

Retuning the Premedical Compass: A Systematic Review of Premedical Course Requirements in American Programs Worldwide

Michelle Chouairy, Laetitia Bou Samra, Christelle Zeidan, Ola El Zein, Bilal Kaafarani

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Abstract

Background: Premedical education provides the academic foundation for entry into medical school, yet requirements differ widely across institutions. Recent MCAT reforms and growing calls for more comprehensive and interdisciplinary premedical training have triggered curricular changes fragmented throughout the literature. The objective of this systematic review is to assess how premedical course requirements in American programs worldwide have changed since year 2000 while also evaluating their motives and outcomes.

Objective: No comprehensive systematic review on how the premedical curriculum has evolved with time exists. Thus, this systematic review, encompassing all these reforms and changes, will be a unified framework that may help both institutions and students be aware of the premedical course requirements on a wider scale and determine which reforms are most effective.

Methods: We systematically searched four databases (MEDLINE, Embase, ERIC, and Education Research Complete) up to July 4, 2025. We included studies focusing on American undergraduate premedical curricula and reporting changes to course or curriculum requirements. Studies discussing non-American programs, medical or post-medical curricula, or requirements beyond courses were excluded. Two reviewers independently screened articles at title abstract and full text levels, with conflicts resolved by consensus among all team members. Data extraction was also performed in duplicate. The Mixed Methods Appraisal Tool (MMAT) was used to assess risk of bias. Because of its heterogeneity, the data was synthesized narratively. The protocol was registered on the Open Science Framework.

Results: We included 70 articles which ranged between mixed-methods, quantitative, qualitative, and descriptive (not studies) designs. Three drivers of reform were identified: conforming to MCAT revisions, educating and forming well-prepared aspiring physicians, and transitioning to competency-based education. Thirty-six studies highlighted adding courses (anatomy, psychology, sociology, humanities), twenty-five described revising existing courses (mainly science courses), five discussed course deletions (mainly organic chemistry and calculus), and ten proposed new curricula (programs or majors). Outcomes prevalently showed improved preparedness for medical school, and positive student feedback and academic performance, though some results were mixed.

Conclusions: Well established reforms to the premedical curriculum can strengthen student preparedness, satisfaction, and motivation. However, effects on academic outcomes remain inconsistent. A balanced approach that merges scientific core courses with social sciences and humanities seems to be the most promising for preparing premedical students for medical school. Clinical Trial: Open Science Framework <https://doi.org/10.17605/OSF.IO/TPSF2>

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Original Manuscript

Retuning the Premedical Compass: A Systematic Review of Premedical Course Requirements in American Programs Worldwide

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Abstract

Background: Premedical education provides the academic foundation for entry into medical school, yet requirements differ widely across institutions. Recent MCAT reforms and growing calls for more comprehensive and interdisciplinary premedical training have triggered curricular changes fragmented throughout the literature. The objective of this systematic review is to assess how premedical course requirements in American programs worldwide have changed since year 2000 while also evaluating their motives and outcomes.

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Results: We included 70 articles which ranged between mixed-methods, quantitative, qualitative, and descriptive (not studies) designs. Three drivers of reform were identified: conforming to MCAT revisions, educating and forming well-prepared aspiring physicians, and transitioning to competency-based education. Thirty-six studies highlighted adding courses (anatomy, psychology, sociology, humanities), twenty-five described revising existing courses (mainly science courses), five discussed course deletions (mainly organic chemistry and calculus), and ten proposed new curricula (programs or majors). Outcomes prevalently showed improved preparedness for medical school, and positive student feedback and academic performance, though some results were mixed.

Conclusions: Well established reforms to the premedical curriculum can strengthen student preparedness, satisfaction, and motivation. However, effects on academic outcomes remain inconsistent. A balanced approach that merges scientific core courses with social sciences and humanities seems to be the most promising for preparing premedical students for medical school.

Review Registration: Open Science Framework <https://doi.org/10.17605/OSF.IO/TPSF2>

Keywords: Premedical Education; Premedical Curriculum; Revisiting Premedical Requirements.



Introduction

Many students aspiring to become doctors choose to follow the American Program whether at an institution in the United States (U.S.) or abroad. This program is characterized by a structured premedical education track, an academic foundation that ensures students enter medical school prepared and ready. The latter includes the completion of an undergraduate degree alongside some essential premedical course requirements in general biology, chemistry, physics, English, and other subjects necessary to prepare students for the MCAT, the Medical College Admission Test, a standardized multiple-choice exam that assesses the students' readiness for admission to medical school.

Historically, premedical education was shaped by the 1910's Flexner Report which highlighted the necessity to establish a premedical curriculum centered on natural sciences like physics, biology, and chemistry.^[1] At that time, these courses were considered tools to "weed out" less prepared medical school applicants until recent critiques and contemporary reports like the HHMI-AAMC (Howard Hughes Medical Institute – Association of American Medical Colleges) have emerged and called for greater emphasis on liberal arts, humanities, and ethics in premedical education.^[2] Over the years, several revisions to the MCAT have been attempted, with the most recent occurring in 2015.^[3]

Indeed, in 2015, the Association of American Medical Colleges (AAMC) revised the MCAT and included psychology and sociology critical analysis sections shifting the premedical focus from natural sciences to broader critical thinking skills.^[4] Nevertheless, these changes created some sort of disconnect between what is tested on the MCAT, what is required for admission by different medical schools, and what is taught in undergraduate institutions.

Changes in the MCAT have led institutions, educators, physicians, and even students to question the content, purpose, and structure of their undergraduate curriculum that differs from one undergraduate institution to another. The undergraduate curriculum of the American Program must be fixed, and various measures and reforms are taking place in many universities around the world. Growing critiques are found in the literature since rethinking premedical education might not be evolving in the right direction. The literature is filled with articles discussing how different institutions are reevaluating their curriculum and changing their premedical requirements. However, the literature available is fragmented.

Motivated by the need to understand the nature and impact of recent modifications to premedical course requirements across the literature, this systematic review may serve as a guide for educators, curriculum designers, medical schools, and students themselves to identify the best combination of courses needed to fulfill the academic requirements for medical education. The aim of this systematic review is to answer the following question: How have premedical course requirements in American undergraduate programs changed since year 2000, and what are the motives and outcomes associated with these modifications?

Through an intricate screening process of the available literature, this systematic review provides an evidence-based, unbiased synthesis of the most effective changes to the premedical curriculum according to their outcome and impact on students' admission to medical school, and future academic performance.

Methods

This systematic review critically synthesizes the literature on premedical requirements in American Programs worldwide. We registered the protocol of this SR on the Open Science Framework (OSF)

(<https://doi.org/10.17605/OSF.IO/TPSF2>) following the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) reporting guidelines.

Search Strategy and Selection Criteria

We searched the following four electronic databases up till July 4, 2025, without language limitation: MEDLINE (using Ovid), Embase (using Elsevier), ERIC and Education Research Complete (using EBSCO). The search strategy included both controlled vocabularies (eg, MeSH and Emtree) and keywords such as premedical requirements, premedical education, prerequisite course for medical school, premedical students, school admission criteria, premedical acceptance, premedical curriculum, premedical courses, prerequisite, precondition, and applying for medical school. The search strategies were developed by the director of evidence synthesis (OZ) at the American University of Beirut (AUB). The full search strategy of Medline is provided in Appendix 1. As for grey literature, both backward and forward citation tracking of all relevant studies were performed.

The articles were selected based on a specific set of inclusion and exclusion criteria shown in Figure 1. Included studies were those published from the year 2000 and onwards that focused on the American programs worldwide, excluding non-American programs. Publications tackling premedical curricula were included, thereby excluding those focusing on medical or post-medical education. The scope was limited to studies analyzing premedical course requirements, whereas those discussing qualifications beyond courses were excluded (e.g., extracurriculars, internships, research, medical school admission criteria, etc.). Eligible sources included original articles, policy documents, reports, reviews, conference proceedings. However, protocols, editorials, errata, essays, books, commentaries, and magazine articles were eliminated.

All articles were imported to Covidence, an online software platform designed to improve the efficiency and experience of creating and maintaining Systematic Reviews.^[5] The platform was also used to detect and remove duplicates.

Pairs of researchers (MEC, LIB, and CIZ) independently performed title and abstract and full text screening in duplicates, and after calibration exercises, until reaching a 95% agreement rate among reviewers. We resolved disagreements among reviewers by discussions among all team members. Duplicate entries were removed manually or by Covidence before screening. The reasons for excluding the studies at the full text level were documented and shown in PRISMA Flowchart, Figure 2.



Figure 1. Exclusion and inclusion criteria.

Data Analysis and Risk of Bias Assessment

Pairs of researchers (MEC, LIB, and CIZ) conducted data extraction independently and in duplicates using a Table developed by the research team. For each study, we abstracted the following variables: author, year, location, institution, type of change (add/remove/revise), motives, outcome, and theme of each study which were compiled into an Excel Table. A unified and comprehensive summary Table was synthesized after resolving any discrepancies in the extracted information through consensus (Table 1).

The Mixed Methods Appraisal Tool (MMAT) was used for quality and risk of bias assessment. This method allows appraisal and description of the methodological quality for three domains: mixed, qualitative and quantitative (partitioned into three sub-domains: randomized controlled, non-randomized, and descriptive).^[6] The risk of bias assessment was completed and the findings were compiled in an Excel spreadsheet.

Due to significant heterogeneity in study designs and the broad range of outcome measures used, a meta-analysis was not possible. Accordingly, the extracted information from included articles was organized in an Excel Table, and the evidence was produced in a narrative review. Studies were grouped according to three key themes related to the addition, removal, or modification of a course. Outcomes were categorized into four types: positive feedback about the course, positive impact and improvement for future career development or medical school, mixed outcomes, or new insights about the course.

Studies from databases (**n = 5383**)
 MEDLINE (n = 2463)
 Embase (n = 1934)
 Education research complete EBSCO (n = 612)
 ERIC EBSCO (n = 374)

References from citation searching (**n = 43**)

[unpublished, non-peer-reviewed preprint]

References removed (**n = 1422**)

Studies screened (**n = 4004**)

Studies excluded (**n = 3669**)

Included

Studies sought for retrieval (**n = 335**)

Studies not retrieved (**n = 4**)

Figure 2. PRISMA flow chart.

Table 2. S

Character

Study Criteria

Study design:

- Quantitative
- Qualitative
- Mixed methods
- Descriptive reports

Inc

Studies assessed for eligibility (**n = 331**)

Studies excluded (**n = 261**)

- Reason 1 - Published Pre-2000 (n = 3)
- Reason 2 - Not the Document Type of Interest (n = 209)
- Reason 3 - Non-American Program (n = 22)
- Reason 4 - Medical and Post-Medical Education (n = 11)
- Reason 5 - Medical School Admission (n = 16)

Drivers of change¹:

- | | |
|----------------------|----------|
| - 2015 MCAT Revision | 14 (27%) |
| - T | 21 (40%) |
| - S | 17 (33%) |

Studies included in review (**n = 70**)

curriculum

Nature of change²:

- | | |
|------------------------------|----------|
| - Course addition | 36 (47%) |
| - Course removal | 5 (7%) |
| - Course redesign | 25 (33%) |
| - New curriculum proposition | 10 (13%) |

¹ The total number of drivers of change does not equal 70 because certain studies did not identify any driver within these categories.

² The total number of types of change exceeds 70 because individual studies could report more than one type of change.

Outcomes³:

- Positive feedback about the course	16 (25%)
- Positive impact and improvement for future career development	25 (38%)
- Mixed outcomes	8 (12%)
- New insight about a course	16 (25%)

³ The total number of outcomes does not equal 70 because some studies did not report outcomes that fell within the four outcome categories the research team defined.

Role of the funding source

There was no funding source for this study. All authors had access to all the data, and all authors were responsible for the decision to submit the manuscript.

Ethical Considerations

Ethical approval was not required as this study was a systematic review.

Results

Study Selection

The search strategy and citation tracking retrieved 4004 articles after duplicate removal. We conducted title and abstract screening, leaving 335 articles for full text screening. We then excluded 265 articles for various reasons, and we included 70 studies in this systematic review (Figure 2).

Following full-text screening, 261 articles were excluded for not meeting selection criteria defined by reasons. Three references were excluded under reason 1 (Published pre-2000), 209 references were excluded under reason 2 (Not the document type of interest), 22 under reason 3 (non-American program), 11 under reason 4 (Medical and post-medical education), and 16 under reason 5 (Medical school admission). Four articles lacked accessible full texts and were subsequently excluded at this stage. Accordingly, 70 studies were included in data extraction, analysis, and quality assessment (Figure 2).

Data Analysis

The included studies were published from 2000 onwards, predominantly in the United States, with occasional exceptions (one in Australia,^[7] one in Qatar^[8]). Study types comprised: 15 mixed-methods studies, 15 quantitative studies, 9 qualitative studies, and 31 descriptive reports that were not eligible for MMAT risk of bias assessment. All institutions involved in these articles were universities following the American undergraduate premedical track (Figure 1).

The remaining 39 articles that qualified as quantitative, qualitative, or mixed methods studies were appraised in Excel using Mixed Methods Appraisal Tool.^[6] Following the risk of bias assessment, three studies that did not effectively explain the relevance of their outcomes to course or curriculum reforms were excluded.^{[9],[10],[11]} Quality scores ranged from meeting none of the five criteria (zero) to meeting all five criteria (five). The Table detailing the risk of bias assessment results is provided in Appendix 2. Each study's design, outcomes, changes to courses and drivers of change are reported in Table 1.

Main Drivers of Change

Across the 67 remaining studies, three recurring drivers of curriculum reform or course modification were identified. First, the demand for medical schools to accept well-rounded students (n=21, 40%, Table 2) drove the integration of courses emphasizing empathy,^[12] patient–physician interactions,^[13] and general education such as global health.^[14] Second, a shift from course-based to competency-based education (n=17, 33%) encouraged institutions to implement interdisciplinary classes^[15] and specialized courses focusing on technical^[16] and interpersonal skills.^[13] Lastly, a significant driver was the 2015 MCAT revision (n=14, 27%), Table 2, which introduced behavioral and social sciences as well as critical reasoning sections. This motivated institutional reforms, as every college sought to prepare students to succeed in the standardized exam indispensable for continuing a career in medicine. Universities responded by introducing courses in reflective writing,^[17] psychology,^[1, 8, 18-20] sociology,^[21-23] and anthropology.^[3, 18]

Main Natures of Change

All the reforms resulting from these convergent institutional motives clustered into four categories, thus characterizing the nature of the changes made. Particularly, thirty-six articles (47%, Table 2) focused on adding new courses to the premedical curriculum in which most frequent additions were courses in anatomy,^[24-28] psychology,^[1, 8, 18-20] statistics,^[1, 18] histology,^[24, 26] and mathematics.^[2, 29] On the other hand, other studies introduced specialized topics such as neuroimmune pharmacology,^[30] point-of-care ultrasound,^[16] childhood obesity,^[31] microbiology,^[32] evolution,^[33-35] and antibiotic resistance.^[36] Simultaneously, several articles also emphasized making humanities-based subjects such as global health,^[18] medical anthropology,^[3, 18] and sociology^[8, 18, 20, 21] required for premedical students to better prepare them for medical school (Table 1).

Twenty-five articles (33%, Table 2) addressed redesigning, revising, or replacing existing courses to align with the shift toward competencies-based tracks. For example, physics,^[1, 37-43] sociology,^[8, 20, 22] biochemistry,^[33, 44-46] and biology^[18, 33, 46, 47] courses were most often targeted for redesign because their content was perceived as diverging from their primary purpose: ensuring student readiness for medical school admission. Some institutions proposed redesigning courses by integrating laboratory components (cadaver^[48] and dissection anatomy and physiology labs^[49, 50]) or changing course duration (intensive general chemistry in one semester^[51]), Table 1.

Furthermore, ten articles (13%, Table 2) proposed new curricula or competency-based sequences^[2, 19, 52, 53] to help students succeed by building interdisciplinary connections and interpersonal skills in which these articles demonstrated that some students could thrive without a traditional science background, as seen in programs such as HuMed.^[54, 55] Particularly, some institutions also designed new majors in biology^[56, 57] and biochemistry^[58] specifically tailored for premedical students and aspiring physicians. Essentially, these programs aimed to achieve a more flexible, inclusive, and comprehensive curriculum that would better fulfill students' needs and cultivate diverse skills (Table 1).

Main Outcomes

Finally, it is critical to note that only five out of 67 articles (7%, Table 2) examined removing courses from the undergraduate premedical track. For instance, chemistry (organic^[2, 23] and general chemistry^[51]) and calculus,^[23] traditionally viewed as “weed out” courses by medical school admissions committees, were the main targets. These reports argued that these courses did not benefit students; instead, they harmed them by adding stress to an already competitive premedical journey (Table 1).

Indeed, a significant pattern of outcomes was retrieved across the 67 analyzed articles in which a large number emphasized the positive impact of these changes on future career development and medical school preparedness (n=25, 38%, Table 2) by comparing GPA (Grade Point Average),^[13, 25] rate of acceptance,^[54] Step 1 scores,^[54] as well as future performances in medical school.^[24, 25, 55, 59] In addition, the incorporation of anatomy courses to the premedical curriculum was proven to be a very good predictor of improvement at the start of the medical school journey (Table 1).^[24, 25] Consequently, well-designed premedical courses can greatly support career development and guide students towards a successful path.

Another apparent outcome encountered was essentially positive feedback regarding the course (n=16, 25%, Table 2), especially in studies that underpinned the interdisciplinary approaches and valued the integration of humanities into the undergraduate premedical years.^[17] In fact, students expressed that integrating different subjects such as biology and math was more interactive.^[15] Moreover, other positive feedback was solicited from students who were taught anatomy and physiology through active, hands-on approaches (Table 1).^[48, 49] In all the aforementioned cases, the changes served to increase student satisfaction and motivation.

To continue, several articles proposed new insights into courses and curricula (n=16, 25%, Table 2), specifically when measurable outcomes were limited. The perceived Versus Actual Use of Mathematics in Medicine instigates a gap between what students believed about the utility of mathematics and what practicing physicians actually reported, hence offering a completely new rationale for curricular reform.^[29] Simultaneously, Disciplinary Authenticity: Reforming Introductory Physics provided valuable lessons about aligning physics curricula with the practices of biomedical science (Table 1).^[47]

Finally, it is important to note that not all reported studies only positive outcomes. Particularly, mixed findings (n=8, 12%, Table 2) were observed where benefits were achieved in certain contexts but no others. By way of example, after taking undergraduate level anatomy, undergraduate premedical students concluded that while students valued anatomy courses, the reform did not lead to measurable quantified improvements in future academic performance.^[27] Essentially, while reforms may fuel engagement and self-perceived readiness, they do not always yield significant changes in traditional academic outcomes such as grades or standardized test scores, then ultimately, medical school preparedness and acceptance (Table 1).^[7, 23, 28, 32, 55, 60, 61]

Discussion

Principal Findings

This systematic review serves as a synthesis of evidence from 70 articles published from 2000 onwards that discussed reforms to premedical course requirements in American programs worldwide. Our designated findings underscore the most common drivers of curricular change pertaining to the 2015 MCAT revision, the increasing importance of preparing well-trained aspiring physicians, as well as the shift toward competency-based education. Particularly, institutions resorted to the addition of new courses such as but not limited to anatomy,^[24-28] psychology,^[1, 8, 18-20] statistics,^[1, 18] and humanities,^[8, 18, 20, 21] revision of traditional ones in order to integrate clinical or laboratory components, and in some cases, diluting some long-standing courses such as organic chemistry^[2, 23] and removal of others like calculus.^[23] Across these interventions, the prevailing outcome was a perceived or (sometimes) measurable improvement in student preparedness for medical school.

In fact, the 2015 MCAT revision played a significant role in reshaping the plight of U.S. premedical requirements in terms of preparation for competencies in biochemistry, behavioral and social sciences, and critical analysis; thus, nudging programs from legacy checklist models towards competency-oriented design. In fact, recent reports framed the exam as both a signal of evolving expectations wherein institutions could use to justify curricular and advising change.^[1, 20, 62] The 2015 MCAT brought about a shift toward evidence-informed, competency-focused preparation, with the strongest momentum coming from local pilots reporting concrete learning advantages.^[40,45,63] Nonetheless, although the MCAT has endured a broader competency profile, misalignment persists between what is tested and what is required. For example, sociology and psychology remain “recommended” rather than required courses at many institutions, hence leaving the option for students to discover these expectations later through advising or even peers.^[21] To illustrate, recent U.S. commentaries also note that applicants can be “MCAT-ready but list-deficient” (or the reverse), depending on the target school, which is essentially an artifact of decentralized governance and historical precedent.^[1, 62, 64] The downstream effect is avoidable inequity: students at campuses with strong pre-health advising or clear catalogs are anticipated to front-load MCAT-tested domains; others may take the exam without formal exposure to key content.^[21] Indeed, evidence from redesigned science sequences (e.g., life-science physics; compact general chemistry) suggests that fit-for-purpose courses can close this gap while preserving rigor, but it is undeniable that adoption remains uneven.^[40, 51, 52, 63]

Our results are consistent with previous reports that have questioned the adequacy of traditional premedical curricula dominated by natural sciences.^[21, 24, 34, 64] Essentially, the pattern of reforms unraveled in this review mirrors broader shifts in medical education, shedding light on the integration of the humanities, ethics, and social sciences to cultivate empathy, cultural competence, and thus critical reasoning.^[17, 31] Meanwhile, reforms were aligned with physics, chemistry, and biology with biomedical contexts resonating with the literature, stressing the need for disciplinary authenticity.^[15, 16, 36, 59] Consequently, these converging trends substantiate the hypothesis that targeted course reform can foster not only cognitive readiness but also professional identity formation at the undergraduate stage.^[12, 13, 65]

Strengths and Limitations

This review has valuable strengths. It is essentially the first to our knowledge to comprehensively examine course-level reform in premedical education across two and a half decades. The inclusion of

both American and international factions following the American Program greatly powers its representativeness. Furthermore, the large number of reads that were included combined with the systematic methodology used to find these articles to provide a strong foundation for synthesizing fragmented literature.

However, limitations must be admitted; considerable heterogeneity in study designs, outcomes, and reporting limited quantitative synthesis. Many studies relied on self-reported student feedback or descriptive accounts without rigorous statistical evaluation, hence raising concerns of response and publication bias. ^[12, 16, 17, 21]

Regardless of these caveats, the findings hold tangible implications. For students, greater transparency in premedical requirements could reduce uncertainty and promote earlier academic planning. ^[61, 64] For educators and institutions, adopting changes based on evidence could improve the quality of education provided to these premedical students. ^[9, 34, 38] At a policy level, medical schools and accrediting bodies should consider harmonizing admission requirements with both MCAT content and undergraduate course offerings to reduce misalignment and student burden. ^[11, 18, 55] Practically, longitudinal research points towards understanding the essentiality of the link between undergraduate course exposure to medical school and career outcomes. ^[24] Essentially, more evidence is needed in order to implement courses that will give the student a comprehensive baggage for medical school. That is why future research should prioritize prospective, longitudinal studies that measure both academic and non-academic outcomes, including well-being and patient-related competencies.

Conclusion

In conclusion, our review accentuates that targeted reforms to premedical course requirements can enhance preparedness for medical school, but it is critical to note that their impact is uneven and context dependent. The latter necessitates a rather balanced approach, integrating rigorous scientific foundations with humanities and social sciences, appears most promising for shaping the next generation of physicians. Therefore, aligning prerequisites to 2015 MCAT competencies, coupled with advising clarity and outcome reporting, significantly offers a pathway to equity, efficiency, and preparedness without sacrificing scientific rigor.

Acknowledgments

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Data Availability

All data used for the study has been included in the manuscript and supplementary material.

Authors' Contributions

BRK and OZ designed the study. OZ did the literature search. MEC, LIB, and CIZ reviewed the titles, abstracts, and full texts screening. All authors participated in regular meetings about interpreting the studies and the article writing. All authors were involved in the drafting of the article and read and approved of the final article. All authors have agreed they are accountable for all aspects of the work.

Conflicts of Interest

We declare no competing interests.

Multimedia Appendix

Two appendices accompany this article as supplementary material: Appendix 1 details the full MEDLINE search terms used in the review, and Appendix 2 presents the MMAT (Mixed Methods Appraisal Tool) Table with risk of bias assessments of the included studies.

References

[1-72]

1. Chambers DA, Cohen RL, Girotti J. A century of premedical education. *Perspect Biol Med*. 2011 Winter;54(1):17-23. PMID: 21399379. doi: 10.1353/pbm.2011.0011.
2. Alpern RJ, Belitsky R, Long S. Competencies in premedical and medical education: the AAMC-HHMI report. *Perspect Biol Med*. 2011 Winter;54(1):30-5. PMID: 21399381. doi: 10.1353/pbm.2011.0001.
3. Stodola TJ, Bruna SP. Medical Anthropology Courses and Concepts Tested on the MCAT: A Content Analysis of 40 U.S. Course Syllabi. *Journal of Medical Education and Curricular Development*. 2021;8:23821205211010812. PMID: 33997288. doi: 10.1177/23821205211010812.
4. Kaplan RM, Satterfield JM, Kington RS. Building a Better Physician — The Case for the New MCAT. *New England Journal of Medicine*. 2012;366(14):1265-8. doi: doi:10.1056/NEJMp1113274.
5. Babineau J. Product review: Covidence (systematic review software). *Journal of the Canadian Health Libraries Association/Journal de l'Association des bibliothèques de la santé du Canada*. 2014;35(2):68-71.
6. Pluye P, Robert E, Cargo M, Bartlett G, O'cathain A, Griffiths F, et al. Proposal: A mixed methods appraisal tool for systematic mixed studies reviews. Montréal: McGill University. 2011;2(1):1-8.
7. Moro C, McLean M, Phelps C. Doing justice when incorporating sustainability into pre-medical curricula. *Medical Education*. 2025;59(6):658-9. doi: <https://doi.org/10.1111/medu.15653>.
8. del Pozo PR, Fins JJ. The Globalization of Education in Medical Ethics and Humanities: Evolving Pedagogy at Weill Cornell Medical College in Qatar. *Academic Medicine*. 2005;80(2):135-40. PMID: 00001888-200502000-00005.
9. Stevens C, Witkow MR. Training scientific thinking skills: Evidence from an MCAT2015-aligned classroom module. *Teaching of Psychology*. 2014.
10. Stowe RL, Cooper MM. Practicing What We Preach: Assessing "Critical Thinking" in Organic Chemistry. *Journal of Chemical Education*. 2017 2017/12/12;94(12):1852-9. doi: 10.1021/acs.jchemed.7b00335.
11. Barr D. The "Turning Point" for Minority Pre-Meds: The Effect of Early Undergraduate Experience in the Sciences on Aspirations to Enter Medical School of Minority Students at UC Berkeley and Stanford University. Center for Studies in Higher Education, UC Berkeley, 2008 2008/11/13. Report No.
12. Vongsachang H, Oshima S, Nguyen C, Gaulocher S, Wang NE. Undergraduate Premedical Student Perceptions of an Emergency Department–Based Social Needs Screening Program. *Medical Science Educator*. 2020 2020/06/01;30(2):673-7. doi: 10.1007/s40670-020-00936-x.
13. Wilson JW, Baer RD, Villalona S. Patient Shadowing: A Useful Research Method, Teaching Tool, and Approach to Student Professional Development for Premedical Undergraduates. *Academic Medicine*. 2019;94(11):1722-7. PMID: 00001888-201911000-00034. doi: 10.1097/acm.0000000000002882.
14. Kolachalama VB. Machine learning and pre-medical education. *Artificial Intelligence in Medicine*. 2022 2022/07/01;129:102313. doi: <https://doi.org/10.1016/j.artmed.2022.102313>.
15. Ryan N, Wallace D. Applications of Calculus to Biology and Medicine: Case Studies from Lake Victoria 2017. ISBN: 978-981-322-277-9.
16. Smalley CM, Browne V, Kaplan B, Russ B, Wilson J, Lewiss RE. Early Innovative Immersion. *Journal of Ultrasound in Medicine*. 2016;35(12):2681-6. doi: <https://doi.org/10.7863/ultra.16.01050>.
17. Bracken RC, Major A, Paul A, Ostherr K. Reflective Writing about Near-Peer Blogs: A Novel Method for Introducing the Medical Humanities in Premedical Education. *Journal of Medical*

Humanities. 2021 2021/12/01;42(4):535-69. doi: 10.1007/s10912-021-09693-3.

18. Ferren AS, Paris DC. Faculty Leadership for Integrative Liberal Learning: American Association of Colleges & Universities; 2015.
19. Fishbein RH. Origins of Modern Premedical Education. *Academic Medicine*. 2001;76(5):425-9. PMID: 00001888-200105000-00009.
20. Mitchell K, Lewis RS, Satterfield J, Hong BA. The new Medical College Admission Test: Implications for teaching psychology. *American Psychologist*. 2016;71(2):125-35. doi: 10.1037/a0039975.
21. Olsen LD. "It's on the MCAT for a Reason": Premedical Students and the Perceived Utility of Sociology. *Teaching Sociology*. 2016;44(2):72-83. doi: 10.1177/0092055x15624744.
22. Lotspeich-Yadao MC, Trevino-Boissel K, Hoekstra C. Integrating Experiential Learning in Introduction to Sociology: Cultivating the Sociological Imagination in Premedical Students. *Teaching Sociology*. 2025;53(2):110-25. doi: 10.1177/0092055x241268787.
23. Schwartz AW, Abramson JS, Wojnowich I, Accordino R, Ronan EJ, Rifkin MR. Evaluating the Impact of the Humanities in Medical Education. *Mount Sinai Journal of Medicine: A Journal of Translational and Personalized Medicine*. 2009;76(4):372-80. doi: <https://doi.org/10.1002/msj.20126>.
24. Forester JP, McWhorter DL, Cole MS. The relationship between premedical coursework in gross anatomy and histology and medical school performance in gross anatomy and histology. *Clinical Anatomy*. 2002;15(2):160-4. doi: <https://doi.org/10.1002/ca.1114>.
25. Kondrashov P, McDaniel DJ, Jordan RM. Premedical anatomy experience and student performance in medical gross anatomy. *Clinical Anatomy*. 2017;30(3):303-11. doi: <https://doi.org/10.1002/ca.22846>.
26. Miller SA, Perrotti W, Silverthorn DU, Dalley AF, Rarey KE. From college to clinic: Reasoning over memorization is key for understanding anatomy. *The Anatomical Record*. 2002;269(2):69-80. doi: <https://doi.org/10.1002/ar.10071>.
27. Louro MD, Meegan G, Rudin LR, Granatosky MC, Thompson NE. Students with prior anatomy experience start out stronger in medical school gross anatomy. *Anatomical Sciences Education*. 2024;17(7):1406-16. doi: <https://doi.org/10.1002/ase.2495>.
28. Thomas R, Yancey T, Skidmore C, Ferrin N, Zapata I, Williams J, et al. The Effects of Pre-medical Anatomy and Clinical Experiences on Medical School Anatomy-Related Academic Performance. *Medical Science Educator*. 2021 2021/12/01;31(6):1839-49. doi: 10.1007/s40670-021-01372-1.
29. Savic M, Martin P. The perceived versus actual use of mathematics in medicine according to pre-medicine students and practicing physicians. *Teaching Mathematics and its Applications: An International Journal of the IMA*. 2017;37(4):192-201. doi: 10.1093/teamat/hrx011.
30. Buch SJ. Neuroimmune Pharmacology as an Emerging Curriculum for Pre-Medical Students. *Journal of Neuroimmune Pharmacology*. 2011 2011/03/01;6(1):68-70. doi: 10.1007/s11481-010-9229-4.
31. Cooke N, Wilson K, Bissett E, Goodell L. A Qualitative Assessment of Undergraduate Pre-Healthcare Student Views of Childhood Obesity. *The FASEB Journal*. 2011 04/01;25. doi: 10.1096/fasebj.25.1_supplement.99.6.
32. Ramos RL, Guercio E, Martinez LR. Pre-Medical Preparation in Microbiology among Applicants and Matriculants in Osteopathic Medical School in the United States. *Journal of Microbiology & Biology Education*. 2017;18(3):10.1128/jmbe.v18i3.372. doi: 10.1128/jmbe.v18i3.1372.
33. Moltzau Anderson J, Horn F. (Re-) Defining evolutionary medicine. *Ecology and Evolution*. 2020;10(20):10930-6. doi: <https://doi.org/10.1002/ece3.6825>.
34. Antolin MF, Jenkins KP, Bergstrom CT, Crespi BJ, De S, Hancock A, et al. EVOLUTION AND MEDICINE IN UNDERGRADUATE EDUCATION: A PRESCRIPTION FOR ALL BIOLOGY STUDENTS. *Evolution*. 2012;66(6):1991-2006. doi: 10.1111/j.1558-5646.2011.01552.x.

35. Nesse RM, Bergstrom CT, Ellison PT, Flier JS, Gluckman P, Govindaraju DR, et al. Making evolutionary biology a basic science for medicine. *Proceedings of the National Academy of Sciences*. 2010;107(suppl_1):1800-7. doi: doi:10.1073/pnas.0906224106.
36. Carvalho CDS. Knowledge and perception of antibiotic resistance and stewardship among pre-health and agriculture undergraduate students. *Journal of Microbiology & Biology Education*. 2024;25(3):e00069-24. doi: doi:10.1128/jmbe.00069-24.
37. Cahn SB, Mochrie SGJ. Biologic: Gene circuits and feedback in an introductory physics sequence for biology and premedical students. *American Journal of Physics*. 2014;82(5):412-21. doi: 10.1119/1.4866290.
38. Mochrie SGJ. Vision and change in introductory physics for the life sciences. 2012.
39. Crouch C, Heller K. Introductory physics in biological context: An approach to improve introductory physics for life science students. *American Journal of Physics*. 2014 04/30;82. doi: 10.1119/1.4870079.
40. Redish EF, Bauer C, Carleton KL, Cooke TJ, Cooper M, Crouch CH, et al. NEXUS/Physics: An interdisciplinary repurposing of physics for biologists. *American Journal of Physics*. 2014;82(5):368-77. doi: 10.1119/1.4870386.
41. Hilborn RC. Physics and the revised Medical College Admission Test. *American Journal of Physics*. 2014;82(5):428-33. doi: 10.1119/1.4862138.
42. Kortemeyer G. The Challenge of Teaching Introductory Physics to Premedical Students. *The Physics Teacher*. 2007;45(9):552-7. doi: 10.1119/1.2809149.
43. Mylott E, Kutschera E, Dunlap JC, Christensen W, Widenhorn R. Using Biomedically Relevant Multimedia Content in an Introductory Physics Course for Life Science and Pre-health Students. *Journal of Science Education and Technology*. 2016 2016/04/01;25(2):222-31. doi: 10.1007/s10956-015-9588-y.
44. Stover S. Integrating case studies into a pre-medical curriculum. *Bioscene*. 2020 05/01;46:23-6.
45. Bolduc KC, McCollough SL, Stoeckman AK. From classroom to clinic: Biochemistry lab for pre-health majors. *Biochemistry and Molecular Biology Education*. 2023;51(1):10-4. doi: <https://doi.org/10.1002/bmb.21675>.
46. Brenner C. Changes in chemistry and biochemistry education: Creative responses to medical college admissions test revisions in the age of the genome. *Biochemistry and Molecular Biology Education*. 2013;41(1):1-4. doi: <https://doi.org/10.1002/bmb.20653>.
47. Watkins J, Coffey JE, Redish EF, Cooke TJ. Disciplinary authenticity: Enriching the reforms of introductory physics courses for life-science students. *Physical Review Special Topics - Physics Education Research*. 2012 04/04;8(1):010112. doi: 10.1103/PhysRevSTPER.8.010112.
48. Afghani B, Manalang J, Salazar A, Lee J, Ki. Should cadaver lab be introduced to premedical students in an effort to promote their interest towards health careers? 2013.
49. Harris DM, Bellew C, Cheng ZJ, Cendán JC, Kibble JD. High-fidelity patient simulators to expose undergraduate students to the clinical relevance of physiology concepts. *Advances in Physiology Education*. 2014;38(4):372-5. PMID: 25434023. doi: 10.1152/advan.00063.2014.
50. Hyatt J-PK, Hurst SA. Novel undergraduate physiology laboratory using a human patient simulator. *Medical Education*. 2010;44(5):523-. doi: <https://doi.org/10.1111/j.1365-2923.2010.03651.x>.
51. Kennerly WW, Frederick KA, Sheppard K. General Chemistry in Just One Semester for All Majors. *Journal of Chemical Education*. 2020 2020/05/12;97(5):1295-302. doi: 10.1021/acs.jchemed.9b00898.
52. Schnoebelen C, Towns MH, Chmielewski J, Hrycyna CA. Design and Evaluation of a One-Semester General Chemistry Course for Undergraduate Life Science Majors. *Journal of Chemical Education*. 2018 2018/05/08;95(5):734-40. doi: 10.1021/acs.jchemed.7b00869.
53. Wasserman JA, Lopez AA, Knickerbocker R, Haywood A, Kibble J, Fraser R, et al. What

Premedical Students Need to Succeed: Updated Premed Competencies for Entering Medical Students. *Academic Medicine*. 9900;10.1097/ACM.0000000000006065. PMID: 00001888-990000000-01144. doi: 10.1097/acm.0000000000006065.

54. Muller D, Kase N. Challenging Traditional Premedical Requirements as Predictors of Success in Medical School: The Mount Sinai School of Medicine Humanities and Medicine Program. *Academic Medicine*. 2010;85(8):1378-83. PMID: 00001888-201008000-00026. doi: 10.1097/ACM.0b013e3181dbf22a.

55. Muller D. FlexMed: a nontraditional admissions program at Icahn School of Medicine at Mount Sinai. *Virtual Mentor*. 2014;16(8):614-7. doi: 10.1001/virtualmentor.2014.16.08.medu2-1408.

56. Goodman BE, Koster KL, Swanson DL. The development and implementation of a new medical biology major including physiology. *Advances in Physiology Education*. 2015;39(2):67-75. PMID: 26031721. doi: 10.1152/advan.00010.2015.

57. Baldi B, Utts J. What Your Future Doctor Should Know About Statistics: Must-Include Topics for Introductory Undergraduate Biostatistics. *The American Statistician*. 2015 2015/07/03;69(3):231-40. doi: 10.1080/00031305.2015.1048903.

58. Fried C, Madar S, Donley C. The Biomedical Humanities Program: Merging Humanities and Science in a Premedical Curriculum at Hiram College. *Academic Medicine*. 2003;78(10):993-6. PMID: 00001888-200310000-00010.

59. Tran J, Meller L, Le V, Tam J, Nicholas A. Behavioral assessment of soft skill development in a highly structured pre-health biology course for undergraduates. *Journal of Microbiology & Biology Education*. 2024;25(2):e00192-23. doi: doi:10.1128/jmbe.00192-23.

60. Peterson CA, Tucker RP. Undergraduate coursework in anatomy as a predictor of performance: Comparison between students taking a medical gross anatomy course of average length and a course shortened by curriculum reform. *Clinical Anatomy*. 2005;18(7):540-7. doi: <https://doi.org/10.1002/ca.20154>.

61. Kadavakollu S, Moullet Z, Yoshida M, Qureshi M, Graneto J, Boyanovsky B. Undergraduate pre-requisite coursework: Six important tips for pre-medical students considering Osteopathic Medical school in the USA. *International Journal of Osteopathic Medicine*. 2021;42:34-42. doi: 10.1016/j.ijosm.2021.10.009.

62. Haburchak DR, Mitchell BC, Boomer CJ. Quixotic Medicine: Physical and Economic Laws Perilously Disregarded in Health Care and Medical Education. *Academic Medicine*. 2008;83(12):1140-5. PMID: 00001888-200812000-00016. doi: 10.1097/ACM.0b013e31818c65c0.

63. Young SC, Colabroy KL, Baar MR. Comparable Educational Benefits in Half the Time: An Alternating Organic Chemistry Laboratory Sequence Targeting Prehealth Students. *Journal of Chemical Education*. 2016 2016/12/13;93(12):2004-11. doi: 10.1021/acs.jchemed.6b00254.

64. Malvitz M, Khan N, Morgenstern LB. College preparation for a medical career in the United States. *PLOS ONE*. 2024;19(2):e0298203. doi: 10.1371/journal.pone.0298203.

65. Merlo G, Ryu H, Harris TB, Coverdale J. MPRO: A Professionalism Curriculum to Enhance the Professional Identity Formation of University Premedical Students. *Medical Education Online*. 2021 2021/01/01;26(1):1886224. doi: 10.1080/10872981.2021.1886224.

66. Charon R. Reading, writing, and doctoring: literature and medicine. *The American Journal of the Medical Sciences*. 2000;319(5):285-91.

67. Dixon L, Pomales B, Hashemzadeh M, Hashemzadeh M. Is Organic Chemistry Helpful for Basic Understanding of Disease and Medical Education? *Journal of Chemical Education*. 2022 2022/02/08;99(2):688-93. doi: 10.1021/acs.jchemed.1c00772.

68. Gishen K, Ovadia S, Arzillo S, Avashia Y, Thaller SR. The Current Format and Ongoing Advances of Medical Education in the United States. *Journal of Craniofacial Surgery*. 2014;25(1):35-8. PMID: 00001665-201401000-00010. doi: 10.1097/01.scs.0000436737.67665.ab.

69. Harder B. Are MOOCs the future of medical education? *BMJ : British Medical Journal*. 2013;346:f2666. doi: 10.1136/bmj.f2666.

70. Sainfort F, Jacko JA, Cohen K, Rosman A, Vieweg J. Disciplinary Intersection of Medicine and Business: A Novel Population Health Management Premedical Pathway for Medicine and Other Health Care Professions. *Population Health Management*. 2022;25(5):616-24. PMID: 35763303. doi: 10.1089/pop.2022.0090.
71. Silverthorn DU, Galey WR, Dalley AE, Bond JS. Medical and premedical scientific competencies: Opportunity and challenge. *The FASEB Journal*. 2009;23(S1).
72. Young AE. Foreword. *Obstetrics & Gynecology*. 2015;126:i. PMID: 00006250-201510001-00001. doi: 10.1097/aog.0000000000001045.



Supplementary Files

Figures

Exclusion and inclusion criteria.



Multimedia Appendixes

The full MEDLINE search terms used in the review.

URL: <http://asset.jmir.pub/assets/afd880e7e2d3e06fa7d3136a18783979.doc>

MMAT (Mixed Methods Appraisal Tool) Table.

URL: <http://asset.jmir.pub/assets/33547e3268357cf5183a8d4aac3183e3.pdf>

As outlined to the editor, we were not able to include Table 1 in the word file. We are uploading it here as Appendix 3.

URL: <http://asset.jmir.pub/assets/c63644b4f6491692b71af71714b226d8.pdf>



TOC/Feature image for homepages

TOC.

