68 (33)	<.0001
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, % [c]	12.36	13.95	9.85	11.96	10.37	<.0001
Residential Region (%) [d]						
Northeast	2090 (36.5)	1085 (32.5)	626 (37.1)	274 (56.3)	105 (51)	
Northwest	969 (16.9)	341 (10.2)	492 (29.1)	102 (20.9)	34 (16.5)	<.0001
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)	
Neighborhood Deprivation Index [e]	0.07	0.37	-0.4	0.03	-0.27	<.0001
Occupation[f], mean %						
Frontline Workers	33.6	35.6	30.2	35.4	31.2	
Healthcare Workers	7.2	7.4	7	6.5	6.6	<.0001
Other Workers	59.2	57	62.7	58.1	62.1	
Education, mean % [g]						
Some High School	6.6	7.2	5.8	7	5.8	
High School	22.3	24	20.2	21.4	19.9	
Associates Degree	8.4	8.6	8.1	8.2	8.4	<.0001
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	

Abbreviations: COVID-19, Coronavirus Disease 2019; KPGA, Kaiser Permanente Georgia;

[a] Other Insurances include military Health Maintenance Organization (HMO) or Preferred Provider Organization (PPO).

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

[c] Poverty line was defined by the Federal poverty level

[d] The Atlanta metro area was divided up by county in four sub-regions

- 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.

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

[f] 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.

[g] 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).

672 **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
Hyperlipidemia	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
Arythmia	172(3)	79 (2.4) §, §§	85 (5) °	3 (0.6) °°°	5 (2.4)	<0.0001
ESRD[a]	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[b]	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[c]	1823 (31.9)	1095 (32.8) §§§	570 (33.7) °	90 (18.5) °°°	68 (33)	<0.0001
3+ Comorbidities[c]	966 (16.9)	560 (16.8) §, §§§	333 (19.7) °	41 (8.4) °°°	32 (15.5)	<0.0001
Charlson Comorbidity Index, mean [SD][d]	1.9 [1.4] §, §§	1.9 [1.5]	2.1 [1.7] °	1.5 [1.1]	1.67 [1.2]	0.0014
Outpatient Medication, No. (%)						
Anti Rheumatic	17 (0.3)	8 (0.2)	7 (0.4)	2 (0.4)	0 (0)	0.5696
Anti Hypertensive	1059 (18.5)	632 (18.9) §§	329 (19.5) °	62 (12.7)	36 (17.5)	0.0062
Anti Asthmatic	890 (15.6)	533 (16)	274 (16.2)	57 (11.7)	26 (12.6)	0.3283
Anti Hyperlipidemic	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
Anti malarial	31 (0.5)	22 (0.7) §	4 (0.2)	4 (0.8)	1 (0.5)	0.2139
Quality of Care Metrics [e]						
Blood Pressure <140/90	1315 (72.4)	811 (69.9) §§	389 (76.7) °	66 (75.9) °°°	49 (79)	<0.0001
Diabetes Uncontrolled (A1C>8)	286 (5)	195 (5.8)	65 (3.8)	18 (3.7)	8 (3.9)	0.1976
Average Exercise minutes, mean [SD] [f]	79.9 [114]	75.3 [113.4] §	91 [128.1]	76.7 [115.6]	87.5 [99.7]	0.0034
EVS Category, No. (%) [g]						
Inactive	1648 (28.8)	998 (29.9)	460 (27.2)	136 (27.9)	54 (26.2)	

Insufficient	1336 (23.4)	814 (24.4%) §	359 (21.3)	107 (22)	56 (27.2)	0.0044
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)	

Abbreviations: COVID-19, Coronavirus Disease 2019; KPGA, Kaiser Permanente Georgia; HbA1c, Glycated Hemoglobin; 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; HTN, Hypertension; EVS, Exercise as a Vital Sign.

Significance Levels: § Black vs. White; §§ Black vs. Hispanic; §§§Black vs Asian; °White vs Hispanic; °°White vs. Asian
°°° Hispanic vs. Asian, significant difference at $p < 0.05$

[a] 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.
[b] CKD classified based on diagnosis reported by the ICD-10 code in patient's medical history.
[c] 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.
[d] 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)
[e] Assessed at the most recent clinical encounter within the last 12 months
[f] Average exercise was collected from self-reported data.
[g] EVS is based on patient reported weekly exercise minutes. We used 3 categories: Inactive for patients who reported less than 10 mins/week, insufficiently active for patients who reported 11-149 minutes/week and sufficiently active for patients who reported 150 or more mins/week.

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

Hospitalization Characteristics	Total no. (%) N = 896[b]	Race/Ethnicity No. (%)				Sex No. (%)		Age group (years) No. (%)		
		Black	White	Hispanic	Asian	Female	Male	18-49	50-64	65+
		Total 556 (62.0%)	Total 257 (28.7%)	Total 51 (5.7%)	Total 32 (3.6%)	Total 458 (51.1%)	Total 438 (48.9%)	Total 271 (30.3%)	Total 322 (35.9%)	Total 303 (33.8%)
Mean Age [c], 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
Health Care Utilization										
Mean Hospital LOS, days, [SD]	7.9 [9.2]	7.9 [9.1] *ƚ	7.2 [7.9] *ƚ	6.9 [7.3] *ƚ	14.5 [17.1] *ƚ,*°, *°°,*°°°	7.3 [8.3] *Δ	8.6 [10.0] *Δ,*ε	6.6 [8.2] *¶	8.5 [9.9] *¶, *◊	8.5 [9.2] *¶,*◊◊
Admitted to ICU [d]	259 (28.9%)	154 (27.7%) *ƚ	71 (27.6%) *ƚ	17 (33.3%) *ƚ	17 (53.1%) *ƚ ,*°,*°°	118 (25.8%) *Δ	141 (32.2%) *Δ,*ε	59 (21.8%) *¶	112 (34.8%) *¶,**◊	88 (29.0%) *¶,*◊◊
Mean ICU LOS, days, [SD]	10.0 [10.5]	10.1 [9.3] *ƚ	8.1 [9.0] *ƚ	8.7 [9.6] *ƚ	17.8 [20.4] *ƚ	9.1 [9.8]	10.7 [11.0]	9.0 [9.0]	9.7 [10.3]	11 [11.7]
Mechanical Ventilation [d]	77 (8.6%)	51 (9.2%) *ƚ	15 (5.8%) *ƚ	4 (7.8%) *ƚ	7 (21.9%) *ƚ,*°,*°°	36 (7.9%)	41 (9.4%)	12 (4.4%) *¶	35 (10.9%) *¶, **◊	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]
Outcomes										
Discharged Alive [d]	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%) **¶,**◊◊
Still Hospitalized [d]	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%)
30 Day Re-admission [d]	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%)
60 Day Re-admission [d]	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%)
Deceased [d]	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%) **¶,**◊◊

Abbreviations: COVID-19, Coronavirus Disease 2019; KPGA, Kaiser Permanente Georgia; ICU, Intensive Care Unit; SD, Standard Deviation; n/a = not applicable;

[a] Significance Levels * P ≤ 0.05, ** P ≤ 0.001

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

[c] Mean age represents all unique hospitalized patients n=827

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

Significance Tests (Categorical: Chi-Squared Test of Significance, Continuous: ANOVA Test of Significance, Two-Sample T-Test of Means)

ƚ Across Race Groups, ° Black vs. Asian; °° White vs. Asian; °°°Hispanic vs. Asian; Δ Across Sex; ε Men vs. Women

¶Across Age Groups; ◊ Age 18-49 vs. 50-64; ◊◊ Age 18-49 vs. 65+; ◊◊◊ Age 50-64 vs. 65+

Table 4: Multivariable logistic regression model odds ratios for hospitalization among all KPGA COVID-19 patients and by race/ethnicity and sex

Population Total sample size n (%)	All COVID-19 n=5,721 (100%)	Race/Ethnicity Black n=3,339 (58,4%)	Race/Ethnicity White n=1,689 (29,5%)	Race/Ethnicity Hispanic n=487 (8.5%)	Race/Ethnicity Asian n=206 (3.6%)	Sex Female n=3,304 (57.8%)	Sex Male n=2,417 (42.2%)
Variables OR (95% CI)							
Demographics							
Race Black	1.43*(1.13,1.83)	n/a[a]	n/a[a]	n/a[a]	n/a[a]	1.46*(1.06,2.02)	
Race Hispanic	1.60*(1.08,2.37)	n/a[a]	n/a[a]	n/a[a]	n/a[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)			0.39*(0.20,0.76)	0.38*(0.15,0.96)	n/a[a]	n/a[a]
Social Determinants							
Medicare Insurance [b]	1.52*(1.12,2.06)	1.92*(1.29,2.88)					
High Unemployment Zip code[c]	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 [d]			0.64*(0.43,0.95)				
High Income Zip code [c]					0.24*(0.08,0.78)		
Comorbidities [e]							
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 [f]	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 [g]							
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)	
Uncontrolled HbA1c >9%							2.01*(1.11,3.62)
Blood Pressure <140/90			0.46* (0.28,0.76)				
Anti-Asthmatic Medication							1.51*(1.06,2.15)
Cough/Cold Medication		1.37* (1.02,1.84)					
Lifestyle Behaviors [g]							
Physically Inactive [i]	1.25*(1.03,1.51)					1.45*(1.12,1.89)	

Abbreviations: KPGA, Kaiser Permanente Georgia; COVID-19, Coronavirus Disease 2019; NE, Northeast; COPD, Chronic Obstructive Pulmonary Disease; CHF, Congestive Heart Failure; HbA1c, Glycated Hemoglobin

[a] not available as an independent variable for stratified models; Significance Levels * P ≤ 0.05, ** P ≤ 0.001

[b] Represents Medicare Population (Aged 65+ and people with disabilities)

[c] 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

[d] NE County Area includes Dekalb, Gwinnett, Forsyth, Hall, Barrow, Jackson, Butts, Gilmer, Pike, Gordon, Jasper, Monroe counties

[e] 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

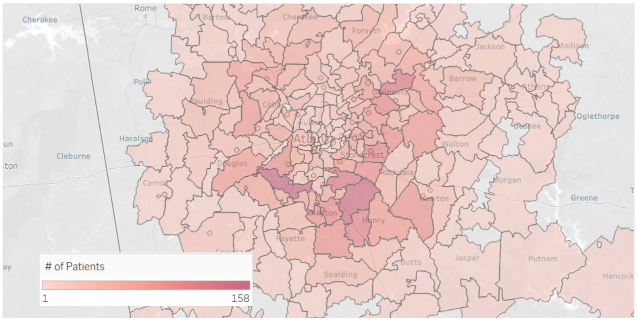
[f] Charlson Comorbidity Index predicts the 10-year mortality of a patient based on age and comorbidities. Scores are summed to provide a total predictive score. The lowest score of 0 corresponds to a 98% estimated 10-year survival rate. (Charlson et al. 1987)

[g] Assessed at the most recent clinical encounter within the last 12 months

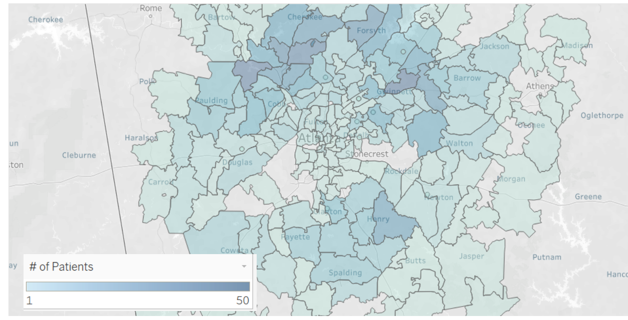
[i] Physically Inactive defined as self-reported weekly exercise < 10 minutes

Kaiser Permanente Georgia's COVID19 Cases By Race/Ethnicity

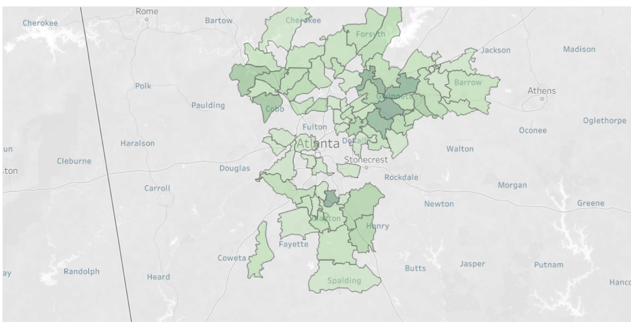
A. Map of Kaiser Permanente Georgia's COVID19 Cases of Race/Ethnicity **Black** in Metro Atlanta Area



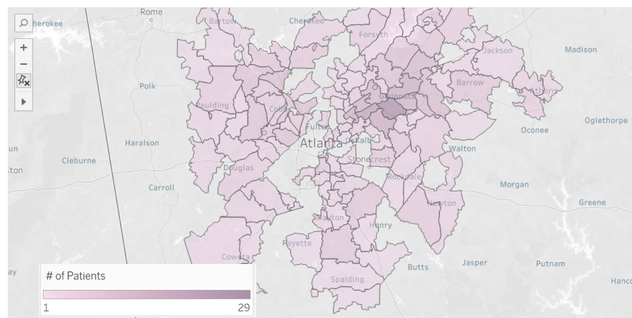
B. Map of Kaiser Permanente Georgia's COVID19 Cases Race/Ethnicity **White** in Metro Atlanta Area



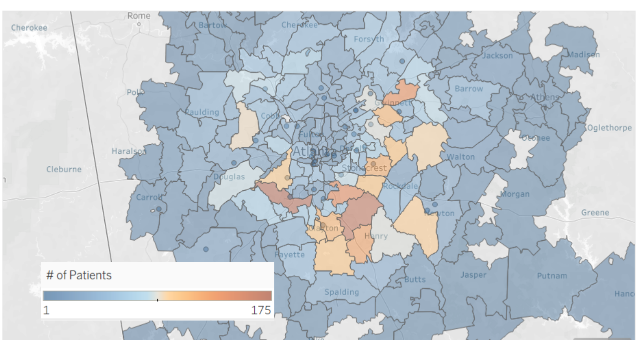
C. Map of Kaiser Permanente Georgia's COVID19 Cases Race/Ethnicity **Asian** in Metro Atlanta Area



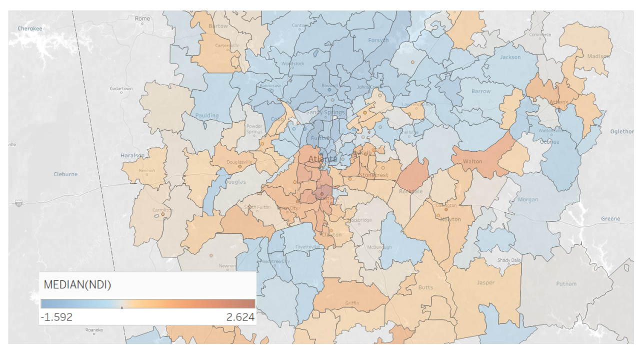
D. Map of Kaiser Permanente Georgia's COVID19 Cases Race/Ethnicity **Hispanic** in Metro Atlanta Area



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



F. Map of Metro Atlanta Neighborhood Deprivation Index



Map of Metro Atlanta Region's COVID19 Cases by Race/Ethnicity

A. Map of COVID19 Cases: Race Black
B. Map of COVID19 Cases: Race White
C. Map of COVID19 Cases: Race Asian
D. Map of COVID19 Cases: Race/ethnicity Hispanic
E. Map of COVID19 Cases: All Races/ethnicities
F. Map of Metro Atlanta Neighborhood Deprivation Index

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Manuscript Page #	Recommendation
Title and abstract	1,2	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	4	Explain the scientific background and rationale for the investigation being reported
Objectives	5	State specific objectives, including any prespecified hypotheses
Methods		
Study design	5	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed
Variables	6-8	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	7,8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	8	Describe any efforts to address potential sources of bias
Study size	6-8	Explain how the study size was arrived at
Quantitative variables	7,8	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	8,9	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, explain how loss to follow-up was addressed
		(*e*) Describe any sensitivity analyses
Results		
Participants	9	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	9,10	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) Summarise follow-up time (eg, average and total amount)
Outcome data	10	Report numbers of outcome events or summary measures over time
Main results	10-12	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear

		which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	9-11	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	13,14	Summarise key results with reference to study objectives
Limitations	17,18	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	13-18	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	17,18	Discuss the generalisability (external validity) of the study results
Other information		
Funding	19	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

BMJ Open

Clinical, Behavioral and Social Factors Associated with Racial Disparities in COVID-19 Patients from an Integrated Health Care System in Georgia: A Retrospective Cohort Study

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Clinical, Behavioral and Social Factors Associated with Racial Disparities in COVID-19 Patients from an Integrated Health Care System in Georgia: A Retrospective Cohort Study

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ABSTRACT

Objectives: To identify socio-demographic, clinical and behavioral drivers of racial disparities and their association to clinical outcomes among Kaiser Permanente Georgia (KPGA) members with COVID-19.

Design: Retrospective cohort of patients with COVID-19 seen from March 3rd to October 29th, 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 hospitalized patients including length of stay, ICU admission, readmission and mortality. We performed multivariable analyses for hospitalization risk among all COVID-19 patients and stratifying by race and sex.

Setting: KPGA, an integrated health care system.

Participants: 5,712 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 under the federal poverty line (12.4%) and in more deprived neighborhoods (neighborhood deprivation index=0.4). Overall, 14.4% (n=827) of this cohort was hospitalized. Asian patients had the highest rates of ICU admission (53.1%) and mechanical ventilation (21.9%). Among all patients: Hispanics (aOR 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 hospitalization. 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 hemoglobin >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 hospitalization.

Conclusions: Black and Hispanic KPGA patients were at higher odds of hospitalization, but not mortality, compared to other race groups. Beyond previously reported socio-demographics and comorbidities, quality of car, lifestyle behaviors and SDOH indicators should be considered when designing and implementing interventions to reduce COVID-19 racial disparities.

ARTICLE SUMMARY: STRENGHTS AND LIMITATIONS OF THIS STUDY

- In the United States 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 is limited.
- As a limitation, the target population in this analysis included only KPGA patients that have insurance and ready access to health care services
- To our knowledge, this is the first COVID-19 retrospective cohort study to incorporate multiple individual and community-level SDOH indicators, pre-pandemic lifestyle behaviors and comorbidity management metrics as drivers of COVID-19 racial disparities

Data sharing statement: All data relevant to the study are included in the article. No additional data is available.

Competing Interest Statement: there are no competing interests for any author.

MANUSCRIPT TEXT

Introduction

As of November 15th 2020, the United States (U.S) had over 10.5 million cases and 250,000 deaths due to coronavirus disease 2019 (COVID-19).[1] This accounts for 20% of the cases and deaths reported worldwide, despite the U.S having about 4% of the global population. It has been widely reported that racial/ethnic minorities, particularly those living in large and diverse urban centers, 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 hospitalizations and death rates among Black populations.[7 8] Subsequent reports from two large health care systems in Louisiana and California, and from the Veterans Affairs health system[9] also found racial disparities in COVID-19 outcomes and clinical risk factors for hospitalization. These reports also theorized that chronic disease control, health behaviors, 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 analyses of potential drivers of these racial disparities.

The U.S. 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 November 20th, the Georgia Department of Public Health (DPH) reported 399,410 confirmed COVID-19 with the following categorization 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 overrepresentation of Black and Hispanic populations in terms of COVID-19 burden has also been observed in other U.S areas.[4 6 9 12-15] Kaiser Permanente Georgia (KPGA) is a regional integrated health care 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 amongst KPGA patients with COVID-19, with respect to demographic and SDOH, pre-pandemic comorbidities/ underlying conditions, quality of care metrics and lifestyle behaviors as well as COVID-19 related clinical outcomes (hospitalization, ICU admission, length of stay, mechanical ventilation, readmission and mortality). Second, to explore the roles of these clinical, behavioral and SDOH factors as potential drivers of racial disparities for COVID-19 hospitalization.

Methods

We performed a retrospective review of KPGA patients seen with COVID-19 related symptoms between March 3rd and October 29th of 2020. Patients were screened according to the U.S. Centers for Disease Control and Prevention (CDC) and Georgia DPH guidelines.[17 18] Patients who met criteria were tested for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) by polymerase chain reaction (PCR). For this analysis, we included any KPGA member with a documented laboratory-confirmed COVID-19 PCR test in their EMR which also integrates tests performed in facilities outside of our health care system. At the start of the epidemic, KPGA prioritized testing among symptomatic health care 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 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 characterized COVID-19 patients by age, sex, self-reported race/ethnicity, insurance type, and area of residence. Race/ethnicity was categorized in our EHR 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 analyses, we excluded COVID-19 patients 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 categorized it into four different regions of metro Atlanta: Northeast, Northwest, Southeast, and Southwest. Residence location was also linked to the neighborhood 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 neighborhood.[19 20] We also utilized ESRI® Business Analyst data, a comprehensive demographic and lifestyle database which 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 this 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 hospitalization for patients with 17 specific common comorbidities. Each condition is assigned a weight from 1 to 6, based on the estimated 1-year mortality hazard ratio 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 utilization.

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 (<140/90mmHg) and (glycated hemoglobin (HbA1c <8% and <9%) blood glucose control. [25]

Exercise Vital Sign (EVS) data was collected from the latest encounter. Patient's physical activity levels were classified as inactive, insufficiently active, and sufficiently active for those self-reporting ≤10 minutes, 11-149 minutes, and ≥150 minutes of exercise/week, respectively. The EVS has been previously validated [26] and is considered a clinically relevant screening tool for physical activity behaviors in health care settings [27 28].

Clinical Outcomes

All patients with COVID-19 who were hospitalized at KPGA affiliated (2 core and 43 non-core) hospitals, were characterized by hospital length of stay (LOS), intensive care unit (ICU) LOS, invasive mechanical ventilation initiation and duration , hospital discharge, 30 and 60-day readmission, currently hospitalized , 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 one day. Mechanical ventilation data was compiled using an 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. Chi-square tests, ANOVAs and two sample t-tests were used to determine

183 significant differences between groups. For two sample t-tests with statistically unequal
184 variances, the Satterthwaite method was applied and reported.

185 Multivariable logistic regression was used to explore factors associated with having a
186 COVID-19 related hospitalization in seven different models: all COVID-19 patients, stratified by
187 race/ethnicity (Black, White, Hispanic, Asian) and by sex. All multivariable logistic regression
188 models included age, sex and race/ethnicity as independent variables and hospitalization as the
189 dependent variable. All additional independent variables were assessed using a bivariate
190 analysis, either chi-squared or two sample t-test, and only the variables showing evidence of a
191 statistically significant (α=0.05) relationship with the dependent variable were considered for
192 entry into the models. Stepwise selection method was used for final independent variable
193 selection with effect entry and effect remain significance levels of 0.05 and adjusted via the
194 Student–Newman–Keuls post hoc test for differences in means. All data analysis was conducted
195 using SAS 9.4 software. The KPGA institutional review board approved this study with a waiver
196 of informed consent. All data relevant to the study are included in the manuscript.

197

198 **Results**

199 *Demographic Characteristics and SDOH*

200 Within the study period, we screened 52,166 patients, tested 42,421 (81.3%) and 5,721
201 (15.2% of tested) patients were confirmed with COVID-19. The mean age of COVID-19 positive
202 patients was 44.8 [15.7] years old (Table 1). A higher proportion of black patients resided in
203 neighborhoods under the federal poverty level (13.95%), with unfavorable NDI (0.37), and with
204 the highest mean percentage of frontline (35.6%) and healthcare workers (7.4%) compared to
205 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 COVID-19 patients 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 neighborhoods(Figure 1).

Comorbidities and Quality of Care

Black patients had the highest rates of obesity (9%), hypertension (34.7%), Asthma (11.3%) and human immunodeficiency virus (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 to other race/ethnicity groups, Black patients had the highest proportion of patients with uncontrolled blood pressure (BP) as defined by BP>140/90 mmHg (30.1%) and the lowest self-reported mean [SD] weekly exercise minutes (75.3 [113.4]; p<0.0001) (Table 2).

Hospitalization and Other Clinical Outcomes

Overall, 827 patients with COVID-19 were hospitalized 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 3). Of those hospitalized, 66% were admitted at our two core Hospitals and 34% at non-core hospitals.

Compared to 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=.0191, and 5.8%, p<0.0001), respectively (Table 3). Asians also had a longer average hospital LOS than Hispanics (14.5 [17.1] vs. 6.9 [7.3], p=0.0064). No significant differences in the rates of re-admission 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 to female patients (Table 3). Compared to patients aged 18 to 49 years, older patients aged 50 to 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 hospitalization (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%).

Multivariable Analysis and Factors Associated with Hospitalization

Overall Model: Socio-demographic factors including increasing age (aOR 0.74, 95% CI [0.61,0.90]), 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 hospitalization for COVID-19 (Table 4). Female sex was associated with lower odds of hospitalization (aOR 0.74, 95% CI [0.61,0.90]) (Table 4).

Comorbidities, quality of care, and lifestyle factors associated with increased odds of hospitalization included patients with COPD (aOR 2.59 [1.67, 4.02]), CHF (aOR 1.79

252 [1.31,2.45]), immunocompromised (aOR 1.77 [1.16, 2.70]), with HbA1c >8% (aOR 1.68 [1.19,
253 2.38]), depression (aOR 1.60 [1.24, 2.06]), hypertension (aOR 1.5 [1.21,1.87]) and higher
254 comorbidity scores (aOR 1.19 [1.11,1.28]) (Table 4). Additionally, self-reported physical
255 inactivity was associated with higher odds of hospitalization (aOR 1.25 [1,03, 1.51]) (Table 4).
256

257 **Race Stratification:** Increasing age was associated to increased odds of hospitalization
258 across all race groups (Table 4).

259 Among Black patients, living in a zip code with high rates of unemployment (aOR 1.09
260 [1.03,1.16]) and having Medicare insurance (aOR 1.92 [1.29,2.88]) were associated with higher
261 hospitalization odds. Clinically, those with a history of COPD (aOR 2.53 [1.24, 5.16]), CHF
262 (aOR 2.19 [1.47, 3.27]) and hypertension (aOR 1.74 [1.30, 2.32]) as well as those with higher
263 CCI (aOR 1.21 [1.11, 1.33]), a recent (past 12 months) uncontrolled HbA1c >8% (aOR 1.74
264 [1.13, 2.66]) or a cough/cold medication prescription (aOR 1.37 [1.02, 1.84]) had higher odds of
265 hospitalization (Table 4).

266 Among White patients, residence in northeast Atlanta (aOR 0.64 [0.43, 0.95]) was
267 protective for COVID-19 hospitalization. White patients with a history of being
268 immunocompromised (aOR 2.54 [1.14, 5.67]), with COPD (aOR 2.49 [1.38, 4,49]), depression
269 (aOR 2.13 [1.42, 3.21]), arrythmia (aOR 1.89 [1.05, 3.42]) and recent blood pressure
270 measurement >140/90 (aOR 2.17 [1.31, 3.57]), as well as those with higher CCI (aOR 1.26
271 [1.12, 1.42]) had increased odds of hospitalization (Table 4).

272 Among Hispanic patients, a recent uncontrolled HbA1c (>8%) measurement was
273 associated with higher odds of hospitalization (aOR 5.95 [2.24, 15.78]) (Table 4). Being a a
274 female was protective for hospitalization 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 hospitalization for COVID-19 (Table 4).

Sex stratification: Increasing age was associated with increased odds of hospitalization in all sex stratified models (Table 4).

Among male patients, residing in a high unemployment zip code was associated with increased odds of hospitalization (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 anti-asthmatic 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 hospitalization odds (Table 4).

Among female patients, socio-demographic factors associated with increased odds of hospitalization 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 hospitalization 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 United States. 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 hospitalization (62% and 5.7%, respectively). White and Asian KPGA patients where not overrepresented in terms of COVID-19 diagnosis (29.5% and 3.6%, respectively) or hospitalization (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 re-admission 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 hospitalized 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 1.3x times increased risk of hospitalization compared to White patients.[15] National data from the CDC from August 2020 indicates that, Black and Hispanic patients were 4.6 and 4.7 times more likely than Whites to be hospitalized for COVID-19.[15] Other studies from academic or integrated health care systems have shown that, after adjustment for age, sex, comorbidities, and income, Black patients had between 1.72 and 2.7 times and Hispanics 1.5 times the odds of hospitalization compared to White patients.[3 29 30]

Compared to 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 neighborhoods with the highest rate of households below the federal poverty level (14 and 12%), with a higher neighborhood deprivation index (0.37 and 0.03), and the highest percentage of frontline workers (35.6 and 35.4%%) compared to 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 plays a role in health disparities, a situation that has been magnified by the COVID-19 pandemic in the U.S.

In addition to SDOH factors, comorbidities have been associated to more severe COVID-19 disease. The prevalence of comorbidities in the U.S. 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 to Black patients, and had a significantly higher prevalence of underlying conditions, such as hyperlipidemia, CAD, CHF, COPD, arrythmia, and depression. Although there is a high prevalence of obesity, diabetes and other chronic diseases in the overall U.S 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 females were significantly (aOR 0.74) less likely to be hospitalized while racial minorities (Black, Hispanic) increasing age and chronic comorbidities were predominant factors associated with higher odds of hospitalization [7,8]. Medicare insurance type was a significant correlate of hospitalization, 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 hospitalization among All-patients (aOR 1.68), Black (aOR 1.74) and particularly Hispanic patients (aOR 5.95). Furthermore, poor blood pressure control (>140/90 mmHg) was a predictive factor for hospitalization (aOR 2.17) among White patients. Overall, these findings suggest that presence of, and poorly controlled comorbidities, increase risk of hospitalization for COVID-19 and that improving clinical management of underlying cardio-metabolic diseases could help ameliorate hospitalization 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 hospitalization 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, neighborhood and physical environment as well as pre-pandemic lifestyle behaviors. Of these metrics, we found that residence in zip codes with a high proportion of unemployment was a consistent factor associated with increased hospitalization risk for All patients (aOR 1.08) and specifically Black patients (aOR 1.09), albeit 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 hospitalization 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 to 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 minutes of moderate to vigorous exercise/week — increased by 25% the odds of hospitalization among patients in our cohort. The effect estimate of physical inactivity was even more pronounced for female patients (aOR 1.45). Several biologic 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 epidemiologic 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 hospitalization risk in our study population, after adjusting for traditional risk factors such as age, body mass index, 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 health care services. However, our analysis showed a diverse socio-economic background of KPGA patients underscoring the role of various SDOH in relation to COVID-19 risk of infection and hospitalization. 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 groups 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 the COVID-19 patients 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 neighborhood level data to extrapolate additional SDOH metrics. Well established U.S 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, hospitalization, clinical outcomes and post-discharge follow-up data, this study provides one of the most comprehensive assessments of COVID-19 patients 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 health care system, Black and Hispanic patients were still being disproportionately affected by COVID-19 infection and risk of hospitalization. However, we found no significant differences in clinical outcomes such as re-admission or mortality across race/ethnicity groups. These outcomes are not very frequent therefore these finding needs 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 hospitalization risk among Black patients. The SDOH have shown to contribute to a more unfavorable baseline health status and therefore, can indirectly impact COVID-19 risk of hospitalization 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 hospitalization risk in different race groups. Therefore, as interventions designed to reduce COVID-19 disparities and the systemic effects of racism [43] 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 behaviors be considered by clinicians, health care systems [44] and public health stakeholders.

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Author Contributions: Drs Lobelo and Shin had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Concept and design: Shin, Lobelo, Koplan

Acquisition, analysis, or interpretation of data: Lobelo, Bienvenida, Leung, Mbanya, Leslie, Shin

Drafting of the manuscript: Lobelo, Shin, Bienvenida, Leung, Mbanya, Leslie

Critical revision of the manuscript for important intellectual content: Lobelo, Koplan, Shin

Statistical analysis: Leung, Leslie

Administrative, technical, or material support: Lobelo, Koplan, Shin

Supervision: Lobelo, Koplan, Shin

Figure 1 Legend. Map of Metro Atlanta Region's COVID19 Cases by Race/ethnicity

A. Map of COVID19 Cases: Race Black

B. Map of COVID19 Cases: Race White

C. Map of COVID19 Cases: Race Asian

D. Map of COVID19 Cases: Race Hispanic

E. Map of COVID19 Cases: All Races

F. Map of Metro Atlanta Neighborhood Deprivation Index

Ethics Statement:

Patient consent for publication

Not required.

Ethics approval

The KPGA institutional review board approved this study with a waiver of informed consent (study ID: 1605119)

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Table 1: Socio-demographic characteristics of KPGA patients with COVID-19 seen from March 3 to October 29th, 2020

	KPGA members by Race No. (%)					
	All N=5,721 (100%)	**Black n=3,339 (58,4%)**	**White n=1,689 (29,5%)**	**Hispanic n=487 (8.5%)**	**Asian n=206 (3.6%)**	**p-value**
Age, mean [SD], y	44.8 [15.7]	43.9 [15.1]	47.1 [17.8]	41.9 [14]	45.8 [15.8]	<.0001
Age range, y						
18-49	3414 (59.7)	2106 (63.1)	865 (51.21)	328 (67.4)	115 (55.8)	
50-64	1686 (29.5)	931 (27.9)	549 (32.5)	140 (28.8)	66 (32)	<.0001
65 and above	621 (10.9)	302 (9)	275 (16.3)	19 (3.9)	25 (12.1)	
Gender						
Male	2416 (42.2)	1270 (38)	820 (48.5)	226(46.4)	100(48.5)	<.0001
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)	
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)	<.0001
Self-pay	326 (5.7)	237 (7.1)	59 (3.5)	17 (3.5)	13 (6.3)	
Other [a]	196 (3.4)	132 (4)	42 (2.5)	19 (3.9)	3 (1.5)	
Median Household Income[b] No. (%)						
25k-50k	1079 (19.4)	855 (25.6)	115 (6.8)	78 (16)	31 (15)	
50k-75k	2746 (49.3)	1814 (54.3)	639 (37.8)	225 (46.2)	68 (33)	<.0001
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, % [c]	12.36	13.95	9.85	11.96	10.37	<.0001
Residential Region (%) [d]						
Northeast	2090 (36.5)	1085 (32.5)	626 (37.1)	274 (56.3)	105 (51)	
Northwest	969 (16.9)	341 (10.2)	492 (29.1)	102 (20.9)	34 (16.5)	<.0001
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)	
Neighborhood Deprivation Index [e]	0.07	0.37	-0.4	0.03	-0.27	<.0001
Occupation[f], mean %						
Frontline Workers	33.6	35.6	30.2	35.4	31.2	
Healthcare Workers	7.2	7.4	7	6.5	6.6	<.0001
Other Workers	59.2	57	62.7	58.1	62.1	
Education, mean % [g]						
Some High School	6.6	7.2	5.8	7	5.8	
High School	22.3	24	20.2	21.4	19.9	
Associates Degree	8.4	8.6	8.1	8.2	8.4	<.0001
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	

Abbreviations: COVID-19, Coronavirus Disease 2019; KPGA, Kaiser Permanente Georgia;

[a] Other Insurances include military Health Maintenance Organization (HMO) or Preferred Provider Organization (PPO).

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

[c] Poverty line was defined by the Federal poverty level

[d] The Atlanta metro area was divided up by county in four sub-regions

- 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.

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

[f] 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.

[g] 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).

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
Hyperlipidemia	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
Arythmia	172(3)	79 (2.4) §, §§	85 (5) °	3 (0.6) °°°	5 (2.4)	<0.0001
ESRD[a]	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[b]	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[c]	1823 (31.9)	1095 (32.8) §§§	570 (33.7) °	90 (18.5) °°°	68 (33)	<0.0001
3+ Comorbidities[c]	966 (16.9)	560 (16.8) §, §§§	333 (19.7) °	41 (8.4) °°°	32 (15.5)	<0.0001
Charlson Comorbidity Index, mean [SD][d]	1.9 [1.4] §, §§	1.9 [1.5]	2.1 [1.7] °	1.5 [1.1]	1.67 [1.2]	0.0014
Outpatient Medication, No. (%)						
Anti Rheumatic	17 (0.3)	8 (0.2)	7 (0.4)	2 (0.4)	0 (0)	0.5696
Anti Hypertensive	1059 (18.5)	632 (18.9) §§	329 (19.5) °	62 (12.7)	36 (17.5)	0.0062
Anti Asthmatic	890 (15.6)	533 (16)	274 (16.2)	57 (11.7)	26 (12.6)	0.3283
Anti Hyperlipidemic	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
Anti malarial	31 (0.5)	22 (0.7) §	4 (0.2)	4 (0.8)	1 (0.5)	0.2139
Quality of Care Metrics [e]						
Blood Pressure >140/90 [f]	501 (27.6)	349 (30.1) §§	118 (23.3) °	21 (24.1) °°°	13 (21)	<0.0001
Diabetes Uncontrolled (A1C>8) [f]	286 (31.8)	195 (34.2)	65 (28.4)	18 (29)	8 (21.6)	0.1976
Average Exercise minutes, mean [SD] [g]	79.9 [114]	75.3 [113.4] §	91 [128.1]	76.7 [115.6]	87.5 [99.7]	0.0034
EVS Category, No. (%) [h]						
Inactive	1648 (28.8)	998 (29.9)	460 (27.2)	136 (27.9)	54 (26.2)	

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Insufficient	1336 (23.4)	814 (24.4%) §	359 (21.3)	107 (22)	56 (27.2)	0.0044
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)	

Abbreviations: COVID-19, Coronavirus Disease 2019; KPGA, Kaiser Permanente Georgia; HbA1c, Glycated Hemoglobin; 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; HTN, Hypertension; EVS, Exercise as a Vital Sign.

Significance Levels: § Black vs. White; §§ Black vs. Hispanic; §§§Black vs Asian; °White vs Hispanic; °°White vs. Asian °°° Hispanic vs. Asian, significant difference at $p< 0.05$

[a] 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.
[b] CKD classified based on diagnosis reported by the ICD-10 code in patient's medical history.
[c] 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.
[d] 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)
[e] Assessed at the most recent clinical encounter within the last 12 months
[f] Blood pressure control was evaluated only amongst patients with hypertension (n=1816) and glucose control amongst patients with diabetes (n=898).
[g] Average exercise was collected from self-reported data.
[h] EVS is based on patient reported weekly exercise minutes. We used 3 categories: Inactive for patients who reported less than 10 mins/week, insufficiently active for patients who reported 11-149 minutes/week and sufficiently active for patients who reported 150 or more mins/week.

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

Hospitalization Characteristics	Total no. (%) N = 896[b]	Race/Ethnicity No. (%) Black Total 556 (62.0%)	White Total 257 (28.7%)	Hispanic Total 51 (5.7%)	Asian Total 32 (3.6%)	Sex No. (%) Female Total 458 (51.1%)	Male Total 438 (48.9%)	Age group (years) No. (%) 18-49 Total 271 (30.3%)	50-64 Total 322 (35.9%)	65+ Total 303 (33.8%)
Mean Age [c], 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
Health Care Utilization										
Mean Hospital LOS, days, [SD]	7.9 [9.2]	7.9 [9.1] *ǂ	7.2 [7.9] *ǂ	6.9 [7.3] *ǂ	14.5 [17.1] *ǂ,*°, *°°,*°°°	7.3 [8.3] *Δ	8.6 [10.0] *Δ,*ᵋ	6.6 [8.2] *¶	8.5 [9.9] *¶, *◊	8.5 [9.2] *¶,*◊◊
Admitted to ICU [d]	259 (28.9%)	154 (27.7%) *ǂ	71 (27.6%) *ǂ	17 (33.3%) *ǂ	17 (53.1%) *ǂ ,*°,*°°	118 (25.8%) *Δ	141 (32.2%) *Δ,*ᵋ	59 (21.8%) *¶	112 (34.8%) *¶,**◊	88 (29.0%) *¶,*◊◊
Mean ICU LOS, days, [SD]	10.0 [10.5]	10.1 [9.3] *ǂ	8.1 [9.0] *ǂ	8.7 [9.6] *ǂ	17.8 [20.4] *ǂ	9.1 [9.8]	10.7 [11.0]	9.0 [9.0]	9.7 [10.3]	11 [11.7]
Mechanical Ventilation [d]	77 (8.6%)	51 (9.2%) *ǂ	15 (5.8%) *ǂ	4 (7.8%) *ǂ	7 (21.9%) *ǂ,*°,*°°	36 (7.9%)	41 (9.4%)	12 (4.4%) *¶	35 (10.9%) *¶, **◊	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]
Outcomes										
Discharged Alive [d]	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%) **¶,**◊◊
Still Hospitalized [d]	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%)
30 Day Re-admission [d]	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%)
60 Day Re-admission [d]	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%)
Deceased [d]	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%) **¶,**◊◊

Abbreviations: COVID-19, Coronavirus Disease 2019; KPGA, Kaiser Permanente Georgia; ICU, Intensive Care Unit; SD, Standard Deviation; n/a = not applicable;

[a] Significance Levels * P ≤ 0.05, ** P ≤ 0.001

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

[c] Mean age represents all unique hospitalized patients n=827

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

Significance Tests (Categorical: Chi-Squared Test of Significance, Continuous: ANOVA Test of Significance, Two-Sample T-Test of Means)

ǂ Across Race Groups, ° Black vs. Asian; °° White vs. Asian; °°°Hispanic vs. Asian; Δ Across Sex; ᵋ Men vs. Women

¶Across Age Groups; ◊ Age 18-49 vs. 50-64; ◊◊ Age 18-49 vs. 65+; ◊◊◊ Age 50-64 vs. 65+

Table 4: Multivariable logistic regression model odds ratios for hospitalization among all KPGA COVID-19 patients and by race/ethnicity and sex

Population Total sample size n (%)	All COVID-19 n=5,721 (100%)	Race/Ethnicity Black n=3,339 (58,4%)	White n=1,689 (29,5%)	Hispanic n=487 (8.5%)	Asian n=206 (3.6%)	Sex Female n=3,304 (57.8%)	Male n=2,417 (42.2%)
Variables OR (95% CI)							
Demographics							
Race Black	1.43*(1.13,1.83)	n/a[a]	n/a[a]	n/a[a]	n/a[a]	1.46*(1.06,2.02)	
Race Hispanic	1.60*(1.08,2.37)	n/a[a]	n/a[a]	n/a[a]	n/a[a]		
Race Asian	1.43 (0.90,2.28)	n/a[a]	n/a[a]	n/a[a]	n/a[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[a]	n/a[a]
Social Determinants							
Medicare Insurance [b]	1.52*(1.12,2.06)	1.92*(1.29,2.88)					
High Unemployment Zip code[c]	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 [d]			0.64*(0.43,0.95)				
High Income Zip code [c]					0.24*(0.08,0.78)		
Comorbidities [e]							
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 [f]	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 [g]							
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)	
Uncontrolled HbA1c >9%							2.01*(1.11,3.62)
Blood Pressure >140/90			2.17*(1.31 – 3.57)				
Anti-Asthmatic Medication							1.51*(1.06,2.15)
Cough/Cold Medication		1.37* (1.02,1.84)					
Lifestyle Behaviors [g]							
Physically Inactive [i]	1.25*(1.03,1.51)					1.45*(1.12,1.89)	

Abbreviations: KPGA, Kaiser Permanente Georgia; COVID-19, Coronavirus Disease 2019; NE, Northeast; COPD, Chronic Obstructive Pulmonary Disease; CHF, Congestive Heart Failure; HbA1c, Glycated Hemoglobin

[a] not available as an independent variable for stratified models; Significance Levels * P ≤ 0.05, ** P ≤ 0.001

[b] Represents Medicare Population (Aged 65+ and people with disabilities)

[c] 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

[d] NE County Area includes Dekalb, Gwinnett, Forsyth, Hall, Barrow, Jackson, Butts, Gilmer, Pike, Gordon, Jasper, Monroe counties

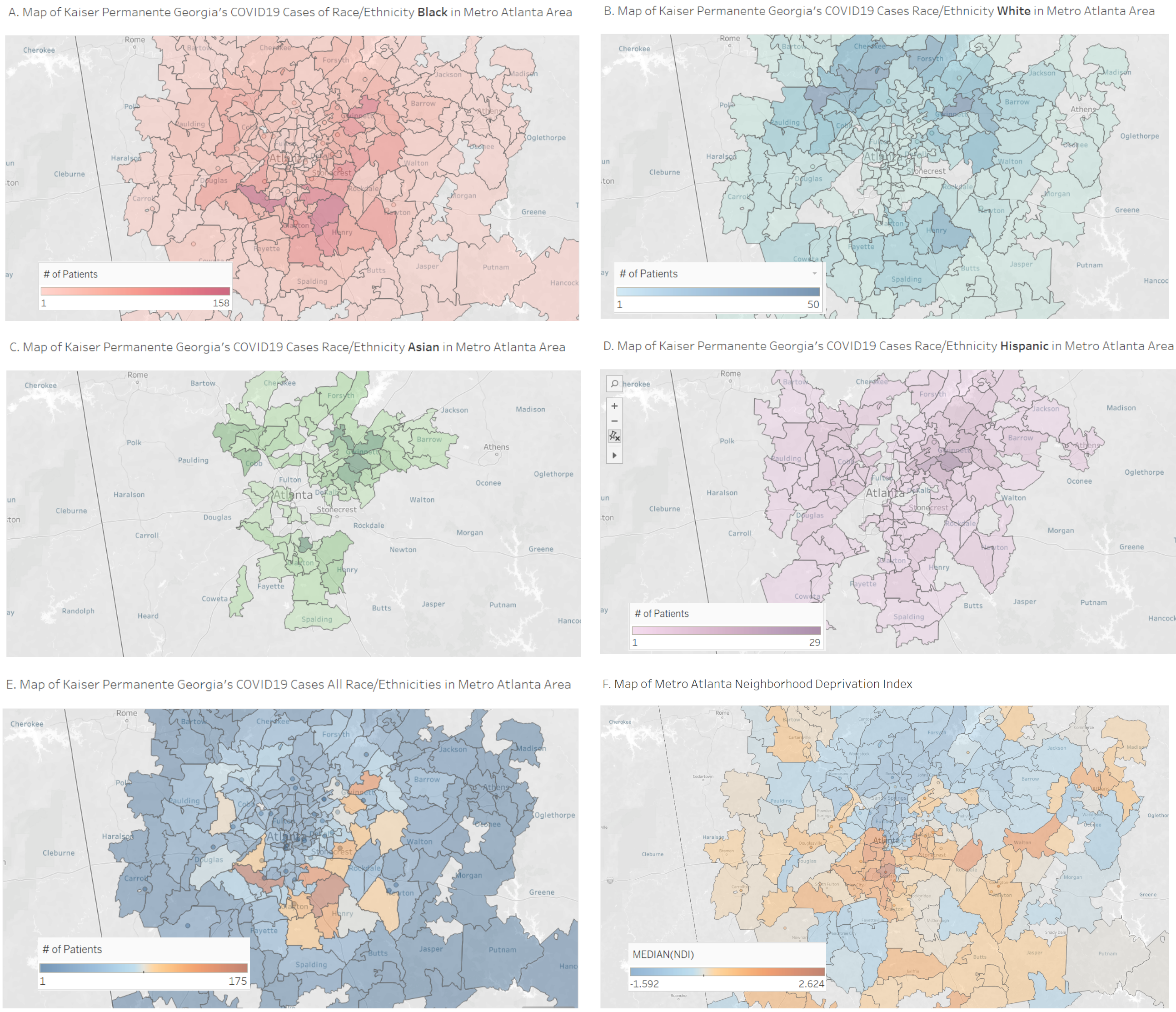
[e] Based on diagnosis reported by the 10th revision of the International Statistical Classification of Diseases and Related Health Problems code (ICD-10) in patient's medical history

[f] 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)

[g] Assessed at the most recent clinical encounter within the last 12 months

[i] Physically Inactive defined as self-reported weekly exercise < 10 minutes

Kaiser Permanente Georgia's COVID19 Cases By Race/Ethnicity



Map of Metro Atlanta Region's COVID19 Cases by Race/Ethnicity

A. Map of COVID19 Cases: Race Black
B. Map of COVID19 Cases: Race White
C. Map of COVID19 Cases: Race Asian
D. Map of COVID19 Cases: Race/ethnicity Hispanic
E. Map of COVID19 Cases: All Races/ethnicities
F. Map of Metro Atlanta Neighborhood Deprivation Index

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Manuscript Page #	Recommendation
Title and abstract	1,2	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	4	Explain the scientific background and rationale for the investigation being reported
Objectives	5	State specific objectives, including any prespecified hypotheses
Methods		
Study design	5	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed
Variables	6-8	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	7,8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	8	Describe any efforts to address potential sources of bias
Study size	6-8	Explain how the study size was arrived at
Quantitative variables	7,8	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	8,9	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, explain how loss to follow-up was addressed
		(*e*) Describe any sensitivity analyses
Results		
Participants	9	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	9,10	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) Summarise follow-up time (eg, average and total amount)
Outcome data	10	Report numbers of outcome events or summary measures over time
Main results	10-12	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear

		which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	9-11	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	13,14	Summarise key results with reference to study objectives
Limitations	17,18	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	13-18	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	17,18	Discuss the generalisability (external validity) of the study results
Other information		
Funding	19	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.