



How to Prepare for the Medical College Admissions Test (MCAT): Six Important Tips for Pre-Medical Students from Rural Areas

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Introduction

By 2030, it is estimated that there will be a shortage of more than one hundred and twenty thousand physicians in the USA [1, 2]. While the general shortage will affect the whole country, rural areas are expected to be impacted the most [3–5]. To address this shortage, it is important to enhance pre-medical students' access to available resources and effectively prepare them for the medical school admission process, especially in rural areas. Taking the Medical College Admissions Test (MCAT) is one of the milestones that every pre-medical student must reach when preparing to apply for a seat at a medical school [6]. Nearly all Osteopathic (DO) and Allopathic (MD) schools require MCAT scores as a pre-requisite for application and also use the MCAT as a selection factor during the admissions process [7, 8]. Even other selected allied health professional schools, including physician assistant and veterinary programs, will consider an applicant's MCAT score during their admission process.

Since its initial development in 1928, the MCAT has gone through six revisions, the most recent being in 2015 [9]. In each revision, the internal qualities of the test have drastically increased to assess the readiness of students for the rigors of medical school education. Addition of the psychological, social, and behavioral science subjects in the latest version tests a medical school applicant's understanding of the importance of population health and cultural competency in attempts to reduce the health care disparities in medicine [10]. While the changes cover a broad range of topics and encourage a more diverse population of applicants, it also significantly increases the total content and has made the exam more difficult for the

diverse population it sought to attract. Despite the assurance that there are no inherent biases against race or ethnicity, the Black and Latino test takers have consistently scored lower than White applicants [11]. Yet, the MCAT's ability to compare applicants who come from diverse backgrounds in a standardized manner is what maintains its status quo as the gateway test into medical school.

Despite the ubiquitous use of the MCAT for admission, it remains uncertain as to the test's ability to predict medical school performance. Graduation from medical school and continuation into residency are dependent upon completion of either the United States Medical Licensing Examination (USMLE), for MD schools, and Comprehensive Osteopathic Medical Licensing Examination (COMLEX), for DO schools. Multiple studies have found a variety of predictive measures for success in board examinations including MCAT, undergraduate GPA, post-baccalaureate experience, preclinical experience, and medical school GPA [12]. While each of the measures carries some predictive weight, one would assume that the specialized test to enter medical school would carry the most, but that has not been found to be the case. According to the published literature, improved board performance was only correlated with the Biological and Biochemical Foundations of Living (BBFL) systems section scores of the MCAT [7, 13]. Regardless of the unclear predictive value of the MCAT, it remains as a crucial measure for the admissions process for nearly all medical schools and is a major choke point for underserved and rural populations.

The chronic shortage of doctors and other health care providers is steadily increasing in rural residents over the urban populace [14, 15]. Even recruiting students from rural areas, who are more likely to practice medicine in similar rural settings, has not staved off the increasing deficit [16]. The cause behind this deficit requires further elucidation, but the little evidence has shown cultural and social differences weighing heavily [17]. Many rural students are hesitant to spend thousands of dollars on commercially available online courses, while other onsite MCAT preparatory courses are simply not

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available. Often students are not aware of the free or reduced-cost online sources and appropriate strategies available to prepare for the MCAT exam. While most pre-medical students join pre-health clubs to pursue medicine, many are still not aware of the vital resources available through American Association of Medical Colleges (AAMC). For some students, it is unclear how to begin preparing for the MCAT. The successful tips and techniques for planning, studying, and testing (Fig. 1) addressed in this manuscript can be used for guidance of pre-medical students who may not have access to traditional resources in attempts to impact the physician shortage problem in the nation, especially in rural areas.

Planning

Tip 1: Finish the Required Coursework

A major concern for nearly every pre-medical student is where to begin MCAT preparation. Often this means asking the question in one of the many online search engines, which can further muddy the waters with thousands of hits from a variety of websites. Top hits from popular engines are undoubtedly going to be paid advertisements from commercially available preparatory courses rather than low-cost preparatory sources from the AAMC. In addition to the prohibitive cost of many commercial courses for rural students, the focus of preparatory course companies is profit driven, regardless of the test outcomes for the students. Prospective applicants should take this into account when looking at the cost/benefit ratio for a commercial course. The costs include much more than just the fee required for the course [18–20]. Applicants should consider, among other things, the time that they will need to devote to be successful in the course, and whether or not that will detract from satisfactory performance in the demanding required coursework for their medical school application.



Fig. 1 Flowchart of tips a pre-medical student can use through the course of their MCAT preparation. *SIRS, Scientific Inquiry and Reasoning Skills

It is essential to finish required undergraduate science and non-science coursework before registering for the MCAT exam. Traditionally, coursework requirements for MD/DO schools in the nation include at least 1 year of organic chemistry (with labs), general chemistry (with labs), physics (with labs), biology (with labs), English, and some even require calculus or statistics as pre-requisites. Students should still investigate specific pre-requisite coursework requirements for the schools they are interested in applying too, as there is sometimes variation from school to school. Completing additional coursework, which correlates with the AAMC exam content syllabus is an effective strategy. Since the Biological and Biochemical Foundations of Living Systems (BBFL) section has the most correlation with board scores after medical school, it is especially important to focus on [7, 21]. With biochemistry as a major part of the BBFL and Chemical and Physical Foundations of Biological Sciences (CPFBS) sections, finishing one semester of biochemistry and cell/molecular biology courses would help pre-medical applicants to get a broader understanding of biomolecules, cells, and organs asked about on the test. Additionally, finishing psychology and sociology courses equips students with the knowledge of the social systems and problems associated with psychological, sociocultural, and behavioral issues, which will help on the Psychological, Social, and Biological Foundations of Behavior (PSBFB) section. Finally, taking English language (for reading comprehension), history, literature, and philosophy courses (Table 1) will improve student performance in the Critical Analysis and Reasoning Skills (CARS) section of the MCAT.

Pre-health advisors are also available at many undergraduate institutions, which provide specific academic options offered at the school. Taking additional upper-level science courses, writing-intensive courses, post-baccalaureate, or graduate-level courses (immunology, microbiology, pharmacology, and physiology) will further strengthen an applicant's testing ability. After completing these courses, examinees should feel prepared and confident to perform well on the test.

Tip 2: Register for the Test Date

Choosing the right time to take the MCAT can be just as important as the time spent preparing and studying for the exam. Under normal circumstances, it is best to register to take the MCAT in the calendar year prior to when a student is planning to enter medical school. This coincides with the beginning of the medical school application cycle, which starts in May and runs until October–January for most MD schools, and May until January–April for most DO schools. Students looking into the Texas Medical & Dental Schools Application Service should check for specific deadlines as they vary widely. Applicants should aim to be prepared to submit their application as early in the cycle as possible.

Table 1 Courses students should consider when planning their academic schedule to prepare strategically for the MCAT exam

CPFBS	CARS	BBFL	PSBFB
General chemistry	English	General Biology	Psychology
Organic chemistry	Reading	Anatomy and	Sociology
Physics	History	Physiology	Statistics
Calculus	Philosophy	Biochemistry	Behavioral sciences
Research	Humanities	Cell biology or	Public health
	Liberal-arts	Molecular biology	

One-year-long courses according to AAMC suggested admission requirements

CPFBS, Chemical and Physical Foundations of Biological Sciences; *CARS*, Critical Analysis and Reasoning Skills; *BBFL*, Biological and Biochemical Foundations of Living Systems; *PSBFB*, Psychological, Social, and Biological Foundations of Behavior

Paying approximately \$315.00 fee to register for the test can be one of the best motivating factors to start serious MCAT preparation [18]. The daunting task of preparing for a test like the MCAT can cause some students to postpone the exam and potentially start the process late, shackling their application to a delayed submission date after many prime spots have already been filled.

While students can schedule the test up to 6–8 months in advance, it is unclear as to the exact amount of time required for MCAT test preparation. According to the AAMC 2018, post-MCAT questionnaire 79.4% of test takers studied eleven or more hours per week, while only 29.4% studied more than 30 h per week [22, 23]. While there are many recommendations, there is no literature correlating number of hours studied with scores on the MCAT, although somewhere between 300 and 400 h is an accepted number. With the current version of the test clocking in at approximately 7 h and 33 min, it is beneficial for a student to work up to devoting 8 h per day for studying to simulate the real test duration. The MCAT tests a student's endurance; therefore, it is important for an examinee to build up stamina, step-by-step, during the preparation period. Choosing an MCAT exam date close to the completion of a preparatory course, or at the pinnacle of their study, will help an examinee to capitalize on their preparation time [23].

Students in rural areas must also overcome demographic and socioeconomic issues to register for the test. To surmount these economic hurdles, eligible rural students can apply to the MCAT Fee Assistance Program for reduced cost of registration, practice materials, and application fees through the AAMC Medical School Admission Requirements website. Beyond the economic barrier, rural students are often required to travel longer distances to the nearest testing facility and in some cases must book hotels the night before the test day which may have adverse psychological impacts on their performance. Students should weight how they will be affected by travel, and how their sleep will be impacted in order to decide where and when to schedule the MCAT.

Studying

Tip 3: Create and Follow a Realistic Study Plan

Foresight and planning are essential when preparing for the sheer volume of content covered on the MCAT. Many students devoting time to MCAT preparation must also juggle concurrent enrollment in coursework at school, work responsibilities, research commitments, family and social obligations, volunteer, and other extracurricular activities. One strategy many students follow, after selecting a start date, is to plan to accelerate time devoted to study as the exam date approaches to ease into the rigorous study schedule and prevent burnout. Planning should begin by brainstorming the available resources and suggested strategies to use those resources. Create a list of problem areas such as pre-requisite courses remaining, cost and availability of preparatory materials, amount of time available each day, and the time remaining until test day. Once students can identify the available resources and strategies, they will need to implement them into their active study plan rather than through passive activities (such as watching videos). Examples for active study habits include the following: creating summary notes at the end of each section, building an MCAT content vocabulary, applying the concepts into real-life scenarios, making flashcards, teaching back the concepts learned to peer students, practicing multiple-choice questions in the passages by using section banks, practicing interpreting data (including figures and graphs), identifying hypotheses, and creating compare-and-contrast charts and concept maps. Rural students can easily apply these active learning strategies into their study plan while preparing for the MCAT. Applying the content into these active strategies by using official practice questions allows test takers to gauge their understanding and application of the concepts studied. Creating a study plan allows students to grasp the breadth of the MCAT content and where they can narrow their focus.

Commercial preparatory courses motivate their students mostly due to the amount of money invested into the course, but proper planning and time management can allow motivated applicants (including rural students) to use the many reliable free or low-cost resources available, with a similar result. Khan Academy's MCAT Collection is a great starting point with 1100 videos and approximately 3000 practice questions covering all categories of the exam, with the added benefit of being open access. Quick content review can also be accessed using the free of cost website mcat-review.org. The AAMC is another resource for an examinee on a budget. Through the official website, students can access a variety of free or low-cost resources, including psychology, sociology, and biochemistry textbooks. Low-cost "Official MCAT Prep" bundles from AAMC are also very popular among the pre-medical communities. Since the AAMC decides the actual content on the MCAT, their official practice materials are especially well informed. Additionally, the AAMC provides multiple full-length exams that give a mirrored exam experience to prepare examinees for test day.

It is important to create a personalized and specific study plan. The AAMC blank Study Plan Worksheets, free on the AAMC website, can help students begin their plan [23]. The plan should account for their use of time until exam day, identifying the amount of time needed to study each day and remembering to allot time for normal responsibilities, including school, work, eating, sleeping, and resting. Students should identify their strongest subjects and plan to devote more time to areas where they are weakest. Once identified, students should find additional tools for weak areas and skills. The personalized study plan will become a living document. Although vast changes should not occur, it is essential to fine-tune the study plan based on improvements made as a student learns and grows over the weeks and months of preparation. Learning to self-motivate through a personal study plan and to be accountable to that plan will allow students to achieve their desired MCAT scores. Additionally, these skills will prepare them to be successful in their medical school career and beyond.

Tip 4: Enhance Your Reading Skills

Reading comprehension is an important skill that is required to achieve desired scores in each of the sections, especially in the CARS section. This section tests an examinees' comprehension, analysis, and reasoning skills by asking them to critically analyze material in each of the nine reading passages. The content for this session is generally taken from ethics, philosophy, studies of diverse cultures, literature, population health, psychology, social sciences, and humanities [24]. Scores in CARS were lower compared with all other sections when comparing scores of 239,681 test takers from data released by AAMC in 2018 [22]. This was especially apparent

in students with English as a second language or international students who immigrated to the USA. Even native English speakers have difficulty with this section often due to the short amount of time allotted for each passage. Examinees will need to quickly read and process information, comprehend the questions, and draw conclusions from the specific topics in the passages. Since reading skills are critical later in medical school performance, cultivating this skill before and during the MCAT preparation period is essential for pre-medical students. A recent study indicates a significant correlation between Nelson-Denny Reading test scores and reasoning-related section scores of the MCAT but not students' performance in osteopathic medical school education, although the authors of the study agree that further research is required to strengthen the findings [25].

Processing information while reading is a skill which can take years to develop. The best way to strengthen this skill is by simply reading as much as possible. While preparing for the MCAT, one should read a variety of forms of literature including news articles, books, and novels with a wide range of topics in both fiction and non-fiction categories. Additionally, reading the occasional scientific journal article will help students learn how to break down dense topics and learn new vocabulary. Students from the current generation tend to favor digital media accessed from smartphones and tablets in the form of video or animation. This is often clouded by distracting notifications from friends, social media, and other apps, which impede their ability to process complex arguments and memory recall [26]. Even the mere presence of a cell phone can negatively affect cognitive functioning during demanding tasks [27]. As such, students should focus on strengthening their reading skills in an environment comparable with the testing conditions. There are a variety of resources available online, such as Read me [28] or Spreeder [29], which can help struggling students to enhance their reading skills. Reading dense medical documentation and scientific journals will occupy a significant amount of a student's time during medical and clerkship rotations [30].

While reading books and articles is important, it is paramount to practice reading passages similar in length and content to the ones seen on the MCAT. Unlike the other sections of the MCAT, the answers for the CARS section are solely based on the passage. While reading these practice passages, examinees are expected to decipher the subtle clues based on vocabulary, sentence structure, and content, much like a physician would discover the clues of a disease. Readers should immerse themselves into the author's point of view and avoid injecting their own opinions or viewpoints on a subject.

Topics for the CARS section can vary widely from science to music theory, and examinees should remember that comprehension is based on what they have learned from the given information in the passage, not prior knowledge. A good practice while reading passages is to consider what information is

important in the passage, what is the main idea or opinion of the author, what is the underlying concept of the passage, and what major themes are presented in the passage. Practicing numerous passage questions will reveal patterns and themes and should help students to learn to eliminate wrong answers and narrow down to the correct answer. Many students will try to read the passage faster, but there is always some trade-off between speed and comprehension [31]. When skimming through the passages, it is important to slow down to a normal speed when arriving at crucial information in the passage. Applying these reading methods to study time will help prepare students for the rigors of the full-length exam.

Testing

Tip 5: Understand and Apply the Basic AAMC Identified Skill Set for Which the MCAT Tests

Scientific reasoning skills are essential to the success of all medical students, which is what the MCAT is designed to test. The AAMC has identified four specific Scientific Inquiry and Reasoning Skills (SIRS) that successful examinees should apply to multiple-choice questions following the passages in each section (Table 2). The MCAT tests a student's ability to apply the SIRS in the context of natural, social, and behavioral sciences. Most of these skills should be encountered by pre-medical students while taking their undergraduate coursework but can be developed through certain MCAT preparatory courses or materials. Recognizing these necessary skills and applying them during preparation will train an examinee to critically analyze the MCAT passages and questions. Proficiency in SIRS will not only help during the MCAT but will also help in students' undergraduate courses and beyond.

The first SIRS, knowledge of scientific concepts, can be mostly achieved through completion of the pre-requisite courses discussed above in tip 1. College-level classes do well at introducing topics and covering a large amount of content, but assessment of that content is usually accomplished through recall of the material or application in known scenarios. The MCAT, however, will assess understanding of those same concepts applied into novel disciplines or scenarios in passage-based multiple-choice questions. For example, if you see the content outline "electronegativity," first try to understand the definition of electronegativity, recognize the

practical examples related to the electronegativity, identify its relationship with closely related concepts, and practice multiple-choice questions based on this concept.

Involvement in undergraduate research projects or taking laboratory courses may help in developing the remaining three skills. Most of the questions related to these skills involve experimental data or scientific information in the passage and ask a student to solve a problem using the given information, relying on basic knowledge. Reading current scientific research literature and applying strategies such as selective and critical reading, assessing the authors conclusions, and identifying key ideas in the paper will benefit students through application of scientific reasoning and problem solving [32].

To enhance reasoning about design and execution of research skills, a student should try to evaluate the scientific principles, theories, or models discussed in the given passages and make appropriate predictions or conclusions. A student should then consider whether the data and observations given in the passage are congruent with the proposed scientific model or not. Finally, a student should attempt to evaluate the author's opinion about causality and consequences, thinking like the author and avoiding insertion of personal opinions. This will be useful throughout the test, but especially in the CARS section. In CPFBS, students will have to use their previous knowledge of scientific formulas and concepts related to a topic while solving problems associated with the given passage.

Finally, data-based and statistical reasoning skill will be enhanced with learning and practicing basic statistical principles. Having a broad understanding of independent, dependent, and confounding variables, as well as descriptive and correlational research methods, will help a student to answer questions related to research techniques. Fundamental ethics of human research is another area that examinees should become familiar with. Experimental methods involving human subjects will help students to understand the basic components of human research.

It is important to have a broad understanding of these concepts before taking the MCAT. The MCAT tests all these concepts at a level that is commonly covered in introductory to mid-level science classes during undergraduate education. While attending science lab courses, understand qualitative and quantitative data collection, data analysis, creating and understanding graphs, design and execution of experiment, and statistical reasoning of the results used in making proper

Table 2 Four different Scientific Inquiry and Reasoning Skills by AAMC are distributed into the questions of each passage

Scientific inquiry and reasoning skills	Approximate number of questions per passage
Knowledge of scientific concepts and principles	2
Scientific reasoning and problem solving	1
Reasoning about the design and execution of research	2
Data-based and statistical reasoning	2

conclusions. Rural students who do not have access to MCAT preparatory courses should apply these tips to develop their knowledge of SIRS and enhance their self-directed learning.

Tip 6: Study, Practice, and Use Full-Length Exams

There is a vast variety of study methods examinees can choose from as they work through the content identified in their study plan. It is crucial for a student to find the right study technique that works for their personal learning style. Flashcards, vocabulary lists, summary sheets, or lecture notes are some useful ways for reviewing the many chapters of content. Review materials available will depend on the resources acquired. The advantages of the commercial preparatory courses are the many review techniques contained in the package. Once content has been covered and reviewed, students should measure their retention and application of the SIRS skills through questions from passage-based scenarios. Concerted studying followed by quizzes and practicing sections of the test is a successful model for MCAT preparation [33, 34]. The greater the number of passages that an examinee practices, the easier it will become to recall content and analyze the questions.

More than any other study technique, however, using full-length practice tests will be the best strategy to conclude preparations for the MCAT. Recreating the atmosphere, setting, and length of the real exam while taking practice exams will help students to develop endurance and the attitude required on the test day. Be sure to take the recommended breaks for the restroom and to eat, so that on test day, an examinee is prepared and will have the energy and focus required for the exam. A student should use their individual scores in each practice section to adjust their study plan (as discussed in tip 3) and recognize areas which need improvement. The AAMC offers three practice exams for a small fee. All test takers should take at least these three practice exams before test day, more depending on the level of confidence, time available, and financial situation. While the results from practice tests will help students to gauge their readiness, they should avoid obsessing about the score, but focus rather on the lessons learned [35]. If students achieve their desired range of scores on multiple full-length practice tests, they should feel confident when entering the testing center on test day.

Summary

Developing effective study skills and proper testing strategies is essential for successfully completing the MCAT, and also for becoming a stellar medical student, passing licensing board exams and even later in the practice of medicine. With an increasing deficit of medical professionals, especially in rural areas, it is imperative to draw from a broader pool of applicants to meet this demand. Applying the principles

addressed in this manuscript will help pre-medical students from all backgrounds to successfully complete one of the biggest milestones for becoming a physician. Learning how to identify areas of struggle and develop a plan of action will establish a pattern of life-long learning essential in the medical field. Additionally, faculty and pre-health advisors can use these tips to advise and encourage pre-medical students from rural areas to broaden the applicant pool and help create a more diverse health care system in our nation.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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