Centering Racial and Ethnic Equity in Health Care Throughout Spatial Data Analysis

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Abstract

Background

The ongoing COVID-19 pandemic as well as a host of social movements have put a nation-sized spotlight on structural inequality and racial disparities in health throughout America. As health care systems begin to advance health equity by holding plans and payers accounting for racial and socioeconomic disparities in care, quantitative methods are needed that emphasize the distinct linkages between physical locations and racially disparate outcomes.

Methods

We apply a counterfactual model to compare differences in avoidable and potentially avoidable emergency department (ED) admissions among a panel of 8,924 non-Hispanic White, Black, and Hispanic Medicaid participants between 2016 - 2018. The magnitude of disparity estimates is examined in relation to geographic proximity to health care providers, neighborhood socioeconomic contexts, as well as the type of primary care delivery model individuals received. The adjusted rates were assessed by generalized estimating equations (GEE) and average marginal effects models to contrast differences in probability of events in association with race/ethnicity, proximity to care, and treatment through patient-centered medical homes (PCMH).

Results

Attending a patient-centered medical home was associated with a 3.4 percentage point ($p < 0.001$) decrease in Black-White racial disparity and a 1.8 percentage point ($p < 0.10$) reduction in the overall Black-White disparity for potentially avoidable ED admissions. PCMH attendance was attributed to a 2.6 percentage point ($p < 0.10$) reduction in Hispanic-White disparities in potentially avoidable admissions, but this difference was not substantial enough to curb the overall Hispanic-White racial disparity in ED admissions. No statistically significant reductions in Black-White or Hispanic-White disparities in avoidable ED admissions were observed.

Conclusion

Medical homes may be able to curb, but not necessarily eliminate, racial disparities in ED admissions. Counterfactual models of health disparities are in line with recent transitions toward evaluating patient- and value-centered health care reform changes as they are designed to measure health and racial equity. This strategy, or variations of it, are adaptable to other investigations where emphasis on physical locations is considered essential to understanding racial disparities in health outcomes.

Background

Over the past 2 years, the ongoing COVID-19 pandemic as well as a host of national and global social movements related to police brutality, Indigenous People's health, corruption, and electoral manipulation have put a nation-sized spotlight on racial health inequities and structural racism. [1-5] At the same time, these trends are not new. Numerous individual-level as well as broader socio-structural factors contribute to racial disparities in health outcomes, particularly across the United States (U.S.). [6] For instance, African American and Hispanic groups have long experienced higher chronic disease prevalence, poorer quality of care, as well as a greater number of barriers to obtain health care services. [7-9]

With sharper focus on longstanding structural and systematic inequities, it becomes essential for geographers and health services researchers to re-emphasize that place is an intrinsic determinant of health. [10] The effects of America's legacy of redlining and the state-sponsored practices of neighborhood segregation endure through disappearing availability of neighborhood resources, quality housing, and cohesion. [11-13] Primary care providers are often less likely to practice within predominantly minority-based neighborhoods. [14-16] The health care "White flight" disproportionately benefits populations residing in more affluent and mostly White suburban areas. [17] Proximity to point sources continues to affect some groups more than others, to name just a few examples. [18, 19] Given these patterns, understanding the potential for different health care models to address the intersection between place, race, and health is fundamental to advance health equity.

Although equitable experiences with primary care are a priority emphasized by the Institute of Medicine (IOM) and other federal agencies, [20] limited empirical work to date considers the intersection between place, race/ethnicity, and other social factors to assess whether primary care delivery models are a viable means to reduce racial disparities in care in America. However, narrowing health disparities is believed to be the most viable mechanism by which the U.S. can improve patient health and wellbeing as well as reduce unnecessary health care utilization and spending. [21, 22] In this study, we apply a counterfactual algorithm to assess racial disparities in avoidable and potentially avoidable emergency department (ED) admissions among a panel of Medicaid participants, with emphasis on relative distances to primary care providers and hospitals as part of the disparity. Our focus in this study is two-fold: First, we outline the use of a counterfactual methodology that lends itself to investigation of racial disparities that includes a spatial component. Second, we use this method to examine the interaction between proximity to care, health services utilization, and race/ethnicity within the context of the primary care delivery models patients received.

Our reason for this two-part focus stems from the current expectations of patient-centered medical homes (PCMH) to eliminate racial disparities in primary care outcomes and interventions. [23] At issue is that recent studies have shown that medical home interventions lower rates of ED use, [24-26] but these investigations have not assessed whether decreased admissions are equally experienced among all racial/ethnic groups. As nearly every state Medicaid agency across the country provides support and resources to clinicians, practices, and families to ensure recipients gain access to PCMHs, [27] assessing its potential to reduce racial disparities in care has several implications for future policy mandates.

Methods

Study area and patient sample

In 2013, South Carolina's Medicaid program began working with its managed care programs to establish medical homes for eligible beneficiaries, the majority of which are designated through the National Committee for Quality Assurance (NCQA). Akin to other patient-based practice structures, such as Ontario's (Canada) Family Health Team Model, [28] medical homes are largely based on physician-led continuity of care delivery that includes multi-specialty care teams that utilize shared decision-making. [29] In the broadest sense, medical homes represent a transformative approach to improving patient care, reducing avoidable utilization, and increasing satisfaction among patients and providers. [30]

At the time of this study, Medicaid beneficiaries were able to attend 297 of the state's 367 medical homes that participated in its managed care network. During this time, medical homes were absent within 9 of the state's 46

counties. In addition, counties that had the greatest proportion of Medicaid participants were also the same counties with access that was more commensurate to hospitals than primary care providers. **Figure 1** illustrates the potential population differences in access to medical homes and hospitals throughout the state.

Our patient sample included a subset of Medicaid participants that met the inclusion criteria for the NCQA Healthcare Effectiveness Data and Information Set (HEDIS®) process measures. The HEDIS® tool is used by nearly every health plan across the U.S. to measure performance, examine different dimensions of care and service, as well as compare outcomes achieved within designated PCMH practices versus traditional primary care clinics. [31, 32] In this study, we used two HEDIS® measures to select the patient panel: initiation for follow-up care for attention-deficit/hyperactivity disorder (ADD) and medication management for children with asthma (MMA). The ADD measure is specific to recipients between 6 and 12 years of age who were newly prescribed ADHD medication. The MMA measure captures children between the ages of 5 and 18 (the age groups of 5-11 and 12-18 were collapsed into a single group). These measures were chosen because they highlight two patient groups that frequently present to EDs for disease-specific care that is often treatable in primary care settings. [33, 37]

Following guidelines in other Medicaid evaluations, [38] the study used a 3-year retrospective longitudinal cohort design, beginning with a baseline (reference) year of 2016. Patient claims were eligible for inclusion if the person was continuously enrolled in Medicaid for the entire 2016 reporting year, but enrollment was allowed to vary in subsequent years (e.g., enrolled in Medicaid during 2016 and 2017 only).

Measuring racial disparity using counterfactual models

Intuitively, all persons have the potential to experience multiple effects of treatment (e.g., experiencing a complication during hospital stay vs. not experiencing a complication, being injured vs. not being injured). Although a constellation of factors can be at the root of these experiences, the position the IOM took in “Unequal Treatment: Confronting Racial and Ethnic Disparities in Health Care” [20] was significant because it specified that variation in patient experiences cannot be justified by differences in a person’s needs, preferences, or attitudes toward care—the primary mechanisms by which racial/ethnic differences in health are often assessed. Rather, the IOM defined racial disparities as arising from two primary mechanisms: the legal and regulatory environment in which health care systems operate (i.e., linguistic barriers, fragmentation of services) and the discrimination that patients experience when obtaining care (i.e., treatment discrimination).

As shown in **Figure 2**, a distinctive feature of the IOM model is that all differences in outcomes between racial/ethnic groups are mediated through factors other than preferences or need. For non-linear models, measuring this effect requires specific techniques that distinguish between modifying factors from conditions that are legitimate drivers of these disadvantages. As such, adhering to the IOM definition of racial disparities requires simulating predictions for outcomes one patient group might experience had their health status, needs, and preferences been identical to their non-minority counterparts, but leaving all other factors that may modify these experiences alone.

The non-linear counterfactual model developed by McGuire et al. (2006) operationalizes the IOM definition of racial disparities and can be constructed in four steps. [39] First, a logistic regression model is fit to examine the effect of race/ethnicity on the outcome of interest and includes all variables and interactions that would typically be included in the analysis. Next, for each minority individual, the ranking of their within-group need-based

characteristics are transformed so that they are ranked proportionately to their ranking of the non-minority (i.e., non-Hispanic White) reference group. For non-linear models, this means replicating the entire shape of the reference group's need-related distribution onto the minority population, not just the reference population's average values. In other words, the first-ranked minority individual receives the same health status value as the first-ranked White individual, the third-ranked minority individual receives the same health status value as the third-ranked White individual, and so on. Next, the logistic regression model is re-estimated after replacing the original need-related variables of minorities with their transformed values. Lastly, the averages of the model are summarized and then interpreted as the hypothetical racial disparity distribution between racial/ethnic groups, usually as an average marginal effect. In this study, we generated predictions by first grouping patient groups by their PCMH status to ensure that aggregate comparisons and rankings were commensurate with the model of primary care that persons attended (e.g., minorities in PCMH were compared to Whites in PCMH, minorities in non-PCMH were compared to Whites in non-PCMH).

Importantly, McGuire et al. (2006) as well as Cook et al. (2012) discuss a number of arguments that can be made both for and against adjusting for geography in counterfactual models. [39, 40] In one view, minority concentration throughout areas that are persistently medically underserved as well as disproportionately impacted by differences in health service access make it appropriate to regard geography as part of the disparity. In short, these patterns are a measurable result of residential segregation. [41] If, however, the focus is to improve the distribution of providers within specific geographic areas or catchments, then access might be considered a nonmodifiable factor, assuming that all areas are already equally served or that all groups are evenly distributed. Alternatively, one could assess the contribution of geographical differences in health by estimating racial disparities with and without adjustment for geography. [42]

PCMH primary care model attribution

We assigned patients to primary care practices where they received their care using the National Provider Identifier (NPI) from the practice where care was received for the year that corresponded with the claim. Primary care-related visits were defined from the claims database using the following provider specialty classification types: "pediatrics," "family practice," and "internal medicine." These three provider types accounted for approximately 35% of all outpatient claims over the entire study period. These specialty codes also represent the three primary specialties used by the NCQA to certify primary care practices as designated medical homes.

It is important to note that it was not possible for our team to identify from the claims data how each Medicaid participant initially elected to enroll with their primary care provider. However, it was possible for us to identify whether the participant's health plan assigned them to a medical home as well as the designation of the practice where care was obtained. As such, Medicaid participants were defined as a PCMH patients if they received their primary care services from a designated medical home. We also included as an interaction a patient's medical home enrollment status as defined by their managed care plan. This attribution method provided the most conservative means to account for a PCMH effect in light of whether a person elected to obtain care from the clinic where they were enrolled, while also allowing us to account for whether proximity to providers was in any way associated with utilization.

Covariates

We were able to identify a limited set of covariate information from the claims data, including the person's age, sex, race, co-morbidity classification, type and amount of health care services received, as well as plan type (e.g., fee-for-service). Co-morbidities were defined using 3M™ clinical risk group classification codes (CRG). CRGs are a population classification system derived from inpatient and ambulatory diagnosis and procedure codes, pharmaceutical data as well as patient functional health status. [43] CRGs assign all patients to one of nine severity-adjusted groups, ranging in scale from healthy/non-users to catastrophic condition status. Fee-for-service enrollees were specified to account for instances that a Medicaid participant was not enrolled under a specific managed care plan. Patient race/ethnicity were limited to the following categories: non-Hispanic White, Black, and Hispanic. Because of small numbers, we excluded all claims where the participant was registered as mixed race/ethnicity, Federally Recognized Native American, American Indian/Other Native American, Alaska Native, Oriental/Asian, Other/Unknown, or Refugee/Entrant/Native Hawaiian. It is important to note that at the time of this study, the race/ethnicity field was not a mandatory data collection point by the South Carolina state Medicaid agency.

Through data linkages, we were able to obtain additional information pertaining to the median household income of the participant's residential census tract as well as the county proportion of medical homes relative to all primary care providers. We included county PCMH proportion to offset the limitation of not having any information as to why a Medicaid participant may have elected to use a PCMH or non-PCMH clinic. PCMH proportion was viewed as a proxy measure of accessibility, based on the presumption that obtaining a service is commensurate with its availability. Income estimates and county PCMH coverage were calculated each year using American Community Survey and the NCQA annual report file.

Emergency department admissions

We used the New York University (NYU) algorithm to measure ED admissions. The NYU algorithm is one of the most widely used tools for analyzing administrative diagnostic claims to classify ED visits based on level of acuity. [44-49] The NYU visit classifications include: "non-emergent," "emergent, but primary care treatable," "emergent, but preventable/avoidable," and "emergent, not preventable/avoidable." [50] As it is possible to have probability scores assigned across all four visit classifications, we used modifications to the event diagnosis groupings validated by Ballard et al. (2010) to assign "non-emergent" and "emergent, but primary care treatable" events into two distinct categories of avoidable and potentially avoidable admissions so long as the probability was greater than 0.50 for either event. [51] We excluded all visits that were flagged because of the result of injury, alcohol or drug-related causes since these conditions usually require ED services regardless of severity.

Geocoding & data linkages

We geocoded all patient claims and provider data at the address level and linked each unique Medicaid participant and care encounter that could be attributed to a pediatric, family practice, or internal medicine primary care visit. Travel distance estimates were constructed for all unique pairing between the participant's residential address and the physical location where primary and emergency care services were obtained. All distance estimates were derived using ESRI's Street Map Premium Address File, which is an enhanced version of commercial street reference data from HERE, TomTom, and INCREMENT P. The network analysis process was built using a composite geocoding algorithm using a validated approach. [52] The geocoded data files were then linked to its corresponding patient-, provider-, and area-level data in SAS statistical software for Windows using SQL scripting language.

In the regression models, travel distance to providers was a continuous measure representing differences in proximity between a person's residence and their primary care provider relative to the distance from the hospital where the admission occurred. Negative values represented the greater proximity (in miles) to hospitals compared to their primary care clinic, whereas positive values reflected better proximity to the primary care provider. Values of zero represent the estimated effect if there was no difference in travel to either location.

Statistical analysis

Our primary endpoint was the probability of avoidable and potentially avoidable ED admissions by PCMH status and patient race/ethnicity. Since Medicaid participants may have had multiple ED visits during the study period as well as may not have been enrolled for all 3 years of the study, we used a logistic model within a GEE to examine the probability of events to accommodate the missingness while explicitly modeling the within-subject correlation. Our model was constructed using an independent correlation structure, which we confirmed using the quasi-likelihood criterion test.

The regression equation below illustrates the basic structure of the model we used to estimate the probability of an admission before re-estimating the need-based factors to build the racial disparity estimates. In notation, the model is:

$$\text{logit}(E(Y_{ij})) = \hat{\beta}_0 + \hat{\beta}_1 \text{RACE} + \beta_2 \text{PCMH}_{ij} + \beta_3 (\text{PCMH}_{ij} \times \text{RACE}_{ij}) + \beta_4 N_{ij} + \beta_5 A_{ij} + \beta_6 P_{ij} + \beta_7 T_{ij}$$

Here, $E(Y_{ij})$ indexes an individual by their medical home attribution type and Y is the placeholder for the dependent variables. PCMH is a nominal indicator of the patient's medical home attribution type; and RACE is an indicator of whether the individual was non-Hispanic White, Black, or Hispanic. The N , A , and P indicators are placeholders for time variant and time-invariant covariates, including need-based factors that were re-estimated to be commensurate with non-Hispanic Whites using the proxy measures of personal needs and preferences (age, sex, co-morbidity), additional patient-level factors (enrollment months, fee-for-service), area factors (median household income, county PCMH saturation rates, geographic proximity to providers), as well as proxy measures for practice-level factors (weekend visit). We included year (T) as a fixed effect. We also included interactions for some of the covariates with patient race. All estimates were assessed as aggregated predictions, contrasted by the interaction between PCMH status and race/ethnicity. We used STATA for Windows bootstrapping estimators to calculate the magnitude of the disparity using an average marginal effect and generate measures of statistical significance using 100 simulations. As such, the geographic question facing population health inquiry is "are patient-centered medical homes capable of altering patient behavior and reducing racial disparities in light of where patients reside relative to the services they access?"

Results

The final patient sample consisted of 14,082 person-years from 8,924 unique Medicaid participants classified as being non-Hispanic White, Black, or Hispanic who met the inclusion criteria for analysis. Over this period, there were 25,441 ED admissions, of which 5,314 and 4,396 were defined as being either avoidable or potentially avoidable, for a person-year rate of 198 and 164 avoidable and potentially avoidable admissions per 1,000 person-years, respectively. A total of 9,752 of the 25,441 admissions were among PCMH patients, of which 2,006 (20.5%) and 1,704 (17.4%) were defined as avoidable and potentially avoidable. Within non-medical home

patients, there were 15,689 admissions, of which 3,308 (21.1%) and 4,396 (17.1%) were defined as avoidable or potentially avoidable.

As shown in **Table 1**, unadjusted comparisons in ED admissions by PCMH status were not statistically significant. Comparisons of proximity to providers varied across the cohort, with patients that were documented as enrolled within a medical home and attending a medical home for their primary care services having the shortest travel distances to clinics as well as hospitals. Medical home patients were statistically significantly more likely to be Black, younger, reside in neighborhoods with higher median income values, as well as have a higher yearly average number of primary care visits. Weekend ED admissions were marginally higher among patients whose primary care provider was a designated medical home.

Regression coefficients for the GEE models are shown in **Table 2**. After adjustment, attending a medical home was not independently associated with decreased risk of either an avoidable or potentially avoidable ED admission. Being Black was independently associated with a decreased risk of potentially avoidable admissions, but was also associated with an increased risk for avoidable admissions. Hispanic ethnicity was associated with an increased risk in avoidable admissions compared to non-Hispanic Whites. Duration of enrollment over the study period exhibited mixed trends depending on admission type, whereas female participants consistently exhibited higher risks compared to males. Patient age and CRG co-morbidity scores showed mixed associations with ED admission risk.

Among the socioeconomic and geographic indicators, county PCMH availability showed an independent association with an ED admission risk. Its interaction with beneficiaries who were Black suggests that greater county-level saturation of medical homes decreases the independent effect of race on avoidable admissions. Neighborhood income had a similar attenuating effect on avoidable admissions among Hispanic patients, but its point estimates did not suggest an independent effect overall. A patient's relative proximity to the hospital versus their proximity to primary care showed an overall negative association with ED admission risk. This reverse association suggests that as hospitals become less convenient (i.e., nearness to hospitals decrease), then the likelihood of admission goes down. However, the standard errors of the point estimates suggest that other trends are also reasonably compatible with our data, given the model assumptions.

Average marginal effects of the regression coefficients are shown in **Table 3**. As shown, being Black exhibited a statistically significant 2.9 percentage point decrease risk of a potentially avoidable admission and a 2.0 percentage point increase in an avoidable admission, respectively. Point estimates for ED admission risk and Hispanic ethnicity were not statistically significant. Attending a PCMH had no observable reduction on ED admissions compared to participants that did not attend a designated medical home. As geographic proximity to hospitals decreased, the probability of an admission decreased by 0.5 to 1.2 percentage points; but this effect was most apparent for avoidable admissions.

Table 4 shows the counterfactual marginal probabilities after altering the health needs and preference variables for minority patients to be those of non-Hispanic Whites. All models were adjusted comparisons. Bootstrapped errors are shown in parentheses. With respect to potentially avoidable ED admissions, medical home attendance reduced Black-White disparities by 3.4 percentage points ($p < 0.001$). Black-White racial disparities were similarly reduced among non-PCMH clinics (1.7 percentage points, $p < 0.10$), leading to an overall 1.8 percentage point reduction in Black-White racial disparities for potentially avoidable admissions ($p < 0.10$). Medical homes were

able to curb Hispanic-White disparities (2.6 percentage points, $p < 0.10$), but the overall 2.8 percentage point difference in admission risk was not statistically significant.

Table 4 also shows an inverted effect between PCMH attribution and race/ethnicity in relation to avoidable admission trends. Although differences in probability of avoidable admissions were largely similar across race/ethnicity among non-PCMH patients, there was a 2.3 ($p < 0.01$) and 5.6 percentage point ($p > 0.10$) increase in avoidable ED risk for Blacks and Hispanics that attended a medical home. However, these differences were not large enough to create an overall increase in racial disparity irrespective of different primary care models. Similar findings were generated for both admission types when the statistical models included geographic proximity to providers as part of the disparity.

Discussion

We analyzed a subset of Medicaid claims data for avoidable and potentially avoidable ED admissions at the patient level. Our focus was on the intersection between race/ethnicity, proximity to health care providers, and the type of primary care delivery model patients experienced; and we compared these trends through building counterfactual predictions of outcomes that minority groups would experience if their health status needs and preferences were identical to their non-Hispanic White counterparts. After adjustment, we observed that differences in risk exhibited among medical home patients was substantial enough to eliminate the overall Black-White racial disparity in potentially avoidable ED admissions. Medical homes exhibited similar effects for potentially avoidable admissions among Hispanic patients; but its effect suggests that it only curbs, rather than eliminates, the overall Hispanic-White disparity trend. These patterns were not consistently observed for ED admissions that were classified as completely avoidable.

This analysis, as well as recent investigations like it, [53] are designed to assess whether medical homes are helping to reduce racial disparities in outcomes attributable to transformations to U.S. primary care delivery models. As shown in this study, observational data on medical home utilization suggests that these primary models may be able to curb, but not necessarily eliminate, racial disparities in care. As our analysis illustrates, exposure rates differ across patient groups, suggesting that non-medical determinants and barriers may also differ across groups. These mixed findings are important to acknowledge as many policy makers believe that historically marginalized persons have the highest ceiling when it comes to PCMH benefit given that they often have the most room for improvement. [23]

To date, whether medical homes can reduce racial disparities in care, particularly in context of where patients and providers are located, has been largely unknown. Previous studies show that medical homes tend to improve health outcomes, lower costs over time, but do not consistently reduce racial or socio-economic disparities in access and quality of care. [53-55] In the same vein, our previous studies have raised concern over the geographic emergence of medical homes across the U.S., which shows trends that favor of more socioeconomically advantaged communities. [56] In this study, we combined claims data with information reflective of the geographic distribution of patients, their primary care providers, and the emergency departments where care was obtained. The effects suggest that spatial metrics remain important non-medical determinants for assessing medical home quality indicators as well as their impact on racial disparities.

These findings are also timely given recent amendments to numerous quality measures as part of an overall strategy to make reimbursement policies more equitable. For example, the Centers for Medicare and Medicaid

Services (CMS) recently amended its Hospital Reduction Readmissions Program (HRRP) to account for differences in readmission risk attributed to differences in patient socioeconomic case mix (HRRP). The NCQA is proposing similar modifications to its Healthcare Effectiveness Data and Information Set (HEDIS®) quality measures. [57] These modifications, and others like it, are designed to emphasize the non-medical determinants that contribute to health inequalities. They are also designed to incentivize providers to address health equity and to ensure that factors beyond clinical determinants are used to as part of primary care treatment. As our analysis illustrates, differences in outcomes for certain events among different patient groups may also be linked to their proximity to care. Expanding risk-adjustment criteria to also include geographic determinants may also help states and different payer groups to deploy structural interventions that can address their effects.

It has been estimated that 13% to 27% of all ED visits could be managed by primary care providers. [58] Prior to the US Patient Protection & Affordable Care Act, Medicaid was the most frequent payer for ED visits. [59] Over the last decade, Medicaid expansion has played a significant role in shifting the use of ED toward primary care options. Notably, trends in ED use for injury-related claims have increased. [60] Similarly, lowering avoidable ED admissions is also one of the key goals of PCMH transformation efforts. However, as with other evaluation metrics, PCMH evaluations have also shown mixed effects of various primary care initiatives regarding the effectiveness of the model on less ED use. [61] In particular, studies typically show that medical home interventions are most effective among chronically ill or intervention-specific cohorts, but a particular focus on race/ethnicity has been lacking. After accounting for patient race/ethnicity as well as several geographic and socioeconomic characteristics, we found that medical homes do show a significant percentage point reduction in overall ED utilization risk for Black and Hispanic patients for some, but not all, ED admission classifications. Contextually, these findings raise questions as to why disparities were eliminated for some admissions, but not for all. Factors such as resource availability or an inability to access clinic care are likely drivers of potentially preventable events. However, the results do provide some evidence that better management of chronic illness by PCMH-certified primary care practices does have an effect on reducing overall racial disparities in their occurrence.

Our study methodology should be interpreted within the contexts its strengths and limitations. One limitation of the methodology is that it average marginal effects models produce a single estimate of differences in risk, which can obscure differences in effects at more extreme values. From a policy/planning perspective, treating all patients as having the same health outcome status as whites may also not be intuitive. An alternative approach would generate marginal effects across a range of representative values (e.g., relative differences in utilization at 5 miles, 10 miles, etc.) and contrast differences in outcomes between racial/ethnic groups and different relative proximities to care. The benefit of this alternative approach is that can show whether the exposure has different effects on different population groups at different relative distances. Its limitation is that it brings one back to comparisons of differences, not disparities.

Our study findings should also be interpreted within the contexts of Medicaid claims data and the patient panels. For instance, these trends represent outcomes among two pediatric patient panels, not all pediatric Medicaid beneficiaries throughout the state. Secondly, we had access to a limited set of clinical, demographic, and socioeconomic factors for the analysis. Although the covariates that were included in this analysis are all meaningful for risk adjustment, other factors that we were unable to obtain (e.g., satisfaction with care, provider race/ethnicity, wait times) would further illuminate the degree to which medical homes have attenuated/eliminated racial disparities in health outcomes. Similarly, we could not determine all mechanisms

underlining a patient's provider choice. Our adjustment for enrollment status as well as county proportion of medical homes was used to help offset this limitation, under the assumption that access to medical homes is proportionate to their availability. Further, we could not confirm whether all individuals initiated their care from their place of residence or how they traveled to obtain care (e.g., car, bus, walk), but we could confirm that all claims analyzed represented physical encounters.

The study results are reflective of South Carolina's transition to a medical home modeled-care program for Medicaid beneficiaries, which follows similar state trends to improve primary care quality and curb escalating health care costs. [62] Among a cohort of enrollees, this study found evidence that medical homes may also be helping to reduce racial disparities in hospital admissions for services that are often more appropriately obtained in primary care settings. The finding that medical homes were the primary drivers for reductions in Black-White and Hispanic-White disparities merits further research in order to identify specific aspects of PCMH interventions that could be attributed to these reductions. Importantly, the racial disparities that we found should be interpreted within the context of a single insurance panel of a patient population that is already among the most socially vulnerable population group in the state. Comparisons with private or other commercial payer groups is likely to change the patterns we observed.

Within the context of geographic investigations, the approach shown in this study could be expanded to re-examine a host of factors that may underline racial disparities in health. Intuitively, this could entail re-estimating spatial hot/cold spots, or re-estimating differences in relative differences between different provider types (e.g., mental health providers), to provide two examples. Methodologically, this would require having access to individual-level data so that estimates of different spatial effects could be partitioned by race/ethnicity and minority frequencies/rates could be re-ranked according to patterns observed among non-Hispanic Whites.

Conclusion

Access to health care services is a multidimensional concept and influenced by factors that have both spatial and a-spatial dimensions. This study attempted to intersect these two dimensions by combining travel distances and impedances to services into counterfactual models designed to measure racial disparities in care. Although there is no method that harnesses every benefit of both approaches, the conflation of geographic proximity into need-based comparisons of racial disparities helps to capture key exposures thought to represent differences in outcomes among socially marginalized populations and is in line with recent efforts to bring greater transparency to where gaps do/do not exist within strategies to reduce disparities in care throughout the U.S.

Declarations

Ethics approval and consent to participate

This study was approved by the University of South Carolina's Institutional Review Board (IRB), number 00093322, titled "The effect of the patient-centered medical home on geographic and racial disparities in health care access"

Consent for publication

No details, images, or videos of an individual person are available in this manuscript.

Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available due to HIPAA and confidentiality restrictions.

Competing interests

The authors declare no competing interests in the preparation of this manuscript.

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Authors' contributions

NB and ALD conceived and designed the study. NB, BC, JB, and ALD acquired, analyzed and interpreted the data. NB wrote the initial draft of the manuscript. NB, BC, JB, and ALD revised the manuscript and accepted it in its final form. NB had full access to all of the data in the study and takes responsibility for the data integrity and the accuracy of the data analysis. All authors read and approved the final manuscript.

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Tables

Table 1 Patient clinical, demographic, and geographic characteristics by PCMH Attribution Type, 2016-2018

Characteristic	PCMH Attribution Type		p value
	Attended	Did not Attend	
Age (SD)	9.8 (3.2)	10.1 (3.2)	0.000
Female	2,212 (39.8)	1,343 (39.8)	0.939
Race/ethnicity			0.000
Non-Hispanic White	1,961 (35.3)	1,392 (41.3)	
Black	3,275 (58.9)	1,799 (53.4)	
Hispanic	321 (5.8)	176 (5.2)	
Clinical risk group			0.085
Healthy/non-users	687 (12.4)	433 (12.9)	
History of significant acute disease	393 (7.1)	276 (8.2)	
Single minor chronic disease	880 (15.8)	572 (17.0)	
Minor chronic disease in multiple organ systems	79 (1.4)	43 (1.3)	
Single dominant or moderate chronic disease	2,695 (48.5)	1,583 (47.0)	
Significant chronic disease in multiple organ systems	813 (14.6)	452 (13.4)	
Dominant chronic disease in 3+ organ systems	4 (0.1)	0 (0.0)	
Dominant and metastatic malignancies	2 (0.0)	2 (0.1)	
Catastrophic condition status	4 (0.1)	6 (0.2)	
Fee-for-service (FFS) plan	292 (5.3)	223 (6.6)	0.007
Primary care visits (SD)	6.7 (6.1)	5.6 (5.0)	0.000
Weekend ED visit	4,601 (29.3)	2,746 (28.2)	0.046
Median household income (SD)	42,272 (14,854)	41,223 (14,509)	0.001

County PCMH proportion (SD)	20.8 (16.2)	15.3 (15.0)	0.000
% ED admissions that were avoidable	3,308 (21.1)	2,006 (20.6)	0.326
% of ED admissions that were potentially avoidable	2,692 (17.2)	1,704 (17.5)	0.518
Primary care distances (miles, SD)			0.000
Not enrolled in a PCMH	35.4 (44.0)	36.0 (38.1)	
Enrolled in a PCMH	32.7 (42.2)	43.0 (31.6)	
Hospital distances (miles, SD)			0.281
Not enrolled in a PCMH	16.9 (42.0)	17.1 (46.2)	
Enrolled in a PCMH	15.7 (51.6)	16.6 (28.4)	

SD (standard deviation); ED (emergency department)

Table 2 GEE regression coefficients for avoidable and potentially avoidable admissions among a panel of Medicaid patients that met the inclusion criteria for HEDIS ADD and MMA measures

	Potentially avoidable admissions			Avoidable admissions		
	Coeff.	SE (95%)	p value	Coeff.	SE (95%)	p value
PCMH attendee	0.013	0.063	0.836	-0.055	0.062	0.370
Assigned to PCMH	-0.099	0.088	0.308	0.135	0.079	0.087
Attended x Assigned	0.147	0.098	0.136	-0.085	0.088	0.333
Age	-0.027	0.005	0.000	0.001	0.005	0.865
Female	0.112	0.034	0.001	0.223	0.032	0.000
Race						
Black	-0.306	0.129	0.018	0.255	0.122	0.038
Hispanic	-0.238	0.293	0.418	0.616	0.284	0.030
Clinical Risk Group						
History of significant acute disease	0.159	0.087	0.066	-0.097	0.080	0.227
Single minor chronic disease	0.079	0.075	0.292	0.098	0.066	0.139
Minor chronic disease in multiple organ systems	0.005	0.163	0.975	-0.051	0.148	0.729
Single dominant or moderate chronic disease	0.049	0.062	0.434	-0.170	0.056	0.002
Significant chronic disease in multiple organ systems	0.067	0.071	0.352	0.090	0.064	0.160
Dominant chronic disease in 3+ organ systems	–	–	–	-0.724	0.756	0.338
Dominant and metastatic malignancies	0.706	0.459	0.124	-1.123	0.742	0.128
Catastrophic condition status	1.069	0.399	0.007	-0.913	0.615	0.138
Fee-For-Service (FFS) plan	-0.083	0.081	0.308	-0.074	0.075	0.320
Weekend ED admission	0.055	0.036	0.130	0.091	0.034	0.007

Enrollment months	0.934	0.428	0.029	-0.722	0.402	0.073
PCP visits	0.445	0.306	0.145	-0.054	0.292	0.854
Median household income	-0.343	0.199	0.084	0.248	0.191	0.193
Income x Black	0.321	0.252	0.202	-0.301	0.236	0.201
Income x Hispanic	0.675	0.531	0.204	-1.622	0.539	0.003
County PCMH saturation	0.208	0.172	0.225	0.294	0.169	0.082
Saturation x Black	0.063	0.214	0.771	-0.482	0.208	0.020
Saturation x Hispanic	0.293	0.689	0.670	0.648	0.647	0.317
Distance to ED vs. PCP	-0.042	0.086	0.625	-0.105	0.090	0.245
Distance x Black	-0.170	0.131	0.194	0.008	0.122	0.945
Distance x Hispanic	0.078	0.208	0.707	0.021	0.205	0.918
Year						
2017	-0.119	0.067	0.075	0.111	0.063	0.081
2018	-0.223	0.111	0.045	0.214	0.105	0.042

Table 3 Average predictive margins for avoidable and potentially avoidable emergency department (ED) admissions among the panel of Medicaid patients that met the HEDIS inclusion criteria, 2016 - 2018

	Potentially avoidable admissions			Avoidable admissions		
	Margin	SE (95%)	p value	Margin	SE (95%)	p value
PCMH patient	-0.004	0.006	0.440	-0.001	0.006	0.898
Assigned to PCMH	-0.001	0.006	0.843	0.014	0.007	0.038
Age	-0.004	0.001	0.000	0.000	0.001	0.865
Female	0.016	0.005	0.001	0.037	0.005	0.000
Race						
Black	-0.029	0.005	0.000	0.020	0.006	0.000
Hispanic	-0.010	0.012	0.425	0.018	0.013	0.167
Clinical Risk Group						
History of significant acute disease	0.023	0.013	0.068	-0.016	0.014	0.214
Single minor chronic disease	0.011	0.010	0.290	0.018	0.012	0.137
Minor chronic disease in multiple organ systems	0.001	0.022	0.975	-0.009	0.025	0.727
Single dominant or moderate chronic disease	0.007	0.009	0.429	-0.028	0.009	0.003
Significant chronic disease in multiple organ systems	0.009	0.010	0.349	-0.015	0.011	0.164
Dominant chronic disease in 3+ organ systems	–	–	–	-0.102	0.082	0.215
Dominant and metastatic malignancies	0.120	0.093	0.196	-0.139	0.059	0.018
Catastrophic condition status	0.199	0.091	0.030	-0.120	0.059	0.038
Fee-For-Service (FFS) plan	-0.011	0.011	0.296	-0.013	0.012	0.282
Enrollment months	0.133	0.061	0.029	-0.119	0.067	0.073
PCP visits	0.063	0.043	0.145	-0.002	0.048	0.966
Median household income	-0.017	0.017	0.306	-0.003	0.018	0.874
County PCMH saturation	0.037	0.015	0.012	0.001	0.016	0.962
Distance to ED vs. PCP	-0.005	0.005	0.272	-0.012	0.006	0.030
Year						
2017	-0.017	0.010	0.079	0.019	0.010	0.059
2018	-0.031	0.015	0.042	0.039	0.018	0.027

SE (Standard Error)

Table 4 Comparison of adjusted predicted probabilities and racial disparities in potentially avoidable and avoidable ED admissions by medical home attribution type (standard errors shown in parentheses)

	Potentially Avoidable Admissions				
	White	Black	Disparity	Hispanic	Disparity
Did not attend a PCMH	0.184** (0.008)	0.168*** (0.005)	-0.017* (0.009)	0.187** (0.018)	0.003 (0.019)
Attended a PCMH	0.194** (0.005)	0.159*** (0.004)	-0.034*** (0.007)	0.168** (0.012)	-0.026* (0.015)
D Disparity			-0.018* (0.011)		-0.028 (0.021)
Avoidable Admissions					
Did not attend a PCMH	0.205*** (0.008)	0.208*** (0.007)	0.003 (0.011)	0.199*** (0.019)	-0.007 (0.020)
Attended a PCMH	0.197*** (0.006)	0.220*** (0.006)	0.023** (0.009)	0.213*** (0.014)	0.056 (0.014)
D Disparity			0.020 (0.014)		0.022 (0.023)

*** p <0.01, ** p < 0.05, * p < 0.10

Figures

Figure 1

Distribution of Medicaid enrollees (ages 18 and younger) to all children in the state in relation to hospital (with emergency department) availability and NCQA-designated patient-centered medical homes.

Figure 2

The U.S. Institute of Medicine's (IOM) "Differences, Disparities, and Discrimination: Populations with Equal Access to Healthcare" conceptualization of racial disparities in health care quality.