5 **STEM Bachelor's Degree Attainment among Women of Color in the United States**

Using Geographic Analysis for Gender and Racial Equity Research

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Science, Technology, Engineering and Mathematics (STEM) education has been the source of innovation for technology and economic development in the United States (Toulmin & Groome, 2007; National Science Board, 2007; Spellings, 2006). A key policy of the U.S. education agenda has been to meet the social demand for STEM education. Producing more STEM graduates and ultimately increasing to a highly qualified and diversified scientific workforce has been the mission of STEM disciplines throughout early childhood to graduate education. According to the Bureau of Labor Statistics, career opportunities in STEM fields are expected to grow by 12.5% between 2012 and 2020, a faster rate than in non-STEM fields (U.S. Congress Joint Economic Committee, 2012). Without increasing women and underrepresented racial minorities (URM)¹ in STEM, the United States would not be able to meet the national demand.

In terms of four-year university enrollment, more than half of students are women in the United States (National Center for Science and Engineering Statistics, 2019). However, women have been underrepresented in STEM fields for decades (Chen & Weko, 2009). The gender disparities in STEM undergraduate majors become wider when racial or ethnic minority demographics are taken into account (Ong et al., 2011). While URM students face more barriers and challenges than their White or Asian peers, women who hold these statuses have “double bind” barriers due to the intersection of gender and race/ethnicity in traditionally White, male-dominated STEM disciplines (Malcom & Malcom, 2011; Ong et al., 2011).

Researchers have found unique challenges among racially minoritized women² undergraduates in engineering (Ong et al., 2020; Ro & Loya, 2015), physics (Ko et al., 2013; Ong, 2005), computer science (Ong, 2011), and mathematics (Borum & Walker, 2012), or STEM in general (Ong et al., 2018). While these researchers explored sub-STEM disciplines, they nevertheless found several common themes. Women of color students experience a lack of mentoring, advising, and role models, microaggressions or stereotyping from their faculty and peers, and minimization of feelings, alienation, or

exclusion from competitive environments (Borum & Walker, 2012; Wilkins-Yel et al., 2019). On the other side, researchers have found that family support, strong pre-college programs, faculty mentoring, and curricular and co-curricular opportunities (e.g., undergraduate research) were critical factors in women of color's success (Carlone & Johnson, 2007; Espinosa, 2011; Ong et al., 2011; Ong et al. 2018).

Although interest is emerging in women of color undergraduates in STEM fields (Ong et al., 2020), so far existing studies have focused on the impact of individual, disciplinary, or institutional characteristics on their success. Few studies address whether the local supply of colleges relates to student success among women of color as measured by STEM bachelor's degree attainment at a community level with respect to the "geography of educational opportunity" (Hillman, 2016). This is a critical question because the availability of colleges and universities substantially varies across local communities in the United States. (Hillman, 2016). The majority of U.S. students attend colleges close to home (Hillman, 2016; Miller, 2012; Tate, 2008); more than half of college students enroll within about 20 miles of their permanent home address (Hillman, 2017). Racially minoritized students are more likely to choose colleges close to home due to family and financial reasons (Klasik et al., 2018; Ovink & Beazey, 2011). The inequity happens when communities with a more racially minoritized population have more two-year colleges but fewer four-year universities (Hillman, 2016). The lack of educational opportunities in local communities affects racially minoritized students' access to higher education and ultimately their completion of bachelor's degrees. In this chapter, we argue that the opportunity for higher education in communities is an even more important factor for women of color to complete STEM bachelor's degrees compared to their counterparts since women of color have close ties to their family and have familial obligations (Gonzalez et al., 2020; Ong et al., 2020).

The purpose of this study is to better understand how a structural barrier, such as the disparity in higher education opportunities by community, relates to STEM bachelor's degree attainment among women of color. In this chapter, we first introduce national-level efforts to promote gender and racial diversity in STEM fields through policies and professional associations. We then review scholarly literature addressing U.S. women, racially minoritized, and women of color undergraduates who study STEM majors. We also review literature on different types of minority serving institutions in the United States and how these institutions serve racially minoritized students, and, we address gaps in current literature. We apply the concepts of "intersectionality" (Crenshaw, 1989; Collins, 1990; Collins & Bilge, 2016) and "geography of educational opportunity" (Hillman, 2016) as a theoretical framework. We present statistical results by analyzing two large-scale national data sets, the Integrated Post-secondary Education Data System (IPEDS) and the American Community Survey (ACS) to conduct a location-level analysis. Finally, we offer implications which target women of color who live in places with a lack of opportunities in higher education.

National Trends and Policies to Diversify STEM Undergraduates

We start this section by demonstrating national statistics that show the gender and racial differences in STEM degree attainment in the United States. We then present the efforts of national policies and professional associations to promote gender and racial equity in STEM education and workforce.

Gender and Racial Differences in STEM Degree Attainment

In the 2015–16 academic year, women received over half of all bachelor's degrees, however, women's STEM³ degree attainment still falls behind their men counterparts (36% vs. 64%) and varies greatly by field of study (National Center for Science and Engineering Statistics, 2019). According to the National Center for Science and Engineering Statistics (2019), women's highest degree share is in biosciences, while their lowest attainments are in computer science and engineering. While women earned about 61% of degrees at the bachelor's level in biosciences, only 19% of computer science degrees, 21% of engineering degrees, and 19% of physics degrees were awarded to women. Similarly, about 20% of the doctorate degrees in computer science, engineering, and physics degrees were awarded to women.

Degree attainment among women in certain STEM disciplines has shown little progress in recent decades (National Center for Science and Engineering Statistics, 2019). From 1996 to 2016, women's participation in social sciences and engineering has gradually increased at all levels, while their education attainment in computer science, mathematics and statistics, and physical science has been stagnant. In computer science, for example, women's share of degrees has decreased from 27% to 19% at the bachelor level, and slightly increased from 28% to 31% and from 16% to 20% at the master's and doctorate level, respectively.

By the same token, the average share of STEM degrees received by URM students has gradually improved, but certain STEM disciplines still lack significant percentages of URM students (National Center for Science and Engineering Statistics, 2019). Overall, URM students earned about 22% of all science and engineering (S&E)⁴ degrees at the bachelor's level and 9% at the doctorate level. In the 2015–16 academic year, Hispanics received about 15% of STEM degrees at the bachelor's level, and Blacks earned about 12% of STEM degrees at the bachelor's level. While the share of Hispanic graduates has improved (14% of science and 10% of engineering bachelor's degrees), Black representation has declined to less than 5% of the degrees in physical sciences, mathematics and statistics, and engineering.

The share of URM men's and women's degree attainment in STEM fields has increased at all levels, albeit with varying amounts of participation (National Center for Science and Engineering Statistics, 2019). At the associate's level, URM women earned more degrees in science and in science and

engineering technologies (science, engineering, health, and other technologies), while their men counterparts tended to receive more associate degrees in engineering. At the bachelor's level, both Hispanic women and Black women received a higher share of degrees in psychology, social science, and biological sciences than in any other S&E field. Black women's participation in computer science, engineering, mathematics and statistics, and physical science, however, has declined over the past 20 years.

National Policies and Professional Organizations

The United States has invested abundant financial resources to broaden participation among women and URM in STEM disciplines for decades (Wilkins-Yel et al., 2019). The Department of Education supports multiple grant programs which have been focused on promoting racial ethnic minority women and men in STEM fields at two-year and four-year colleges; for example, the Minority Science and Engineering Improvement Program (U.S. Department of Education, 2020) and the Hispanic Serving Institutions—STEM programs (U.S. Department of Education, 2019). The National Science Foundation (NSF) also supports research projects for a diverse and well-prepared engineering workforce through the Broadening Participation in Engineering grant (Smith, n.d.). Although it is not targeted at undergraduate students, but focused on faculty, the NSF created the ADVANCE-Institutional Transformation (IT) grant to build evidence-based research expanding the participation of women faculty in STEM (DeAro & Camacho, n.d.). The ADVANCE grant has played a key role in developing an equitable environment for women faculty in STEM departments on campus, which also can affect women students in the long term.

In addition to national-level grant funds, there are multiple professional organizations to promote women and URM students' learning and success in STEM fields in the United States. For example, the Women in Engineering Proactive Network seeks to transform policies, practices, and culture in engineering education to attract, retain, and graduate women and support a network of women engineering students at 200 higher education institutions (Women in Engineering ProActive Network, n.d.). A number of nonprofit, professional organizations support STEM students of color, such as the National Society of Black Engineers (<https://www.nsbe.org/home.aspx>), American Indian Science and Engineering Society (<https://www.aises.org/>), the Society of Hispanic Professional Engineers (<https://shpe.org/>), and the Society of Asian Scientists and Engineers (<https://www.saseconnect.org/about-sase>). These organizations offer scholarships, networking, mentorship, and career development opportunities for racially minoritized college students and research shows that participating in these organizations has positive impacts on learning outcomes and persistence for students of color (Ro et al., 2016).

Despite the enormous investment and efforts of national policies and professional organizations, women and racially minoritized groups are still

underrepresented in STEM fields and progress remains extremely slow. In the next section, we review empirical research addressing women, racially minoritized, and women of color students' experiences and performance in STEM undergraduate programs in the United States and discuss the gaps in the existing literature on gender and racial equity in STEM education literature.

Women, Racially Minoritized, and Women of Color Students in STEM

A substantial amount of research has been devoted to explaining the gender gaps in STEM enrollment and persistence. Scholars and policy makers have made a connection between mathematics proficiencies at an early age and STEM major choice and persistence (Seymour & Hewitt, 1997). Students who have lower levels of mathematics and science scores, it is theorized, are less likely to choose and persist in STEM majors (Adelman, 1999, 2006). Yet, more recent national studies show that women students outperform men in mathematics in secondary and postsecondary education (Riegle-Crumb & King, 2010; Wang et al., 2013). Mathematics achievement is not the reason women do not choose STEM fields; in fact, women who are good at mathematics tend to choose other majors which are more women-friendly, gender-balanced fields (Wang et al., 2013).

URM students have faced different challenges when they choose STEM majors. URM students tend to exhibit low levels of mathematics performance in secondary education because their schools do not offer advanced mathematic courses or resources to promote mathematic proficiencies; therefore, they are not able to choose a major in STEM due to admissions or degree requirements (Bozick & Ingels, 2007; McGee & Martin, 2011; Oakes, 2003). The lack of preparedness in mathematics performance and the lack of mathematic curricular exposure among URM students should not be understood as the individual students' deficiency. Scholars contend that secondary public school systems issues, such as lower quality mathematics curricula and lack of mathematic course sequences, a lack of direction and advice from mathematics teachers and school counselors, as well as other—parental, economic, social, and cultural—factors cause a lack of mathematics preparation among racially minoritized students (McGee & Martin, 2011; Oakes, 2003).

While the majority of STEM education literature has focused on women and racially minoritized students, scholars have suggested that women of color students should receive more attention (Ong et al., 2020). Scholars claim that women of color experience a “double bind,” which refers to the unique barriers faced by women scientists and engineers of color as they simultaneously navigate race- and gender-based discrimination and exclusion in White, male-dominated STEM fields (Malcom & Malcom, 2011; Ong et al., 2011). Scholars have revealed double bind barriers and challenges that women of color students have faced in STEM disciplines (Ong et al., 2011, 2020; Pawley, 2019; Wilkins-Yel et al., 2019). Black and Latina women students struggle to develop their identity as

scientists or engineers when experiencing bias, stereotypes, and microaggressions from White faculty and peers (McGee, 2016). Asian women engineering students often express lower levels of self-assessed learning outcomes than their women peers even after accounting for college admission standardized test scores (Ro & Kim, 2019). Women of color students express feeling unwelcomed, unsupported, and invisible (Espinosa, 2011).

Scholars do not just focus on the challenges and barriers that women of color students have faced in STEM. Rather, some researchers have revealed how and why women of color students stay and succeed in STEM fields (Gonzalez et al., 2020; Ong et al., 2018; Rodriguez et al., 2017). Founded on an asset-based approach, these studies emphasize how institutions should change the White, male-dominated culture of STEM fields through policies and practices rather than attempting to change individual women of color students. For example, studies show that women of color students want and need to create a “surrogate family support system” (Ong et al., 2020, p. 601). By conducting a systematic review of research with 65 empirical studies about women of color undergraduates in engineering, Ong et al. (2020) found that the “sense of family-like support” (e.g., a network that was “a home away from home” or “like family”) is vital for women of color to feel a sense of belonging and persist in engineering (p. 601). These community gatherings can happen formally or informally with peers, faculty, or alumni (Ong et al., 2020).

Minority Serving Institutions

Students of color tend to have distinctive experiences across institutional settings, such as Historically Black Colleges and Universities versus Predominately White Institutions. In the following section, we review the literature on different types of minority serving institutions in the United States and how these institutions serve racially minoritized students, particularly in STEM fields.

Minority Serving Institutions (MSIs) have played a key role in expanding higher education opportunities for students of color and producing a diverse pool of graduates in STEM fields (John & Stage, 2014). MSIs contain Historically Black Colleges and Universities (HBCUs), Hispanic Serving Institutions (HSIs), Tribal Colleges and Universities (TCUs), and Asian American and Native American Pacific Islander-Serving Institutions (AANAPISIs) (U.S. Department of Education, 2020b). While HBCUs have nurtured Black student success and ultimately have cultivated Black communities in general, these institutions also have contributed to diversifying STEM in the workforce and graduate education (Gasman & Nguyen, 2014; Perna et al., 2009). The top 20 institutions that award STEM bachelor’s degrees to Black students included ten HBCUs in 2006 and 2010 (Gasman & Nguyen, 2014). In 2016, about 31% of Black U.S. citizens and permanent residents who obtained S&E undergraduate degrees did so from HBCUs (National Center for Science and Engineering Statistics, 2019).

HSIs serve a large population of Hispanic or Latinx⁵ students. Many HSIs were historically Predominately White Institutions (PWI), but became designated as HSIs after reaching 25% Hispanic, full-time equivalent enrollment (John & Stage, 2014). In 2017, there were 523 institutions that were designated HSIs, enrolling 66% of Latinx undergraduate students (Hispanic Association of Colleges & Universities, 2019). HSIs produced 40% of the STEM bachelor's degrees earned by Latinx students in 2010 (Núñez et al., 2016).

TCUs provide college access primarily to American Indian students. Currently, there are 32 fully accredited TCUs which serve almost 30,000 college students (U.S. Department of Education, 2020a). Most TCUs have associate degree programs (U.S. Department of Education, 2020a); thus, Native American students who want to study STEM majors at the bachelor's level must enroll beyond TCUs. The federal government developed the AANAPISIs program in 2008 (National Commission on Asian American and Pacific Islander Research in Education [NCAAPIRE], 2012). Institutions with at least 10% of Asian American and Pacific Islander (AAPI) students, a significant percentage of low-income students, or lower than average educational expenditure per student, receive federal grants through this program (NCAAPIRE, 2012).

Racially minoritized STEM students who attend MSIs have expressed positive perceptions of their college experiences (Palmer et al., 2013; Perna et al., 2009), compared to those attending PWIs. STEM students of color develop social support systems and network with their peers and alumni at MSIs (Carpi et al., 2017). For example, Black STEM students at HBCUs have positive relationships with their faculty and perceive HBCUs as nurturing environments (Gasman et al., 2017; Perna et al., 2009). Latinx STEM faculty members implement strategies, such as integrating Latinx students into the culture of STEM disciplines, offering professional networking, and supporting Latinx students beyond STEM majors, from within the university at HSIs (Bensimon et al., 2019). Studies also confirm that women of color STEM students have positive experiences and receive support from their peers and faculty at MSIs (Borum & Walker, 2012).

Despite the contribution of MSIs in supporting racially minoritized students, these institutions have faced challenges in terms of funding and capacity in attempting to offer sufficient STEM educational opportunities. MSIs have relied heavily on public funding as a source of revenue and have received limited available financial support and space (Espinosa et al., 2018; National Academies of Sciences, Engineering, and Medicine, 2019; Nellum & Valle, 2015; Nelson & Frye, 2016). Lack of resources results in a lack of financial support for things like stipends or transportation for students to engage in internships, research, or other learning experiences. MSIs often do not have graduate students and post-doctoral students who can teach undergraduates; thus, laboratory training or undergraduate research opportunities could be more limited than at research universities (Carpi et al., 2017). Although MSIs have promoted gender and racial equity in STEM fields, their faculty and students have suffered from having relatively lower resources than those at predominately White institutions.

Conceptual Framework

To better understand how the opportunities of higher education relate to STEM bachelor's degree attainment at a local community level, with a particular focus on racially minoritized women, we apply two conceptual frameworks: (1) intersectionality and (2) geography of education. We briefly explain the two frameworks and offer research questions in the following section.

Intersectionality

Anti-racism and feminist scholars posit that policy makers and researchers should apply an intersectionality lens to acknowledge “the complexities of oppression” and the “systemic structure of inequality” that women of color have faced (Harris & Patton, 2019, p. 350; Crenshaw, 1989; Collins, 1990; Collins & Bilge, 2016). As reviewed in this chapter, policy reports that analyze nation-wide statistics have shown that women, racially minoritized groups, and women of color are underrepresented in STEM education and in the workforce, relative to their share of the U.S. population. A significant body of literature also concludes that these groups have been excluded, stereotyped, and discriminated against in STEM fields (Ong et al., 2011; Ong et al., 2020). Although researchers found that more inclusive teaching and learning pedagogies, faculty mentoring and advising, and a variety of co-curricular opportunities can support women of color STEM undergraduates, these interventions are often limited to fixing individual or classroom environments. There is a dearth of studies to address how location- or community-level structures, such as the geography of educational opportunities, affect women of color STEM students' access, persistence, and degree completion. For example, researchers have not paid close enough attention to whether STEM degree attainment among women of color is evenly or unevenly distributed across the United States. Researchers have not addressed how the opportunities of higher education institutions by types (four-year or two-year, private or public, or MSIs) or the proximity of universities offering STEM degree programs relate to STEM bachelor's degrees among women of color.

In this chapter, we apply an intersectionality framework to secondary, quantitative data. Intersectionality studies have been used primarily in the form of qualitative studies, but scholars increasingly acknowledge the importance of an intersectionality framework in quantitative study design (Schudde, 2018). Intersectional scholars claim that collecting and analyzing quantitative evidence should demonstrate how social systems and power structures differently affect individuals who have intersected marginalized identities (Bauer, 2014; Schudde, 2018). While intersectionality scholars clarify that the contribution of the intersectionality framework is to reveal both “individual- and social-level causes” that reinforce the inequalities and perpetuate the oppression against marginalized groups, many intersectionality studies (both quantitative and qualitative) are limited by an individual-level analysis (Harris & Patton, 2019). Intersectional

quantitative researchers suggest that researchers should avoid simply summing up the parts of multiple social categories (Bauer, 2014). Rather, researchers should apply “an intersectional framework to processes or policies” (Bauer, 2014, p. 12). The focus of this chapter is the relationship between the number of STEM bachelor’s degrees and the geography of educational opportunities at the community-level, rather than individual-level analysis.

Geography of Education

Studies on geography of education suggest a substantial geographical variation in the availability of colleges and universities (i.e., two-year vs. four-year, public vs. private) across local communities (Hillman, 2016, 2017; Klasik et al., 2018). The quantity and quality of higher education opportunities provided in local communities was highly associated with the racial/ethnic and socioeconomic compositions of the local population. Hillman (2016) found systematic patterns along lines of race and class, where communities with larger Hispanic populations and lower educational attainment levels tend to have more two-year colleges but fewer four-year colleges nearby. This disparity would affect those who aspire to pursue STEM majors more negatively, given that two-year institutions offer only a limited range of STEM majors (Wang, 2020).

Furthermore, existing studies on the benefits of MSIs to STEM access overlook whether MSIs are close enough to home for racially minoritized, low-income students who aspire to study STEM majors. Dache-Gerbino (2018) argues that many of the most racially segregated and low-income areas do not have MSIs nearby. Social network and familial commitments affect racial minority and low-income students’ college enrollment decisions (Byun et al., 2012; Cox, 2016). By interviewing 16 low-socioeconomic status (SES) Black and Latinx high school students, Cox (2016) found that her study participants experienced the stress of residential mobility throughout their life because of family backgrounds (e.g., immigrant, military) and much more complicated and less stable family configurations than their high-SES or White peers. While low-SES students and students of color aspire to attain four-year college degrees, their family income and employment, financial aid, and residential mobility often prevent them from enrolling in four-year colleges (Cox, 2016; Holland, 2020). These studies revealed low-SES students and students of color in metropolitan and rural areas, in particular, have more barriers to traveling from home to college due to familial obligations and culture.

While the proximity of school to home and residential mobility affects college choice among students of color, women of color students may consider these factors more seriously than their men of color or White peers. Family is one of the important factors in the college choice decision-making process for women of color (Perna et al., 2009). Women of color students who choose STEM majors show a higher level of self-efficacy and academic success from family members’ support and encouragement (Zeldin & Pajares, 2000; Perna

et al., 2009). For example, literature indicates Latinx culture deeply relies on family support and encouragement; thus, Latinas perceive family as a resource to succeed in college (Contreras Aguirre et al., 2020; Gonzalez et al., 2020). Given that family culture and support is critical to women of color for their success in college, women of color undergraduates may want to choose colleges close to their home.

In this chapter, we do not measure how the distance of universities influence individual students' choice of STEM majors. To shed light on the community-level opportunities (or disparities) of higher education, we focus on the community-level opportunities and STEM bachelor's degree attainment for our analysis. We examine four research questions through a community-unit analysis.

Research Questions:

- 1 Do numbers of STEM bachelor's degree recipients by gender and race/ethnicity differ by location (Northeast, Midwest, South, and West) in the United States?
- 2 Do numbers of STEM bachelor's degree recipients by gender and race/ethnicity relate to the number of different types of higher education institutions (four-year vs. two-year, public vs. private) in a local community after controlling for community characteristics?
- 3 Do numbers of STEM bachelor's degree recipients by gender and race/ethnicity relate to the number of Minority Serving Institutions in a local community after controlling for community characteristics?
- 4 Do numbers of STEM bachelor's degree recipients by gender and race relate to the number of STEM bachelor's degrees offered by higher education institutions after controlling for institutional and community characteristics?

Methods

Data and Sample

We analyze a community-level data set to examine how the number of STEM bachelor's degree recipients by gender and race/ethnicity varies across the United States (Research Question 1). To better understand the role of higher education opportunities in STEM bachelor's degree attainment in a community, we examine how the number of STEM bachelor's degree holders relates to the different types of higher education opportunities in a community (Research Questions 2 and 3). Finally, to study the importance of bachelor's level STEM learning opportunities, we examine how the number of STEM bachelor's degree recipients in a local community relates to the total number of STEM bachelor's degrees offered by four-year institutions in a local community (Research Question 4). We draw data from two large-scale national data sets, the U.S. Census Bureau's (2020) American Community Survey (ACS) and the Integrated Postsecondary Education Data System (IPEDS).

The ACS is a national representative sample with an annual sample size of about 3.5 million addresses. It provides reliable and timely demographic, social, and economic data at both the individual and community level.

We generated a community-level data set based on ACS's Public Use Microdata Sample (PUMS) data to create measures of education attainment by combinations of academic majors at the bachelor's degree level and by gender and race.⁶ PUMS consists of individual records for about 1% of the total U.S. population, which allows us to generate reliable variables at the community-level. The smallest geographic areas that can be identified in the PUMS are the Public Use Microdata Areas (PUMAs), which are defined by the Census Bureau based on three criteria: (1) each PUMA must have a population of 100,000 or more; (2) PUMAs are based only on aggregations of counties and census tracts and do not cross state boundaries; and (3) boundaries are contiguous (U.S. Census Bureau, 2020). We use PUMAs as analytical units in this study as a proxy of local communities and aggregate individual-level characteristics to the PUMA level.⁷ Our sample includes 982 PUMAs identified in 2018 ACS PUMS data. Unless otherwise noted, we refer to PUMAs as communities in the rest of the chapter for simplicity.

We use IPEDS to create community-level measures of higher education institutions at the PUMA level. We start with a full sample of U.S. degree-granting higher education institutions in the 2017–18 academic year and then aggregate institution-level characteristics to community-levels based on institutions' geographic locations by PUMA level. Since we are interested in the number of higher education institutions that can be physically and locally accessed, we exclude online-only institutions from the sample (Hillman, 2016). In the analyses of the second and third research questions, our analytical sample includes 490 PUMAs with at least one higher education institution offering STEM bachelor's degrees.⁸

Variables

The outcome variable is the number of people in the population who are over 25 years old and who have a bachelor's degree in a STEM major. The ACS has detailed information about the field of study for bachelor's degrees received by respondents and we coded these fields into 38 categories that can be largely matched to two-digit⁹ Classification of Instructional Programs (CIP) codes. We define STEM fields as Agriculture, Environment and Natural Resources, Architecture, Computer and Information Sciences, Engineering, Engineering Technologies, Biology and Life Sciences, Mathematics and Statistics, Physical Sciences, Nuclear, Industrial Radiology, and Biological Technologies, Electrical and Mechanic Repairs and Technologies, and Transportation Sciences and Technologies. We examine the outcome measure by six different racial-gender groups: White men, Asian men, URM men, White women, Asian women, and URM women. The URM group includes Black and African American, Hispanic of any race, Native American and

Indian, and other or two or more races. All the analyses are conducted separately for each of these eight groups for comparison.

For the second research question, the independent variables of interest are variables of communities' higher education opportunities, including number of higher education institutions located in a community by institutional type (i.e., two-year private, two-year public, four-year private, and four-year public) in PUMAs. For the third research question, we measure the number of Minority Serving Institutions as independent variables. Specifically, we identify institutions as Black or African American serving institutions if either their Black or African American enrollment accounts for over 25% of total enrollment (National Center for Science and Engineering Statistics, n.d.) or they are recognized as Historically Black Colleges or Universities (HBCUs). We define Hispanic Serving Institutions (other minority serving institutions) if their Hispanic enrollment is over 25% of their total enrollment, and we also define other minority serving institutions if their Asian, Native American or Indian, other or two or more races, and race unknown enrollment is over 25% of their total enrollment. The remaining institutions are labeled as non-minority serving institutions. For the fourth research question, to measure the STEM educational opportunities, we use the total number of STEM bachelor's degrees offered at four-year higher education institutions.

We also control for a variety of communities' demographic, social, and economic characteristics, including quartiles of the percentage of the non-White population, median income, population below the poverty level, number of employees working in STEM occupations, unemployment rate, and indicators of census regions (Northeast, Midwest, South, and West).

Analytical Strategy

For the first research question, we present the number of STEM bachelor's degree recipients by gender, race/ethnicity and geography. We provide descriptive statistics of STEM bachelor's degree recipients by gender (men, women) and the interaction between gender and race (White men, Asian men, URM men, White women, Asian women, URM women) across four different census regions (Northeast, Midwest, South, West). We also provide the gender and racial composition of each region to demonstrate the underrepresentation of women and URM women. For the second and third research questions, we employ Ordinary Least Squares (OLS) regression and run regressions separately by six racial-gender groups. We examine the relationship between the number of STEM bachelor's degree holders and the number of different types of higher education institutions in a local community after controlling for local community characteristics (Model 1). Keeping outcome and control variables the same, we replace the number of higher education institutions by type with the number of Minority Serving Institutions (Model 2). For the fourth research question, we include the number of STEM bachelor's degrees awarded by higher education institutions in Model 1 and Model 2 to examine the

relationship between the number of STEM bachelor’s degree recipients and the STEM higher education opportunities in a local community.

Findings

STEM Bachelors’ Degree Recipients by Gender, Race, and Geography

In Table 5.1, we provide an overview of the percentage of STEM bachelor’s degree recipients in the Northeast, Midwest, South, and West regions by race/ethnicity and gender. We also offer the gender and racial population composition of these regions to show the over(under)representation of STEM bachelor’s degree holders by gender and race/ethnicity in different regions. Compared to the population share of men and women (49% vs. 51%), men have a higher percentage of STEM bachelor’s degrees (67%–70%) than women (30%–33%) in all four regions. Within each region, not surprisingly, White men account for the biggest share of STEM bachelor’s degree holders. While White men STEM bachelor’s degree holders are overrepresented (50%–58%) compared to their share of the population (30% to 37%) in each region, White women STEM bachelor’s degree holders (20% to 23%) are underrepresented compared to their share of the population (31% to 38%) in all four regions. We observe both Asian men (4%–11%) and Asian women (2%–6%) STEM bachelor’s degree recipients

Table 5.1 STEM Bachelor’s Degree Recipients and Population by Gender, Race, and Geographic Region

<i>Census region</i>	<i>Men</i>	<i>Women</i>	<i>White men</i>	<i>Asian men</i>	<i>URM men</i>	<i>White women</i>	<i>Asian women</i>	<i>URM women</i>
STEM Bachelor’s Degree Recipients								
Northeast	66.9%	33.1%	49.6%	10.1%	7.2%	23.0%	5.3%	4.8%
Midwest	69.0%	31.0%	55.0%	6.6%	7.4%	23.1%	3.5%	4.5%
South	69.9%	30.1%	58.0%	4.2%	7.7%	23.2%	2.4%	4.6%
West	69.6%	30.4%	49.9%	11.4%	8.3%	19.8%	6.0%	4.6%
Populations								
Northeast	48.6%	51.4%	32.3%	3.9%	12.0%	34.3%	4.1%	13.3%
Midwest	48.6%	51.4%	34.0%	1.8%	12.5%	35.7%	2.0%	14.0%
South	49.2%	50.8%	37.1%	1.0%	10.9%	38.3%	1.2%	11.5%
West	49.4%	50.6%	30.1%	3.7%	15.4%	30.8%	4.1%	16.0%

Northeast includes Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New Jersey, New York, Pennsylvania. Midwest includes Indiana, Illinois, Michigan, Ohio, Wisconsin, Iowa, Nebraska, Kansas, North Dakota, Minnesota, South Dakota, Missouri. South includes District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia, Alabama, Kentucky, Mississippi, Tennessee, Arkansas, Louisiana, Oklahoma, Texas. West includes Arizona, Colorado, Idaho, New Mexico, Montana, Utah, Nevada, Wyoming, Alaska, California, Hawaii, Oregon, Washington.

to be overrepresented compared to their shares of the population (1%–4% for both Asian men and Asian women) in all four regions. Both URM men (7%–8%) and URM women (4%–5%) STEM bachelor's degree holders have lower representation of URM men (11%–15%) and URM women (11%–16%) in the population across all regions. Despite the slight differences across regions, we observe White women, URM women, and URM men are underrepresented among STEM bachelor's degree recipients, compared to their population shares, in all four regions.

STEM Bachelor's Degree Attainment and Geography of Opportunities

By using OLS regression analyses, we examine how the number of STEM bachelor's degree recipients relates to higher education opportunities (measured by different types of higher education institutions in Model 1 and MSIs in Model 2) and STEM educational opportunities (measured by the total number of STEM bachelor's degrees awarded by four-year institutions) within a local community (measured by PUMAs). We run the OLS regression separately by gender and racial groups (See Table 5.2).

Table 5.2 STEM Bachelor's Degree Attainment and Geography of Opportunities

	(2)	(3)	(4)	(6)	(7)	(8)
	White Men	Asian Men	URM Men	White Women	Asian Women	URM Women
Model 1						
Number of 4-year public institutions	.007 (.006)	−.007 (.013)	.004 (.008)	.003 (.007)	.011 (.015)	.014 (.009)
Number of 4-year private institutions	.004 (.003)	.007 (.007)	.009* (.006)	.007 (.004)	.019** (.008)	.012* (.006)
Number of 2-year public institutions	−.008* (.004)	−.011 (.011)	−.009 (.006)	−.007 (.005)	−.023* (.013)	−.026*** (.007)
Number of 2-year private institutions	−.01 (.006)	−.007 (.015)	.020* (.011)	−.015** (.007)	−.017 (.016)	.020 (.012)
Log (number of STEM BA degrees)	.002 (.011)	−.019 (.022)	.000 (.016)	.009 (.014)	.020 (.021)	.025 (.017)
Observations	487	447	482	483	430	468
R-squared	.912	.701	.761	.897	.666	.72

	(2)	(3)	(4)	(6)	(7)	(8)
Model 2						
Number of Black or African American serving institutions (including HBCU)	-.005	-.000	.008	-.005	-.006	.018**
	(.004)	(.009)	(.007)	(.005)	(.010)	(.008)
Number of Hispanic serving institutions	.003	-.007	.028***	.001	-.003	.019*
	(.005)	(.010)	(.009)	(.006)	(.010)	(.010)
Number of other minority serving institutions	-.008	.091***	-.000	.005	.079***	-.005
	(.010)	(.018)	(.013)	(.011)	(.020)	(.015)
Number of non-minority serving institutions	-.000			-.009***	-.000	-.002*
-.005**	-.001					
	(.001)	(.002)	(.001)	(.001)	(.002)	(.002)
Log (number of STEM BA degrees)	.005	-.027	.001	.011	.017	.030*
	(.011)	(.021)	(.016)	(.013)	(.022)	(.017)
Observations	487	447	482	483	430	468
R-squared	.912	.712	.764	.896	.672	.719

Note: Robust standard errors in parentheses. Outcome variables are logarithms of number of population who receive STEM bachelor's degree for each gender and racial group. All models include a full set of control variables: quartiles of the percentage of non-White population, logarithms of total population, median income, population below the federal poverty line, employees working in the STEM occupations, unemployment rate, and dummies of geographic regions. * p<0.1 ** p<0.05 *** p<0.01.

Model 1 from Table 5.2 indicates that there is no statistical relationship between the number of people who obtain STEM bachelor's degrees and the number of four-year public institutions in a community. We find that the number of Asian women and URM women who receive STEM bachelor's degrees increases about 2.0% and 1.2%, respectively, for every additional four-year private institution in a community. However, the number of Asian women and URM women who receive STEM bachelor's degrees decreases about 2% and 3%, respectively, for every one unit increase of two-year public institutions in a community. The number of White women who receive STEM bachelor's degrees also decreases about 1.5% for every one unit increase of two-year private institutions. The number of White men who receive STEM bachelor's degrees decreases about 0.8%, for every additional

two-year public institution in a community. The number of URM men who obtain STEM bachelor's degrees is positively related to the number of both four-year and two-year private schools in a local community.

Model 2 in Table 5.2 presents the relationship between the number of STEM bachelor's degrees attained by race/ethnicity and gender and the number of Minority Serving Institutions. We found that the number of people of color (Asian women, URM women, Asian men, and URM men) who obtain STEM bachelor's degrees is significantly positively associated with the number of Minority Serving Institutions in a local community. Specifically, for every additional number of Black or African American serving institutions (including HBCUs), the number of URM women who receive STEM bachelor's degrees in a local community increases 1.8%. For every additional number of Hispanic Serving Institutions, the number of URM women who attain STEM bachelor's degree increases 1.9% and the number of URM men who receive STEM bachelor's degrees increases 2.8%. For every additional number of other minorities serving institutions, the number of Asian men and Asian women who attain STEM bachelor's degree increases 9.1% and 7.9%, respectively. The number of non-minority serving institutions (i.e., Predominately White Institutions) is negatively associated with the number of White women, Asian women, and Asian men who obtain STEM bachelor's degrees in a local community. In terms of STEM educational opportunities, we find that the number of URM women who attain STEM bachelor's degrees is significantly positively associated with the number of STEM degrees that universities awarded in a community after controlling for number of minorities serving institutions and local community characteristics.

We acknowledge the limitations of our study. Although we recognize the difference in access and success among different URM groups, we combine the groups in the analysis due to sample size and missing cases. We also lump together different types of minority serving institutions into other minority serving institutions, which have served different racial and ethnic groups in the United States. We address the needs of future research to examine different educational opportunities for specific racial and ethnic gender groups in the following section.

Discussion and Implications

In this chapter, we examine how the number of residents who obtain STEM bachelor's degrees relates to the different types of higher education institutions (two-year vs. four-year, private vs. public), different types of Minority Serving Institutions, and number of STEM bachelor's degrees offered by four-year institutions in local communities. We discuss the findings with existing literature and offer implications for future research, policy, and practices.

First, we find that communities that have more Asian women and URM women residents with STEM bachelor's degrees have more four-year private institutions, but we did not find the same pattern with four-year public institutions. Second, when a community has more two-year public institutions, the

community has fewer women of color residents with STEM bachelor's degrees. We want to emphasize that these findings do not imply any causal relationship. These findings relate to previous research in that the opportunities of higher education institutions have systematic patterns along lines of race and class (Dache-Gerbino, 2018; Hillman, 2016; Klasik et al., 2018). For example, Hillman (2016) found that communities with more two-year colleges but fewer four-year colleges nearby tend to have larger Hispanic populations and lower educational attainment. Our study offers a more nuanced relationship: communities having more four-year private colleges, but fewer two-year public colleges, have more STEM bachelor's attainment among women of color.

This finding may not be surprising in that communities with more higher education institutions have more residents with STEM bachelor's degrees. We only find that communities having more four-year higher education opportunities (and fewer two-year colleges) tend to have more Asian women, URM women, and URM men residents who earn STEM bachelor's degrees. Interestingly, we do not find this pattern with White women, White men, and Asian men. More research is needed to explore whether the different context of local communities may be attractive to women of color with STEM degrees. Although we control for a variety of communities' demographic, social, and economic characteristics in our analysis, communities that have more four-year private institutions may offer a more gender-balanced workforce, better K-12 educational opportunities for children, or more politically liberal living environment.

We also find communities with more MSIs have more racially minoritized residents who receive STEM bachelor's degrees, even after taking into account the structural diversity of local populations (i.e., the percentage of the non-White population). Again, this result does not suggest that the residents graduate from MSIs. Racially minoritized residents may receive their degrees from any type of institutions (and any locations), but seem to live in communities which offer more MSIs. As we acknowledge as the limitation of this study, we do not know specifically whether communities having more HBCUs have more Black residents with STEM bachelor's degrees or whether communities having more HSIs have more Hispanic residents with STEM bachelor's degrees. We also do not know the reason of the positive correlation. More studies focusing on individual-level analysis through both qualitative and quantitative studies are needed to examine whether the proximity of MSIs encourages racially minoritized students to access and to obtain STEM bachelor's degrees and how the relationship differs by gender. More studies need to address how the close ties to family among women of color affect how far they choose to travel to study for college education and STEM majors.

We also offer implications for policy and practice. We describe that the distribution of STEM bachelor's degree recipients by racial-gender groups does not vary across the four regions in the United States (Table 5.1). In all regions, URM men and women who obtain STEM bachelor's degrees are underrepresented, compared to their share of the population. For example, the West region, which has a higher percentage of the URM population, still contains similar

percentages of URM STEM bachelor's degree recipients compared to other regions. Thus, efforts to increase the number of URM degree holders, particularly URM women, should continue to receive national attention regardless of region.

While the shortage of women of color in STEM fields happens everywhere, we also learn from this study that communities offering more four-year higher education institutions and MSIs have more women of color residents with STEM bachelor's degrees. When administrators and faculty offer STEM outreach programs to recruit more women of color students, we suggest that they should actively reach out to communities with fewer four-year institutions but more two-year institutions, or communities having a lack of higher education opportunities in general. The professional association for women and URM scientists and engineers also calls for offering more resources to communities with lack of higher education and STEM education opportunities.

Conclusion

The Department of Education in the United States advises that "... no matter where children live, they have access to quality learning environments. A child's zip code should not determine their STEM fluency" (U.S. Department of Education, 2020c). To achieve this goal, it is necessary to study how the geography of higher educational opportunities relates to STEM bachelor's degree attainment in local communities. In this chapter, we find that the number of residents who obtain STEM bachelor's degrees varies by the opportunities of higher education institutions in local communities. Particularly, the number of women of color residents who have STEM bachelor's degrees is positively associated with the number of four-year private institutions, but negatively related to the number of two-year public institutions. The availability of MSIs also positively relates to the number of STEM bachelor's holders among both men and women of color in a local community. The number of URM women STEM bachelor's degree holders is positively related to the number of STEM bachelor's degrees awarded by four-year institutions. Our study indicates that the opportunities of higher education, particularly four-year private institutions and MSIs, have a positive relationship with STEM success among women of color in a local community. Policy makers and scholars should pay attention to the disparities in the opportunities of higher education institutions to promote gender and racial equity in STEM education and workforce.

Notes

- 1 We use the term, "underrepresented racial minorities (URM)," when we include Blacks, Hispanics, American Indian/Alaska Natives, and Native Hawaiian or Other Pacific Islanders, and two or more races.
- 2 We use the terms "racially minoritized women" and "women of color" interchangeably when we include Asian American women and URM women.

- 3 In the *Status and Trends in the Education of Racial and Ethnic Groups 2018 report*, STEM fields include biological and biomedical sciences, computer and information sciences, engineering and engineering technologies, mathematics and statistics, and physical sciences and science technologies.
- 4 As per the National Center for Science and Engineering Statistics 2019 report, degrees awarded data in science and engineering (S&E) fields include astronomy, chemistry, physics, atmospheric sciences, earth sciences, ocean sciences, mathematics and statistics, computer sciences, agricultural sciences, biological sciences, psychology, social sciences, and engineering. The difference in the definition of S&E and STEM is that S&E includes social sciences; thus, there is a higher percentage of URM S&E degree attainment.
- 5 We use the term “Latinx” to refer to students who self-identified as Hispanic or who trace their ancestry to Mexico, Central America, South America, Spain, and Caribbean islands, such as Cuba and Puerto Rico (Salinas & Lozano, 2017).
- 6 The ACS PUMS data used in this study is download from the IPUMS USA database (Ruggles et al., 2020).
- 7 Person weights are used in aggregating individual-level variables to PUMA-level variables.
- 8 The sample size of each model varies ranging from 430 to 490 because outcome variables in some models (e.g., Asian women STEM bachelor’s degree attainments in PUMAs) have missing values.
- 9 The Classification of Instructional Programs (CIP) codes, which was developed by the U.S. Department of Education’s National Center for Education Statistics (NCES) is widely used in tracking and reporting fields of study and program completion in the Integrated Postsecondary Education Data System (IPEDS) (NCES, 2020).

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