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Imaging Utilization During the COVID-19 Pandemic Highlights Socioeconomic Health Disparities

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Abstract

Objective: The devastating impact from the coronavirus disease 2019 (COVID-19) pandemic highlights long-standing socioeconomic health disparities in the United States. The purpose of this study was to evaluate socioeconomic factors related to imaging utilization during the pandemic.

Methods: Retrospective review of consecutive imaging examinations was performed from January 1, 2019, to May 31, 2020, across all service locations (inpatient, emergency, outpatient). Patient level data were provided for socioeconomic factors (age, sex, race, insurance status, residential zip code). Residential zip code was used to assign median income level. The weekly total imaging volumes in 2020 and 2019 were plotted from January 1 to May 31 stratified by socioeconomic factors to demonstrate the trends during the pre-COVID-19 (January 1 to February 28) and post-COVID-19 (March 1 to May 31) periods. Independent-samples t-tests were used to statistically compare the 2020 and 2019 socioeconomic groups.

Results: Compared with 2019, the 2020 total imaging volume in the post-COVID-19 period revealed statistically significant increased imaging utilization in patients who are aged 60 to 79 years (\(P = .0025\)), are male (\(P < .0001\)), are non-White (Black, Asian, other, unknown; \(P < .05\)), are covered by Medicaid or uninsured (\(P < .05\)), and have income below $80,000 (\(P < .05\)). However, there was a significant decrease in imaging utilization among patients who are younger (<18 years old; \(P < .0001\)), are female (\(P < .0001\)), and have income \(\geq \$80,000\) (\(P < .05\)).

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INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic continues to take a significant toll on the health of the population with over 7 million people affected in the United States, resulting in over 200,000 deaths as of September 21, 2020 [1]. The devastating impact from the pandemic highlights the long-standing socioeconomic health disparities and inequities in the US health care system. Preventive measures intended to contain the spread of severe acute respiratory syndrome coronavirus 2 virus, such as stay-at-home orders and social distancing efforts, have been challenging to effectively implement in low-socioeconomic and underserved communities [2]. Crowded living conditions and employment in public-facing occupations, such as services and transportation, impair effective social distancing [3]. As a consequence, health care policy and the social determinants of health disproportionately affected the welfare of the minority, older, and lower-income populations and the population insured by Medicaid or uninsured. The most pervasive health disparities have been observed among African American and Latino individuals, with both groups suffering both higher rates of COVID-19 infection and disease-related mortality [3]. The underlying socioeconomic factors that contribute to health disparities are complex and multifactorial, including age, sex, race, ethnicity, insurance status, education, and income level.

In the United States, racial and ethnic variation in the access and utilization of medical resources has been well established. There is a growing body of literature reporting socioeconomic health disparities in diagnostic imaging and interventional radiology [4,5]. There is a concern that these health disparities may be exacerbated when medical resources are limited, as seen during the COVID-19 pandemic. At the onset, health care institutions reallocated resources and limited some routine care, including imaging, in preparation for the rapid influx of patients requiring medical attention. Radiology practices developed imaging recommendations for the judicious use of cross-sectional imaging, ultrasound, and interventional radiology to prevent spread of COVID-19 disease to patients and health care providers [6,7].

Much has been written about the impact of COVID-19 on imaging volumes. Overall imaging volume declined, with the largest decline in the outpatient setting [6]. Inpatient imaging volume initially declined in preparation and subsequently rose with the influx of patients who tested positive for COVID-19 [7]. The rebound in inpatient imaging volume revealed a significant shift away from cross-sectional and advanced imaging modalities (CT, MRI, nuclear medicine, interventional procedures) toward radiography during the pandemic [7]. However, detailed analyses of the specific Current Procedural Terminology–coded groups revealed that the individual imaging examinations of CT angiography chest, radiography chest, and ultrasound venous duplex had significantly increased imaging volumes in the late post-COVID-19 period, shedding light on the specific types of imaging examinations needed to appropriately care for patients with COVID-19 [7]. Although much is now known about imaging volumes during the pandemic, there is a relative paucity of data regarding the impact of COVID-19 on imaging utilization by different socioeconomic groups. Understanding the impact of social determinants on imaging utilization may assist health care leaders in allocating appropriate imaging resources during and after the COVID-19 pandemic.

The purpose of this study was to evaluate socioeconomic factors related to imaging utilization during the COVID-19 pandemic. We analyzed patient-level imaging data to assess socioeconomic factors stratified by the patient service location (inpatient, emergency department, outpatient) during the COVID-19 pandemic in a large health care system.

METHODS

We performed a retrospective review of the radiology invoices in the charge master from January 1, 2019, to May 31, 2020, to evaluate socioeconomic factors related to imaging utilization during the COVID-19 pandemic in a large integrated health care system. All consecutive billing invoices were obtained according to the date of service across all patient locations (inpatient, emergency department, outpatient). Patient-level data were obtained from the radiology professional billing system containing patients’ contact information (residential address and zip code), payor billing information (insurance type), and demographic data (birth date, sex, race). At the time of scheduling and registration, staff either obtain these data on new patients or reconfirm these data on existing patients in our health care system. Institutional review board approval and waiver of
informed consent was obtained for this retrospective analysis.

Our health care system is located in the New York metropolitan area serving a highly diverse population. In New York City, the first confirmed COVID-19 patient was on March 1, 2020 (week 10) with the number of daily new cases increasing to over 10,000 from April 3 to April 25, 2020 (weeks 15-18) [1]. Since then, a steady decline occurred with only 1,282 new daily cases reported on May 31, 2020 (week 22). Given this timeline, the data set was split to compare the pre-COVID-19 (January 1 to February 28) and post-COVID-19 (March 1 to May 31) periods. The February 2020 imaging data were adjusted to reflect the same 28 days of imaging data acquired in February 2019 by removing 1 day (February 29, 2020) from the data analysis for similar comparisons. Our health care system had no significant decline in the number of imaging scanners in 2020 that could have potentially affected the access and availability of imaging during the COVID-19 pandemic.

The data variables were categorized as age (<18, 18-39, 40-59, 60-79, ≥80 years old), sex (male, female), race (White, Black, Asian, other or multiracial, unknown), and insurance status (commercial, Medicare, Medicaid, uninsured). Self-pay status was included in the uninsured group. The residential zip code was linked to the median annual household income level (<$60,000, $60,000-$79,999, $80,000-$119,999, $120,000-$149,999 and ≥$150,000) reported by the US Census Bureau [8].

Statistical Analysis
The weekly total imaging volumes in 2020 and 2019 were analyzed from January 1 to May 31 (weeks 1-22) stratified by socioeconomic factors (age, sex, race, insurance status, income level) to demonstrate the trends during the pre-COVID-19 (January 1 to February 28) and post-COVID-19 (March 1 to May 31) periods. The February 2020 imaging data were adjusted to reflect the same 28 days of imaging data acquired in February 2019 by removing 1 day (February 29, 2020) from the data analysis for similar comparisons. Our health care system had no significant decline in the number of imaging scanners in 2020 that could have potentially affected the access and availability of imaging during the COVID-19 pandemic.

The number of imaging services performed was aggregated to calculate the mean weekly volume and percentage of imaging volume for each group within the socioeconomic categories in the 2020 and 2019 post-COVID-19 periods. Additional subanalyses were performed comparing the 2020 and 2019 socioeconomic factors during the post-COVID-19 period stratified by patient service location (inpatient, emergency department, outpatient). In these analyses, the same weeks in the 2020 and 2019 calendar years were compared to account for monthly or seasonal variation. In addition, the 2020 post-COVID-19 mean weekly proportion of imaging examinations for each socioeconomic category were also compared with the 2020 pre-COVID-19 period. Independent-samples t tests were used to assess statistical significance among socioeconomic variables.

Multivariable logistic regression analyses were performed to assess the association of the socioeconomic factors with the imaging utilization performed during the 2020 post-COVID-19 period (dependent variable, Y = 1), using the 2019 post-COVID-19 period as the dependent variable (Y = 0). In the regression model, the independent variables and reference variables were selected based on the individual t test analyses to evaluate the statistically significant socioeconomic groups in a multivariable regression model. Using individual patient-level data, the multivariable logistic regression analyses were stratified by inpatient (n =
196,351), emergency department (n = 296,952), and outpatient (n = 237,409) settings to assess if differences exist by patient service locations. P values < .05 determined statistical significance. SAS version 9.4 (SAS, Cary, North Carolina) was used for all statistical analyses.

RESULTS
The total imaging case volume during the post-COVID-19 (March 1 to May 31) period was 348,539 examinations in year 2020 and 526,128 examinations in year 2019. In year 2020, the composition mix of the total imaging volume during the post-COVID-19 period was composed of 42% (147,385 of 348,539) emergency department examinations, followed by 33% (114,933 of 348,539) inpatient and 25% (86,221 of 348,539) outpatient examinations. In year 2019, the total imaging volume during the post-COVID-19 period was composed of 39% (205,774 of 526,128) emergency department examinations, followed by 37% (196,619

Fig 2. The 2020 and 2019 imaging utilization trend data from January 1 to May 31 stratified by age (A), sex (B), and race (C) for the statistically significant groups within each socioeconomic category. A transition point is observed at week 10 (red vertical line), indicating the shift in the imaging utilization in the first week of the post–coronavirus disease 2019 period. Calendar weeks are presented on the x axis and the weekly proportion of imaging examinations on the y axis.
of 526,128) outpatient and 24% (123,735 of 526,128) inpatient examinations. A statistically significant difference \((P < .0001)\) was observed in the composition mix of the patient service locations for the total imaging case volume during the 2020 post-COVID-19 (March 1 to May 31) period compared to 2019 (Fig. 1).

The 2020 and 2019 trend data for the total imaging case volume from January 1 to May 31 stratified by the socioeconomic factors revealed the pattern of changes in the imaging utilization according to age, sex, race, insurance status, and income level. Figures 2 and 3 show the trend data for the statistically significant groups in each socioeconomic category. A transition point occurred at week 10 with imaging utilization changing (increasing or decreasing) during the first week in the post-COVID-19 period, corresponding to the first confirmed patient testing positive for COVID-19 in New York City on March 1, 2020 (week 10). The highest peak and lowest trough occurred at weeks 15 to 16, which also correspond to the peak in the incidence of COVID-19 cases in this geographic region. A gradual return to baseline was observed with the trend data approaching near baseline by week 22 compared with the pre-COVID-19 (January 1 to February 28) period.

During the post-COVID-19 period, statistically significant differences were observed in the composition mix of the socioeconomic factors (age, sex, race, insurance status, income level). Figure 4 reveals the individual comparisons of the 2020 and 2019 composition change in each variable group within the socioeconomic category during the post-COVID-19 period. Overall, there was statistically significant increased imaging utilization in the mean weekly proportion of patients aged 60 to 79 years \((P = .0025)\), male patients \((P < .0001)\), non-White patients (Black \(P = .0077\), Asian \(P = .0002\), other \(P = .0001\), unknown \(P = .02\)), patients on Medicaid \((P < .0001)\), uninsured patients \((P = .0013)\), and patients in lower income brackets of \(< $60,000 \ (P = .0043)\) and \(\geq $60,000 \text{ to } $79,999 \ (P = .0012)\) during the COVID-19 pandemic. In contrast, statistically significant decreased imaging utilization was seen in younger patients \(< 18 \text{ years old} \ (P < .0001)\), female patients \((P < .0001)\), White patients \((P = .0003)\), commercially insured patients \((P < .0001)\), and patients in higher income brackets \(\geq $80,000 \text{ to } $119,999 \ (P = .0092)\), \(\geq $120,000 \text{ to } $149,999 \ (P = .0015)\), and \(\geq $150,000 \ (P < .0001)\). Table 1 confirms similar findings when comparing these socioeconomic factors in the 2020 post-COVID-19 (March 1 to May 31) and 2020 pre-COVID-19 (January 1 to February 28) periods.

The subanalyses stratifying the comparisons of the socioeconomic factors by patient service location (inpatient,
emergency department, outpatient) revealed similar observations (Tables 2 to 4). Overall, the socioeconomic findings were concordant among the inpatient and emergency department settings for age, sex, race, and income level. The only exception was in the insurance status category for the commercially insured group, which showed statistically increased imaging utilization in the inpatient setting ($P < .0001$). In contrast to the other patient service locations, in the outpatient setting, there was statistically significant increased imaging utilization in patients aged 18 to 39 years ($P = .0011$) and decreased imaging utilization in 40- to 59-year-old patients ($P = .0164$). Additional discordant findings are seen in the income level for the outpatient location with statistically decreased imaging in patients <$60,000 ($P = .0155$) and increased imaging utilization in patients $80,000 to $119,999 level ($P < .0001$).

Furthermore, the multivariable logistic regression analyses revealed the strength of the association of the socioeconomic factors with the imaging utilization during the post-COVID-19 period (Table 5). The following socioeconomic groups were selected as the independent

**Fig 4.** Comparison of the 2020 and 2019 mean weekly composition mix of the socioeconomic factors for total imaging volume in the post-coronavirus disease 2019 period is displayed in stacked bar graphs for age (A), sex (B), race (C), insurance status (D), and income level (E). The percentage composition for each socioeconomic group is indicated in the column with the total summed to 100% on the y axis. *$P$ value $< .05$.**
variables (and corresponding reference variables) in the regression model based on the statistical significance observed in the t test comparisons: age 60 to 79 (all other age groups: <18, 18-39, 40-59, ≥80), sex male (female), race White (non-White: Black, Asian, other, unknown), commercial insurance (noncommercial insurance groups: Medicaid, Medicare, uninsured), income ≥ $80,000 (income < $80,000). Across all patient service locations, patients aged 60 to 79 years and male patients had statistically significant positive associations with imaging utilization during the 2020 post-COVID-19 period, and White race had significant negative associations. Some further insights are revealed by evaluating the odds ratio to assess the strength of associations particularly in the different patient service locations. The male sex variable had the strongest positive association with imaging utilization during the pandemic, which remained consistent across all patient service locations. The greatest effect was observed for the inpatient location, with male patients having 33% higher odds compared with female patients. In contrast, the White race variable had the strongest negative association with imaging utilization during the pandemic across all patient service locations. The greatest effect was also seen for the inpatient location with 29% lower odds of White patients compared with non-White patients (Blacks, Asian, other, unknown). Insurance status and income level were variable depending on the patient service location. In the emergency department location, commercial insurance and

### Table 1. Comparison of the 2020 mean weekly composition mix of the socioeconomic factors for total imaging volume in the post-COVID-19 and pre-COVID-19 periods

| Socioeconomic Factors | 2020 Post-COVID-19 | 2020 Pre-COVID-19 | P Value |
|-----------------------|-------------------|------------------|--------|
| **Mean %** | **SD** | **Mean %** | **SD** | **P Value** |
| **Age (y)** | | | | |
| <18 | 4.90 | 0.64 | 5.91 | 0.26 | <.0001* |
| 18-39 | 14.18 | 1.29 | 15.36 | 0.65 | .0108* |
| 40-59 | 27.93 | 1.24 | 27.57 | 1.02 | .4825 |
| 60-79 | 37.02 | 2.08 | 35.21 | 0.38 | .0090* |
| ≥80 | 15.98 | 1.09 | 15.95 | 0.67 | .9449 |
| Total | 100 | 100 | 100 | 100 | |
| **Sex** | | | | |
| Male | 48.48 | 5.43 | 38.35 | 0.62 | <.0001* |
| Female | 51.52 | 5.43 | 61.65 | 0.62 | <.0001* |
| Total | 100 | 100 | 100 | 100 | |
| **Race** | | | | |
| Asian | 7.17 | 0.51 | 6.87 | 0.29 | .1346 |
| Black | 17.08 | 1.31 | 15.73 | 0.42 | .0033* |
| Other | 20.85 | 2.50 | 17.71 | 0.37 | .0007* |
| Unknown | 5.36 | 0.56 | 5.05 | 0.26 | .1283 |
| White | 49.54 | 4.36 | 54.64 | 0.60 | .0012* |
| Total | 100 | 100 | 100 | 100 | |
| **Insurance** | | | | |
| Commercial | 34.60 | 2.42 | 37.35 | 0.83 | .0017* |
| Medicaid | 19.20 | 1.01 | 16.80 | 0.42 | <.0001* |
| Medicare | 40.50 | 1.41 | 40.65 | 0.40 | .7519 |
| Uninsured | 5.69 | 0.81 | 5.20 | 0.46 | .1162 |
| Total | 100 | 100 | 100 | 100 | |
| **Income ($)** | | | | |
| <60,000 | 13.32 | 2.09 | 11.25 | 0.37 | .0039* |
| 60,000-79,999 | 27.65 | 1.39 | 26.14 | 0.48 | .0024* |
| 80,000-119,999 | 39.63 | 1.39 | 40.98 | 0.53 | .0055* |
| ≥120,000-149,999 | 15.57 | 1.51 | 17.15 | 0.40 | .0028* |
| ≥150,000 | 3.84 | 0.42 | 4.48 | 0.21 | .0001* |
| Total | 100 | 100 | 100 | 100 | |

COVID-19 = coronavirus disease 2019.
*P < .05.
higher income level ($\geq 80,000$) had significant negative associations with imaging utilization. In contrast, the outpatient location showed that higher income level ($\geq 80,000$) had significant positive association with imaging utilization, but commercial insurance was not statistically associated.

**DISCUSSION**

The COVID-19 pandemic has highlighted long-standing health disparities in the United States and has had a disproportionate impact on the health and well-being of individuals of lower socioeconomic status, thus compounding the pre-existing inequities in the US health care system. The findings from this study revealed statistically significant changes in the composition mix of the socioeconomic factors of patients undergoing imaging during the COVID-19 pandemic. Overall, older patients (aged 60-79 years), male patients, and non-White (Black, Asian, other, unknown) patients received significantly more medical imaging during the COVID-19 pandemic compared with the same weeks in the prior year. In addition, this study revealed that patients with lower income levels ($<80,000$) had significantly increased imaging utilization and patients with higher income levels $\geq 80,000$ had significantly decreased imaging utilization during the post-COVID-19 period. With regard to insurance status, Medicaid recipients and uninsured patients had significantly increased imaging utilization compared with the same weeks in the prior year.
utilization, and patients with commercial (private) insurance had significantly decreased imaging utilization during the post-COVID-19 period. These findings are consistent with the health disparities reported in the literature related to the increased prevalence of COVID-19 among these groups.

Furthermore, some differences were observed when the socioeconomic factors were stratified by patient service location (inpatient, emergency department, outpatient). In the emergency department and inpatient locations, the socioeconomic factors that were related to statistically increased imaging utilization followed the same pattern of patient demographics that were most impacted by the pandemic (older, males, non-White, and lower income) because these patients experienced a higher prevalence of COVID-19 and were likely seeking care in the emergency department and subsequently admitted to the hospital. Additionally, the multivariable regression model revealed that the male sex variable had the strongest positive association and the White race variable had the strongest negative association with imaging utilization during the COVID-19 pandemic across all patient service locations, with the greatest effect observed in the inpatient setting.

In contrast, the patients that had significantly decreased proportions of imaging utilization in the outpatient location during the 2020 post-COVID-19 period were female, younger (<18 and 40-59 years old), and White and had lower income (<$60,000) and higher income (>$120,000) levels. One possible explanation for this decline in the use of

| Table 3. Comparison of the 2020 and 2019 mean weekly composition mix of the socioeconomic factors for the emergency department service in the post-COVID-19 period |
|---------------------------------------------------------------|
| Emergency Socioeconomic Factors | 2020    | SD   | 2019    | SD   | P Value |
| Age (y) | | |
| <18 | 4.62 | 1.47 | 7.72 | 0.52 | <.0001* |
| 18-39 | 19.75 | 2.61 | 21.66 | 0.58 | .0230* |
| 40-59 | 26.91 | 2.10 | 24.41 | 0.82 | .0011* |
| 60-79 | 30.29 | 2.73 | 27.47 | 0.77 | .0031* |
| ≥80 | 18.44 | 1.86 | 18.75 | 0.74 | .5843 |
| Total | 100 | | 100 | | |
| Sex | | |
| Male | 48.36 | 2.74 | 43.30 | 0.57 | <.0001* |
| Female | 51.64 | 2.73 | 56.69 | 0.57 | <.0001* |
| Total | 100 | | 100 | | |
| Race | | |
| Asian | 6.84 | 0.70 | 6.60 | 0.26 | .2557 |
| Black | 18.73 | 1.10 | 18.93 | 0.56 | .5731 |
| Other | 21.92 | 2.36 | 19.28 | 0.51 | .0017* |
| Unknown | 4.03 | 0.79 | 3.70 | 0.24 | .1568 |
| White | 48.48 | 3.98 | 51.49 | 0.87 | .0192* |
| Total | 100 | | 100 | | |
| Insurance | | |
| Commercial | 30.69 | 1.61 | 32.10 | 0.57 | .0094* |
| Medicaid | 20.30 | 1.20 | 20.69 | 0.69 | .3308 |
| Medicare | 38.91 | 2.25 | 37.58 | 0.77 | .0542 |
| Uninsured | 10.09 | 0.85 | 9.63 | 0.79 | .1678 |
| Total | 100 | | 100 | | |
| Income ($) | | |
| <$60,000 | 13.40 | 1.70 | 11.95 | 0.41 | .0099* |
| 60,000-79,999 | 28.62 | 1.32 | 27.96 | 0.81 | .1358 |
| 80,000-119,999 | 39.36 | 1.28 | 41.02 | 0.79 | .0007* |
| 120,000-149,999 | 14.94 | 1.06 | 15.41 | 0.52 | .1656 |
| ≥15,000 | 3.67 | 0.34 | 3.66 | 0.27 | .9073 |
| Total | 100 | | 100 | | |

COVID-19 = coronavirus disease 2019.
*P < .05.
Table 4. Comparison of the 2020 and 2019 mean weekly composition mix of the socioeconomic factors for the outpatient service in the post-COVID-19 period

| Outpatient Socioeconomic Factors | 2020    | 2019    | P Value |
|----------------------------------|---------|---------|---------|
|                                  | Mean %  | SD      | Mean %  | SD      |         |
| Age (y)                          |         |         |         |         |         |
| <18                              | 3.60    | 0.53    | 4.61    | 0.16    | <.0001* |
| 18-39                            | 14.58   | 1.89    | 12.36   | 0.34    | .0011   |
| 40-59                            | 35.87   | 1.95    | 37.55   | 1.24    | .0164   |
| 60-79                            | 38.36   | 1.71    | 37.75   | 1.12    | .299    |
| ≥80                              | 7.59    | 1.19    | 7.73    | 0.38    | .6815   |
| Total                            | 100     |         | 100     |         |         |
| Sex                              |         |         |         |         |         |
| Male                             | 33.07   | 4.33    | 26.52   | 0.50    | .0001   |
| Female                           | 66.93   | 4.33    | 73.48   | 0.50    | .0001   |
| Total                            | 100     |         | 100     |         |         |
| Race                             |         |         |         |         |         |
| Asian                            | 5.37    | 0.62    | 5.51    | 0.34    | .4605   |
| Black                            | 12.36   | 1.57    | 11.23   | 0.31    | .0250   |
| Other                            | 16.09   | 1.21    | 15.88   | 0.60    | .5811   |
| Unknown                          | 8.48    | 0.35    | 7.35    | 0.38    | <.0001* |
| White                            | 57.71   | 2.05    | 60.02   | 0.73    | .0017   |
| Total                            | 100     |         | 100     |         |         |
| Insurance                        |         |         |         |         |         |
| Commercial                       | 52.51   | 1.64    | 53.38   | 1.01    | .1177   |
| Medicaid                         | 13.25   | 1.22    | 11.94   | 0.56    | .0027   |
| Medicare                         | 32.56   | 1.35    | 32.86   | 1.29    | .5679   |
| Uninsured                        | 1.69    | 0.30    | 1.83    | 0.15    | .1475   |
| Total                            | 100     |         | 100     |         |         |
| Income                           |         |         |         |         |         |
| 60,000                           | 8.44    | 0.81    | 9.11    | 0.42    | .0155   |
| 60,000-79,999                    | 24.59   | 2.02    | 23.58   | 0.61    | .0972   |
| 80,000-119,999                   | 43.24   | 1.17    | 41.20   | 0.52    | <.0001* |
| 120,000-149,999                  | 18.94   | 1.47    | 20.32   | 0.54    | .0061   |
| ≥150,000                         | 4.81    | 0.67    | 5.79    | 0.38    | .0002   |
| Total                            | 100     |         | 100     |         |         |

COVID-19 = coronavirus disease 2019.
*P < .05.

Table 5. Multivariable logistic regression analyses of the socioeconomic factors with imaging utilization during the 2020 Post-COVID-19 period stratified by patient service location

| Socioeconomic Factors | Inpatient (n = 196,351) | Emergency (n = 296,952) | Outpatient (n = 237,409) |
|-----------------------|-------------------------|-------------------------|-------------------------|
|                       | OR (95% CI)             | P Value                 | OR (95% CI)             | P Value                 | OR (95% CI)             | P Value                 |
| Age 60-79 y           | 1.09 (1.07-1.11)        | <.0001*                 | 1.14 (1.12-1.16)        | <.0001*                 | 1.04 (1.02-1.06)        | .0002*                  |
| Sex male              | 1.33 (1.31-1.35)        | <.0001*                 | 1.22 (1.20-1.24)        | <.0001*                 | 1.23 (1.20-1.25)        | <.0001*                 |
| Race White            | 0.71 (0.70-0.72)        | <.0001*                 | 0.88 (0.87-0.90)        | <.0001*                 | 0.92 (0.90-0.93)        | <.0001*                 |
| Commercial insurance  | 1.13 (1.11-1.15)        | <.0001*                 | 0.96 (0.95-0.98)        | <.0001*                 | 1.00 (0.98-1.02)        | .9695                   |
| Income ≥ $80,000      | 0.93 (0.91-0.94)        | <.0001*                 | 0.95 (0.94-0.97)        | <.0001*                 | 1.05 (1.03-1.07)        | <.0001*                 |

CI = confidence interval; COVID-19 = coronavirus disease 2019; OR = odds ratio.
*P < .05.
outpatient imaging services is that these patient groups were delaying their care during the COVID-19 pandemic as a consequence of the CMS recommendation to limit nonessential and nonurgent medical care [9]. This mandate particularly affected the performance of routine outpatient imaging, such as breast cancer screening, which would disproportionately affect the younger, female population. Additionally, the economic downturn caused by the pandemic resulted in high rates of unemployment and loss of medical insurance [10], which may have disproportionately impacted those patients with prior commercial insurance and lower-income households. However, we also consider the possibility that these findings can be explained by the pre-existing disparities related to imaging services reported in the literature [11], in particular to cancer screening and follow-up imaging [12,13]. If this is indeed the case, this delayed care may lead to potential adverse health consequences for these populations. Understanding the impact of the decline in the utilization of imaging services for specific patient groups is important to better guide health policy during and after the pandemic to ensure imaging needs are met. If this issue is not addressed proactively, it may potentially result in widening of existing disparities in radiology in the postpandemic era that includes access to outpatient imaging services, especially cancer screening programs.

The main limitation of this study is the retrospective design using aggregated volume data, thus limiting our ability to perform more detailed regression analyses evaluating the key socioeconomic factors driving specific types of imaging utilization by Current Procedural Terminology–coded groups during the COVID-19 pandemic. Another limitation is that our health care institution experienced an extremely high volume of patients with COVID-19 during the pandemic, potentially limiting the generalizability of these results to less affected institutions. Given the rapid spread of COVID-19 across the country with several states now surpassing the total number of cases in New York, other institutions are likely experiencing a high volume of COVID-19 patients, and these results may serve as a reference. However, further studies in other regions in the United States would be helpful to analyze the geographic variability.

Understanding socioeconomic health disparities is a critical step in assessing the short- and long-term effects from the COVID-19 pandemic. It is important for health care leaders to be aware of these health disparities in directing utilization of resources during the pandemic and subsequent recovery. Imaging utilization stratified according to socioeconomic factors may help predict the demand for imaging services during a potential resurgence of the COVID-19 pandemic.

TAKE-HOME POINTS

- During the COVID-19 pandemic, significant changes in the composition mix of socioeconomic factors were observed, with patients aged 60 to 79 years, male patients, non-White (Black, Asian, other, unknown) patients, uninsured patients or patients with Medicaid, and patients with income levels <$80,000 having increased imaging utilization, consistent with the known health disparities in COVID-19 prevalence.
- Patients aged <18 years, female, White, and commercially insured and those at income levels ≥ $80,000 received significantly decreased imaging during the post-COVID-19 (March 1 to May 31) period, with unknown potential health consequences of delayed care.
- Identifying socioeconomic health disparities related to imaging utilization is an initial step toward understanding the need for imaging resources in specific patient groups during the COVID-19 pandemic and subsequent recovery.
- In a time of a health care crisis, it is important to understand socioeconomic factors related to imaging utilization to direct imaging resources to ensure adequate access and availability.

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REFERENCES

1. Worldometer. United States. Available at: https://www.worldometers.info/coronavirus/country/us/. Updated September 21, 2020. Accessed September 21, 2020.
2. Yancy CW. COVID-19 and African Americans. JAMA 2020;323:1891-2.
3. Hooper MW, Napoles AM, Perez-Stable EJ. COVID-19 and racial/ethnic disparities. JAMA 2020;323:2466-7.
4. Safdar NM. An introduction to health disparities for the practicing radiologist. J Am Coll Radiol 2019;16:542-6.
5. Schrager JD, Patzer RE, Kim JJ, et al. Racial and ethnic differences in diagnostic imaging utilization during adult emergency department visits in the United States, 2005 to 2014. J Am Coll Radiol 2019;16:1036-45.
6. Naidich JJ, Bolyenkov A, Wang JJ, Chusid J, Hughes D, Sanelli PC. Impact of the COVID-19 pandemic on imaging case volumes. J Am Coll Radiol 2020;17:865-72.
7. Naidich JJ, Boltyenkov A, Wang JJ, Chusid J, Hughes D, Sanelli PC. Coronavirus disease 2019 (COVID-19) pandemic shifts inpatient imaging utilization. J Am Coll Radiol 2020;17:1289-98.

8. United States Census Bureau. B19013 median household income in the past 12 months (in 2020 inflation-adjusted dollars). 2018 American Community Survey 5-year estimates. Available at: https://data.census.gov/cedsci/all?q=B19013%20median%20household%20income%20in%20the%20past%2012%20months%20(in%202018%20inflation-adjusted%20dollars%20in%202020 inflation-adjusted%20dollars%20year)

9. CMS. Non-emergent, elective medical services, and treatment recommendations 2020. Available at: https://www.cms.gov/files/document/cms-non-emergent-elective-medical-recommendations.pdf.

Accessed December 9, 2020.

10. Vagal A, Mahoney M, Anderson JL, et al. Recover wisely from COVID-19: responsible resumption of nonurgent radiology services. Acad Radiol 2020;27:1343-52.

11. Betancourt JR, Tan-McGrory A, Flores E, López D. Racial and ethnic disparities in radiology: a call to action. J Am Coll Radiol 2019;16(4 Pt B):547-53.

12. Flores EJ, Park ER, Irwin KE. Improving lung cancer screening access for individuals with serious mental illness. J Am Coll Radiol 2019;16(4 Pt B):596-600.

13. Lacson R, Wang A, Cochon L, et al. Factors associated with optimal follow-up in women with BI-RADS 3 breast findings. J Am Coll Radiol 2020;17:469-74.