Differences Between Physician Social Networks for Cardiac Surgery Serving Communities With High Versus Low Proportions of Black Residents

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Background: Compared with white patients, black patients are more likely to undergo cardiac surgery at low-quality hospitals, even when they live closer to high-quality ones. Opportunities for organizational interventions to alleviate this problem remain elusive.

Objectives: To explore physician isolation in communities with high proportions of black residents as a factor contributing to racial disparities in access to high-quality hospitals for cardiac surgery.

Research Design: Using national Medicare data (2008–2011), we mapped physician social networks at hospitals where coronary artery bypass grafting procedures were performed, measuring their degree of connectedness. We then fitted a series of multivariate regression models to examine for associations between physician connectedness and the proportion of black residents in the hospital service area (HSA) served by each network.

Measures: Measures of physician connectedness (ie, repeat-tie fraction, clustering, and number of external ties).

Results: After accounting for regional differences in healthcare capacity, the social networks of physicians practicing in areas with more black residents varied in many important respects from those of HSAs with fewer black residents. Physicians serving HSAs with many black residents had a smaller number of repeated interactions with each other than those in other HSAs ($P < 0.001$). When these physicians did interact, they tended to assemble in smaller groups of highly interconnected colleagues ($P < 0.001$). They also had fewer interactions with physicians outside their immediate geographic area ($P = 0.048$).

Conclusions: Physicians in HSAs with many black residents are more isolated than those in HSAs with fewer black residents. This isolation may negatively impact on care coordination and information sharing. As such, planned delivery system reforms that encourage minorities to seek care within their established local networks may further exacerbate existing surgical disparities.

Key Words: cardiac surgery, racial disparities, social network analysis

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Research has consistently demonstrated that black patients die more often after coronary artery bypass grafting (CABG) procedures than white patients of comparable health.[1,2] These poorer surgical outcomes relate, in part, to differential access to high-quality hospitals.[3] For reasons that are not attributable to simple geographic proximity, black patients are more likely than their white counterparts to undergo CABG procedures at hospitals with higher rates of surgical mortality.[4] This problem seems to be most pronounced in communities that are home to many black residents.[4]

Although research assessing the emergence and maintenance of racial disparities in cardiovascular health has proliferated dramatically in recent years, the underlying mechanisms remain unclear. A number of potential contributors have been identified, ranging from differential socioeconomic status and educational attainment[5–7] to the varying capacity of hospitals treating black and white patients.[8] Seminal work by Bach et al[9] suggests an additional explanation—primary care physicians (PCPs) who treat black patients report lower levels of access to specialty care and other important clinical resources.

However, separate and unequal patterns of hospitalization for CABG procedures may be due to more than specialist access alone. Referral relationships that work to shape collaboration between PCPs and specialists in the communities that they serve could also contribute. PCPs rely heavily upon frequent interactions with their specialist colleagues for clinical guidance and support.[10–12] In this way, physicians are embedded in a dynamic network of referral relationships. Insofar as the networks serving communities

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with many black residents are poorly organized, the physicians in them may be more isolated from one another and, thus, be poorly equipped relative to physicians in other communities to collaborate and provide high-quality surgical care.

In this context, we analyzed national Medicare claims from beneficiaries aged 66 years and older who underwent CABG procedures between 2008 and 2011. We then used the tools of social network analysis to map the physician referral networks at the hospitals where these beneficiaries received their cardiac surgery. After characterizing these networks across a range of structural properties that are known to have an impact on coordination and information sharing, we compared the connections among physicians in hospital service areas (HSAs) with both high and low proportions of black residents.

METHODS

A network is a collection of points (or nodes) connected together in a series of lines (called ties). In a social network, the nodes represent individuals within a particular social environment, and each tie connecting them denotes some form of interaction.[13] In this study, we examined physician social networks, where individual physicians are tied together by a series of shared patients.[14–16] We mapped these networks using medical claims data from the Medicare program. Empirical work has shown that shared patients in medical claims are a predictor of meaningful relationships between physicians.[17]

Study Population

We began by identifying all beneficiaries aged 66 years and older from the Medicare Provider Analysis and Review (MedPAR) file who underwent a CABG procedure between January 1, 2008 and December 30, 2011 (N = 164,280). We chose this procedure for several reasons. First, racial disparities in access to high-quality hospitals are well documented for CABG.[3] Second, by focusing on patients who were all treated with the same procedure, we enhanced the comparability of our study population. Third, cardiac surgery almost inevitably involves patient referrals from a PCP to a specialist. As these referrals often determine hospital placement, they may be particularly important for understanding how network dynamics perpetuate disparities.

To ensure complete encounter data around surgery, we required that beneficiaries had continuous enrollment in Medicare parts A and B 6 months before surgery and 60 days after hospital discharge for inclusion in our sample. We chose to exclude Medicare Advantage patients because the services provided to them are captured inconsistently in their claims. Extracting from the MedPAR file, we determined the hospitals where each patient's surgery had been performed. For descriptive purposes, we anchored the physician social networks described below on these hospitals.

Identifying Physicians Who Provided Care Around the Surgical Episode

After identifying all patients who underwent CABG at each sample hospital, we determined the physicians that provided perioperative care to them through paid claims in the Carrier file. We used the encrypted National Provider Identifier and appropriate Medicare provider specialty codes to identify each patient's treating surgeon. We designated the cardiac surgeon who billed for a CABG procedure nearest to the patient's surgery date (from the MedPAR file) to be the treating surgeon.

Next, we used the plurality algorithm described by Pham et al[18] to distinguish each patient's PCP. In brief, we reviewed all fee-for-service claims filed on the beneficiary's behalf in the 6 months leading up to the index hospitalization. The patient's PCP was designated as the internal medicine, family practice, or general practice physician (based on associated National Provider Identifiers and provider specialty codes) who billed for the greatest number of evaluation and management services during this time period.

We then determined the other medical and surgical specialists who participated in the surgical episode by defining a claims window that encompassed the surgery. Using service dates in the Medicare files, we abstracted all claims filed within 30 days of and 60 days after the index hospitalization. We considered evaluation and management services and procedures but excluded claims from specialties in which physicians were not involved in direct patient care (eg, radiology) or had limited roles in perioperative management (eg, anesthesia).

Mapping Physician Social Networks

Once all physicians who delivered care during the surgical episode had been determined, we used a 2-stage process to map the physician social networks at each sample hospital. In the first stage, we aggregated across a hospital's patients within each study year to generate a bipartite network such that ties connected patients to physicians. In the second stage, we created a unipartite projection of the bipartite network where physicians were directly connected to one another with ties representing shared patients.

For our main analysis, only 1 shared patient was required to define a tie between 2 physicians. However, physician survey data suggest that a physician is more likely to report an information-sharing relationship with another physician as the number of shared patients (measured by medical claims) increases between the 2.[17] Thus, we explored higher tie thresholds but found no substantive differences in the network properties described below. Because these alternative thresholds likely eliminated some ties that represented true relationships, only the results of our main analysis are reported herein.

Summarizing Physician Connectedness

Having mapped the physician social networks for cardiac surgery at each sample hospital, we then summarized the internal patterns of connection among the physicians. We characterized these networks across a range of properties that are known to have an impact on coordination and information sharing, including the network's repeat-tie fraction, its clustering coefficient, and its number of external ties (Table 1). Assessing these properties allowed us to make direct comparisons between the networks themselves.

TABLE 1. Description of Network Terms

Structural Property	Definition	Operationalization
Repeat-tie fraction	Tendency for physicians in it to have worked together in the past	The fraction of physician pairs in a network that shared one or more patients above our tie threshold
Clustering	Tendency for physicians in it to assemble in smaller groups of highly interconnected colleagues	The mean probability that 2 physicians in it, who have a tie with a particular physician, have themselves a shared patient
No. external ties	Tendency for physicians in a network to have contact with others outside their immediate area	The total physicians in a given network who practiced outside the core-based statistical area where the network's anchor hospital was located

Repeat-tie Fraction

A network's repeat-tie fraction reflects the tendency for physicians in a network to have worked together in the past. Network theory suggests that communication between actors improves as the frequency of interactions that make up a relationship increases.[19] Therefore, a high repeat-tie fraction would be considered desirable from a care coordination perspective. We calculated the repeat-tie fraction as the proportion of physician pairs in a network that shared 2 or more patients in common.

Clustering

Clustering refers to the tendency for physicians in a network to assemble into tightly interconnected clusters (referred to as cliques) around shared patients.[13,20] Networks with high levels of clustering may yield benefits to some patients because physicians who collaborate with the same group of colleagues regularly are more likely to develop a shared sense of familiarity and trust.[10,21–23] Clustering may also provide physicians with more opportunities to interact with their local colleagues and trade updates on the status of shared patients.[24–26] Despite these benefits, clustering can also be problematic. When members of a network are more heavily interconnected within their own clusters, they tend to be more inward looking and, therefore, less willing or able to access new knowledge and ideas from outside sources.[24] We calculated each network's clustering as the probability that 2 physicians in the network—each of whom shared a patient with a common third doctor—also shared a patient themselves.

External Ties

External ties represent the tendency for physicians to share patients with practitioners outside of their immediate area. Research from the high-technology sector indicates that ties of this type facilitate innovation and the diffusion of new ideas.[20,27,28] As such, a physician working in a social network with many external ties is more likely to be aware of the latest medical advances. We calculated the number of external ties as the total physicians in a given network who practiced outside the core-based statistical area where the network's sample hospital was located.

Measuring the Proportion of Black Residents in an HSA

To determine the proportion of black residents in a given HSA, we used publically available data from the 2010 US Census. Specifically, we divided the number of black residents in an HSA by the total number of residents in it based on population estimates from the ZIP Code Tabulation Area Demographic Profile Summary File. Expressed as a percent, we then sorted all HSAs into 3 comparably sized terciles of low (0%–6%), moderate (6%–17%), and high (17%–78%) black proportion.

Accounting for Other Influences on Racial Disparities

Racial disparities in cardiac surgery are a complex phenomenon. Prior research has documented that differences in access to high-quality hospitals are subject to many influences.[29] To explore whether physician social networks may play an independent role in creating and perpetuating these disparities, we, therefore, also considered an array of sociocultural, healthcare capacity, and hospital factors.

Sociocultural Factors

Studies of racial disparities point to the important role of structural factors, including ongoing asymmetries in the socioeconomic status of black versus white patients,[5,30] differences in educational attainment,[31,32] and racial and ethnic discrimination in the healthcare system.[33] To address these considerations, we constructed control variables for the proportion of residents in each HSA living below the federal poverty line, living in rural areas, holding a graduate or professional degree, and/or who were over age 65. We also assessed differences across HSAs with respect to their ethnic composition by developing measures of their total population and their proportion of Hispanic residents.

Healthcare Capacity Factors

Studies have also shown that racial disparities can be attributed, in part, to healthcare capacity factors. Overall, black patients tend to have lower levels of access to new cardiac technologies and intensive-care services than do their white counterparts.[3,34–37] In addition, researchers have proposed that the higher rates of complications identified among black patients may be linked to poor follow-up care or insufficient referrals for rehabilitative services.[38] Therefore, we used data collected by the *Dartmouth Atlas* to create a series of measures to account for the number of acute care beds, PCPs, specialist physicians, and surgeons per capita in the HSAs served by our physician social networks.[39]

Hospital Factors

Some have suggested that racial disparities in cardiac surgery may be caused by differences in the severity of patients' cardiac disease at the time of diagnosis[40] or the higher rates of comorbid illnesses—especially hypertension and

diabetes—among black patients.[41–43] Accordingly, we used an established diagnosis code-based algorithm for use with medical claims to calculate the average Charlson index score for each sample hospital's patients.[44]

In addition, we used data based on ZIP code of residence to compute several variables that captured the socioeconomic condition of patients treated at the hospital, including the proportions of patients who lived below the poverty line, lived in a rural area, and had a graduate education. We also determined the proportions of treated patients who were black or Hispanic. Finally, we assessed each hospital's mean annual caseload, the number of CABG referrals that came from outside the HSA where the sample hospital was located, and the hospital's academic affiliation.[45]

Statistical Analysis

As an initial step, we used 1-way analysis of variance to characterize the HSAs and sample hospitals served by our physician social networks over the factors described above, stratifying them by the their proportion of black residents tercile. We then estimated a series of multivariate regression models to determine whether the patterns of connection among physicians in a network related to the proportion of black residents in the HSA that the network served. The dependent variable for each of these models was one of the 3 network properties. Because repeat-tie fraction and clustering are both proportions, we use a random-effects tobit specification with left and right censoring at 0 and 1, respectively. We used a random-effects negative binomial specification to model external ties, as the variable is a count and takes on only non-negative integer values. The independent variable was the proportion of black residents in the HSA served by the network. We adjusted our models for the measured sociocultural, healthcare capacity, and hospital factors thought to influence disparities. We also controlled for the number of physicians in the network.

We performed all analyses using Stata SE Version 13.1. All tests were 2-tailed and we set the probability of type 1 error at 0.05. The institutional review board of the University of Michigan approved this study.

RESULTS

Characteristics of HSAs With High and Low Proportions of Black Residents

As shown in Table 2, people in HSAs with many black residents were more likely than those in HSAs with few black residents to live below the federal poverty line ($P<0.001$). Their communities were also less rural ($P<0.001$). Although there were comparable numbers of PCPs and surgeons practicing across HSAs, areas with more black residents tended to

TABLE 2. Characteristics of HSAs and Sample Hospitals in 2011, Stratified by the Proportion of Black Residents

	Low Proportion		Moderate Proportion		High Proportion		
	Mean	SD	Mean	SD	Mean	SD	*P*
HSA level							
Sociocultural measures							
Population (log)	12.64	1.01	13.25	1.05	13.68	1.11	0.00
Proportion of Hispanic residents	0.17	0.21	0.17	0.15	0.13	0.13	0.00
Proportion of residents with graduate education	0.11	0.06	0.11	0.06	0.11	0.04	0.41
Proportion of residents living beneath the federal poverty line	0.14	0.06	0.15	0.05	0.19	0.05	0.00
Proportion of residents living in rural areas	0.17	0.18	0.12	0.14	0.11	0.13	0.00
Proportion of residents aged 65 years and above	0.14	0.04	0.13	0.04	0.12	0.03	0.00
Healthcare capacity measures							
Acute care hospital beds per 1000 residents	2.14	0.60	2.27	0.52	2.72	0.64	0.00
PCPs per 100,000 residents	66.94	16.01	67.61	16.90	68.25	15.84	0.54
Medical specialists per 100,000 residents	42.26	12.37	45.42	14.63	49.67	12.98	0.00
Surgeons per 100,000 residents	37.98	9.88	37.37	8.63	38.50	8.13	0.22
Hospital-level							
No. patients	37.50	33.70	46.26	41.98	49.76	49.45	0.00
No. physicians (log)	4.56	0.77	4.86	0.77	4.82	0.99	0.00
Proportion of patients from outside the CBSA	0.52	0.25	0.50	0.24	0.49	0.25	0.15
Academic hospital	0.47	0.50	0.53	0.50	0.61	0.49	0.00
Charlson score	2.29	0.62	2.36	0.57	2.40	0.63	0.04
Proportion of patients living below federal poverty line*	0.13	0.05	0.13	0.04	0.15	0.05	0.00
Proportion of patients with graduate education*	0.09	0.04	0.10	0.04	0.09	0.04	0.22
Proportion of patients living in a rural area*	0.29	0.23	0.25	0.19	0.26	0.21	0.01
Proportion of Hispanic patients	0.15	0.18	0.13	0.13	0.10	0.11	0.00
Proportion of black patients	0.01	0.03	0.03	0.07	0.09	0.13	0.00
Hospitals (N)	380		381		372		

All tests are 2-tailed tests (1-way analysis of varince). Data on sociocultural measures (eg, total resident population, race/ethnicity measures, rural/urban designation, poverty, and education) were compiled using data from the 2010 US Census, then aggregated from the ZIP code tabulation area level to the HSA level by matching local ZIP codes. Capacity and some hospital-level measures (eg, academic affiliation) were compiled using statistics from the *Dartmouth Atlas of Health Care* and the American Hospital Association Annual Survey. Other measures (eg, total patients/and physicians) were calculated using the Medicare Provider Analysis and Review data for 2008–2011 CABG procedures.

*Estimated using levels found in patients' home ZIP codes.

CBSA indicates core-based statistical area; HSA, hospital service area; PCP, primary care physician.

use higher numbers of medical specialists ($P<0.001$). In addition, they had significantly more acute care hospital beds per capita than HSAs with fewer black residents ($P<0.001$).

Characteristics of Sample Hospitals in HSAs With High and Low Proportions of Black Residents

The sample hospitals in HSAs with high and low proportions of black residents are also displayed in Table 2. Hospitals in HSAs with many black residents tended to have larger physician staffs ($P<0.001$) and greater annual caseloads ($P<0.001$). They were also more likely to have an academic affiliation ($P<0.001$). Further, as indicated by the Charlson score, sample hospitals in HSAs with many black residents had a less favorable case-mix ($P=0.040$). Unadjusted 60-day mortality rates (Fig. 1) also differed significantly between sample hospitals in areas with low and high proportions of black residents (5.8% vs. 6.7%, respectively; $P=0.001$).

Proportion of Black Residents and Physician Social Network Organization

Even after adjusting for the HSA and hospital factors displayed in Table 2, we found that the relationships between physicians serving HSAs with higher proportions of black residents differed in measurable ways from those in HSAs with low proportions of black residents (Table 3). Specifically, physicians in areas with higher proportions of black residents had fewer repeated interactions with each other ($P<0.001$). When physicians in HSAs with more black residents did interact, they tended to assemble in smaller groups of highly interconnected colleagues, as measured by the clustering coefficient ($P<0.001$). Moreover, they had fewer interactions with physicians outside their local community ($P=0.048$). To test the robustness of these findings, we analyzed the physician social networks for 2 other surgical cohorts (one for patients undergoing colectomy, and the other for total hip replacement) and observed consistency of our results (available upon request).

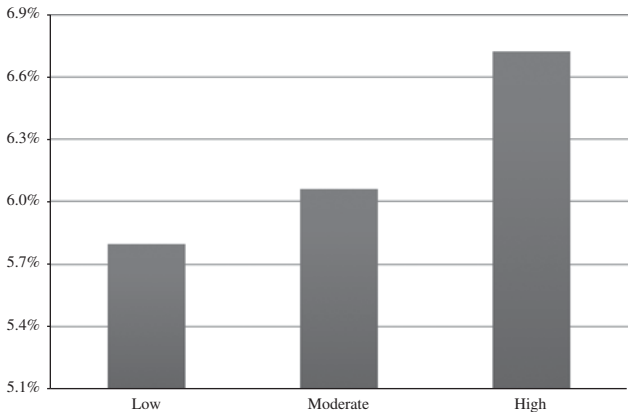

FIGURE 1. Sixty-day mortality rates across hospital service areas, stratified by the proportion of black residents.

Figure 2 shows 6 physician social networks from HSAs with higher and lower proportions of black residents. The networks are visualized using spring embedder methods, whereby physicians (represented by red and light blue points) are positioned through an iterative algorithm in such a way to reveal intrinsic network organization. Clear structural differences are apparent. There is more clustering among physicians at selected hospitals in Boynton Beach, Houston, and Detroit, however, the physicians have few repeated interactions [represented by dark (vs. pale) lines] than providers in comparable HSAs with lower proportions of black residents. The number of external ties (represented by light blue points) is also sparser.

DISCUSSION

We found substantial differences between physician social networks formed around CABG procedures serving HSAs with high and low proportions of black residents. Low repeat-tie fractions, high levels of clustering, and few external ties seem to be more common in communities with many black residents. As such, the physicians serving these communities are more isolated. Given their isolation, physicians in HSAs with high proportions of black residents are expected to have less exposure to current practice standards and the latest medical advances. In this context, our findings could help explain the diminished access that black patients have to high-quality hospitals for cardiac surgical care.

Physician isolation could relate to the fact that the care of black patients is often concentrated among a small number of providers,[9] who operate in chaotic and understaffed work environments and are less likely to report high job satisfaction when compared with those who predominantly treat nonminority patients.[46] Insofar as these physicians are "stretched thin" and experience higher rates of turnover, their networks are expected to be less well connected. Yet, we observed that HSAs with more black residents tended to use higher numbers of medical specialists. In addition, our sample hospitals in HSAs with many black residents tended to have larger physician staffs.

Homophily, or the tendency of individuals with similar characteristics to interact with one another, may also contribute to our findings.[47] A prior claims-based analysis showed that physicians are more likely to share patients with colleagues who have patient panels and practice locations like their own.[14] However, the observations on physician connectivity in HSAs with more black residents were robust to case-mix and other provider-level factors. Regardless of the reasons for them, our findings suggest that the physician social networks in HSAs with high proportions of black residents are poorly organized for cardiac surgical care delivery.

Our study must be considered in the context of several limitations. First, our analysis was based entirely on elderly Medicare beneficiaries. It is possible that patient-sharing relationships between physicians may differ for younger patients. This limitation is particularly relevant to our study given that black patients tend to have an earlier onset of heart

TABLE 3. Multivariate Models of Physician Social Networks and Proportion of Black Residents

	Repeat Ties		Clustering		External Ties	
	Coef.	SE	Coef.	SE	Coef.	SE
Proportion of black residents	−0.09***	0.02	0.09***	0.02	−0.58*	0.29
HSA level						
Sociocultural measures						
Population (log)	−0.02***	0.00	0.01***	0.00	0.03	0.03
Proportion of Hispanic residents	−0.07***	0.02	0.07**	0.03	−0.20	0.32
Proportion of residents with graduate education	−0.10*	0.05	−0.05	0.05	1.10	0.63
Proportion of residents living beneath the federal poverty line	0.15***	0.04	−0.28***	0.05	3.89***	0.54
Proportion of residents living in rural areas	0.01	0.02	0.00	0.02	2.23***	0.25
Proportion of residents aged 65 years and above	−0.09	0.05	−0.08	0.06	1.88*	0.76
Healthcare capacity measures						
Acute care hospital beds per 1000 residents	0.00	0.00	−0.01*	0.00	−0.20***	0.05
PCPs per 100,000 residents	0.00	0.00	0.00	0.00	0.00	0.00
Medical specialists per 100,000 residents	−0.00***	0.00	0.00*	0.00	−0.01**	0.00
Surgeons per 100,000 residents	0.00**	0.00	0.00	0.00	0.00	0.00
Hospital-level						
No. patients	0.00***	0.00	0.00	0.00	−0.00*	0.00
No. physicians (log)	0.03***	0.00	−0.15***	0.00	1.56***	0.03
Proportion of patients from outside the CBSA	−0.05***	0.01	0.01	0.01	0.75***	0.07
Academic hospital	0.00	0.00	0.00	0.00	−0.06*	0.03
Charlson score	0.00**	0.00	0.02***	0.00	−0.06**	0.02
Proportion of patients living below federal poverty line†	−0.10**	0.04	0.11*	0.05	2.44***	0.48
Proportion of patients with graduate education†	−0.05	0.05	−0.04	0.06	−1.72**	0.60
Proportion of patients living in a rural area†	0.03**	0.01	−0.07***	0.01	0.68***	0.12
Proportion of Hispanic patients	0.00	0.02	0.00	0.03	−1.00**	0.31
Proportion of black patients	0.03**	0.01	−0.01	0.02	−0.93***	0.19
Constant	0.32***	0.05	1.09***	0.05	−5.15***	0.64
Year-fixed effects	Yes		Yes		Yes	
State-fixed effects	Yes		Yes		Yes	
Hospital random effects	Yes		Yes		Yes	
Observations (N)	4529		4529		4529	
Hospitals	1180		1180		1180	
Log-likelihood	6869.84		5721.66		−1,6107.18	
df	74		74		74	

Standard errors in parentheses.
Estimates are derived from random effects negative binomial (external ties) and tobit (clustering and repeat ties) regression models.
†Estimated using levels found in patients' home ZIP codes.
CBSA indicates core-based statistical area; Coeff., coefficient; *df*, degrees of freedom; HSA, hospital service area; PCP, primary care physician.
*$P<0.05$.
**$P<0.01$.
***$P<0.001$; 2-tailed tests.

disease. Second, we anchored our physician social networks around hospitals in each HSA. If the treating surgeons that we identified operated multiple hospitals in the same year, the issue of network interdependency arises. However, consistent with the work of others, we found that surgeon loyalty to a single hospital was very high, limiting the potential for autocorrelation.[48] Third, our analysis only considered relationships between physicians that occur through shared patients. Because ties may occur by other mechanisms (eg, "curbsides" or professional society comembership) not easily captured in claims, our analysis may underestimate the amount of information sharing between physicians.

Finally, we emphasize that the network differences identified herein are not intended as a comprehensive explanation for all existing health disparities between black and white patients, or even the subset of those pertaining to cardiac surgery. A variety of factors have been explored to account for such disparities, and in all likelihood, many act in concert to influence the delivery of cardiac surgery. Our purpose in advancing physician social networks as a potential contributor is not to supersede other proposed mechanisms. However, we would suggest that while predisposition to high blood pressure surely stimulates racial disparities, factors like it operate well beyond the immediate control of either physicians or patients. Moreover, although structural factors surely contribute in important ways to racial disparities, physicians hold little influence over, for instance, where patients live. Physician referral network organization, by contrast, offers a tangible, accessible corrective (if only a partial one)—a factor that physicians can control and manipulate "on the ground," right now and for all patients, in an effort to minimize race-based disparities in care.

Limitations notwithstanding, our study has important implications for planned payment and delivery system reforms, most notably those associated with accountable care organizations (ACOs). The success of an ACO depends, in part, on its ability to influence costs and quality in treating its patient population. Because patients who travel outside their

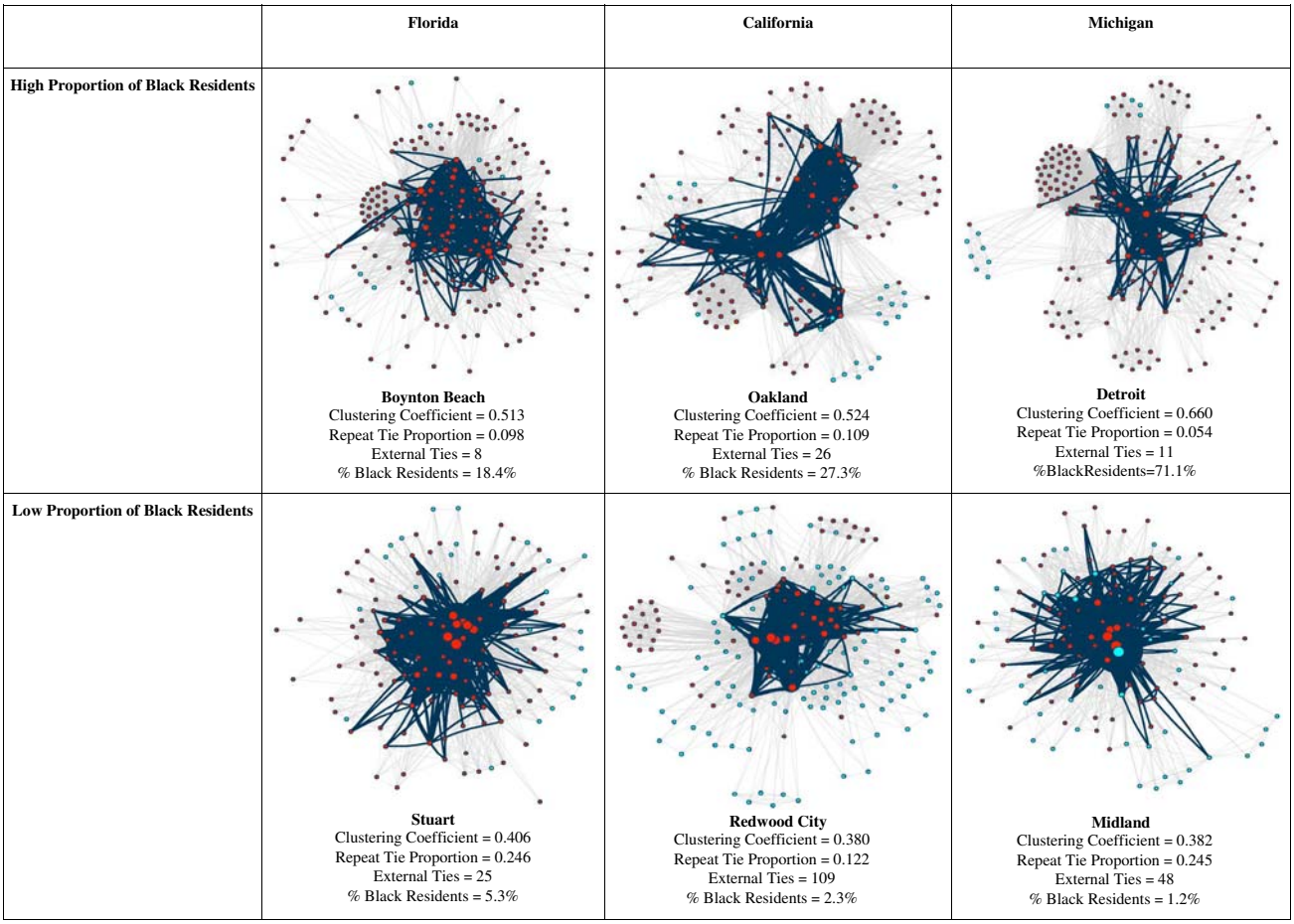

FIGURE 2. Physician social networks in 6 hospital service areas, 3 with higher and 3 with lower proportions of black residents. Red points indicate physicians practicing within the core-based statistical area where the anchor hospital is located. The size of the red point corresponds to the number of patients treated by the physician during the calendar year. Although there is more clustering of physicians in Boynton Beach, Oakland, and Detroit, the physicians have few repeated interactions [represented by dark (vs. pale) lines]. The number of external ties (represented by light blue points) is also sparser than in the network serving Stuart, Redwood City, and Midland.

assigned ACO create financial risk, ACOs must develop strategies to keep patients within their own system. To the extent that these strategies work to limit patient movement, minorities may be trapped within established local networks. Where local networks are poorly organized, these interventions may have the potential to exacerbate existing racial disparities in surgical outcomes, rather than working to minimize them.

To prevent this unintended consequence of ACO implementation, additional research is needed to establish the social, professional, and administrative mechanisms that drive network tie formation in the context of surgical care. A sustained program of research, synthesizing both quantitative analyses (such as our own) of referral patterns and qualitative analyses of physician decision making in situ, will lead us to a better understanding of the individual decisions and contexts that shape physician social networks. This understanding will allow ACO managers to incentivize desirable interactions between physicians, thereby enhancing minority access to high-quality providers and reducing persistent surgical disparities.

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