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Exploring Intersectional Typologies of (Dis)advantage in United States Medical School Applicants

Alison Howe
University of Vermont

EXPLORING INTERSECTIONAL TYPOLOGIES OF (DIS)ADVANTAGE IN UNITED STATES MEDICAL SCHOOL APPLICANTS

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Alison K. Howe

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Dissertation Examination Committee:

Bernice Garnett, M.P.H., Sc.D., Advisor
Jan Carney, M.D., M.P.H., Chairperson
Jason Garvey, Ph.D.
Sean Hurley, Ph.D.
Cynthia J. Forehand, Ph.D., Dean of the Graduate College

ABSTRACT

Increasing diversity in the medical workforce is necessary to address public health needs and reduce health disparities, particularly in low-income and minority communities. The populations that experience these inequalities are the same populations that remain underrepresented in medicine. Research has demonstrated that social-concordance in the physician-patient dyad is associated with better patient outcomes and that students from underserved communities are more likely to return to practice in underserved areas. Despite academic medicine's continued commitment to admitting and training diverse individuals to address health disparities and increase cultural competency in medical students, a three-decade trend of the majority of medical students coming from socioeconomically privileged backgrounds continues. Research addressing access to medical education has focused mainly upon silos of gender, race, ethnicity, sexual orientation, and socioeconomic status and, therefore, does not realistically contextualize the backgrounds and experiences of applicants.

The three papers in this dissertation represent an exploration of these issues within a national sample of applicants to United States medical schools (n=47,958) in 2018-2019. In the first manuscript, a person-centered quantitative analytical approach guided by the theory of intersectionality informed the creation of a 5-class advantage status typology and found that over half of applicants were classified into the most advantaged typology. The second paper builds upon this work to incorporate applicant demographic qualities and describe the composition of most-likely typology membership to explore further the interplay between demographics, privilege, and oppression. Privileged identity intersections correlated with belonging in advantaged typologies, while those historically associated with inequality had higher odds of mixed and disadvantaged typology membership. The third article examines the probability of typology membership against measures of success within the medical school application process. Findings demonstrated that advantaged applicants had higher academic metrics, applied broadly, and had higher odds of acceptance to at least one medical school. However, this association lessened when adjusting for applicant Medical College Admission Test scores, a standardized exam widely used by medical schools to assess applicant readiness.

This exploratory research study contributes needed context to understand socioeconomic and sociodemographic diversity of the medical school applicant pool and heterogeneous outcomes in the admissions process. Exploring and describing these effects using methods that allow multiple applicant traits to co-exist is a first step toward enhancing medical school admissions' understanding of how to mitigate barriers to the accessibility of medical education. Reducing or eliminating these barriers may increase the diversity of medical students, thereby shaping the physician workforce to improve public health and effectively address health inequalities.

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DEFINITION OF KEY TERMS

Accepted to medical school

Applicants who have successfully submitted applications, passed initial screening and received an invitation to interview, successfully interviewed, and whom the admissions committee votes to admit are considered accepted to that school. Applicants can receive multiple acceptances or no acceptances.

Advantage status

This term is used to summarize the spectrum of advantage and disadvantage representing both privilege and oppression.

Applications

Medical school applicants fill out one primary application each year that they apply. This is the American Medical College Application System (AMCAS.) Each medical school to which the applicant applies may require a school-specific secondary application, which often include essay prompts and require an additional fee to submit. Schools may waive the fee for any applicant who qualified for the AAMCs Fee Waiver Program.

Association of American Medical Colleges (AAMC)

A non-profit organization that represents medical schools, teaching hospitals, and medical societies. The AAMC operates the AMCAS medical school application.

American Medical College Application System (AMCAS)

A common application service run by the AAMC where medical school applicants can submit a primary application to medical schools in the U.S.

Bayesian Information Criterion (BIC)

In the context of this study, BIC is one of the measures indicating goodness-of-fit of an LCA model. During the process of class enumeration, lower BICs are considered a better fit.

Class enumeration

The process of testing goodness-of-fit in a latent class analysis (LCA) for k+1 number of classes.

English as a Second Language (ESL)

In this study, English speakers are defined as those who speak English at a native or functionally native level. This construct is also referred to as language minority in this research study.

Entropy

In the context of this study, entropy is a goodness-of-fit measure used for class enumeration of LCA models. It represents the degree of distinction of the classes from one another and higher entropy values are considered a better fit.

Expectation Maximization (EM)

In LCA, an iterative algorithm that is used in estimating latent class models as part of maximum likelihood model estimation.

Fee-Assistance Program (FAP)

Applicants can apply through a fee waiver from the AAMC, which reduces the cost of the MCAT exam and AMCAS application fees. The AAMC verifies eligibility for the program through the applicant's tax returns; eligibility is based upon the U.S. Department of Health and Human Services poverty level guidelines.

First-generation

In this context, an applicant is considered a first-generation applicant if they are the first in their family to pursue higher education.

Grade Point Averages (GPAs)

Postsecondary GPAs are submitted as part of transcripts for the AMCAS application. GPA terminology are the overall GPA (Total GPA or uGPA) and the GPA specific to biology, chemistry, physics, and math (Science GPA or BCPM GPA.)

Language Minority

In this project, an applicant is considered a language minority if they do not speak English at a native or functionally native level. Also referred to as English as a Second Language (ESL)

Latent Class Analysis (LCA)

A reductive analytical technique that models an underlying construct in a dataset. The models are tested for best fit using class enumeration.

Lo-Mendell-Rubin Adjusted Likelihood Ratio Test (LMR LRT)

The LMR test measures the improvement in fit between class models (i.e., comparing k-1 and k class models) and generates a *p*-value that can be used to determine if there is a statistically significant enhancement in fit to include another class.

Log-likelihood

A logarithmic transformation of the likelihood function, which expresses the goodness-of-fit of a statistical model to a sample of data for unknown parameter values. In LCA class enumeration procedures, a higher log-likelihood indicates a better goodness-of-fit.

Matriculated into medical school

Applicants who have been accepted to a medical school can choose to attend that school. Applicants become matriculated medical students upon the first day of the curriculum, usually an orientation course.

Maximum Likelihood (ML)

An estimator for latent class models that uses the expectation maximization (EM) algorithm. A process for estimating probability distribution parameters by maximizing a likelihood function, rendering the observed data most likely.

Medical College Admissions Test (MCAT)

In this study, highest total MCAT score achieved by the applicant is used. The MCAT is a proxy for academic aptitude and is used by medical schools as a measure of applicant readiness. The MCAT is comprised of sections: biological and biochemical foundations of living systems, chemical and physical foundations of biological systems, psychological, social, and biological foundations of behavior, and critical analysis and reasoning skills. The first three sections represent scientific inquiry and reasoning skills.

Missing at Random (MAR)

A dataset is assumed to have data that is MAR if missingness is not completely random because it can be accounted for by variables that have complete information**.**

Pell Grant

A form of postsecondary funding federal aid for students pursuing higher education who demonstrate financial need and who have not yet achieved a bachelor's, graduate, or professional degree. Pell Grant funding does not need to be repaid.

Race/ethnicity

In this study, applicants can choose race and ethnicity categories to identify their backgrounds. The AAMC condensed responses into three categories: Underrepresented in Medicine (URM), White only or Asian only, and Other or multiple other. The White only or Asian only category comprises groups historically overrepresented in medicine.

Return on Application Investment (ROAI)

A formula that calculates the number of applications submitted by an applicant minus the number of acceptances received by that applicant over the number of applications submitted by the applicant.

Sex

In this research project, there were three categories that applicants could choose in response to the question "What is your sex?": female, male, and unknown/decline to respond.

Self-report disadvantaged status

Representative of a question on the AMCAS that asks, "Do you wish to be considered a disadvantaged applicant by any of your designated medical schools that may consider such factors (social, economic, or educational)?" Applicants are able to designate themselves as having disadvantaged backgrounds or not.

Socioeconomic status (SES)

A complex construct that refers to the accessibility to monetary or material resources.

Underrepresented in Medicine (SES)

In this research study, this is a specific category of race and ethnicity, and is widely used in medical education research. However, medical schools are able to tailor this definition according to the school's mission and/or local healthcare workforce, this analysis uses a historical definition of URM. Applicants included in the URM category self-reported that they were Black, Mexican-American, Native-American (American Indians, Alaska Natives, and Native Hawaiians), and mainland Puerto Ricans

CHAPTER 1

Increasing diversity in the medical workforce is a crucial strategy to address public health needs, adequately care for a diverse patient population, and address predicted workforce shortages in medically underserved areas.

Persistent health care disparities disproportionally affect low-income households and racial and ethnic minority communities when compared with the general population in the same geographic area (Liao et al., 2011). The 2017 National Healthcare Quality and Disparities Report from the U.S. Department of Health and Human Services (2018) found that while healthcare access, quality of care, and some healthcare disparities improved, there were still persistent disparities for low-income and uninsured populations. In addition to increasing diversity in the healthcare workforce, strategies to improve health disparities in the U.S. should target low-income and medically underserved areas because actionable determinants of health such as personal behavior, social issues, health care, and the environment have a disproportionate impact on the poor (Schroeder, 2007).

When compared with White Americans, disparities in measures representing person-centered care, patient safety, healthy living, treatment efficacy, care coordination, and affordability of care remained for Black Americans, Asians, American Indians/Alaska Natives, Hispanics, and Native Hawaiians/Pacific Islanders. Additionally, an urban-rural divide persists regarding access to care (Agency for Healthcare Research and Quality, 2018). A landmark document published by the Institutes of Medicine in 2011 detailed the knowledge gaps of the medical and scientific communities about

healthcare for LGBTQ people (Institute of Medicine of the National Academies, 2011). In findings from a national survey, individuals who identified as lesbian, gay, bisexual, or transgender were at high risk of experiencing discrimination when seeking health care, sometimes escalating to verbal or physical abuse (Lamda Legal, 2010). The Lambda Legal survey also found that persons of color and/or low-income were particularly susceptible to discriminatory or substandard care and that fears of discrimination were a significant barrier to seeking care. A national survey of transgender persons found poor health outcomes as an effect of marginalization, refusal of medical care, and having to offer guidance to medical providers regarding transgender care (Grant et al., 2011).

Benefits of Diversity in Medicine

A central issue in addressing disparities in access to care and patients receiving culturally appropriate care is diversifying the healthcare provider workforce. The groups of Americans most burdened by health disparities are the same groups that remain underrepresented as medical practitioners. Boosting the diversity of medical students may have a longer-term direct impact on healthcare quality and access.

Research findings emphasize that social-concordance in the physician-patient dyad leads to more extended visits, increased patient satisfaction, and positive patient affect (Cooper et al., 2003; Laveist & Nuru-Deter, 2002; Saha, Komaromy, Koepsell, & Bindman, 1999; Thornton, Powe, Roter, & Cooper, 2011). Black and Hispanic patients reported that the physician's race or ethnicity influenced their choice of a physician (Saha, Taggart, Komaromy, & Bindman, 2000).

Research into increased medical student diversity has demonstrated trends on the practitioner side, as well. Female physicians and physicians of racial or ethnic minorities were found to be more likely to serve minority and low-income communities (Cantor, Miles, Baker, & Barker, 1996; Marrast, Zallman, Woolhandler, Bor, & McCormick, 2014; Wayne, Kalishman, Jerabek, Timm, & Cosgrove, 2010). Medical students from racial or ethnic minorities and those from disadvantaged backgrounds were more likely to apply to a program created to train physicians in providing care to underserved communities (Bailey & Willies-Jacobo, 2012).

Increasing the diversity of medical students influences and prepares other medical students to provide culturally appropriate care. Medical students indicate that they value diversity on campus and the associated opportunities for them to build cultural competence (Hung et al., 2007; Whitla et al., 2003). Diverse student cohorts enrich the learning environment by exposing students to new perspectives (Fenton et al., 2016; Gurin, Dey, Hurtado, & Gurin, 2002; Gurin, Nagda, & Lopez, 2004; Morrison & Grbic, 2015). These expanded perspectives and increased cultural competence result in new physicians who are more likely to work in a medically underserved region, feel increased readiness to care for patients from other racial and ethnic backgrounds, and who become advocates for increasing access to care (Saha, Guiton, Wimmers, & Wilkerson, 2008).

Over the past three decades, the number of women in medicine has steadily increased. Historical data demonstrate that in 1980, approximately 31% of medical school applicants and 29% of matriculated medical students were women (Association of American Medical Colleges, 2018b; Association of American Medical Colleges, 2018c).

In 2019, women outnumbered men in the number of applicants to medical school, the number of accepted applicants, and the number of matriculating medical students (Association of American Medical Colleges, 2019c).

Applicants to medical school face numerous hurdles in order to be competitive enough to gain admission to medical school. Applicants with fewer resources, familial connections, and time for academics have even more hurdles to overcome in order to make it into medical school. Many individuals with difficult life circumstances who dream of becoming physicians may never achieve a bachelor's degree, the minimum degree required for admission to medical education. In addition, the expense of the medical school application process itself can be a deterrent for those with fewer resources. Though there are ways that applicants may be able to cut some costs (e.g., applying for fee waivers, applying to schools nearby, applying to fewer schools), not all costs can be avoided.

There has been limited research into medical applicants with different varieties of hardships, disadvantages, and privileges, and no studies employing person-centered methods to try to understand if subpopulations of applicants with varying levels of access to resources exist and whether these subpopulations have different experiences in accessing medical education. Further, research about socioeconomic disadvantage and access to medical education has typically not considered the impact of other types of identity factors that may represent additional barriers for medical school applicants (e.g., first-generation students, non-native English speakers.) Researchers assessing a parental education/occupation classification measure for medical school applicants created by the

Association of American Medical Colleges (AAMC) recommended that medical admissions personnel consider the measure in light of other markers of disadvantage as part of holistic review due to the potential misclassification of applicants inherent to the measure. Currently, admissions personnel might struggle to do this given that there is little research into other markers of applicant disadvantage, which markers might be meaningful, and whether these indicators might interact with one another if they co-exist within applicants. In order to learn more about applicants via items representing advantage or disadvantage on the AAMC's American Medical College Application System (AMCAS) application, these items require exploration in context with one another in order to provide meaning and guidance to admissions personnel.

At present, the medical education community is aware of the sustaining disparity in SES between medical students and the population of the United States. However, the relationship between advantage status and access to medical education must be explored in order to increase the chance of effectively addressing the class disparity in medical education. Though indicators of advantage status appear on the AMCAS applications, there are little to no data exploring these indicators of SES and advantage status and how they may impact access to medical education nor whether certain combinations of indicators make applicants less likely to succeed in admission to medical school.

This research will build upon efforts to address disadvantage in medical school applicants, by examining whether there are typologies representing the advantage status of U.S. medical school applicants that are associated with heterogeneous outcomes in the medical admissions process. In effect, this research will provide additional meaning and

understanding to the presence of barriers or facilitators in the background of medical applicants that can inform medical school admissions personnel as they consider policies and procedures to achieve higher levels of equity in their admissions process. It may highlight the need for medical school applications to include specific contextual indicators of advantage status as part of the admissions process. The intersectional approach toward building typologies of advantage and disadvantage and exploring outcomes may provide evidence regarding the components that would be most important for consideration in the medical admissions process.

Applying to medical school. Medical school serves as the gateway toward becoming a physician, and most students enrolled in medical school ultimately graduate with their degree; therefore, medical school admissions decisions play a crucial role in shaping the composition of the physician workforce (Association of American Medical Colleges, 2014; Maher et al., 2013). Recognizing the need to recruit a diverse pool of medical students and allow medical schools to recruit students according to their institutional diversity goals and social mission, the AAMC includes demographic indicators in the centralized AMCAS to inform medical admissions personnel. AMCAS serves as the application system for 146 medical schools in the United States; 8 medical schools in Texas have their own centralized medical and dental school application service ("Participating medical schools and deadlines," n.d.).

Though each medical school has a unique admissions process, medical school admissions personnel typically make decisions about applicants based upon academic metrics, experiences, interview day performance, and how the individual might

contribute to the school's social mission (Association of American Medical Colleges, 2018e). Medical schools typically judge applicants' ability to succeed academically in medical school through undergraduate grade point average (uGPA) and Medical College Admissions Test (MCAT) scores. Admissions committees view these metrics as valid indicators of applicant readiness to handle the rigor of medical education curricula. uGPA and MCAT score are known for their strong psychometric properties and validity in predicting performance in medical school, though uGPA can vary depending on institution and applicant major (Julian, 2005).

In 2015, the MCAT exam underwent a redesign in order to reflect the evolving nature of medicine. In addition to assessing scientific knowledge and principles, the new MCAT assesses critical analysis skills and principles from behavioral and social science. Researchers have been monitoring academic outcomes for medical students who took the new MCAT as they progress through medical school curricula. Lucey and colleagues are in the process of conducting a nine-year study of twenty-one medical schools in order to assess the validity of the new MCAT exam (Lucey, Hanson, Goodell, & Girotti, 2018). Early data indicate a relationship between MCAT score and performance in pre-clerkship courses, on-time progression to clerkships, passing the United States Medical Licensing Exam (USMLE) Step 1 on the first attempt, and higher USMLE Step 1 scores (Lucey et al., 2018). Researchers have found that the new MCAT exam predicts similar performance on first-year medical school academic outcomes for students from different sociodemographic backgrounds, such as URM students, parental education less than a

bachelor's degree, and female gender, as compared with their respective referent groups (Busche et al., 2019).

In 2007, the AAMC encouraged medical schools to begin a holistic approach in assessing applicants. Holistic review requires that medical school admissions committees view applicants in an individualized manner framed within the mission of the school (Association of American Medical Colleges, 2013). Employing a holistic approach to admissions allows applicant academic metrics and achievements to be viewed within the context of applicants' experiences, adversities, and resilience (Witzburg & Sondheimer, 2013). Research investigating the composition of applicants selected for an interview at one medical school before and after beginning a mission-driven holistic review demonstrated that holistic review increased the number of female, URM, first-generation, and self-identified LGBTQ applicants in the interview pool (Grabowski, 2018). However, true holistic review must begin in the initial screening process and continue through the admissions process (Witzburg & Sondheimer, 2013).

Barriers to Increasing the Diversity of Medical Students

There are known factors that serve as barriers to recruiting a diverse group of medical students. An overarching barrier is the competitive nature of the process; applicants face stiff competition to be selected as a medical student, and any disadvantages or barriers may have a more substantial impact than in a less competitive field.

The first hurdle to entering medical school is the applicant's academic achievement. Expectations are high; the content taught in medical school is known to be

extremely difficult, and with many less open seats than interested applicants, medical schools may prioritize choosing students who have shown demonstrated success in mastering tough concepts. Quality rankings of medical schools place significant weight upon the average MCAT and uGPA scores for an institution's student body and applicants with higher scores self-select by applying to schools with higher rankings. In order to improve a school's ranking, they must choose applicants with higher scores. Applicants who are historically underrepresented in medicine (URM) tend to have lower MCAT and uGPA scores, and medical schools may face lower ranking if they focus upon increasing diversity by accepting and matriculating more diverse applicants (Association of American Medical Colleges, 2019c; Heller et al., 2014; Steinecke, Beaudreau, Bletzinger, & Terrell, 2007).

Medical schools may struggle to implement a truly holistic review process in the initial screening stages because of the resources that would be required to perform an in-depth review of the thousands of applications they receive each year. Some medical schools employ school-specific academic metric thresholds and/or formulas for initial screening procedures. Schools are not open about the details of their admissions policies and procedures. However, these screening formulas likely include academic metrics such as MCAT score and uGPA due to the validity evidence of these measures and the lack of validity evidence for other sections of the application (e.g., personal statements, letters of reference) (Julian, 2005). Given that MCAT and uGPA measures tend to be lower for URM applicants, reliance upon thresholds or quantitative formulas consisting of

academic metrics would jeopardize the diversity of the applicants invited to interview and selected for admission.

These associations are problematic with the consideration that medical schools, even when employing an in-depth holistic review, may still use academic thresholds as an initial screening procedure in order to reduce the thousands of applications to an amount that can be examined more closely. This screening procedure places URM applicants at risk of early elimination from the small pool of applicants who will be invited to interview at the school. In an ideal world, holistic review would prevent the initial screening based upon academic metrics; in the real world, admissions departments do not possess the time to review every application they receive and must have a method to narrow the number of applicants who will move forward in the process.

Another significant barrier is the expense of applying to medical school. In 2019, an applicant would need to pay $315 to take the MCAT exam, $170 to apply to one school through AMCAS, and $40 for each additional school ("The cost of applying to medical school," n.d.). The AAMC offers a Fee Assistance Program to offset some of these costs for applicants in need of financial assistance ("Who Is Eligible to Participate in the Fee Assistance Program?," n.d.). In a survey of individuals who took the MCAT in 2018, 43.4% of respondents indicated they had difficulty affording preparation courses and materials, resources that might improve their scores on the exam (Association of American Medical Colleges, 2019a). Schools may have secondary applications that applicants must complete, many requiring an additional fee for submission. Should an applicant receive invitations to interview at a medical school, they must consider costs for

travel and overnight accommodations. If applicants apply broadly to many schools (as is commonly suggested for the best chance of an offer of admission) and are unsuccessful and participate in the application process for multiple years, the costs can be unwieldy. If an applicant is successful and is offered acceptance to a school that they would like to attend, the applicant must submit a deposit to hold their spot in the incoming class.

The economic diversity of successful applicants who matriculate into medical school has remained stagnant for three decades. Research demonstrates that 75% of medical students continue to fall within the top two quintiles of household-income (Association of American Medical Colleges, 2018a). Similarly, most medical students have parents with higher levels of education as compared with the U.S. population as a whole (Association of American Medical Colleges, 2018a).

These lingering economic disparities may be tied to inequalities in access to higher education; completing a four-year degree from an accredited institution is the minimum requirement to be considered for medical school admission ("Admission requirements," n.d.). It may also exist because of the high costs related to academic preparation as well as applying and traveling for interviews. Applicants with higher access to resources can apply to more schools, consider geographically distant schools, and afford expensive preparatory materials and services. These may serve as facilitators in the process of accessing medical education.

Socioeconomic status (SES) is a construct that represents access to social and economic resources (Duncan, Daly, McDonough, & Williams, 2002). For applicants seeking medical education in the United States, social resources might be defined as

devoted time to study rather than supporting a family, speaking English at a native (or functionally native) level, one or more parents who have experience in higher education, a parent who is a physician and the increased connections to medical school and volunteer opportunities in healthcare. Medical school applicants from low-income backgrounds may not have the resources for academic preparation, but they also may not have opportunities to gain enriching volunteer and medical experience if their time is limited by needed employment during high school and college, and they tend to lack the familial professional connections that higher SES applicants may have (Fenton et al., 2016).

In 2019, the average four-year cost of attendance for public medical schools was $250,222, and the cost of attending private medical schools was $330,180 (Association of American Medical Colleges, 2018d). In an annual survey of Class of 2018 medical school graduates, 75% of graduates held education debt from medical school and/or their pre-medical education. The median amount of debt for indebted students was $200,000; 32% of graduates reported carrying debt from their pre-medical education (median amount $25,000), and 14% of graduates had credit card debt (median $5,000) (Association of American Medical Colleges, 2018d).

The AAMC recognized the need for SES diversity in medical students. They created a parent education/occupation measure (EO) on the AMCAS application to assist medical schools in identifying the SES of applicants. Grbic and colleagues found that the EO measure correlated with other indicators representing socioeconomic disadvantage and that EO status was lower in African American and Hispanic applicants, older

applicants, and those who reported paid employment experience. However, they also found that 36% of those with lower EO classifications had no other indicators of disadvantaged status, while 9% of applicants assigned to higher EO classifications had other indicators of disadvantage (Grbic, Jones, & Case, 2015). These findings led the authors to recommend that admissions committees consider multiple indicators of SES and disadvantage as part of holistic review in order to avoid misclassification of applicants and indicated that they planned longitudinal tracking matriculated students in order to assess academic outcomes. However, there was no specific mention of including admissions outcomes as part of their validation studies on the EO measure.

Other research on issues related to SES in medical school applicants focused upon a measure on the AMCAS that asks the applicant if they would like to be considered disadvantaged in light of social, economic, or educational factors, and, if yes, asks them to write a short essay explaining their answer. Lowrance and Birnbaum (2019) found that applicants' interpretation of disadvantage varied and that those with similarity in backgrounds and hardship had different interpretations of disadvantage and whether they felt they were disadvantaged. Some applicants shied away from identifying themselves as having experienced hardship due to reluctance to provide details they considered personal. Responses were also contextual; those with peers in higher SES strata considered themselves disadvantaged even if they had not experienced hardship, and those with peers with a great deal of hardship did not feel that they themselves could be disadvantaged (Lowrance & Birnbaum, 2019).

The University of California, Davis, School of Medicine has attempted to quantify socioeconomic inequity by creating a continuous scale that includes items representing hardship from the AMCAS application in order to inform the admissions process at their school (Talamantes, Henderson, Fancher, & Mullan, 2019). The scale includes parental education level, family income level and whether the family had used public assistance programs, family income, having lived in a medically underserved community, applicant contribution to family income, financial receipt of need-based scholarship, and whether applicants qualified to have application fees waived as part of the AAMC's fee waiver program. At present, there is no guidance on the specifics of the scale and how its use may have impacted outcomes in the admissions process at U.C. Davis medical school (Talamantes et al., 2019).

Additionally, Fenton and colleagues (2016) explored a method to increase medical school diversity by developing a socioeconomic disadvantage scale using indicators on AMCAS to adjust applicant academic metrics. Simulations run incorporating this SES adjustment addressed socioeconomic and URM disparities while maintaining academic readiness (Fenton et al., 2016).

There have been numerous studies exploring relationships between medical school applicant demographic characteristics and barriers within the medical education pipeline. However, no studies have examined the intersecting identities of medical applicants and investigated whether access to medical school is homogenous across multiple dimensions of social strata. In particular, given the costs of applying to medical school and the lingering income inequalities for those who attend medical school,

socioeconomic status, and other markers of advantage status require the attention of medical education researchers. A study focusing on widening participation in medicine relates that "this study underscores the importance of recognizing the intersection of other factors with socioeconomic status and how they contribute to students' aspirational biographies" (Gore, Patfield, Holmes, & Smith, 2018, p. 227). A more thorough understanding of how aspects of applicant advantage and disadvantage relate to outcomes in the medical education admissions process may identify potential barriers and contribute needed information in order to "continue to refine the medical school application process itself to eliminate unnecessary barriers" (Fernandez, 2019, p. S5).

Individuals are complex, and researching applicant qualities and personal backgrounds as if these factors exist in a vacuum will not accurately portray the interplay of significant privileges and marginalizations that may contribute to heterogeneous outcomes in the medical school application process. An intersectional approach to exploring applicant qualities and outcomes can help untangle patterns and consider multiple aspects of identities as part of the analysis.

Recently, intersectionality has been described as a "research imperative for education researchers" (Tefera, Powers, & Fischman, 2018). Eckstrand (2016) states, "An intersectional framework provides the cornerstone for actualizing a truly inclusive and equitable health care environment that welcomes and formally recognizes contributions from all members of the academic medical community and reduces health disparities experienced by underserved populations" (p. 906). This research employs an

intersectional framework to understand medical school applicant typologies and the relationships of those typologies with access to medical education.

CHAPTER 2

It is crucial to review the relevant scholarly literature as a means of understanding the underlying concepts integral to the discussion of disadvantage, privilege, and intersectionality and how they may influence access to medical education. A review of the historical landscape of higher education and medical education provides an appropriate context for understanding shifting demographics and access to education. Next, discussion of disparities and inequalities in access to higher education and medical school demonstrates the obstacles that diverse and disadvantaged students face in the process of pursuing academic degrees. A description of what drives students or potential students to pursue a medical degree is provided in order to understand motivations of applicants or detractors of would-be applicants. The complexity of identity, identity theory, and traversing multiple aspects of identities is discussed. Theoretical perspectives regarding the nuance of intersectionality and the complexities involved in using quantitative methods to explore intersectionality are presented to provide context to the methods proposed for this research. Last, researchers exploring developmental psychology topics by using individual or family characteristics to create typologies to predict a child's risk provides a segue into the methods employed in this research study.

Historical Landscape of Higher Education and Medical School

The first higher education institution in the United States was Harvard College, instituted in 1636. Higher education has, in many ways, leveled the playing field with regard to diversity and access though inequities remain. The Morrill Act of 1862 broadened access to higher education by establishing agricultural colleges to facilitate

practical education for students who would otherwise not have had access to elite higher education institutions, including several historically Black colleges and universities. In 1944, Congress enacted the GI Bill to provide scholarships for military veterans to attend college or university. The Pell Grant was introduced in 1965. Pell Grants are a federally funded grant program that assists low-income students in need of financial assistance in order to attend college. Recently, distance education has facilitated online learning and graduation to individuals who are unable to physically attend university. Because of these historical expansions and funding opportunities, students from all backgrounds may have opportunities to pursue higher education, but significant disparities remain.

Discourse on how admissions can account for applicant advantage and disadvantage in order to diversify the student body is well underway at the undergraduate level. Faced with the similar issue of thousands of applications and the ease of sorting by quantitative data for screening alongside a reluctance to rely upon standardized testing, the College Board recently introduced an adversity score. The adversity score was a single number on a 100-point scale and was based upon an applicant's geographic environment and school quality. The adversity score would accompany SAT scores and could be used as a proxy measure to place academics and test scores within the context of an applicant's neighborhood and school. Shortly after the College Board announced its innovation, controversy arose. It was felt that the score would bestow advantage upon families who gentrify low-income neighborhoods and concern that an applicant's complex background could not be accurately distilled down to one number. In reaction, the College Board opted for a dashboard approach. Landscape™ allows undergraduate

admissions representatives to understand obstacles the applicant has overcome while providing information about applicant neighborhood and high school, as well as the range of SAT scores at the applicant's school and zip code ("College Board announces improved admissions resource," 2019). In a simulation study, the inclusion of these contextual data made admissions officers more likely to admit a low-SES student and increased the positive assessment of the applicant's academic history (Bastedo, Glasener, Deane, & Bowman, 2019).

In 1765, the Medical College of Philadelphia (now the University of Pennsylvania) opened its doors as the first medical college in the United States (Starr, 1982). In 1910, the Flexner Report established biomedical sciences as the core of medical education (Cooke, Irby, Sullivan, & Ludmerer, 2006). Medical education began incorporating the study of foundational biomedical science concepts into what had been a purely clinical curriculum. This shift resulted in an emphasis on scientific knowledge over skills like clinical reasoning, practical skills, compassion, and integrity (Cooke et al., 2006). It also led medical school admissions to focus upon applicant academic performance in order to predict success in the foundational science curriculum, with less of an emphasis on character, behavior, or other characteristics that might make an applicant a competent physician (Witzburg & Sondheimer, 2013).

Modern medical schools recognize the advantages of increasing diversity in their student bodies. In the United States, medical school is a requirement in order to become a physician. Therefore, medical schools recognize that they have a responsibility to address inequities in the physician workforce through the applicants they select for admission.

Holistic review arose as a method to address diversity concerns by assessing medical applicants' academic achievement in context of their experiences, environment, and resilient qualities. However, medical schools are limited to their applicant pool. They are not able to select an individual for admission who did not apply, nor can they accept individuals who have left the educational pipeline or who choose not to apply.

Leaky Pipelines: Inequalities in Access to Higher Education and Medical School

Social, financial, and cultural resources in an individual's family of origin strongly predict their highest level of educational attainment (Shavit & Blossfeld, 1993). SES has been at the forefront of educational research, but there is an ongoing debate over its meaning and measurement (Sirin, 2005).

SES is thought to be transmitted intergenerationally, although individuals can mitigate this relationship by achieving higher levels of education, thereby contributing to increased social mobility (Bloome, Dyer, & Zhou, 2018; Liu, 2018; Sirin, 2005). SES is positively correlated with academic achievements such as admission to universities and high scores on standardized tests, creating a barrier for those at the lower end of the SES spectrum to access higher education (Sirin, 2005). Higher education research demonstrates that students from lower SES backgrounds are at higher risk for interruptions in undergraduate degree obtainment, working through college, or employment gaps between high school and college (Goldrick-Rab, 2006; Roksa & Velez, 2012).

Researchers in higher education consider students who are first in their families to attend higher education to be known as "first-generation students" (Gofen, 2009;

Pascarella, Pierson, Wolniak, & Terenzini, 2004). First-generation college students are typically racial or ethnic minority students from economically disadvantaged backgrounds who have difficulty in the context of higher education (Choy, 2001). Some researchers criticize the use of the label for students, stating that it makes the experiences of first-generation students difficult to truly understand, in that it "masks their differences across multiple dimensions of social life" (Nguyen & Nguyen, 2018, p. 148).

The number of first-generation college students varies depending on the definition used. Using data from the National Center for Educational Statistics (NCES), 7.2% of college students who were enrolled in financial assistance programs in 2011-2012 had parents who did not attend high school; 26.3% of these students had parents whose highest level of education was achieving a high school diploma (Radwin, Wine, Siegel, & Bryan, 2013).

Non-native language speakers may also be at a disadvantage in accessing higher education and the social mobility that comes along with it.

Access to medical school has not been equal for most years since the inception of the profession. It is well documented that being the wrong gender, practicing the wrong religion, and having the wrong skin color inhibited interested individuals from crossing the threshold into medical school because of the biases of those who made admissions decisions (Starr, 1982). Up through the 1960s, a lack of diversity remained within the student bodies of U.S. medical schools, which was echoed in physician demographics (Fischbach & Hunt, 1999). In the past, faculty and administrators may have actively

worked to prevent the enrollment of medical school applicants who were not White males (Starr, 1982; Walsh, 1977).

Women's access to medical education arose after public pressure and the demand from society for competent and empathetic physicians (Walsh, 1977). The first women and Black men admitted to medical school had to endure covert and overt protests from their White male classmates (Walsh, 1977). Progress since then has been slow, but addressing the gender disparity has been effective. Women now outnumber men in the number of applicants, accepted applicants, and matriculants to U.S. medical schools (Association of American Medical Colleges, 2019b).

In addition to the unchanging pattern of medical students having high family incomes, medical students also have accomplished parents. For example, approximately half of the fathers of medical students have a graduate degree compared to 12% of men in the U.S. population. Furthermore, approximately one-third of the mothers of medical students have a graduate degree compared with approximately 10% of U.S. women (Association of American Medical Colleges, 2018a). Having at least one parent who is familiar with higher education may bestow advantage on individuals who are better equipped to navigate and access higher education. For medical students, if at least one parent is a physician, it is likely that they not only benefitted from the parent's familiarity with medical education as a whole but may also have experienced specific privileges. An applicant may be more likely to be accepted into a medical school in which a parent is an alumnus, or they may have benefitted from connections to the healthcare system and thus

ample volunteer opportunities in healthcare to strengthen their applications to medical school.

Aspiring to Medical School.

In the United States, the field of medicine is one of the highest-ranked professions in occupational prestige scales (Hauser & Warren, 2008). This prestige may attract or deter individuals from applying to medical school.

Kraus found that those that ranked themselves as members of a lower class tend to explain social and personal outcomes in terms of contextual factors and attributes this tendency to a diminished sense of control over one's outcomes (Kraus, Piff, & Keltner, 2009). This diminished locus of control may deter individuals from pursuing additional education or prestigious jobs.

There is a similar pattern of a lower prevalence of lower SES medical students in the United Kingdom. An exploration of the phenomenon produced a theory that "habitus as identity" led lower SES individuals to be less likely to identify with medicine and to be encouraged by counselors and teachers to aspire to medical school, while parental support was a positive influence in pushing lower SES students to pursue medical education (Mathers & Parry, 2009). McHarg found similar themes in a qualitative study of UK medical students; access to medical school was found to be facilitated by family support and having positive role models and inhibited by the discouragement of teachers (McHarg, Mattick, & Knight, 2007).

When studying 362 URM students who indicated interest in becoming physicians upon matriculating as freshmen at Stanford University in the U.S., researchers found a

steep drop off in interest as compared with non-URM students. Qualitative data indicated that URMs cited experience in chemistry courses and unsupportive advisors as to the reasons they were no longer interested in medicine (Barr, Gonzalez, & Wanat, 2008).

More research is needed on what deters would-be medical school applicants from pursuing a career in medicine, particularly those that are URM and/or disadvantaged.

Identities and Negotiating Multiple Identities

In order to discuss the concept of multiple identities, we must first define identity, identity theory, and identity work. Ashforth et al. (2008) define the construct of identity as "a self-referential description that provides contextually appropriate answers to the question 'Who am I?' or 'Who are we?'" (p. 372).

Historically, identity theory was thought to be split into two related but discordant strands. Stryker (2000) focused upon the linkage between social structures and identities, while Burke (1980) concentrated the theory on the internal process of self-verification. Unifying these two strands, Stryker and Burke (2000) collaborated to define identity theory as concerned with identity as the parts of the self comprised of the meanings to which people attach to the multiple roles they play in highly diversified modern societies. Individuals occupy multiple roles and identities; therefore, Ashforth and colleagues (2008) define identity theory as concerned with how the social embedding of positions within relational networks increases the probability of activation and success in a given situation.

Identity work is the process by which individuals try to make sense of day-to-day events, particularly those that threaten self-identity, to preserve self-esteem and a sense of concordance (Ashforth et al., 2008).

Role-identities have been thought of as subunits of the self (James, 1968). In 1980, Burke used an interactionist perspective and recommended tenets for measuring an individual's self-concept while accounting for multiple identities. He stated:

> (1) that the self is composed of an organized set of identities, (2) that identities are self-in-role meanings, (3) that identities are defined relationally in terms of counter-identities, (4) that identities are reflexive, (5) that identities influence role performance indirectly through the construction of self-in-role images, and (6) that identities motivate behavior" (p. 28).

With consideration of these sets of identities, identity theory that posits that identity is formed via a comparison of oneself against other groups becomes incredibly complex. Must an individual take every facet of their identity associated with their sense of self and decide whether that subunit is concordant or discordant with the social comparison? Further, this would require consideration of one's identity sub-units while ignoring any examining relationships between sub-identities.

Research has progressed to begin conceptualizing multiple identities, the configuration of multiple identities, and how the identities are negotiated in context and when interacting.

West and Zimmerman (1987) explored identity construction within organizations by taking a perspective of identities such as gender as an enactment

performed by women and men through interactions in situated contexts. They believe that gender is an ongoing performance and that each individual chooses how they relate to societal expectations while interacting with others. Discussing the issue of multiple identities, Watson (2008) states that individuals must accept and work within current and predominant discourses and subjectivities, but also believes the individual may manipulate the variety of philosophies that sometimes overlap (or clash) in order to create a sense of self that they can consider their own.

These ideas create a more complex conceptualization of identity: one where individuals work within intersections of structures of power and control while also possessing agency in the ways they construct and negotiate their identities within these systems in order to create a meaningful sense of self.

Intersectionality

Kimberlé Crenshaw (1989, 1991) coined the term "intersectionality" as a way to describe the issues encountered by women of color in the legal system. She described how courts would not consider the possibility of simultaneous discrimination involving both race and gender and routinely dismissed the discrimination cases of black women. Courts followed legal doctrine and associated racial discrimination with black men and gender discrimination with white women. If black men and white women held positions of power, courts reasoned that discrimination specific to black women could not be taking place. This oversight is, in itself, an example of discrimination via multiple-oppressions against black women.

Drawing parallels to these legal cases, Crenshaw deemed feminist theory and anti-racist practice insufficient because both failed to recognize black women's unique experiences. Instead of considering piecemeal identities, Crenshaw urges examining experience with consideration to the "intersections of racism and patriarchy" (Crenshaw, 1991, p.1241). Intersectionality specifies that pieces of an individual's identity are not independent of one another and are continually interacting and informing one another. For example, under the theory of intersectionality, it is possible that social justice movements aim to address oppression in one area may perpetuate it in another. A black woman at a Women's March might experience racism, and she may experience sexism at a Black Lives Matter gathering. Multiple oppressions can be thought of as synergistic, creating a unique experience that must be acknowledged.

Intersectionality serves as a framework of understanding oppression and privilege and how dimensions of power intersect and interact across social dimensions (Cho, Crenshaw, & McCall, 2013). Although initially focused upon gender, race, and class, feminist theories of intersectionality critique the idea that social constructs such as class or socioeconomic status could be separate from race, sex, sexual preference, age, and physical ability (Crenshaw, 1989; Southgate, Kelly, & Symonds, 2015). Exploratory research of the interplay of social disparities can offer valuable insight into the social and political dynamics of medical education and how these dynamics might contribute to oppression and privilege, resulting in differing outcomes for subgroups of applicants.

Intersectionality as Praxis Employing intersectionality as a praxis and analytical technique has produced a dynamic field of new knowledge and exponential growth of

publications (P. Collins, 2015; P. Collins & Chepp, 2013). Recognition of power dynamics is essential to performing research in alignment with the intention of intersectionality (Rice, Harrison, & Friedman, 2019). However, some scholars have critiqued the notion of performing research guided by intersectionality. Warner and Shields (2013) cautioned that researchers might place equal weight on all identity factors in carrying out their research. In reality, privilege and oppression might be experienced as additive, exponential, synergistic, or subjective and relative (P. H. Collins, 2000; Veenstra, 2013). Identities may also be ordinal by nature, with subordinate identities interacting with gender. Curiously, when Veenstra (2013) explored the relativity of social inequalities in a telephone survey of Canadian adults, wealthy men and men with a technical school or community college diploma reported the lion's share of instances of discrimination, while wealthy women without diplomas reported the least. Veenstra also explored the routineness of discrimination in daily life and found that men without a high school diploma reported the most discrimination and that men and women with university degrees reported the lowest amount of routine experiences of discrimination (Veenstra, 2013). Given the discordance in self-identity and experiences of oppression, it could be argued that using intersectionality theory to inform quantitative analysis of self-report data might not adhere entirely to intersectionality frameworks because of an inability to explore any further than the dataset (Warner & Shields, 2013).

Quantitative research into social phenomena involves analyzing continuous or categorical data and cannot be expanded beyond the data that are captured. Additionally, identities are inflexible in that they are confined to the categories offered, which are

primarily built from current social constructs. However, Warner and Shields point out that a study by Galupo and Gonzalez (2013) that explored friendship patterns across race, sexual orientation, and gender created value in intersectional research by making intersections of identities visible. Warner and Shields (2013) believe that quantitative research and empirical data analysis are faithful to feminist intersectional theory by highlighting the intersections of privilege and oppression. Perhaps the ideal approach is to perform quantitative analysis focused upon the full spectrum of a construct in order to retain complexity. For example, oppression can only be researched only by considering advantage and disadvantage. This concept echoes McCall (2005), who believes that solely focusing on subordinate groups in intersectional research risks overlooking clusters of power and privilege and would not allow for simultaneous advantage and disadvantage within individuals and identities.

Bowleg (2013) posited a fundamental tenet of intersectional theory is "social identities are intersectional, not additive and thus cannot be ranked" (p. 759). However, the results of Bowleg's qualitative study of Black gay and bisexual men conflicted with this tenet; respondents ranked their identities by importance as well as building their identities by identifying with all intersections of social attributes.

Given both Bowleg (2013) and Veenstra's (2013) found discordant findings that conflicted with their interpretation of how intersectionality operates within individuals and sense of self, it is possible that the intersections of identities and the interplay of disadvantage and advantage create experiences and identities in a context and may be known only to the individual. This complexity may tie back into the process of identity

work, where individuals have agency to build and manage their identities within situational contexts in order to create a sense of self that is meaningful to the individual.

Quantitative Methods Guided by Intersectionality

Due to the complexity of the concept of intersectionality and the lack of guidance on methods to include the multiple dimensions of individuals, research employing quantitative methods situated in theory had been limited (McCall, 2005). An early theoretical focus in intersectional research regarding the experiences of black women resulted in methods that inadvertently treated black women as a monolithic group (Nash, 2008). Nash describes such phenomena as an example of projects employing intersectionality theory while inadvertently replicating the precise issue the studies are meant to critique.

McCall (2005) developed three distinct methodologies to guide research methods grounded in intersectionality: anticategorical complexity, intercategorical complexity, and intracategorical complexity. Each is distinct, based upon their view and use of categories.

McCall's (2005) anticategorical approach deems that social life is so complicated that fixed categories "produce inequalities in the process of producing differences" (p. 1773), and therefore researchers might only simplistically use social categorizations. Conversely, researchers employing McCall's intercategorical complexity approach strategically apply analytical categories for assessing inequalities along multiple dimensions. An example of the intercategorical approach might be stratified results of cross-coded groups (e.g., middle-class black women) describing multi-group

intersections or regression models with two identity covariates as well as an interaction term, where the results of interaction vary from those predicted by combining the effects of each identity. The proposed research study is an example of an intercategorical quantitative approach using an intersectional framework. Intracategorical complexity falls between these two extremes, both recognizing and employing a critical stance toward social classes and groupings. In quantitative research, an intracategorical approach might focus on the complexity of one particular identity intersection.

Researchers might consider examining qualitative research in order to guide their quantitative methods by incorporating evidence to the role the intersections of identity can play (Green, Evans, & Subramanian, 2017; Ragin & Fiss, 2017). Informing empirical methods based on the findings of qualitative literature is especially important in education, where policies and practices may have a heterogeneous impact on students' identities (Schudde, 2018). As this research is a secondary analysis of an existing dataset, the quantitative analysis is not informed by qualitative findings; it is not known if qualitative data collection informed the creation of items representing advantage status on the AMCAS application.

Researchers may run up against a barrier when attempting to account for the multiple dimensions in quantitative research methods. Sociology scholars have argued that the act of classifying people into groups is a source of injustice in that the process of stratification allocates people into social categories and that resources are then allocated based upon the boundaries of these categories (Massey & Massey, 2007). To the degree that cultural and social identities align with these categories, categorization also relates to

inequality in that it can form attitudes, behaviors, and social identities of societies (Wildhagen, 2015). This creates a dilemma for quantitative researchers hoping to explore trends guided by intercategorical methods and the framework of intersectionality; intersections can only be explored if there are clearly defined categories, but the act of defining categories may itself be an act of marginalization. This seems an inherent limitation that should be disclosed by researchers exploring intersectional identities using quantitative methods.

Quantitative studies exploring intersectional identities may also encounter problems related to sample size if the sample is divided into smaller subgroups, making it challenging to detect an effect (Schudde, 2018). Researchers employing quantitative methods to investigate multiple oppressions are also challenged by the social construction of categories and fluidity of categorization, presenting substantial design challenges to empirical methods (Else-Quest & Hyde, 2016a). The proposed research study has the advantage of a large sample size, which allays concerns over diminished statistical power when dividing the sample into subgroups; however, it is constrained by the challenges introduced through categorization as described by Else-Quest. The data are self-report, and therefore the categories are directly or indirectly (for calculated variables) chosen by the applicant. The applicant is limited to the answer sets provided, and any change over time that might lead to a different selection cannot be accounted for in this study.

Applied Intersectionality: Demographic Factors as Predictors of Risk

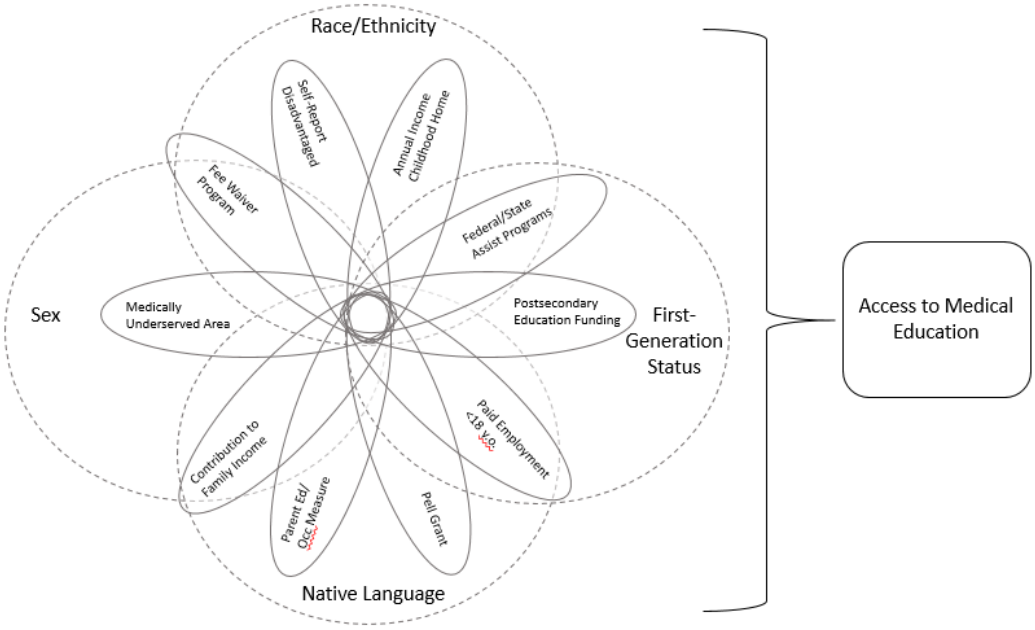
It is common to see demographic variables reported as descriptive statistics in quantitative studies, particularly in the developmental research field (Lanza & Cooper,

2016). Family demographics and socioeconomic traits are used to develop typologies using exploratory latent class analysis (LCA) models in order to estimate the risk of adverse outcomes for children related to academic, emotional, and behavioral outcomes (Buehler & Gerard, 2013; Lanza, Rhoades, Greenberg, & Cox, 2011; Rhoades, Greenberg, Lanza, & Blair, 2011; Roy & Raver, 2014; Yazejian, Bryant, Freel, & Burchinal, 2015). This research study employs a similar approach by using medical applicants' self-reported data about themselves and their childhood circumstances to develop typologies that may predict different outcomes in the medical admissions process.

Conceptual Model

Figure 1 demonstrates the conceptualization of this study. It visualizes the perspective of intersectionality by representing advantage status qualities, and demographic qualities are interwoven within individuals. This research study will first use a person-centered analysis technique in order to assess underlying patterns of advantage status in a sample of two years of medical school applicants in order to build typologies. Next, demographic variables (representation in medicine and gender) will be assessed to understand if they predict membership in the typologies. Last, the medical school applicant outcomes will be assessed for members in the typologies, in order to understand whether certain combinations of disadvantage or privilege result in heterogeneous outcomes within the medical school admissions process.

Figure 1. Conceptual model



Theoretical Framework

The theoretical framework chosen for a research study serves as the context and grounding foundation for the study rationale and methodology. This research is situated within critical theory since it exposes and challenges the dominant social, economic, and political structures (Held, 1980). The methods build upon the idea that critical epistemological insights need to be taken into account in order to challenge the foundations of medical education and practice, to encourage a more nuanced conceptualization concerning different forms of marginalization and to engage in critical approaches to knowledge building that can inform our understanding of injustice (Farias et al., 2016). Research questions grounded in this theory place specific emphasis on matters of power that can affect the pursuit of social justice and avoidance of oppression

(Johnson et al., 2007). Quantitative approaches borne of a critical epistemological stance can thus assess and explore patterns of injustice (Hope et al., 2019).

This research is also heavily informed by feminist theory in the form of Crenshaw's seminal work defining the concept of intersectionality (Crenshaw, 1989; Crenshaw, 1991). Feminist research approaches view gender as a grounded organizing principle that shapes the conditions of lives and consciousness (Creswell, 2012). Chang and Culp (2002) state that now that intersectionality has conceptualized the symbiotic and interconnected nature of race, gender, sexuality, and class, the next step is to begin articulating points of intervention. Marecek (2016) posits that the original intention of intersectionality was to study the social categories used to describe people and not a study of the persons themselves.

This research uses a quantitative framework in order to explore and describe a phenomenon as a starting point for new hypotheses regarding advantage status as it relates to access to medical education and increased diversity in medical school and the physician workforce. The intercategorical quantitative and theoretical approach is novel in medical education research, in that the person-centered analytical technique explores aspects of advantage status in a nationwide sample of applicants to medical school and allows indicators of both disadvantage and privilege in accessing medical education to co-occur. The analysis technique does not relegate individuals and associations with admissions outcomes to a single dimension of their identities; instead, applicant experiences and familial and environmental conditions are used to build typologies and retain the intersectional complexity inherent in individual applicants. Membership in

these typologies will be assessed for associations with medical school admissions outcomes.

CHAPTER 3

Research Design and Methods

The three manuscripts in this dissertation follow a progression where first an advantage status typology was built, the demographic composition of the typology categories was examined, and, last, the probability of typology membership and outcomes within the medical school admissions process were examined. The second and third papers both build upon the creation of the advantage status typologies.

Research Questions

The three distinct papers in this dissertation represent an exploratory study utilizing a secondary analysis of data about U.S. medical school applicants from their medical school applications.

The articles address three main research questions:

Article 1: An Intersectional Exploration of U.S. Medical School Applicant (Dis)advantage Typologies

1. Among the applicants to U.S. medical school, what are the emerging latent classes representing advantage status typologies?

Article 2: Exploring the Demographic Compositions of U.S. Medical School Applicant Advantage Status Typologies

2. What are the demographic compositions of the emerging latent classes?

Article 3: U.S. Medical School Applicant Advantage Status Typologies and Impacts on the Accessibility of Medical Education

3. What is the relationship between applicant latent class membership and applicant outcomes in the medical school admissions process?

Study Context and Population

The exploratory analysis used AAMC AMCAS self-report data from all applicants to 146 U.S. medical schools in the 2018-2019 application cycle. The AAMC provided a de-identified dataset with measurements of applicant identity, backgrounds, academic success, as well as measurements indicating how individuals performed in the admission process. This study focused on measures of advantage status for medical school applicants.

Individuals listed as non-U.S. Citizens and non-Permanent Residents (n=1,948, 3.8% of the dataset) were omitted from the file since they did not receive the full set of questions used in this analysis. Additionally, 1,858 applicants supplied no data for any advantage status indicators and were excluded from the LCA model. The final file used for analysis contained self-report data from AMCAS applications for 47,958 applicants.

The University of Vermont Institutional Review Board categorized this study as not falling under the definition of human subjects research.

Data Analysis

The raw dataset containing measures extracted from AMCAS applications was cleaned and recoded. Prior to beginning analysis, patterns of missing data were evaluated in IBM SPSS v. 25. The pattern of missing data was classified as Missing at Random (MAR) based upon Missing Values Analysis performed on two versions of the dataset: one with missingness indicative of an absence of information, and one that also coded

"unknown," "don't know," or "N/A" answers to advantage status measures to missing. Unknown responses suggested that an elusive true value existed but was not accessible, whereas non-applicable responses suggest that the query had no meaning to the respondent (Allison, 2002).

Conversely, a "decline to answer" response implies that a true value exists and is accessible, but the applicant prefers to withhold details from anyone reviewing their application. Answers that a respondent declined to answer were kept in the analysis. Response frequencies within the dataset before and after recoding unknown and non-applicable answers to missing were provided.

Non-U.S. Citizens and non-permanent residents were excluded from the dataset because they did were not asked to answer any of the advantage status items on the AMCAS application. Simple comparisons between those remaining in the dataset and non-U.S. Citizens and non-permanent residents were run to compare MCAT scores, GPAs, gender, and English as a second language.

Since analyses of large datasets can produce significant *p*-values attached to inconsequential effects (Greenwald et al., 1996), it is important to characterize the magnitude of differences. Effect sizes for the comparisons in the first manuscript were calculated. For Independent samples t-tests, Hedges' *g* measures effect size was weighted to the size of each sample (Field, 2013). Phi was provided as a measure-effect size for chi-square tests of two nominal variables; and, for chi-square tests of nominal variables with more than two levels, Cramer's *V* is the appropriate estimate of effect size (Field, 2013).

Descriptive statistics were run in SPSS version 25 to describe the sample. The ten advantage status indicators were imported into Mplus version 8 in order to conduct an exploratory LCA on the binary, nominal, and ordinal advantage status measures. LCA is a reductive technique similar to psychometric analyses such as exploratory factor analysis; instead of evaluating the underlying properties of an instrument, we assess a latent construct driving applicant homogenous response patterns on observed variables (Collins & Lanza, 2010).

Effective use of LCA involves fitting the most parsimonious model. Parsimony is accomplished through a model with the smallest number of latent classes to describe the associations between the indicators accurately. Subsequent models were constructed and estimated with 1 to 7 latent classes to determine the best model to fit the variables. The fit of these iterative models was tested using the Bayesian information criterion (BIC), a statistic incorporating model fit and model parsimony, and the Lo-Mendell-Rubin Adjusted Likelihood Ratio Test, which tests the k model against the k+1 model.

Model parameters in LCA are estimated by maximum likelihood (ML) using the expectation-maximization (EM) procedure (Collins & Lanza, 2010). A benefit of using ML estimation is that it does not exclude cases unless the case has missing data on all observed variables. ML is, therefore, able to analyze based upon the premise that any missingness is classified as missing at random (MAR) (Collins & Lanza, 2010). Because LCA employs ML techniques with EM procedures, it is unnecessary to impute missing values.

LCA produces probabilities of membership in each class for each case, also referred to as posterior probabilities. Additionally, a measure of most likely class membership based on the individual's highest probability of typology membership is created (Collins & Lanza, 2010). Although applicants may have probabilities describing the degree of belonging to multiple typologies in LCA, most likely membership is mutually exclusive and selects the class with the highest probability for each individual (Clark & Muthén, n.d.; Geiser, 2012).

In the focus on describing relationships between typologies and demographic qualities in the second paper, most likely advantage status typology membership was used for the initial analyses to promote exploration of applicants' demographic features in relation to advantage status. Posterior probabilities were used to examine associations between intersectional identities and the probability of typology membership.

Most likely typology membership in the five-class advantage status model was converted to a series of five dummy variables in SPSS v 25. Additionally, dummy variables for each demographic variable were created for inclusion as independent variables in logistic regression models. Creating binary dummy variables allowed regression results to be interpreted for the presence or absence of the indicator quality.

Logistic regression models were then used to investigate single demographic variables and most-likely typology membership odds. Odds ratios demonstrating typology membership odds for individuals possessing the quality of interest were presented, along with 95% confidence individuals. Confidence intervals that excluded one indicated statistical significance, with intervals below one indicating lower odds and

intervals higher than one signaling increased odds for those with the presence of the variable as compared to those who lack the variable (Szumilas, 2010). In order to investigate the intersections of applicant demographic traits with the probability of typology membership, Spearman's rho correlation coefficients were presented. Odds ratios and associated 95% confidence intervals and Spearman's rho correlation coefficients are both effect size measures.

In the last paper, descriptive analyses were conducted for applicant academic metrics and behaviors and outcomes in the medical school admissions process. The descriptive data were presented using an applicant's most likely advantage status typology; other analyses in the portion of the project exploring demographic characteristics of typology membership project use probability of typology membership.

Correlations between the probability of typology membership and the number of applications, number of acceptances, as well as a novel application of a return on investment formula were presented. Details of the applicant return on admissions investment (ROAI) appear in the methods section of paper three. Effect sizes representing the magnitude of associations in paper three were provided through Pearson correlation coefficients and odds ratios along with 95% confidence intervals.

Binomial logistic regression was conducted in order to generate odds ratios and accompanying 95% confidence intervals demonstrating the associations between the probability of typology membership and dichotomous outcome measures of accepted to at least one medical school as well as matriculated into a medical school.

MCAT score was used as a covariate in the logistic regression models in order to understand the associations between the probability of advantage status typology membership and dichotomous outcome measures when controlling for a proxy of applicant academic aptitude and/or test-taking ability. This measure was chosen because U.S. admissions officers generally regard the applicant MCAT score as a measure of academic readiness for medical school; some schools may use pre-screening to set a baseline for acceptable MCAT scores to introduce an ordinal measure to sort the thousands of applications they receive each year.

Measures

Variables representing aspects of applicant advantage status in the AMCAS application were used to form advantage status typologies based upon applicant response patterns arising from an underlying latent construct. Measures were selected from AMCAS as indicative of applicant advantage status if they were related to socioeconomic status, represented potential obstacles in navigating the educational system as a whole, corresponded to more or less difficulty preparing for medical school, and/or introduced barriers or facilitators to full participation in the medical school application and interview process.

Specifics on how variables were coded, and indicator and referent categories are within the manuscripts.

Advantage Status Measures

Postsecondary Education Funding. This measure asks applicants to respond to the prompt "How have you paid or did you pay for your postsecondary application?" by

filling in percentages for the following sources: academic scholarship, need-based financial scholarships, student loans, other loans, family contribution, applicant contribution, or other. This study focused on applicant responses to two categories: need-based financial funding and family contribution. Replicating Grbic et al.'s (Grbic et al., 2015) coding scheme, the first level represents the highest-need, lowest family contribution by designating this category as those applicants with 25% or more need-based scholarship and less than 25% family contribution. This study adds three more categories:

- The first level was comprised of applicants with at least 25% need-based scholarship and less than 25% family contribution
- The second level contained applicants with less than 25% need-based scholarship and less than 25% family contribution
- The third level included applicants with at least 25% need-based scholarship funding and at least 25% family contribution, and
- The highest level contained applicants with at least 25% family contribution and less than 25% need-based scholarship

Fee-Assistance Program. Applicants can request a fee waiver from the AAMC based upon the U.S. Department of Health and Human Services poverty level guidelines. The fee waiver program reduces the cost to register for the MCAT exam and reduces AMCAS application fees (*Who Is Eligible to Participate in the Fee Assistance Program?*, n.d.). Consideration for the fee waiver program requires submission of household tax returns to AMCAS and subsequent verification of income levels. In this

dataset, the fee waiver indicator will be positive if the applicant applied for a fee waiver for the AMCAS application process and was verified as eligible. The second category is those that did not use or did not receive the fee waiver. This measure is the only advantage status variable that is verified and not solely self-report by the applicant.

Self-Report Disadvantaged Status. Guidance from the AAMC says that an applicant might consider themselves as disadvantaged if they "grew up in an area that was medically underserved or had insufficient access to social, economic, and educational opportunities" (*2019 AMCAS Applicant Guide*, 2019). The question asks, "Do you wish to be considered a disadvantaged applicant by any of your designated medical schools that may consider such factors (social, economic, or educational)?" Applicants are able to designate themselves as having disadvantaged backgrounds or not.

Family Use of Federal or State Assistance Programs. Applicants answered the question, "Have members of your immediate family ever used federal or state assistance programs?" Applicants selected yes, no, or declined to respond.

Annual Income in Childhood Home. This construct is measured via the question, "What was the income level of your family during the majority of your time from birth to 18?" The answer set consists of fourteen income categories with $75,000 or over as the highest level. The dataset released by AAMC condenses the 14 categories into three income category ranges: (less than $50,000, $50-74,999, $75,000 or more) as well as an option if the applicant declines to respond.

Contribution to Overall Family Income. Applicants were asked, "Were you required to contribute to the overall family income (as opposed to working primarily for your own discretionary spending)? Applicants could select yes, no, or decline to respond.

Paid Employment before Age 18. Applicants were asked to report whether they held paid employment prior to age 18. Applicants could select yes, no, or decline to respond.

Pell Grant Recipient. This measure represents applicants who have received funding the federal government provides to students who have demonstrated financial need, among other factors. Applicants select that they had received a Pell grant or that they had not.

Medically Underserved Area. Applicants can designate if they believe that the area where they grew up was medically under-served. Applicants could select yes, no, or decline to respond.

Parent Education/Occupation Measure. The AAMC created a socioeconomic indicator based upon a combination of applicants' parental education and occupation. Applicants are classified into five groups (EO1-EO5) based upon four categories of parental education and two categories of occupation (*Assessing Financial Need Using the AAMC Socioeconomic Status Indicators (EO1, EO2),* n.d.). EO1 represents applicants whose parent has less than a bachelor's degree, EO2 indicates applicants whose parent has at least a bachelor's degree and is in a "service, clerical, skilled and unskilled" occupation. EO3- EO5 levels contain applicants whose parent has an "executive, managerial, or professional" position and a bachelor's degree (EO3), master's degree

(EO4), or a doctorate or professional degree (EO5). The AAMC released three levels of this variable: EO1, EO2, and EO3-EO5.

Demographic Measures

Medical school applicant self-report measures on four demographic variables representing race, sex, English language proficiency, and first-generation status.

Race/Ethnicity. This measure has a three-category answer set: URM, White only or Asian only, Other or multiple other. The AAMC defines the term underrepresented in medicine (URM) as "those racial and ethnic populations that are underrepresented in the medical profession relative to their numbers in the general population." Historically, the AAMC determines URM membership via the applicant's answers to race and ethnicity questions on the AMCAS application. Applicants were URM if they self-reported that they were Black, Mexican-American, Native-American (American Indians, Alaska Natives, and Native Hawaiians), and mainland Puerto Ricans (*Underrepresented in Medicine Definition—Initiatives—AAMC*, n.d.).

Sex. Applicants were able to self-identify as male, female, or they could choose "unknown/decline to respond."

First-Generation. First-generation status is inferred from the information that an applicant provides about their parents' education. Applicants who did not report that one or more of their parents earned bachelor's degrees were considered first-generation students. This is a dichotomous variable, with an applicant designated as first-generation or not.

Language Minority. Applicants provided information on the languages that they speak. The data were recoded into a variable representing fluency in English. Applicants who did not describe that they speak the English language at a native level were classified as language minorities, while those that indicated speaking English at a native level were the referent group. Language minority status was also referred to as speaking English as a second language (ESL).

Academic Metrics

The AAMC shared three measures of medical school applicant academic aptitude and/or test-taking ability.

BCPM GPA. This measure represents the applicant's post-secondary grade point average for any courses falling into the categories of biology, chemistry, physics, and math. BCPM GPA is also known as the "Science GPA." BCPM GPA is a continuous measure ranging from 0 – 4.

Total GPA. This measure represents the grade point average for all post-secondary courses taken by the applicant. Total GPA is a continuous measure ranging from 0 – 4. This measure may also be referred to as uGPA or undergraduate GPA.

MCAT score. Applicants were required to take the Medical College Admission Test and could submit multiple scores if they took the test repeatedly. For this study, the highest total MCAT score obtained by the applicant was used as a covariate in regression models as a proxy for academic ability and test-taking skills. Total MCAT scores range from 472 to 528, with a midpoint of 500.

Access to Medical Education

The AAMC tracks medical school applicant outcomes. The following served as outcome variables in regression models assessing whether class membership predicts an applicant's success in accessing medical education.

Number of Applications. This continuous measure indicates how many medical schools to which the applicant applied.

Number of Acceptances. This continuous measure represents the number of medical schools to which an applicant was accepted for admission. This variable was also recoded to create a dichotomous version of the measure with applicants coded to yes if they had received at least one acceptance to a medical school to which they applied.

Matriculated. If accepted, applicants have the choice to attend one of the medical schools to which they were accepted. Accepted applicants might opt to attend medical school or decide not to enroll in any medical school. Matriculation is a dichotomous measure.

Validity Issues

This exploratory research project has many strengths. It contributes to scholarly research about medical school applicants and, because it represents a two-year national sample of applicants, is generalizable. Employing a quantitative approach using LCA strengthens this study due to the elimination of the one-dimensional approach to understanding applicant outcomes and via the person-centered nature of the analysis. Additionally, the composition of the latent classes will be driven by the patterns within the dataset itself, reducing the possibility of researcher preconceptions and biases.

Finally, the inclusion of effect sizes allows for an idea of the magnitude of differences within the analyses.

There are also limitations and challenges to validity inherent to this research project. The most substantial limitation is that by studying advantage status as a barrier at the medical school applicant level, it cannot account for those individuals who might dream of becoming a physician but do not apply to medical school. These individuals may have experienced barriers earlier in life that prevent them from meeting the minimum requirements to apply to medical school or present such significant obstacles that the idea of going to medical school was no longer a practical one.

The presence of missing data in the advantage status indicator variables may be indicative of sampling bias if the individuals who had missing data are somehow inherently different from those who do not. If the data are MCAR, there are fewer concerns for decreased external validity.

LCA assigns individuals to their most likely class based upon probability; in reality, each individual has fractional class membership and may have non-zero probabilities of membership in other classes. Using most likely class membership may introduce error (Clark & Muthén, n.d.). For example, an individual with 0.51 probability of being a member of Class A and 0.49 of Class B membership will be assigned as a most likely member of Class A.

Additionally, the majority of the measures used to construct the classes are based upon self-report from medical school applications. Therefore, the analysis is subject to the limitations of self-report data, such as whether the categories were a good fit for all

applicants and whether applicants were truthful. A lack of truthfulness might occur if applicants do not want to disclose details about themselves or if they perceive specific selections on the application that could increase their chance of admission to medical school. Variables in this analysis could be subject to either of these biases, other than the variables that are verified by AMCAS (fee-waiver) or are part of the AAMC's record-keeping (admissions outcome variables.) In addition to these specific concerns, using an existing data set impacts an ability to measure constructs; the questions that are asked of applicants may represent a threat to construct validity if they do not accurately capture the construct of interest (Shadish et al., 2002). Whether the questions on the application truly measure the constructs that are part of this research study is not clear.

Though the dataset is large and represents all applicants to U.S. medical schools in 2018-2019, AMCAS data are cross-sectional. The static nature of the dataset will not allow for capturing and describing any fluidity in the social constructs represented by sociodemographic questions. By analyzing only one-year of data, we also assume that the medical school applicant pool remains relatively homogenous from year to year.

This study seeks to understand and describe differences in admissions and learning outcomes experienced by different identities, but cannot examine what other factors may shape these differences. Factors that are not assessed as part of the AMCAS application may also represent significant barriers in access to medical education.

Last, because this exploratory study uses quantitative methods, it lacks the in-depth analysis of nuanced and complex topics that qualitative research would generate. However, the outcomes of this research project may identify high-risk or privileged

typologies that would allow researchers to generate new hypotheses that can be explored through qualitative or mixed-methods design.

Although this research study significantly advances discourse on socioeconomic diversity in medical applicants, systematic biases within the education system as a whole undoubtedly restricted the pool of applicants. This pool is limited in scope to individuals who have graduated from high school and obtained bachelor's degrees. Research shows that achieving these outcomes is more accessible for some groups than others, which represents an injustice since higher education levels are known to be a method for families to break out of the cycle of poverty (Bloome et al., 2018; Liu, 2018; Sirin, 2005).

A significant limitation to this research is that the exploration of medical school applicant backgrounds is limited to the concepts addressed in the AMCAS application, the answer set categories corresponding to those measures, and the condensed categories released by the AAMC for research. In 2018-2019, the AMCAS asked questions about gender identity and LGBTQ status, but these were not made available for this analysis, which limits its inclusiveness and prevents exploration of the relationship of these variables to advantage status.

It is also important to consider that the majority of the data on the AMCAS application are self-report. This research is based upon the creation of advantage status typologies, but the AAMC verified only one of the measures used in the LCA (eligibility for the AAMC's fee assistance program). In addition to the known pitfalls regarding the accuracy of self-report data, the competitive process of applying for medical school may

motivate applicants to choose answers based upon what they suspect may give them a leg up rather than the answers that accurately represent their identities and backgrounds.

The class enumeration process in this dataset was more complex than expected, with no clear point of diminishing returns. The log-likelihood plots and BIC values had to be tested to find a point where the slope leveled for both measures (Nylund-Gibson & Choi, 2018). Additionally, the choice of the 5-class model was informed by theory and interpretability (Collins & Lanza, 2010; Nylund-Gibson & Choi, 2018). Such solutions likely added subjectivity to the enumeration process. The 5-class model, however, appeared to be the most parsimonious fit for a complex dataset.

CHAPTER 4

An Intersectional Exploration of U.S. Medical School Applicant (Dis)advantage Typologies

Abstract

Purpose

Diversifying the medical student body is crucial toward building a more diverse and culturally competent physician workforce to address healthcare disparities in the United States effectively. Despite a shift toward holistic review in medical admissions, the majority of medical students come from households in the top two quintiles of household income.

Method

This study used a person-centered intersectional approach to examine response patterns to ten binomial, nominal, and ordinal measures representing socioeconomic factors within a national dataset representing all applicants to 146 United States medical schools in 2018-2019. Latent typologies were produced based upon applicant response patterns. Enumeration procedures were followed to determine the proper number of typologies representing the most parsimonious fit with the dataset.

Results

Five latent classes were derived from a dataset representing 47,958 applicants to medical school. Examination of typologies revealed that two typologies represented the most advantaged applicants, two of the most disadvantaged applicants, and one mixed

typology. Further, 57% of applicants were likely members of the advantaged typologies, 18% disadvantaged typologies, and 25% members of the mixed advantage typology.

Conclusions

It is important to explore socioeconomic diversity and the backgrounds of applicants in medical admissions using methods that incorporate context and nuance. This generalizable research study demonstrates that enhancing the socioeconomic diversity of medical students will require solutions to diversify the applicant pool itself.

Introduction

Increasing diversity within the United States (U.S.) medical workforce is an essential strategy for meeting public health challenges, adequately caring for a diverse population of patients, and resolving expected shortages of physicians in medically underserved areas. The classes of Americans disproportionately burdened by health disparities are the same groups who remain underrepresented as physicians. Persistent inequalities in health care disproportionally impact low-income households and racial and ethnic minority communities when compared with the general population in the same geographic area.[1]

Diversifying the healthcare provider workforce is a central issue in resolving inequalities in patient access to culturally appropriate care. Research findings reinforce the importance of physicians' background as it relates to healthcare and outcomes. Social-concordance in the physician-patient dyad leads to prolonged appointments, improved patient satisfaction, and positive patient affect.[2–5] Black and Hispanic patients indicated that the physician's race or ethnicity and the physician's willingness to speak the language of the patient influenced their selection of a doctor.[4] Female physicians and physicians of racial or ethnic minorities were more likely to serve minority and low-income communities.[6–9] Medical students from racial or ethnic minorities and those from disadvantaged backgrounds were more likely to apply to a program designed to prepare physicians to provide care to underserved communities.[10] Increased diversity of the physician workforce benefits patients and produces physicians more likely to practice in underserved communities.

There are also direct benefits to the medical school learning environment. Increasing the diversity of medical students influences and prepares other medical students to provide culturally suitable care. Diverse cohorts of students enrich the learning environment by connecting learners to new perspectives,[11–14] and medical students indicate they value campus diversity and the associated opportunities for them to improve their cultural competence.[15,16] Expanded experiences and improved cultural skills create new physicians who are more likely to work in a medically underserved region, feel increased readiness to care for patients from other racial and ethnic backgrounds, and who become advocates for greater access to care.[4]

Recognizing these benefits, medical schools strive to achieve greater diversity amongst medical students. Considering that most students will successfully graduate from medical school, admissions committees have direct power to change the composition of the physician workforce by whom they choose to admit to medical school.[17,18] While positive strides have been made in increasing the number of female [19] and underrepresented in medical school (URM) [20] applicants entering into medical school, room for improvement remains. There is a long-standing stagnation of economic and class diversity amongst medical students. For three decades, seventy-five percent of medical students have fallen into the top two quintiles of household income. [21] Medical students also have accomplished parents: approximately half of fathers and one-third of mothers of medical students possess graduate degrees, as compared with 12% and 10%, respectively, of the U.S. population.[21] There is a clear need to include medical students of varied economic backgrounds in diversity efforts by increasing the number of medical

students from low-income families, underserved areas, and challenging life circumstances.

Premedical applicants are considered ready for medical school if they possess strong academic backgrounds, have spent time shadowing physicians, performed scientific research, and found time to volunteer for worthy causes. [22] Applicants lacking resources for additional academic preparation, connections to the clinical healthcare system, financial safety nets, and enough free time to volunteer are already at a disadvantage in the admissions process.[11]

Socioeconomic status (SES) represents a construct related to the accessibility of social and economic resources.[23] SES is thought to be transmitted intergenerationally, although low-SES individuals can mitigate this relationship by attaining higher education levels, thus increasing their social mobility.[24–26] However, there is evidence of racial gaps in upward mobility. Research has shown that upward mobility is less possible for blacks as compared with whites, and that early life experiences may be influential in determining educational attainment and thus mobility in black families.[27]

Because SES positively correlates with academic achievements such as university admission and higher scores on standardized tests, admissions that rely upon standardized test achievement create a barrier for those at the lower end of the SES spectrum to access higher education.[26] Applicants with more barriers in their backgrounds incur additional challenges within the educational system in the United States. Students from lower SES backgrounds face additional barriers in postsecondary education, such as an increased risk for interruptions obtaining undergraduate degrees, having to maintain employment

throughout college or employment gaps between high school and college.[28,29] Because lingering economic disparities in medical education may be tied to inequalities in access to higher education; completing a four-year degree from an accredited institution is the minimum requirement to be considered for admission to U.S. medical schools.[30]

In 2019, the average four-year cost of attendance for public medical schools was $250,222, and the cost of attending private medical schools was $330,180.[31] In an annual survey of Class of 2018 medical school graduates, 75% of graduates held education debt from medical school and/or their premedical education. The median amount of debt for indebted students was $200,000; 32% of graduates reported carrying debt from their premedical education (median amount $25,000), and 14% of graduates had credit card debt (median $5,000).[31] Applying to medical school and traveling for interviews is expensive. Fixed costs to apply are estimated at upwards of $500, not including preparation materials, courses, or repeating the Medical College Admissions Test (MCAT) in pursuit of a higher score.[32] On top of these fixed costs, applying to more schools increases costs. Additional expenses such as school-specific secondary applications and costs of interview preparation and travel can approach $700 for each school.[32]

Applicants with increased access to resources are advantaged in that they may apply broadly to more medical schools, consider geographically distant schools, afford expensive preparatory materials and services, and attend interviews for distant schools.[32] Furthermore, they are more insulated from the financial risk of applying for medical school, since there is no guarantee of success in such a competitive process.[32]

Advantage Status and Medical Admissions

SES disparities have not gone unnoticed by the academic medicine community. A Fee Assistance Program seeks to mitigate some of the expense of taking the MCAT and applying to medical schools.[33] The American Association of Medical Colleges (AAMC) created a two-factor parental education/occupation measure (EO) in the American Medical College Application System (AMCAS) application to assist medical schools in understanding the background of their applicants.[34]

In addition to these measures intended to even the playing field for low-SES applicants, the medical education research community has begun to study this aspect of diversity in earnest. Grbic and colleagues[35] found that the five-level EO measure correlated with indicators representing socioeconomic disadvantage and that EO status was lower in African American and Hispanic applicants, older applicants, and those who reported paid employment experience. However, they also found that 36% of those with lower EO classifications had no other indicators of SES disadvantaged status, while 9% of applicants assigned to higher EO classifications had other indicators of disadvantage.[35] These findings led the authors to recommend that admissions committees consider multiple indicators of SES and disadvantage as part of holistic review in order to avoid misclassification of applicants.

Other singular measures of SES and disadvantage were found similarly helpful but limited. Lowrance and Birnbaum[36] found that applicants' interpretation of advantage status and willingness to disclose on a self-report indicator varied. Some applicants shied away from identifying themselves as having experienced hardship due to reluctance to

provide details they considered personal. Interpretations of advantage status were highly contextual; those with peers in higher SES strata considered themselves disadvantaged even if they had not experienced hardship, while those with peers with a great deal of hardship did not feel that could also be disadvantaged.[36]

The University of California, Davis, School of Medicine has attempted to quantify SES inequality in its applicants by creating a continuous scale from items representing hardship from the AMCAS application.[37] The scale includes measures including the education level of parents, family income in the childhood home, family usage of public assistance programs, applicant contribution to family income, childhood residence located in a medically underserved community, receipt of need-based scholarship funding, and qualification for the AAMC's fee waiver program.

Fenton and colleagues[11] explored a method to increase diversity within one medical school by developing a socioeconomic disadvantage scale using indicators on AMCAS to adjust applicant academic metrics. They first performed factor analysis on SES measures from applicant AMCAS data and ran regression models incorporating this SES adjustment in their admissions process. The simulation seemed to reduce socioeconomic and URM disparities while maintaining academic readiness.[11]

Incorporating Intersectional Theory in Medical Admissions Research

Individuals are complex and studying applicant characteristics and histories as if such factors occur in a vacuum cannot accurately portray the interplay of advantages and marginalizations individuals experience based upon their background and identities. Kimberlé Crenshaw[38,39] coined the term "intersectionality" as a way to describe the

idiosyncrasies of injustice that women of color encountered in the legal system. Intersectionality specifies that pieces of an individual's identity or background are interdependent, continually interacting and informing one another. Aspects of privilege and oppression might be experienced as additive, exponential, synergistic, or subjective and relative.[40,41] Further, sole focus upon subordinate groups in intersectional research risks overlooking clusters of power and privilege and would not allow for simultaneous advantages and disadvantages to co-occur within individuals.[42]

Modeling Socioeconomic Typologies

Empirical quantitative approaches to exploratory research situated in intersectionality can highlight the intersections of privilege and oppression.[43] Quantitative methods can be used to understand the advantage status of medical school applicants and how their backgrounds and identities may contribute to outcomes in the admissions process.

Medical schools receive thousands of applications each year, and individual advantage status measures on the AMCAS are at risk of condensing (and perhaps misrepresenting) an applicant's complex social and economic background. This study explores employing person-centered quantitative methods driven by intersectionality theory to describe and understand the complexity of privileges and barriers of applicants to U.S. medical schools and if certain combinations of these factors may lead to different experiences and outcomes in the accessibility of medical education. A more thorough understanding of how aspects of applicant privilege and adversity measures relate to outcomes in the medical education admissions process may identify potential barriers and

contribute needed information in order to improve the admissions process and eliminate barriers that limit accessibility for low-SES applicants.[44]

This research employs an intersectional framework to understand medical school applicant advantage status typologies. It uses the methodological approach of latent class analysis (LCA), which can be used to unknown latent classes of individuals within the dataset based upon response patterns. The process of class enumeration in LCA produces two parameters: latent class prevalences (the probability of membership in each latent class) as well as item-response probabilities (the probability of each response to the observed variables).[45] LCA is an analytical technique that aligns with the complexity of an intersectionality framework in that it is a person-centered analysis and will allow for an understanding of how the advantage status variables relate to one another, in addition to examining associations between the latent variable and covariates. LCA is an example of an intercategorical quantitative approach to the complexity of intersectionality in that it strategically applies analytical categories to assess inequalities amongst multiple dimensions.[42] Aspects of 2018-2019 medical school applicant identities, backgrounds, and experiences will co-exist with one another in the process of identifying underlying advantage status typologies. This study will highlight intersections of advantage status, examine subordinate groups as well as clustering of power and privilege while allowing for the possibility that certain groups may include individuals with a mixture of simultaneous privilege and marginalization.[42,43]

This project aims to contribute to the medical education community's understanding of potential barriers to achieving a diverse physician workforce by first

describing the underlying response patterns to items representing potential barriers or facilitators by a national cohort of medical applicants. Specifically, this research study explores the 2018-2019 applicant pool to U.S. medical schools in order to assess emerging latent classes representative of advantage status typologies.

Method

Study design and population

This exploratory research study used self-report data from AAMC AMCAS applications from all applicants to 146 U.S. medical schools in the 2018-2019 application cycle. The AAMC supplied a de-identified dataset with measures of applicant identity, backgrounds, academic success, as well as measures demonstrating how individuals fared in the medical school admissions process. This study focuses on measures of advantage status.

Individuals listed as non-U.S. Citizens and non-Permanent Residents (n=1,948, 3.8% of the dataset) were removed from the file since they did not receive the full set of questions used in this analysis. Additionally, 1,858 applicants supplied no data for any advantage status indicators and were eliminated from the LCA model. The final file used for analysis contained self-report data from AMCAS applications for 47,958 applicants.

The University of Vermont Institutional Review Board categorized this study as not falling under the definition of human subjects research.

Analysis

The dataset was cleaned and recoded. Prior to beginning analysis, patterns of missing data were evaluated in IBM SPSS v. 25. Missing data were classified as Missing

at Random (MAR) based upon Missing Values Analysis conducted on two versions of the dataset: one with missingness indicative of an absence of information, and one that also included the responses of "unknown," "don't know," or "N/A" to advantage status measures also coded to missing. Unknown responses indicate that there is an unobserved inaccessible true value, while not applicable responses indicate that the question had no meaning to the respondent.[46] Conversely, a response of "decline to answer" indicates that a true value exists and is accessible, but the applicant is choosing to withhold the information from anyone reviewing their application. These responses were kept the analysis. Table 2 provides details as to the response frequencies in the dataset before and after recoding these values to missing.

Because non-U.S. Citizens and non-permanent residents were excluded from the dataset, simple comparisons were run to compare MCAT scores, GPAs, applicant sex, and English as a second language. Effect sizes for these comparisons were calculated. For Independent samples t-tests, Hedges' *g* measures effect size is weighted to the size of each sample.[47] For chi-square tests of two nominal variables, phi is presented as a measure effect size; for chi-square analyses of nominal variables with more than two levels, Cramer's *V* is the appropriate estimate of effect size.[47]

Descriptive statistics were run in SPSS version 25 before exporting the dataset into Mplus version 8 in order to conduct an exploratory latent class analysis (LCA) on the binary, nominal, and ordinal advantage status measures. LCA is a reductive technique similar to psychometric tests such as exploratory factor analysis, except instead of understanding the underlying properties of an instrument, we assess a latent construct

driving homogenous response patterns on observed variables amongst the sample of applicants.

The goal of the latent class analysis is to find the most parsimonious model. Parsimony is achieved by a model with the smallest number of latent classes that will adequately describe the associations between the indicators. Subsequent models were built and estimated with 1 through 7 latent classes to identify the optimal model to fit the variables. The fit of these iterative models was explored using the Bayesian information criterion (BIC), a statistic that weighs model fit and model parsimony, and the Lo-Mendell-Rubin Adjusted Likelihood Ratio Test, which tests the *k* model against the *k*+1 model.

The parameters of the LCA model are estimated by maximum likelihood (ML) using the expectation-maximization (EM) procedure. An advantage of using ML estimation is that it does not exclude cases from the analysis unless they have no responses on all observed variables and is, therefore, able to perform the analysis with an assumption that any missingness is missing at random (MAR).[45] Because we are employing ML techniques with EM procedures, it is not necessary to impute missing values.

Measures

Variables representing aspects of applicant advantage status in the AMCAS application were used to form advantage status typologies based upon applicant response patterns arising from an underlying latent construct. Measures were selected from AMCAS as indicative of applicant advantage status if they were related to socioeconomic

status, represented potential obstacles in navigating the educational system as a whole, corresponded to more or less difficulty preparing for medical school, and/or introduced barriers or facilitators to full participation in the medical school application and interview process.

Table 2 lists the answer sets for the ten measures, and the codes used in this analysis are presented in brackets below.

Postsecondary education funding. This measure asks applicants to respond to the prompt "How have you paid or did you pay for your postsecondary application?" by filling in percentages for the following sources: academic scholarship, financial need-based scholarships, student loan, other loan, family contribution, applicant contribution, or other. This study will focus on applicant responses to two categories: financial need-based funding and family contribution. Replicating Grbic et al.'s[35] coding scheme, the first level will represent the highest-need, lowest family contribution by designating this category as those applicants with 25% or more need-based scholarship and less than 25% family contribution. The measure in this study adds to this with three other categories:

- The first [1] level is comprised of applicants with at least 25% need-based scholarship and less than 25% family contribution
- The second [2] level contains applicants with less than 25% need-based scholarship and less than 25% family contribution
- The third level [3] includes applicants with at least 25% need-based scholarship funding and at least 25% family contribution, and

- The highest level [4] contains applicants with at least 25% family contribution and less than 25% need-based scholarship

Fee-assistance program. Applicants may request a fee waiver from the AAMC based upon the U.S. Department of Health and Human Services poverty level guidelines. The fee waiver program reduces the cost to register for the MCAT exam and reduces AMCAS application fees.[33] Consideration for the fee waiver program requires submission of household tax returns to AMCAS and subsequent verification of income levels. In this dataset, the fee waiver indicator will be positive [1] if the applicant applied for a fee waiver for the AMCAS application process and was verified as eligible. The second category is those that did not apply or did not receive the fee waiver [0]. This measure is the only variable that is verified and is not purely self-report.

Self-report disadvantaged status. Guidance from the AAMC says that an applicant might consider themselves as disadvantaged if they "grew up in an area that was medically underserved or had insufficient access to social, economic, and educational opportunities."[48] The question asks, "Do you wish to be considered a disadvantaged applicant by any of your designated medical schools that may consider such factors (social, economic, or educational)?" Applicants are able to designate themselves as having disadvantaged backgrounds [1] or not [0].

Family use of federal or state assistance programs. Applicants answered the question, "Have members of your immediate family ever used federal or state assistance programs?" Applicants answer "yes" [1], "no" [0], or decline to respond [2].

Annual income in childhood home. This construct is measured via the question, "What was the income level of your family during the majority of your time from birth to 18?" The answer set consists of fourteen income categories with $75,000 or over as the highest level. The dataset released by AAMC condenses the 14 categories into three income category ranges (less than $50,000 [3], $50-74,999 [2], $75,000 or more [0]) as well as decline to respond [4].

Contribution to overall family income. Applicants were asked, "Were you required to contribute to the overall family income (as opposed to working primarily for your own discretionary spending)? Applicants could select yes [1], no [0], or decline to respond [2].

Paid employment before age 18. Applicants were asked to report whether they held paid employment prior to age 18. Applicants could select yes [1], no [0], or decline to respond [2].

Pell grant recipient. This measure represents applicants who have received funding the federal government provides to students who have demonstrated financial need, among other factors. Applicants select that they had received a Pell grant [1] or that they had not [0].

Medically underserved area. Applicants can designate if they believe that the area where they grew up was medically under-served. Applicants could select yes [1], no [0], or decline to respond [2].

Parent education/occupation measure. The AAMC created a socioeconomic indicator based upon a combination of applicants' parental education and occupation.

Applicants are classified into five groups (EO1-EO5) based upon four categories of parental education and two categories of occupation.[34] EO1 represents applicants whose parent has less than a bachelor's degree, EO2 indicates applicants whose parent has at least a bachelor's degree and is in a "service, clerical, skilled and unskilled" occupation. EO3- EO5 levels contain applicants whose parent has an "executive, managerial, or professional" position and a bachelor's degree (EO3), master's degree (EO4), or a doctorate or professional degree (EO5). The AAMC released three levels of this variable: EO1 [1], EO2 [2], and EO3-EO5 [3].

Results

Sample characteristics

As compared with non-U.S. citizens and non-permanent residents, U.S. citizens and permanent residents had lower MCAT scores, GPAs and were more likely to be native or functionally native English speakers. Table 1 describes these results, with effect sizes showing that the differences are small despite significant *p*-values.

The sample used for the LCA consisted of 47,958 medical school applicants. Applicants who had no data in any of the advantage status variables (n=1,858) were excluded from the analysis. A Missing Values Analysis produced no significant differences between patterns of missingness in the raw dataset and a dataset with the responses of "unknown," "don't know," and "N/A" recoded to missing. Table 2 provides details as to the variable frequencies in the dataset before and after recoding for LCA.

When examining individual advantage status responses in Table 2, the majority of medical school applicants in 2018-2019 had substantial family contributions to their post-

secondary education costs, did not apply the AAMC Fee-Assistance Program to their AMCAS application, did not consider themselves disadvantaged, and did not receive Pell Grants, and held employment prior to the age of 18. However, most applicants did not need to use this income to contribute to their family's income. Further, the majority of applicants grew up in families that did not need to rely upon federal or state assistance programs, had annual incomes of $75,000 or more, had highly educated parents with non-service careers, and did not grow up in medically underserved areas.

Class Enumeration

Table 3 contains goodness-of-fit indicators produced in the process of building class structures based upon applicant response patterns. A good model would have a higher log-likelihood, lower Bayesian Information Criterion, and high entropy. Adding in k+1 classes did not produce a clear stopping point. In this case, researchers might examine the plots of the log-likelihood and BIC for k+1 classes and inspect for a point of diminishing returns, similar to the examination of a scree plot in factor analysis.[49]

Figure 1 displays these plots. The slope of both line graphs appears to diminish with the 5-class model. The 5-class model had high entropy, meaning it possessed functional differentiation between classes, and the item-response probabilities were easily interpreted. Thus, the 5-class model was chosen as the best fit for the latent constructs in the advantage status measures dataset.

The Five Typologies

Once the class structure was chosen, the item response probabilities for each of the five typologies were examined to understand the qualities of typology members.

Table 4 contains the item-response probabilities for each of the ten advantage status variables used in the LCA.

The data pointed toward the five-class solution, with two typologies containing applicants with significant privileges in their backgrounds, two typologies of applicants with significant disadvantages in their backgrounds, and one typology with a mix of advantages and disadvantages. Figure 2 displays the prevalence of the typologies within the applicant pool. The Advantaged and Advantaged and Private typologies contained the majority of medical school applicants (57%) in 2018-2019.

The two advantaged typologies were differentiated by a willingness to answer questions if a "Decline to respond" option was offered. Members of the Advantaged class were forthcoming with answering the questions, while the Advantaged and Private class answered if needed, but declined to share additional details of their backgrounds when provided with the ability to opt-out of a question related to their socioeconomic status or background.

The two disadvantaged classes were solely differentiated by whether they needed to contribute to family income before the age of 18. One group of applicants were employed before the age of 18 years old, and also had to contribute to their family's income. The other group did not hold jobs before the age of 18 and universally did not contribute to family income. As such, the two classes were assigned as Disadvantaged and Disadvantaged Caretakers.

Members of the Mixed typology were likely to endorse responses indicating a lack of belonging to either the advantaged or disadvantaged typologies. Members of this

group may have funded their post-secondary education through self-funding, student loans, and/or academic scholarships. Applicants in this group are likely to report a mid-range annual income in their childhood home, had parents with higher levels of education and occupation, and generally do not identify as disadvantaged. Though they held paid employment prior to 18 years of age, they did not need to contribute to their family's income. They were not likely to have received Pell Grants or come from a medically underserved area.

Discussion

This research project employed a person-centered analytical approach that allowed examination of all applicants to U.S. Medical schools in the 2018-2019 applicant cycle. Data from the AAMC's AMCAS application system were used to understand further the complex issue of socioeconomic diversity amongst medical school applicants and students. The robust dataset allows for a high degree of generalizability, and the nuanced analysis is the first of its kind to examine the persistent issue of socioeconomic disparities in the accessibility of medical education. It explores the complicated construct if SES using an analytical method that analyzes response patterns in a dataset to uncover underlying constructs within the responses themselves.

The most striking finding in this study is that the majority of medical school applicants fall into the most advantaged categories of the ten advantage status measures on the AMCAS. While it is known that medical students tend to be from affluent backgrounds[21], this study describes the high level of privilege of the majority of the medical applicant pool. This finding suggests that long-standing systematic biases and

marginalizations experienced by lower SES throughout the education system[28] may form a bottleneck prior to the stage of applying to medical schools. Applicants with fewer barriers are thus highly overrepresented in the pool of applicants.

Medical admissions officers are feasibly limited in increasing the socioeconomic diversity of medical students if highly advantaged applicants outweigh the numbers of applicants with mixed or disadvantaged backgrounds. Further, advantaged applicants have likely benefitted from systemic privileges within the education system itself, may have been able to afford expensive preparatory materials for the MCAT, and may have had access to shadowing or volunteer positions in healthcare that allows them to network and gain valuable experience.[50] Additionally, if these applicants with advantaged backgrounds have family members who are employed within the healthcare system, or who have familiarity with preparation for medical school and the application process itself, they will have a significant leg up as compared to less advantaged applicants.[50]

Many disadvantaged individuals who want to become doctors will never make it to the medical school application stage. Just over 20,000 applicants from the 2018-2019 admissions cycle successfully matriculated into medical school.[51] There are more than enough seats for applicants classified into their most-likely typology of Mixed, Disadvantaged Caretakers, or Disadvantaged. Not all significantly advantaged applicants will matriculate into medical school, simply because there are fewer seats than there are advantaged applicants.

The differentiation between the two advantaged typologies and disadvantaged typologies is compelling. The Advantaged and Private group may not have answered

optional questions out of a desire for privacy, shame, or an attempt to game the system, knowing that admissions officers seek a diverse pool of medical students. It is not known why they chose this response pattern as compared with members of the most significant typology (Advantaged), who were forthcoming about the privileges in their backgrounds. This typology had less than 650 most-likely members, but it was repeatedly distinguished as a separate class when examining item-response probabilities during the process of LCA class enumeration.

The two disadvantaged typologies representing subordinate groups differed based upon the likelihood of whether the applicant was burdened with a need to contribute to their family's income. Such a duty would leave the caretaking applicants with less time to devote to volunteering and may also limit academic achievement.[52,53] Additionally, if there is still a need to contribute to family income at the time of applying to medical school, the caretaking applicants may be limited geographically to the medical schools to which they can attend. They may send money back home, but they may also feel a need to stay geographically close to the family that they support. The majority of those in the Disadvantaged typology were likely to label themselves as having had disadvantaged background, while just over half of the Disadvantaged Caretakers were likely to consider themselves to be disadvantaged. Members of the Disadvantaged typology were also more likely to indicate having come from a medically underserved area as compared with the Disadvantaged Caretakers. It is unknown if there is a significant difference in how members of the Disadvantaged typology make meaning of their backgrounds and experiences as compared with the Disadvantaged Caretakers. Lowrance and Birnbaum[36]

found that applicants' choice to indicate whether or not they were disadvantaged was highly contextual. Social comparisons to peer groups were more important than a background containing hardship in whether applicants considered themselves disadvantaged. In this study, it is possible that the Disadvantaged Caretakers group were less likely to see themselves as significantly burdened in life if they were surrounded by peers living in similar circumstances. Simply experiencing hardship during childhood may have proved insufficient for most participants to deem themselves disadvantaged. Participants' decision processes were confounded by the need to rely on social comparisons to determine whether they were disadvantaged and impression management to decide whether to apply as such.

The Mixed typology contains individuals with a mixture of simultaneous privilege and marginalization, reminiscent of an intersectional approach allowing for power and oppression to comingle within individuals.[42,43] Members of this group may have funded their post-secondary education through self-funding, student loans, and/or academic scholarships. Applicants in this group are likely to report a mid-range annual income in their childhood home, had parents with higher levels of education and occupation, and generally do not identify as disadvantaged. Though they held paid employment prior to 18 years of age, they did not need to contribute to their family's income. They were not likely to have received Pell Grants or come from a medically underserved area.

The analytical technique used in this research study is consistent with intersectionality framework in that it is a person-centered analysis and allowed advantage status variables to relate to one another.[54] The intersections of variables representing

backgrounds and experiences can bestow advantage for applicants accessing medical education or introduce significant barriers to access as a result of multiple marginalizations.[55]

Though this research study significantly advances discourse on socioeconomic diversity in medical applicants, systematic biases within the education system as a whole undoubtedly restricted the pool of applicants. This pool is limited in scope to individuals who have graduated from high school and obtained bachelor's degrees. Research shows that achieving these outcomes is more accessible for some groups than others, which represents an injustice since higher education levels are known to be a method for families to break out of the cycle of poverty.[24–26]

Another limitation is that this analysis is limited to the questions asked of applicants on the AMCAS and the answer options corresponding to those questions. Additionally, we are restricted by the measures released by AAMC, and the condensing of answer sets by the AAMC prior to releasing the data.

The process of class enumeration in this dataset was more complex than expected, with no clear point of diminishing returns. It was necessary to examine the plots of log-likelihood and BIC values to examine a point where the slope leveled out for both measures.[49] Additionally, the choice of the 5-class model was informed by theory and interpretability.[45,49] These choices may have added subjectivity to the process. However, it does appear that the 5-class model is the most parsimonious fit for a complex dataset.

This research study lays the groundwork for more in-depth analyses of the typologies. Demographic associations with the latent class structure should be examined

in order to sharpen fidelity to an intersectional approach to understanding medical school applicants. It will be interesting to know the proportions of applicant sex, race/ethnicity, first-generation status, and native language within the context of the five advantage status typologies. Furthermore, assessing outcomes within the medical school admissions process will enhance the academic medicine community's understanding of how typology membership may be associated with additional barriers or privileges in the accessibility of medical education.

A similar person-centered analytic approach could also be used by medical education researchers to assess academic outcomes, board scores, attrition, and residency match rates across the spectrum of undergraduate and graduate medical education.

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Table 1. Comparisons of U.S. Citizens or Permanent Residents and non-U.S. Citizens or Permanent Residents Medical School Applicants during the 2018-2019 Admissions Cycle

	U.S. Citizens and permanent residents	Non-U.S. Citizens and permanent residents	*p*-value	Effect Size
Sex	*n (%)*	*n (%)*	*Chi-square*	*Cramer's V*
Female	25,395 (51.0)	1,023 (52.5)	.341	.006 (.341)
Male	24,407 (49.0)	924 (47.4)		
Unknown or Declined to respond	14 (0.0)	1 (0.1)		
English as Second Language	*n (%)*	*n (%)*	*Chi-square*	*Phi*
Native or functionally native English speaker	45,552 (95.0)	1,929 (84.0)	.000	-.093 (.000)
Less than native or functionally native English speaker	2,406 (5.0)	310 (16.0)		
Academic Metrics	*M (SD)*	*M (SD)*	*Ind. Samples t-test*	*Hedges' g*
MCAT 2015 Score	505.54 (9.28)	506.86 (9.58)	.000	0.147
Total GPA	3.71 (0.28)	3.73 (0.29)	.036	0.051
Science GPA	3.46 (0.43)	3.54 (0.46)	.000	0.180

Table 2. Description of Advantage Status Measures of U.S. Medical School Applicants during the 2018-2019 Admissions Cycle

Advantage Status Variables		All Applicants (n=52,777) n (%)	Applicants included LCA* (n=47,958) n (%)**
Post-secondary education funding	High need-based funding, low family contribution	7,798 (14.8)	7,566 (17.1)
	Low need-based funding, low family contribution	15,029 (28.5)	14,283 (32.3)
	High need-based funding, high family contribution	1,720 (3.3)	1,669 (3.8)
	Low need-based funding, high family contribution	22,222 (42.1)	20,767 (46.9)
	Missing	6,008 (11.4)	
Fee-assistance program (FAP)	Applied FAP to AMCAS application	4,548 (8.6)	4,420 (9.2)
	No FAP (or did not apply FAP)	46,273 (87.7)	43,538 (90.8)
	Missing	1,956 (3.7)	
Disadvantaged (self-report)	Disadvantaged	8,291 (15.7)	7,850 (16.4)
	Not disadvantaged	42,530 (80.6)	40,108 (83.6)
	Missing	1,956 (3.7)	
Family used state/federal assistance programs	Yes	12,458 (23.6)	12,004 (27.4)
	No	33,166 (62.8)	31,244 (71.3)
	Decline to respond	732 (1.4)	590 (1.2)
	Unknown	4,465 (8.5)	
	Missing	1,956 (3.7)	
Annual income in childhood home	Less than $50,000	10,572 (20.0)	9,876 (23.2)
	$50,000 -74,999	6,939 (13.1)	6,610 (15.5)
	$75,000 or more	25,170 (47.7)	24,088 (56.6)
	Decline to answer	2,247 (4.3)	1,988 (4.7)
	Don’t know	5,893 (11.2)	
	Missing	1,956 (3.7)	
Contributed to family income when under 18 years old	Yes	4,529 (8.9)	4,245 (8.9)
	No	45,288 (85.8)	42,876 (89.4)
	Decline to answer	1,004 (1.9)	837 (1.7)
	Missing	1,956 (3.7)	0 (0.0)
Employed before 18 years old	Yes	29,755 (56.4)	28,305 (59.0)
	No	20,593 (39.0)	19,270 (40.2)
	Declined to respond	473 (0.9)	383 (0.8)
	Missing	1,956 (3.7)	
Pell Grant recipient	Yes	14,350 (27.6)	14,350 (30.7)
	No	34,890 (66.1)	32,388 (69.3)
	Missing	3,311 (6.3)	
Childhood area medically underserved	Yes	11,004 (20.8)	10,318 (23.1)
	No	35,749 (67.7)	33,905 (75.8)
	Declined to respond	617 (1.2)	495 (1.0)
	Unknown	3,451 (6.5)	
	Missing	1,956 (3.7)	

Table 2. Description of Advantage Status Measures of U.S. Medical School Applicants During the 2018-2019 Admissions Cycle (continued)

AAMC Parental Education/ Occupation Measure	EO1	8,720 (16.5)	8,601 (19.7)
	EO2	4,119 (7.8)	4,047 (9.3)
	EO3,4, or 5	31,617 (59.9)	30,971 (71.0)
	N/A	3,234 (6.1)	
	Unknown	3,127 (5.9)	
	Missing	1,960 (3.7)	

* Applicants included in Latent Class Analysis (LCA) after data cleaning and recoding: removal of non-U.S. Citizens/non-Permanent Residents, removal of applicants with no information on any advantage status variables, and recoding "unknown", "don't know", and "N/A" responses to missing. 1,956 individuals who consistently had no answers to any advantage status variables not included in LCA.
** Percentages do not include missing.

Table 3.
Goodness of Fit for Latent Class Analysis Models of 10 Advantage Status Indicators for Applicants to U.S. Medical Schools in 2018-2019 (n=47,958)

No. Classes	Npar	LL	BIC	E_k	LMR LRT (*p*-value)
1	19	-304,655.7	609,516.1		
2	39	-257,588.4	515,597.1	.897	93699.9 (.333)
3	59	-252,781.3	506,198.5	.799	9569.8 (<.001)
4	79	-250,216.1	501,283.6	.808	5106.7 (<.001)
5	99	-247,646.2	496,359.3	.830	5116.1 (<.001)
6	119	-246,421.7	494,126.0	.816	2437.6 (<.001)
7	139	-245,700.2	492,898.5	.814	2227.4 (<.001)

Npar = number of parameters in model
LL = final log-likelihood
BIC(LL) = Bayesian Information Criterion (based on log-likelihood)
E_k = Entropy
LMR LRT = Lo-Mendell-Rubin Adjusted Likelihood Ratio Test

Figure 1.
Log-likelihood and Bayesian Information Criteria (BIC) Plots Informing Latent Class Model Selection for Applicants to U.S. Medical Schools in 2018-2019 (n=47,958)

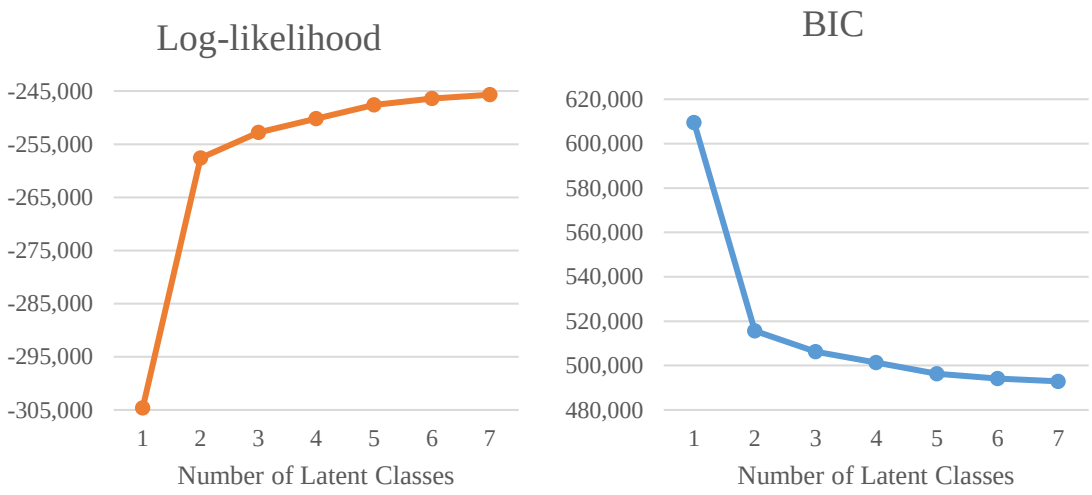
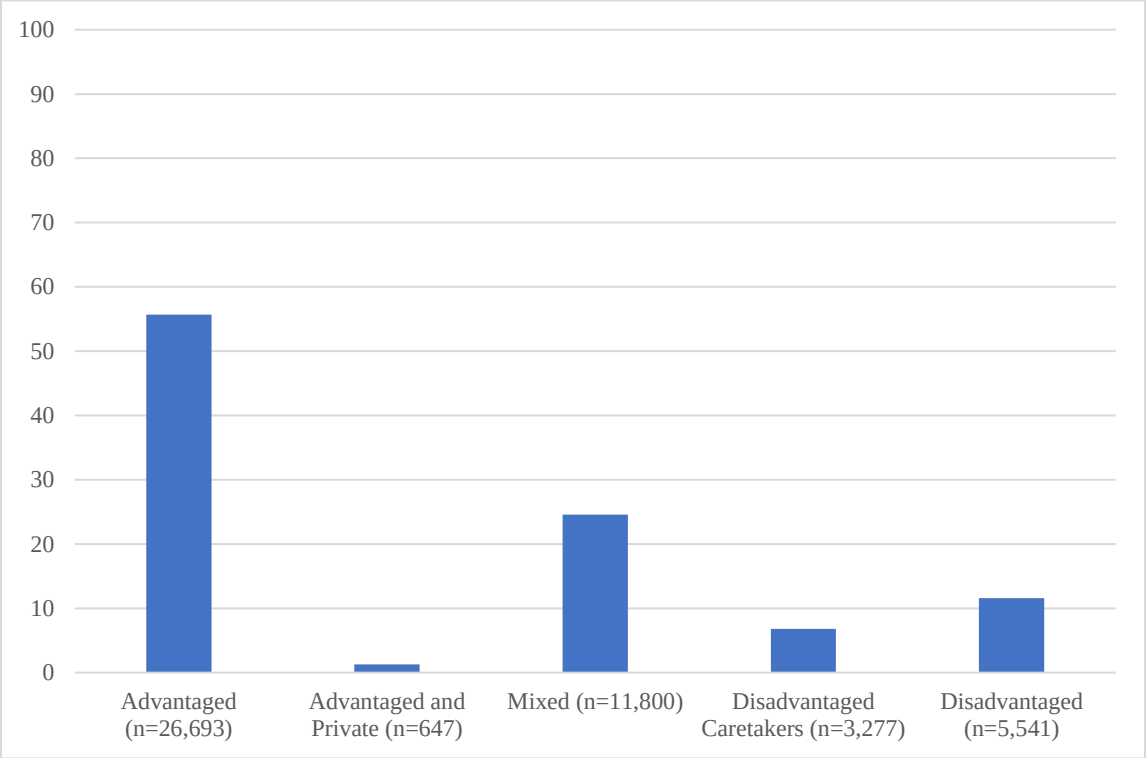


Figure 2.
Prevalence of Advantage Status Typologies for Applicants to U.S. Medical Schools in 2018-2019 (n=47,958)



Prevalence based upon most-likely class assignment

Table 4. Description of Item Response Probabilities from 5 Advantage Status Typologies of Applicants to U.S. Medical Schools in 2018-2019 (n=47,958)

	Label	Advantaged	Advantaged and Private	Mixed	Disadvantaged Caretakers	Disadvantaged
Postsecondary Education Funding	High Need Low Family Cont.	.010	.037	.182	**.573**	**.646**
	Low Need Low Family Cont.	.225	.333	**.518**	.385	.289
	High Need High Family Cont.	.025	.036	.069	.011	.043
	Low Need High Family Cont.	**.740**	**.593**	.231	.031	.023
Fee-Assistance Program	Did not apply FAP to application	**1.000**	**.986**	**.966**	**.592**	**.533**
	Applied FAP to application	.000	.014	.034	.408	.467
Self-Report Disadvantaged	No	**.992**	**.956**	**.858**	.222	.438
	Yes	.008	.044	.142	**.778**	**.562**
Family used State/Federal Assistance Programs	No	**.930**	.259	**.642**	.129	.273
	Yes	.067	.102	.354	**.864**	**.718**
	Dec. to respond	.004	**.639**	.004	.006	.009
Annual Income in Childhood Home	<$50,000/year	.005	.022	.207	**.890**	**.874**
	$50-$74,999/year	.045	.084	**.419**	.091	.112
	≥$75,000/year	**.884**	.241	.366	.015	.010
	Dec. to respond	.064	**.653**	.009	.004	.004
Contributed to Family Income	No	**.988**	.382	**.910**	.121	**1.000**
	Yes	.009	.039	.079	**.821**	.000
	Dec. to respond	.003	**.579**	.011	.058	.000
Employed before 18 years old	No	.419	.150	.367	.000	**.708**
	Yes	**.579**	**.519**	**.631**	**.982**	.290
	Dec. to respond	.002	.331	.002	.018	.002
Pell Grant Recipient	No	**.983**	**.847**	**.543**	.082	.028
	Yes	.017	.153	.457	**.918**	**.972**
Childhood Area Medically Underserved	No	**.901**	.384	**.707**	.333	.487
	Yes	.097	.151	.289	**.657**	**.503**
	Dec. to respond	.003	**.465**	.004	.010	.010
Education Occupation Measure	EO1	.051	.099	.286	**.630**	**.566**
	EO2	.040	.053	.155	.157	.206
	EO3,4 or 5	**.909**	**.847**	**.559**	.213	.228

CHAPTER 5

Exploring the Demographic Compositions of U.S. Medical School Applicant Advantage Status Typologies

Abstract

Purpose

The purpose of this study is to explore the demographic characteristics of medical school applicants through an intersectional lens and their relationship with five advantage status typologies.

Method

Self-report application items from a cohort of 2018-2019 applicants to U.S. medical schools were used to construct a 5-class advantage status typology. Applicants were classified into their most-likely typology based upon response patterns. The most-likely typology membership was used to explore relationships between typology and demographic characteristics, individually and accounting for intersecting identities representing opportunities for privilege and marginalizations.

Results

First-generation and English language minority students had higher odds of being classified into disadvantaged typologies. Female applicants and those underrepresented in medicine (URM) had higher odds of most-likely membership in disadvantaged classes, while male applicants and applicants identifying as white only or Asian only were more likely to have had privileged backgrounds. Intersecting identities of URM, first-generation, and language minorities increased the odds of classification into mixed or disadvantaged typologies

Conclusions

This study describes the demographic characteristics of medical school applicants, with and without intersections, in relation to advantage status typologies. Demographic characteristics associated with additional barriers to achievement in post-secondary education were associated with less advantaged typologies.

Introduction

Increasing diversity within the U.S. medical workforce is a key strategy for resolving public health issues, caring for a diverse population of patients, and resolving expected physician shortages in underserved areas. American groups overburdened by health disparities are the same ones that are underrepresented in medicine (URM). Persistent health care inequalities have a disproportionate impact on low-income households and ethnic minorities over the general population in the same geographic area.[1]

Privilege and Disadvantage on the Path to Medical School

Besides the unchanging pattern of high family income medical students, parents have also received advanced degrees. For example, about half of medical student fathers have graduate degrees compared to 12% of people in the U.S. population. Moreover, about one-third of medical student mothers have a graduate degree compared to about 10% of U.S. women.[2]. Having at least one parent familiar with higher education will offer an advantage to those best qualified to navigate and access higher education. For medical students, if at least one parent is a physician, they may not only benefit from the familiarity of the parent with medical education as a whole but may have encountered different privileges. A candidate may be more likely to be admitted into a medical school where a parent is an alumnus, or they may have benefited from links to the healthcare system and had enough volunteer opportunities in healthcare to support their medical school applications.

Race, Ethnicity, and Sex

Historically, U.S. medical schools admitted relatively few URM applicants.[3] Additionally, in the late 1990s through 2010, URM enrollment declined in many schools following judicial and legislative guidance restricting the use of race and ethnicity consideration in admission decisions.[4,5] Women's access to medical education matched public pressure and society's desire for qualified and empathic physicians.[6] The first women and black men to medical school had to face hidden and visible protests from their White male classmates.[6] Progress has been sluggish, but in recent times seems to have successfully addressed the gender disparity in medicine. Women now constitute the majority of applicants, approved applicants, and students entering U.S. medical schools.[3]

This progress may be due to the increased use of a holistic approach to assessing applicants. Holistic review ensures requires that medical school admissions committees view applicants contextualized within the mission of the school. [7] A holistic approach to admissions prompts medical schools to consider academic metrics and successes in the light of applicants ' backgrounds, adversities, and resilience.[8] Research examining the composition of applicants chosen for an interview at a medical school before and after a mission-driven holistic analysis found that the number of female, URM, first-generation, and self-identified applicants in the interview pool increased.[9]

First-Generation

Students who are first in their families to attend a higher education institution are referred to as “first-generation” students.[10] First-generation college students are usually students of racial or ethnic minorities from socioeconomically disadvantaged families who tend to additional have difficulty in the context of higher education.[11]

Typically, first-generation college students are racial or ethnic minority students with disadvantaged backgrounds who may experience additional challenges navigating higher education norms and culture.[11] The National Center for Education Statistics (NCES) estimates that approximately 7% of college students enrolled in need-based financial assistance programs had parents who had not graduated from high school and that 26% had parents whose highest level of education was a high school diploma.[12]

Language Minorities

Medical school applicants who are not native English speakers may experience additional difficulty in the medical school application process. Applications to U.S. medical schools are largely self-report information, and non-English speakers may not interpret prompts in the same manner as a native English speaker, and they may report items in a manner that introduces measurement error.[13] Those with limited English language proficiency have been found to approach personal statements differently[14], have content in letters of recommendation situated within local academic cultures[15], and may struggle in admissions interviews.[16]

These demographic factors represent social constructs, and they may not represent medical school applicant experiences when examined in on their own. Certainly, it is important to understand how these traits relate to experiences and outcomes. However, it is also essential to employ methods that allow these traits to co-exist within medical school applicants, since the combinations of identity factors may result in different experiences than assessing the traits on their own.

Intersectionality

Kimberlé Crenshaw [17,18] coined the phrase "intersectionality" as a way to describe the problems that women of color faced when courts would not recognize the simultaneous discrimination of both race and gender. Crenshaw found feminist ideology and anti-racist action insufficient because both refused to consider the unique experiences of black women. Instead of contemplating piecemeal identities, Crenshaw urges recognition of "intersections of sexism and patriarchy."[18]

Intersectionality states that facets of an individual's personality are not distinct, continually communicating and educating each other. The theory acknowledges the impossibility of separating social categories including race, ethnicity, gender, and sexuality: the various identities we have should be regarded as transformative rather than additive.[19] Intersectionality acts as a mechanism for recognizing inequality and privilege and how power structures overlap and connect across social dimensions.[20] Although initially focusing on gender, ethnicity, and class, feminist intersectional theories reject the idea that social constructs such as class or socioeconomic status could be independent of race, sex, sexual preference, age, and physical ability[17,21].

While feminist theory has been employed in medical education and medical education research[22], there is a lack of research studies employing an intersectional framework to describe and understand the multiple dimensions of medical students and applicants in order to understand relationships of power.[23] Exploratory work on the interplay of social inequalities can provide valuable insight into the social and political dynamics of medical education, and how these dynamics can lead to inequality and privilege, resulting in different outcomes for applicant subgroups. Accordingly, this

research focuses on exploring and describing the demographic compositions of a 5-class medical school applicant advantage status typology.

Methods

Study Design and Population

This exploratory research study used self-report data from AAMC's AMCAS applications from a national sample of applicants to 146 U.S. medical schools in the 2018-2019 application cycle. This research focuses on associations between a five-class advantage status typology built using latent class analysis (LCA) and self-report applicant characteristics.

Applicants who were not U.S. citizens or permanent residents (n=1,948) were removed from the analysis since they were not asked to provide information about their backgrounds. The final file used for analysis contained self-report data from AMCAS applications for 47,958 applicants. Additionally, 1,858 applicants supplied no data for any advantage status indicators and were eliminated from the LCA model.

This research student was deemed not to fit the definition of human subjects research by the University of Vermont Institutional Review Board.

Measures

Advantage status typology. Measures used in the LCA were: post-secondary education funding, fee-assistance program, self-report disadvantage status, family use of federal or state assistance programs, annual income in the childhood home, contribution to overall family income, paid employment before age 18, Pell Grant recipient, medically underserved area, parent education/occupation measure. Class enumeration procedures were followed to produce a five-class advantage status typology framework based upon

applicant response patterns to advantage status measures. The typologies are Advantaged, Advantaged and Private, Mixed, Disadvantaged, and Disadvantaged Caretakers.

Demographic measures. Medical school applicant self-report measures on four demographic variables representing race, sex, English language proficiency, and first-generation status.

Race/ethnicity. This measure has a three-category answer set: URM, White only or Asian only, Other or multiple other. The AAMC defines the term underrepresented in medicine (URM) as "those racial and ethnic populations that are underrepresented in the medical profession relative to their numbers in the general population." Historically, the AAMC determines URM membership via the applicant's answers to race and ethnicity questions on the AMCAS application. Applicants were URM if they self-reported that they were Black, Mexican-American, Native-American (American Indians, Alaska Natives, and Native Hawaiians), and mainland Puerto Ricans.[24] A series of three dummy codes were created from this variable where those that did not choose the category were recoded to 0, and those that chose the category were recoded to 1.

Sex. Applicants were able to self-identify as male, female, or they could choose "unknown/decline to respond." A series of three dummy codes were created from this variable where those that did not choose the category were recoded to 0, and those that chose the category were recoded to 1.

First-generation. First-generation status was inferred from the information that an applicant provides about their parents' education. Applicants who do not report that one or more of their parents earned bachelor's degrees are considered first-generation

students. First-generation applicants are coded as the indicator group [1], while those applicants who are not first-generation were coded as the referent group [0].

Language minority. Applicants provide information on the languages that they speak. The data were recoded into a variable representing fluency in English. Applicants who do not describe that they speak the English language at a native level will be classified as language minorities [1], while those that indicate speaking English at a native level will be the referent group [0]. Language minority status may also be referred to as speaking English a second language (ESL.)

To further explore applicants' demographic qualities through an intersectional lens, combinations of the demographic traits were created. This approach aligns with Crenshaw's postulation that the experiences of individuals cannot be boiled down to singular traits and that the intersections of these traits may cause an alteration of experience as compared with isolated traits.[17,18]

Analysis

This work builds upon an intersectional five-class advantage status typology for 2018-2019 applicants to 146 U.S. medical schools built using latent class analysis (LCA) in MPlus v 8. The five typologies are Advantaged, Advantaged and Private, Mixed, Disadvantaged, and Disadvantaged Caretakers.

This exploratory research study used self-report data from the Association of American Medical Colleges (AAMC) American Medical College Application System (AMCAS) applications from all applicants to 146 U.S. medical schools in the 2018-2019 application cycle. The AAMC supplied a de-identified dataset with measures of applicant identity and backgrounds.

Using LCA in Mplus software produces two types of typology membership probability for each applicant based upon the applicant's response patterns. First, applicants have probability scores of belonging to each of the typologies, also known as posterior probabilities. Additionally, most likely typology membership is a mutually exclusive categorization that is assigned based upon each applicant's highest posterior probability. Given that applicants can have non-zero posterior probabilities for more than one typology, the use of most likely typology includes error.[25,26] Still, the use of most-likely typology membership is attractive to researchers, in what is called the "classify-analyze" approach. Both types of membership classification statistics were used in this analysis.

Most likely typology membership was converted to five dummy variables in SPSS v 25, with 0 indicating those who were not assigned to the typology and 1 indicating applicants who were most likely members of the typology. Additionally, dummy variables for each demographic variable were created for inclusion as independent variables in logistic regression models. Binary dummy variables allow regression results to be interpreted for the presence or absence of the demographic quality. These dummy coded variables can also be combined to create new variables that represent the presence or absence of a combination of identity traits.

Logistic regression models were used to examine demographic variables and the odds of typology membership. Independent variables include single demographic qualities; odds ratios demonstrating the odds of typology membership for individuals with the quality are presented, along with 95% confidence intervals for the odds ratios. Confidence intervals that exclude 1 indicate statistical significance, with values less than

one indicating lower odds and values above one indicating increased odds for those with the presence of the variable as compared to those with the absence of the variable.

In order to incorporate an intersectional approach to the demographic characteristics, combinations of identity traits were created. These combinations allow for an exploration of how associations change with the addition or subtraction of the self-report demographic characteristics.

Because analyses of large datasets can produce inconsequential effects with significant p-values[27], odds ratios and their associated confidence intervals, as well as Spearman's rho correlation coefficients represent effect sizes, which indicate the magnitude of observed effects.

Results

The five advantage status typologies were indicated based upon response patterns within the AMCAS applications. When considering most likely members of classes, the Advantaged and Advantaged and Private typologies contained 57% of applicants to medical school in 2018-2019. The Advantaged class was associated with responses aligning with the most privileged categories on the advantage status measures. The Advantaged and Private group had similar answers but did not disclose their history on questions where they were able to decline to answer.

About a quarter of applicants were most likely members of a Mixed typology, who funded their post-secondary education through student loans, academic scholarships, or self-funding. They reported a mid-range income in their childhood home, had parents with higher levels of education and occupation, and most do not consider themselves to

be disadvantaged. They were not likely to receive Pell grants or have spent their childhood in medically underserved areas.

Approximately 20% of the sample were most likely members of two Disadvantaged typologies, who were differentiated by whether they held jobs and needed to contribute to their family's income prior to the age of 18 years old. The typology that worked during their formative years in order to support their families was labeled Disadvantaged Caretakers, and the others were labeled as Disadvantaged.

Figure 1 demonstrates the most likely typology memberships for First-Generation Applicants and those who do not speak English at a native or functionally native level. First-Generation applicants were most likely members of the Mixed typology and less-likely members of the Advantaged classes. Language minority applicants were most likely members of the Disadvantaged typology, with the fewest most likely members of the Disadvantaged Caretakers group.

There did not seem to be substantial differences between males and females when it comes to typology membership proportions. There were differences in the group who chose "Unknown or Decline to Respond" as their sex. Almost 40% were members of the Advantaged and Private group and were less represented in the Disadvantaged typology. However, this group of applicants was small (n=14), and results should be interpreted with caution.

Finally, Figure 3 displays the most likely typology membership for groupings of applicant self-reported race and ethnicity. White or Asian only applicants were most likely members of the Advantaged typology (63.4%) and less likely to be members of the Disadvantaged typologies. In comparison, a little more than a quarter of URM applicants

were in Advantaged typologies, tending to be most likely members of the Mixed and Disadvantaged typologies. Finally, about 50% of applicants in the Other or Multiple Other race and ethnicity category were most likely members of the Advantaged typologies and less likely members of the Disadvantaged typologies.

Table 1 demonstrates that first-generation applicants had higher odds of falling into the Disadvantaged Caretakers (OR 7.36 95% CI 6.62-8.18), Disadvantaged (OR 5.91 95% CI 5.40-6.48), and Mixed (OR 2.07 95% CI 1.93-2.23) typologies as compared with non-first generation applicants. First-generation applicants also had lower odds of having advantage status item response patterns associated with the Advantaged (OR 0.10 95% CI 0.09-0.11) and Advantaged and Private (OR 0.34 95% CI 0.21-0.56) typologies.

Applicants who did not speak English at a native or functionally native proficiency had statistically significant odds of membership in the Disadvantaged (OR 4.48 95% CI 4.10-4.90), Disadvantaged Caretakers (OR 2.88 95% CI 2.57-3.23), and Mixed (OR 1.18 95% CI 1.08-1.29) typologies as compared with native or functionally native English speakers. They also had statistically significant lower odds of membership in Advantaged (OR 0.20 95% CI 0.18-0.22) and Advantaged and Private (OR 0.57 95% CI 0.36-0.90) typologies than native English speakers.

As compared with those who did not self-report as female, female applicants had higher odds of membership in the Disadvantaged group (OR 1.30 95% CI 1.23-1.37), and lower odds of membership in the Advantaged and Private (OR 0.76 95% CO 0.65-0.89) and Advantaged (OR 0.93 95% CI 0.901-0.97) typologies.

Male applicants had higher odds of most likely membership in the Advantaged and Private (OR 1.27 95% CI 1.09-1.49) and Advantaged (OR 1.07 95% CI 1.03-1.11)

typologies and lower odds of membership in the Disadvantaged typology (OR 0.77 95% CI 0.73-0.82) as compared with applicants who did not self-identify as male.

Applicants who self-reported as Unknown or Decline to Respond to the question about sex had statistically significantly higher odds of membership in the Advantaged and Private typology (OR 40.93 95% CI 13.68-122.48) as compared with applicants who self-reported as male or female.

URM applicants had higher odds of membership in the Disadvantaged (OR 3.92 95% CI 3.69-4.17), Disadvantaged Caretakers (OR 3.87 95% CI 3.59-4.17), and Mixed (OR 1.36 95% CI 1.28-1.43) typologies as compared with non-URM applicants. They also had statistically lower odds of membership in the Advantaged (OR 0.22 95% CI 0.21-0.23) and the Advantaged and Private (OR 0.65 95% CI 0.51-0.83) typologies.

Applicants who self-reported their race as White only or Asian only had a threefold increased odds of membership in the Advantaged (OR 3.16 95% CI 3.03-3.29) typology, and statistically lower odds of membership in the Disadvantaged Caretakers (OR 0.26 95% CI 0.24-0.27), Disadvantaged (OR 0.32 95% CI 0.31-0.34), and Mixed (OR 0.78 95% CI 0.75-0.82) typologies.

Medical school applicants who self-reported their race and ethnicity as Other or Multiple Other race/ethnicity had higher odds of belonging to the Disadvantaged Caretakers (OR 1.74 95% CI 1.59-1.91), Advantaged and Private (OR 1.66 95% CI 1.36-2.03), Disadvantaged (OR 1.16 95% CI 1.07-1.26), and Mixed (OR 1.08 95% CI 1.02-1.15) typologies, and lower odds of membership in the Advantaged (OR 0.72 95% CI 0.68-0.76) typology as compared with applicants who self-reported other races and ethnicities.

Table 2 incorporates an intersectional view of applicant demographic characteristics and how they relate to posterior probabilities of typology membership. In order to put the associations of intersectional in perspective, it first lists the associations for singular traits. For example, Table 2 demonstrates that female applicants have a -0.015 (p<.05) inverse correlation coefficient with the probability of membership in the Advantaged typology. Progressing down through the table, the addition of a female applicant's race and ethnicity alters this relationship. URM female applicants have a stronger inverse correlation (-0.221, p<.05) of the probability of belonging to the Advantaged typology, White only or Asian only females have a positive correlation coefficient (0.140, p<.05). In contrast, female applicants who were classified in the Other/Multiple Other race and ethnicity category had a small inverse association (-0.040, p<.05). Adding in first-generation status to female applicants means they have a lower probability of membership in the Advantaged typology (-0.235, p<.05).

A similar exploration reveals that applicants identifying with races and ethnicities in the White only or Asian only category have a lower probability of membership in the Disadvantaged Caretakers typology (-0.195, p<.05), but separating White only or Asian only individuals who are first-generation reveals that they have a stronger positive probability of membership in this typology (0.575, p<.05). This relationship is also stronger than the first-generation status on its own (0.290, p<.05.) The intersections of these identities result in higher statistical association with the probability of belonging to the Disadvantaged Caretakers typology than either factor on its own.

Discussion

In order to address lingering healthcare disparities in the United States a more diverse physician workforce is required.[28–32] While many may think of diversity in medical education in terms of race, ethnicity, and gender, it should also include socioeconomic status.[33] By increasing the number of medical students of lower socioeconomic status, it is hypothesized that these students will contribute to increased cultural competence in their peer students, but also will be more likely to practice in an underserved area.[34] This research study explores the relationship between advantage status typologies and demographic factors in a cohort of medical school applicants.

The analysis explored the demographic characteristics comprising the typologies and odds ratios of most-likely typology membership for single demographic measures as well as intersections of these measures with posterior probabilities of typology membership. Intersections of privilege aligned with membership in advantaged typologies, while those historically associated with oppression and increased barriers had higher odds of most-likely membership in the Mixed and disadvantaged typologies. Consideration of additional characteristics associated with more considerable challenges in the U.S. seemed to increase the odds of disadvantaged typology membership. However, some of the confidence intervals were quite wide for combinations of identity traits, which most likely reflects the smaller sample size as more characteristics were added. Interestingly, a combination of first-generation, ESL, and URM or Other/Multiple Other race/ethnicity identities were completely absent from most-likely membership in the Advantaged typology.

Although these results reflect the literature about what is known regarding disadvantage in the U.S. and within education research, this study has presented these data through a novel lens in medical education research. LCA allowed the ten advantage status measures to overlap as the dataset was reduced into categories best fitting response patterns within the dataset. This approach is in contrast to studies that examine single measures, or those that aggregate measures[33] with an underlying assumption that the magnitude all relationships between advantage status measures are additive. Additionally, self-report demographic characteristics were examined in a manner that also allowed measures to co-exist with another. The results of this analysis add context to the complex notions of socioeconomic advantages and disadvantages and intersectionality within a cohort of U.S. medical school applicants and may assist admissions officers in understanding how advantage and medical school applicant identities overlap. Taking an intersectional approach to applicant identities and backgrounds allows for highlighting the intersections of privilege and oppression.[35] For example, examining multiple identity traits of individuals demonstrated that applicants who are White only or Asian only had a small inverse correlation with the probability of belonging in the Disadvantaged Caretakers typology, and first-generation applicants had a larger positive correlation with the posterior probability of being classified into the Disadvantaged Caretakers group. However, applicants possessing both of these traits had strong probabilities of being members of the Disadvantaged Caretakers group. The intersection of these two traits highlighted the additional barriers that this group of applicants have likely faced in their lives.

A significant limitation to this research is that the exploration of medical school applicant backgrounds is limited to the concepts addressed in the AMCAS application, the answer set categories corresponding to those measures, and the categories released by the AAMC for research. In 2018-2019, the AMCAS asked questions about gender identity and LGBTQ status, but these were not made available for this analysis, which limits its inclusiveness and prevents exploration of the relationship of these variables to advantage status. Data on the AMCAS application are self-report, and given the competitive nature of applying for medical school, applicants may choose their answers based upon what they suspect may give them a leg up, rather than most accurately representing their identities and backgrounds. Additionally, the use of most-likely typology status classification is less precise than using the continuous posterior probabilities of class membership.[26]

This research aligns with previous research about medical school applicant backgrounds but conceptualizes identities and backgrounds through an intersectional lens. Additional research should build upon this analysis and explore trends related to successful outcomes in the medical school application process.

This study is the first to employ an intersectional lens when researching medical school applicant advantage status in addition to applicant demographic qualities. Enhancing the medical admissions community's understanding of the applicant pool using methods that allow applicant traits and experiences to co-exist. Because an intersectional approach may introduce additional fidelity to our understanding of the applicants, this research may be the bridge between statistical exploration and putting the

knowledge gained into practice to reduce barriers in the accessibility of medical education and effectively shape the nation's physician workforce.

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Figure 1.
Proportions of Most Likely Typology Membership of 2018-2019 U.S. Medical School Applicants by First-Generation and Language Minority Status (n=47,958)

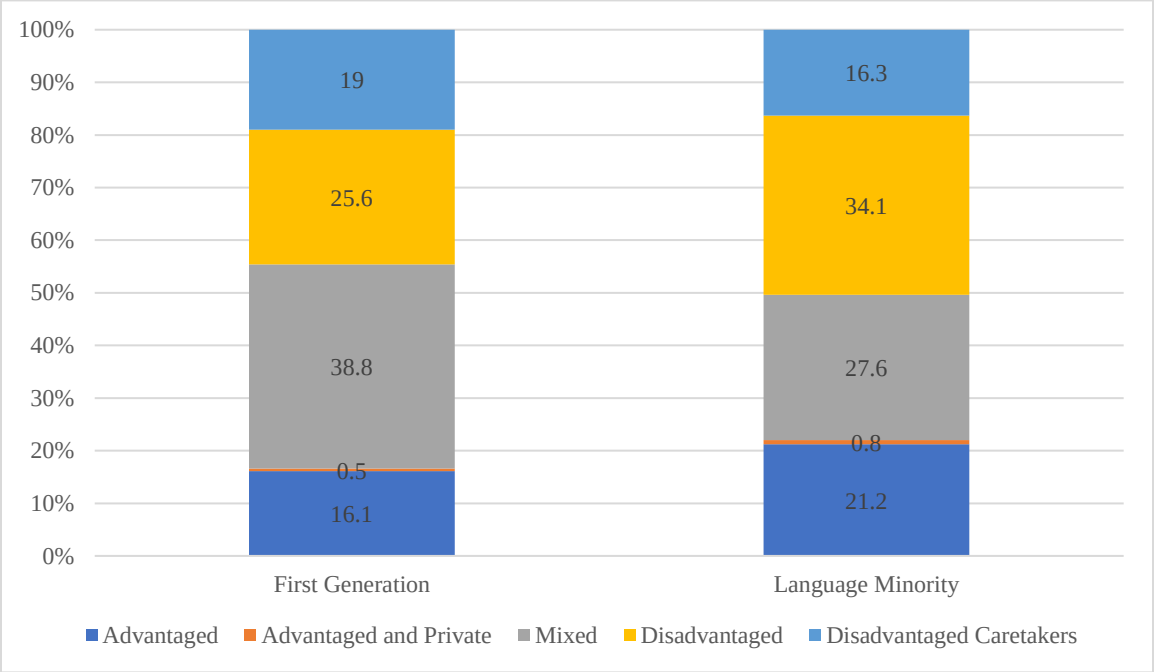
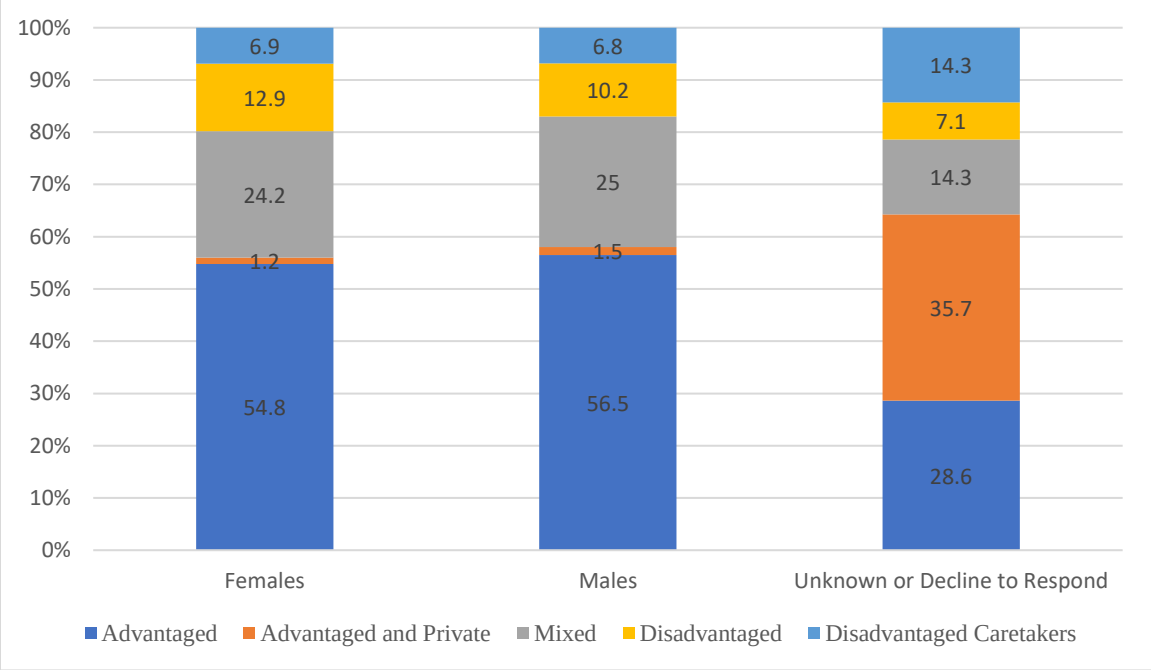


Figure 2.
Proportions of Most Likely Typology Membership of 2018-2019 U.S. Medical School Applicants by Sex (n=47,958)



Unknown or Decline to Respond group n = 14. Use caution when interpreting results.

Figure 3.
Proportions of Most Likely Typology Membership of 2018-2019 U.S. Medical School Applicants by Race/Ethnicity (n=47,958)

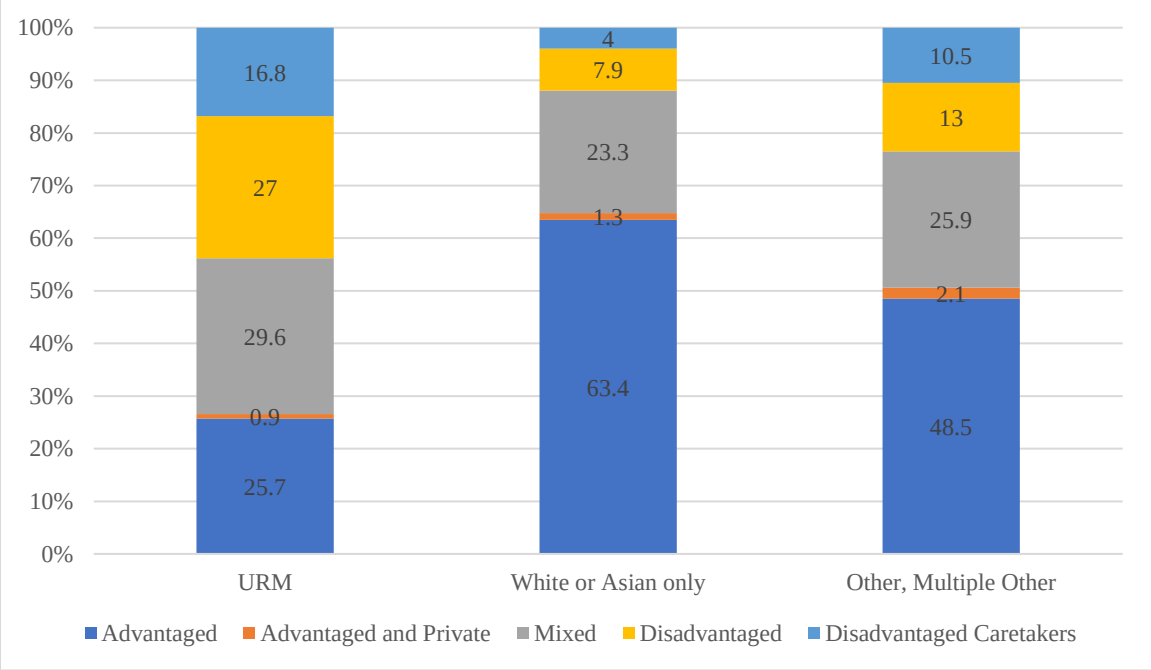


Table 1.
Odds Ratios of Advantage Status Typology Membership for 2018-2019 Applicants to U.S. Medical Schools

	Predictors	Odds Ratio	95% Confidence Interval
First-Generation Applicants	Advantaged	0.10	0.09 – 0.14
	Advantaged and Private	0.34	0.21 – 0.56
	Mixed	2.07	1.93 – 2.23
	Disadvantaged	5.91	5.40 – 6.48
	Disadvantaged Caretakers	7.36	6.62 – 8.18
Language Minority Applicants	Advantaged	0.20	0.18 – 0.22
	Advantaged and Private	0.57	0.36 – 0.90
	Mixed	1.18	1.08 – 1.29
	Disadvantaged	4.48	4.10 – 4.90
	Disadvantaged Caretakers	2.88	2.57 – 3.23
Female Applicants	Advantaged	0.93	0.90 – 0.97
	Advantaged and Private	0.76	0.65 – 0.89
	Mixed	0.96	0.92 – 1.00
	Disadvantaged	1.30	1.23 – 1.37
	Disadvantaged Caretakers	1.02	0.95 – 1.10
Male Applicants	Advantaged	1.07	1.03 – 1.11
	Advantaged and Private	1.27	1.09 – 1.49
	Mixed	1.04	1.00 – 1.09
	Disadvantaged	0.77	0.73 – 0.82
	Disadvantaged Caretakers	0.98	0.91 – 1.05
Unknown Decline to Respond Applicants	Advantaged	0.32	0.10 – 1.02
	Advantaged and Private	40.93	13.68 – 122.48
	Mixed	0.51	0.11 – 2.28
	Disadvantaged	0.59	0.08 – 4.50
	Disadvantaged Caretakers	2.27	0.51 – 10.16
URM Applicants	Advantaged	0.22	0.21 – 0.23
	Advantaged and Private	0.65	0.51 – 0.83
	Mixed	1.36	1.28 – 1.43
	Disadvantaged	3.92	3.69 – 4.17
	Disadvantaged Caretakers	3.87	3.59 – 4.17
White or Asian Only Applicants	Advantaged	3.16	3.03 – 3.29
	Advantaged and Private	0.93	0.79 – 1.11
	Mixed	0.78	0.75 – 0.82
	Disadvantaged	0.32	0.31 – 0.34
	Disadvantaged Caretakers	0.26	0.24 – 0.28
Other, Multiple Other Applicants	Advantaged	0.72	0.68 – 0.76
	Advantaged and Private	1.66	1.36 – 2.03
	Mixed	1.08	1.02 – 1.15
	Disadvantaged	1.16	1.07 – 1.26
	Disadvantaged Caretakers	1.74	1.59 – 1.91

Table 2.
Correlation Coefficients of Identity Traits and Intersections of Identity Traits and Probability of Typology Membership for 2018-2019 Applicants to U.S. Medical Schools

Identity Traits	Advantaged	Advantaged & Private	Mized	Disadvantaged	Disadvantaged Caretakers
Males	0.015*	0.043*	-0.021*	-0.031*	-0.010*
Females	-0.015*	-0.044*	-0.021*	0.031*	0.009*
Unk/Dec to Resp	-0.009*	0.015	-0.012*	-0.005	0.004
URM	-0.288*	-0.076*	-0.003	0.221*	0.191*
White or Asian	0.276*	0.056*	0.007	-0.195*	-0.195*
Mult Other	-0.056*	0.009	-0.006	0.019*	0.054*
First-Gen	-0.332*	-0.107	0.072*	0.235*	0.290*
ESL	-0.174	-0.055	-0.013*	0.165*	0.061*
URM Males	-0.166*	-0.040*	-0.006	0.115*	0.113*
URM Females	-0.221*	-0.061*	0.001	0.181*	0.143*
URM Unk/Dec to Resp	-0.001	0.008	0.005	-0.003	-0.002
White or Asian Male	0.117*	0.058*	0.026*	-0.093*	-0.086*
White or Asian Female	0.140*	-0.007	-0.020*	-0.088*	-0.095*
White or Asian Unk/Dec to Resp	-0.002	0.004	-0.007	-0.001	0.002
Mult Other Male	-0.035*	0.016*	-0.002	0.004	0.037*
Mult Other Female	-0.040*	-0.004	-0.005	0.022*	0.037*
Mult Other Unk/Dec to Resp	-0.012*	0.016*	-0.012*	-0.006*	0.005
First-Gen Male	-0.222*	-0.066*	0.069*	0.149*	0.192*
First-Gen Female	-0.237*	-0.082*	0.031*	0.176*	0.209*
First-Gen Unk/Dec to Resp	-	-	-	-	-
First-Gen URM	-0.195*	-0.080*	-0.055*	0.151*	0.173*
First-Gen White or Asian	-0.235*	-0.065*	0.194*	0.167*	0.575*
First-Gen Mult Other	-0.116*	-0.036*	-0.004	0.063*	0.123*
First-Gen URM Males	-0.124*	-0.054*	-0.035*	0.090*	0.107*
First-Gen URM Female	-0.149*	-0.059*	-0.041*	0.120*	0.134*
First-Gen URM Unk/Dec to Resp	-	-	-	-	-
First-Gen White or Asian Male	-0.165*	-0.040*	0.100*	0.112*	0.136*
First-Gen White or Asian Female	-0.162*	-0.051*	0.074*	0.120*	0.134*
First-Gen White or Asian Unk/Dec to Respond	-	-	-	-	-
First-Gen Mult Other Male	-0.080*	-0.023*	0.007	0.042*	0.085*
First-Gen Mult Other Female	-0.084*	-0.028*	-0.012*	0.047*	0.088*
First-Gen Mult Other Unk/ Dec to Resp	-	-	-	-	-
ESL Male	-0.113*	-0.040*	-0.011*	0.099*	0.043*
ESL Female	-0.130*	-0.037*	-0.007	0.130*	0.042*
ESL Unk/Dec to Resp	-0.006	0.010*	-0.008	-0.003	-0.002
ESL URM	-0.133*	-0.044*	0.012*	0.124*	0.050*
ESL White or Asian	-0.089*	-0.028*	0.004	0.094*	0.021*
ESL Mult Other	-0.068*	-0.019*	-0.022*	0.049*	0.035*
ESL URM Male	-0.089*	-0.035*	-0.017*	0.082*	0.032*
ESL URM Female	-0.098*	-0.026*	0.000	0.092*	0.038*
ESL URM Unk/Dec to Resp	-	-	-	-	-
ESL White or Asian Male	-0.058*	-0.021*	0.007	0.054	0.017*
ESL White or Asian Female	-0.068*	-0.018*	-0.001	0.079*	0.013*
ESL White or Asian Unk/Dec to Resp	-	-	-	-	-
ESL Mult Other Male	-0.044*	-0.008	-0.013*	0.025*	0.027*
ESL Mult Other Female	-0.052*	-0.020*	-0.018*	0.044*	0.023*

Table 2.
Correlation Coefficients of Identity Traits and Intersections of Identity Traits and Probability of Typology Membership for 2018-2019 Applicants to U.S. Medical Schools (continued)

ESL Mult Other Unk/Dec to Resp	-0.006	0.010*	-0.008	-0.003	-0.002
First-Gen ESL URM Male	-0.038*	-0.017*	-0.016*	0.037*	0.017*
First-Gen ESL URM Female	-0.040*	-0.016*	-0.021*	0.031*	0.031*
First-Gen ESL URM Unk/Dec to Resp	-	-	-	-	-
First-Gen ESL White or Asian Male	-0.031*	-0.014*	0.010*	0.025*	0.017*
First-Gen ESL White or Asian Female	-0.032*	-0.013*	-0.003	0.025*	0.018*
First-Gen ESL White or Asian Unk/Dec to Resp	-	-	-	-	-
First-Gen ESL Mult Other Male	-0.013*	0.002	-0.003	0.003	0.014*
First-Gen ESL Mult Other Female	-0.017*	-0.009	-0.005	0.009	0.013*
First-Gen ESL Mult Other Unk/Dec Resp	-	-	-	-	-

Coefficients are Spearman's rho.
Unk/Dec to Respond = UnknownDecline to Respond
URM = Underrepresented in medicine race/ethnicity
White or Asian = White only or Asian only race/ethnicity
Mult Other = Other or Multiple Other race/ethnicity
First-Gen = First-generation applicant
ESL = English as a Second Language/Language Minority Applicant
** Indicates that association is statistically significant ($p < .05$)*

CHAPTER 6

U.S. Medical School Applicant Advantage Status Typologies and Impacts on the Accessibility of Medical Education

Abstract

Purpose

For three decades, the majority of medical students come from the top two quintiles of household income. This research study was carried out to explore associations between advantage status typology membership and access to medical education with and without controlling for MCAT score.

Method

This study builds upon a five latent class typology classification to understand the relationships between advantage status typologies and academic metrics, applications submitted, acceptances received, and matriculation into medical school. A return on application investment metric explores associations for applications submitted to acceptances received for each typology, and odds ratios for acceptance and matriculation by typology are presented

Results

Academic metrics increased with increasing advantage status typology, with advantaged students having the highest scores. Applicants applied to an average of 16.81 medical schools, and the average number of acceptances was 0.87. The probability of membership in the Advantaged typology is associated with the highest return on application investment and higher odds of acceptance and matriculation, though adding MCAT score as a covariate in logistic regression models reversed the trend. When controlling for the

impact of MCAT score, those in the Advantaged typology were statistically less likely to be accepted and matriculate into medical school. The reverse patterns were found in the Disadvantaged and Disadvantaged Caretakers groups.

Conclusions

The probability of membership in the most advantaged typology is associated with higher academic metrics, applying to more medical schools, and receiving more acceptances to medical school. However, applicant MCAT score seems to play a significant role in outcomes in medical school admissions.

Introduction

Diversity within the United States (U.S.) medical workforce is an essential strategy for addressing public health issues, effectively caring for a diverse patient population, and overcoming anticipated physician shortages in medically underserved areas. The groups most burdened by health disparities remain underrepresented in the physician workforce. Inequalities in health care disproportionally impact low-income households and racial and ethnic minority communities.[1]

Research findings reinforce the importance of physicians' background in resolving inequalities in patient access to culturally appropriate care. Social-concordance between physicians and patients leads to prolonged appointments, improved patient satisfaction, and positive patient affect.[2–5] Physician race or ethnicity influenced Black and Hispanic patients' selection of a doctor.[4] Physicians of racial or ethnic minorities, and female physicians were more likely to serve minority and low-income communities.[6–9] Expanding the diversity of the physician workforce benefits patients and produces physicians more likely to practice in underserved communities.

There are also significant benefits of increased diversity to the learning environment of medical schools by influencing and preparing other students to provide culturally competent care by connecting them to new perspectives.[10–13] Physicians trained in a diverse learning environment are more likely to work in a medically underserved region and feel prepared to care for patients from other racial and ethnic backgrounds.[4]

The Costs of Medical School

In 2019, the average four-year cost of attending public medical schools was $250,222, and the cost of attending private medical schools was $330,180.[14] In an annual survey of recent medical school graduates in 2018, 75 percent of graduates retained debt from medical school and/or their premedical education. For indebted students, the median amount of debt was $200,000. A third of graduates reported carried debt from their premedical education (median $25,000), and approximately 14% of graduates were carrying debt on credit cards (median $5,000).[14]

The costs of applying to medical school can be prohibitive. Not including preparation materials and courses, or repeat Medical College Admissions Tests (MCAT), fixed costs to apply can approach $500.[15] In addition, applying to more schools increases costs. Additional expenses such as school-specific secondary applications and costs of interview preparation and travel can approach an additional $700 for each school to which an applicant applies.[15]

Medical school applicants with greater access to resources benefit by an ability to apply broadly to more medical schools, apply in multiple years, consider geographically distant schools, purchase expensive preparatory materials, courses, and services, as well as attend interviews for remote schools.[15] The costs involved in applying to medical school are invested in the hope that the applicant receives at least one acceptance to a school to which they applied.[16] In considering this investment, advantaged applicants are more cushioned from the financial risk involved in applying for medical school, because in such a competitive environment there is no guarantee of success.[15]

The Barriers to Success in Medical Admissions

Premedical candidates are considered ready for medical school if they have rigorous academic qualifications, have spent time shadowing healthcare providers, conducted scientific research, and have found time to volunteer for worthy causes.[17] During the admissions process, medical school applicants who lack opportunities for rigorous academic training and preparation, access to healthcare providers for experience within medical settings, financial safety nets, and ample free time may have weaker applications.[10,18]

Every year, medical schools receive thousands of applications, and individual advantage status indicators on the American Medical College Application System (AMCAS) risk misrepresenting the complex social and economic history of an applicant. A measure created by the AAMC to assess an applicant's parents' education and occupation (EO) found that 36% of applicants whose EO measures pointed toward adversity had no other indicators of disadvantage.[19] Further, applicant responses to a self-report indicator of a disadvantaged background were answered in context with consideration to the disadvantage or privilege level of the applicant's peers.[20] A more detailed understanding of how aspects of applicant privilege and hardship measures relate to outcomes in the medical education admissions process may identify the characteristics of applicants who experience barriers and remove obstacles that restrict accessibility for disadvantaged applicants.[21]

Adjusting for Adversity

In 2018, the University of California, Davis, School of Medicine sought to measure socioeconomic (SES) disparities in applicants by developing continuous scale

from items from the AMCAS applications that reflect hardships.[22] The scale includes indicators including parent education level, childhood family income, family use of public assistance services, applicant contribution to family income, childhood residence in a medically underserved population, receipt of need-based scholarship funding, and the American Association of Medical College's (AAMC) fee waiver program.

Fenton and colleagues[10] investigated a mechanism for increasing diversity within one medical school by creating a scale of socioeconomic disadvantages using AMCAS measures to supplement and contextualize academic metrics for applicants. Simulations conducted integrating this SES scale in their admissions process seemed to reduce inequalities associated with low SES and URM while retaining academic readiness.[10]

The testing of scales and mathematical adjustments in undergraduate medical admissions reflects continuing discourse in higher education admissions. In 2019, the College Board introduced an adversity score to represent postsecondary education applicant school quality and geographic environment to increase the accessibility of postsecondary education to low-SES applicants.[23] This adversity score would accompany the Scholastic Aptitude Test (SAT) scores and could be used as a proxy measure to place academics and test scores within the context of an applicant's neighborhood and school. The public pushed back at the idea of improperly distilling complex backgrounds into one number, and the approach was criticized as bestowing advantage upon those who were part of gentrifying lower-income neighborhoods. The College Board developed a dashboard, which would provide university admissions staff with information about obstacles the applicant has overcome.[23] These include the applicant's neighborhood and school, and the range of SAT scores in the applicant's school and zip code. A simulation

study found that the inclusion of these contextual data made schools more likely to admit a low-SES applicant.[24] Though directly comparable data are not available for medical school applicants, measures on the AMCAS may be suitable for an eventual applicant SES dashboard. Further study is needed to understand which factors would be essential to include.

Specifically, this research study aims to examine the relationship between the probability of medical school applicants belonging to a 5-class advantage status typology with outcomes the applicant experiences within the admissions process with and without adjusting for the impact of applicant MCAT score. Moreover, this project involves the creation and application of a return on investment (ROI) formula to analyze applicant probability of typology membership in relation to the investment (applications submitted) and the return on the investment (acceptances received.)

Method

Study Design and Population

This exploratory research study used self-report data from AAMC's AMCAS applications from all applicants to 146 U.S. medical schools in the 2018-2019 application cycle. The AAMC supplied a de-identified dataset with measures of applicant identity, backgrounds, academic success, as well as measures demonstrating how individuals fared in the medical school admissions process. This research focuses upon associations between a five-class advantage status typology built using latent class analysis (LCA), academic metrics, and outcomes in the admissions process.

Individuals listed as non-U.S. Citizens and non-Permanent Residents (n=1,948, 3.8% of the dataset) were removed from the file since they did not receive the full set of

questions used in this analysis. Additionally, 1,858 applicants supplied no data for any advantage status indicators and were eliminated from the LCA model. The final file used for analysis contained self-report data from AMCAS applications for 47,958 applicants.

This research student was deemed not to fit the definition of human subjects research by the University of Vermont Institutional Review Board.

Measures

Advantage status typologies. Measures used in the LCA were: post-secondary education funding, fee-assistance program, self-report disadvantage status, family use of federal or state assistance programs, annual income in the childhood home, contribution to overall family income, paid employment before age 18, Pell Grant recipient, medically underserved area, parent education/occupation measure. Class enumeration procedures were followed to produce a five-class advantage status typology.

Academic metrics. The AAMC also shared three measures of medical school applicant academic aptitude and/or test-taking ability.

BCPM GPA. This measure represents the applicant's post-secondary grade point average for any courses falling into the categories of biology, chemistry, physics, and math. BCPM GPA is also known as the "Science GPA." BCPM GPA is a continuous measure ranging from 0 – 4.

Total GPA. This measure represents the grade point average for all post-secondary courses taken by the applicant. Total GPA is a continuous measure ranging from 0 – 4.

MCAT score. Applicants are required to take the Medical College Admission Test and may submit multiple scores if they take the test repeatedly. For this study, the highest

total MCAT score obtained by the applicant will be used as a covariate in regression models as a proxy for academic ability and test-taking skills. Total MCAT scores range from 472 to 528, with a midpoint of 500.

Access to medical education. The AAMC tracks medical school applicant outcomes. The following will serve as outcome variables in regression models assessing whether class membership predicts an applicant's success in accessing medical education.

Number of applications. This continuous measure indicates how many medical schools to which the applicant applied.

Number of acceptances. This continuous measure represents the number of medical schools to which an applicant was accepted for admission. This variable will also be recoded to create a new dichotomous "yes/no" version of the measure with applicants coded to yes having received at least one acceptance to a medical school to which they applied.

Matriculated. If accepted, applicants have the choice to attend one of the medical schools to which they were accepted. Accepted applicants might opt to attend medical school or decide not to enroll in any medical school. Matriculation is a dichotomous measure.

Analysis

This work builds upon the creation of an intersectional five-class advantage status typology for 2018-2019 applicants to 146 U.S. medical schools built using latent class analysis (LCA). The five typologies are Advantaged, Advantaged and Private, Mixed, Disadvantaged, and Disadvantaged Caretakers.

Descriptive analyses were performed for applicant academic metrics and behaviors and outcomes in the medical school admissions process. The descriptive data are presented by most likely advantage status typology, which is a mutually exclusive categorization that assigns an applicant to the typology to which they have the highest probability of membership. Because applicants can have non-zero probabilities of belonging to more than one typology, most likely typology membership includes a degree of error.[25] Subsequent analyses are other analyses in this project use probability of typology membership.

Included in the descriptive data characterizing the applicants who are most likely members of each typology is a novel formula created to investigate applicants' return on admissions investment (ROAI). The ROAI is an applied version of the traditional return on investment (ROI) formula used in economics and finance. The ROI characterizes the net profit of an investment as a ratio to the cost of the investment.[16]

The ROI formula is:

$$ROI = \frac{current\ investment\ value - \ cost\ of\ investment}{cost\ of\ investment}$$

Accordingly, the application of this formula to an investment in applications to medical school is:

$$ROAI = \frac{n\ acceptances\ received - n\ applications\ submitted}{n\ applications\ submitted}$$

Applicants cannot receive more acceptances than the number of applications they submit, so the values of the ROAI will always range from -1 to 0. The most favorable ROAI outcome is 0 since this would mean an applicant received an acceptance from

every medical school to which they applied. Ratios closer to -1 indicate a worse ROAI for applicants.

Correlations between the probability of typology membership and number of applications, number of acceptances, and ROAI are presented. Binomial logistic regression was performed in order to produce odds ratios demonstrating the associations between the probability of typology membership and dichotomous outcome measures of accepted to at least one medical school as well as matriculated into a medical school. Odds ratios are measures of association that represent the odds that a particular outcome will result for specific exposures as compared to the absence of the exposure.[26] An odds ratio of 1 would indicate no association between the exposure and the outcome, above 1 indicates higher odds of an outcome, and below 1 indicates lower odds of an outcome. Statistical significance for odds ratios can be determined by whether the confidence intervals include 1 (when assessing single odds ratio), or any overlap (when comparing two odds ratios to one another).

MCAT score was used as a covariate in the logistic regressions in order to understand the associations between the probability of advantage status typology membership and dichotomous outcome measures when controlling for applicant academic aptitude and/or test-taking ability. The MCAT score is primarily considered to be a marker of academic readiness for medical school by admissions officers in the United States; some schools may use pre-screening to set a baseline for acceptable MCAT scores amongst the thousands of applications they receive each year. Like most standardized tests, MCAT scores tend to decrease for applicants from disadvantaged backgrounds.[27] Admissions officers are urged to select applicants toward the middle of

the pack of MCAT scores in order to increase the diversity of their medical student body.[28]

Because the dataset is large and statistically significant findings are likely even if the difference is inconsequential, effect sizes in the form of Pearson Correlation Coefficients and Odds Ratios were calculated to present the magnitude of statistical associations.[29]

Results

The five-class advantage status typology structure consisted of the following groups: Advantaged, Advantaged and Private, Mixed, Disadvantaged, Disadvantaged Caretakers. The Advantaged and Advantaged and Private typologies included 57 percent of medical school applicants when considering their most-likely class membership. The Advantaged class was linked to response patterns on advantage status measures that indicated the most advantageous choices. The Advantaged and Private class had similar answers but did not disclose their backgrounds on questions where they could choose an option declining to respond.

Approximately one-quarter of applicants were classified as most-likely members of the Mixed typology; members in this class financed their post-secondary education with student loans, academic scholarships, or self-financing. Applicants in the Mixed typology reported mid-range incomes in their childhood home, had parents with higher levels of education and occupations, and a majority did not consider themselves to be disadvantaged. They were unlikely to receive Pell Grant funding or to have spent their formative years in a medically underserved area.

Lastly, approximately 20 percent of the sample were most likely members of two Disadvantaged typologies, largely distinguished from one another by whether they held jobs prior to the age of 18 and whether earned income was used to support their family. Most likely members of the typology that worked to help their families were labeled as the Disadvantaged Caretakers group, while those that did not have to work nor contribute to family income fell into the Disadvantaged typology.

Descriptive data for the sample can be found in Table 1. Based upon most-likely typology membership, those applicants in the Advantaged class had the highest scores on academic metrics (BCPM GPA, Total GPA, and MCAT score), while applicants in the Disadvantaged Caretakers group had the lowest. Overall, applicants applied to an average of 16.81 medical schools. Applicants most likely in the Advantaged and Private typology applied to the most schools (18.75), while applicants most likely in the Mixed typology applied to the fewest (14.91). Members of the Advantaged typology similarly received the greatest amount of acceptances (M=0.99, SD=1.53), on average, while members of the Advantaged and Private group received the fewest acceptances on average (M=0.66, SD=1.25). The overall average number of acceptances for the entire cohort of applicants was 0.87 (SD=1.48). The average ROAI was -0.894, with applicants in the Advantaged class having the best return ratio (-0.885), and most-likely members of the Disadvantaged class having the worst (-0.917.)

Figure 1 demonstrates the associations between the probability of typology membership and GPAs and MCAT total score. An increased probability of membership in the Advantaged group was associated with higher Science and Total GPA and MCAT

score. The probability of membership in a Disadvantaged group was associated with lower GPAs and MCAT scores.

To gain an understanding if the probability of typology membership was associated with "more bang for the buck" in terms of applications to acceptances, a Return on Admissions Investment (ROAI) was calculated. This metric is derived by the difference between the number of applications and the number of admissions divided by the number of applications. The ROAI is positively correlated with the likelihood of membership in the Advantaged group and negatively correlated with the probability of membership in the Mixed, Disadvantaged, and Disadvantaged Caretakers classes. A small negative association with the Advantaged and Private group was not statistically significant.

The results of logistic regression modeling with at least one acceptance to medical school as the dependent variable are presented in Table 2. Each unit increase in the probability of membership in the Advantaged typology was associated with an 84% increased chance of admission to one or more medical schools (OR 1.835, 95% CI 1.761-1.912). However, when controlling for the impact of MCAT score, this association reverses, and each unit increase in the probability of membership in the typology meant a 14% reduction in the chance of admission (OR 0.857, 95% CI 0.815-0.902).

The probability of membership in all other typologies was associated with unfavorable odds of admission to one or more medical schools. These associations reversed when controlling for MCAT score for probabilities of membership in the Disadvantaged (OR 1.210, 95% CI 1.206-1.424) and Disadvantaged Caretakers group (OR 1.610, 1.466-1.789). A similar pattern was found when the probability of typology

membership was compared with matriculating into medical school for all applicants. The odds of matriculation for each increase in probability of membership in the Advantaged cohort was favorable (OR 1.807, 95% CI 1.733-1.883) until controlling for the impact of MCAT score (OR 0.860, 95% CI 0.818-0.905), and the probability of membership in the Disadvantaged and Disadvantaged Caretakers groups was associated with a lowered chance of matriculation until adding MCAT score as a covariate to the models. When the analysis was restricted to applicants accepted to one or more schools, the association between the probability of Advanced typology membership and matriculation was not statistically significant in either the univariate model or when controlling for MCAT score. Probability of membership in the Disadvantaged group for accepted applicants was associated with a 55% increased chance of matriculating (OR 1.554, 95% CI 1.106-2.181) and increased to a 76% increased chance of matriculating (OR 1.761, 95% CI 1.228-2.525) when controlling for the impact of MCAT score.

Discussion

This research study replicates some information that is known and further expands upon it by classifying medical school applicants into advantage status typologies. Rather than attributing disadvantage to silos of race/ethnicity or single measures of SES, this research takes a nuanced stance to understand the backgrounds of medical students and intersections of privilege and hardship and how these intersections relate to the accessibility of medical education.

This study demonstrates that applicants with more access to resources via most likely membership in advantaged typologies are able to submit more applications, and, on average, have higher MCAT scores, GPAs, and ROAI values.

An unexpected finding was that most likely members of the Mixed typology submitted the fewest number of applications, even as compared with applicants in more disadvantaged classes. This finding may be due to the impact of the AAMC's Fee Assistance Program (FAP)[30], which is available to low-income applicants to offset the costs of taking the MCAT and applying to medical schools. Applicants who are most likely in the Mixed typology may find themselves over the income limits for the FAP, while also not in possession of the same access to financial resources that those in the more advantaged typologies may have.

Membership in the Advantaged status typology was associated with not applying or qualifying for the FAP program and Advantaged applicants submitted an average of 17.74 applications to medical schools in 2018-2019. Applying recent cost estimates[15], if applicants in the Advantaged typology received interview invitations to one-half of these schools, their costs for taking the MCAT once, applying to schools, and interviewing at the schools approach $7,000. This amount is likely to be out of reach for applicants classified into the Mixed, Disadvantaged, and Disadvantaged Caretakers typologies.

In an effort to level the playing field by making the application process more affordable for all applicants, the AAMC recently announced that all applicants will be able to apply to up to 20 medical schools for free, and has expanded access to the Fee Assistance Program (FAP) to include refugees and applicants who are recipients of Deferred Access for Childhood Arrivals (DACA).[31]

This exploratory research study provides evidence that increasing the number of free applications will likely prove helpful for those in the Mixed typology, in particular, since most would not likely be eligible under the FAP. However, many medical schools

require secondary applications that often require additional costs for submission. This may negate the advantage of additional applications for applicants not eligible for the FAP, since these medical schools may have policies to waive secondary application costs for those applicants covered by the FAP.

Additionally, the impact of the increased number of free applications to medical schools might shift a burden onto admissions officers at medical schools, who can expect the number of applications they receive to go up. Many medical schools have embraced holistic review[32,33] of applicants; however, the process of considering detailed backgrounds and levels of success in light of adversities is resource-intensive. The AAMC is to be lauded for the decision to support applicants with more adversity in their backgrounds apply to more medical schools, but it is unclear how this decision will affect admissions staff. If medical schools lack the resources to handle the likely increase in applications, more schools may shift toward quantitative sorting via screening formulas, which tends to boost the chances of more privileged applicants.

Further, one must consider that those applicants in the most prevalent typology – Advantaged – tend to have a positive return on investment when considering the ratios of applications submitted to acceptances received. This relationship may be related to higher academic metrics, access to academic support, and an increased ability to apply to geographically distant schools and attend in-person interviews at schools far from home. Additionally, resources are not just monetary. Applicants most likely in the Advantaged Class had highly educated parents with high incomes; many may work in healthcare, which would allow applicants direct access to shadowing and volunteering opportunities, thus contributing to more robust healthcare experiences for medical school applications.[18]

Membership in the Advantaged and Private group shared similarities with the purely Advantaged class but were reluctant to answer questions when a "decline to respond" category was offered. This research study demonstrates that the increased probability of membership in this group seems associated with an inverse correlation with GPAs and also lacks the moderate positive correlation with MCAT scores that is associated with the probability of membership in the Advantaged typology. One might speculate that these individuals understand that they have experienced limited socioeconomic hardship but desire an edge in the competitive admissions process if they do not have strong academic metrics on their side. They may see opting out of responses about their background as a way to get past initial admissions screenings since they have an understanding of the importance of holistic review and diversity recruitment efforts in medical admissions.

The odds of acceptance to medical school and matriculation in medical school were greatest for higher probabilities of membership in the Advantaged typology. However, these relationships disappeared when MCAT was added as a covariate to the models. This change may suggests that the increased odds are an artifact of the high MCAT scores associated with members of the Advantaged typology. The opposite pattern was observed for the probability of membership in the Disadvantaged or Disadvantaged Caretaker typologies; the odds of acceptance and matriculation to medical school were lower with increasing probability of membership but became higher when controlling for MCAT score.

This phenomenon suggests that the lower MCAT scores associated with typology membership are potentially confounding the relationship between typology membership

and markers of success in medical school admissions. When limiting the analysis to applicants accepted to one or more medical schools, an increased chance of membership in the Disadvantaged typology was associated with higher odds of matriculating, even when controlling for MCAT scores. Perhaps members of this typology are more motivated to enroll, or this relationship could be due to the presence of scholarships or other modes of financial support.

An alternative explanation for the reversals of statistically significant associations in advantaged and disadvantaged typologies when MCAT score was included as a covariate in logistic regression models may be related to multicollinearity. Regression analyses seek to isolate the associations between each predictor (independent) variable and the outcome (dependent) variable. When the independent variables in a model are correlated, estimating the independent effect of a predictor variable on an outcome while holding covariates constant is no longer possible because the independent variables change in unison. Average MCAT score varied with typology membership; therefore, multicollinearity is potentially a factor.

The interplay between SES, standardized testing and admissions is complex. Structural racism and classism have long led to minority and marginalized communities to have lower-performing schools, less access to additional academic support, and lower standardized test scores.[34] Medical school admissions tend to place a high value on MCAT scores as a predictor of success in the challenging medical school curriculum. However, placing too much emphasis on MCAT scores in medical school admissions makes it challenging to create medical school cohorts that reflect underserved communities.[27] In this study, advantaged groups had higher MCAT scores and higher

odds of acceptance to at least one school. This relationship reversed when incorporating MCAT as a covariate in the analysis. Disadvantaged groups had lower MCAT scores and lower odds of acceptance, but when MCAT was included as a covariate, group members had higher odds of acceptance and matriculation into medical school.

This introduces the possibility that odds of acceptance are likely confounded by medical schools' value on high MCAT scores; the scores may be valued since they imply increased student success, but also because the prestige of the medical school increases with higher average student MCAT scores.[28] Applicants with mid-range MCAT scores were found to be more diverse, and schools can increase diversity amongst their classes by selecting applicants with mid-range scores.[35]

Adding interaction terms for typology membership and applicant MCAT score to the logistic regression models can investigate potential confounding. These interaction terms would test the hypothesis that the relationship between typology membership on admission or matriculation was different for applicants with varying levels of MCAT scores.

Research incorporating regression modeling to examine the impact of inclusion or exclusion of academic metrics like MCAT score from medical applicant interviewers found that when interviewers were provided with the applicant's GPA and MCAT score, these academic metrics explained more of the variation in interview score as when these scores were withheld from interviewers. When MCAT score was examined for an interaction with cohorts of applicants with academic metrics provided or withheld from interviewers in regression models, a statistically significant interaction on applicant interview scores was not observed.[36]

The results of this study may inform the development of a scale or weighting system since it is not currently known which combination of advantage factors seem to create the largest facilitators and barriers toward successful matriculation into medical school. While the scope of this study is not able to untangle whether the interaction of advantage status indicators is summative, exponential, synergistic, or subjective, it is a starting point toward further research. It does demonstrate that treating indicators of advantage and disadvantage as additive may best fit with Advantaged applicants; These applicants comprised 57% of the dataset and had selected the most privileged choices to every advantage status question on the AMCAS. However, the complexity of the interplay of advantage status measures increases for those in the Mixed, Disadvantaged, and Disadvantaged Caretakers typologies, and a summative scale may not capture the experiences of these groups nor accurately reflect the magnitude of marginalizations members of these groups experience.

This research study has many strengths, namely access to a generalizable dataset from a national sample of medical applicants as well as data about how these applicants fare in the extremely competitive medical school admissions process. Additionally, the intersectional approach to SES did not require placing applicants in silos as partial representations of their backgrounds. Further, consideration of applying to medical school as an investment and creating a novel formula to understand how the returns on this investment may vary by typology is a new method of approaching disadvantage in medical school applicants.

Most medical students will graduate from their programs with a degree, so medical admissions committees are able to shape the qualities of the new physician

workforce to best address health inequalities in the United States. This research project provides new insight into the complex topic of SES in medical school applicants. It may prove useful to admissions officers, who may not know what aspects of applicant background are associated with privilege or marginalization in the admissions process. Data on medical school applicant backgrounds are compelling, but it is difficult to ignore the fact that no single measure can capture applicant adversity.[20,33] These data provide needed insight into trends and allow applicant characteristics to co-mingle in order to best approach intersectional applicant identities and experiences.

Some limitations associated with this research are reliance upon the questions that are asked of medical applicants and the nature of the data released by the AAMC for research use. Applicant data advantage status variables are all self-report, except for the FAP program; the AAMC verifies eligibility for the FAP. Further, there were difficulties in fitting a latent class structure to the dataset of advantage status variables. However, the findings of this research project do follow what is known about applicants, while also providing new information via an analytical technique that has not been used to examine underlying latent variables in applicants to medical school.

The next steps related to this research might be to repeat the latent class analysis and include covariates to group the data and assess model fit amongst subgroups. Surprising associations found in this research study could be explored further, namely, the barriers faced by those applicants who are most likely members of the Mixed typology, and how differences between members of the Disadvantaged group and the Disadvantaged Caretakers typology shape outcomes in applying to medical school.

Additionally, LCA can be used to explore outcomes for those successful in accessing medical education.

This study provided needed information on a topic of great concern in increasing diversity in medical education and the physician workforce. Using an intersectional lens to develop advantage status typologies that are based upon an underlying construct driving applicant response patterns and examining the likelihood of membership in these typologies with how successful applicants are in accessing medical education adds context to the complex topic of class and SES in medical applicants.

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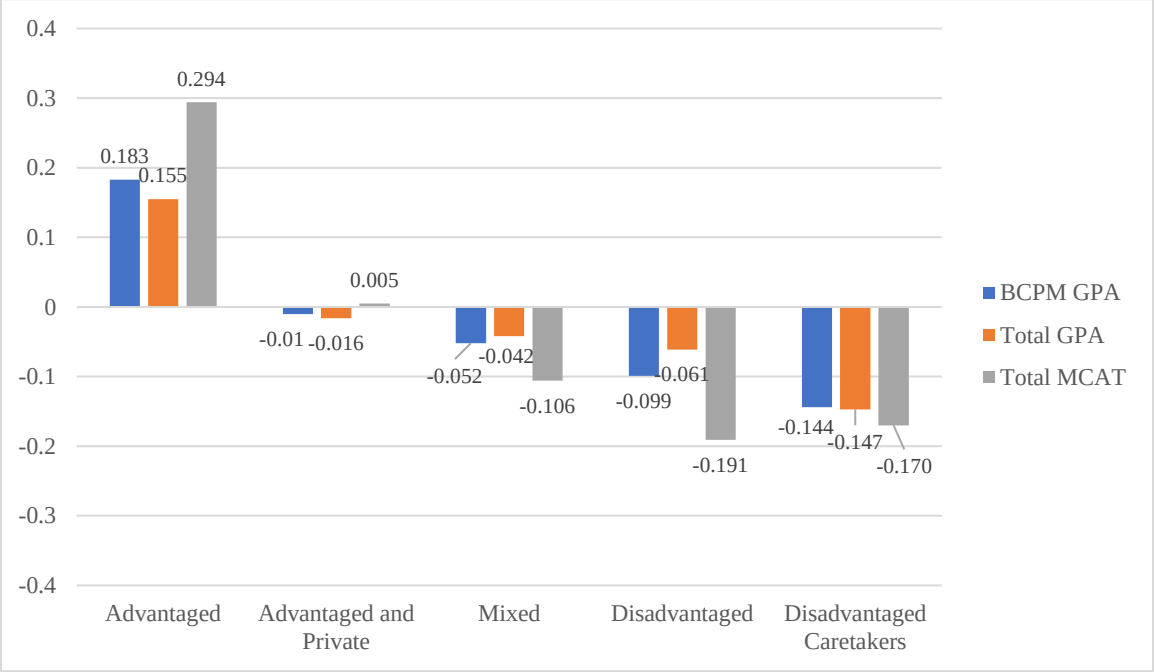
Table 1. Descriptive Academic Metrics and Admissions Outcomes for 2018-2019 Applicants to U.S. Medical Schools by Most Likely Typology Membership

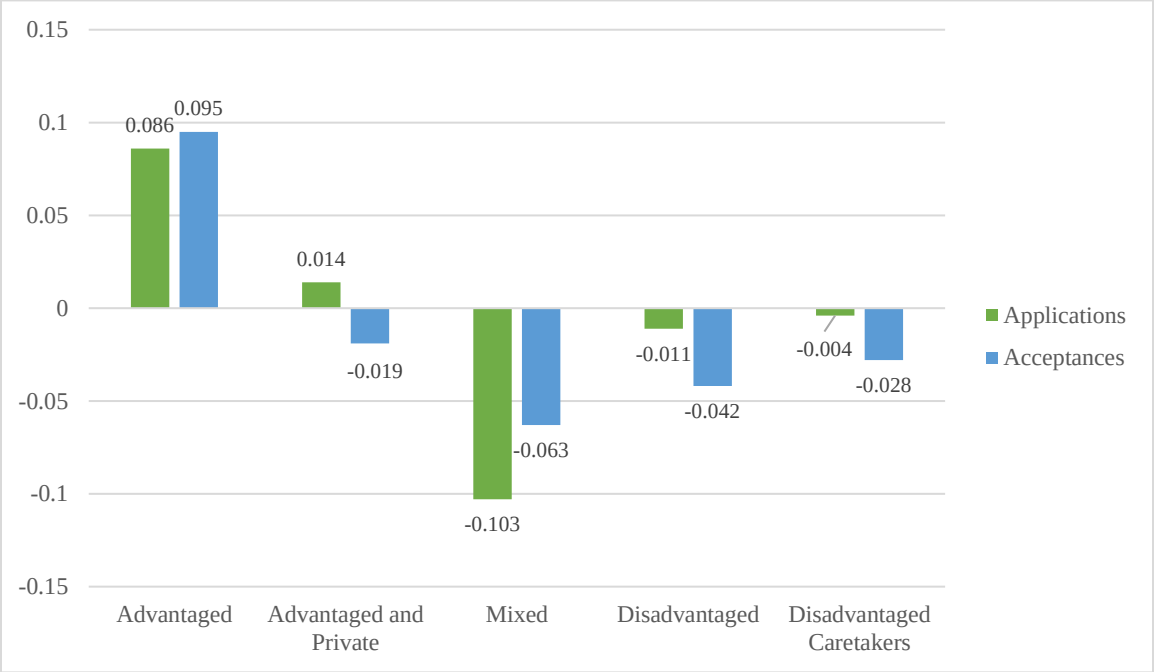
	All	Advantaged	Advantaged & Private	Mixed	Disadvantaged	Disadvantaged Caretakers
n	47,958	26,693	647	11,800	5,541	3,277
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*
BCPM GPA	3.46 (0.43)	3.53 (0.39)	3.43 (0.44)	3.43 (0.44)	3.35 (0.47)	3.26 (0.48)
Total GPA	3.71 (0.28)	3.62 (0.25)	3.68 (0.30)	3.69 (0.30)	3.67 (0.30)	3.57 (0.35)
Total MCAT	505.70 (9.24)	507.98 (8.32)	506.40 (8.82)	504.10 (9.24)	501.18 (9.86)	500.57 (9.23)
Applications	16.81 (12.44)	17.74 (12.59)	18.75 (15.77)	14.91 (11.92)	16.24 (11.59)	16.77 (12.88)
Acceptances	0.87 (1.48)	0.99 (1.53)	0.66 (1.25)	0.73 (1.35)	0.71 (1.42)	0.73 (1.53)
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Accepted to ≥ 1 school	44.0	49.5	37.1	38.6	34.9	34.6
Matriculated (all applicants)	42.4	47.8	35.7	37.1	34.0	33.2
Matriculated (accepted applicants)	96.4	96.5	96.3	96.1	97.4	95.9
	Average Ratio	*Average Ratio*	*Average Ratio*	*Average Ratio*	*Average Ratio*	*Average Ratio*
Return on Admissions Investment (ROAI)	-0.894	-0.885	-0.897	-0.906	-0.917	-0.915

Figure 1. Correlation of 2018-2019 U.S. Medical School Applicant Likelihood of Typology Membership with BCPM GPA, Total GPA, and Total MCAT score (n=47,958)



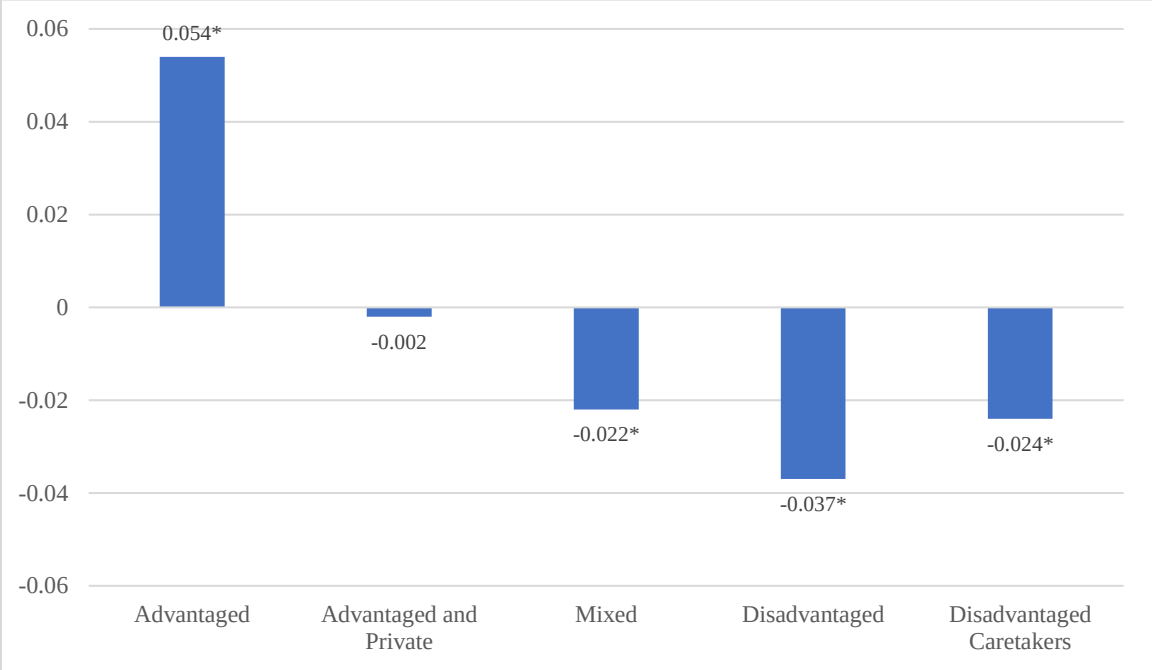
Pearson correlation coefficients. All associations statistically significant ($p<.05$) except MCAT score in Advantaged and Private group.

Figure 2. Correlation of 2018-2019 U.S. Medical School Applicant Likelihood of Typology Membership with Average Number of Applications and Acceptances to Medical Schools (n=47,958)



Pearson correlation coefficients. All associations statistically significant ($p<.05$) except average number of applications in Disadvantaged Caretakers group.

Figure 3. Correlation of 2018-2019 U.S. Medical School Applicant Likelihood of Typology Membership with Return on Admissions Investment (ROAI) (n=47,958)



ROAI=(number of acceptances – number of applications)/number of applications
Pearson correlation coefficients. Associations in typologies with asterisks on data labels indicate statistically significant associations (p<.001.)

Table 2. Logistic Regression with Probability of Typology Membership with and without MCAT Score as a Covariate Predicting at least one Acceptance to Medical School for 2018-2019 Applicants to U.S. Medical Schools

	Predictors	Odds Ratio	95% Confidence Interval
Advantaged	Membership Probability	1.835	1.761 - 1.912
	Membership Probability	0.857	0.815 - 0.902
	MCAT Score	1.184	1.180 - 1.188
Advantaged & Private	Membership Probability	0.723	0.608 - 0.860
	Membership Probability	0.565	0.458 - 0.697
	MCAT Score	1.181	1.177 - 1.185
Mixed	Membership Probability	0.672	0.637 - 0.708
	Membership Probability	0.931	0.874 - 0.991
	MCAT Score	1.181	1.177 - 1.185
Disadvantaged	Membership Probability	0.576	0.538 - 0.617
	Membership Probability	1.310	1.206 - 1.424
	MCAT Score	1.183	1.179 - 1.187
Disadvantaged Caretakers	Membership Probability	0.813	0.576 - 0.872
	Membership Probability	1.610	1.466 - 1.789
	MCAT Score	1.184	1.180 - 1.188

Table 3. Logistic Regression with Class Probability or Class Probability and MCAT Score Predicting Odds of 2018-2019 U.S. Medical School Applicants Matriculating into Medical School

		All Applicants		Accepted Applicants	
	Predictors	Odds Ratio	95% Confidence Interval	Odds Ratio	95% Confidence Interval
Advantaged	Membership Probability	1.807	1.733-1.883	1.008	0.852-1.192
	Membership Probability	0.860	0.818 - 0.905	0.924	0.770 – 1.109
	MCAT Score	1.178	1.174 – 1.182	1.026	1.014 – 1.038
Advantaged & Private	Membership Probability	0.740	0.607 – 0.862	0.885	0.443-1.769
	Membership Probability	0.579	0.470 - 0.714	0.988	0.447 – 2.186
	MCAT Score	1.176	1.172 - 1.179	1.025	1.013 – 1.037
Mixed	Membership Probability	0.672	0.637 – 0.709	0.866	0.701 - 1.072
	Membership Probability	0.924	0.868 – 0.984	0.876	0.701 – 1.094
	MCAT Score	1.175	1.171 – 1.179	1.024	1.012 – 1.036
Disadvantaged	Membership Probability	0.779	0.556 – 0.836	1.554	1.106 – 2.181
	Membership Probability	1.339	1.232 – 1.455	1.761	1.228 – 2.525
	MCAT Score	1.177	1.173 – 1.181	1.028	1.016 – 1.040
Disadvantaged Caretakers	Membership Probability	0.763	0.577 – 0.674	0.864	0.632 – 1.182
	Membership Probability	1.572	1.432 – 1.727	0.972	0.697 – 1.358
	MCAT Score	1.178	1.174 – 1.182	1.024	1.013 – 1.037

CHAPTER 7

Implications and Significance

This research study has many strengths, including the exploration of a generalizable dataset from a national sample of medical applicants as well as the presentation of data on how these applicants perform in the highly competitive medical school admission process.

The results add to the growing body of quantitative research undertaken to explore the concept of intersectionality. By employing a quantitative person-centered approach like LCA to develop typologies of medical school applicant advantage status, this study highlights the intersections of privilege and multiple marginalizations. This work will promote a reconsideration of the use of any single measures of SES as part of the medical school admissions process. Single measures of socioeconomic status and advantages are insufficient to provide needed context to summarize applicants' complex backgrounds (Grbic et al., 2015; Lowrance & Birnbaum, 2019).

While admissions committees are encouraged to employ a holistic approach to reviewing applicants, the introduction of intersectional typologies contributes needed context about types of applicant backgrounds. When single measures are insufficient, asking committees to consider ten advantage status variables for each applicant is not realistic. The introduction of typologies driven by response patterns of medical applicants is both a person-centered and a reductive technique to allow committees to consider types of SES backgrounds as part of holistic review. Further, advantage status typologies represent a holistic presentation of all advantage status variables representing applicant backgrounds; holistic review considers the applicant in context, and advantage status

typologies offer a method to reduce a complex construct into a more accessible framework to operationalize a holistic review of applicants.

This study fills a significant gap in the medical education literature for research exploring aspects of diversity and inclusion without relegating participants to single social construct silos and conceptualizing identities and experiences through an intersectional lens. By allowing advantage status measures to co-exist during the creation of a class system informed by applicant response patterns, the results demonstrated how over half of the medical school applicants indicted backgrounds containing the most privileged categories. This fact adds context about the applicant pool to what is already known about the majority of medical students originating from high-income households with educated parents holding advanced degrees.

Demographic associations within the latent class structures were explored to sharpen fidelity toward an intersectional approach to understanding medical school applicants. The second paper demonstrated that applicant traits associated with greater struggle and oppression in the U.S. were more likely to fall into the mixed and disadvantaged typologies and that intersections of these traits were almost totally absent from most-likely membership in advantaged typologies.

The third paper describes how access to medical school is disparate across social strata. The focus on aspects of applicant advantage status typologies is compelling, given the dearth of research on what dimensions of intersecting combinations of barriers or facilitators might prove to be most significant in the medical school application process. This exploration found that the probability of advantaged typology membership was associated with higher academic metrics, applying to more schools, receiving more

acceptances to medical schools, and an increased likelihood of matriculating into medical school as compared with the probability of belonging to mixed or disadvantaged typologies. However, when MCAT was added as a covariate to regression models for outcomes of acceptance and matriculation, the associations lessened. This phenomenon suggests that the relationships may be confounded by the higher MCAT scores associated with advantaged typology membership, and medical schools' tendency to screen applicants by MCAT and GPA scores and/or view higher MCAT scores as an indication of increased chances of success in medical school. Alternate or additional explanations for this effect may be due to multicollinearity between MCAT and typology membership or interactions influencing varied effects of the predictor variables on associations with outcome variables.

The majority of medical students will graduate with a degree; thus, medical admissions committees can directly shape the future physician workforce to better tackle health inequalities in the U.S. through their decisions on which applicants to offer acceptance. This research project provides admissions committees with new insight into the complex topic of SES in medical school applicants. Knowing that no single measure can accurately capture applicant adversity (Grbic et al., 2019; Lowrance & Birnbaum, 2019), admissions officers may desire clarity on what aspects or combinations of applicant background are associated with privilege or marginalization in the admissions process. These data provide needed insight into trends while allowing applicant advantage status measures to co-mingle in order to best approach intersectional applicant identities and experiences.

However, if medical school admissions personnel are choosing applicants from a pool of applicants weighted by advantaged backgrounds, it is unclear how much of an impact selection processes might have on the diversity of the physician workforce. This speaks to a need for academic medicine to increase the proportion of mixed and disadvantaged typology members in the applicant pool.

Recommendations

Achieving socioeconomic diversity in medical applicants and students is a complex issue with many potential points of intervention. Still, a sensible first step might be increased development of pipeline programs, where medical schools partner with high schools, community colleges, and undergraduate universities to encourage and mentor disadvantaged students and those underrepresented in medicine to increase their chances of successfully accessing medical education.

The ranking of medical schools may result in limited diversity of medical students. Academic metrics like average student grade point average and MCAT score are used to rank the quality and prestige of medical schools and are used by applicants to understand to which medical schools they should apply to maximize their chances of success. Given that, on average, applicants from underrepresented groups may possess lower academic metrics, ranking places undue pressure on schools to recruit only those underrepresented applicants with higher MCAT scores and GPAs. Thus, the act of ranking schools by academic metrics presents a barrier to a greater diversity of medical students. The ranking process should shift away from incorporating academic metrics in ranking formulas, but these data should still be accessible to applicants to allow them to best target schools to which they apply in order to maximize their chances of success.

The accrediting body of U.S. medical schools, the Liaison Committee on Medical Education (LCME), asks medical schools to report on pipeline programs, efforts that are made to increase the diversity of medical students, and the resulting diversity in their medical student body. However, these well-intentioned requirements may have unintended consequences. Medical schools may be hesitant to target particular groups of underrepresented applicants if they anticipate that recruitment could prove particularly challenging (Laraque-Arena, 2019). A medical school's failure to meet recruitment goals could introduce additional risk to successful reaccreditation, and therefore, schools may naturally want to set only feasible goals. In order to encourage schools to take risks and target groups of applicants that, in practice, may prove challenging to recruit, the LCME should consider shifting focus toward the process (e.g., identified groups, the efforts made to recruit applicants from those groups), rather than focusing on the success of those recruitment efforts.

This research also offers policy implications for the AAMC. Though the AAMC provides support for disadvantaged typology members, such as need-based aid and fee waiver programs, the probability of membership in the Mixed typology was associated with fewer applications to schools and a lower return on investment of those applications. Expanding need-based programs to include members of this typology might facilitate increased representation of Mixed typology members in medical school and, eventually, the physician workforce. The AAMC's efforts to provide a set number of free applications to all applicants will certainly help members of the mixed and disadvantaged typologies to apply to more medical schools. However, applicants in the advantaged classes will also receive these benefits. Given that this typology constitutes a majority of

the applicant pool and members have high ROAI, perhaps the AAMC could offer free applications to only those in the Mixed, Disadvantaged, and Disadvantaged Caretaker typologies. The AAMC could also consider developing a need-based award program for interview travel costs, or encourage schools to incorporate more virtual interviews so that students of less-advantaged backgrounds do not have to pay for travel and will have a higher chance of attending interviews.

Finally, an easily implemented policy change for the AAMC involves questions on the AMCAS application. This research identified a group of applicants that seemed to have highly advantaged backgrounds but were able to decline to answer indicators that might provide more context for admissions committees. Given that an answer option of declining to answer indicates that there is a real value for the item, but the applicant does not want to provide it, it is not clear why applicants are able to opt-out of responding. Questions related to advantage status should be required for all applicants, including non-U.S. Citizens and non-permanent residents. The AAMC could also consider changing more self-report items to those that can be verified. For example, applicants self-report about having lived in medically underserved areas. Given that applicants may not know this status and there are reliable data sources identifying these areas, the AAMC might consider a different strategy, such as using zip codes supplied by applicants to generate an indicator of having lived in medically underserved areas.

This novel research study allows for the generation of new hypotheses to help medical schools develop strategies to overcome challenges in recruiting a diverse body of medical students and increasing physician workforce diversity, ultimately reducing national health inequalities. Medical education researchers might consider the use of a

similar person-centered analytical approach to evaluate academic performance, licensing exam scores, retention, and residency match rates across the continuum medical education.

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