ORIGINAL RESEARCH

# Residential Segregation and Emergency Department Utilization Among an Underserved Urban Emergency Department Sample in North Carolina

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**BACKGROUND** Residential segregation is a spatial manifestation of structural racism. Racial disparities in emergency department (ED) utilization mirror social inequity in the larger community. We evaluated associations between residential segregation and ED utilization in a community with known disparities and geographically concentrated social and health risk.

**METHODS** Cross-sectional data were collected from electronic medical records of 101 060 adult ED patients living in Mecklenburg County, North Carolina in 2017. Community context was measured as residential segregation using the dissimilarity index, categorized into quintiles (Q1–Q5) using 2013–2017 American Community Survey estimates, and residency in a public health priority area (PHPA). The outcome was measured as total ED visits during the study period. Associations between community context and ED utilization were modeled using Anderson's behavioral model of health service utilization, and estimated using negative binomial regression, including interaction terms by race.

**RESULTS** Compared to areas with the lowest proportions of Black residents (Q1), living in Q4 was associated with higher rates of ED utilization among Black/Other (AME = 0.11) and White (AME = 0.23) patients, while associations with living in Q5 were approximately equivalent (AME = 0.12). PHPA residency was associated with higher rates of ED utilization among Black/Other (AME = 0.10) and White patients (AME = 0.22).

**LIMITATIONS** Associations should not be interpreted as causal, or be generalized to the larger community without ED utilization. Health system leakage is possible but limited.

**CONCLUSIONS** Residential segregation is associated with higher rates of ED utilization, as are PHPA residency and other individual-level determinants.

While the primary function of US emergency departments (EDs) is to stabilize seriously ill or injured patients, they are increasingly becoming a safety net for medically underserved patients to meet care demands that are inaccessible from other parts of the health care system [1]. EDs serve all patients, regardless of their ability to pay [2]. Thus, as the most accessible entry point into the health care system, EDs are a mirror of community social inequity [3]. Racial disparities in emergency medicine outcomes are widely documented [4–6]. Compared to their White counterparts, Black patients have longer lengths of hospital stay [7], higher odds of injury-related mortality [8, 9], lower rates of hospitalization for heart failure [10], and higher rates of 30-day readmission [11]. Community-level indicators of social and economic inequity have emerged as important contextual determinants of racial health disparities that highlight the mechanisms of structural disadvantage. With an increasing burden of health care occurring in the ED [12], more evidence is needed to highlight the complex relationships between community-level contextual factors and ED utilization

Research has demonstrated that race and other individual-level demographic factors are determinants of ED utilization. Black patients are more likely to utilize the ED for ambulatory care-sensitive conditions (ACSC), conditions that are treatable or preventable in a primary care setting [13, 14] and have higher rates of avoidable ED utilization [15–17]. A prior case study among ED patients living in Charlotte, North Carolina, demonstrated higher odds of ACSC-related ED utilization among Black patients (odds ratio [OR] = 1.63; 95% confidence interval [CI], 1.56–1.70) compared to White patients [18]. Insurance status is a well-documented determinant of ED utilization, with higher rates of frequent or heavy ED utilization among patients with Medicaid or Medicare insurance [19, 20] and among those without insurance [21]. Heavy ED utilization is also an indication of underlying chronic disease and unmet health

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needs among those who use the ED for avoidable or preventable health care [22] and those with heavy use of the larger ambulatory health care system [23].

Residential segregation is a fundamental cause of racial disparities in health outcomes [24]. As a mechanism of community context, residential segregation is a spatial manifestation of structural racism [25] that results in the geographic concentration of poverty and associated risk factors among minority race communities [26, 27]. Prior research is limited by methodological flaws in the measurement of residential segregation [28, 29]. Despite the availability of theory-based indices [30, 31], most health services researchers use racial/ethnic composition (e.g., % of race/ethnicity population in a geographic unit) as a proxy measure of segregation [32]. Measures of composition fail to capture complex spatial inequality because they do not account for racial clustering or relative differences within the larger geographic region [33]. Only two studies currently identified have applied formal index measures of residential segregation to evaluate associations with ED utilization. One study found that exposure increased the odds of asthma-related ED visits among Medicaid-enrolled children (OR = 1.04; 95% CI: 1.01–1.08) [34]. Another study found a significant interaction effect by race among adults with end-stage renal disease with higher odds of ED readmission among Black residents and lower odds among White residents [35].

Mecklenburg County, North Carolina is a community with recognized health and economic disparities [36]. The purpose of this study was to evaluate the relationship between residential segregation and ED utilization among community residents and assess the extent to which associations vary by patient race. To improve upon methodological flaws in prior studies, a theory-driven formula of residential segregation was used.

## Methods

### *Setting*

Atrium Health is the one of the largest vertically integrated health care systems in the United States, spanning North Carolina, South Carolina, and Georgia. The system's 2017 footprint included 35 EDs with an average of over 4200 visits per day. With headquarters in Mecklenburg County, Atrium Health provides a majority of the emergency medicine in the surrounding community across 6 local EDs, while also serving a majority of the Medicaid-insured and uninsured populations. Public health priority areas (PHPAs), identified by the county health department as having disproportionately low educational attainment and high poverty, are the focus of ongoing social and public health intervention [37, 38]. The geographic concentration of social and health risk factors in this community, along with the availability of secondary data from of a robust electronic medical record (EMR) infrastructure, provided an ideal opportunity for an in-depth evaluation of the relationship between community context and ED utilization.

### *Conceptual Framework*

We applied Anderson's behavioral model of health service utilization [39] to conceptualize ED utilization through a framework of predisposing, enabling, and need factors. According to the model, predisposing factors represent demographic and social structures including race as an individual-level determinant and residential segregation as an indicator of community context. Enabling factors facilitate utilization of health services, such as having insurance coverage, while needs factors motivate service utilization and include indicators of unmet health care needs such as avoidable ED utilization and/or concurrent heavy utilization of the larger ambulatory health care system. A conceptual framework is presented in Figure 1.

### *Study Design and Data Sources*

The study design was cross-sectional and covered the period January 1 to December 31, 2017. Data were obtained from Atrium Health EMRs and the US Census Bureau American Community Survey (ACS) 5-year 2013-2017 estimates [40]. The research protocol was approved by the Atrium Health Institutional Review Board (IRB) and exempt from review by the University of South Carolina IRB.

### *Sample*

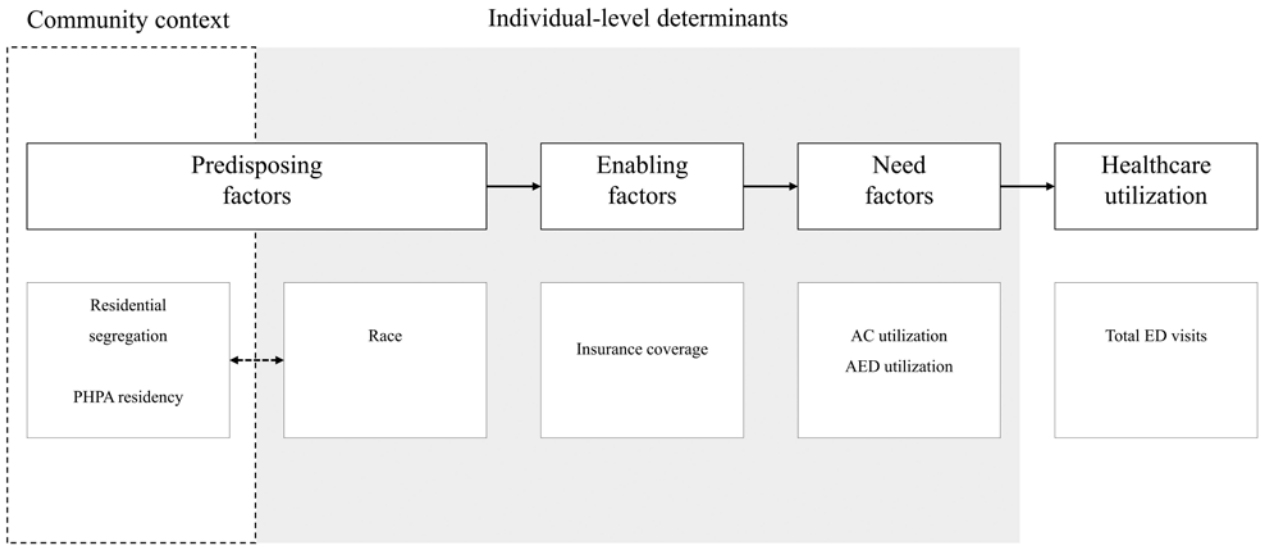
Individual-level data were obtained from EMRs (Cerner Corporation, Kansas City, Kansas) of patients aged 18 years and older living in Mecklenburg County who visited an Atrium Health ED during the study period (n = 101 810). Records were identified by the home address associated with the first visit to the ED during the study period. Patients who died (n = 721) were removed to reduce misclassification bias for the dependent variable because they do not have a comparable opportunity for health care utilization, along with unknown gender (n = 16), and those with extreme and potentially miscoded ages (n = 13). The final individual-level sample was 101 060. County data were downloaded from the ACS public use files as estimated population counts of Black and non-Black residents by Mecklenburg County ZIP code tabulation areas (ZCTAs).

## Measures

### *Predisposing Factors*

***Residential segregation.*** The dissimilarity index formula [41] was adapted to measure residential segregation by ZCTA. Dissimilarity represents the percentage of a group that would have to move for each ZCTA to have the same proportions as the larger county, calculated as the difference between total counts of Black and non-Black residents by ZCTA relative to the larger county using the following formula: $B\_i/B\_total - B\_i\^c/B\_total\^c$ where $B$ is the number of Black residents in ZCTA $i$, and $B\_total$ is the number of Black residents in the larger county, $B\_i\^c$ is number of non-Black residents in ZCTA $i$, and $B\_total\^c$ is the number of non-Black residents in the larger county. Our application of this

**FIGURE 1.**
**The Anderson Model of Health Care Utilization to Explain the Relationship Between Residential Segregation, Race, and Emergency Department Utilization**




**Abbreviations.** PHPA, public health priority area; ED, emergency department; AC, ambulatory care, AED avoidable emergency department

formula produced a continuous score for each ZCTA ranging from negative values, representing a fewer number Black residents, to positive values, representing a greater number of Black residents. Values were categorized into quintiles for analysis, with quintile 1 (Q1) representing the bottom 20% of the distribution (i.e., areas with the lowest proportions of Black residents) and quintile 5 (Q5) representing the top 20% of the distribution (i.e., areas with highest proportions of Black residents). Patient home address ZCTAs were scored by quintile. Quintiles were analyzed in regression models using a categorical variable with Q1 serving as a reference group. This method has been applied in prior research to rank areas using a continuous index of geography-based exposure to sociodemographic risk factors [42].

Continuous scores were compiled into an index measuring residential segregation in the overall county using the standard dissimilarity index formula: $1/2 \sum(i=1)^N |B\_i/B\_total - B\_i^c/B\_total^c|$. The index ranges between 0 and 1 with a value ≥ 0.6 indicating high segregation, 0.3–0.6 indicating moderate segregation, and ≤ 0.3 indicating low segregation between ZCTAs relative to the larger county.

***Public health priority area residency.*** A binary variable (Yes versus No) was created to indicate living in one of 6 ZCTAs identified as PHPAs: 28217, 28208, 28216, 28206, 28205, and 28212, as a proxy measure for exposure to concentrated social and health risk.

***Demographics.*** Race was categorized into White, Black, and other/unknown groupings for analysis. Other characteristics adjusted for in the analysis were: gender (male or female), ethnicity (Hispanic/Latino and non-Hispanic/Latino), and age, defined as a continuous variable.

### *Enabling and Needs Factors*

***Insurance coverage.*** The primary source of payment indicated for the first visit in the study sample was used as a proxy for socioeconomic status using the categories Medicaid, Medicare, private, other, or uninsured. Patients indicating "self-pay" were recoded to represent the uninsured.

***Ambulatory care utilization.*** The total number of visits to ambulatory care (AC) was measured as the total number of unique encounters to Atrium Health facilities under the specialty categories of: Allergy, Cardiovascular, Dermatology, Endocrinology, Family Medicine, Internal Medicine, Primary Care Behavioral Health, Rheumatology, Sleep Medicine, Sports Medicine, Urgent Care, and General Obstetrics and Gynecology. Total AC visits were categorized into 0 visits, 1 visit, and >1 visit levels.

***Avoidable emergency department utilization.*** The avoidability of ED visits during the study period was determined using the New York University Emergency Department algorithm (NYU Algorithm), a validated classification system that estimates the probability of an ED visit as being: 1) nonemergent, 2) emergent, primary care treatable, 3) emergent, preventable or avoidable, and 4) emergent, not preventable or avoidable [43]. Visits for drug and/or alcohol use, mental health conditions, and injury are separated from the avoidability classification, including those visits that are unable to be classified by the algorithm. Visits were classified as avoidable if the probability of categories 1–3 was 50% or greater, and consistent with prior research [44, 45]. Avoidable ED utilization (AED) was quantified in the analysis as a binary variable (Yes versus No) to indicate if a patient had any ED visit during the study period classified as avoidable.

**TABLE 1.**
**Patient Characteristics by Community Context Factors (N = 101 060)**

| Characteristic | Residential segregation quintile[a] | | | | | PHPA residency | | Total |
|---|---|---|---|---|---|---|---|---|
| | Q1 | Q2 | Q3 | Q4 | Q5 | Yes | No | |
| | No. (%) | No. (%) | No. (%) | No. (%) | No. (%) | No. (%) | No. (%) | No. (%) |
| Total | 16,449 | 10,701 | 14,740 | 20,731 | 38,439 | 33,709 | 67,351 | 101,060 |
| Insurance coverage | | | | | | | | |
| Medicaid | 1,415 (8.60) | 1,732 (16.19) | 2,286 (15.51) | 4,090 (19.73) | 8,034 (20.90) | 7,677 (22.77) | 9,880 (14.67) | 17,557 (17.37) |
| Medicare | 3,850 (23.41) | 2,001 (18.70) | 2,002 (13.58) | 2,499 (12.05) | 5,469 (14.23) | 4,488 (13.31) | 11,333 (16.83) | 15,821 (15.66) |
| Private | 7,888 (47.95) | 4,112 (38.43) | 6,000 (40.71) | 6,745 (32.54) | 12,445 (32.38) | 8,912 (26.44) | 28,278 (41.99) | 37,190 (36.80) |
| Other | 219 (1.33) | 131 (1.22) | 257 (1.74) | 300 (1.45) | 516 (1.34) | 409 (1.21) | 1,014 (1.51) | 1,423 (1.41) |
| Uninsured | 3,077 (18.71) | 2,725 (25.46) | 4,195 (28.46) | 7,097 (34.23) | 11,975 (31.15) | 12,223 (36.26) | 16,846 (25.01) | (28.76) 29,069 |
| Gender | | | | | | | | |
| Female | 9,563 (58.14) | 6,296 (58.84) | 8,434 (57.22) | 11,812 (56.98) | 22,587 (58.76) | 19,268 (57.16) | 39,424 (58.54) | 58,692 (58.08) |
| Male | 6,886 (41.86) | 4,405 (41.16) | 6,306 (42.78) | 8,919 (43.02) | 15,852 (41.24) | 14,441 (42.84) | 27,927 (41.46) | 42,368 (41.92) |
| Age | | | | | | | | |
| Mean (SD) | 47.56 (20.03) | 44.29 (18.60) | 42.07 (16.53) | 39.89 (16.00) | 41.08 (16.48) | 40.72 (15.96) | 43.20 (18.09) | 42.38 (17.44) |
| Race | | | | | | | | |
| White | 9,963 (60.57) | 4,498 (42.03) | 4,447 (30.17) | 3,426 (16.53) | 4,898 (12.74) | 4,490 (13.32) | 22,742 (33.77) | 27,232 (26.95) |
| Black | 3,461 (21.04) | 4,372 (40.86) | 7,228 (49.04) | 12,864 (62.05) | 27,912 (72.61) | 23,793 (70.58) | 32,044 (47.58) | 55,837 (55.25) |
| Other/Unknown | 3,025 (18.39) | 1,831 (17.11) | 3,065 (20.79) | 4,441 (21.42) | 5,629 (14.64) | 5,426 (16.10) | 12,565 (18.66) | 17,991 (17.80) |
| Ethnicity | | | | | | | | |
| Non-Hispanic/Latino | 12,920 (78.55) | 8,318 (77.73) | 11,626 (78.87) | 16,042 (77.38) | 30,941 (80.49) | 27,181 (80.63) | 52,666 (78.20) | 79,847 (79.01) |
| Hispanic/Latino | 1,619 (9.84) | 1,153 (10.77) | 2,099 (14.24) | 2,913 (14.05) | 3,755 (9.77) | 3,865 (11.47) | 7,674 (11.39) | 11,539 (11.42) |
| Declined/Unknown | 1,910 (11.61) | 1,230 (11.49) | 1,015 (6.89) | 1,776 (8.57) | 3,743 (9.74) | 2,663 (7.90) | 7,011 (10.41) | 9,674 (9.57) |
| AC utilization[b] | | | | | | | | |
| 0 visit | 8,628 (52.45) | 6,389 (59.70) | 9,913 (67.25) | 14,665 (70.74) | 26,878 (69.92) | 24,433 (72.48) | 42,040 (62.42) | 66,473 (65.78) |
| 1 visit | 1,177 (7.16) | 774 (7.23) | 959 (6.51) | 1,371 (6.61) | 2,557 (6.65) | 2,177 (6.46) | 4,661 (6.92) | 6,838 (6.77) |
| >1 visit | 6,644 (40.39) | 3,538 (33.06) | 3,868 (26.24) | 4,695 (22.65) | 9,004 (23.42) | 7,099 (21.06) | 20,650 (30.66) | 27,749 (27.46) |
| AED utilizationt[c] | | | | | | | | |
| Yes | 8,965 (54.50) | 6,320 (59.06) | 9,280 (62.96) | 13,456 (64.91) | 25,107 (65.32) | 22,615 (67.09) | 40,513 (60.15) | 63,128 (62.47) |
| No | 7,484 (45.50) | 4,381 (40.94) | 5,460 (37.04) | 7,275 (35.09) | 13,332 (34.68) | 11,094 (32.91) | 26,838 (39.85) | 37,932 (37.53) |

**Abbreviations.** SD, standard deviation; AC utilization, ambulatory care utilization; AED utilization, avoidable emergency department utilization

[a]Residential segregation quintiles (Q1–Q5) calculated using continuous scores from the dissimilarity index formula [41] as the difference between total counts of Black and non-Black residents by ZCTA relative to the larger county. Q1 depicts areas with the lowest relative proportions of Black residents and Q5 depicts areas with the highest relative proportions of Black residents.

[b]AC utilization calculated as the total number of unique encounters to Atrium Health facilities defined under the specialty categories of: Allergy, Cardiovascular, Dermatology, Endocrinology, Family Medicine, Internal Medicine, Primary Care Behavioral Health, Rheumatology, Sleep Medicine, Sports Medicine, Urgent Care; and General Obstetrics and Gynecology

[c]AED utilization was classified using the New York University Algorithm [43] as having at least 1 emergency department visit during the study period with a combined probability of nonemergent, emergent primary care treatable, or emergent preventable or avoidable utilization as 50% or greater.

### *Outcome*

The total number of ED visits was calculated as the total billed unique ED encounters by individual, identified by a unique patient identification number.

## Analyses

Descriptive statistics were used to quantify demographic differences between levels of exposure to community context factors (quintiles and PHPA residency). The associations between predisposing (quintiles, PHPA residency, and race), enabling (insurance coverage), and needs (AC utilization and AED utilization) factors and the outcome of ED utilization were modeled using a zero-truncated negative binomial regression to account for overdispersion and the absence of zero responses [46], adjusted for gender, ethnicity, and age. The significance of the overdispersion parameter was tested using Poisson regression models for comparison. Estimates were exponentiated and interpreted as incident rate ratios. Due to high collinearity between community context factors, 2 distinct versions of the model were estimated with either quintiles or PHPA residency included as the primary exposure of interest.

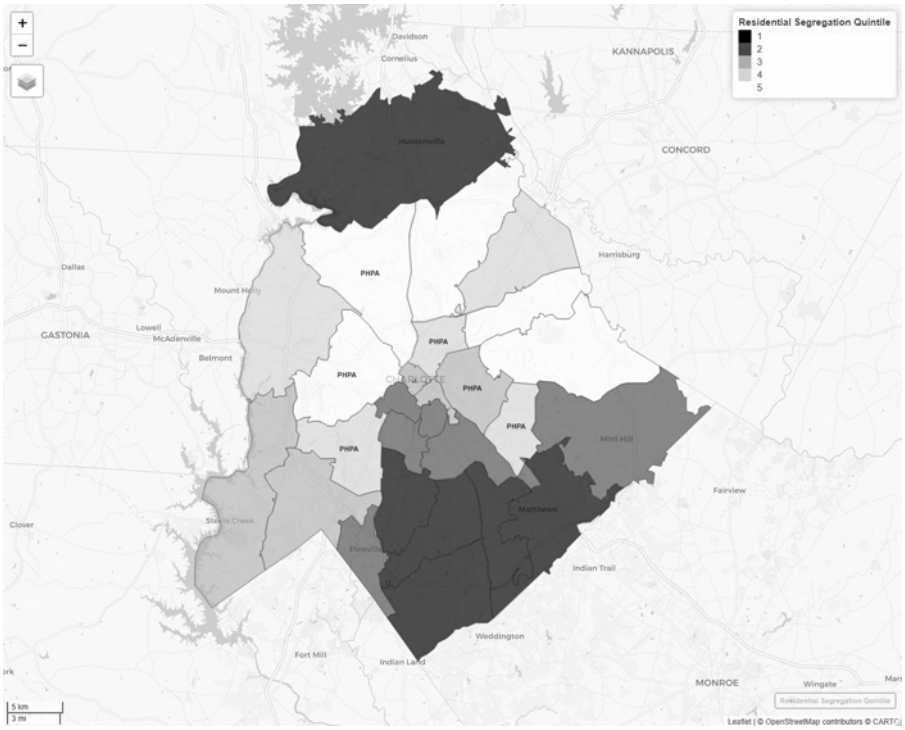
To evaluate the extent to which race impacts the relationship between community context and ED utilization, an interaction term between each exposure and race was tested for significance. Models with significant interaction terms were stratified by race and estimates were reported for each race stratum as average marginal effects in alignment with best practices [47]. Standard errors for all models were estimated using block bootstrap (with blocks defined by ZCTAs) with 50 replications to account for correlation between patients by ZTCA. Statistical significance was considered as a P-value of less than 0.05. All analyses were performed using R version 3.5.1 [48].

## Results

The study sample consisted of 101 060 Mecklenburg County residents who visited an Atrium Health ED during 2017. Characteristics of the sample are presented in Table 1 across levels of exposure to community context factors. The overall county dissimilarity index score was 0.38 on a 0–1 scale, indicating moderate segregation and a 38% difference in the proportions of Black and non-Black residents between ZCTAs compared to the proportions in the overall county. Quintiles are visualized in Supplemental Figure A.

Results from regression analysis including quintiles as a measure of community context are presented in Table 2. No significant associations between quintiles and ED utili-

**SUPPLEMENT FIGURE A.**
**Quintiles of Residential Segregation by ZIP Code Tabulation Area (ZCTA)**




Note. Residential segregation quintiles (Q1 – Q5) calculated using continuous scores from the dissimilarity index formula [41] as the difference between total counts of Black and non-Black residents by ZCTA relative to the larger county. Q1 depicts areas with the lowest relative proportions of Black residents and Q5 depicts areas with the highest relative proportions of Black residents.
Public Health Priority Area (PHPA) residency defined as living in one of 6 ZIP code tabulation areas identified by the county health department as areas with disproportionately low educational attainment and high poverty.

**TABLE 2.**
**Associations Between Community Context, Patient Characteristics, and Emergency Department Utilization**

| Model 1: Residential segregation quintile[a] | | | | Model 2: PHPA residency[b] | | | |
|---|---|---|---|---|---|---|---|
| | IRR | 95% CI | P value | | IRR | 95% CI | P value |
| Predisposing factors | | | | | | | |
| Quintile (ref = Q1) | | | | PHPA residency (ref = No) | | | |
| Q2 | 1.05 | 0.98 to 1.12 | 0.195 | Yes | 1.07 | 1.01 to 1.13 | 0.021 |
| Q3 | 1.06 | 0.98 to 1.15 | 0.165 | -- | -- | -- | |
| Q4 | 1.09 | 0.98 to 1.21 | 0.117 | -- | -- | -- | |
| Q5 | 1.07 | 1.00 to 1.15 | 0.053 | -- | -- | -- | |
| Race (ref = White) | | | | Race (ref = White) | | | |
| Black | 1.06 | 1.02 to 1.10 | 0.001 | Black | 1.07 | 1.03 to 1.11 | <0.001 |
| Other/Unknown | 0.90 | 0.87 to 0.93 | <0.001 | Other/Unknown | 0.91 | 0.88 to 0.94 | <0.001 |
| Enabling factors | | | | | | | |
| Insurance coverage (ref = Private) | | | | Insurance coverage (ref = Private) | | | |
| Medicaid | 1.44 | 1.40 to 1.49 | <0.001 | Medicaid | 1.43 | 1.39 to 1.48 | <0.001 |
| Medicare | 1.29 | 1.26 to 1.31 | <0.001 | Medicare | 1.29 | 1.26 to 1.31 | <0.001 |
| Other | 1.11 | 1.05 to 1.17 | <0.001 | Other | 1.11 | 1.05 to 1.17 | <0.001 |
| Uninsured | 1.15 | 1.13 to 1.18 | <0.001 | Uninsured | 1.15 | 1.12 to 1.17 | <0.001 |
| Need factors | | | | | | | |
| AC utilization[c] (ref = >1 visit) | | | | AC utilizationc (ref = >1 visit) | | | |
| 1 visit | 0.96 | 0.94 to 0.98 | <0.001 | 1 visit | 0.96 | 0.94 to 0.98 | <0.001 |
| 0 visit | 0.92 | 0.91 to 0.93 | <0.001 | 0 visit | 0.92 | 0.91 to 0.93 | <0.001 |
| AED utilization[d] (ref = No) | | | | AED utilizationd (ref = No) | | | |
| Yes | 1.62 | 1.56 to 1.68 | <0.001 | Yes | 1.62 | 1.56 to 1.68 | <0.001 |

**Abbreviations.** PHPA, public health priority areas; IRR, incident rate ratios; CI, confidence interval; AC utilization, ambulatory care utilization; AED utilization, avoidable emergency department utilization

**Note.** Estimates calculated using a zero-truncated negative binomial model, adjusted for ethnicity, gender, and age.

[a]Residential segregation quintiles (Q1–Q5) calculated using continuous scores from the dissimilarity index formula [41] as the difference between total counts of Black and non-Black residents by ZCTA relative to the larger county. Q1 depicts areas with the lowest relative proportions of Black residents and Q5 depicts areas with the highest relative proportions of Black residents.

[b]PHPA residency defined as living in one of six ZIP code tabulation areas identified by the county health department as areas with disproportionately low educational attainment and high poverty.

[c]AC utilization calculated as the total number of unique encounters to Atrium Health facilities defined under the specialty categories of: Allergy, Cardiovascular, Dermatology, Endocrinology, Family Medicine, Internal Medicine, Primary Care Behavioral Health, Rheumatology, Sleep Medicine, Sports Medicine, Urgent Care; and General Obstetrics and Gynecology

[d]AED utilization was classified using the New York University Algorithm [43] as having at least 1 emergency department visit during the study period with a combined probability of non-emergent, emergent primary care treatable, or emergent preventable or avoidable utilization as 50% or greater.

zation were observed. Black patients (versus White) had a 6% higher rate of ED utilization (incident rate ratio [IRR] = 1.06; 95% CI, 1.02–1.10). Having Medicaid insurance (versus private insurance) was associated with a 44% higher rate of ED utilization (IRR = 1.44; 95% CI, 1.40–1.49). A similar association was observed among those who were uninsured, although the magnitude of effect was notably smaller. Patients without AC utilization during the study period had an 8% lower rate of ED utilization (IRR = 0.92; 95% CI, 0.91–.93) compared to those with more than one AC visit. Having at least one AED visit during the study period was associated with a 62% higher the rate of ED utilization (IRR = 1.62; 95% CI, 1.56–1.68).

Regression results with PHPA residency as a measure of community context are presented in Table 2. Almost identical associations were observed. In contrast, PHPA residency was significantly associated with a 7% higher rate of ED utilization (IRR = 1.07; 95% CI, 1.01–1.13) (Table 2).

Interaction terms were significant at $P < 0.05$, indicating that the relationship between community context measures and ED utilization varied by race of the individual. The sample was stratified by race into Black/Other and White strata. Results are presented by stratum in Table 3. Quintiles and PHPA residency were positively associated with ED utilization among both strata, with a larger magnitude of effect observed among the White stratum for some associations. Black/Other patients living in Q4 (versus Q1) had an 11% higher rate of ED utilization (AME = 0.11) while White patients living in Q4 (versus Q1) had a 23% higher rate of ED utilization (AME = 0.23) representing a relative 116% difference between strata. When comparing the most extreme quintiles (Q1 versus Q5), the associations among Black/Other and White strata are approximately equivalent (AME = 0.12). Living in a PHPA was associated with a 10% higher rate of ED utilization among Black/Other patients (AME = 0.10) and a 22% higher rate of ED utilization among White patients (AME = 0.22) with a similar 115% relative difference. Predicted rates of ED utilization as a function of quintiles and PHPA residency are presented in Figure 2 by race stratum (Figure 2).

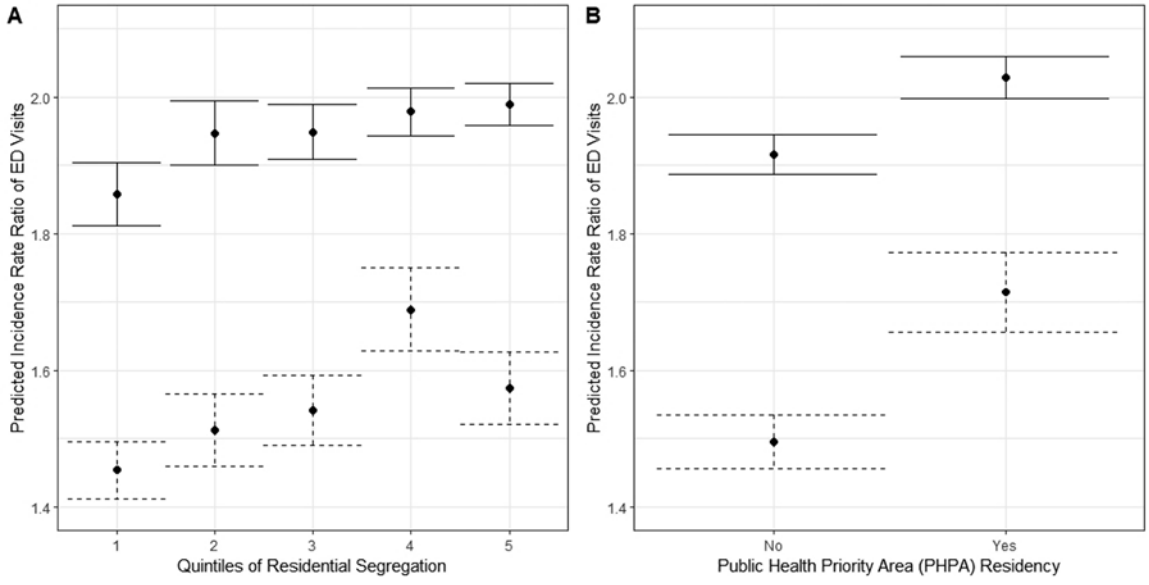
## Discussion

Our study highlighted relationships between community context and ED utilization among Mecklenburg County ED patients. Patients in our sample were disproportionately exposed to geography-based indicators of social and economic risk. Over 50% lived in areas with the highest proportions of Black residents, and 33% were PHPA residents compared to 22% in the overall county. Visualization of residential segregation quintiles showed the geographic concentration of areas with higher proportions of Black residents along a central ridge, known locally as the "crescent" that includes PHPAs. Prior work has shown that residents of PHPAs (versus. non-PHPAs) have higher rates of chronic health conditions including overweight/obesity (66% versus 60%) and high blood pressure (44% versus 27%) along with higher death rates per 100 000 persons for diabetes (23.2 versus 12.4) and heart disease (113.6 versus 107.7) [37].

We modeled determinants of ED utilization using Anderson's behavioral model of health service utilization framework. Race was a significant predisposing, individual-level factor with higher rates of ED utilization among Black patients compared to their White counterparts. Insurance coverage is an enabling factor for overall health care utilization. In our study, ED patients with Medicaid or Medicare insurance, and patients without insurance coverage, had higher rates of ED utilization compared to those with private insurance. This result is consistent with prior studies showing heavy ED use among the Medicaid-insured population [19, 20] and could be an indicator of unmet health needs. Results for need factors included in our models align with this evidence, showing that ED patients with greater AC utilization and AED utilization during the study period had higher rates of ED utilization [22, 23].

The relationships between predisposing community context factors and ED utilization varied by patient race. Among both race groupings, living in areas with the highest proportions of Black residents was associated with higher rates of ED utilization, as was living in a PHPA. These relationships could be explained by prior evidence showing associations between residential segregation and lower rates of health insurance coverage [49], worse access to a usual source of care [50], and environmental disparities in health care resources [51–53]. While the predicted rate of ED utilization was higher among Black/Other patients across all levels of exposure to community context factors, some associations were stronger among White patients. David R. Williams explains the relationship between racism and health through pathways of institutional/structural racism, cultural racism, and the accumulation of psychosocial stress from individual experiences of racial discrimination [54], including well-documented discriminatory health care practices and implicit physician bias [55–62]. Thus, exposure to residential segregation and concentrated social and health risk factors among White patients does not include residual

**FIGURE 2.**
**Predicted Incident Rate Ratio of Emergency Department Visits by Quintiles of Residential Segregation (A) and Public Health Priority Area Residency (B): Interaction Effect Between Black/Other (solid) and White (dashed) Patients**




Note. Residential segregation quintiles (Q1 – Q5) calculated using continuous scores from the dissimilarity index formula [41] as the difference between total counts of Black and non-Black residents by ZCTA relative to the larger county. Q1 depicts areas with the lowest relative proportions of Black residents and Q5 depicts areas with the highest relative proportions of Black residents.
Public Health Priority Area (PHPA) residency defined as living in one of 6 ZIP code tabulation areas identified by the county health department as areas with disproportionately low educational attainment and high poverty.

**TABLE 3.**
**Average Marginal Effects of Community Context and Emergency Department Utilization by Race**

| | | Black/Other | | White | | % |
|---|---|---|---|---|---|---|
| | | AME (SE) | P value | AME (SE) | P value | Difference[c] |
| Quintile[a] (ref = Q1) | | | | | | |
| | Q2 | 0.08 (0.03) | 0.002 | 0.06 (0.02) | 0.012 | 26.31 |
| | Q3 | 0.08 (0.02) | < 0.001 | 0.09 (0.02) | < 0.001 | -6.75 |
| | Q4 | 0.11 (0.02) | < 0.001 | 0.23 (0.03) | < 0.001 | -115.59 |
| | Q5 | 0.12 (0.02) | < 0.001 | 0.12 (0.02) | < 0.001 | -2.40 |
| PHPA residency[b] (ref = No) | | | | | | |
| | Yes | 0.10 (0.01) | < 0.001 | 0.22 (0.02) | < 0.001 | -114.64 |

**Abbreviations.** AAME, average marginal effect; SE, standard error; PHPA, public health priority area
Note. Estimates calculated using a zero-truncated negative binomial model, adjusted for insurance coverage, ambulatory care utilization, avoidable emergency department utilization, ethnicity, gender, and age.
[a]Residential segregation quintiles (Q1–Q5) calculated using continuous scores from the dissimilarity index formula [41] as the difference between total counts of Black and non-Black residents by ZCTA relative to the larger county. Q1 depicts areas with the lowest relative proportions of Black residents and Q5 depicts areas with the highest relative proportions of Black residents.
[b]PHPA residency defined as living in one of 6 ZIP code tabulation areas identified by the county health department as areas with disproportionately low educational attainment and high poverty.
[c]% Difference calculated as the difference between Black/Other AME and White AME, divided by Black/Other AME

confounding from larger, cumulative effects of racism [30].

With a single year, cross-sectional study design, results should not be interpreted as causal associations or be generalized to the larger community population without ED utilization. Health system leakage is a limitation in our study [63, 64], although the effect is limited as Atrium Health is a majority provider of emergency medicine and underinsured health care in the community. Measuring residential segregation by ZCTA allowed for comparability with PHPAs, but the sensitivity of the measure may be reduced compared to a measure based on smaller geographic units. Lastly, the generalizability of the NYU algorithm has been criticized [65], although it has been validated among nationally representative and Medicare-insured samples [43, 44].

## Conclusions

Living in residentially segregated areas with higher proportions of Black residents and areas with geographically concentrated social and health risk is associated with higher rates of utilization among ED patients. Weaker associations among Black patients than among White patients may be attributed to the confounding effects of structural racism that are uniquely experienced by communities of color. Results can provide evidence for local efforts to improve health care access and available resources in high-risk communities. NCMJ

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