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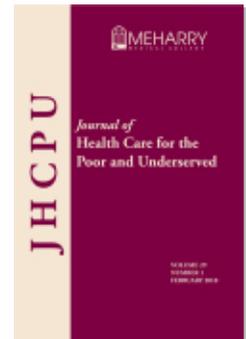
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The Racial and Ethnic Composition and Distribution of Primary Care Physicians

Imam M. Xierali, PhD
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Abstract: Racial and ethnic minority physicians are more likely to practice primary care and serve in underserved communities. However, there are micro-practice patterns within primary care specialties that are not well understood. To examine the differences among primary care physician practice locations by specialty and race/ethnicity, a retrospective study was conducted on U.S. medical graduates who were direct patient care physicians in 2012. The group-specific contributions to primary care accessibility were decomposed by individual group of minorities underrepresented in medicine (URM). Results confirm significant differences not only in their distribution across underserved areas but also in their racial/ethnic composition by primary care specialties, with internist most diverse and family physicians least diverse. However, stratified analysis shows that within each primary care subspecialty, URM physicians were more likely to practice in underserved areas than their White peers regardless of specific specialties.

Key words: Primary care physicians, diversity, accessibility, underserved communities.

The geographic mal-distribution of the health care workforce is a persistent problem transcending international boundaries.^{1,2} The prolonged existence of U.S. communities without adequate physician services is a continuing challenge to medical and public health systems in the United States. A 1998 Council on Graduate Medical Education (COGME) Report identified the geographic maldistribution of health care providers as “one of the most persistent characteristics of the American health care system.”³[Executive Summary, p.xiii] Previous studies have assessed the factors that appear to influence physician practice in underserved areas.^{4,5,6} Previous studies also found that minority physicians under-represented in medicine (URM) are more likely to practice primary care and serve in medically underserved areas and increasing physician workforce diversity could improve physician distribution both by specialty and by geography.^{7,8} For example, research indicates medically underrepresented minority physicians are important for delivery of primary care, provide care to indigent and minority populations, and improve access to health care services in underserved communities.^{9,10,11,12}

However, while the racial and ethnic diversity of the U.S. population continues to

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increase, the physician workforce has been diversifying at a much slower speed and uneven course. Reports of general lack of diversity in a number of medical and surgical specialties, such as radiology, oncology, emergency medicine, orthopedic surgery, obstetrics and gynecology, and ophthalmology documented the continuing lack of diversity in certain specialties.^{13,14,15,16,17,18} Studies have documented the significant distributional differences among primary care physicians by specialties. Family physicians constitute the largest group of primary care physicians, and their distribution is believed to be more proportionate to the population distribution than are those of other physician specialists.^{19,20} However, there are no recent studies on differences in diversity composition across primary care specialties nor of the role that diversity of the physician workforce plays in improving geographic distribution of physician workforce.

In a time of growing health workforce needs nationwide, sufficient supply and equitable distribution of physician workforce is critical for the public's access to health care.²¹ While there are differences in terms of the level of diversity by physician specialties,²² within specialties there may be significant differences in practice locations by physician race and ethnicity. Furthermore, there is a lack of understanding of regions most dependent on URM physicians, largely due to the lack of detailed data at local areas. Although URM physicians tend to practice in underserved areas, their regional impact is not well understood. For example, while the Black or African American population is concentrated in the Southeast and urban areas, do Black or African American physicians distribute the same way? In this study we examine the differences in racial and ethnic diversity of primary care physicians from a national perspective and study the association between physician race/ethnicity and their geographic distribution controlling for their specialty. A secondary purpose of this study is to depict the regional distribution of areas most affected by the presence of primary care physicians who were from backgrounds underrepresented in medicine.

Methods

This is a retrospective cohort study. The American Institutes for Research Institutional Review Board approved this study and granted a waiver of informed consent from study participants. Physician demographic and practice information was from the American Medical Association (AMA) Physician Masterfile (December 31, 2012 data snapshot).²³ The Masterfile includes data on all current physicians residing in the United States who meet the educational and credentialing requirements to be recognized as physicians. Physicians' race and ethnicity information was retrieved from the Association of American Medical Colleges (AAMC) databases. Racial and ethnic groups were defined as mutually exclusive groups: (1) Hispanic or Latino (of any race), referred to as *Hispanic*; (2) non-Hispanic White, referred to as *White*, (3) non-Hispanic Black or African American, referred to as *Black*, (4) non-Hispanic Asian or Asian American, referred to as *Asian*, (5) non-Hispanic American Indian, Alaska Native, Native Hawaiian, or Pacific Islander, grouped as one category as *Native*, and (6) others, defined in this study as any non-Hispanic person with multiple races, unknown racial and ethnic information, or not classifiable in one of the previous categories. The underrepresented minority in medicine concept was first addressed by the AAMC in 1970 and was modified in

2004 to describe minorities that are underrepresented relative to their numbers in the general population, which currently includes Black, Hispanic, and Native (American Indian, Alaska Native, Native Hawaiian, or Pacific Islander).²⁴

The study cohort is direct patient care primary care physicians who graduated from medical schools in or after 1980. We choose to limit our sample because there was not a systematic collection of race/ethnicity information before the 1980s for U.S. medical graduates. We excluded international medical graduates (IMGs) in this study in that U.S. medical school diversity efforts are mostly relevant for U.S. medical graduates, and there is a lack of race/ethnicity data for substantial proportion of IMGs in our data sources. *Primary care physician* is a term used here that refers to physicians whose self-declared primary care specialties are in family medicine, general practice, general internal medicine, and general pediatrics.

We studied variations in physician practice locations by physician race and ethnicity stratified by their specialties. The AMA Masterfile was georeferenced and matched to rural and medically underserved areas in 50 U.S. states, District of Columbia, and Puerto Rico (excluding other U.S. territories). Specifically, we studied variations in primary care physician practice locations in federally designated Primary Care Health Professional Shortage Areas (HPSAs; as of February 2013),²⁵ Medically Underserved Areas/Populations (MUA/P; as of February 2013),²⁶ and rural areas stratified by physician specialties. Rural areas are defined in this study as census tracts with Rural-Urban Commuting Area Codes (2010 version) from 4 to 10.²⁷ The three geographic areas are usually associated with a lack of access to health care services and they spatially overlap in many areas. Centers for Medicare and Medicaid Services (CMS) provides millions of dollars annually in bonus payments to providers for services given in areas with certain types of shortage designations. Section 1833(m) of the Social Security Act provides bonus payments for physicians who furnish medical care services in geographic areas that are designated by the Health Resources and Services Administration (HRSA) as primary care HPSAs.²⁸ Section 330 of the Public Health Service (PHS) Act defines the Federal Health Center Program as the funding opportunity for organizations to provide primary care services in medically underserved urban and rural communities.²⁹ Therefore, the main outcome measure of this study is the proportion of physicians by race and ethnicity practicing in HPSAs, MUA/Ps, and rural areas. Bivariate measures of association were used to assess the relationship between physician race/ethnicity and their practice location.

Data on the race and ethnicity of physicians come from a variety of AAMC data sources but mainly from the self-reported information collected in the American Medical College Application Service (AMCAS®), the Electronic Residency Application Service (ERAS®), and the Medical College Admission Test (MCAT®). Other sources include self-reported data from the Matriculating Student Questionnaire, the Graduation Questionnaire, and the Summer Medical and Dental Education Program, as well as secondary data from the AAMC Student Records System, the GME Track, and the Faculty Roster. Priority was given to self-reported application data. Data on the diversity of the U.S. population come from the 2013 American Community Survey 5-year Estimates.³⁰

To depict the regional impact of each group of URM physicians on primary care accessibility, we used the Two-Step Floating Catchment Areas (2SFCA) method to decompose URM individual group contributions to primary care accessibility.^{31,32} The 2SFCA is a variant of the gravity model widely used in spatial accessibility studies.³¹ In this study, we used the census tracts with a 30-mile threshold to calculate the primary care accessibility defined as the number of primary care physicians available per 10,000 population. Because the overall primary care accessibility is the sum of accessibility contributed by each racial and ethnic physician group, decomposition of accessibility by physician racial and ethnic groups enable visualization of each group's contribution to primary care accessibility. Specifically, to depict a URM group's impact on primary care accessibility (e.g., Black primary care physicians' contribution) first, the global accessibility index was calculated at local area level with primary care physicians of all racial and ethnic groups; then Black physicians were removed and the accessibility index was recalculated. The two indices were then compared and the drop in the local accessibility index was measured as a percentage and mapped across the nation. Areas with higher percentages were deemed to be more sensitive to the presence of, in this case, Black primary care physicians, for primary care accessibility. The above steps were repeated for each and overall URM groups.

Results

There were 147,815 direct patient care primary care physicians in the study cohort. Of these, 800 (or 0.5%) physician locations were not geocoded due to errors or missing address information. In the cohort, 6.8% (or 10,064) were Black, 5.9% (or 8,697) Hispanic, 0.7% (or 1,014) American Indians/Alaska Natives/Native Hawaiian or Pacific Islanders (Native Americans), 11.2% (or 16,504) Asian, 72.5% (107,222) White, 2.9% (or 4,314) with other or unknown race/ethnicity (see Figure 1). Race and ethnicity data of 97.2% of the physicians were based on self-reported data sources and 0.5% were based on secondary non-self-reported data sources. The URM groups (Black, Hispanic, and Native Americans) together constitute 13.4% of the cohort. The diversity of these primary care physicians did not reflect population diversity in the nation. The percentage of URM physicians is substantially lower than the percentages of people belonging to those racial/ethnic groups in the overall U.S. population (30.5%). In 2013, 12.1% of the U.S. population was Black, 17.6% Hispanic, 4.8% Asian, 0.8% Native Americans, and 62.5% non-Hispanic Whites.³⁰ Although the Asian group appears to be overrepresented in the physician pool, many studies have pointed out that combining Asian as a single group masks important differences among sub-groups.³³

Among primary care specialties, there are significant differences in diversity. While Whites constitute the majority of all specialties, their proportion is lowest among internists (68.4%) and highest among family physicians and general practitioners (75.9%); pediatricians land in the middle (72.6%). Black and Asian physicians have higher proportions in internal medicine (7.8% and 15.6%) and pediatrics (7.3% and 11.3%) than in family medicine and general practice (5.8% and 7.5%), whereas Native Americans and Hispanics have higher proportions in family medicine and general practice (0.9%).

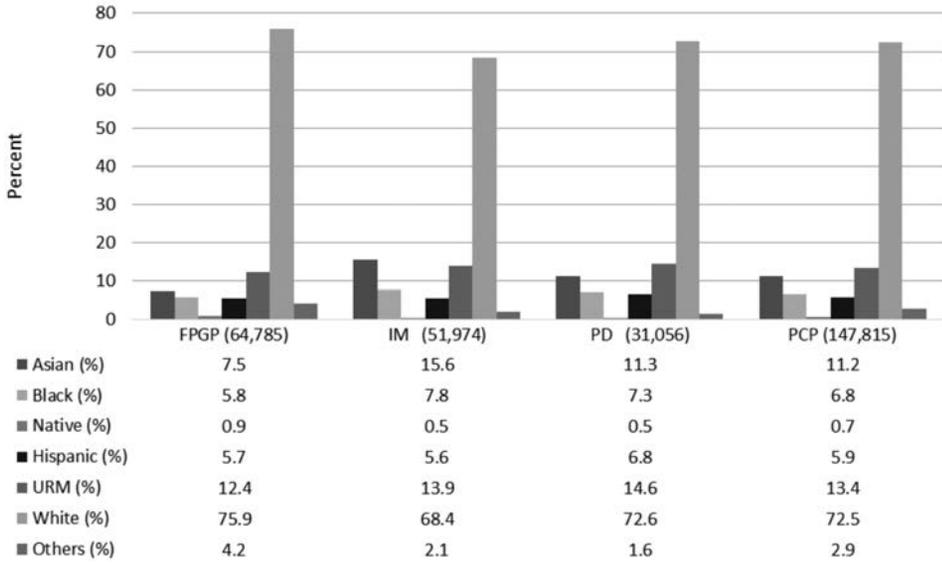


Figure 1. Racial ethnic composition of primary care physicians in the study cohort.

Notes:

FPGP= Family Physicians and General Practitioners

IM= General Internists

PD= Pediatricians

PCP= Primary Care Physicians

There are also significant difference in geographic distribution across primary care specialties with family physicians and general practitioners overall having higher proportion practicing in HPSA, MUA/P, and rural areas in the study cohort (see Figures 2 through 4). Among primary care physicians as a whole, substantial racial/ethnic differences exist in how they distribute geographically ($p < .0001$). Black, Native American, and Hispanic groups have higher proportions practicing in HPSA, MUA/P, and rural areas compared with White primary care physicians and the Asian group, who have smaller proportions practicing in these areas. Within each primary care specialty, significant differences by race and ethnicity ($p < .0001$) also exist across the geographies. Black, Native Americans, and Hispanic groups have higher proportions practicing in HPSA and MUA/P than their White peers in all three primary care specialties. Native American primary care physicians have the highest proportion practicing in rural areas, whereas White primary care physicians have higher proportions practicing in rural areas compared with Black or Hispanic primary care physicians. In particular, the Native American primary care physicians have high proportions practicing in all three underserved areas. The Asian primary care physicians also have a substantial number practicing in these areas, but their proportions practicing in these areas are much smaller compared with any other racial/ethnic group.

Decomposition analysis by URM groups shows that the area most sensitive to the presence of Black primary care physicians is the Southeast, where there tends to be a higher proportion of Black residents than elsewhere (see Map-1). Specifically, their impacts are much higher in eastern Maryland, eastern Virginia, North Carolina, South

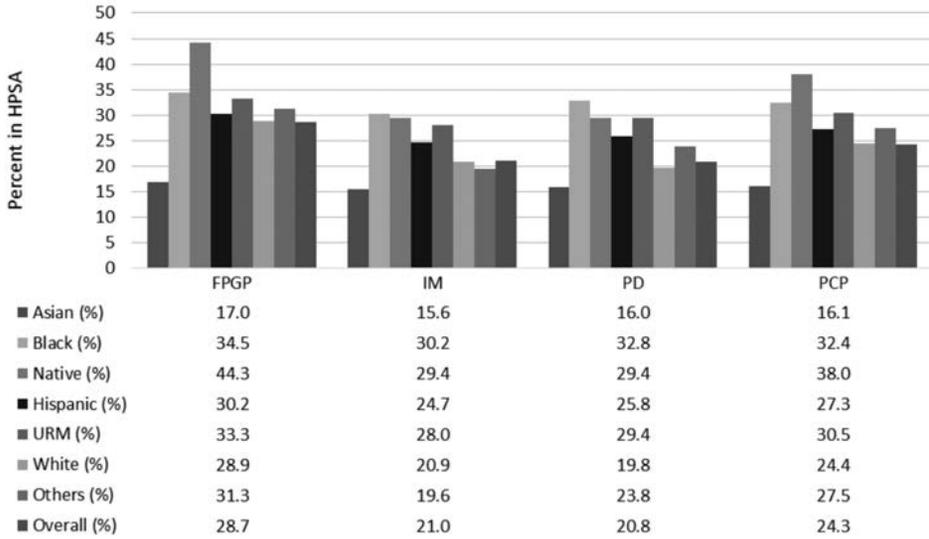


Figure 2. Variations in practice location by primary care physician race ethnicity and specialty: Percent in HPSA.

Notes:

FPGP= Family Physicians and General Practitioners

IM= General Internists

PD= Pediatricians

PCP= Primary Care Physicians

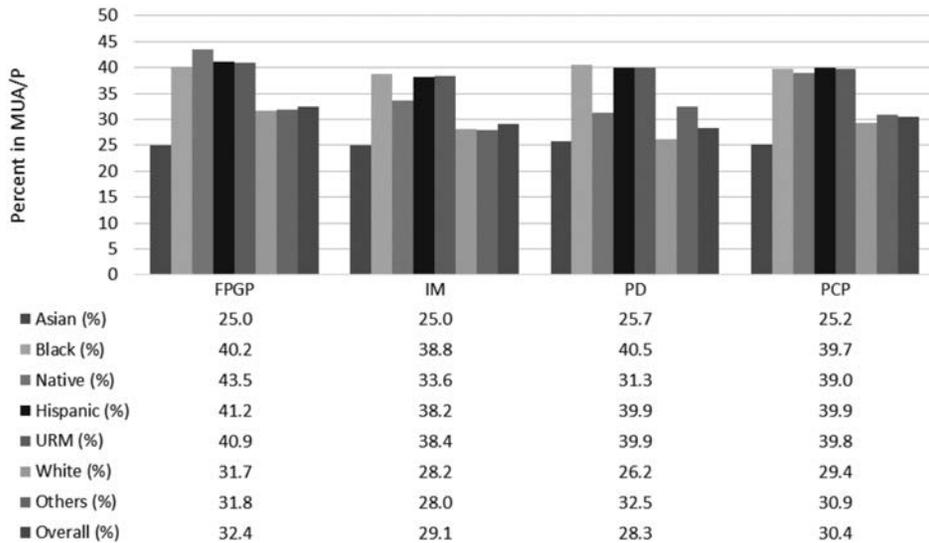


Figure 3. Variations in practice location by primary care physician race ethnicity and specialty: Percent in MUA/P.

Notes:

FPGP= Family Physicians and General Practitioners

IM= General Internists

PD= Pediatricians

PCP= Primary Care Physicians

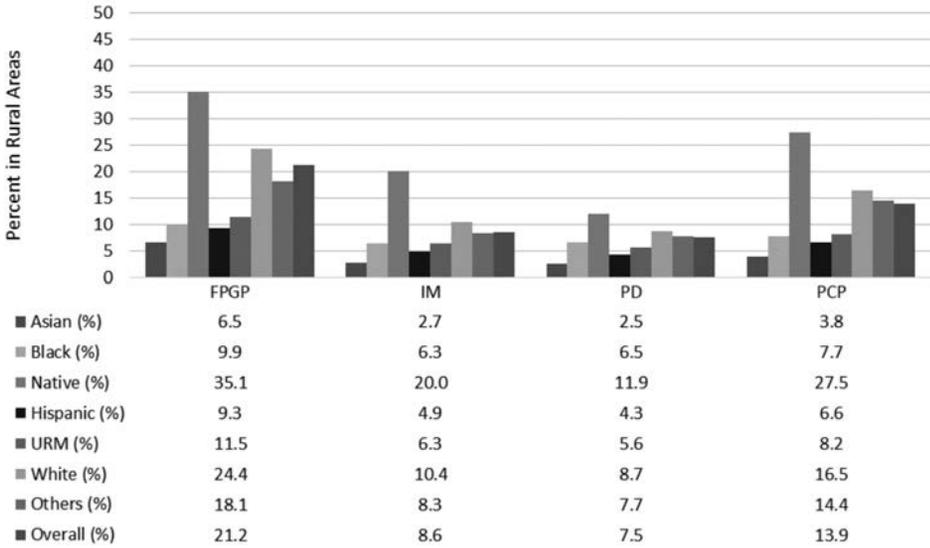


Figure 4. Variations in practice location by primary care physician race ethnicity and specialty: rural areas.

Notes:

FPGP= Family Physicians and General Practitioners

IM= General Internists

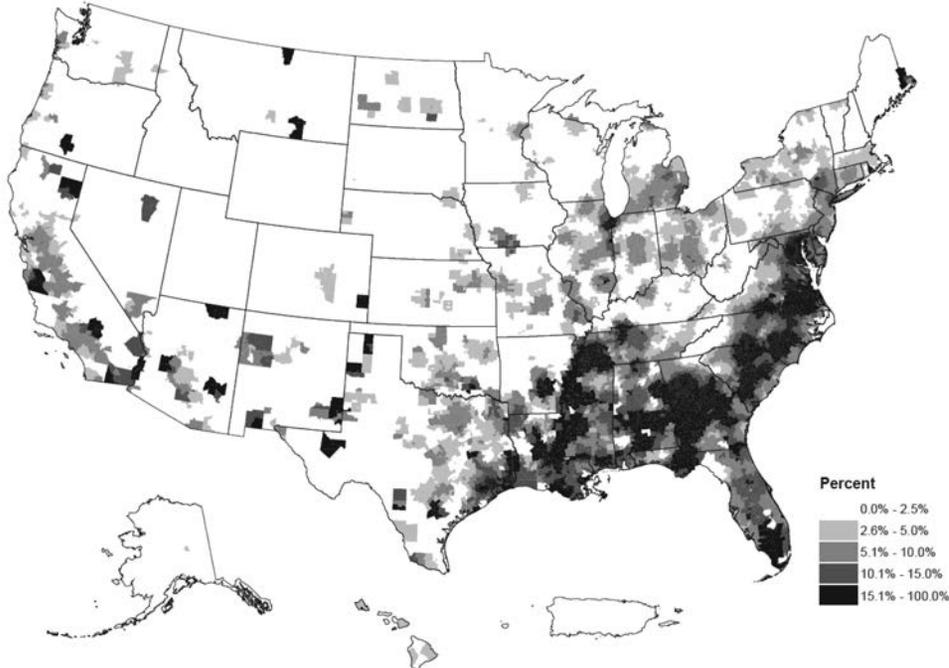
PD= Pediatricians

PCP= Primary Care Physicians

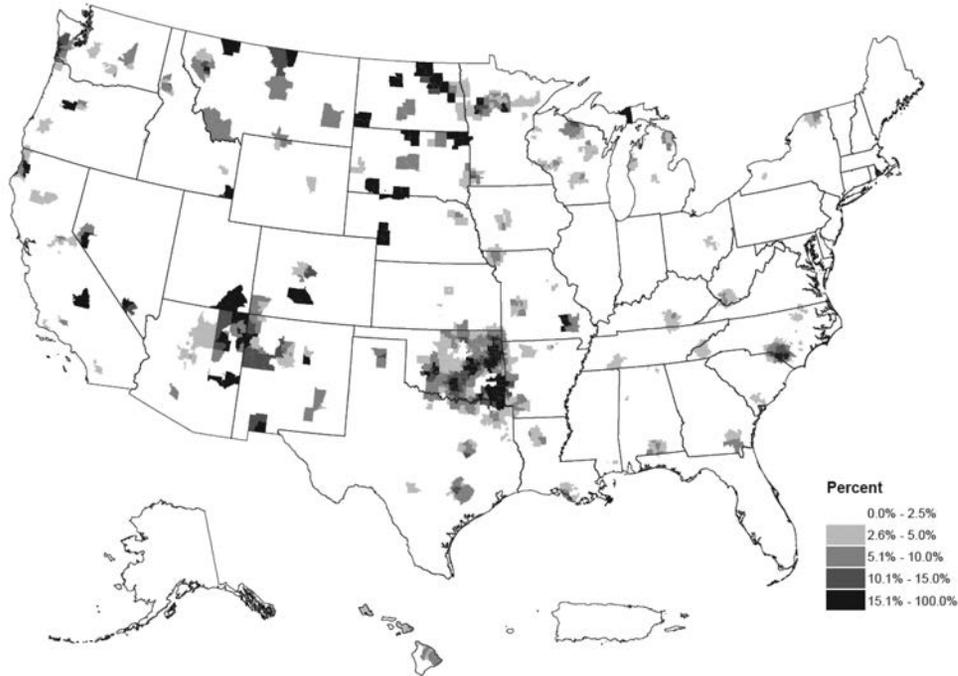
Carolina, Georgia, Alabama, Mississippi, western Tennessee, Louisiana, eastern Texas, and Florida than in other areas of the nation. Areas most sensitive to the presence of Native American primary care physicians are in Arizona, New Mexico, Colorado, Utah, Oklahoma, and pockets of the Mountain states where there tends to be a high proportion of Native Americans in the population (see Map-2). Florida, southern Texas, New Mexico, central Colorado, Arizona, California, Washington, and Puerto Rico stand out as most affected for primary care accessibility by the presence of Hispanic primary care physicians (see Map-3). When the three URM groups are combined together, their overall impact is even clearer (see Map-4): URM primary care physicians are very important for primary care accessibilities in the minority-concentrated areas of the East Coast, the South, and the West Coast areas of the U.S.

Discussion

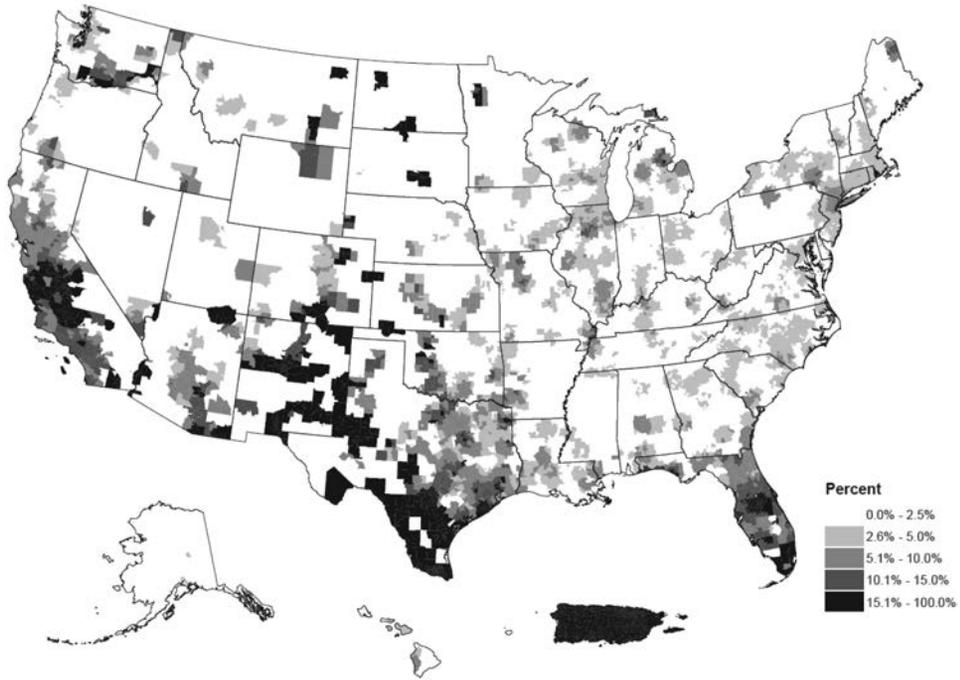
The results suggest that there are not only significant differences among primary care specialties in terms of geographic distribution, but also significant differences among primary care specialties in terms of diversity. Internal medicine physicians appear to be less likely to practice in underserved areas; however, this group appears to be more diverse. Although there are specialty differences in terms of practicing in underserved areas, physicians of Black, Native American, or Hispanic origins are more likely to practice in areas federally designated as medically underserved or experiencing health



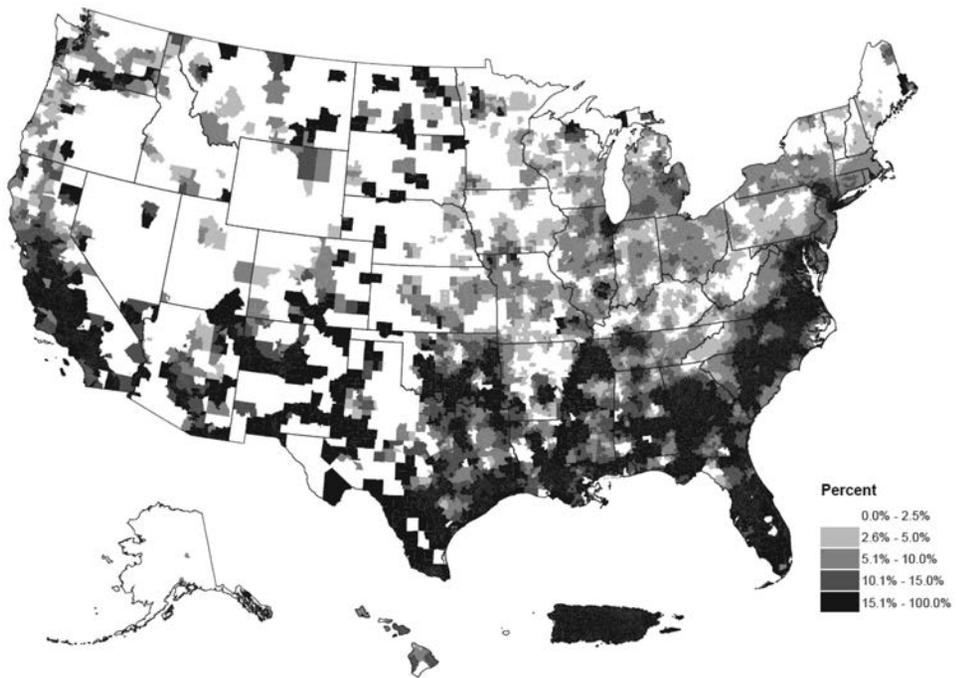
Map-1: Impact of Black primary care physician on primary care spatial accessibility



Map-2: Impact of Native American primary care physician on primary care spatial accessibility



Map-3: Impact of Hispanic primary care physician on primary care spatial accessibility



Map-4: Impact of URM primary care physician on primary care spatial accessibility

professional shortages than White physicians regardless of the specific primary care specialties they are practicing in. Native American primary care physicians are significantly more likely than other groups to practice in rural areas of the United States.

These characteristics suggest that while increasing physician workforce diversity could have a profound impact on access to health care in these areas, certain areas would be affected more with increase of certain groups of URM physicians. For example, while an increase in Black physicians might improve access to urban areas in the U.S. south, an increase in physicians from Native American backgrounds could most affect rural tribal areas. From a workforce policy perspective, increasing representation from Black, Hispanic, and Native American populations in particular may help reduce the persistent geographic maldistribution of the overall physician workforce. Furthermore, diversifying the physician workforce may also be key in addressing health disparities among racial and ethnic groups.³⁴ This also has significant implications in an era of health care insurance expansion that disproportionately affects racial and ethnic minority patients.³⁵

The observation that URM primary care physicians appear to be important for primary care accessibility in minority-concentrated areas of the nation calls for the study of the origins of these physicians in that previous studies have linked physician rural practice location and their places of birth: physicians born in rural areas were more likely to practice in rural areas.⁶ As AAMC data collection on medical school applicants encompasses more information on the trajectory of applicant growth from birth location, high schools, parental information to undergraduate education information, future study should be conducted to examine factors related to the correlation of URM primary care physicians and minority population distribution to further elucidate the question of who would be likely to serve in the underserved areas. These insights could then be used to inform whom to select for medical school admissions and how to train them to help eliminate health disparities and improve population health in the underserved areas.

This study also advanced the use of a traditional method of spatial accessibility. Decomposition analysis of spatial accessibility enables better visualization that is natural and easy to understand for lay persons. The method effectively highlights areas most sensitive to the presence of physicians from certain racial and ethnic group. The method is also flexible and relatively easy to implement. It can be used to visualize dominance of spatial competitions by physician specialties, or areas most affected by spatial uncertainty in physician practice location, for instance. Future works are needed, however, to strengthen its statistical significance test by utilizing simulation technique.

Limitations of this study require acknowledgement. First of all, the study did not examine the mediating effect of physician gender on the relationship between physician race and ethnicity and their practice location. While men continues to be the majority of physician workforce, however, more women are entering the physician workforce and some specialties are now female-majority, for instance, pediatrics and obstetrics and gynecology.³⁶ Female proportions are even higher in residency programs at the end of 2015: pediatrics residents 73.1%, family medicine residents 54.7%, and internal medicine 43.2%.³⁷ Among younger non-White physicians, women make up a greater percentage of the workforce and Black physicians already have higher female percentage than male percentage.²² Within our study cohort, 46.9% of the physicians were female.

However, 63.8% of Black and 52% of Asian were female. The gender effect on physician specialty choice and geographic distribution needs further study. Second, the study was limited to primary care physicians who were non-IMGs. International medical graduates currently occupy one fourths of the physician workforce in the nation and they were more likely than U.S. medical graduates to practice in primary care specialties and served in rural and underserved areas.^{38,39} For instance, 27.1% of direct patient care primary care physicians who graduated from medical school in 1980 or later were IMGs. Among internists, IMG occupied 37.1%, higher than in family medicine/general practitioners (19.4%) and pediatricians (21.8%). However, race and ethnicity information was not clear for 31.6% of these IMGs. As most IMGs eventually become U.S. citizens or permanent residents, future studies should detail on their contribution to physician workforce diversity as more data on IMG race and ethnicity becomes available.⁴⁰ Third, this study was cross-sectional in design and therefore unable to capture the relocation history of physicians across geographic areas. Some physicians could have served in rural or underserved area in the past. Previous study of migration pattern of obstetrician-gynecologists (ob-gyns) found that approximately one in every three ob-gyns in the United States moved at least once in the past 10 years to counties that were predominantly urban or with less poverty and certain racial and ethnic groups were more likely to relocate than others.⁴¹ Future research tracking primary care physicians migration into and out of underserved areas seems warranted.

As the nation continues its march toward greater racial and ethnic diversity, physician workforce diversity has become an increasingly important and urgent matter.⁴² Diversity, instead of being merely an issue of inadequate representation, is a powerful tool that leverages the ideas, skill sets, and philosophies of different people from different backgrounds.⁴³ Eliminating disparities in K-12 education, enhancing pipeline programs and college level interventions, transforming medical school admissions through holistic review processes, and improving URM placement into Graduate Medical Education are some promising ways to increase physician diversity.^{18,42,44,45,46}

In conclusion, there are significant differences in primary care physician practice patterns not only by racial and ethnic composition but also by particular specialties. Under-represented minority primary care physicians are important for primary medical care geographic accessibilities in the minority concentrated areas of the nation. Even though significant geographic differences exist among primary care subspecialties, racial and ethnic minority physicians under-represented in medicine are more likely to practice in underserved communities regardless of specialties. Future studies should disaggregate data further as there are important insights to be harnessed that may lead to improved policy and national physician workforce planning. While this study shows strong associations between physicians' racial and ethnic identities and where they ultimately practice, it cannot suggest any cause. There are many other factors that ultimately determine where physicians choose to practice and their specialty choice which go beyond the scope of this study. This analysis suggests that it is important to move beyond aggregated classifications such as "minorities" or "primary care physicians" when doing workforce analysis as there are important nuances that may lead to improved future workforce interventions and planning that may ultimately lead to greater access to care for all patients in the nation.

Conflict of interest

All authors confirm there is nothing to declare; No conflict of interest.

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References

1. World Health Organization (WHO). The World Health Report 2006: working together for health. Geneva, Switzerland: WHO, 2006. Available at: <http://www.who.int/whr/2006/en/>.
2. Crisp N, Chen L. Global supply of health professionals. *N Engl J Med*. Mar 6;370(10):950–7.
3. Council on Graduate Medical Education. Physician distribution and health care challenges in rural and inner-city areas. Rockville, MD: Department of Health and Human Services, 1998. Available at: <https://www.hrsa.gov/advisorycommittees/bhpradvisory/cogme/Reports/tenthreport.pdf>.
4. Hughes S, Zweifler J, Schafer S, et al. High school census tract information predicts practice in rural and minority communities. *J Rural Health*. 2005 Summer;21(3):228–32. <https://doi.org/10.1111/j.1748-0361.2005.tb00087.x>
PMid:16092296
5. Ogunyemi D, Edelstein R. Career intentions of U.S. medical graduates and international medical graduates. *J Natl Med Assoc*. 2007 Oct;99(10):1132–7.
PMid:17987917 PMCid:PMC2574406
6. Phillips RL, Doodoo MS, Petterson S, et al. Specialty and geographic distribution of the physician workforce: what influences medical student & resident choices? Washington, DC: Robert Graham Center, 2009. Available at: <http://www.graham-center.org/dam/rgc/documents/publications-reports/monographs-books/Specialty-geography-compressed.pdf>.
7. Xierali IM, Nivet MA, Fair MA. Analyzing physician workforce racial and ethnic composition associations: physician specialties. *Analysis in Brief*. 2014 Aug;14(8). Available at: <https://www.aamc.org/download/401798/data/aug2014aibpart1.pdf>.
8. Xierali IM, Castillo-Page L, Conrad S, et al. Analyzing physician workforce racial and ethnic composition associations: geographic distribution. *Analysis in Brief*. 2014 Aug;14(9). Available at: <https://www.aamc.org/download/401814/data/aug2014aibpart2.pdf>.
9. Grumbach K, Mendosa R. Disparity in human resources: addressing the lack of diversity in the health professions. *Health Aff(Millwood)*. 2008 Mar–Apr;27(2):413–22. <https://doi.org/10.1377/hlthaff.27.2.413>
PMid:18332497

10. Grumbach K, Odom K, Moreno G, et al. Physician diversity in California: new findings from the California Medical Board Survey. San Francisco, CA: Center for California Health Workforce Studies, University of California, 2008. Available at: http://futurehealth.ucsf.edu/Content/29/2008-03_MD_Diversity_in_CA_New_Findings_from_the_CA_Med_Board_Survey.pdf.
11. Walker KO, Moreno G, Grumbach K. The association among specialty, race, ethnicity, and practice location among California physicians in diverse specialties. *J Natl Med Assoc.* 2012 Jan–Feb;104(1–2):46–52.
[https://doi.org/10.1016/S0027-9684\(15\)30126-7](https://doi.org/10.1016/S0027-9684(15)30126-7)
12. Saha S. Taking diversity seriously: the merits of increasing minority representation in medicine. *JAMA Intern Med.* 2014 Feb 1;174(2):291–2.
<https://doi.org/10.1001/jamainternmed.2013.12736>
PMid:24378744
13. Chapman CH, Hwang WT, Both S, et al. Current status of diversity by race, Hispanic ethnicity, and sex in diagnostic radiology. *Radiology.* 2014 Jan;270(1):232–40. Epub 2013 Oct 28.
<https://doi.org/10.1148/radiol.13130101>
PMid:23901125
14. Chapman CH, Hwang WT, Deville C. Diversity based on race, ethnicity, and sex, of the US radiation oncology physician workforce. *Int J Radiat Oncol Biol Phys.* 2013 Mar 15;85(4):912–8. Epub 2012 Nov 1.
<https://doi.org/10.1016/j.ijrobp.2012.08.020>
PMid:23122983
15. Landry AM, Stevens J, Kelly SP, et al. Under-represented minorities in emergency medicine. *J Emerg Med.* 2013 Jul;45(1):100–4. Epub 2013 Mar 13.
<https://doi.org/10.1016/j.jemermed.2012.11.064>
PMid:23490110
16. Day CS, Lage DE, Ahn CS. Diversity based on race, ethnicity, and sex between academic orthopaedic surgery and other specialties: a comparative study. *J Bone Joint Surg Am.* 2010 Oct 6;92(13):2328–35.
<https://doi.org/10.2106/JBJS.I.01482>
PMid:20926728
17. Rayburn WF, Xierali IM, Castillo-Page L, et al. Racial and ethnic differences between obstetrician-gynecologists and other adult medical specialists. *Obstet Gynecol.* 2016 Jan; 127(1):148–52.
<https://doi.org/10.1097/AOG.0000000000001184>
PMid:26646119
18. Xierali IM, Nivet MA, Wilson MR. Current and future status of diversity in ophthalmologist workforce. *JAMA Ophthalmol.* 2016 Sep 1;134(9):1016–23.
<https://doi.org/10.1001/jamaophthalmol.2016.2257>
PMid:27416525
19. Xierali IM, Hsiao CJ, Puffer JC, et al. The rise of electronic health record adoption among family physicians. *Ann Fam Med.* 2013 Jan–Feb;11(1):14–19.
<https://doi.org/10.1370/afm.1461>
PMid:23319501 PMCID:PMC3596022
20. Makaroff LA, Xierali IM, Petterson SM, et al. Factors influencing family physicians' contribution to the child health care workforce. *Ann Fam Med.* 2014 Sep–Oct;12(5):427–31.
<https://doi.org/10.1370/afm.1689>
PMid:25354406 PMCID:PMC4157979

21. Heisler EJ. Physician supply and the Affordable Care Act. Washington, DC: Congressional Research Service, 2013. Available at: <http://healthcarereform.procon.org/sourcefiles/crs-physician-supply-and-affordable-care-act.pdf>.
22. Association of American Medical Colleges. Diversity in the physician workforce: facts and figures 2014. Washington, DC: Association of American Medical Colleges, 2014. Available at: <http://aamcdiversityfactsandfigures.org/>.
23. American Medical Association (AMA). AMA Physician Masterfile. Chicago, IL: American Medical Association, 2017. Available at: <http://www.ama-assn.org/ama/pub/about-ama/physician-data-resources/physician-masterfile.page>.
24. Page KR, Castillo-Page L, Poll-Hunter N, et al. Assessing the evolving definition of underrepresented minority and its application in academic medicine. *Acad Med*. 2013 Jan; 88(1):67–72. <https://doi.org/10.1097/ACM.0b013e318276466c> PMID:23165265
25. Health Resources and Services Administration (HRSA). Health Professional Shortage Areas (HPSAs). Rockville, MD: HRSA, 2013. Available at: <https://bhwhrsa.gov/shortage-designation/hpsas>.
26. Health Resources and Services Administration (HRSA). Medically Underserved Areas/Populations (MUA/P). Rockville MD: HRSA, 2013. Available at: <https://bhwhrsa.gov/shortage-designation/muap>.
27. U.S. Department of Agriculture. 2010 rural-urban commuting area codes. Washington, DC: U.S. Department of Agriculture, 2013. Available at: <https://www.ers.usda.gov/data-products/rural-urban-commuting-area-codes/>.
28. Centers for Medicare & Medicaid Services. Physician bonuses. Baltimore, MD: Centers for Medicare & Medicaid Services, 2017. Available at: <https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/HPSAPSAPhysicianBonuses/index.html>.
29. Health Resources and Services Administration (HRSA). What are federally qualified health centers (FQHCs)? Rockville MD: HRSA, 2017. Available at: <https://www.hrsa.gov/healthit/toolbox/RuralHealthITtoolbox/Introduction/qualified.html>.
30. U.S. Department of Commerce. 2013 American Community Survey 5-year estimates. Washington, DC: U.S. Department of Commerce, 2014. Available at: <https://www.census.gov/programs-surveys/acs/data/summaryfile.html>.
31. Wang F. Quantitative methods and socio-economic applications in GIS (2nd ed.). Boca Raton, FL: CRC Press, 2014.
32. Wang F. Measurement, optimization, and impact of health care accessibility: a methodological review. *Ann Assoc Am Geogr*. 2012;102(5):1104–12. Epub 2012 Mar 27. <https://doi.org/10.1080/00045608.2012.657146> PMID:23335813 PMCID:PMC3547595
33. Islam NS, Khan S, Jang D, et al. Methodological issues in the collection, analysis, and reporting of granular data in Asian American populations: historical challenges and potential solutions. *J Health Care Poor Underserved*. 2010 Nov;21(4):1354–81. PMID:21099084 PMCID:PMC3086449
34. Marrast L, Zallman L, Woolhandler S, et al. Minority physicians' role in the care of underserved patients: diversifying the physician workforce may be key in addressing health disparities. *JAMA Intern Med*. 2014 Feb 1;174(2):289–91. <https://doi.org/10.1001/jamainternmed.2013.12756> PMID:24378807
35. Xierali IM, Hughes LS, Nivet MA, et al. Family medicine residents: increasingly

- diverse, but lagging behind underrepresented minority population trends. *Am Fam Physician*. 2014 Jul 15; 90(2):80–1.
PMid:25077576
36. Association of American Medical Colleges. 2016 Physician Specialty Data Report. Washington, DC: Association of American Medical Colleges, 2016. Available at: <https://www.aamc.org/data/workforce/reports/457712/2016-specialty-databook.html>.
 37. Brotherton SE, Etzel SI. Graduate medical education, 2015–2016. *JAMA*. 2016 Dec 6;316(21):2291–2310.
<https://doi.org/10.1001/jama.2016.13513>
PMid:27923074
 38. Hing E, Lin S. Role of international medical school graduates in providing office-based medical care: United States, 2005–2006. Hyattsville, MD: National Center for Health Statistics, 2009. Available at: <https://www.cdc.gov/nchs/data/databriefs/db13.pdf>.
 39. American College of Physicians. The role of international medical graduates in the U.S.
 40. Norcini JJ, van Zanten M, Boulet JR. The contribution of international medical graduates to diversity in the U.S. physician workforce: graduate medical education. *J Health Care Poor Underserved*. 2008 May;19(2):493–9.
<https://doi.org/10.1353/hpu.0.0015>
PMid:18469420
 41. Xierali IM, Nivet MA, Rayburn WF. Relocation of obstetrician–gynecologists in the United States, 2005–2015. *Obstet Gynecol*. 2017 Mar;129(3):543–50.
<https://doi.org/10.1097/AOG.0000000000001901>
PMid:28178048
 42. Xierali IM, Castillo-Page L, Zhang K, et al. AM last page: the urgency of physician workforce diversity. *Acad Med*. 2014 Aug;89(8):1192.
<https://doi.org/10.1097/ACM.0000000000000375>
PMid:24918758
 43. Nivet MA. Diversity 3.0: a necessary systems upgrade. *Acad Med*. 2011 Dec;86(12):1487–9.
<https://doi.org/10.1097/ACM.0b013e3182351f79>
PMid:22130259
 44. Kirch DG. Transforming admissions: the gateway to medicine. *JAMA*. 2012 Dec 5;308(21): 2250–1.
<https://doi.org/10.1001/jama.2012.74126>
PMid:23212504
 45. Witzburg RA, Sondheimer HM. Holistic review—shaping the medical profession one applicant at a time. *N Engl J Med*. 2013 Apr;368(17):1565–7. Epub 2013 Apr 10.
<https://doi.org/10.1056/NEJMp1300411>
PMid:23574032
 46. Sondheimer HM, Xierali IM, Young GH, et al. Placement of U.S. medical school graduates into graduate medical education, 2005 through 2015. *JAMA*. 2015 Dec 8;314(22):2409–10.
<https://doi.org/10.1001/jama.2015.15702>
PMid:26647264