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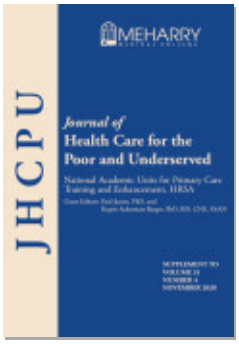

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ORIGINAL PAPER

The Relationships among Self-Designated Disadvantage, Socioeconomic Disadvantage, and Academic Performance in Medical School: A Multi-Institutional Study

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Abstract: As medical schools seek to address the growing disparity between the socioeconomic makeup of their students and the general population, it is important to understand the academic trajectory of disadvantaged students. We used a locally-developed multicomponent socioeconomic disadvantage (SED) measure and the self-designated disadvantaged (SDA) question ["yes" (+) or "no" (–)] from the American Medical College Application Service application to examine academic performance of students from three disadvantaged categories (high SED/SDA+, high SED/SDA–, and low SED/SDA+); with low SED/SDA– as the reference group across five California schools. Compared with reference, the DA+ subgroups scored lower on USMLE Step 1 and Step 2 Clinical Knowledge examinations and received fewer clerkship Honors. After adjustment for academic metrics and sociodemographic variables, high SED subgroups performed similarly to reference, but performance gaps for low SED/SDA+ students persisted. Medical schools must better understand the institutional and other drivers of academic success in disadvantaged students.

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Key words: Physician workforce diversity, self-designated disadvantage, socioeconomic disadvantage, medical licensing examinations, medical school academic performance, health disparities.

The growing gap between the racial, ethnic, and socioeconomic makeup of medical school classes and that of the general population means medical education is slipping out of reach for many students from disadvantaged and underrepresented in medicine (URiM) backgrounds.[1] Such inequitable representation may contribute to health disparities as URiM physicians are more likely to provide care for patients of color and to practice in high-need areas with fewer health services.[2–4] In addition, patients from minority backgrounds report better communication and understanding, greater satisfaction, and better adherence when they are cared for by racially and linguistically concordant physicians.[5–8] Less than 10% of medical students come from the lowest two quartiles of family income,[9,10] and Black and Hispanic medical students are three times as likely as their White counterparts to come from families with combined parental incomes of less than $50,000.[11] Low-income students are more likely to attend underfunded and underperforming K–12 schools,[12] to have limited access to academic preparation,[13–17] and to bear work obligations resulting in additional educational disadvantages.[18] Once in medical school, URiM students continue to experience adversity in the form of unsupportive, racist, or discriminatory learning environments, which may further impair academic performance and increase attrition in this group.[19,20]

The academic trajectory of disadvantaged students in medical school has not been well characterized.[21] A recent qualitative study highlighted the problematic definition of *disadvantaged* in the American Medical College Application Service (AMCAS) application and the challenges it poses for applicants.[22] In a previous simulation using data from applicants to the University of California Davis School of Medicine (UC Davis), we assembled eight indicators from the AMCAS application to create a continuous, multi-component scale of socioeconomic disadvantage (SED), a granular and potentially more reliable measure of disadvantage.[23] Students scoring 20 or greater on this 0–100 scale were considered socioeconomically disadvantaged (high SED) based on the receiver operating characteristics (ROC) as described below (see Methods). Subsequently, we examined associations of SED and URiM status (Black or African American, Hispanic, Native American, or Pacific Islander race and ethnicity) with U.S. Medical Licensing Examination (USMLE) Step 1 and Step 2 Clinical Knowledge (CK) performance and number of third-year clerkship Honors at UC Davis. Although URiM status was not associated with academic performance, high SED students had lower Step 1 scores and fewer Honors than their low SED counterparts, even after adjustment for demographics, undergraduate grade point average (GPA), and Medical College Admissions Test (MCAT) performance.[24]

The AMCAS application also includes a single Yes/No question asking whether applicants wish to *self-designate* as disadvantaged (SDA+). In a previous analysis, high SED scores and SDA+ were highly correlated; however, there was a subset of students with discordant disadvantaged categories (high SED/SDA– and low SED/SDA+).[23] In another single-institution study, we examined three disadvantaged categories (high

SED/SDA+, high SED/SDA–, and low SED/SDA+; with low SED/SDA– as the non-disadvantaged reference group), and found all categories of disadvantaged students received fewer third-year clerkship Honors than the reference group. USMLE Step 1 and 2 CK scores were also lower for both high SED/SDA+ and low SED/SDA+ students but not for high SED/SDA– students, suggesting the SED and SDA designations might variably predict medical school performance.[25] In that study, there were too few SDA+ students to fully evaluate their differential performance.

To characterize the academic trajectory of disadvantaged students, we examined performance of students from all three disadvantaged categories in a larger sample from five University of California medical schools. This multi-institutional, longitudinal dataset is particularly appropriate due to the rich racial and ethnic diversity of the applicant pool, in which approximately 20% are URiM and 15% SDA+.[23]

Methods

We conducted this retrospective study from June 18, 2018 to March 15, 2019 using data from the California Longitudinal Evaluation of Admission Practices (CA-LEAP) consortium, which has been fully described elsewhere.[26,27] The CA-LEAP consortium includes the David Geffen School of Medicine at UCLA; UC Davis; UC Irvine School of Medicine; UC San Diego School of Medicine; and UC San Francisco School of Medicine. We obtained ethics approval from the institutional review boards of the participating schools via the UC Reliance Registry (protocol #605118-6).

The study population included a total of 1,460 medical students who matriculated to CA-LEAP schools during the three-year study period from 2011 to 2013. Although the vast majority of California applicants apply to all CA-LEAP schools (confidential unpublished data), complete AMCAS application data was available only for the 1,262 students (86.4%) who applied to UC Davis; thus, the final study cohort included 1,262 matriculants. The 198 students (13.5%) with missing AMCAS data had higher undergraduate GPA and MCAT scores (data not reported).

Data collection. The University of California, Davis provided the following anonymized information from each AMCAS application: age; self-designated gender, race and ethnicity; cumulative undergraduate GPA and MCAT score; and application year. Students were classified as URiM if they had indicated Black or African American, Hispanic, Native American, or Pacific Islander race and ethnicity. We also included the answer (yes or no) to the aforementioned AMCAS SDA question. The instructions regarding SDA status from the AMCAS Instruction Manual state, "You might consider yourself disadvantaged if you grew up in an area that was medically underserved or had insufficient access to social, economic, and educational opportunities. If you answer Yes, you'll have 1,325 characters to explain why you consider yourself a disadvantaged applicant."[28] Self-reported disadvantage (SDA+) was defined as an affirmative response to the AMCAS SDA question.

Using methods described previously,[23,29] we employed the following eight self-reported indicators from the AMCAS application to derive a composite SED score: (1) AMCAS fee waiver received for medical school application; (2) childhood spent

in an underserved area; (3) family assistance program recipient; (4) family income level (categorized as <$25,000, $25,000–$49,999, $50,000–$74,999, or ≥$75,000); (5) applicant contribution to family income; (6) any financial need-based scholarship for post-secondary education; (7) percentage of post-secondary education costs contributed by family; and (8) parents' highest level of educational attainment (categorized as less than high school graduate, high school graduate, some college (did not graduate), or college graduate). All missing data were coded as the most advantaged category. In a factor analysis, we found that these eight variables loaded onto a single underlying construct (each variable loaded greater than 0.25 onto the main factor; Eigenvalue = 2.60 for main factor, 0.17 for next factor).[30] The factor score was rescaled from 0 to 100, with higher scores indicating greater socioeconomic disadvantage. Apart from the AMCAS fee waiver element, all elements of the SED score were self-reported. Socioeconomic disadvantage (high SED) was defined as a SED score of ≥20 based on the ROC of the relationship between the SED score and SDA+; sensitivity of this cutoff in predicting SDA+ was 93.8% and the specificity was 83.8%. Because distribution of the SED score was bimodal, with most scores clustering under 15 or over 50, varying the cutoff score made little difference to the sensitivity and specificity.

USMLE Step 1 and Step 2 scores and failures. The three-part USMLE examination is sponsored by the Federation of State Medical Boards and the National Board of Medical Examiners (NBME). In the U.S., individuals with a doctor of medicine (MD) degree are required to pass all three USMLE Step exams before being permitted to practice medicine. Step 1 assesses understanding and application of basic science concepts relevant to medical practice (score range 1–300).[31] Step 2 CK assesses the ability to apply the medical knowledge, skills, and understanding of clinical science needed to provide patient care under supervision (score range 1–300).[32] Before January 2014, the minimum passing score for Step 1 was 188; it was subsequently increased to 192. Before July 2014 the minimum passing score for Step 2 CK was 203; it was subsequently increased to 209.[31] The USMLE statistically adjusts for differences in difficulty in both exams across years using statistical procedures and considers scores to be comparable across years within a three to four-year window.[31] We chose these measures of academic performance because they influence residency matching and career choices. Step 3 (not reported here) is the final examination leading to a license to practice medicine without supervision.

Third-year clerkship grades. We considered final grades (Honors, Pass, or Fail) in all required clinical clerkships. The number of required clerkships varied from six to eight across the schools and grading formulas varied among clerkships and schools. However, key components for all clerkships included supervising residents' and attending physicians' subjective ratings, as well as the students' score on the corresponding NBME Clinical Science subject examination (widely referred to as the "shelf examination"). According to the NBME, the subject examinations "are achievement tests in a broad sense, requiring medical students to solve scientific and clinical problems."[32]

Analyses. Analyses were conducted using Stata (version 15.1, StataCorp, College Station, TX). We employed the chi-square test (for categorical variables) and ANOVA

test (for continuous variables) to compare characteristics of students across the four combined SED/SDA categories.

Using three disadvantaged categories (high SED/SDA+, high SED/SDA–, and low SED/SDA+; with low SED/SDA– as the reference group), we developed four sequential sets of regression models to examine different SED/SDA associations with USMLE Step 1 and Step 2 CK score (linear regressions) and total number of third-year clerkship Honors (negative binomial regression, to adjust for overdispersion in the count of Honors). For each set of outcomes, the models were sequentially adjusted for: (a) school (to adjust for unmeasured medical school differences) and matriculation year (to adjust for extraneous differences due to matriculation year); (b) SED score (from 0–100 to account for differences in mean SED scores within each SED/SDA category, particularly between high SED/SDA+ and high SED/SDA– students); (c) the variables in (b) plus age, gender, and URiM status to examine the extent to which observed differences among groups reflected differences in demographic characteristics; and (d) the variables in (c) plus pre-medical school academic metrics (undergraduate GPA and MCAT score) to examine the extent to which observed differences between groups reflected prior academic performance.

Results

Table 1 shows the personal characteristics of the 1,262 students who matriculated to the five CA-LEAP medical schools over three consecutive years, by combined SED/SDA categories and overall. Just over half were female, approximately 20% were URiM, and nearly 22% (275) were SDA+. Among the SDA+ group, 222 students (81%) also had a high SED score (≥20), indicating socioeconomic disadvantage; the remainder were considered low SED. Among the 987 (78%) who did not self-report disadvantage (SDA–), nearly all (923 or 94%) were low SED. SDA+ students were more likely to be URiM than their SDA– counterparts, regardless of SED score. Students from URiM groups were overrepresented in both high SED/SDA+ (49%) and low SED/SDA+ (70%) groups.

Table 1 also shows the unadjusted associations of the four SED/SDA categories with academic metrics. Regardless of SED score, SDA+ students had lower mean undergraduate GPA, MCAT scores, and Step 1 and Step 2 CK scores and fewer clerkship Honors than their SDA– counterparts. Among all subgroups, the low SED/SDA– students (the reference group) had the highest academic metrics and most clerkship Honors.

Adjusted academic performance. Table 2 shows the results of four sets of regression models examining the associations of the four SED and SDA combinations with academic performance outcomes. For USMLE Step 1 (Table 2, top panel), compared with the reference group, scores were lower for the three disadvantaged groups in model (a). In models (b) and (c), scores were lower for both self-reported disadvantaged groups (high SED/SDA+ and low SED/SDA+). In model (d) with full adjustment including demographics and cumulative undergraduate GPA, and total MCAT score, only low SED/SDA+ students had lower Step 1 scores.

For USMLE Step 2 CK (Table 2, middle panel), compared with the reference group, all disadvantaged groups had lower scores in model (a). After adjusting for SED in model (b) and demographic characteristics and undergraduate GPA and MCAT score

Table 1.

STUDENT CHARACTERISTICS BY COMBINED SED AND SDA CATEGORY AND OVERALL

Characteristic	Combined SED and SDA Category				p value[b]	Total
	High SED/SDA+ N=222	High SED/SDA– N=64	Low SED/SDA+ N=53	Low SED/SDA–[a] N=923		N=1262
Age, mean (SD)	25.9 (3.2)	25.1 (3.6)	24.9 (2.3)	24.3 (2.6)	<.001	24.7 (2.8)
Female, no. (%)	118 (53.2%)	33 (51.6%)	28 (52.8%)	466 (50.5%)	.90	645 (51.1%)
URiM, no. (%)	109 (49.1%)	6 (9.4%)	37 (69.8%)	98 (10.6%)	<.001	250 (19.8%)
SED score, mean (IQR)[c]	92.0 (73.4, 97.5)	49.5 (28.2, 70.6)	5.0 (1.6, 7.3)	1.6 (1.4, 2.2)	<.001	1.6 (1.6, 12.1)
Undergraduate GPA, mean (SD)	3.5 (0.3)	3.8 (0.2)	3.5 (0.2)	3.7 (0.2)	<.001	3.7 (0.2)
Total MCAT score, mean (SD)	29.4 (3.7)	33.8 (2.7)	29.4 (3.4)	33.8 (3.0)	<.001	32.8 (3.6)
Medical school academic performance						
USMLE Step 1, mean (SD), N=1247	219.1 (20.9)	232.4 (17.6)	217.7 (17.5)	237.0 (17.2)	<.001	232.8 (19.4)
USMLE Step 2 CK, mean (SD), N=1173	234.9 (15.8)	242.1 (16.6)	233.9 (15.7)	248.2 (14.1)	<.001	245.1 (15.6)
Third-year Clerkship Honors, median (IQR), N=1262	0 (0, 2)	1 (0, 2)	0 (0, 1)	2 (0, 3)	<.001	1 (0, 3)

Notes:

[a] Non-Disadvantaged reference group

[b] p values refer to the unadjusted comparisons of each characteristic across the 4 SED/SDA categories. For categorical variables, the groups were compared with chi-squared tests and for continuous variables the groups were compared using one-way analysis of variance.

[c] SED score range 0–100, scores greater than or equal to 20 considered high SED. See Methods for score calculation.

CK= Clinical Knowledge; GPA= Grade Point Average; IQR= Interquartile Range; MCAT= Medical College Admission Test; SDA= Self-Designated Disadvantage on American Medical College Application Service Application; SED= Socioeconomic Disadvantage; URiM= Under-Represented in Medicine; USMLE= US Medical Licensing Examination

Table 2.

ASSOCIATIONS OF COMBINED SED AND SDA CATEGORIES WITH ACADEMIC PERFORMANCE MEASURES[a]

Model adjustors	Model a School and Matriculation year	Model b Model a + SED[b]	Model c Model b + age, gender, URiM	Model d Model c + GPA, MCAT
USMLE Step 1 (N=1247)	PE (95% CI)	PE (95% CI)	PE (95% CI)	PE (95% CI)
High SED/SDA+	**−16.3 (−19.0,−13.6)**	**−11.0 (−18.5,−3.4)**	**−8.4 (−15.7,−1.2)**	−1.7 (−8.5,5.2)
High SED/SDA−	**−5.1 (−9.7,−0.5)**	−1.9 (−8.2,4.3)	−2.2 (−8.2,3.8)	−2.3 (−7.9,3.3)
Low SED/SDA+	**−19.1 (−24.0,−14.2)**	**−18.9 (−23.9,−14.0)**	**−14.5 (−19.5,−9.6)**	**−7.5 (−12.2,−2.8)**
Low SED/SDA−[c]				
USMLE Step 2 Clinical Knowledge (N=410)	PE (95% CI)	PE (95% CI)	PE (95% CI)	PE (95% CI)
High SED/SDA+	**−13.0 (−15.4,−10.7)**	−7.5 (−14.1,−1.0)	−4.3 (−10.6,2.0)	−0.8 (−6.9,5.4)
High SED/SDA−	**−6.8 (−10.7,−3.0)**	−3.4 (−8.8,1.9)	−3.1 (−8.2,2.1)	−3.3 (−8.3,1.7)
Low SED/SDA+	**−14.5 (−18.7,−10.3)**	**−14.4 (−18.6,−10.1)**	**−10.5 (−14.8,−6.3)**	**−6.6 (−10.8,−2.4)**
Low SED/SDA−[c]				
Total clerkship Honors (N=528)	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)
High SED/SDA+	**0.5 (0.4,0.6)**	0.7 (0.4,1.1)	0.8 (0.5,1.3)	0.9 (0.6,1.5)
High SED/SDA−	**0.5 (0.4,0.7)**	0.7 (0.5,1.0)	0.7 (0.5,1.0)	0.7 (0.5,1.0)
Low SED/SDA+	**0.3 (0.2,0.4)**	**0.3 (0.2,0.4)**	**0.3 (0.2,0.5)**	**0.4 (0.3,0.6)**
Low SED/SDA−[c]				

Notes:

[a] Statistically significant associations ($p < .05$) are indicated by **bold font**

[b] adjusted for difference in SED score on a continuous 0–100 scale

[c] Non-Disadvantaged reference group

SDA= Self-Designated Disadvantage on American Medical College Application Service Application; GPA= Grade Point Average; IRR= Incidence Rate Ratio; MCAT= Medical College Admission Test; PE= Parameter Estimate; SED= Socioeconomic Disadvantage; URiM= Under-Represented in Medicine; USMLE= US Medical Licensing Examination

in models (c) and (d), only low SED/SDA+ students had significantly lower USMLE Step 2 CK scores.

Regarding total number of clerkship Honors (Table 2, bottom panel), all combinations of SED and SDA students had fewer Honors than the reference group in model (a). After adjustment in the other models as described above, only low SED/SDA+ students had fewer clerkship Honors.

Discussion

Across five public California medical schools, students who self-reported being disadvantaged (SDA+) on their AMCAS application scored lower on USMLE Step 1 and Step 2 CK and received fewer clerkship Honors than non-disadvantaged students in unadjusted analyses. After adjustment for academic metrics and sociodemographic characteristics, high SED/SDA+ students performed similarly to the low SED/SDA– reference group, whereas among low SED students, the performance gap between SDA+ and SDA– students remained. Stated differently, students who self-designate as disadvantaged, but do not demonstrate high socioeconomic disadvantage, may be at heightened risk for academic difficulties in medical school—more evidence of the need for medical schools to identify and address systemic barriers limiting the success of disadvantaged students.

What is the nature of self-designated disadvantage and how does it relate to academic performance? The study's design and dataset cannot answer these questions. Students may use the AMCAS disadvantaged (SDA) prompt to disclose their experiences in a marginalized or underrepresented group, which may not otherwise be included in their application. Reporting SDA+ may reflect exposure to childhood adverse experiences,[33] including childhood maltreatment, bullying, and growing up with mental illness or substance use[34] in the family.[35,36] Students from negatively stereotyped or devalued social groups are more likely to experience bias and discrimination,[37,38] low self-efficacy and sense of belonging,[34,39,40] imposter syndrome (i.e., the feeling that they do not deserve to "be there" and that they have simply fooled anyone who thinks otherwise)[41] and microaggressions[42]—any one of which may adversely affect academic progression in medical school.[21]

Despite our findings, we caution against labeling SDA+ students as academically risky, because doing so might exclude many URiM applicants in the admission process or contribute to underperformance during medical school. Other authors have raised concerns that applicants with significant hardship may be reluctant to use the SDA prompt.[22] Our data suggest a 'protective' effect of high SED on performance of SDA+ students (compared with low SED/SDA+ students). We speculate high SED students may have developed additional resilience, grit, or success strategies through socioeconomic adversity[43] or academic enhancement programs for low-income students such as Mathematics, Engineering Science Achievement programs (MESA),[44] Federal TRIO Programs (TRIO),[45] and Summer Health Professions Education Programs.[46]

We believe medical schools should implement strategies to counter the structural barriers to success for all disadvantaged students,[47] as part of a commitment to diversify the physician workforce.[48] Faculty development programs that address barriers

to success (e.g., racism, discrimination and bias, stereotype threat, microaggressions, imposter syndrome, belonging) may help faculty to understand the students better and improve their own teaching and evaluation practices.[42,49,50] Medical schools should teach about racism[51] and the impact of curricula and learning environment in reinforcing stereotypes,[52,53] which may influence students' career decisions to practice in high-need communities.[54] Schools should examine the role of examination practices in fostering the social-class achievement gap[55] and potential bias in supervisors' ratings of learners, which may lead to underrepresentation of Black and Asian students in the Alpha Omega Alpha Honor Medical Society and limit their career opportunities.[21,56–58] Teaching institutions should develop policies and trainings to address discrimination[38] and harassment.[59] Sharing longitudinal academic performance data across institutions may also contribute important lessons for medical educators. Large-scale, coordinated efforts are needed to support academic success and reduce attrition among disadvantaged students.

Strengths and limitations. A key strength of our study was the use of data across multiple medical schools, addressing the generalizability concerns of previous, single-institution reports. The study also had some limitations. First, the data come from five California public medical schools, so whether the findings apply to other regions or private institutions is unclear. Second, our data predates availability of the AAMC's Socioeconomic Status Indicator, which was added to AMCAS in 2014.[60] This two-factor indicator, based on parental education (E) and occupation (O), identifies applicants from socioeconomically disadvantaged backgrounds. However, the EO variables are part of the SED score used in our study. Third, we were unable to examine the performance of first-generation college students (i.e., those whose parents do not have at least a bachelor's degree). Starting in 2019, the AMCAS application included a first-generation college student indicator, facilitating such analyses in the future.[28] As noted above, it is also possible that some applicants with significant hardships or barriers were reluctant to report SDA, due to concerns about negative reactions among application screeners.[22] Lastly, matriculants with missing data (13.5% of study sample) had higher academic metrics, which raises concern about generalizability.

In conclusion, our study findings suggest the need for medical schools to understand more fully the drivers of academic success for disadvantaged students. The mission of equity of opportunity is critical to addressing the needs of diverse populations. As medical schools commit to recruiting and educating students that more closely mirror the U.S. population, they must also address structural barriers within their institutions that limit success of students from disadvantaged and underrepresented groups.

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