



Cross-sectional Study

Variability in tuition and curriculum among allopathic and osteopathic medical schools in the United States

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ABSTRACT

Background: Medical school tuition has increased dramatically. We aimed to characterize allopathic and osteopathic medical school tuition and its association with geographic region, pre-clerkship and clerkship curriculums, and compare tuition between allopathic and osteopathic schools.

Methods: US allopathic and osteopathic in-state tuition were extracted from the AAMC and AACOM databases and adjusted for cost-of-living. Schools were divided by geographic regions (West, Midwest, South, Northeast). Pre-clerkship and clerkship curricula characteristics were collected from school websites. Pre-clerkship curricula were categorized into one of six categories: 1) discipline-based, 2) organ system-based, 3) combined discipline/organ system based, 4) team-based learning, 5) mixed, and 6) other. Clerkship curricula characteristics collected included; required research block, out-of-state elective option, and global health (international) elective option. This study was reported according to STROCSS guidelines.

Results: For allopathic schools, unadjusted and adjusted tuition was significantly higher in the Northeast. After adjusting for cost of living, the West displayed significantly larger in-state tuition than the South. No association was seen between tuition and pre-clerkship curriculum. Of the clerkship characteristics, presence of a required research block or global health electives corresponded to higher tuitions. For osteopathic schools, tuition in the West was significantly higher than the South and Midwest. Schools that offered a discipline-based pre-clerkship curriculum had higher tuitions than other curricula. Clerkship characteristics were not associated with tuition variation.

Conclusions: US medical school tuition is highly variable, demonstrating associations with geographic regions and curriculum characteristics. There is increasing value in team-based learning modalities in improving professional communication skills.

1. Introduction

The decision to train as a physician has always been an investment of hard work, personal sacrifice, and, increasingly so, finances. Since the 2013–2014 school year, tuition has increased by 22.5% and, in the past year alone, by 10.3% [1,2]. The average medical student debt is \$200,000 and projected to reach \$750,000 by 2033 [2–4].

For many potential applicants, tuition is an important consideration. For some, it will be the ultimate barrier to pursuing a medical education. Tuition has been shown to be variable across the United States (US) resulting in an uneven financial burden on medical students. Studies have demonstrated correlations with region and medical school ranking [5,6]. However, given recent uptrends in tuition, current factors

contributing to tuition variation need to be further explored.

High levels of indebtedness among graduates are matters of concern to the community. From a purely financial standpoint, current educational financing may not withstand debt levels above a certain ceiling [7]. Further, high debt has been shown to influence graduates' choice of specialty [8,9]. Studies have shown that students with higher debt levels placed more importance on future income [10] and were less likely to pursue a career in primary care despite recent policies providing financial incentive to do so [11–13].

Medical student debt has repeatedly been shown to be negatively associated with mental well-being and academic outcomes [14]. Therefore, it is important to objectively characterize the reason for such variability and growth in medical school tuition and increase

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transparency.

One of the main selling points of medical schools is its curriculum. In recent years, medical schools have been moving from the traditional Flexner model, consisting of two years of discipline-based didactics and two years of clerkships, to an integrated or mixed curriculum [15]. Further, there has been an increased emphasis on team-based learning, whether in the classroom or other modalities, such as simulation. Schools also offer various elective options, such as research blocks or Global Health electives (GHE), which may influence a student's decision to attend. Given the variety in curricula offered, medical school applicants must consider which seems more appropriate for their learning. Ultimately, if these elective options factor into higher tuition, applicants must carefully consider the cost-benefit. This, however, has not been addressed in the literature.

Existing literature has assessed variation in allopathic medical school tuition by region, ranking, and population density. However, no study has assessed tuition variability in osteopathic schools or compared tuition between allopathic and osteopathic schools, which could be an important consideration for applicants. Therefore, this study aims to analyze tuition variability in allopathic and osteopathic medical schools by geographic region, and analyze variability in tuition when adjusted for cost-of-living (COL).

There is an additional paucity of literature assessing type of curriculum and electives offered at allopathic medical schools in the US, and any correlation with tuition. Therefore, the second goal of this study was to assess the type of curriculum associated with variability in school tuition.

2. Methods

This is a cross sectional study that includes all Liaison Committee on Medical Education (LCME)-accredited US medical schools in all fifty states, District of Columbia (DC), and Puerto Rico, and all osteopathic medical colleges as recognized by the American Association of Colleges of Osteopathic Medicine (AACOM). The study included all accredited schools under each respective organization (i.e. AAMC for allopathic schools, AACOM for osteopathic schools) and their satellite locations with unique tuitions to account for locational variability even within the same institution. US allopathic medical schools' 2020–2021 academic year annual tuition public data was extracted from the Association of American Medical Colleges (AAMC) online *Tuition and Student Fees for First-Year Students AAMC Tuition and Student Fees Questionnaire*. Osteopathic medical colleges' 2020–2021 academic year annual tuition was extracted from the AACOM *Annual Osteopathic Medical School Questionnaire*. The in-state tuition was utilized.

All medical schools were categorized by geographic regions, as defined by the US Census Bureau (West, Midwest, South, Northeast). Tuition variability was analyzed separately by regions and by state through mean, median, and quartiles; allopathic and osteopathic medical school tuitions were then compared.

2.1. Adjusting for geographic differences in cost of living (COL)

In order to adjust for geographic differences in the cost of in-state tuition among medical schools, the 2020 American Chamber of Commerce Research Association Cost of Living Index (COLI) was obtained, where an index of 100 was treated as 1.00. Adjusted mean in-state tuition (MIST) was computed by multiplying the in-state tuition of each medical school by the corresponding state-level COLI and calculating their respective categorical averages.

2.2. Curriculum

Each medical school's curriculum was classified by predominant learning modality, defined as the type of curriculum used during at least two of the pre-clerkship semesters, as collected from medical school's

websites (curriculum roadmaps, academic calendar, and course catalogs) and divided into pre-clerkship and clerkship. Pre-clerkship curricula were classified by six categories: 1)discipline-based, 2)organ system-based, 3)combined discipline and organ system-based, 4)team-based learning, 5)mixed, and 6)other [17]. The curricula sub-types were obtained from the AAMC Curriculum Directories and prior literature [18], with the addition of team-based learning and a combined discipline and organ system-based curriculum. Curricula were categorized as mixed if they were composed of two or more of the pre-defined categories (1–4) and as other if they were completely unique and did not fall under the pre-defined categories (1–4). Clerkship characteristics, including presence of a required research/scholarly block, out-of-state (OOS) elective option, and option for GHEs (international) were recorded. This study is reported according to STROCSS guidelines [16] and was registered in research registry under identifying number researchregistry6981.

2.3. Statistical analysis

IBM SPSS Statistics v26.0 (Armonk, NY) was used for statistical analysis. ANOVA test was used to evaluate the MIST (and adjusted MIST) and corresponding Census regions and pre-clerkship curricula. The Bonferroni post-hoc test was used when analyzing and comparing mean tuition by region in order to correct for multiple testing. Independent-sample t-tests were used to evaluate the difference in MIST (and adjusted MIST) between allopathic and osteopathic medical schools. In addition, independent-sample t-tests were utilized to evaluate significant differences between the MIST of allopathic and osteopathic medical schools and the presence/absence of corresponding pre-clerkship curricula features (e.g. required research, GHE, etc.) Two-tailed p-values were used in each analysis. Significance was defined as $p < 0.05$. This study was conducted in compliance with ethical standards, used publicly available data and deemed exempt by our Institutional Review Board.

3. Results

Out of a total of 151 allopathic medical schools, the average in-state tuition was \$41,741 (median: \$40,479) and the mean adjusted in-state tuition was \$45,117 (median: \$46,323). Out of a total of 37 osteopathic medical schools with 41 unique tuitions, the average in-state tuition was larger than allopathic schools' even after adjusting for COL.

3.1. Allopathic medical schools

The South region harbored the most allopathic medical schools at 57 (37.8%) schools, followed by the Northeast, Midwest, and West region (Table 1a). The South region exhibited the lowest MIST, followed by the West, Midwest, and Northeast (Table 1a). The Northeast displayed a significantly larger mean tuition than the West ($p < 0.001$), Midwest ($p = 0.026$), and South ($p < 0.001$) regions. The Midwest displayed a significantly larger MIST than the South ($p = 0.007$) region (eTable 1).

Out of 151 total allopathic medical schools, 146 contained sufficient information about their curriculum to be included in this analysis. The most prevalent curriculum type among allopathic schools was organ system-based (44.5%), followed by mixed organ system/discipline-based (24.0%), team-based (18.5%), primarily discipline-based (11.0%), and "other" (2.1%). Team-based was the only curriculum type implemented at a medical school that did not charge tuition. There was no significant correlation between MIST and curriculum type (Table 1b, eTable 2).

However, allopathic programs that offered a required research/scholarly project exhibited a significantly larger MIST than those that did not ($p < 0.001$). In addition, allopathic medical schools that offered a GHE in their curriculum demonstrated significantly larger MIST than those that did not ($p = 0.017$) (Table 1c).

Table 1a
In-state mean tuition of U.S. Allopathic medical schools by region.

U.S. Region	Number of Allopathic Medical Schools	Mean Tuition (\$)	Standard Deviation	95% Confidence Interval of Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
All	151	\$41,742	14,771	39,367	44,117	0	65,566
West	23	\$37,353	15,515	30,644	44,062	0	64,538
Midwest	35	\$44,151	11,949	40,046	48,255	29,680	65,476
South	57	\$34,876	14,532	31,020	38,731	0	62,060
Northeast	36	\$53,075	8936	50,052	56,098	36,030	65,566

Table 1b
Comparison of the mean Tuition and preclerkship curriculum of allopathic medical schools.

Preclerkship Curriculum	Number of Allopathic Medical Schools	Mean Tuition (\$)	Standard Deviation	95% Confidence Interval of Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
All	146	\$42,126	14,523	39,751	44,502	0	65,566
Primary Discipline	16	\$40,881	14,281	35,968	51,657	18,593	62,980
Primarily Organ System	65	\$44,509	14,786	37,342	44,420	11,442	65,566
Mixed Organ System/ Discipline	35	\$43,264	13,907	39,430	49,589	15,566	63,776
Team-Based (PBL/TBL)	27	\$22,069	10,786	37,763	48,766	0	65,476
Other	3	\$43,812	14,523	-4725	48,863	15,616	34,521

Table 1c
Comparison of curriculum feature and mean tuition in allopathic medical schools.

Curriculum Feature		N	Mean Tuition (\$)	Standard Deviation	95% Confidence Interval		Significance (2-tailed)
					Lower Bound	Upper Bound	
Required Research/Scholarly Project	Yes	43	48,561	14,922	4773	14,884	<0.001
	No	106	38,732	13,828			
OOS Non-Subi-Clerkships	Yes	62	41,956	13,801	-4016	5752	0.726
	No	85	41,087	15,478			
Global Health	Yes	96	43,820	14,015	1081	10,869	0.017
	No	54	37,845	15,488			

Abbreviations: PBL/TBL = Problem-based Learning/Team-based Learning; OOS = Out-of-state.

3.2. Osteopathic medical schools

The South harbored 17 (40.5%) osteopathic schools, followed by 9 (21.4%) in the Northeast region, and 8 (19.0%) in each the West and Midwest region (Table 2a). The West region displayed the largest MIST, followed by the Midwest region, Northeast region, and South region (Table 2a). Only one significant difference in MIST for osteopathic schools was observed between the West (\$59,341) and the South (\$44,686) (p = 0.016) (eTable 3).

Out of 42 total osteopathic medical schools, 41 contained adequate information regarding their curriculum to be included in this analysis. The most prevalent curriculum type among osteopathic medical schools was organ system-based (51.2%), followed by team-based (17.1%), mixed organ system/discipline-based (14.6%), “other” curriculum (9.8%), and primarily discipline-based (7.3%) (Table 2b). Osteopathic schools offering a discipline-based curriculum displayed a significantly higher MIST than those that offer a team-based curriculum. There were

no significant differences by curriculum type otherwise (Table 2c) (eTable 4).

3.2.1. Mean in-state tuition adjusted for cost of living

Overall, osteopathic medical schools displayed a significantly higher MIST than did allopathic medical schools (p < 0.001). Likewise, after adjusting for differences in geographical COL, osteopathic medical schools exhibited a significantly larger MIST than did allopathic medical schools (p = 0.024).

3.3. Allopathic medical schools

The Northeast exhibited the largest adjusted MIST, followed by the West, the Midwest, and the South region (eTable 5). In comparison to the unadjusted MIST of allopathic medical schools, after adjusting for state COL, the Northeast remained the highest tuition; however, the West became the second-highest adjusted MIST (Table 1a, eTable 1).

Table 2a
Mean in-state tuition of U.S. Osteopathic medical schools by region.

U.S. Region	Number of Osteopathic Medical Schools	Mean Tuition (\$)	Standard Deviation	95% Confidence Interval of Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
All	42	49,812	11,652	46,181	53,442	13,079	73,348
West	8	59,341	5100	55,077	63,605	53,500	71,146
Midwest	8	52,981	10,279	44,387	61,574	37,068	73,348
South	17	44,686	12,496	38,261	51,111	13,079	56,000
Northeast	9	48,206	10,424	40,193	56,218	34,830	60,450

Table 2b

Comparison of the Mean In-State Tuition and Preclerkship Curriculum of Osteopathic Medical Schools. *41 out of 42 total osteopathic schools contained sufficient information about their curriculum to be included in this analysis.

Preclerkship Curriculum	Number of Osteopathic Medical Schools	Mean Tuition (\$)	Standard Deviation	95% Confidence Interval of Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
All	41*	49,601	11,715	45,903	53,299	13,079	73,348
Primary Discipline	3	67,211	8971	45,373	89,050	57,140	73,348
Primarily Organ System	21	50,536	9842	46,056	55,016	22,472	59,650
Mixed Organ System/ Discipline	6	51,465	5201	46,007	56,924	44,000	58,600
Team-Based (PBL/TBL)	7	40,110	13,959	27,200	53,020	13,079	56,000
Other	4	45,300	11,825	26,483	64,116	34,830	60,450

Table 2c

Comparison of curriculum feature and mean in-state tuition in osteopathic medical schools.

Curriculum Feature		N	Mean Tuition (\$)	Standard Deviation	95% Confidence Interval		Significance (2-tailed)
					Lower Bound	Upper Bound	
Required Research/Scholarly Project	Yes	5	48,074	2625	-6759	2815	0.408
	No	37	50,046	12,384			
OOS Non-Subi-Clerkships	Yes	31	48,818	12,860	-12,073	4485	0.360
	No	11	52,612	6986			
Global Health	Yes	25	48,634	12,181	-10,345	4528	0.434
	No	17	51,543	10,952			

Abbreviations: PBL/TBL = Problem-based Learning/Team-based Learning; OOS = Out-of-state.

The Northeast continued to display a significantly larger MIST than the Midwest and South ($p < 0.001$, respectively) and the West ($p = 0.008$) regions. The South no longer exhibited a significantly larger MIST than the Midwest region, however, the West region exhibited a significantly larger MIST ($p = 0.040$) than the South region after adjusting for COL (eTable 6).

After adjusting for geographical COL, allopathic medical schools that offered a mixed organ system/discipline-based curriculum displayed the largest MIST, followed by primarily discipline-based, organ system-based, team-based, and finally, "other" curricula (eTable 5). MIST did not differ significantly by curriculum type after adjusting for COL (eTable 7).

Allopathic medical schools that offered a required research/scholarly project displayed significantly larger adjusted MIST as compared to those that did not ($p < 0.001$) (eTable 5). In addition, allopathic medical schools that offered a GHE demonstrated significantly larger adjusted MIST than those that did not ($p = 0.020$) (eTable 5). Finally, no significant difference in adjusted MIST was found between allopathic medical schools that did and did not offer out-of-state (OOS) non-subintern clerkships ($p = 0.440$) (eTable 5).

3.4. Osteopathic medical schools

After adjusting for geographical COL, osteopathic medical schools in the West region exhibited the largest MIST, followed by the Northeast, Midwest, and South regions (eTable 8). The West region demonstrated a significantly higher MIST than the Midwest ($p = 0.009$), South ($p < 0.001$), and Northeast regions ($p = 0.019$). Otherwise, no significant differences in adjusted MIST of osteopathic medical schools (eTable 9).

After adjusting for geographical COL, osteopathic medical schools offering primarily a discipline-based curriculum demonstrated the largest MIST, followed by primarily organ system-based, mixed organ system/discipline-based, "other" curricula, and team-based curricula (eTable 8). MIST did not differ significantly by curriculum type after adjusting for COL (eTable 10).

No significant differences in the adjusted MIST were observed between osteopathic schools that did and did not offer a research elective, OOS non-subintern clerkships, or GHEs (eTable 11).

4. Discussion

Our study demonstrates that medical school tuition across the US is highly variable for both allopathic and osteopathic schools, even when adjusted for COL. However, the contributing factors and ramifications for such variation are poorly understood [1–3,13]. Existing literature has demonstrated significant variability in tuition for allopathic schools, even within the same city [5,6]. One key factor observed in this study was geographic region, with allopathic medical school tuition being highest in the Northeast. This finding is consistent with those in prior literature. In 2020, Ginocchio et al. published a retrospective study investigating factors associated with patterns in 2018–2019 U.S. medical school tuition, including total enrollment, establishment year, and other characteristics extracted from the AAMC online Medical School Admission Requirement database [5]. The study found that for the included 148 schools, tuition was significantly correlated with geographic region and highest in the Northeast (\$49,662), even after adjusting for cost-of-living. In addition, tuition demonstrated positive correlations with medical schools' regional population density and years since establishment and negative correlations with US News rank and NIH rank (more expensive for higher ranked schools). This trend has remained constant over time; a retrospective analysis by Gil et al. published in 2015 containing all 123 AAMC-accredited allopathic medical schools also demonstrated significantly higher tuition in the Northeast (\$45,892) than any of the other three regions [6]. Variation in the reported in-state tuition among allopathic medical schools may be influenced by differences in in-state tuition reported by the AAMC vs. U.S. News and World Report, and changes in tuition over time [5,6]. However, these findings may reflect a true difference in tuition by geographic region, which could be explained by a concentration of high population density areas in the Northeast when compared to other geographic regions, which would disproportionately increase tuition. A geographic analysis of areas of population density correlated with locations of medical schools would provide interesting insight into this potential contributing factor.

Unlike previous studies [5,6], there was no significant variation in the West, Midwest, and South regions, demonstrating some evening out of tuition in those regions. When adjusted for COL, tuition in the

Northeast was even higher, suggesting a disproportionately high tuition. Furthermore, the West exhibited a significantly higher MIST ($p = 0.040$) than the South region after adjusting for COL. In contrast, the MIST of the Midwest region was no longer significantly greater than the South region as in the unadjusted analysis. It has been previously demonstrated that the strongest independent predictor of tuition is US News & World rank [5]. However, the US News ranking system is largely based on a qualitative assessment of the medical school itself, utilizing peer and residency director assessment scores as a surrogate for quality of the medical school education [19]. The quantitative assessment lies with undergraduate statistics, such as MCAT scores and ‘undergraduate achievement’, as well as acceptance rate, faculty-to-student ratio, and research productivity of the institution. None of these factors actually measure the quality of the medical school curriculum. The schools are also not ranked based on other factors that may indicate successful medical training, such as rates of residency matching and the quality of the programs that respective graduates match into, which may be helpful objective measures of quality medical training. Further, factors such as faculty-to-student ratio and research productivity may be influenced by school funding; faculty are significantly less likely to stay at an institution if there are fewer opportunities for promotion and reduced support for scholarly activities [20]. This gives an inherent ranking advantage to those institutions that are long-established and have broader networks, without active assessment of educational quality itself. As our study did not find a significant correlation between curriculum type and tuition, further investigation assessing curriculum types by institutional ranking may be helpful in providing more objective contributions to higher tuition. Prior literature has further cited increased demand for and potential quality of educators at more highly ranked institutions as reasons for higher tuitions [5]. However, faculty at institutions are largely ranked through academic productivity, which is a poor surrogate for actual teaching ability. Again, it is important to create objective measures to quantify the quality of medical education. Although some may use Step 1 scores as a benchmark, the USMLE has indicated that scores will be reported as pass/fail as of January 2022. Therefore, other measures should be established. Our study did find regional differences in tuition; based on these findings, it may be interesting to assess the geographic distribution of highly ranked institutions and whether it correlates with geographic trends in tuition.

Osteopathic medical school tuition was highest in the West, and significantly higher in the West than in the Midwest and South when adjusted for COL. The variation could be in part due to the type of curriculum offered, as observed. Although it has not been studied, osteopathic tuition may also correlate with school rankings. If so, the geographic distribution of highly ranked osteopathic schools may also be worthwhile to investigate. More likely, the West contains several desirable locations to live, including three of the top 5 best states (Washington, rated at number 1; Utah at 3; Idaho at 5) according to U.S. News [20]. This demonstrates significant overlap with the best states for young adults, including Utah at 1 and Idaho at 5, all of which may create higher demand for schools located within these states. However, prior literature has further demonstrated variation within localities, indicating that location is only one contributing factor and does not justify such tuition variability [5].

Our study also demonstrated that osteopathic medical school tuition was significantly higher than that of allopathic medical schools, with and without adjusting for COL. It is unlikely that this discrepancy is due to school ranking alone, as per U.S. News rankings osteopathic schools do not disproportionately constitute the higher rankings. This specific variation is most likely due to the majority of osteopathic schools being private institutions [21], although this variation was largely accounted for by only comparing in-state tuitions. It may also be that there are fewer osteopathic schools but a higher demand proportional to that of allopathic medical schools, resulting in increased tuitions.

Our study is also the first to characterize allopathic and osteopathic medical school curricula. There was no association between type of

allopathic medical school pre-clerkship curriculum and tuition. Interestingly, there was a significant difference in the mean tuition of osteopathic medical schools by pre-clerkship curriculum, with those utilizing a discipline-based curriculum demonstrating significantly higher tuition. Discipline-based curricula have been around since the 1900s and are the traditional type of curriculum [22]. Institutions that offer discipline-based curricula may be longer established. Length of establishment has been previously hypothesized to correlate with higher medical school rankings; based on the U.S. News ranking criteria, as mentioned previously, this may be the case. Peers and program directors may be more inclined to view well-established and longer-established institutions more favorably. This, however, requires more granular investigation as similar trends were not demonstrated for allopathic schools. This trend may also have only been demonstrated for osteopathic schools given the smaller sample size. Otherwise, medical school applicants may be more inclined to apply to those osteopathic schools offering the tried and true discipline-based curricula, which would increase demand.

However, it may be worthwhile for applicants to strongly consider schools that offer team-based learning, for a variety of reasons. First and foremost, medicine is increasingly a team-based practice, and requires professional intra- and inter-disciplinary communication. The AMA endorses the most effective way to practice medicine is as a part of a physician-led team, allowing for maximization of all healthcare skillsets [23]. Communication is also important in a patient-physician relationship. Team-based learning allows trainees to practice these communication skills in a variety of settings and on a variety of topics. A quasi-experimental study by Faezi et al. found that a cohort of 84 third-year medical students who participated in team-based learning demonstrated higher engagement, higher satisfaction, and better long-term learning that those who participated in traditional didactics-based learning over the course of three 3-h weekly rheumatology learning sessions [24].

This study also looked at three clerkship curricula characteristics: a required research/scholarly project block, out-of-state electives (non-Sub-Internship), and presence of a GHE. For allopathic medical schools, adjusted tuition was significantly higher for those schools that require a research block and those that offered a GHE, and there was no significant difference for osteopathic schools. These electives offer trainees the opportunity to become not only more well-rounded physicians but also more well-rounded academicians. Research experience in training as a medical student can also translate to more job opportunities in academic medicine after residency. Learning how to conduct research as a student can provide tremendous benefit when conducting more autonomous research as a resident and beyond. Global health opportunities are also important, as cultural competency and sensitivity are highly valued in a physician [25]. Therefore, this finding could indicate that a research block and GHE cost more for schools to offer. For example, medical students attending a GHE often undergo training prior to departure and may incur additional costs on the school and may be reflected in the tuition [26]. Future studies may consider investigating any variations in tuition between schools that offer full vs. partial stipends for GHEs. Alternatively, it could indicate that schools that offer the two are more highly sought after by medical students, and so tuition is driven up by demand.

As our study demonstrated, tuition variability is still significant across geographic regions, although less so than previous years. High costs could play a barrier to potential medical school applicants. Additionally, a longstanding concern in the medical community has been the role of debt in choice of specialty. The AAMC concluded that education debt does not seem to play a major role in specialty choice [4]. Despite this, there is a lack of accountability governing medical school tuition, which seem to be largely unrelated to type of curriculum offered.

Some medical schools have taken steps to alleviate the increasing financial burden on medical students. One medical school has offered free tuition to all its students, with the goals of reducing debt, increasing

students who choose primary care specialties, and increasing the socioeconomic diversity of the student body [27]. Eight US medical schools have implemented three-year programs to combat rising debt and a predicted physician shortage [28]. The current Biden administration has proposed plans for student loan forgiveness and extension of student loan forbearance. Other efforts include no-loan financial aid packages, fully paid tuition and fees for physician-scientists, and merit-based scholarships [29].

This study has several limitations. First, this study did not include costs of medical education outside of tuition (e.g. student health insurance and additional fees). Second, the curriculum for each medical school was collected from each school's website. Schools are not required to advertise GHEs or research opportunities on their website; therefore, our analysis likely falls short of the true number of schools offering either research or GHEs. Our study also did not assess all aspects of the curricula completely so there is room for further granularity. Finally, we were unable to assess other variables that likely factor into a school's MIST, such as academic match results, research and academic productivity, academic funding/resources and quality of life.

Future studies should investigate the effects of the variability in tuition as a potential barrier to medical education. This is of particular importance to underrepresented racial/ethnic minorities, as they are overrepresented in lower socioeconomic status [30]. The magnitude and variability of tuition across regions is likely to create additional financial barriers for underrepresented minorities. Therefore, we recommend increased transparency from medical schools regarding factors that determine tuition, as further granularity in various curricula and associated administrative costs may provide more insight into the inconsistencies seen in medical school tuition.

5. Conclusions

US medical school tuition is highly variable and is highest in the Northeast and in the West region for allopathic and osteopathic medical schools, respectively. Greater tuition is associated with some elements of curriculum, including discipline-based curriculum for osteopathic schools and some electives (research and global health) in allopathic schools. However, there are other contributory factors, such as geographic distribution of highly ranked schools, that require further investigation. Despite limited literature assessing the effectiveness of various curriculum types, there are benefits to the newer team-based curricula, including more opportunities to practice communication. Tuition continues to be a significant consideration and potential barrier

for medical school applicants; while some schools have taken measures to bridge this gap, efforts to continue improving access to medical education should continue. Additional studies allowing for objective quantification of curricular quality and quality of overall medical education will help enhance transparency and provide further understanding of tuition variability.

Provenance and peer review

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None.

Ethical approval

This study was conducted in compliance with ethical standards, reviewed by our institutional review board and deemed exempt.

Trial registry number

This study only used publicly available data, and registered with UIN researchregistry6981. No human subjects' data was used.

Author contributions

Study design and conception: Adel Elkbuli.

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All authors read and approved the final manuscript.

Guarantor

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eTable 1
Comparison of the Mean In-State Tuition of U.S. Allopathic Medical Schools by Region.

Census Region	Mean Difference (\$)	95% Confidence Interval of Mean		Significance	
		Lower Bound	Upper Bound		
West	Midwest	-6798	-16,116	2521	0.318
	South	2477	-6099	11,053	1.000
	Northeast	-15,722	-24,989	-6455	<0.001
Midwest	West	6798	-2521	16,116	0.318
	South	9275	1820	16,730	0.007
	Northeast	-8924	-17,165	-683	0.026
South	West	-2477	-11,053	6099	1.000
	Midwest	-9275	-16,730	-1820	0.007
	Northeast	-18,199	-25,590	-10,809	<0.001
Northeast	West	15,722	6455	24,989	<0.001
	Midwest	8924	683	17,165	0.026
	South	18,199	10,809	25,590	<0.001

eTable 2

Comparison of the Mean Tuition and Preclerkship Curriculum of Allopathic Medical Schools. Abbreviation: PBL=Problem Based Learning; TBL = Team Based Learning

Preclerkship Curriculum(I, J)		Mean Difference (\$) (I – J)	95% Confidence Interval		Significance
			Lower Bound	Upper Bound	
Primarily Discipline	Primarily Organ System	2931	-8128	13,991	0.949
	Mixed Organ System/Discipline	-697	-12,656	11,262	1.000
	Team-Based (PBL/TBL)	548	-11,955	13,051	1.000
	Other	21,743	-3190	46,676	0.119
Primarily Organ System	Primarily Discipline	-2931.	-13,991	8128	0.949
	Mixed Organ System/Discipline	-3629	-11,937	4680	0.747
	Team-Based (PBL/TBL)	-2383	-11,457	6690	0.950
	Other	18,812	-4590	42,214	0.178
Mixed Organ System/Discipline	Primarily Discipline	697	-11,262	12,656	1.000
	Primarily Organ System	3629	-4680	11,937	0.747
	Team-Based (PBL/TBL)	1245	-8906	11,396	0.997
	Other	22,440	-1400	46,281	0.076
Team-Based (PBL/TBL)	Primarily Discipline	-548	-13,051	11,955	1.000
	Primarily Organ System	2383	-6690	11,457	0.950
	Mixed Organ System/Discipline	-1245	-11,396	8906	0.997
	Other	21,195	-2922	45,313	0.114
Other	Primarily Discipline	-21,743	-46,676	3190	0.119
	Primarily Organ System	-18,812	-42,214	4590	0.178
	Mixed Organ System/Discipline	-22,440	-46,281	1400	0.076
	Team-Based (PBL/TBL)	-21,195	-45,313	2922	0.114

eTable 3

Comparison of the Mean In-State Tuition of U.S. Osteopathic Medical Schools by Region.

Census Region		Mean Difference (\$)	95% Confidence Interval of Mean		Significance
			Lower Bound	Upper Bound	
West	Midwest	6361	-8426	21,147	1.000
	South	14,655	1976	27,335	0.016
	Northeast	11,135	-3235	25,505	0.224
Midwest	West	-6361	-21,147	8426	1.000
	South	8295	-4385	20,974	0.459
	Northeast	4775	-9595	19,145	1.000
South	West	-14,655	-27,335	-1976	0.016
	Midwest	-8295	-20,974	4385	0.459
	Northeast	-3520	-15,711	8671	1.000
Northeast	West	-11,135	-25,505	3235	0.224
	Midwest	-4775	-19,145	9595	1.000
	South	3520	-8671	15,711	1.000

eTable 4

Comparison of the Difference in Mean In-State Tuition and Preclerkship Curriculum of Osteopathic Medical Schools. Abbreviation: PBL=Problem Based Learning; TBL = Team Based Learning.

Preclerkship Curriculum(I, J)		Mean Difference (\$) (I – J)	95% Confidence Interval		Significance
			Lower Bound	Upper Bound	
Primarily Discipline	Primarily Organ System	16,675	-1568	34,918	0.087
	Mixed Organ System/Discipline	15,746	-5154	36,646	0.217
	Team-Based (PBL/TBL)	27,101	6706	47,497	0.004
	Other	21,911	-662	44,486	0.061
Primarily Organ System	Primarily Discipline	-16,675	-34,918	1568	0.087
	Mixed Organ System/Discipline	-929	-14,611	12,753	1.000
	Team-Based (PBL/TBL)	10,427	-2473	23,326	0.162
	Other	5237	-10,888	21,361	0.882
Mixed Organ System/Discipline	Primarily Discipline	-15,746	-36,646	5154	0.217
	Primarily Organ System	929	-12,753	14,611	1.000
	Team-Based (PBL/TBL)	11,356	-5088	27,799	0.295
	Other	6166	-12,913	25,244	0.884
Team-Based (PBL/TBL)	Primarily Discipline	-27,102	-47,497	-6706	0.004
	Primarily Organ System	-10,427	-23,326	2473	0.162
	Mixed Organ System/Discipline	-11,356	-27,799	5088	0.295
	Other	-5190	-23,715	13,336	0.928
Other	Primarily Discipline	-21,912	-44,486	662	0.061
	Primarily Organ System	-5237	-21,361	10,888	0.882
	Mixed Organ System/Discipline	-6166	-25,244	12,913	0.884
	Team-Based (PBL/TBL)	5190	-13,336	23,715	0.928

eTable 5a
Adjusted* Mean In-State Tuition of U.S. Allopathic Medical Schools by Region.

U.S. Region	Number of Allopathic Medical Schools	Mean Adjusted Tuition (\$)	Standard Deviation	95% Confidence Interval of Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
All	151	45,117	18,921	37,336	56,587	0	87,679
West	23	46,962	22,259	38,381	46,507	27,407	62,039
Midwest	35	42,444	11,828	31,028	40,684	0	96,380
South	57	35,856	18,195	57,164	65,234	44,715	83,220
Northeast	36	61,199	11,926	42,074	48,159	0	96,380

eTable 5b
Comparison of the Adjusted* Mean Tuition and Pre-clerkship Curriculum of Allopathic Medical Schools.

Preclerkship Curriculum	Number of Osteopathic Medical Schools	Mean Tuition (\$)	Standard Deviation	95% Confidence Interval of Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
All	146	45,637	18,768	42,567	48,707	0	96,380
Primary Discipline	16	47,989	19,172	37,773	58,206	17,991	81,832
Primarily Organ System	65	45,073	19,696	40,193	49,954	15,501	96,380
Mixed Organ System/ Discipline	35	48,032	19,525	41,325	54,739	15,062	83,220
Team-Based (PBL/TBL)	27	44,693	14,672	38,889	50,497	0	69,601
Other	3	25,853	18,228	-19,427	71,133	15,111	46,899

eTable 5c
Comparison of Preclerkship Curriculum Feature and Adjusted* Mean In-State Tuition in Allopathic Medical Schools. *Adjusted Mean Tuition refers to the mean in-state tuition after adjusting for geographical differences in COL. Adjusted mean in-state tuition was computed by multiplying the in-state tuition of each medical school by the corresponding state-level COLI and calculating their respective categorical averages. The COLI's were obtained from the 2020 American Chamber of Commerce Research Association Cost of Living Index, where an index of 100 was treated as 1.00. Abbreviations: PBL/TBL = Problem-based Learning/Team-based Learning; OOS = Out-of-state, COLI = Cost of Living Index

Curriculum Feature	n	Adjusted Mean Tuition (\$)	Standard Deviation	95% Confidence Interval		Significance (2-tailed)	
				Lower Bound	Upper Bound		
Required Research/Scholarly Project	Yes	43	54,752	19,901	7502	20,250	<0.001
	No	106	40,875	16,944			
OOS Non-Subi-Clerkships	Yes	62	46,483	19,164	-3839	8790	0.440
	No	85	44,007	19,103			
Global Health	Yes	96	47,780	18,690	1155	13,771	0.020
	No	54	40,318	18,724			

eTable 6
Comparison of the Adjusted* Mean In-State Tuition of U.S. Allopathic Medical Schools by Region.

Census Region		Mean Difference (\$)	95% Confidence Interval of Mean		Significance
			Lower Bound	Upper Bound	
West	Midwest	4518	-7201	16237	1.000
	South	11106	321	21891	0.040
	Northeast	-14237	-25891	-2583	0.008
Midwest	West	-4518	-16237	7201	1.000
	South	6588	-2788	15963	0.373
	Northeast	-18755	-29119	-8391	<0.001
South	West	-11106	-21891	-321	0.040
	Midwest	-6588	-15963	2788	.373
	Northeast	-25343	-34637	-16048	<0.001
Northeast	West	14237	2583	25891	0.008
	Midwest	18755	8391	29119	<0.001
	South	25343	16048	34637	<0.001

*Adjusted Mean Tuition refers to the mean in-state tuition after adjusting for geographical differences in COL. Adjusted mean in-state tuition was computed by multiplying the in-state tuition of each medical school by the corresponding state-level COLI and calculating their respective categorical averages. The COLI's were obtained from the 2020 American Chamber of Commerce Research Association Cost of Living Index, where an index of 100 was treated as 1.00.

eTable 7

Comparison of the Difference in Adjusted* Mean Tuition and Preclerkship Curriculum of Allopathic Medical Schools. Abbreviation: PBL=Problem Based Learning, TBL = Team Based Learning.

Preclerkship Curriculum (I, J)		Mean Difference (\$) (I – J)	95% Confidence Interval		Significance
			Lower Bound	Upper Bound	
Primarily Discipline	Primarily Organ System	2916	-11,543	17,376	0.981
	Mixed Organ System/Discipline	-43	-15,678	15,593	1.000
	Team-Based (PBL/TBL)	3296	-13,050	19,642	0.981
	Other	22,136	-10,461	54,733	0.335
Primarily Organ System	Primarily Discipline	-2916	-17,376	11,543	0.981
	Mixed Organ System/Discipline	-2959	-13,822	7903	0.943
	Team-Based (PBL/TBL)	380	-11,483	12,242	1.000
	Other	19,220	-11,376	49,816	0.415
Mixed Organ System/Discipline	Primarily Discipline	43	-15,593	15678	1.000
	Primarily Organ System	2959	-7903	13,822	0.943
	Team-Based (PBL/TBL)	3339	-9932	16,610	0.957
	Other	22,179	-8990	53,348	0.288
Team-Based (PBL/TBL)	Primarily Discipline	-3296	-19,642	13,050	0.981
	Primarily Organ System	-380	-12,242	11,483	1.000
	Mixed Organ System/Discipline	-3339	-16,610	9932	0.957
	Other	18,840	-12,691	50,371	0.468
Other	Primarily Discipline	-22,136	-54,733	10,461	0.335
	Primarily Organ System	-19,220	-49,816	11,376	0.415
	Mixed Organ System/Discipline	-22,179	-53,348	8990	0.288
	Team-Based (PBL/TBL)	-18,840	-50,371	12,691	0.468

*Adjusted Mean Tuition refers to the mean in-state tuition after adjusting for geographical differences in COL. Adjusted mean in-state tuition was computed by multiplying the in-state tuition of each medical school by the corresponding state-level COLI and calculating their respective categorical averages. The COLI's were obtained from the 2020 American Chamber of Commerce Research Association Cost of Living Index, where an index of 100 was treated as 1.00.

eTable 8a

Adjusted* Mean In-State Tuition of U.S. Osteopathic Medical Schools by Region.

U.S. Region	Number of Allopathic Medical Schools	Mean Tuition (\$)	Standard Deviation	95% Confidence Interval of Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
All	42	51,486	14,910	46,839	56,132	12,656	81,039
West	8	70,051	7449	63,823	76,278	59,946	81,039
Midwest	8	50,184	11,327	40,714	59,653	34,229	73,291
South	17	42,897	12,353	36,545	49,248	12,656	56,169
Northeast	9	52,364	13015	42,360	62,368	35,568	68,206

eTable 8b

Comparison of the Adjusted* Mean Tuition and Pre-clerkship Curriculum of Osteopathic Medical Schools. Abbreviations: PBL/TBL = Problem-based Learning/Team-based Learning, COL = Cost of Living.

Preclerkship Curriculum	Number of Osteopathic Medical Schools	Adjusted Mean Tuition (\$)	Standard Deviation	95% Confidence Interval of Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
All	41	51,078	14,857	46,388	55,767	12,656	81,039
Primary Discipline	3	65,801	12,477	34,805	96,797	51,397	73,291
Primarily Organ System	21	53,626	14,935	46,827	60,424	21,472	81,039
Mixed Organ System/Discipline	6	51,230	9501	41,260	61,200	38,790	65,525
Team-Based (PBL/TBL)	7	40,093	13,798	27,332	52,854	12,656	54,188
Other	4	45,654	15,425	21,109	70,198	34,229	67,593

*Adjusted Mean Tuition refers to the mean in-state tuition after adjusting for geographical differences in COL. Adjusted mean in-state tuition was computed by multiplying the in-state tuition of each medical school by the corresponding state-level COLI and calculating their respective categorical averages. The COLI's were obtained from the 2020 American Chamber of Commerce Research Association Cost of Living Index, where an index of 100 was treated as 1.00.

eTable 9
Comparison of the Adjusted* Mean In-State Tuition of U.S. Osteopathic Medical Schools by Region.

Census Region		Mean Difference \$	95% Confidence Interval of Mean		Significance
			Lower Bound	Upper Bound	
West	Midwest	19867	3770	35964	0.009
	South	27154	13351	40957	<0.001
	Northeast	17687	2043	33330	0.019
Midwest	West	-19867	-35964	-3770	0.009
	South	7287	-6516	21090	0.900
	Northeast	-2180	-17824	13463	1.000
South	West	-27154	-40957	-13351	<0.001
	Midwest	-7287	-21090	6516	0.900
	Northeast	-9467	-22739	3804	0.326
Northeast	West	-17687	-33330	-2043	0.019
	Midwest	2180	-13463	17824	1.000
	South	9467	-3804	22739	0.326

*Adjusted Mean Tuition refers to the mean in-state tuition after adjusting for geographical differences in COL. Adjusted mean in-state tuition was computed by multiplying the in-state tuition of each medical school by the corresponding state-level COLI and calculating their respective categorical averages. The COLI's were obtained from the 2020 American Chamber of Commerce Research Association Cost of Living Index, where an index of 100 was treated as 1.00. Abbreviation COL = Cost of Living.

eTable 10
Comparison of the Difference in Adjusted* Mean Tuition and Pre-clerkship Curriculum of Osteopathic Medical Schools.

Pre-clerkship Curriculum (I, J)		Mean Difference (I - J) \$	95% Confidence Interval		Significance
			Lower Bound	Upper Bound	
Primarily Discipline	Primarily Organ System	12,175	-12,673	37,024	0.627
	Mixed Organ System/Discipline	14,571	-13,896	43,039	0.588
	Team-Based (PBL/TBL)	25,708	-2074	53,489	0.081
	Other	20,147	-10,601	50,896	0.346
Primarily Organ System	Primarily Discipline	-12,175	-37,024	12,673	0.627
	Mixed Organ System/Discipline	2396	-16,241	21,032	0.996
	Team-Based (PBL/TBL)	13,532	-4038	31,103	0.199
	Other	7972	-13,991	29,935	0.834
Mixed Organ System/Discipline	Primarily Discipline	-14,571	-43,039	13,896	0.588
	Primarily Organ System	-2396	-21,032	16,241	0.996
	Team-Based (PBL/TBL)	11,137	-11,261	33,535	0.615
	Other	5576	-20,411	31,563	0.972
Team-Based (PBL/TBL)	Primarily Discipline	-25,708	-53,489	2074	0.081
	Primarily Organ System	-13,532	-31,103	4038	0.199
	Mixed Organ System/Discipline	-11,137	-33,535	11,261	0.615
	Other	-5561	-30,794	19,673	0.969
Other	Primarily Discipline	-20,147	-50,896	10,601	0.346
	Primarily Organ System	-7972	-29,935	13,991	0.834
	Mixed Organ System/Discipline	-5576	-31,563	20,411	0.972
	Team-Based (PBL/TBL)	5561	-19,673	30,794	0.969

*Adjusted Mean Tuition refers to the mean in-state tuition after adjusting for geographical differences in COL. Adjusted mean in-state tuition was computed by multiplying the in-state tuition of each medical school by the corresponding state-level COLI and calculating their respective categorical averages. The COLI's were obtained from the 2020 American Chamber of Commerce Research Association Cost of Living Index, where an index of 100 was treated as 1.00. Abbreviations: PBL/TBL = Problem-based Learning/Team-based Learning, COL = Cost of Living.

eTable 11
Comparison of Preclerkship Curriculum Feature and Adjusted* In-State Tuition in Osteopathic Medical Schools.

Curriculum Feature		N	Adjusted Mean Tuition (\$)	Standard Deviation	95% Confidence Interval		Significance (2-tailed)
					Lower Bound	Upper Bound	
Required Research/Scholarly Project	Yes	5	47,352	3020	-19,151	9768	0.118
	No	37	52,044	15,795			
OOS Non-Subi-Clerkships	Yes	31	49,547	15,431	-17,844	3042	0.160
	No	11	56,948	12,356			
Global Health	Yes	25	50,283	16,298	-12,515	6573	0.533
	No	17	53,254	12,872			

*Adjusted Mean Tuition refers to the mean in-state tuition after adjusting for geographical differences in COL. Adjusted mean in-state tuition was computed by multiplying the in-state tuition of each medical school by the corresponding state-level COLI and calculating their respective categorical averages. The COLI's were obtained from the 2020 American Chamber of Commerce Research Association Cost of Living Index, where an index of 100 was treated as 1.00. Abbreviations: OOS = Out-of-state, COL = Cost of Living.

Declaration of competing interest

None.

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