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First-generation and continuing-generation college graduates' application, acceptance, and matriculation to U.S. medical schools: a national cohort study

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ABSTRACT

Many U.S. medical schools conduct holistic review of applicants to enhance the socioeconomic and experiential diversity of the physician workforce. The authors examined the role of first-generation college-graduate status on U.S. medical school application, acceptance, and matriculation, hypothesizing that first-generation (vs. continuing-generation) college graduates would be less likely to apply and gain acceptance to medical school.Secondary analysis of de-identified data from a retrospective national-cohort study was conducted for individuals who completed the 2001–2006 Association of American Medical Colleges (AAMC) Pre-Medical College Admission Test Questionnaire (PMQ) and the Medical College Admissions Test (MCAT). AAMC provided medical school application, acceptance, and matriculation data through 06/09/2013. Multivariable logistic regression models identified demographic, academic, and experiential variables independently associated with each outcome and differences between first-generation and continuing-generation students. Of 262,813 PMQ respondents, 211,216 (80.4%) MCAT examinees had complete data for analysis and 24.8% self-identified as first-generation college graduates. Of these, 142,847 (67.6%) applied to U.S. MD-degree-granting medical schools, of whom 86,486 (60.5%) were accepted, including 14,708 (17.0%) first-generation graduates; 84,844 (98.1%) acceptees matriculated. Adjusting for all variables, first-generation (vs. continuing-generation) college graduates were less likely to apply (odds ratio [aOR] 0.84; 95% confidence interval [CI], 0.82–0.86) and be accepted (aOR 0.86; 95% CI, 0.83–0.88) to medical school; accepted first-generation college graduates were as likely as their continuing-generation peers to matriculate. Students with (vs. without) paid work experience outside hospitals/labs/clinics were less likely to apply, be accepted, and matriculate into medical school. Increased efforts to mitigate structural socioeconomic vulnerabilities that may prevent first-generation college students from applying to medical school are needed. Expanded use of holistic review admissions practices may help decision makers value the strengths first-generation college graduates and other underrepresented applicants bring to medical educationand the physician workforce.

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Introduction

Decades of research show that medical student and physician diversity is correlated with improved educational experiences, better patient-care outcomes, and culturally competent healthcare [1–10]. The Association of American Medical Colleges (AAMC) affirmed that attracting a diverse class of students should be central to a medical school's mission [11,12]. In 2008, the Liaison Committee on Medical Education (LCME) adopted accreditation standards requiring all LCME-accredited medical schools to develop initiatives and policies to attract students from diverse backgrounds, including those from groups Underrepresented in Medicine (URiM) [13]. Nevertheless, racial, ethnic and socio-demographic disparities remain in medical school enrollment [14,15]. Forty-two percent of students who graduated with a bachelor's degree in academic year 2015–2016 self-identified as first-generation college students (college students with no parent with a bachelors' or higher degree) [16]. Data show that less than half that number (20%) of U.S. medical school matriculants self-identified as first-generation college graduate, with a disproportionate proportion self-identifying as from racio-ethnic group and of low-income status stratus [17,18].

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Studies examining the path to medical school by first-generation college graduates' are lacking. First-generation college graduates comprise a diverse group with intersectional identities related to gender, sexual orientation, race, ethnicity, and socioeconomic status [19]. Undergraduate schools have recognized distinctive assets (e.g., grit and perseverance) that first-generation college students bring to their institutions [20,21] and medical schools have followed suit, recognizing that this diverse subset of physician aspirants possess backgrounds underrepresented in medicine that may lead them to innovate in areas of medicine that have been under investigated and/or less understood, adding depth and breadth to the approaches used to address healthcare challenges [22]. These aspects of their background contribute to the diversity of heathcare teams, and have been correlated with better patient health outcomes including improvement in healthcare quality, medical education and training [8]. The Association of American Medical Colleges has enabled medical school admissions to better identify students who self-identify as first-generation college graduates through the use of a first- generation college student indicator added to the American Medical College Application Service (AMCAS) in 2017 [23]. Using a more holistic enrollment management framework increases the diversity of medical school applicants and matriculants, and enhances students and medical institutions ability to provide optimal care for patients [24]. These data provide evidence that first-generation college aspirants differ from their continuing-generation peers in ways that reduce the likelihood they will attend college, due to factors such as less knowledge about the college application process, fewer financial resources and less college application-related social support [25]. We suspect that these disparities are present for first-generation college graduates aspiring to the MD degree however, to date, such data does not exist.

To expand our understanding of first-generation college graduates' experiences and challenges to applying to medical school, we conducted a retrospective analysis of data for a cohort of students considering a career in medicine. We sought to examine differences in the likelihood of medical school application, acceptance, and matriculation, comparing first-generation and continuing-generation college graduates who demonstrated strong interest in pursuing a career in medicine by taking the Medical College Admission Test (MCAT) and completing the AAMC's Pre-MCAT Questionnaire (PMQ), a voluntary survey administered to students taking the MCAT and which solicited information about students' backgrounds, attitudes and premedical school academic and extracurricular activities and experiences. We hypothesized that the likelihood of applying to medical school and being accepted to medical school would be lower for first-generation (vs. continuing-generation) college graduates, when controlling for academic, experiential, and other demographic factors.

Methods

Design and data acquisition

We conducted a secondary analysis of data obtained from the AAMC for a national cohort of 262,813 individuals who voluntarily completed the Pre-Matriculation Questionnaire (PMQ) in calendar years 2001 through 2006, The AAMC provided individually linked, de-identified data, including demographics, academic and experiential data from the PMQ, first-attempt MCAT scores, year of examination, and medical school application, acceptance, and matriculation from the AAMC Data Warehouse. Updated data were acquired on 9 June 2013, to allow for adequate time for PMQ respondents to apply to and matriculate into medical school, since many individuals do not apply to medical school immediately after a first-attempt MCAT. Of 262,813 PMQ respondents in 2001–2006, 250,432 (95.3%) completed MCAT and were therefore eligible to apply, get admitted and matriculate, the three consecutively nested outcomes of this study. Of these 250,432 eligible students we consecutively excluded 36,935 respondents who did not complete all PMQ items of interest, 129 with lacking data on sex and 2152 lacking parental education data. Thus, our final study sample included 211,216 PMQ respondents (84.3% of eligible PMQ respondents). This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines [26] and the Institutional Review Board at Washington University in St. Louis approved this study as non-human-subjects research.

Demographic variables

A binary variable for first-generation college-graduate status was generated based on responses to PMQ items regarding parents' education (no parent attained a bachelor's degree or higher [first-generation] vs. at least one parent attained college with a bachelor's degree or higher [continuing-generation]). Self-reported data on sex, race, and ethnicity were obtained from the PMQ or the AAMC Student Records System, if these data were not reported on the PMQ. Data on race/ethnicity were categorized as non-Hispanic White, non-Hispanic Asian/Pacific Islander, underrepresented in medicine ([URiM]; Black/African American, Hispanic, American Indian/Alaskan Native), and a combined group of other/multiple/unknown race/ethnicity due to their small numbers. Based on

previous reports of suboptimal outcomes among older medical school matriculants [27], age reported on the PMQ was dichotomized (≥23 vs. <23 years old).

Experiential variables

Experiential variables included affirmative responses to a PMQ item about participating in any of seven programs intended to prepare high school or college students for careers in medicine or other professional fields. We included summer academic-enrichment programs for college students, college laboratory research apprenticeships, and MCAT-preparation courses. We also included affirmative responses to a PMQ item about participating in any of 16 'extracurricular activities and/or work experiences,' from which we included 'paid or volunteer work in hospitals, medical clinics, or labs,' and 'any other paid work.'

Academic variables

The AAMC provided first-attempt MCAT scores for each PMQ respondent who completed the MCAT version in use from 1991 through January 2015. Verbal Reasoning, Biological Sciences, and Physical Science section scores, each ranging from 1–15, were summed to compute a composite MCAT score ranging from 3–45. The AAMC provided Carnegie Classification data for each PMQ respondent's undergraduate institution [28]; a six-category variable was created for analysis: 1) doctoral universities with very high research activity, 2) other doctoral universities with high research activity and doctoral/professional universities, 3) master's colleges and universities, 4) baccalaureate Arts & Sciences colleges, 5) all other undergraduate institution classifications (e.g., Associates, Special Focus, and Tribal Colleges), and, 6) classification not specified.

Outcomes

The AAMC provided records for three outcomes of interest: medical school application, acceptance, and matriculation by June 2013.

Statistical analysis

Chi-square tests and analysis of variance (ANOVA) were used to bivariately compare distribution of categorical and continuous variables, respectively, across categories. Three multivariable logistic regression models were run to determine whether first-generation (vs. continuing-generation) college-graduate status was independently associated with the outcomes: medical school application among all PMQ respondents in the sample; medical school acceptance among applicants; and matriculation among those who were accepted. Each model was adjusted for all demographic, academic and experiential variables of interest. We also stratified by race/ethnicity and by sex to determine if first-generation status was associated with each outcome within each group. Adjusted odds ratios (aOR) and 95% confidence intervals (CI) were reported for each variable. Two-tailed P values < 0.05 were considered significant. Statistical analyses were performed using IBM SPSS version 25 (IBM SPSS, Inc., Chicago, IL. USA).

Results

Of the 211,216 eligible PMQ respondents, 24.8% self-identified as first-generation college graduates. 142,847 (67.6%) of eligible PMQ respondents applied to medical school, of which 86,486 (60.5%) were accepted and of those who were accepted 84,844 (98.1%) matriculated.

Table 1 shows data for medical school application, acceptance and matriculation rates by college-graduate generation status and other demographic, academic and experiential characteristics. Of the 142,847 students who applied to medical school, of which, 30,320 (21.2%) were first-generation graduates, 73,953 (51.8%) were female, 22,607 (15.8%) were URiM, and 31,626 (22.1%) were ≥23 years old. Of 86,486 applicants accepted to medical school (60.5% of all applicants), 14,708 (17.0%) were first-generation graduates, 43,022 (49.7%) were female, 13,157 (15.2%) were URiM, and 15,698 (18.2%) were ≥ 23 years old. Of 84,844 matriculants, 14,418 (17.0%) were first-generation graduates, 42,119 (49.6%) were female, 12,983 (15.3%) were URiM, and 15,337 (18.1%) were ≥ 23 years old.

Table 2 shows the variables associated with medical school application, acceptance, and matriculation. Compared with each variable's respective reference group, students who had higher MCAT scores, self-identified as Asian/Pacific Islander or URiM, attended other doctoral universities, participated in an MCAT-preparation course, a college research apprenticeship, a summer academic-enrichment program, and paid or volunteer work in hospital/clinic/lab settings were more likely to apply to medical school. In contrast, respondents who were first-generation college graduates, women, other/multiple/unknown race/ethnicity, ≥ 23 years old, attended master's colleges/universities and other undergraduate institutions, and reported other paid work experiences were less likely to apply to medical school.

In addition, applicants who had higher MCAT scores, were women and URiM, attended other doctoral universities and baccalaureate Arts & Sciences colleges, reported participating in MCAT-preparation courses, college research apprenticeships, summer academic-enrichment programs, and paid or volunteer work in hospital/clinic/lab settings were more likely

Table 1. Characteristics of 2001–2006 PMQ respondents who completed the MCAT and the comparison of subsequent application, acceptance and matriculation rates by student characteristics.

	Total Sample[a] N = 211,216	Applied[b] N = 142,847	Accepted[c] N = 86,486	Matriculated[d] N = 84,844
College-graduate generation based on parent's education, No. (%)				
Continuing-generation	158,914 (75.2)	112,527 (70.8)	71,778 (63.8)	70,426 (98.1)
First-generation	52,302 (24.8)	30,320 (58.0)	14,708 (48.5)	14,418 (98.0)
PMQ/MCAT year, No. (%)				
2001	29,480 (14.0)	20,298 (68.9)	13,116 (64.6)	12,827 (97.8)
2002	34,514 (16.3)	23,316 (67.6)	14,399 (61.8)	14,110 (98.0)
2003	35,851 (17.0)	24,520 (68.4)	15,062 (61.4)	14,777 (98.1)
2004	35,826 (17.0)	24,220 (67.6)	14,505 (59.9)	14,253 (98.3)
2005	37,678 (17.8)	25,295 (67.1)	14,823 (58.6)	14,577 (98.3)
2006	37,867 (17.9)	25,198 (66.5)	14,581 (57.9)	14,300 (98.1)
MCAT score, mean (SD) †	24.9 (6.7)	26.6 (6.1)	29.1 (5.0)	29.1 (5.0)
Sex				
Male	96,983 (45.9)	68,894 (71.0)	43,464 (63.1)	42,725 (98.3)
Female	114,233 (54.1)	73,953 (64.7)	43,022 (58.2)	42,119 (97.9)
Race/ethnicity, No. (%)				
Non-Hispanic White	125,535 (59.4)	86,654 (69.0)	54,685 (63.1)	53,563 (97.7)
Non-Hispanic Asian/PI	42,207 (20.0)	27,876 (66.0)	16,025 (57.5)	15,766 (98.4)
URiM	34,087 (16.1)	22,607 (66.3)	13,157 (58.2)	12,983 (98.7)
Other/multiple/unknown	9,387 (4.4)	5,710 (60.8)	2,619 (45.9)	2,532 (96.7)
Carnegie classification, No. (%)				
Research universities with very high research activity, No. (%)	89,686 (42.5)	72,385 (80.7)	48,791 (67.4)	48,099 (98.6)
Other Doctoral universities, No. (%)	33,312 (15.8)	23,631 (70.9)	12,943 (54.8)	12,694 (98.1)
Master's colleges and universities, No. (%)	30,336 (14.4)	19,807 (65.3)	9,334 (47.1)	9,136 (97.9)
Baccalaureate A&S colleges, No. (%)	19,371 (9.2)	15,201 (78.5)	10,276 (67.6)	10,080 (98.1)
Other institutions, No. (%)	6,613 (3.1)	3,950 (59.7)	1,793 (45.4)	1,756 (97.9)
Not specified, No. (%)	31,898 (15.1)	7,873 (24.7)	3,349 (42.5)	3,079 (91.9)
Age on PMQ, No. (%)				
< 23 years	158,138 (74.9)	111,221 (70.3)	70,788 (63.6)	69,507 (98.2)
≥ 23 years	53,078 (25.1)	31,626 (59.6)	15,698 (49.6)	15,337 (97.7)
MCAT-preparation course, No. (%)				
No	91,587 (43.4)	56,598 (61.8)	32,748 (57.9)	31,969 (97.6)
Yes	119,629 (56.6)	86,249 (72.1)	53,738 (62.3)	52,875 (98.4)
College laboratory research apprenticeship, No. (%)				
No	139,246 (65.9)	89,437 (64.2)	50,874 (56.9)	49,834 (98.0)
Yes	71,970 (34.1)	53,410 (74.2)	35,612 (66.7)	35,010 (98.0)
College academic-enrichment summer program, No. (%)				
No	185,587 (87.9)	124,333 (67.0)	75,036 (60.4)	73,583 (97.8)
Yes	25,629 (12.1)	18,514 (72.2)	11,450 (61.8)	11,261 (98.3)
Paid or volunteer work in hospitals/clinics/labs, No. (%)				
No	60,206 (28.5)	36,748 (61.0)	21,130 (57.5)	20,659 (97.8)
Yes	151,010 (71.5)	106,099 (70.3)	65,356 (61.6)	64,185 (98.2)
Other paid work, No. (%)				
No	99,978 (47.3)	67,837 (67.9)	42,087 (62.0)	41,370 (98.3)
Yes	111,238 (52.7)	75,010 (67.4)	44,399 (59.2)	43,474 (97.6)

Abbreviations: PMQ, Pre-Medical College Admission Test Questionnaire; MCAT, Medical College Admission Test; PI, Pacific Islanders, including Native Hawaiian; URiM, underrepresented in medicine, including Black/African American, Hispanic, and American Indian/Alaska Native groups; A&S, Arts & Sciences.

[a]Distribution of characteristics of the study population (column percents).

[b]Comparison of frequency and proportion of total eligible students who applied for admission, by each student characteristic. All comparisons were statistically significant at $p < 0.001$ except 'Other paid work' being significant at $p = 0.039$.

[c]Comparison of frequency and proportion of applicants to medical school who were accepted, by each student characteristic. All comparisons were statistically significant at $p < 0.001$

[d]Comparison of frequency and proportion of accepted students who matriculated, by each student characteristic.

†MCAT is a continuous variable, therefore only mean and standard deviation of those who applied, were accepted and, matriculated are presented

to be accepted to medical school. Applicants who were first-generation college graduates, non-Hispanic Asian/Pacific Islander or other/multiple/unknown race/ethnicity, older, completed the PMQ/MCAT in more recent years, attended masters colleges/universities, or reported other paid work experiences were less likely to be accepted into medical school.

Among individuals accepted to medical school, the likelihood of matriculation did not differ significantly between first-generation and continuing-generation college graduates. Respondents with higher MCAT scores, who completed the PMQ/MCAT in more recent years, self-identified as URiM, participated in MCAT-preparation courses, and reported paid or volunteer work in hospital/clinic/lab settings were more likely to matriculate. into medical school; Women, respondents with other/multiple/unknown racial/ethnic groups responses, and older, attended other doctoral universities, masters colleges/universities, and baccalaureate Arts & Sciences colleges, and reported other paid work were less likely to matriculate.

Compared to continuing-generation college graduates, first-generation graduates had lower MCAT scores, were more likely to be women, URiM, ≥ 23 years old, and participated in other paid work; and less likely to participate in MCAT-preparation courses, college research apprenticeships, and paid or

Table 2. Multivariable logistic regression models identifying variables independently associated with medical school application, acceptance, and matriculation.

	Applied to Medical School aOR (95% CI)	Accepted to Medical School aOR (95% CI)	Matriculated into Medical School aOR (95% CI)
College-graduate generation based on parent's education			
Continuing-generation	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
First-generation	0.84 (0.82–0.86)	0.86 (0.83–0.88)	1.01 (0.88–1.15)
MCAT score[a]	1.18 (1.18–1.19)	1.31 (1.30–1.31)	1.02 (1.01–1.04)
PMQ/MCAT year[b]	1.00 (0.99–1.01)	0.88 (0.88–0.89)	1.03 (1.003–1.06)
Sex			
Male	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Female	0.94 (0.92–0.96)	1.17 (1.14–1.21)	0.78 (0.70–0.86)
Race/Ethnicity			
Non-Hispanic White	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Non-Hispanic Asian/PI	1.06 (1.03–1.09)	0.73 (0.70–0.76)	1.13 (0.98–1.30)
URiM	2.23 (2.16–2.31)	3.68 (3.53–3.84)	1.76 (1.48–2.10)
Other/multiple/unknown	0.93 (0.89–0.98)	0.54 (0.50–0.57)	0.59 (0.47–0.73)
Carnegie classification			
Research universities with very high research activity	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Other Doctoral universities	1.06 (1.02–1.09)	1.12 (1.08–1.16)	0.80 (0.69–0.93)
Master's colleges/universities	0.93 (0.90–0.96)	0.90 (0.86–0.93)	0.77 (0.65–0.91)
Baccalaureate A&S colleges	1.01 (0.97–1.05)	1.20 (1.14–1.25)	0.83 (0.70–0.97)
Other institutions	0.90 (0.85–0.95)	1.03 (0.96–1.12)	0.83 (0.59–1.16)
Not specified	0.07 (0.07–0.08)	0.34 (0.33–0.36)	0.17 (0.15–0.20)
Age on PMQ			
< 23 years	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
≥ 23 years	0.79 (0.77–0.81)	0.58 (0.57–0.60)	0.85 (0.75–0.96)
MCAT-preparation course			
No	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Yes	1.26 (1.23–1.28)	1.05 (1.02–1.08)	1.42 (1.29–1.58)
College laboratory research apprenticeship			
No	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Yes	1.10 (1.07–1.13)	1.14 (1.11–1.17)	1.05 (0.94–1.17)
College academic-enrichment summer program			
No	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Yes	1.27 (1.23–1.32)	1.28 (1.23–1.34)	1.00 (0.85–1.18)
Paid or volunteer work in hospitals/clinics/labs			
No	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Yes	1.36 (1.32–1.39)	1.18 (1.14–1.21)	1.18 (1.06–1.33)
Other paid work			
No	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Yes	0.90 (0.88–0.92)	0.86 (0.84–0.88)	0.83 (0.74–0.92)

Abbreviations: aOR, adjusted odds ratio; 95% CI, 95% confidence interval; MCAT, Medical College Admission Test; PMQ, Pre- MCAT Questionnaire; PI, Pacific Islanders, including Native Hawaiian; URiM, underrepresented in medicine, including Black/African American, Hispanic, and American Indian/Alaska Native groups; A&S, Arts & Sciences.

[a]aOR > 1.00 indicates greater likelihood of application, acceptance, and matriculation for each unit increase in MCAT score.

[b]aOR < 1.00 indicates lower likelihood of acceptance, and aOR > 1.00 indicates greater likelihood of matriculation, for each increase in PMQ year.

volunteer work in hospital/clinic/lab settings (each chi-square, $P < 0.001$) (Table 3).

The independent effect of generation status on medical school application, acceptance and matriculation that was observed in the overall study population, persisted within the strata of race/ethnicity and sex such that first generation college graduates were less likely to apply to medical school (Supplemental Table 1).

Discussion

To our knowledge, this is the first national-cohort study to explore medical school application, acceptance and matriculation between first-generation and continuing-generation college graduates who considered applying to U.S. medical schools. First-generation college graduates bring a unique intersectionality of multiple components of their self-identity, however how aspects of this identify may impact the pursuit of a medical career has yet to be discussed. Our data show that although competitive first-generation college graduates took concrete steps toward pursuing a medical career, (i.e., completed the PMQ and MCAT), they were less likely than continuing-generation graduates to apply and be accepted to U.S. LCME-accredited medical schools.

There may be several reasons for first-generation college graduates' lower likelihood of medical school application and acceptance. Applying to medical school is daunting, and the challenges may be more burdensome for first-generation undergraduates, 51% of whom are from URiM groups (compared to 30% of continuing-generation undergraduates), and 27% of whom come from low-income background (<$20,000/year) families (compared to 6% of continuing-generation undergraduates) [28]. The impact of sex, minority status, socioeconomic class and other identities by first-generation students may influence

Table 3. Comparison of respondent characteristics, by first-generation and continuing-generation college-graduate status. (N = 211,216).

	First-generation N = 52,302 (%)	Continuing-generation N = 158,914 (%)	p-value *
PMQ/MCAT year			
2001	7,534 (14.4)	21,946 (13.8)	<0.001
2002	8,827 (16.9)	25,687 (16.2)	
2003	8,936 (17.1)	26,915 (16.9)	
2004	8,786 (16.8)	27,040 (17.0)	
2005	9,106 (17.4)	28,572 (18.0)	
2006	9,113 (17.4)	28,754 (18.1)	
MCAT score, mean (SD)	22.2 (6.5)	25.8 (6.5)	<0.001
Sex			
Male	22,447 (42.9)	74,536 (46.9)	<0.001
Female	29,855 (57.1)	84,378 (53.1)	
Race/ethnicity			
Non-Hispanic White	28,045 (53.6)	97,490 (61.3)	<0.001
Non-Hispanic Asian/PI	8,853 (16.9)	33,354 (21.0)	
URiM	13,021 (24.9)	21,066 (13.3)	
Other/multiple/unknown	2,383 (4.6)	7,004 (4.4)	
Carnegie classification			
Research universities with very high research activity	17,326 (33.1)	72,360 (45.5)	<0.001
Other Doctoral universities	9,437 (18.0)	23,875 (15.0)	
Master's colleges and universities	10,814 (20.7)	19,522 (12.3)	
Baccalaureate A&S colleges	3,746 (7.2)	15,625 (9.8)	
Other institutions	2,451 (4.7)	4,162 (2.6)	
Not specified	8,528 (16.3)	23,370 (14.7)	
Age on PMQ			
< 23 years	34,837 (66.6)	123,301 (77.6)	<0.001
≥ 23 years	17,465 (33.4)	35,613 (22.4)	
MCAT-preparation course			
No	25,744 (49.2)	65,843 (41.4)	<0.001
Yes	26,558 (50.8)	93,071 (58.6)	
College laboratory research apprenticeship			
No	36,407 (69.6)	102,839 (64.7)	<0.001
Yes	15,895 (30.4)	56,075 (35.3)	
College academic-enrichment summer program			
No	45,287 (86.6)	140,300 (88.3)	<0.001
Yes	7,015 (13.4)	18,614 (11.7)	
Paid or volunteer work in hospitals/clinics/labs			
No	15,295 (29.2)	44,911 (28.3)	<0.001
Yes	37,007 (70.8)	114,003 (71.7)	
Other paid work			
No	22,808 (43.6)	77,170 (48.6)	<0.001
Yes	29,494 (56.4)	81,744 (51.4)	

Abbreviations: PMQ, Pre-Medical College Admission Test Questionnaire; MCAT, Medical College Admission Test; PI, Pacific Islanders, including Native Hawaiian; URiM, underrepresented in medicine, including Black/African American, Hispanic, and American Indian/Alaska Native groups; A&S, Arts & Sciences.

*p-values for difference in mean MCAT scores is based on ANOVA. The remainder are based on Chi-square tests.

how they navigate the application process [29]. In our study, PMQ respondents who were women, URiM, older, and engaged in other paid work during or after college were overrepresented among first-generation college graduates, which mirrors findings in the undergraduate literature [29,30]. In stratified models, within each racio-ethnic and sex group, first-generation graduates were less likely than peers to apply to medical school. First-generation graduates were also more likely to engage in paid work, and respondents who worked for wages were less likely to matriculate after acceptance. Financial strains compelling some first-generation respondents to seek employment while attending college, may be a barrier to pursuing a career in medicine, due to inability to pay costs related to the application process. The AAMC's Fee Assistance Program (FAP), when accessible, may lower prospective medical student's financial burden by waiving the cost of primary medical school applications. However, a number of students are not aware that FAP exists, and waiving fees does not effectively increase the economic capital for first-generation applicants. The differences between first-generation and continuing-generation graduates' participation in other paid work experiences highlight deep socioeconomic inequalities across the premedical-education continuum. Working for pay while in undergraduate school also has the potential to negatively impact academic performance and limit prospective applicants 'ability to take advantage of opportunities to pursue extracurricular research, academic, and clinical experiences that may enhance their prospects for acceptance. The structural societal constructs that many first-generation college graduate physician aspirants confront, by virtue of factors such as their parents' educational backround, their ethno-racial background and income level put them at risk for

academic redlining, the systematic exclusion of potentially qualified applicants due to test-score cut-offs imposed by admissions committees [31].

Implications

The AAMC has expressed commitment to making the medical school application process more accessible and affordable [32]. When designing approaches to improve the application and acceptance rates of qualified applicants from underrepresented groups, there is a need to thoroughly understand the extent to which structural barriers such as food and housing insecurity may necessitate employment for these premedical students. Applicants' backgrounds, experiences, and access to financial and social capital, may combine with structural inequities to prevent first-generation college graduates from applying to medical school.

First-generation college graduates, as a group, have multiple identities based on gender, race, ethnicity, income and locale. By virtue of these diverse and intersecting identities, they bring an abundance of assets such as resourcefulness, experience with formal systems, and innovation to medical education and training. Although by the time they arrive at medical school, many have overcome societal constructs to their success, before, during and after college graduation, that experience provides them distinctive assets that come directly out of those experiences. Of note, some undergraduate institutions (e.g., other doctoral universities and baccalaureate Arts & Sciences colleges) were associated with greater likelihood of application and acceptance to medical school, suggesting that students who were considering a medical career and attended these types of undergraduate institutions may have been particularly well supported during this process. Participation in extracurricular activities (e.g., college research apprenticeships, academic-enrichment programs, and volunteer or paid work in hospital/clinic/lab settings) were each, positively associated with medical school application and acceptance. Notably, only respondents who reported volunteer or paid work in hospital/clinic/lab settings were more likely to matriculate after acceptance. Academic and extracurricular activities associated with greater likelihood of medical school application, acceptance, and matriculation can help first-generation college graduates, and other minoritized groups to succeed in their medical career aspirations and can also serve to increase, not only physician-workforce diversity, but improve health outcomes for all [1–7]. Consequently, institutional support is needed for programs to assist learners to access these experiences and cultivate mentoring relationships throughout premedical education with a view to boost first-generation college students' opportunities for success in the medical school preparation and application process.

First-generation applicants were less likely to be accepted into medical school, even after controlling for several demographic, academic, and experiential variables. To increase the diversity of the medical student population, many schools employ holistic review [33]. A flexible, mission-aligned, holistic admissions process [24] involves considering experiences (e.g., research, extracurricular activities, service), attributes (e.g., first-generation, gender and URiM status), and metrics (e.g., grades and MCAT scores) throughout the screening, interview and selection process [33–36]. Holistic admissions review has been effective in improving the inclusion of URiM applicants [15,35,37] and holds promise for increasing medical school acceptance of URiM and first-generation students [24,38].

Although less likely to apply and be accepted to medical school, first-generation college graduates were as likely as their continuing-generation peers to matriculate, suggesting that mitigating structural barriers with resources might increase their numbers in the preparation and acceptance phases. First-generation college graduate physician aspirants do not appear to be deterred from matriculating despite the probable accrual of educational loan debt to facilitate full-time attendance. In the premedical preparation and application stages, first-generation respondents reported higher participation in non-medical paid work and lower participation in research apprenticeships, perhaps due to structural vulnerabilities related to income, time, and social connections. Although there is a paucity of research on first-generation college graduates' experiences during medical school, recent data show that first-generation college graduates were neither more nor less likely to take a leave of absence compared with their continuing-generation counterparts [39], suggesting that, when given the opportunity to matriculate, they are just as likely to thrive as their continuing-generation peers.

Strengths and limitations

A strength of this study is the availability of data for the entire, national cohort of MCAT examinees who completed the PMQ from 2001 through 2006, with a minimum 7-year follow-up. As an observational study, however, causal inferences cannot be made. There are other limitations in this study. We acknowledge the potential inflation of Type I error due to multiple secondary hypotheses and sub-analyses. Type I error was not corrected for because this was an exploratory analysis. Covariates were selected based on previous studies or sociological plausibility, however there may be unmeasured variables that influence

medical school application, acceptance, and matriculation that this study did not capture. First-generation college graduates may be more likely to apply to Doctor of Osteopathic Medicine (DO) schools or international schools [40]; our data did not include those students because the AAMC does not collect data from applicants to DO schools thus this could be an important avenue for future research. Another limitation is that we could not control for parental income with the data available, although college education correlates with parental socio-economic status. In addition, parents who have not attended or graduated from college may have, relative to college graduate parents, less medical school-related social capital, social networks and 'funds of knowledge' that could help develop an early interest in and exposure to the field, and, fewer financial resources to support their child as prepare for medical training [41–44].

Although holistic review was being utilized by many schools during the study period, the AAMC's Holistic Review Project was not developed or broadly implemented until 2007 [38], after many respondents in our cohort had already begun the application process. Prospective studies of the impact of holistic review on medical school acceptance of URiM and first-generation college graduates remain limited [38]. Given the intentions of holistic review to increase the diversity of the population of future physicians and ultimately the physician workforce, additional research with more recent cohorts is needed to identify factors that deter otherwise qualified aspiring physicians from applying to medical school.

Our findings underscore the importance of enhancing equity in the medical school application and acceptance process. For example, tailored advising and mentoring approaches that meet applicants where they are, as well as accessible academic support and coaching in standardized test-taking skills, may mitigate MCAT-score disparities and improve college course performance for applicants from first-generation college graduates and others from groups underrepresented in medicine. Applying holistic review approaches to medical school admissions may expand admissions committees' consideration of first-generation college graduates. Finally, robust financial resources that go beyond application fee waivers to cover the inherent costs of medical school preparation and application are imperative. More research on the pathways, outcomes, and experiences of first-generation college students striving to become the next generation of health care providers will continue to enhance awareness of where support systems are needed and inform about the structural and practical changes that are needed to ensure equity in the medical school admissions process in the USA. It is imperative that we redouble our efforts to ensure that medical education and, indeed, medicine itself, benefit from the myriad of assets first generation medical students, residents and physicians bring to their peers, institutions, their patients.

Conclusion

In conclusion, this study found that first-generation college graduates were less likely to apply to and be accepted into medical school compared to their continuing-generation peers. However, once accepted into medical school, both first-generation and continuing-generation college graduates were equally likely to matriculate medical school. In addition, greater proportions of first-generation graduates identified as women and members of URiM groups. As discussed, generation status had a bearing on medical school application, acceptance and matriculation, consistent across race/ethnicity and sex.

We identified extracurricular activities along the educational continuum that can provide opportunities for intervention to retain greater numbers of first-generation college graduates in the physician-training pipeline. To our knowledge, these activities among first-generation college students aspiring to become physicians had not been previously explored. The imperative of increased diversity, equity, and inclusion in medical education requires recognizing that focusing on diversity in recruitment is insufficient. To ensure equitable access to medical education, dismantling the visible and invisible social, financial, and structural barriers that may deter promising premedical students from progressing on the premedical-to-medical school pathway is critical. Increased inclusion of first-generation college graduates and others from historically marginalized groups with distinctive talents, strengths, perspectives, and experiences, will benefit medical education and help, make progress toward equitable, culturally safe and responsive health care.

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Ethical approval

The Institutional Review Board at Washington University in St. Louis approved this study as non-human-subjects research.

Disclaimers

Neither the Association of American Medical Colleges, the Northeast Group on Educational Affairs, nor the National Institute of General Medical Sciences were involved in the design or conduct of the study; collection, management, analysis, or interpretation of the data; preparation, review, or approval of the manuscript; or the decision to submit the manuscript for publication.

Data availability

The data are proprietary and were used under a fully executed data-use agreement. Contact the Association of American Medical Colleges regarding acquisition of research data.

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