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# Training Future Scientists: Predicting First-year Minority Student Participation in Health Science Research

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## Abstract

Using longitudinal data from the UCLA Cooperative Institutional Research Program (CIRP) and Your First College Year (YFCY) surveys, this study examines predictors of the likelihood that science-oriented students would participate in a health science undergraduate research program during the first year of college. The key predictors of participation in health science research programs are students' reliance on peer networks and whether campuses provide structured opportunities for first-year students even though only 12% of freshmen in the sample engaged in this activity. These experiences are particularly important for Black students. The findings inform efforts to orient students at an early stage, particularly under-represented minorities, toward biomedical and behavioral science research careers.

### Keywords

Undergraduate science research; Racial/ethnic minorities; College impact; First-year experiences

## Introduction

Anticipated demographic changes in the U.S. population will produce dramatic increases in racial/ethnic minority high school graduates entering college by 2015 (Carnavale and Fry 1999). Despite this growth, under-represented racial minority (URM)[1] students are not graduating at the same rate as White and Asian American students, particularly in the sciences (Campbell et al. 2000). Such disparities present even more cause for concern when considering that minority students are as likely as their White counterparts to pursue a science major in college (National Science Foundation (NSF) 2002), but are less likely to graduate with a science degree (Barlow and Villarejo 2004). Of the URM students who entered college in 1989 intending to major in science or engineering, only 27% earned a baccalaureate degree in one of these fields by 1994. In comparison, 46% of White and Asian American students earned a degree in these fields (Huang et al. 2000).

The narrow pipeline to graduate science programs extends the shortage of URM students eligible to pursue careers requiring advanced science degrees, which has resulted in only 6% of our nation's scientists and engineers being URMs (NSF 2002). This pattern of under-representation has an impact on the national economy, as the need for trained research scientists outweighs the current supply of human capital (National Science and Technology



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[1]Under-represented racial minorities (URMs) include Black, Latina/o, and American Indian students.

Council 2000). As countries such as China and India graduate more students trained in the science and technology fields (Freeman 2005), training and maintaining a diverse workforce is essential to U.S. competitiveness in a global marketplace (U.S. Department of Education 2006).

In addition, health issues specific to minority communities are currently understudied by research scientists. It is not coincidental that racial/ethnic minorities are also under-represented in these fields, as minority scientists are substantially more likely than their majority counterparts to study minority issues (Nicholas 1997). They also tend to come from unique insider perspectives where, "minority scientists' general knowledge and understanding of their communities can facilitate the resolution of population-specific health problems" (Committee for the Assessment of NIH Minority Research Training Programs 2005, p. 21). Thus, from both market competition and social justice viewpoints, increasing URM representation among the ranks of research scientists is a critical national interest.

One means of becoming acculturated into science majors, thereby increasing the chances of pursuing graduate study in science fields, is participating in research as an undergraduate (Lopatto 2004). Although a body of evidence exists that supports the benefits of undergraduate research (see for example, Barlow and Villarejo 2004; Foertsch et al. 1997; Jonides 1995; Nagda et al. 1998), little research has identified the individual and institutional forces that attract students into these programs and experiences at an early stage in their undergraduate career. Yet, more than 80 institutions across the country offer such research opportunities to first-year students. This developing trend is a fruitful area of research that may change faculty minds about when we should begin to direct students into research careers. At the same time that students acquire the dispositions, skills, and knowledge for science, engagement in and access to research opportunities through formal programs could reinforce the relevance of introductory coursework.

Our long-term research goal is to understand how the biomedical and behavioral sciences can expand and diversify the research and teaching workforce. A key emphasis of our research is to study how URM students gain access to and become engaged in undergraduate activities that lead to health science research careers. The purpose of this study is to identify facilitators and barriers to URM students becoming involved in undergraduate science research during their first year of college.

## Research and Theory Guiding the Study

Undergraduate science courses have been long criticized for ineffective pedagogy, oversized classes, grading on a curve, and focusing exclusively on memorization at the expense of developing critical thinking (see for example, Seymour and Hewitt 1997; Strenta et al. 1993). Students intending to major in the sciences often confront their first significant obstacle in the form of introductory science courses, also known as "gatekeeper" classes due to their role in limiting access to science degrees by "weeding out" those students whose academic competencies are allegedly not in line with expectations for success in the discipline (Seymour and Hewitt 1997).

Practices such as grading on a curve frequently promote intense competition among students, which discourages cooperation among students and fosters a "survival of the fittest" mentality (Epstein 2006). These gatekeeper courses tend to feature high attrition rates among URMs, as they are more likely than White and Asian American students to have attended high schools that inadequately prepare students for advanced work in mathematics and the sciences (Schneider 2000; Vetter 1994). For instance, URM students are much more likely to attend high schools that do not have an Advanced Placement curriculum (Solórzano and Ornelas 2004; The College Board 2001). However, even the

most talented students may begin to seek other majors if their exposure to science is limited to large courses that do not engage their interests or do not convey a sense of purpose to the study of science.

To address the attrition rates of students majoring in the sciences, especially URMs, institutions have begun to emphasize the benefits of participating in undergraduate research programs. Scholars consistently have found that undergraduate research experiences are one way to attract and retain students in science majors, enhance the educational endeavors of science undergraduates, and serve as a pathway toward careers in science (Kinkead 2003; Lopatto 2004). Several studies have identified a broad range of benefits stemming from undergraduate research, including improved knowledge and understanding of science (Sabatini 1997); development of technical, problem-solving, and presentation skills (Kardash 2000; Mabrouk and Peters 2000; Seymour et al. 2004); clarification of graduate school or career plans (Kardash 2000; Sabatini 1997); and development of a professional self-confidence (Lopatto 2003; Mabrouk and Peters 2000).

Research experiences also have been shown to boost URM-specific retention, academic achievement, and graduate school enrollment (Barlow and Villarejo 2004; Foertsch et al. 1997; Jonides 1995). For example, a University of Michigan undergraduate research program for first- and second-year students found that participation contributed to lower attrition rates, higher grades, and positive effects on self-esteem (Nagda et al. 1998). Specifically, the research program benefited African American students whose academic performance was below the median for their racial group. Positive trends were also found for Hispanic and White students who participated in the program during their sophomore year. Such programs are often highly structured, including opportunities for students to be mentored by upper-division students, graduate students, and faculty who model research professionalism (Kinkead 2003).

Many programs exist to initiate students into research careers following graduate study, and some target URMs specifically (Kinkead 2003). In a review of programs for URM undergraduates in the science and technical fields, professional development—including conducting and presenting research—was identified as a key support area motivating students to remain and excel in their field of study (Gándara and Maxwell-Jolly 1999). By participating in these research-related activities that clarify what science researchers do, students gain exposure to the inner workings of the discipline and familiarity with research careers. A major asset of undergraduate research programs or conducting research with faculty is the potential to enhance positive student–faculty interaction and mentorship. Fostering student–faculty interaction is particularly important to keeping URM students engaged during their undergraduate years because these interactions are linked to numerous positive cognitive and affective outcomes, including academic achievement, educational aspirations, student self-concept, and persistence (Astin 1977, 1993; Chickering 1969; Kuh 1995; Kuh and Hu 2001; Pascarella 1985; Pascarella and Terenzini 1977, 1978; Spady 1970).

Such increased student–faculty interactions have been cited as key reasons by URMs for pursuing graduate study (Carter 2002; Ibarra 1996). A noteworthy example is the Meyerhoff Scholars Program at the University of Maryland, Baltimore County, a program known for its success record in helping participants achieve higher grade point averages, participate in summer research internships, graduate in science and engineering majors at higher rates, and earn admission to graduate programs at higher rates (Maton et al. 2000). The program also contributes to students' identification with science as a probable career and high achievement among African American students (Fries-Britt 1998).

While the focus of the present study is on participation in a health science research program, other structured opportunities on campus also influence this outcome. Studies on the first-year experience, such as those assessing the importance of first-year seminars, freshman-interest groups, and learning-living-residence experiences, emphasize the need for actively engaging this population of students in the initial year of college, and facilitating their entry into a learning community (see for example, Kinkead 2003; Schroeder and Mable 1994; Upcraft et al. 2003); however, structured opportunities that contribute to first-year student participation, particularly in research endeavors, largely have gone unexamined. Previous studies primarily have focused on the benefits of undergraduate research participation (for example, Nagda et al. 1998; Seymour et al. 2004) and have not explicitly investigated the individual and institutional influences on students to become involved in research.

## Conceptual Framework

The current study examines the individual, social, and structural factors that both promote and reduce students' likelihood of pursuing research opportunities during the first year of college. Drawing from the frameworks of goal commitment, social capital, and the effects of institutional context, this study focuses on those factors associated with first-year students' decisions to participate in a health science research program. We seek to identify these forces with the aim of providing research findings that can guide institutions in their efforts to recruit, retain, and graduate greater numbers of successful URM scientific researchers.

Past research on student engagement (for example, Astin 1993; Tinto 1993) has been criticized for putting too much emphasis on the individual effort in becoming integrated or involved in the institution and not enough emphasis on how forces outside the control of the student might affect his or her engagement (Braxton 2000; Tierney 1992). URM students in particular face major structural barriers to accessing and achieving in higher education (Gándara and Maxwell-Jolly 1999; Hurtado and Carter 1997; Loo and Rolinson 1986; Wilson 2000), to the point where working hard and having high expectations may be insufficient if structural constraints, such as inadequate financial aid, a lack of institutional resources, or a hostile campus climate, impede their academic progress.

In spite of the challenges URM students face, many beat the odds, sometimes in ways that are astounding and speak to the resilience and dedication on the part of these students. Thus, we have chosen to blend three concepts that represent different individual, collective, and structural variables that may influence student participation in undergraduate research during the first year of college.

### Goal Commitment and Academic Engagement

Few campuses offer research programs specifically geared toward first-year students, yet students find ways to participate in research opportunities early in their undergraduate careers. To the extent that consciously set goals influence individual action (Ryan 1970), students who aspire for undergraduate and graduate degrees in the sciences may engage in specific behaviors that enable them to achieve their goals. The way that individuals take steps toward reaching a goal is often shaped by their level of commitment to that goal (Cabrera et al. 1990). Difficult goals elicit high levels of performance, as individuals recognize the need to invest greater levels of energy and effort to complete challenging objectives (Locke and Latham 2002). Because of the level of effort necessary to accomplish difficult goals, goal commitment is a critical component of the goal attainment process (Klein et al. 1999).

Two key factors influence goal commitment: the aspects of the actual goal that make achievement of the goal important to the individual and the individual's self-efficacy (Locke

and Latham 2002). Tangible rewards (e.g., money) and intangible benefits (e.g., a sense of personal success) may influence goal attainment for the individual, further generating motivation to reach one's goals (Locke and Latham 2002). Self-efficacy consists of an individual's belief that he or she is able to manage a certain situation or complete a task (Bandura 1997). Fostering a person's self-assessment of his or her ability to reach a goal becomes an important part of actually being able to stay committed to reaching the goal itself. Individuals may experience increases in their levels of self-efficacy through additional training in the skills and competencies required to achieve the goal, connecting with influential role models, and developing networks of support (White and Locke 2000).

Becoming involved in scientific research early in college indicates a potentially strong commitment to pursuing not only a science major but also an advanced science degree, as previous research points to the importance of undergraduate research experiences in encouraging students to go on to graduate study (Barlow and Villarejo 2004). To the extent that URM students understand how participating in a structured research program improves their likelihood of reaching their educational goals, they may seek out research experiences as early as their first year of college.

## Making Connections: The Roles of Institutional Agents and Peer Networks

In addition to individual-level factors affecting student involvement in research, several group-level factors may play a role in influencing student decisions to pursue research opportunities early in the college experience. Framed in a social capital context, the probability that URM undergraduates engage in research opportunities as first-year students might be related to their connections with institutional agents and peers.

Defined as the advantages that individuals gain through their engagement in social networks and relationships (Portes 1998), social capital operates in multiple ways to promote the academic endeavors of students, especially when they initially enter college. Kao (2004) identifies three major ways that social capital functions within relationships; such relationships can shape "(1) obligations and expectations, (2) information channels, and (3) social norms" (p. 172). While some new undergraduates may come into college with an understanding of the value of research experiences in complementing their science education and preparing for possible graduate study in the sciences, not all students may possess knowledge of such opportunities or know how to access them. Establishing support systems with high levels of social capital may enable first-year students to learn more about research opportunities at their undergraduate institutions as well as the importance of research participation.

Some critiques of social capital argue that the theory reflects an inherent deficit perspective (Valencia and Solórzano 1997; Yosso 2006) and that it neglects the racial hierarchies existing in society and among youth in educational settings (Akom 2006). Bourdieu and Passeron (1977) originally used social capital to explain how an inequality is perpetuated, as certain resources, experiences, and pools of information are passed on through privileged social networks related to parental income and class status. As Yosso (2006) notes, an assumption follows that communities of color by nature "lack" the capital needed for success, and thus they are perpetually disadvantaged. Such an interpretation ignores the strengths that students of color draw upon to succeed in education.

Research applying social capital theory to aspects of higher education has concentrated on how students obtain access to social capital (Lin 1999; Portes 1998), develop their own capital (Portes 1998), and draw upon it as a vital resource to navigate the educational system (Lin 1999; Stanton-Salazar and Dornbusch 1995). Although some studies stress the influence of parental encouragement in students' development of social capital (Perna 2004;

Perna and Titus 2004), the current study focuses on the influence of institutional agents (Stanton-Salazar 1997; Stanton-Salazar and Dornbusch 1995) and peer groups (Lin 1999) in generating social networks that provide access to academic information and opportunities within institutions of higher education. Social capital, including mentoring and peer relationships, may play a particularly important role in helping URMs navigate the complexities of the campus. Developing greater levels of social capital may also help them to counteract the influence of a hostile campus climate.

Institutional representatives have the critical role of connecting students to various resources within an institution (Stanton-Salazar and Dornbusch 1995). For instance, Stanton-Salazar and Dornbusch (1995) examined how counselors and teachers in high schools facilitated the transmission of information and opportunities to Mexican-origin high school students. These institutional agents tended to mentor students who demonstrated academic potential, and students in turn capitalized on their relationships with their mentors to continue to receive institutional resources and support.

The strength and utility of these relationships may depend upon students' academic orientations, as students with higher levels of academic performance and higher degree aspirations generally derive greater rewards from their social networks compared to those with lower levels of academic achievement and educational expectations (Stanton-Salazar and Dornbusch 1995). In the context of our study, the connections that first-year students might cultivate with institutional agents may increase the chances that they will learn about unique opportunities such as structured undergraduate science research programs. Institutional agents such as academic advisors, faculty, or student affairs administrators may play a particularly important role for URM students because they are in positions to provide mentorship and support for these students as well as advocate for their needs on a larger, administrative level. Academic advisors and faculty especially may serve to facilitate or hinder a student's access to opportunities such as undergraduate research because they are most likely to assess students' potential and refer students to opportunities accordingly.

Similarly, students may draw upon their peers for access to information and opportunities (Coleman 1988; Lin 1999), especially if they are unable to rely on family for support. Furthermore, the strength of these peer relationships can affect the scope of the resources gained through the relationship (Lin 1999). For instance, Treisman (1985) observed that Asian American students often benefited from studying in groups and drawing upon their peers for resources and support. Observing that Black students tended to study alone, he created a similar model specifically for Black and Latina/o students to help them navigate the large, gatekeeper math and science courses, with much success.

Treisman's (1985) research suggests that in addition to trying to overcome academic barriers, URM students may experience social isolation related to race/ethnicity, particularly at predominantly White institutions (Loo and Rolison 1986; Wilson 2000). This social isolation may limit student access to information and resources on their home campuses. URMs may become more integrated into the campus by establishing social networks of support with peer groups, given that association with peer learning groups may increase science students' likelihood of persisting in their major (Astin and Astin 1992; Born et al. 2002; Drane et al. 2005; Hurtado et al. 2007; Springer et al. 1999).

Though Treisman's work may be dated, the central concepts of reducing isolation and having peer networks who share information, resources, and academic interests remain important for contemporary study. Fries-Britt (1998) identifies the complication of racial isolation for Black achievers, where students rarely experience connections with other Black students who are academically oriented toward science. This isolation makes it harder for

students to identify support structures without the existence of a program that addresses diversity and academic excellence.

Reformulations of Tinto's model of student departure (1975, 1993) continue to highlight the need for students to be both academically and socially integrated in the college environment but are beginning to address many issues of particular relevance to students of color, including the importance of the racial climate, sense of belonging, validation in academic environments, concern about finances, and the family as an external push or pull factor (Hurtado and Carter 1997; Nora et al. 2005). To this end, Hurtado et al. (2007) showed the importance of positive cross-racial interactions and perceptions of the racial climate in relation to success at managing the academic environment for URM science majors and sense of belonging for all students. However, peer relationships can have different effects depending upon the level of experience and correct information about navigating college. Support from upper-division students positively affected students' academic adjustment during the first year of college, whereas receiving advice from fellow first-year students actually reduced students' success at managing the academic environment (Hurtado et al. 2007).

## Institutional Context and Student Outcomes

Structures, resources, and characteristics of institutions exert considerable influences on student outcomes (Pascarella and Terenzini 2005; Porter 2006; Titus 2006). In examining how selectivity, size, and research orientation might have an impact on student engagement, Porter (2006) found that institutional selectivity positively contributed to student engagement, whereas size and research orientation negatively contributed. The significance of selectivity gives merit to research on peer effects (Antonio 2004; Pascarella and Terenzini 2005).

Additionally, institutional type has a role in shaping opportunities to engage in undergraduate research. Research universities in particular are well known for providing students the experience of learning in a research-rich environment while engaging intellectually with faculty involved in generation of new knowledge. Such universities, however, have also been criticized for their emphasis on research over teaching, and for not directing sufficient resources to the general education of undergraduates (Merkel 2003). The 1998 report of the Boyer Commission on Educating Undergraduates in the Research University urged institutions to reinvigorate their ongoing efforts to improve undergraduate education, and specifically, to focus on incorporating inquiry-based learning activities into students' first-year experiences (Boyer Commission on Educating Undergraduates in the Research University 1998). Indeed, the aspect of undergraduate education on which research universities have placed greatest attention has been independent research and other creative endeavors during the first year of college (Katkin 2003). At institutions that actively have included undergraduates in the research enterprise, these experiences are regarded as educational opportunities promoting the transition to graduate education (Merkel 2003).

Public and private institutions face different challenges in cultivating a culture of undergraduate research (Merkel 2003). Public institutions tend to be large, complex organizations structured by separate colleges that are further divided by departments and programs. Private institutions are typically smaller and more selective in their undergraduate admissions (Merkel 2003). With a lower student–faculty ratio, members of the faculty and administration are more likely to know students on an individual basis. These and other factors positively contribute to undergraduate research involvement, as attending a private college, especially an elite institution, has been found to increase the probability of attending graduate school at a major research institution (Eide et al. 1998).

With respect to how the institutional context might shape the experiences of diverse students, Minority-Serving Institutions (MSIs), including Historically Black Colleges and Universities (HBCUs) and Hispanic-Serving Institutions (HSIs), are well positioned to serve URM students. Not only do such institutions educate a disproportionately large number of URM students (Laden 2004; Provasnik and Shafer 2004), but they also are known for cultivating an environment that is culturally responsive, conducive to learning, and affirming of student experiences (Outcalt and Skewes-Cox 2002). However, with some exceptions, such institutions tend to have low educational expenditures per student (Benitez 1998). Thus, it is uncertain how attending such institutions may facilitate or hinder the likelihood of URM students being able to engage in research during college.

## Methodology

### Data Source and Sample

This research utilizes data from two of the Higher Education Research Institute's (HERI) surveys: the 2004 Cooperative Institutional Research Program (CIRP) Freshman Survey and the 2005 Your First College Year (YFCY) Survey. Participants completed the Freshman Survey either during fall orientation or the summer before their freshman year and the YFCY at the end of their freshman year (see Keup and Stolzenberg 2004; Sax et al. 2004, for more detail of both surveys). This study utilized two sampling strategies. First, a National Institutes of Health (NIH) grant allowed for the targeted recruitment and participation of a variety of MSIs with NIH-funded programs and institutions with a reputation of graduating large numbers of baccalaureates in the sciences in both CIRP and YFCY survey pools. Within these targeted institutions, we identified three subgroups: URM students intending to major in the biomedical and behavioral sciences, URM students intending to major in other fields, and White and Asian American students intending to major in the biomedical and behavioral sciences. The URM students intending to major in the biomedical and behavioral science fields composed the baseline sample. In addition, we randomly selected matched samples of White and Asian American science majors as well as URM non-science majors. This process yielded 2,900 longitudinal respondents distributed across the three subgroups.

The second sampling strategy drew students from CIRP-participating institutions with NIH-sponsored programs. We limited our sample to CIRP institutions that returned YFCY surveys for at least 80% of their first-time, full-time students to control for variability in the sampling process. We applied the same sampling strategy described above to this second sample of institutions, which yielded 2,149 longitudinal cases across the three subgroups. Thus, combining the samples from the two processes yielded a longitudinal sample of 5,049 students in 160 institutions. The average response rate across the two processes was 22.5%, and appropriate weights were calculated to address the low response rates (see Hurtado et al. 2007 for complete sampling details and weighting methodology).

Because the present study focuses on factors predicting research participation among biomedical and behavioral science majors, the URM non-science majors were excluded from the analyses. Excluding these students yielded an initial analytic sample of 3,217 students. Further, missing data on the outcome variable and constraints of the hierarchical generalized linear modeling (HGLM) techniques used to analyze data in this study resulted in a final analytic sample of 3,095 students attending 129 institutions for this particular study.

To supplement the institutional characteristics provided by the CIRP and YFCY surveys, data from the Integrated Postsecondary Education Data System (IPEDS) 2004 database were merged into the database. In addition, an online survey was administered to institutional

representatives, academic deans, and faculty of institutions within the CIRP/YFCY sample to develop a better understanding of the structure of opportunity for first-year research participation. The survey addressed the following areas:

- Are there programs for undergraduates to participate in research at the institution?
- Do these programs exist in the biomedical and behavioral sciences?
- Are these programs available to first-year students?

The response rate for the online institutional survey was 87.5%.

Table 1 reflects the measures and scale ranges for all the constructs in the model from data collected at orientation, at the end of freshmen year, from IPEDS, and from the online survey of institutions participating in CIRP and YFCY.

The analyses include several latent variables, including success at managing the academic environment, sense of belonging, social self-concept, academic self-concept, and positive cross-racial interactions (see Hurtado et al. 2007, for more information on the construction of these factors). Table 1 reports the alpha reliabilities for each of these factors for both the full sample and the sub-sample of Black students, as the sample for this study was significantly smaller than the sample used in Hurtado et al. (2007). Factor loadings, however, remained consistent across the samples from both studies. Additionally, this study constructed a factor representing student–faculty interactions via the same methods discussed in Hurtado et al. (2007). Table 1 includes the individual items, factor loadings, and alpha reliabilities of this new factor.

## Data Analysis

We utilized the expectation-maximization (EM) algorithm on continuous variables to compensate for missing values in the dataset. It provides a more accurate estimation for missing data relative to other options such as mean replacement (i.e., replacing missing values with the mean value for the variable across respondents) (McLachlan and Krishnan 1997). When individual survey items have a small fraction of non-responses, maximum likelihood (ML) estimates are generated and resulting values filled in place of the non-responses (McLachlan and Krishnan 1997). Missing values analysis suggested that missing data occurred at random across all variables. Additionally, variables included in the analysis had less than 2% missing data, which falls within the parameters suggested by Allison (2002).

This study aims to determine the influence of student- and institutional-level factors on an individual's likelihood of participating in a research program during the first year of college. Having a binary outcome variable as well as clustered, multi-level data make HGLM the most appropriate form of statistical analysis for this study (Raudenbush and Bryk 2002). The use of multi-level techniques to analyze multi-level, clustered data provides an efficient method to consider the interactive effects of students within their institutional environments. With single-level analyses, the only way to measure the effect of each institution would be to create dummy variables representing each college or university in the study and then create interaction variables for institutions and student experiences. The potential for multicollinearity among the interaction terms and dummy variables as well as a significant reduction in the degrees of freedom would make such a model difficult to interpret (Stapleton and Lissitz 1999). Furthermore, research has demonstrated that the use of single-level statistical analyses on multi-level data may result in underestimated standard errors, which may lead to a Type I statistical error (Raudenbush and Bryk 2002).

HGLM has the capability to handle clustered data. Data from the 2004 CIRP and 2005 YFCY databases have a clustered design, as students are nested within institutions. The data in this study do not represent a random sample of college students. Whereas single-level statistical techniques assume a random sampling of cases, HGLM does not make this assumption (Thomas and Heck 2001).

To justify the use of HGLM techniques, the outcome variable must vary across institutions. In this case, institutions must vary in the average likelihood of student participation in research programs. In HLM models, the intra-class correlation (ICC) is often reported to demonstrate the variance in the outcome between institutions; however, since the outcome variable in HGLM is dichotomous, the level-one variance is hetereoscedastic, and the ICC is not instructive (Raudenbush and Bryk 2002). Instead, inspecting graphs of empirical Bayes (EB) estimates can be used to determine the amount of variation between institutions. The EB graphs demonstrated substantial variance between institutions; therefore, this study proceeds with both within- and between-institution models.

Because the outcome variable for this study is dichotomous, the sampling model is Bernoulli (Raudenbush and Bryk 2002):

$$\text{Prob}\,(Y_{ij}=|\beta_{ij})=\Phi_{ij}, \quad (1)$$

The level-1, or within-institution, model is:

$$\begin{aligned}\text{Log}\left[\frac{\Phi ij}{1-\Phi ij}\right] = {} & \beta_{0j}+\beta_{1j}*(\text{STUDENT CHARACTERISTICS})_{ij} \\ & +\beta_{2j}*(\text{GOAL COMMITMENT FACTORS})_{ij} \\ & +\beta_{3j}*(\text{STUDENT EXPERIENCES})_{ij}\end{aligned} \quad (2)$$

where *i* denotes the student and *j* denotes the institution. Student characteristics include demographic variables, prior academic achievement, and mother's level of education. Goal commitment factors include students' degree aspirations, social and academic self-concepts, and senses of belonging and academic success. Student experiences represent participation in honors courses, professional clubs, first-year experience programs as well as interactions with their peers, faculty, academic advisors, and teaching assistants.

The parameters identified in Eq. 2 describe the distribution of first-year research participation at institution *j* for the various independent variables. The intercept for Eq. 2 varies between institutions, whereas the coefficients for each of the independent variables are restricted to be the same for all institutions. In this case, students' average likelihood of participating in a research program is assumed to be different depending on the institutional context; however, the effects of individual experiences are assumed to be the same regardless of where the student attends college.

The institution-level predictors are included in Eq. 3, which models the intercept term in Eq. 2:

$$\begin{aligned}B_{0j} = {} & \gamma_{00}+\gamma_{01}*(\text{INSTITUTIONAL CHARACTERISTICS})_{j} \\ & +\gamma_{02}*(\text{INSTITUTIONAL FINANCIAL INFORMATION})_{j} \\ & +\gamma_{03}*(\text{INSTITUTIONAL RESEARCH OPPORTUNITIES})_{j}+\mu_{j}\end{aligned} \quad (3)$$

where *j* denotes the institution. Institutional characteristics include size, selectivity, type, control, and minority-serving status (e.g., HBCU, HSI). Institutional financial information refers to average institutional revenue generated per full-time equivalent student. The

institutional research opportunity variable represents a dichotomous indicator of whether the institution provides first-year students with the opportunity to participate in a formal health science research program. This indicator variable measures the structure of opportunity within institutions. Although it is expected that students attending institutions that offer health science research opportunities to first-year students will be more likely to participate, this study seeks to determine the extent to which students can access those opportunities. Enrollment at an institution without a structured research program does not preclude a first-year student from engaging in health science research, as students may seek such opportunities at nearby colleges and universities or participate when individual research projects recruit apprentices (as some may do with funds through grants that stipulate a training component). The institutional variables identified above describe how the institutional context affects a student's average likelihood of participating in a sponsored research program during their first year of college.

The use of multi-level modeling requires the consideration of how variables are centered. Centering subtracts the mean value of a variable from the value of each individual observation (Porter and Umbach 2001); therefore, grand-mean centering subtracts the mean value of a variable for the entire sample from that variable's value for each individual observation. In contrast, group-mean centering calculates the mean of a variable for all observations within the specific group or, in this case, institution, and subtracts it from that variable's value for each observation.

This study uses grand-mean centering for all variables in the analysis. Grand-mean centering the variables in the analysis facilitates the interpretation of the intercept in the model (Raudenbush and Bryk 2002). This centering technique adjusts for between-institution differences in student-level variables. In this study, the intercept in Eq. 2 represents the odds of participation in a research program for students with the average characteristics and college experiences for the entire sample.

The results from the analyses are reported as odds-ratios in order to improve interpretability. In this study, odds-ratios indicate the change in the odds of participation in a health science research program, relative to not participating in such an experience, associated with a one-unit change in a certain independent variable when holding constant other variables in the model (Hedeker and Gibbons 2006). Odds-ratios greater than one suggest an increase in students' likelihood of participating in a research program, whereas values less than one indicate a reduction in their likelihood of participation (Hedeker and Gibbons 2006).

## Limitations

This study is limited in at least three ways. First, as with any research conducting secondary data analysis, this study is limited by the variables and data included in the CIRP 2004 and YFCY 2005 datasets. Second, the use of HGLM requires a substantial number of cases for every variable included in the model, as Raudenbush and Bryk (2002) recommend at least 10 cases for every independent variable. Because the student sample included more than 3,000 students, the student-level model was able to accommodate a number of predictors; however, with just 129 institutions in this study, the institution-level model was limited to no more than 12 independent variables. Finally, HGLM requires variation in the outcome variable within each group, and this constraint required us to eliminate institutions that contained fewer than two students. This limitation reduced the level-two sample by 31 institutions and the level-one sample by 56 students.

# Results

## Descriptive Statistics

Table 2 presents descriptive statistics of the student and institutional sample. Overall, 12% of the students in the sample participated in a health science research program during their first year. The descriptive statistics suggest that the sample was racially diverse, as it included students who identified as Latina/o (21%), White (32%), Black (31%), Asian American (11%), and American Indian (4%). Women compose 77% of the overall sample of students, which reflects the increasing trend of women's decisions to major in biological and behavioral sciences (Pryor et al. 2007). Nearly 80% of students in this study planned to live on campus during their first year, and students entered college with high school grade point averages (GPA) ranging between B+ and A−. Only 15% of students had participated in a high school summer research program. The vast majority of students in this study planned to pursue either a medical degree (40%) or a Ph.D. (38%).

With respect to students' college experiences, 15% enrolled in an honors course while 50% of students enrolled in a first-year experience course. Just 9% of students participated in a learning community whereas approximately 25% of this study's participants joined a pre-professional or academic departmental club. Students with on-campus employment were 25% of the sample, and 20% of the participants worked off campus.

In terms of the institutional sample, private institutions composed 58% of the institutional sample, and four-year colleges accounted for 64% of institutions in the study. The colleges and universities in this study demonstrated a moderate level of selectivity (mean SAT = 1,111). Approximately 65% of institutions surveyed reported offering formal health science research programs that provided first-year students the opportunity to participate.

## Full Sample Health Science Research Model

Table 3 presents the final hierarchical generalized linear models for the full sample of students as well as the Black student sub-sample. For the full sample of students, results suggest that Black students (odds ratio = 0.65*) have significantly reduced odds of participating in health science research programs compared to their White counterparts; however, this significant relationship emerged only after controlling for students' college experiences and institutional characteristics. To investigate further, we conducted subsequent analyses on the Black student population exclusively, and we will return to those findings later. Results suggested that Latina/o (odds ratio = 1.00), Asian American (odds ratio = 0.71), and American Indian (odds ratio = 1.10) students were not significantly different from White students in their likelihood of engaging in research. Similarly, women did not differ significantly from men in their odds of participating in a health science research program. Students who intended to live on campus during their first year had significantly greater odds (odds ratio = 1.26*) of research participation than their off-campus peers. In general, prior academic achievement did not have a significant relationship with the odds of research participation. Only participation in a high school summer research program was significantly related to health science research participation in the first year; however, this relationship became non-significant after controlling for students' college experiences and institutional characteristics. These results suggest indirect relationships to investigate in the future.

In addition to students' background characteristics, a number of students' college experiences emerged as significant in the final model. Within this model, students' social networks and structured opportunities for first-year students played significant roles in promoting participation in health science research programs. Students who enrolled in a first-year experience course (odds ratio = 1.62***) and joined a pre-professional or

academic departmental club (odds ratio = 1.82***) had significantly greater odds of participating in a health science research program compared to their counterparts who lacked these college experiences. Similarly, students who sought advice from their upper-division peers (odds ratio = 1.20*) were significantly more likely to engage in a formal research program than individuals who did not take advantage of peer networks. In contrast, seeking advice from first- and second-year students had no significant effect on students' likelihood of research engagement (odds ratio = 1.05).

Similarly, interacting with academic advisors and teaching assistants had no significant effect on the odds of participating in health science research (odds ratio = 1.04 and odds ratio = 1.00, respectively). However, the results indicate that students who spent more time engaging with faculty members had significantly greater odds (odds ratio = 1.08*) of participating in health science research during their first year. This finding indicates that, among the various relationships students develop with key institutional agents, their contact with faculty is associated with increased odds of participation in a health science research program. Interestingly, the analyses suggest that, among the college experience variables, students' degree aspirations, senses of belonging, and academic and social self-concepts had no significant relationship with health science research participation in the first year of college. We will return to this point in the conclusion.

Among the environmental pull factors tested in the analyses, only students' sense that family responsibilities interfered with their college experience had a significant relationship to health science research participation. Notably, students who agreed more strongly that family responsibilities interfered with college had significantly higher odds of participating in a health science research program (odds ratio = 1.18*). In contrast, familial support did not play a significant role in participation (odds ratio = 1.08). It may be that students with unusual family responsibilities seek involvement in such programs because they provide both financial and social support.

Among the institutional predictors, only two variables had a significant relationship with students' average likelihood of participating in a health science research program. Institutions that enrolled higher numbers of undergraduate and graduate students (odds ratio = 1.31*) and that provided structured health science research programs available for freshman participation (odds ratio = 1.64*) significantly increased first-year students' average likelihood of participating in health science research. The structure of opportunity variable was the last level-two measure added to the institutional model. The addition of this variable did not significantly affect the results of the other variables already included in the model. The significance of having a structured program is not surprising, as students at institutions without formal, structured opportunities have a more difficult time engaging in health science research projects (e.g., through other local institutions or identification of faculty projects). In contrast, institutional selectivity, type, control, and revenue per student had no significant effects on students' odds of participation in health science research. The HGLM model for the full sample of students explained 7% of the between-institution variance in students' likelihood to participate in health science research programs in their first year of college.

## Black Student Health Science Research Model

Because this study had a particular interest in the experiences of URM students, and the fact that Black students showed a lower likelihood of participating after controlling for institutional characteristics, we conducted a separate yet identical analysis for the sub-sample of Black students. Table 3 presents the results of this analysis.

For the Black student sub-sample, no demographic characteristics significantly predicted participation in a health science research program. Among the college experience measures, Black students' social self-concept had a significant, positive relationship with participation in health science research (odds ratio = 1.48**). Students who maintained a greater sense of social confidence upon entering college significantly enhanced their odds of engaging in health science research. Similar to the full sample, degree aspirations, sense of belonging, and academic self-concept had no significant relationship with students' odds of research engagement. Additionally, Black students who received advice from a junior or senior had significantly greater odds of participation in health science research (odds ratio = 1.11*). Unlike the aggregate model, however, participation in a learning community was a significant positive predictor of research participation (odds ratio = 3.60*). Similarly, higher frequencies of cross-racial interactions significantly, albeit modestly, enhanced Black students' odds of health science research participation (odds ratio = 1.02*).

Considering environmental pull variables, the analyses suggest that Black students differed from students in the aggregate sample. Black students who indicated having more serious financial concerns about paying for college were significantly less likely to participate in health science research than their peers who were less concerned about finances. In contrast, students' familial support and responsibilities had no significant relationship with research participation.

Among the institutional variables, institutional size, type, control, and revenue per full-time equivalent student had no significant effect on the average likelihood of Black students' participation in research. Similarly, attending an HBCU had no significant effect. Black students who attended institutions offering formal health science research opportunities to first-year students were more than four times as likely to participate in research than Black students at institutions without such programs (odds ratio = 4.31*). The HGLM model for Black students explained approximately 14% of the between-institution variance in the likelihood of health science research participation in the first year.

## Characteristics of Health Science Research Programs Available to First-year Students

Because of the significant role that structure of opportunity seems to play in positively affecting students' likelihood to participate in an undergraduate health science research program, we examined the characteristics associated with these programs. Table 4 presents descriptive statistics from the online supplemental survey of the health science research programs offered by institutions. Approximately 63% of institutions with these programs pay first-year students for their work on the research projects, and 76% of these programs provide students with volunteer research opportunities. First-year students can also receive course credit for their research work, as 67% of the programs offer independent study credit.

In addition to providing tangible incentives for participation, a number of these research programs offer students important mentorship and practice for their careers. Nearly 90% of the programs reported in this study include a faculty mentorship component, and 60% of these opportunities feature a structured peer mentor program. Additionally, 75% of the institutions indicate that their programs offer students important information about medical school preparation, and almost 90% provide some form of graduate school guidance, such as GRE preparation. Participants also have the opportunity to present their findings at professional conferences, as 93% of the programs included this professional development component.

### Institutions with Health Science Research Programs Available to First-year Students

In addition to gaining a better understanding about the types of experiences offered within the programs, we used descriptive analyses to understand the types of institutions that offer health science research programs to first-year students. Table 5 presents these descriptive statistics. These programs appeared equally across all types of institutions in this study, as 67% of the HSIs and Predominantly White Institutions (PWIs) and 65% of the HBCUs in this study reported having formal health science research programs. Colleges and universities have unequal participation, as 35% of the former and 70% of the latter offer these programs. No difference existed between private and public institutions.

Institutional differences emerged among selectivity, size, and resources. More selective institutions provided students with opportunities for health science research in the first year of college. Similarly, larger institutions seemed more likely to have these undergraduate research programs compared to their smaller counterparts. Additionally, institutions that generated more revenue per full-time equivalent student offered more opportunities than those that had fewer financial resources. This suggests a conscious effort to include first-year students among large institutions with resources to make health science research a part of undergraduate life.

## Conclusion: Implications for Research and Practice

Even among a sample of students who aspire to major in the health or behavioral sciences and pursue an advanced degree at college entry, we find that few first-year students actually participate in a health science research program—as most of the funded program initiatives focus on juniors and seniors. This raises an important dilemma: Should freshmen be encouraged to engage in research with faculty so early in their college career? Although an answer to this question awaits analyses of longitudinal outcomes, we conclude here that any early efforts to provide structured opportunities for students are essential if we wish to be intentional about attracting and increasing the number of diverse students in critical health science fields. Earlier studies of this science-oriented cohort revealed very few students aspired to a scientific research career (or knew what it entailed) at college entry even though they shared values and dispositions toward making contributions to scientific research (see for example, Hurtado et al. 2006), which suggests that early efforts are necessary to acquaint and direct students toward research careers if we truly intend to expand the pool of research scientists.

Some campuses have left it up to freshmen motivated enough to seek faculty research opportunities, whereas other campuses have forged ahead in designing programs that include first-year students, determining that an early orientation to research yields numerous benefits for undergraduate education. Important links with other academic structures that result in participating in a health science research program were identified, including involvement in a first-year experience course (all students) or a living-learning community (Black students). If these structures are not linked administratively, it appears that the students are linked across them.

Access to and engagement in these programs may primarily be through students' peer networks. Students who participated in a pre-professional program or departmental club were likely more aware of the existence of research programs and therefore more likely to participate. Those students who received advice from juniors and seniors (presumably already declared in a major) were more likely to be involved in research in the first year of college. Programs may largely depend on students' peer networks to spread the word about the opportunities and rely on upper-division students to articulate the benefits that such an investment of time offers during the first year.

It is interesting to note that students' own psychological sense of integration (successfully managing the academic environment in the first year and sense of belonging to college) was not directly related to participating in a health science research program. However, previous research demonstrates how closely these constructs are related to aspects of the racial climate and quality of interactions on campus for racial/ethnic minorities as well as majority students (Hurtado et al. 2007; Hurtado and Carter 1997). This clearly indicates that not all forms of student engagement operate similarly in relation to students' sense of integration. It may well be that students engage in a health science research program for very pragmatic reasons such as a way to learn more about a particular discipline or as a vehicle to pay for college.

Given that the majority of the structured programs offer some financial support for students, these programs attract students for multiple reasons that are connected with student finances. However, we found that Black students who have the least concern about financing college were more likely to participate in these programs. It will be important to investigate further whether such students have scholarships or enter with sufficient family incomes that afford them the time to consider participating in research in the first year. Still, programs may be more successful in attracting a wide range of students to research careers with opportunities to earn and learn—an approach that mirrors the graduate school model.

Other unique findings for Black students provide greater insight into the characteristics of those students who gain access to and are engaged in research at an early stage in their undergraduate career. A higher social self-concept and peer connections were key factors for increasing Black students' likelihood of participation in research. Furthermore, reports of positive cross-racial interactions represented an important positive predictor for Black students, indicating the significance of the racial dimension of social capital for these students. This work contributes to the growing research on successful Black collegians (for example, Fries-Britt 1998) who continue to face racial isolation and stigma from a variety of communities. This has required them to develop high social regard for themselves in order to build bridges across multiple communities and gain access to academic programs that will lead to a science career. Encountering diverse student peers in academic settings, with common learning and career goals, may resolve this dilemma. Programs can be structured to address both diversity and excellence to help students achieve academic goals and eventually diversify the cadre of researchers and professionals.

Institutional researchers are often encouraged to be involved in the evaluation component of health science research programs or other programs designed to promote undergraduate research and engagement on campus. While much effort is devoted to understanding the outcomes (short- and long-term) of these programs for reporting to external funding sources, we also encourage more research on the differences among students who gain access to these programs. Program information can be merged with cohort data collected at first-year orientation, end of first year surveys, and enrollment data to gain better understanding of areas for program improvement. Understanding why particular students have less access to specific resources also serves as a way to obtain an early appraisal of field-specific equity indicators of baccalaureate attainments for diverse student groups (Bensimon 2004). If programs include freshmen in order to nurture talent in the sciences, student participation may become a central pathway on many campuses that averts the "science sieve," or sorting of students in the first year of college. Continuing to monitor the impact of these programs on multiple student outcomes will be important as students enter into the major and begin their journey toward graduate school.

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## Table 1

Description of variables and measures

| Variables | Scale range |
|---|---|
| Dependent variable | |
| Participation in a health science research program during the first year of college | 0 = no, 1 = yes |
| Independent variables | |
| *Student background characteristics* | |
| Gender: female | 0 = no, 1 = yes |
| Ethnic background: Latino, African | 0 = no, 1 = yes |
| American/Black, American Indian, Asian/Asian | |
| American | |
| Mother's education | 1 = grammar or less, 8 = graduate degree |
| High school grade point average | 1 = D, 8 = A or A+ |
| Planning to live on campus | 0 = no, 1 = yes |
| Years of mathematics in high school | 1 = none, 7 = five or more |
| Years of science in high school | 1 = none, 7 = five or more |
| Participation in a health science research summer program | 0 = no, 1 = yes |
| *Goal commitment, psychological sense of integration, and campus perceptions* | |
| Success at managing the academic environment | A standardized scale of five variables, measured separately on a three-point scale: 1 = unsuccessful to 3 = completely successful. Full sample alpha = 0.78. Black sample alpha = 0.75 |
| Sense of belonging | A standardized of three variables, measured separately on a four-point scale: 1 = strongly disagree to 4 = strongly agree. Full sample alpha = 0.84. Black sample alpha = 0.81 |
| Social self-concept | A standardized scale of three variables, measured separately on a five-point scale: 1 = lowest 10% to 5 = highest 10%. Full sample alpha = 0.73. Black sample alpha = 0.74 |
| Academic self-concept | A standardized scale of four variables, measured separately on a five-point scale: 1 = lowest 10% to 5 = highest 10%. Full sample alpha = 0.60. Black sample alpha = 0.60 |
| Students at the institution are treated like numbers | 1 = strongly disagree, 4 = strongly agree |
| Faculty are interested in the well-being of students | 1 = strongly disagree, 4 = strongly agree |
| Aspire to a master's degree | 0 = no, 1 = yes |
| Aspire to a PhD | 0 = no, 1 = yes |
| Aspire to an MD, DDS, or DDO | 0 = no, 1 = yes |
| Aspire to another professional degree | 0 = no, 1 = yes |
| *College experiences and social networks* | |
| Interaction with academic advisor | 1 = never, 6 = daily |
| Interaction with graduate students and teaching asst. | 1 = never, 6 = daily |
| Took an honors course | 0 = no, 1 = yes |
| Enrolled in a learning community/cluster program | 0 = no, 1 = yes |
| Enrolled in a first-year experience seminar | 0 = no, 1 = yes |
| Joined a pre-professional or department club | 0 = no, 1 = yes |
| Participated in an academic enrichment/support program for under-represented minority students | 0 = no, 1 = yes |
| Received advice/academic advising from a junior/senior | 1 = not at all; 4 = frequently |

| Variables | Scale range |
|---|---|
| Received advice/academic advising from a first-year student | 1 = not at all; 4 = frequently |
| Discussed course content outside of class with students | 1 = not at all; 4 = frequently |
| Positive cross-racial interactions | A standardized scale of seven items, measured separately on a five-point scale: 1 = never to 5 = very often. Full sample alpha = 0.89. Black sample alpha = 0.91 |
| Student/faculty interactions | A standardized scale of two variables, measured separately on a six-point scale: 1 = not at all to 6 = daily. Full sample alpha = 0.69. Black sample alpha = 0.69. Factor loadings: interacted with faculty during office hours (0.87) and interacted with faculty outside of class and office hours (0.87) |
| Working on campus | 0 = no, 1 = yes |
| Working off campus | 0 = no, 1 = yes |
| *External push/pull factors* | |
| Rely on family support to succeed | 1 = not at all, 4 = frequently |
| Concern of financing college | 1 = no concern, 3 = major concern |
| Family responsibilities interfere with school work | 1 = not at all, 4 = frequently |
| *Institutional characteristics* | |
| Institutional control | 0 = public, 1 = private |
| Institutional type | 0 = university, 1 = four-year college |
| Institutional selectivity | Range: 400–1,600 |
| Historically Black College/University | 0 = no, 1 = yes |
| Hispanic-serving institution | 0 = no, 1 = yes |
| Total full-time enrollment (log transform) | Range: 6.06–10.96 |
| Total revenues per full-time enrollee (log transform) | Range: 8.91–11.78 |
| Institution offers a health science research program to freshmen | 0 = no, 1 = yes |

**Table 2**

Descriptive statistics for students and institutions

| Variable name | N | Mean | SD | Min. | Max. |
|---|---|---|---|---|---|
| *Outcome variable* | | | | | |
| Participated in health science research | 3095 | 0.12 | 0.32 | 0.00 | 1.00 |
| *Background characteristics* | | | | | |
| Latina/o | 3095 | 0.21 | 0.41 | 0.00 | 1.00 |
| White | 3095 | 0.32 | 0.47 | 0.00 | 1.00 |
| Black | 3095 | 0.31 | 0.46 | 0.00 | 1.00 |
| Asian American | 3095 | 0.11 | 0.31 | 0.00 | 1.00 |
| American Indian | 3095 | 0.04 | 0.20 | 0.00 | 1.00 |
| Female | 3095 | 0.77 | 0.42 | 0.00 | 1.00 |
| High school GPA | 3095 | 6.73 | 1.30 | 1.00 | 8.00 |
| Plan to live on campus | 3095 | 0.78 | 0.85 | 0.00 | 1.00 |
| Years of high school math | 3095 | 5.94 | 0.55 | 1.00 | 7.00 |
| Years of high school science | 3095 | 3.80 | 1.03 | 1.00 | 7.00 |
| Mother's education | 3095 | 5.23 | 1.97 | 1.00 | 8.00 |
| Participated in high school research program | 3095 | 0.15 | 0.36 | 0.00 | 1.00 |
| *Goal commitment, psychological sense of integration, and campus perceptions* | | | | | |
| Success at managing the academic environment | 3095 | 2.12 | 0.45 | 1.00 | 3.00 |
| Sense of belonging | 3095 | 3.04 | 0.58 | 1.00 | 4.00 |
| Social self-concept | 3095 | 3.46 | 0.77 | 1.00 | 5.00 |
| Academic self-concept | 3095 | 3.72 | 0.57 | 1.75 | 5.00 |
| Students feel they are treated like numbers | 3095 | 2.02 | 0.83 | 1.00 | 4.00 |
| Students believe faculty have interest in students | 3095 | 2.98 | 0.67 | 1.00 | 4.00 |
| *Degree aspirations* | | | | | |
| Less than bachelor's degree | 3095 | 0.01 | 0.08 | 0.00 | 1.00 |
| Bachelor's degree | 3095 | 0.05 | 0.21 | 0.00 | 1.00 |
| Master's degree | 3095 | 0.14 | 0.34 | 0.00 | 1.00 |
| Ph.D. | 3095 | 0.38 | 0.48 | 0.00 | 1.00 |
| M.D./D.D.S./D.D.O | 3095 | 0.40 | 0.49 | 0.00 | 1.00 |
| Other professional degree (J.D., MBA) | 3095 | 0.03 | 0.18 | 0.00 | 1.00 |

| Variable name | N | Mean | SD | Min. | Max. |
|---|---|---|---|---|---|
| *College experiences and social networks* | | | | | |
| Interact with academic advisors | 3095 | 2.50 | 0.98 | 1.00 | 6.00 |
| Interact with graduate assistants/TAs | 3095 | 2.82 | 1.59 | 1.00 | 6.00 |
| Took an honors course | 3095 | 0.15 | 0.36 | 0.00 | 1.00 |
| Participated in a learning community | 3095 | 0.09 | 0.29 | 0.00 | 1.00 |
| Took a first-year experience course | 3095 | 0.50 | 0.50 | 0.00 | 1.00 |
| Participated in pre-professional/dept. club | 3095 | 0.24 | 0.43 | 0.00 | 1.00 |
| Participated in academic enrichment program | 3095 | 0.16 | 0.37 | 0.00 | 1.00 |
| Received advice from juniors/seniors | 3095 | 2.24 | 0.99 | 1.00 | 4.00 |
| Received advice from freshmen/sophomores | 3095 | 2.30 | 0.95 | 1.00 | 4.00 |
| Experienced positive cross-racial interactions | 3095 | 3.01 | 0.96 | 1.00 | 4.75 |
| Student–faculty interactions | 3095 | 5.20 | 2.20 | 2.00 | 12.00 |
| Worked on campus | 3095 | 0.25 | 0.43 | 0.00 | 1.00 |
| Worked off campus | 3095 | 0.20 | 0.40 | 0.00 | 1.00 |
| Discussed academics outside of class | 3095 | 3.27 | 0.70 | 1.00 | 4.00 |
| *Environmental pull* | | | | | |
| Feel supported by family in college | 3095 | 3.32 | 0.93 | 1.00 | 4.00 |
| Financial concerns about paying for college | 3095 | 1.95 | 0.66 | 1.00 | 3.00 |
| Family responsibilities interfere with college | 3095 | 1.81 | 0.92 | 1.00 | 4.00 |
| *Students within schools* | | | | | |
| Students within schools | 3095 | 24.00 | 35.73 | 3.00 | 351.00 |
| *Institutional characteristics* | | | | | |
| Institutional control—Private | 129 | 0.58 | 0.50 | 0.00 | 1.00 |
| Offer first-year health science research programs | 129 | 0.65 | 0.48 | 0.00 | 1.00 |
| Institutional type—College | 129 | 0.64 | 0.48 | 0.00 | 1.00 |
| Selectivity | 129 | 1111.00 | 146.51 | 780.00 | 1510.00 |
| Historically Black College or University | 129 | 0.14 | 0.35 | 0.00 | 1.00 |
| Hispanic-serving institution | 129 | 0.07 | 0.26 | 0.00 | 1.00 |
| Log transformation of institutional size | 129 | 8.84 | 1.19 | 6.06 | 10.96 |
| Log transformation of revenue per FTE | 129 | 10.08 | 0.69 | 8.91 | 11.78 |



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**Table 3**

HGLM models for full sample and black student sub-sample

| Variable | Full sample | | | Black student sub-sample | | |
|---|---|---|---|---|---|---|
| | Log odds | SE | Odds ratio | Log odds | SE | Odds ratio |
| Student-level fixed effects | | | | | | |
| *Background characteristics* | | | | | | |
| Female (male reference group) | 0.17 | 0.20 | 1.18 | 0.56 | 0.38 | 1.75 |
| Latina/o | 0.00 | 0.19 | 1.00 | | | |
| Black | −0.43 | 0.20 | 0.65* | | | |
| Asian American | −0.34 | 0.26 | 0.71 | | | |
| American Indian (White reference group) | 0.09 | 0.34 | 1.10 | | | |
| Mother's education | 0.00 | 0.03 | 1.00 | 0.07 | 0.08 | 1.07 |
| High school GPA | 0.02 | 0.07 | 1.02 | 0.02 | 0.13 | 1.03 |
| Plan to live on campus | 0.23 | 0.10 | 1.26* | 0.24 | 0.20 | 1.28 |
| Years of high school math | 0.00 | 0.12 | 1.00 | 0.13 | 0.28 | 1.14 |
| Years of high school science | 0.07 | 0.08 | 1.08 | −0.13 | 0.13 | 0.88 |
| Participated in high school summer research program | 0.20 | 0.17 | 1.22 | 0.25 | 0.35 | 1.29 |
| *Goal commitment, psychological sense of integration, and campus perceptions* | | | | | | |
| Success at managing the academic environment | −0.06 | 0.16 | 0.94 | −0.04 | 0.31 | 0.96 |
| Sense of belonging | −0.12 | 0.18 | 0.89 | 0.21 | 0.26 | 1.24 |
| Social self-concept | 0.22 | 0.09 | 1.24 | 0.39 | 0.19 | 1.48** |
| Academic self-concept | −0.06 | 0.13 | 0.95 | −0.59 | 0.28 | 0.56 |
| Belief that students are treated like numbers | −0.11 | 0.08 | 0.90 | 0.11 | 0.22 | 1.12 |
| Belief that faculty are interested in students | −0.11 | 0.10 | 0.90 | −0.27 | 0.17 | 0.77 |
| Aspire for master's degree | 0.41 | 0.33 | 1.45 | 1.06 | 1.10 | 2.90 |
| Aspire for Ph.D. | 0.23 | 0.32 | 1.26 | 1.77 | 1.14 | 5.84 |
| Aspire for M.D./D.D.S/D.D.O | 0.13 | 0.32 | 1.14 | 1.71 | 1.23 | 5.53 |
| Aspire for other professional degree | 0.12 | 0.52 | 1.13 | 0.15 | 1.40 | 1.16 |
| *College experiences and social networks* | | | | | | |
| Interact with academic advisors | 0.04 | 0.07 | 1.04 | 0.07 | 0.16 | 1.08 |
| Interact with graduate students/TAs | 0.00 | 0.05 | 1.00 | 0.20 | 0.11 | 1.22 |
| Enrolled in honors course | 0.06 | 0.19 | 1.06 | −0.05 | 0.41 | 0.95 |

| Variable | Full sample | | | Black student sub-sample | | |
|---|---|---|---|---|---|---|
| | Log odds | SE | Odds ratio | Log odds | SE | Odds ratio |
| Participated in learning community | 0.30 | 0.27 | 1.34 | 1.28 | 0.62 | 3.60* |
| Enrolled in first-year experience course | 0.49 | 0.13 | 1.62*** | 0.50 | 0.38 | 1.65 |
| Joined a pre-professional/departmental club | 0.60 | 0.13 | 1.82*** | 0.16 | 0.32 | 1.17 |
| Participated in minority academic enrichment program | 0.29 | 0.17 | 1.34 | 0.81 | 0.29 | 2.25 |
| Frequency: received advice from juniors and seniors | 0.18 | 0.08 | 1.20* | 0.10 | 0.15 | 1.11** |
| Frequency: received advice from freshmen | 0.05 | 0.07 | 1.05 | −0.04 | 0.16 | 0.96 |
| Frequency: discussed academics outside of class | 0.24 | 0.12 | 1.27 | 0.40 | 0.20 | 1.49 |
| Frequency: experienced positive cross-racial interactions | 0.00 | 0.08 | 1.00 | 0.02 | 0.13 | 1.02* |
| Frequency: student–faculty interactions | 0.08 | 0.03 | 1.08* | 0.08 | 0.08 | 1.08 |
| Worked on campus for pay | 0.13 | 0.15 | 1.13 | 0.47 | 0.32 | 1.60 |
| Worked off campus for pay | 0.29 | 0.17 | 1.33 | 0.25 | 0.36 | 1.28 |
| *Environmental pull* | | | | | | |
| Belief that family supports student in college | 0.08 | 0.08 | 1.08 | 0.08 | 0.15 | 1.08 |
| Extent of financial concerns | −0.03 | 0.11 | 0.97 | −0.47 | 0.17 | 0.62* |
| Belief that family responsibilities interfere with college | 0.17 | 0.08 | 1.18* | 0.19 | 0.13 | 1.21 |
| Institution fixed effects | | | | | | |
| *Institutional characteristics* | | | | | | |
| Private (public reference group) | −0.08 | 0.24 | 0.92 | 0.27 | 0.53 | 1.30 |
| College (university reference group) | 0.04 | 0.27 | 1.04 | −0.22 | 0.69 | 0.80 |
| Selectivity | 0.00 | 0.00 | 1.00 | −0.01 | 0.00 | 1.00 |
| HBCU | 0.19 | 0.38 | 1.20 | −0.19 | 0.61 | 0.83 |
| HSI | −0.19 | 0.42 | 0.83 | | | |
| Institutional size | 0.27 | 0.14 | 1.31* | −0.04 | 0.33 | 0.97 |
| Institutional revenue per full-time equivalent student | 0.37 | 0.28 | 1.45 | 0.62 | 0.53 | 1.86 |
| Offer health science research to freshmen | 0.49 | 0.17 | 1.64** | 1.46 | 0.35 | 4.31* |
| Random effects (variance component) | | | 0.25*** | | | 0.86*** |
| Chi-square | | | 189.63*** | | | 103.63*** |
| Intercept reliability | | | 0.30 | | | 0.35 |
| Explained variance | | | 0.07 | | | 0.14 |

*Note*. The full sample includes 3,095 students at 129 institutions. The sub-sample of Black students includes 868 students at 67 institutions



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**Table 4**

Characteristics of health science research programs available to freshmen

| Variable | Mean | SD |
|---|---|---|
| Paid positions | 0.63 | 0.48 |
| Volunteer positions | 0.76 | 0.45 |
| Independent study credit | 0.67 | 0.48 |
| Faculty mentorship | 0.88 | 0.38 |
| Peer mentorship | 0.60 | 0.49 |
| Preparation for medical school | 0.75 | 0.42 |
| Preparation for graduate school | 0.87 | 0.39 |
| Financial support for program participants | 0.82 | 0.45 |
| Presentation opportunities | 0.93 | 0.38 |

*Source*. Online survey of YFCY and Freshman Survey participating institutions, Higher Education Research Institute, UCLA

## Table 5

Cross-tabulation of institutional characteristics with health science research program

| Variable | Does not offer program | Offers program |
|---|---|---|
| HSI | 33% | 67% |
| HBCU | 35% | 65% |
| PWI | 33% | 67% |
| University | 30% | 70% |
| College | 65% | 35% |
| Public | 33% | 67% |
| Private | 36% | 64% |
| Means | | |
| Average selectivity (SAT composite) | 1,074 | 1,130 |
| Average FTE enrollment | 11,118 | 13,617 |
| Average revenue per FTE student | $26,388 | $33,373 |

*Source*. IPEDS data merged with online survey of YFCY and Freshman Survey participating institutions, Higher Education Research Institute, UCLA