Research Training and Certification Protocol for Medical Students

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Early and frequent exposure to research is imperative to initiating and sustaining long term for medical student research interest. The attitude and approach of physician mentors has been demonstrated to have a substantial effect on student perceptions of research involvement. The purpose of this study is to determine best practices for assessing student perceptions for a research certification program. An additional long-term objective is to utilize these findings to help maintain interest in research throughout their medical careers. Research is an essential aspect of the prestige of medical schools, and the benefits of academic research institutions have numerous facets, including more funding opportunities, access to the latest technologies and techniques, and high institutional quality ranking.

A mixed-methods, quality improvement survey was distributed by the MSU Office of Student Affairs and Services to all medical students. The collection period began in Fall 2020, with the post-test period in Spring 2021. There were 52 unique, paired respondents included in the analysis. Nominal data was analyzed using chi-squared testing. Paired-sample t-test and was used for Likert scale questions. Qualitative data assessment methodology was performed using content analysis theory. The four difference exposures ranged from required and elective coursework to scholarly conferences and extracurricular research. To classify respondents into
stratifications based on research knowledge/experience and research importance
responses were converted to numeric values. The improvement in knowledge/experience was
noted to be statistically significant. The change over time was not found to be statistically
significant for research importance. However, for the aggregate data, the improvement noted
from the pre- and post-op period was significant.

The results of this survey indicate several insights regarding the qualities that best
c caracteresize the most knowledgeable and experienced medical students in research. Also, there
are factors that determine which of these are most likely to continue to be in engaged during
residency and into practice. While gender and ethnicity dynamics do not play a substantial role
in research interest and exposure, students do tend to be older with higher levels of education.
The significant improvement observed in pre- and post-test comparison reinforces not only the
importance of research exposure, but also that the experience be multimodal in nature.

A flexible myriad of approaches has been observed, both in this study and the literature
to be the ideal means of encouraging students to engage and maintain research interest. In the
longer view, it may also prove to have the same utility beyond medical school. Having a better
understanding of how students perceive research is essential for advancing curricula that
supports and encourages prospective physician scientists. A promising starting point is to
identify the key characteristics of students who are most likely to actively participate in
research both in medical school and beyond. Once that profile is understood, the experiences
and exposures of those students can be used as template to optimize research involvement for
future students.
RESEARCH TRAINING AND CERTIFICATION PROTOCOL FOR MEDICAL STUDENTS

by

Michelle Arisleida Padley

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for the degree of Doctor of Philosophy
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I still have not really registered that this journey is nearly at its end. Or rather, it is the beginning of another chapter in my academic sojourn.

As with most odysseys, the most fruitful ones are not taken alone. I would not be here with an incredibly supportive network, who provided a soundboard off which to bounce ideas (both good and bad), scholarly collaboration, as well as just for conversation and relaxation or even for gentle reminders to take those all-important breaks along the way.

I would like to acknowledge and offer my deepest gratitude to my doctoral committee, starting with my advisor, Dr. Rob Lyerla for his guidance and encouragement along the way. Dr. Mark Trottier offered invaluable direction and expertise, and made this entire process more enjoyable, and contributed his first-hand experiences from his unique perspective. This was immensely helpful for helping me to become a better mentor and professor for my students. Dr. Kieran Fogarty provided the best devil’s advocate, and always encouraged me to look at things from new angles. My other collaborators include Lindsey Behrend, my professional colleague, best friend and first reader, as well as about the only person who understands what I mean when I “forget the subject” -- including myself. Her veracious familiarity with obscure aspects of history really opened new avenues of thought I would not have otherwise known to explore. As she would often state: “Galen is inescapable.”

I would also like to gratefully acknowledge the assistance of all the faculty and staff at Western Michigan University's College of Health and Human Services Interdisciplinary Health Sciences program, as well as the helpful facilitation of my collaborators and personnel at
Michigan State University’s College of Human Medicine. The research physicians at my practice offered me the opportunity to work with medical students when I first started in my professional position. I am endlessly grateful for this, as it began my first forays into teaching, and sparked the interest that led to this project. All of the students that I have had the privilege to mentor over the past decade and a half also played a valuable role in this endeavor. I am better as a student, instructor, and co-author from my experience with them, and their boundless enthusiasm for research projects never fails to renew my own vigor in what can at times become routine.

Finally, none of this would have been possible without my family (genetically related and otherwise) and friends. My mother Aris and my sister Suzette, who have been behind me from the very beginning, never complained about the view. Also, Frederic Oehmke, who would coax me out of my writing cave for sustenance, rest, and entertainment. It was always time well spent.

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As wiser philosophers than me have said, every journey starts with a first step. Here’s mine.

Michelle Arisleida Padley
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CHAPTER I

INTRODUCTION

The purpose of my dissertation is to determine the best practices for assessing perceptions by medical students for a pilot research certification program in a research-intensive university setting. An additional long-term objective is to use these findings to help maintain student interest in research throughout their medical careers.

Statement of the Problem

The vast majority of medical students (over 85%) are actively involved in research during medical school, while only a fraction of physicians devote their practice solely to research (Jain, et al., 2019). The students reasoning for participation may vary (personal interest, residency selection), but it is generally understood by mentors and educators that positive and prompt participation in research experiences is imperative to initiating and sustaining long term interest in clinical studies for early medical students (Burgoyne, et al., 2010). There are a myriad of ways to encourage students to engage in research, but the literature suggests that the best, most lasting impressions are closely related to the individual’s experiences, particularly mentor attitudes and empirical data collection methodology, rather than specific subject matter (Burgoyne, et al., 2010) (Klowak, et al., 2018). Therefore, obtaining an understanding of medical student perceptions of research is imperative to this project, and in order to gain more insight on what keeps students engaged in research beyond residency and into practice. Research methodology, including scholarly engagement and collaboration with colleagues toward
common goals are not just important to skill development, they also play a foundational role in medical practice (Velez, et al., 2017).

While a student’s ambition to match into a competitive residency program is one driving force for medical student research participation, I hypothesize that the drastic decline in physician’s engaged in research isn’t only attributable to that factor (Jain, et al., 2019). However, it is unclear as to the degree physicians engage in primary or secondary research as a part of their practice. Rather, that 1.5% reference from the literature (PSW-WG, 2014) is specific to physicians who devote the majority of their practice to academically driven research (often specialty-trained MD-PhD physician-scientists) (PSW-WG, 2014). This does not include those who engage in outcomes and registries, investigator-initiated projects, or clinical trials as a smaller percentage of their practice. Regrettably, there is a paucity in the literature concerning the true number of physicians in these levels of involvement.

**Importance of Study**

Research and innovation are vital aspects of medicine. Early student engagement has been shown to translate to continuing involvement in research during clinical practice (Collier, 2012) (Ommering, et al., 2018) (Velez, et al., 2017). The clinical breakthroughs by physician-scientists and other research clinicians have made such an impact on medical therapy that the U.S. federal government established an ongoing endowment to the Medical Scientist Training Program over half a century ago (Harding, et al., 2017). These are in addition to other federally-funded research-focused medical training tracks that encourage the career development of physicians scientists as well as their projects, as well as additional support to cover educational
costs (Brown, 2018) Research activities for medical students are emphasized not just for the completion of projects, but also for the critical analysis, professional development and intercommunication proficiencies garnered through research education (Velez, et al., 2017).

A number of surveys have been conducted to assess students’ perceptions of and approaches to research. These studies evaluated what respondents thought about their own research experiences, and their impact on future professional goals. Their results demonstrated that mentor attitudes and research experiences are more beneficial for students than project focus (as well as a major facilitating factor for continuing involvement) (Klowak, 2018) (Pathipathi, 2016) (Siemens, 2010). While these studies do provide valuable insight on medical student impressions of research, this project seeks to determine if specific research activities change those impressions over time. In addition, a long terms goal of this research is to determine if there are potential determinants that predict the continuing of research participation past medical school.

There are multiple stakeholders that may benefit from this research, including student researchers, who may obtain a better idea of how to approach mentors and gain an understanding of the type of research experiences that prove most beneficial professionally. The Research Certificate Selection Committee at Michigan State University College of Human Medicine could use a portion of the results as guidance for qualifying factors for selection of student participants. This group and other faculty at the university could also utilize the data to develop research curricula with a view to encourage long-term research participation by students. The overall research community may benefit from this knowledge to help guide the
development of research training programs for students and residents, and over the long term, from an influx of physician researchers who have had encouraging early research experiences. Mentors would appreciate (and be more willing to collaborate with) students that were more aware of research commitments and have a realistic approach to project involvement.

Theoretical Framework

The National Institutes of Health have been the predominant source of funding for biomedical and research training in the United States since the introduction of the MSTP program in 1962. After several decades of rapid growth of both student enrollment and support, there was a marked decrease in financial backing the past three decades (a static negative of funding since the 1990’s) (PSW-WG, 2014). As a result of this policy change, there has been a steady decrease in the percentage of the medical and research workforce who receive specialty training and support due to this decline in funding. Therefore, other options to supplement the physician research workforce are needed, including non-MSTP programs, research year internships, and research certification programs that are concurrent to conventional MD/DO school programs (PSW-WG, 2014). An extensive analysis of the participation in research by physicians in training is outlined throughout Chapter 2.

Velez, et al., presented a compelling assessment of the importance of research as an essential aspect of teaching medical students. The foundations of educating students in research concepts lies with Evidence-Based Medicine (EBM), a primary driving force for clinical care. The introduction to the principles of EBM is essential to early medical education and continues to guide student decision-making about overall career objectives (Rosenblatt, et al., 2006)
(Velez, et al., 2017). Further, a robust research portfolio prepares students for the substantial demand and competition of clinical residency and practice, as well as that of academic medicine. This can further drive a clinician to roles of leadership and mentoring in their respective specialties (Velez, et al., 2017).

It follows that factors that encourage students to engage in research, and maintain their interest throughout clinical practice, should be taken into account when determining the factors which sustain research involvement. At current, 85% of medical students participate in research, but the number drops off severely in residency and into attending status (LCME. 2021). This is demonstrated by the 1.5% of practicing physicians (a decrease from 4.75% four decades ago) who report a primarily research-focused practice, which has been steadily decreasing in recent decade (PSW-WG, 2014)(Garrison & Deschamps, 2019). Furthermore, the current cohort of physician scientists are aging, without younger practitioners to mentor and take their place (Jain, et al., 2019). Therefore, it is imperative to determine the aspects that lead to this significant downward trend and mitigate the factors as much as possible. Additionally, it’s beneficial to look beyond academically dominant practices to include physicians who include research as a small proportion of their vocations. It is important to note that it is not feasible or desirable for the physician workforce to be comprises of a majority of physician scientists. Rather, the goal is to arrest the decline, and re-emphasize the importance of research as an important aspect of medical care. Since student motivation for research participation includes residency placement, desire to work with a specific mentor or specialty, as well personal interests (Klowak, 2018) (Pathipathi, 2016)(Siemens, 2010), the most influential factors that motivate post educational research pursuits remain elusive.
Research Questions

The proposed research questions are as follows:

1) How does medical student knowledge of concepts and perceptions about research change following second semester research experiences and electives (research internships, research-day presentations and research intersession), as well as research-intensive university environment?

2) What factors predict interest in continuing research participation beyond medical school?

Definitions of Terms

The terminology guide below will assist the reader in terms on context throughout the text:

Medical Student – Any person enrolled in any academic program and pursuing an MD or DO degree (or MD-combined degree, such as MD-PhD) at a U.S. MD or DO-granting medical school (AAMC, 2021).

Physician-in-Training - A physician (medical school graduate) who is engaged in a graduate training program in medicine (which includes all specialties) and who participates in patient care under the direction of attending physician)(NRMP, 2022)
Physician-Scientist - Physicians (MDs or DOs with or without additional degrees) who devote regular components of their professional effort seeking new knowledge about health, disease, or delivery of patient care through research. (AAMC, 2021)

Physician-Researcher – An informal term for any medical doctor who engages in research during their practice, either within or outside of an academic setting.

Principal Investigator – An independent or institutional-affiliated grantee and lead researcher for a funded protocol a laboratory study or a clinical research trial who is ultimately responsible scientific and/or technical project conduct. This individual does not necessarily need to be a physician (NSF, 2002)
CHAPTER II

BACKGROUND/SIGNIFICANCE

Medical research experience, and an understanding of the scientific method is an invaluable skill set for future clinicians (Collier, 2012). Through formal and mentored instruction in research, students acquire the competence to critically consume and analyze scholarly literature, making them better equipped to determine between “good” and “poor” research methods and publications. Students are also able to keep up with the latest techniques and treatment modalities in their chosen professional specialty (Chang et al., 2015). Further, research capabilities can be applied to other areas of clinical care, fostering intellectual curiosity and an atmosphere of inquiry for both students and collaborators. Additionally, students who are interested in pursuing careers in research can gain expertise and make important connections early in their medical education throughout project involvement (Burgoyne, et al., 2010).

It follows that medical students have always played a key role in the advancement of clinical knowledge. Early in the days of organized medical academics, students have made invaluable contributions. This includes the identification of certain aspects of human anatomy, describing physiological functions (Islets of Langerhans and insulin) and discovering innovative medical treatments (Penicillin). Many physicians in training have demonstrated an interest and talent for research early in their careers (Stringer & Ahmadi, 2009). However, until only a few decades ago, the research-specific career course pathway had yet to be formalized. The objective of the background is to follow the thread of research involvement, the influence of research-
intensive scholarly environs (and the positive and negative connotations) for physician students
from early history through to the present day. Further discussion of the interrelationships of
formalized research instruction as an aspect of medical education will be elaborated later in this
paper.

A Brief History of Medical Education

The foundations of modern medicine are rooted in the archaic principles of mysticism,
herbalism, and alchemy (Fulton, 1953). These dogmas were practiced in tandem throughout the
regions of the ancient world, although the applications and philosophies could vary widely. The
earliest cultures with recorded medical treatment modalities include Egypt, Greece, China and
Rome. It is important to note that medical advances did not occur in isolation. Many early
civilizations engaged in intercommunication, on both friendly and belligerent terms (Flexner,
1924) (Fulton, 1953) (Xie, et al, 2007). In Greece, for instance, one of their primary clinical
philosophies (Knidian) closely aligned with the medical belief structure in Egypt at the same
time (Turgut, 2011). Meanwhile in BCE China, practitioners from India (and more recently
discovered, further west) shared knowledge in arts and sciences, including medical theories
(Deshpande, 2001). This is not to discount the contributions to the discipline from other
civilizations, but relatively few archives of these methods survived to the modern day. Therefore,
the research of historians is somewhat limited to the contemporary notations of practitioners
and scholars, as well as by the perceptions of past record-keepers.

A common theme among these early cultures (that continues to this day) is the emphasis
on the apprenticeship system. One-on-one teaching was and is foundational, with practical
skills and wisdom passed on from one generation to the next. Through this educational relationship, the knowledge base is continually being broadened and defined. Initially, this process was based mostly on the individual opinions and experiences of the teacher-practitioner. As humans became more mobile and migratory in nature, they would travel to larger metropolises seeking medical knowledge. Naturally, the nuclei of human civilizations became centers of excellence for education and culture, as they continue to be today.

Even in larger cities, the apprenticeship structure was still dominant until only a few hundred years ago. This exclusive approach was non-systematic, in stark contrast to how medicine is taught and practiced in the modern day. There are advantages and disadvantages to this technique when it is applied to teaching. The non-standardized mentoring methodology of medical instruction takes an in-depth view of very specific conditions but can be greatly hindered by the narrow worldview of mentors and a lack of scientific rigor (Fulton, 1953)(Lang, 2013).

Although this more primitive era was dominated by a non-systematic approach to education, innovation still flourished (Lang, 2013). Concerning the very beginning of research and clinical science, investigations were conducted through crude techniques, dissections (as local custom permitted) and lectures among learned colleagues. In the historical annals below, there are numerous examples of how the foundations of shared knowledge and discoveries scientists several centuries ago with established by early practitioners. Even then, research principles were an essential aspect of medicine, even if these practitioners did not know what they were as a discipline during their time. Further, a noted characteristic that is shared across
cultures and millennia is that an atmosphere of scientific inquiry engenders improvements and advancements for all aspects of society, from medicine and education to technology and invention. This is prevalent throughout history (as will be noted below), although research experience and exposure as a formal discipline and component of medical education is less than a century old (Harding, et al., 2017).

Classical Greece

As was common throughout the ancient world, medical education consisted almost exclusively of apprenticeships by students with a learned mentor. There were very few formal institutions of education for the learning of any subjects, including medicine and patient treatment (Kleisiaris et al., 2014). Medical schools of thought in early Classical Ancient Greece were delineated in two philosophies, named for two prominent Mediterranean cities where they were thought to have originated: Knidos (now Yazıköy, Muğla Province in Modern-day Turkey) and Kos (a Greek island in the Dodecanese archipelago that still retains that name)(Turgut, 2011). The Knidian practice of medicine was based on diagnosis and treatments and was less focused on the condition of the individual patient. These treatments often took the form of gastrointestinal purges and simple dietary changes (Turgut, 2011). It can also fairly be stated that Knidian dogmatic practitioners were more concerned with the specialized didactic aspects of medicine, devoting the majority of their practice to documenting disease processes and symptoms with a high-level detail. Additionally, although it was not particularly useful in this regard at the time, the very descriptive manner in which followers of this school recorded
medical phenomenon provides the earliest seeds of rigor which are essential to many aspects of medical practice, from epidemiology to research methods. (Lang, 2013).

By contrast, Koan medicine was more patient oriented. The main objective was to consider the prognosis of a medical condition first and foremost (Turgut, 2011). This required a deeper understanding of the disease process, and a view of illness from a more generalized perspective (Turgut, 2011). The cornerstones of modern medical practice foundational to the Koan’s include the concepts of physical wellness along with the importance of diet and physical activity in maintaining wellness (establishing the earliest roots of preventative medicine) (Tountas, 2009).

Later in the era, Pythagorean philosophies of medical practice were similarly divided into two distinct groups: the akousmatikoi (translated to “esoteric statement”) and the mathematikoi (translated to “scientific statement”) (Gregory, 2015). The akousmatikoi adhered to Pythagorean orthodoxy and resisted any scientific developments and discoveries as they may have a deleterious effect on their belief system. By contrast, mathematikoi Pythagoreans integrated their spiritual convictions with the innovations in mathematics and other scientific endeavors (Gregory, 2015). For the purposes of medical education, the mathematikoi encouraged scientific inquiry and debate, and engaged in lectures and scholarly activity, sharing knowledge and discoveries in their academic communities, which were inherently research-intensive. Therefore, it’s important to acknowledge their contributions to medicine as well as research, and the contributions of practitioners in training, although they did not know anything of the scientific method contemporaneously (Gregory, 2015).
Roman Empire

The Roman Empire spanned for a century and a half, coinciding with the demise of the Ptolemaic Pharaohs and the gradual transition to Rome as the center of the Western world. Even with the social upheaval, Alexandria remained an important intellectual metropolis. As such, many prominent scientists and philosophers were educated there, and spread the scholarly advancements of the Mouseion (conservatory of higher education) throughout the empire (Erskine, 1995). The library at Alexandria provided the template for other such institutions in many cities, including the first publicly accessible library in Rome (Dix, 1996). Direct observation comprised the majority of thought on medical education throughout the Roman Empire in the first century CE. The first of these was founded in Rome, but there were eventually a number of these organizations established in the vast territories of the Empire (Drabkin, 1957).

Galen was one of most enduring, renowned physicians and scientists of the ancient world. Similar to Wang Bing in eighth century China (mentioned later in this dissertation), he took the responsibility of compiling medical knowledge of generations of clinicians very seriously. He also, like several historiographers both before and after him, added his own medical discoveries and interpretations (Unschuld, 2016). Also similar to individuals of uncommon intelligence and influence, Galen was also possessed of a very substantial ego and tended to be viewed as a very antagonistic figure both by contemporaries and historians. He was decidedly competitive and strong in terms of debate, somewhat pompous and not terribly open
to views opposing his own. He would also often go out of his way to discredit others in order to support his own theories (Nutton, 2005).

Despite his shortcomings, Galen’s contributions to medicine and early applications of research can hardly be underestimated. His inherent desire to present and publish the results of his scholarly endeavors, diffusing his knowledge to other practitioners and students, is a vital aspect of research to the present day (Horsley, 2011). Notably, his most egregious anatomical assertion of the Humoral Theory inspired Renaissance physicians Andries van Wesel (Andrea Vesalius) and William Harvey to systematically repudiate his assumptions (Markatos, et al., 2019) (Horsely, 2011). These two scientists, who questioned some of the principles in the Galenic Corpus, actually applied Galen’s own principles of experimentation: meticulous documentation, environmental standardization, and technique refinement to conduct their studies (Pasipoularides, 2013). They, then, imparted these lessons to their students. This teleological approach to clinical questions, observations, and methodology, denotes that not just the lessons but the techniques were taught to later physicians in training. Further, his approach to medicine also considered the limits of the human mind in terms of medical knowledge, this was a refined iteration of the stance first taken by Alcmaeon in Ancient Greece six centuries earlier (Santacroce, 2019). Additionally, the equal importance that he placed on scientific research methodology and clinical treatment demonstrated a significant advancement in the approach of a scholar/researcher in the practice of medicine. This offers a primitive example of the importance of the role of the physician scientist in the education and practice of physicians (Pasipoularides, 2013).
Simultaneously outside of the West, many other cultures were developing their own approaches to medical treatment and education. The medical training system in China offers a rich comparative history to their Western counterparts, with numerous discoveries occurring in tandem, while others pre-date the West by many centuries. This conspectus is by no means entirely comprehensive, but rather a truncated account of the most important contributions of medical scholarly activity and clinician training modalities over the past three and half millennia. A few notable examples of medical education and the role of research from the various imperial dynasties are noted below.

Tang Dynasty (618-907 CE)

This era benefited greatly from the extensive expansion of the academic structure for training physicians during the previous Lui Song Dynasty. The novel methodology for clinical education that was continued and refined into the Tang was pioneered by Sun Simiao (birthdate unknown to 682 CE) (Wu, 2018). He was highly prolific in his writing and teachings, building upon the lessons of previous scientists. His influence was so great that he was known as Yaowang (King of Medicine) during his lifetime and long afterwards (Zheng, 1986).

In addition, many teachers, philosophers, and scientists were not necessarily active practitioners of medicine but engaged in experimentation and scholarly activities. This began the still relevant position of clinical professor, known at the time as medical academician (Wu, 2018). Building on the knowledge base that was garnered from these new institutions, the Tang
Dynasty served as a turning point in medical and scientific discoveries for the Chinese Imperial Era. A new organization for providing governmental oversight for medical education was established late in the Tang: The Great Medical Service (Tai Yi Chu). Further innovative ideas, from sources home and abroad flourished, and the educational system required substantial change to facilitate the dissemination of clinical knowledge to eager scholars (Wu, 2018). The Esoteric Scripture of the Yellow Emperor (Huangdi Nailing) was compiled in 762 by Wang Bing during the Tang, although portions of the 81 chapter compendium originated from as early as the Han Dynasty in the second century BCE (Unschuld, 2016). This has become an essential academic text for training practitioners in this discipline.

Mongolian Empire & Yuan Dynasty (1206-1368)

The most expansive contiguous land empire in human history began with the nomadic tribes on the Mongolian Chinese border in the beginning of the 13th century. At its peak in 1279, it extended from Korea and South China Sea in the east and the Euphrates River (modern day Iraq and Syria) and Moscow in the West. It encompassed the entirety of China and Tibet to the border of the Indian subcontinent to the south and the majority of sub-Siberia (modern day Russia) through the north (Safavi-Abbasi, et al., 2007).

Paradoxically, invaluable advancements in human knowledge were dispersed through the hostile Mongolian invasion and conquest of China and neighboring countries including Korea, Northern India, and other parts of Southeast Asia. However, from these grim origins, the Khanate and their campaign of conquest lead to a cultural explosion in the exchange and
advancement of ideas that rivals that of the European Renaissance or even the Internet Age in terms of influence (Safavi-Abbasi, et al., 2007).

The conquest was undertaken by a number of means, from diplomacy and local treaties to violent takeover. However, over the course of decades, an interesting phenomenon occurred. Known historically as Pax Mongolic or Peaceful Mongolia, this was a period of considerable harmony considering the vast land under Khanate control (Buell, 2007). Initiated during the reign of the fifth Khan, Kublai (also known as the founding Yuan emperor Shizu) was marked by relative religious freedom, sharing of knowledge, traditions, and culture (Buell, 2007). There were also other inherent advantages to their tolerance of the vast myriad of cultures under the Khaganate. Mathematicians and scientists throughout the empire were able to freely exchange ideas, fostering a scholarly community. Medical figures that were well-known at the time utilized the Silk Road to collaborate with others, as well as seek out training and employment far from their homelands (Lane, 2006).

For the first time, the purpose of medical education was indicated to provide service to the government and the Empire, including the subjects in the community. Knowledge was centralized; with the imperial government, scholars and local officials working together to build and maintain institutes of higher learning. A major change defining this period was the development of the Four Great Schools, first established during the Jinx several centuries earlier. This quartet of approaches to medicine includes the first of the non-secular schools separate from Confucian theology institutions (similar to the Galenic schools which delineated themselves from religion in Europe at the same time) (Shinn, 2009) (Siraisi, 1977).
To facilitate the appointment of clinical instructors for these revived medical schools, paid positions were offered, which were highly desirable to local physicians and others interested in becoming educators. Intellectuals and physicians were given generous salaries and other incentives (including silk/silver tax and civil service exemptions), to travel and teach and share their knowledge (Safavi-Abbasi, et al., 2007). Another unique aspect of these innovations was the expansion of the availability of medical training, offering education to those from humble beginnings. The most prominent example of this expanding enrollment, opening opportunities not only to the sons of physicians and nobility, but also for families in other trades, as well as physicians of other backgrounds who were deemed to possess ideal dispositions to practice medicine. This model even permitted the education of non-Yuan students and physicians (Shinnok, 2002).

Students and other local practitioners were obligated to read current medical literature and submit reports of clinical activities to medical erudites and clinical school faculty, creating a system of evaluation of clinical competency, as well as continuing education requirements (Shinno, 2002). Apprenticeships for new physicians also continued beyond medical school. Professors and pupils were also encouraged to meet bimonthly, burn incense, discuss medical theories, reflect on practices, and draft notes for review. Such activities (sans the incense) are antecedents to the modern journal club (Rivero-Müller & Nees 2019). The scholarly discourse that occurs during journal clubs often provides fertile ground for research ideas and potential collaborative studies, intrinsic to research-focused curricula (Rivero-Müller & Nees 2019).
There were also substantial efforts to prevent unqualified individuals from practicing or teaching medicine, as well as to identify those most suited to the task. For example, in 1305, an additional edict was passed, which stated that professors who permitted students to be negligent in their studies were to be penalized (Shinno, 2002). A requirement for one to be literate to practice medicine, an edict from 1285, sought to discourage deficient clinicians, along with a number of requirements for the ramifications of malpractice.

**Ming Dynasty (1368-1644 CE)**

The Yongle Emperor (third rule of the Ming Dynasty) promoted discovery and commerce with countries outside of China (Tsai, 2001). The travels of Admiral Zheng He, (an instrumental figure in the overthrow of the Jianwen Emperor leading to the Yongle enthronement), spanned from 1405 to 1433, bringing wealth and new discoveries to the Ming. Among these treasures were many benefits to medical training and knowledge (Tsai, 2001). Evidence of these explorations can be found in the pivotal text of the era: Compendium of Materia Medica (Bencao Gangmu) by Li Shizhen (Ho, 1996). While much of the clinical information was not new, Li took the time to evaluate and verify common remedies to ensure effectiveness and safety, demonstrating the utilization of basic research principles and evidence-based medicine for this task (Tsai, 2001).

This extensive pharmacopeia also included herbs and plants that were brought back to China during Zheng He’s voyages (Tsai, 2001). At the conclusion of the Ming, and into the Qing, the medical school structure evolved with the integration of traditional Chinese medicine techniques and Western remedies into the education system. Additionally, the development of
prefectural medical schools, founded several centuries earlier, continued to gain prominence (Leung, 1987). Their unique positions in the region encouraged specialization. Although not a specific specialty, research methodology was considered to be an essential component of each of these schools and subspecialties, and individual and collaborative noncompulsory projects were encouraged (Tsai, 2001).

European Renaissance

The European Renaissance (c. 14th - 17th century C.E.) was an era of cultural transformation that began in Northern Italy but extended throughout Europe and beyond. During this time, archaic theories were challenged, and the knowledge of antiquity was rediscovered (Siraisi, 2009). During the Middle Ages, most physicians did not attend formal universities, let alone graduate from them. Further, many competent physicians did not have the means or inclination to attend a university. Also, doctors who were formally educated were not necessarily adept at treating illnesses, due to archaic methods and knowledge. The continued prejudices and limitations on entrance to these institutions based on gender and ethnicity continued to stymie the education of women and other marginalized groups well beyond the innovations of the Renaissance (Custers & Cate, 2018)(Siraisi, 2009).

A number of individual scientists made a name for themselves by engaging in research that specifically sought to confirm (or disprove) medical principles that were thought to be long settled. Once such scientist was Andries van Wesel (Latinized Andreas Vesalius) (1514-1564 CE). After completing his medical education at The University of Leuven and the Sorbonne in Paris, he began to practice and teach primarily at Padua, but traveled throughout Italy to lecture
and treat patients from all levels of society (Markatos, et al., 2019). During his sojourns, he became more aware of the inconsistencies of Galen’s texts and engaged a medical illustrator (Johan van Calcar) to assist in visualizing his discoveries. At the same time, van Wesel became a sought-after anatomy instructor at the University of Padua, encouraging his students to take part in his animal autopsy labs, and to conduct their own independent research endeavors. These extracurricular activities, while not required to complete their education, are foundational examples of early research electives (Markatos, et al., 2019).

Archaic medical knowledge, thought to be long settled, continued to be challenged in the British Isles as well. Dr. William Harvey was an anatomist and practicing clinician, whose academic trajectory was similar to van Wesel, nearly half a century before. Initially educated at Cambridge, he obtained his medical training at Padua, where van Wesel had taught for several years (Wright, 2012). There, his seminal works (as well as former students and their pupils) were fundamental aspects of the clinical scholarly community. He returned to England, where he attained an M.D. at Cambridge, and joined the adjunct faculty in 1604 (Wright, 2012). At the same time, he established his own private practice in London, and also worked and taught at St. Bartholomew’s, the oldest teaching hospital in Europe from 1609 to 1643 (Waddingston, 2003). Founded in 1123, this academic institution was supported by a local monastery in London and has endured for nearly a millennium. The first formal program trained students at Bart’s was recorded in 1662, although they were certainly scholars at the hospital much earlier (Waddingston, 2003).
Over this period, the preeminent institutions of medical education in the British Isles were Oxford, Cambridge, and University College of London in England. The Universities of Edinburgh and Glasgow in Scotland were also scholarly centers. Of these distinguished centers of higher learning, Edinburgh possesses a few important distinctions, particularly in the lineage of medical education in the United States. The university was founded during the Renaissance (1583), and medicine was certainly an early subject of study. A collaborative effort between various groups of clinicians and scientists including chemists, anatomists, and midwives, as well as physicians and surgeons, the medical school was established in 1725, the first of its kind in the United Kingdom (Dow, 2001). It soon boasted a teaching hospital (eventually the Royal Infirmary of Edinburgh, 1729), access to a state-of-the-art chemistry and pharmacology lab (through profession and renowned chemist, James Crawford), and strong local political and financial support (Emerson, 2004).

The medical school flourished in the city, at times referred to colloquially as “the Athens of the North” as scientific endeavors of every type advanced on nearly all fronts (Dingwall, 2010). Students came from home and abroad, and soon not only the illustrious staff and subjects were not the only drawn but the very methodology of the school. The Edinburgh School created the model for a number of formative medical schools in Europe, Canada, and the United States. A further evolution of the templates set in Bologna and Leiden, the requirements at Edinburgh encouraged large numbers of students to apply and study but applied very rigorous standards to complete a medical doctorate (MD). In fact, Edinburgh was the first school to award an MD (Dingwall, 2010). Students were advised to take a wide variety of scientific courses, and full program completion required three years of lectures, as well as a thesis defense on a specific area
of research interest (Emerson, 2004). In the 19th century, this scholarly requirement further evolved to include a dissertation of independent study, along with a theoretical defense component (Custers, et al., 2018). This became the standard throughout Western Europe in the next two centuries (Custers, et al., 2018). Many alumni utilized this model and went on to found schools in Pennsylvania (College of Philadelphia School of Medicine, first in the Colonies, soon to be the United States) as well the other “first six” American medical schools (Columbia, Harvard, Dartmouth, Maryland and Yale). Further analysis of this Edinburgh connection will be elaborated upon in the section outlining medical education in the United States below.

As it was in previous eras, medical education continued to be limited to individuals of means with access to major metropolitan areas (Custers & Cate, 2018). Licensure required not only education and proficiency, but also a certain “gentlemanly” bearing. Additionally, the course for a physician was much longer and more arduous than that of surgeon, an inverse of the requirements today (Grill, et al, 2010). Additionally, the delineation in the level of public and professional esteem between scholarly medical practitioners and more practical surgeons (often members of craftsman guild rather than true academics), may have been a holdover from the pre-renaissance norms and taboos against autopsy or any other activity that be perceived as desecration of the human body (Gregory & Cole, 2002). The growing acceptance in the medical community of utilizing cadavers for dissection provided a pivotal turning point in clinical education, as well as research into the form and function of the human body (Gregory & Cole, 2002).
On a more macabre note, this increased demand for human cadaveric specimens, a method pioneered in the French capital, and therefore known as the “Paris method,” led to a new extracurricular for medical students, as well as cottage industry for enterprising criminals. Although it was declining, the stigma surrounding dissection lingered (Gregory & Cole, 2002). Moreover, very few wanted to donate themselves to scientific research, nor did they wish to grant permission on behalf of deceased loved ones. Therefore, to obtain specimens for medical schools and training institutes, a number of anatomists resorted to unsavory means of retrieval, exhuming the bodies of the recently departed. In some instances, this gruesome practice was tasked to medical students, who were often intoxicated during the proceedings (Fowler & Powers, 2016). Unfortunately, they were not terribly efficient, and the specimens were often damaged in transit. To counter this desecration, public officials increased the punishments for those who got caught, and families began to go to great lengths to secure cemeteries and burial sites. Some went as far as to create elaborate systems and traps to detect any disturbances or sealing coffins in concrete sarcophaguses (Clark, 1962). Students and others were eventually supplanted by professionals, plying the trade of grave robbing under the euphemistic term of resurrection men. These individuals could unearth their query within a few short minutes, leaving the appearance of the gravesite untouched. (Clark, 1962)

This illicit practice was imported and practiced by American anatomists and physicians. So rampant was the body snatching in poor communities that civil unrest of the impoverished led to the New York Doctor’s Anatomy Riot (1788). After storming into the New York Hospital, rioters took several days to subdue, and as many as twenty people were killed. Also, most of the
doctors and physicians-in-training fled for their lives, and already low community sentiment of the medical profession plummeted (Tward & Patterson, 2002).

In other parts of the Colonies, students, and professors at such illustrious universities as Harvard establishing secret organizations like the “Spunker Club” (1770), which intended purpose was obtain clinical specimens through grave robbery. They studied the modus operandi of the resurrection men, and apparently took considerable pride in the similarly meticulous techniques of its members (Saifulaina, 2017). Making a deplorable situation worse, efforts to safeguard “respectable” (i.e., White, middle class and above) cemeteries in both the United States and Europe, the unscrupulous continued to plunder the graves of enslaved Black persons in the Antebellum south, Indigenous burial grounds, and those of other marginalized minorities (Davidson, 2007). There was little in the way of repercussions for these actions for violations, even when legislative efforts were made nationwide in the 1800’s to allow for the legal procurement of cadaveric specimens for instructional and research purposes (Davidson, 2007).

The Thirteen Colonies to the United States (1765 – 1910)

Aspiring American physicians would often journey to Europe and return to their home practices with what they learned, as their personal circumstances allowed. This knowledge was used to treat patients, and, in some cases, train other clinicians who were not fortunate enough to have the resources to travel abroad. This apprentice system was inherited from the European model. These included specialized instruction in the principles of physics, laboratory exposure and hands-on experience. The advent of the Revolutionary War (and subsequent conflicts)
made adhering to these standards more difficult, drawing away talent and students from medical practice (Flexner, 1910).

Although they were the best educated of their American peers, these physicians were still behind the curve compared to their European colleagues in terms of their skills and expertise. However, their inherent focus on the active treatment, outcomes-focused prototype put them at a distinct advantage. This is due to several factors, from reduced access to formal medical and educational institutes historically established, as well as the urgency of treating patients in the real world. This resulted in a reduced focus of the philosophical and didactic aspects of medical education, and more practical application. Thomas Bond of the University of Pennsylvania famously wrote at the time: “Books alone can never give him Adequate Ideas of Disease and the best methods of Treating them” (Cheyney, 2014).

The First American Medical Schools

The first American medical schools were founded on this tradition of apprenticeship and practicality, as well as the scholarly education received by those who traveled abroad. The College of Philadelphia School of Medicine, now known as the Perelman School of Medicine at the University of Pennsylvania) was established in 1765 by Dr. John Morgan and his colleagues, including the well-renowned anatomy lecturer Dr. William Shippen, Jr (Cheyney, 2014). Dr. Morgan was an alum of Philadelphia College and obtained his medical training at the University of Edinburgh. Attendance that that prestigious Scottish institution had the additional benefit of clinical rotations throughout the United Kingdom. This included anatomy labs and direct patient treatment apprenticeships in London with preeminent practitioners in their field of the
time (Cheyney, 2014). Dr. Shippen was also trained at Edinburgh, and Dr. Thomas Bond, a co-founder of the Pennsylvania Hospital was also educated there, as well as Paris and other parts of Europe (Carson, 1869).

Medical education at The School of Medicine utilized curricula based on numerous aspects of this British model, which included medical lectures, clinical apprenticeships at the local tertiary institution (Pennsylvania Hospital, founded by Dr. Bond and Benjamin Franklin), and working directly with private practice physicians (Carson, 1869). Notable early alumni include Dr. Philip Syn Physick (a pivotal figure in surgical methodology in the United States) who developed a number of innovative treatment techniques throughout his career. He, in turn, was educated by Dr. Adam Kuhn, an inaugural medical college faculty member, as well as a founding member of the College of Physicians of Philadelphia, the first professional organization of its kind in the United States (Brown, 1950). Nathanial Chapman was a graduate as well, best known as the founder of the American Medical Association (Carson, 1869). Also, Benjamin Rush (a Declaration of Independence signatory) and pioneer in mental health classification and treatment, as well as professor at the School of Medicine (Carson, 1869). In 1791, the rivalry between the College of Philadelphia and the University of the State of Pennsylvania evolved into a cooperative partnership, and the medical school became a part of the university (Carson, 1869). This successful and rigorous program of medical study was followed in the next two decades by the establishment in quick succession of another five medical schools at King’s College New York (1814), now Columbia University, Harvard College (1782), Dartmouth (1798), Maryland (1807), and Yale (1813).
The Medical School at King’s College in New York City (now the Columbia University Vagelos College of Physicians and Surgeons) was also based on University of Edinburgh (Garrison, 1925). Its founding physician Dr. Samuel Bard had a very similar background to that of his contemporary, Dr. Morgan. Dr. Bard attended King’s College as well as the University of Edinburgh (Garrison, 1925). He returned to private practice in the United States after three years in Europe for medical training, and drafted the plan for the establishment of the medical school, as well as the foundation of an associated hospital, the Hospital in the City of New York, (currently the main institution of the New York-Presbyterian Hospital System). It is also notable that Dr. Bard completed both of these lofty ambitions before the age of 30 (Stookey, 1967). The medical school at King’s College was the first institution in the Colonies to award the Medical Doctor (M.D.) degree, just as was awarded to the graduates at Edinburgh (Stookey, 1967). The school was closed during the British Occupation of New York during the Revolutionary War and was reopened as Columbia College in 1784. In 1791 Columbia College became Columbia University, and in 1814, the medical school was merged with the newly established (1807) College of Physicians and Surgeons (Garrison, 1925). This loose alliance was intended to raise the profile of both programs, and Dr. Bard was appointed as the president of the college.

Harvard Medical School was established in 1782, under physicians Dr. John Warren and Benjamin Waterhouse, both Harvard alumni themselves, with additional medical training in Boston apprenticeship (Warren) and Edinburgh and Leiden University (Waterhouse) (Harrington, 1905). A third member of the founding faculty, Dr. Aaron Dexter taught pharmacology and chemistry. The first classes did not require rigorous admission requirements from potential students. Rather, tickets were purchased to attend lectures on a range of
subjects. Further, only two courses of lectures were sufficient to confer a Doctor of Medicine degree (Moore, 1953). Originally founded in Cambridge, the school was moved to Boston in 1810 (Harrington, 1905). The purpose of this relocation was to be in closer proximity to Massachusetts General Hospital, which opened in 1811. Although initially medical training was concentrated at this specific tertiary center, presently Harvard Medical School does not utilize a primary hospital (Moore, 1953). Rather, it works with many distinct research institutions and educational centers for excellence in the greater Boston-Cambridge area (Moore, 1953). Further, the move to Boston had an additional purpose. In the early years following its charter, Harvard was not considered to be the most prestigious of medical schools, in contrast to its current standing (Moore, 1953). More information about the significant impact of the reform spanning from the 1860's to the early 20th century will be elaborated upon below.

A little over 120 miles north and a half a decade later in 1797, Dartmouth Medical College was founded in Hanover, NH. This was recommended by Dr. Nathan Smith in response to the dearth of clinicians in the disparate and scattered settlements in the area (Blough & Grossman, 1999). In contrast to the other first six schools, Dartmouth did not possess the financial resources available in the bigger cities where they were established. The college itself did not have a building on campus exclusively for its use, and Dr. Smith needed to conduct his lectures from a house he personally rented for the purpose until 1799, and then a single classroom in Dartmouth Hall. In response to a request from Dr. Smith, the “New Medical House,” the first structure for the medical college received funding from the New Hampshire State legislature in 1811 (Blough & Grossman, 1999). Another stark demonstration of this disparity was evident in that, for the first thirteen years of its existence, from 1797 to 1810, it consisted of only one faculty
member: Dr. Nathan Smith himself. Dr. Smith was a Harvard graduate who had also pursued his medical education at the University of Edinburgh (Blough & Grossman, 1999). Due to this limitation, Dartmouth’s program was much more of an apprenticeship system than other medical schools of the time. There was an advantage to this system, as smaller classes afforded students more individualized attention, and graduates benefited from directly treating rural patients in the Connecticut River Valley (Blough & Grossman, 1999).

In 1810, when another faculty member and professional colleague of Dr. Smith, Dr. Lyman Spaulding was brought on full-time, though he had assisted Dr. Smith with instruction since he completed his education (Spaulding, 1916). Dr. Spaulding was also an early graduate of Dartmouth Medical School, therefore a former student of Dr. Smith. In 1800, the two worked together while Dr. Spaulding was still in training on studying the utilization of cowpox vaccine for the prevention of smallpox in humans (Spaulding, 1916). This another is an excellent example of how, even in those early years, physicians and students collaborated on “research” endeavors, although their methods were often rudimentary. Two years after Dr. Spaulding’s appointment, with the initial offering of a Bachelor’s degree being updated to the medical doctor degree based on the revision of the curricula. Dr. Smith departed from Hanover in 1813 but continued to present annual lectures for another four years afterward. Following his resignation, founded two more medical schools at Bowdoin College in Maine (1821 - 1921) and University of Vermont (1822). He also served as one of the first founding faculty members at Yale’s medical school.

The College of Medicine of Maryland (since 1812, the University of Maryland School of Medicine) was established in response to anatomical riot (Lamberg, 2007). This was during a
cadaver dissection demonstration by Dr. John Beale Davidge, who would go on to cofound the school with Dr. Nathaniel Potter with the support of Maryland State Assembly (Lamberg, 2007). Charted in 1807, Maryland shares many similarities to the other five schools, as well as a few crucial differences.

Concerning their education, Dr. Davidge was a graduate of St. John’s College, and then he traveled to Edinburgh to study anatomy, and remained in Scotland to earn a Medical Doctorate from the University of Glasgow in 1793. He became a well-respected anatomist and skilled surgeon, a profession that was quite uncommon in the fledgling United States, especially one as proficient as Dr. Davidge (Schimpff & Rapoport, 1992). Dr. Potter was a graduate of the University of Pennsylvania under Dr. Rush. As the founding professor of medical theory and practice, he designed the structure and curriculum of the new medical school. A scholar and scientist who published widely, Dr. Potter performed research to verify treatments and direct patient care, often with assistance of their medical students (Lamberg, 2007). Both he and Dr. Davidge published treatises on the Yellow Fever epidemic of 1797, with Dr. Potter extending his studies to human subjects, namely himself. Through personal experimentation, he was able to confirm that yellow fever was not transmissible from person to person. A contemporary to Thomas Jefferson, the President asserted these medical findings in his annual address to Congress in 1805 (National Archives, 2016).

While the scholarly lineage of its founders was comparable, the early structure was distinct in that it was sole college initially founded as a public institution. Additionally, there was no state funding provided for the new school, so professors taught out of their practices and
homes (Lamberg, 2007). These same instructors financed and built their own teaching facility, and upon its completion in 1812, the college was renamed the University of Maryland School of Medicine, and the university incorporated additional courses of study, including law, fine arts, and sciences (Schimpff & Rapoport, 1992). In 1840, one of these other specialties would include the world’s first professional school of dentistry (Lamberg, 2007). The medical building, Davidge Hall is still standing and active to this day (Lamberg, 2007). Thirteen years later, the Baltimore Infirmary (now the University of Maryland Medical Center) was the first academic hospital built for the explicit purpose of teaching medical students and other clinicians (Schimpff & Rapoport, 1992).

The Medical Institute at Yale College in New Haven, CT was chartered in 1810 as a collaboration with the Connecticut Medical Society. However, due to program curricula development (as well as the War of 1812), the college did not begin offering courses until 1813 (Burr, 1934). Along with Dr. Smith, founding instructors included Dr. Benjamin Silliman, chemistry department chair, (who was also educated at Yale and Edinburgh) and Dr. Johnathan Knight (Yale alumni who also completed medical apprenticeships and lectures at the University of Pennsylvania Medical School). In fact, Dr. Knight was still completing his medical education in Philadelphia when he was appointed to the anatomy, surgery, and midwifery chair at Yale (Burr, 1934). Further, he was awarded an honorary MD degree by Yale in 1818, six years after his appointment (Burr, 1934). Dr. Eli Ives (professor of Materia Medica) was a 1799 Yale graduate who pursued a local physician’s apprenticeship, who was conferred an honorary MD in 1811, also attended Dr. Rush’s lectures at Pennsylvania (Blumer, 1932).
As compared to their early counterparts, and to the current day, courses of medical study at Yale have always been structured differently. Being the latest of the early colonial schools, Yale benefited from the experiences of its predecessors, and was able to avoid some of the initial challenges faced by the others (i.e. a physical building to house the school was in place before the inaugural class and generous external funding) This resulted in larger class sizes, and the introduction of what is now termed “breakout sessions” (small groups of student assigned to work on a specific project/task) (Blumer, 1932). These early structural differences uniquely and presciently equipped Yale for a strong research focus. Since 1839, Yale has required a research dissertation for medical school completion. Also, beginning in the 1980’s, Yale has entrained the last year and half of medical school to directed coursework, specialty internships and independent research (Yale, 2021). Many other schools have followed suit in the subsequent decades.

In 1800, the populations of Philadelphia (University of Pennsylvania), New York (Columbia), Baltimore (University of Maryland) and Boston (Harvard) were 41,220, 60,514, 26,514 and 24,937, respectively (Desmet & Rappaport, 2017). By contrast, the populations of Hanover (Dartmouth) and New Haven (Yale) were 1,912, and 5,157, respectively (Desmet & Rappaport, 2017). This drastic difference led to an inherent focus on autonomy, as well as the primary types of patients that were treated by new local graduates. In this way, early differences between rural and urban patients in US medicine became more prevalent as well. Metropolitan centers have always been desirable destinations for medical training. Universities and hospitals are centered here, scholars and students travel for education and exposure to different specialties. From their inception, these first medical schools, five of these are among the eight
elite Ivy League universities, established the standard bearers of the training model that continues to prevail in medical education: innovation, research, and collaboration. Maryland distinguished itself as the first institute to be known for scholarly medical activity.

The similar blueprint of these formative institutions, and similarities in the education of their founders continues to define medical education in America to the present day. Most of the founders attended and/or graduated from the University of Edinburgh, others attended lectures by alumni of the English and Scottish programs. A simple explanation for this preference is the shared language, but the prestige of the program cannot be understated. Beginning in the late 17th century, Edinburgh was a cultural hub in the United Kingdom and Europe, with the surge of medical and scientific activity being deemed the “Scottish Enlightenment” (Dingwall, 2010). They engaged in shared knowledge based on these similar philosophies about medical education, as evidenced in their collaborations and as well as how some of these physicians went on to be instrumental in developing other medical schools beyond their initial institution. However, unlike the traditional European academic model, many of these instructors continued their clinical practices while teaching. This is similar to the clinical adjunct professorship position that many attending physicians occupy today (Barchi & Lowery, 2000). This position also provides an important mentorship pathway for research, as many physician instructors also engage in their own research as a part of their practice, either independently or in conjunction with their academic affiliations (Custers & Cate, 2018). Early medical students tended to be younger, often having completed a college education before postgraduate medical training. This concept of utilizing a proven technique is again an example of the early employment of the
scientific method, determining what works elsewhere and repeating it through methods focusing on accuracy and precision (Custers & Cate, 2018).

As often happens throughout human history, this unprecedented time of progress and growth was also marred by a zeitgeist of anti-intellectualism: an unfounded skepticism that led to a backlash against the academic community, which unfortunately coincided with this rapid expansion of medical education institutes (Slawson, 2012). The presidency of Andrew Jackson (1829 - 1937) ushered in the era of the Jacksonians: who adhered strongly to principles of egalitarianism, entrepreneurship, and individuality, but also railed against the arrogant authority of intellectuals, as well as the expansion of rights for non-White individuals and women (Hofstadter, 1963).

In general, the practice of medicine was still thought to be a petty, privileged boys club by many in society. The movement toward suspect treatments was driven, at least in part, by the drive to democratize medicine and training. Paradoxically, the same elites that we so despised by the Jacksonians and secular practitioners had some similar motivations for standardizing education and regulating medications: to make them safe and accessible to the population (Davis, 1855). Further, these actions went a long way toward changing the impressions from this pejorative view to a more respected profession. Unfortunately, research involvement for both active physicians and medical students was considered to be suspect by many of the Jacksonians, due to their affiliation with respected institutions (Hofstadter, 1963). Additionally, the scandals related to obtaining cadavers for education and research also tarnished the reputations of medical schools engaged in research (Davidson, 2007).
The era was also characterized by the rise of patent medicines. These formulations and tinctures claimed miraculous results. In actuality, they ran the gamut from innocuous placebos to dangerous concoctions of drugs and high proof alcohol (Estes, 1988). While a few of the purveyors of these pharmaceuticals were in earnest, most others quickly realized the high lucrative incentives to peddling curatives to the general public, regardless of efficacy or safety. Given that there were no regulatory agencies that restricted ingredients, access for more potent additives, or even that the treatment did what it claimed (the Pure Food and Drug act of 1906 was several decades in the future), those with minimal to no medical training could adhere a label on (and sell) just about anything (Korr, 2020). Therefore, new clinicians could get involved in a number of ways, from inventing their own “cures” to paid promotion of other patented products (Estes, 1988). The reforms of the early 20th century would purge the market of the most dangerous of these practices, and the Food and Drug Administration would require rigorous clinical trials in order get drugs to market after the 1960's. However, patent medicines would continue to play a major role in the healthcare system, and the “snake-oil salesmen” and disreputable clinicians would continue to be a problem in medicine into the 21st century (Korr, 2020).

Medical Education in The United States & Canada (The Flexner Report)

For the most complete understanding of the underpinnings of modern medical education and research requirements into the present day, a comprehensive understanding of the causes and effect of the Flexner Report is essential. By the beginning of the 20th century, the groundwork was in place for a substantial overhaul of the medical education system in the
United States. Johns Hopkins had recently instituted a Bachelor's degree requirement for entrance and introduced a medical residency, extending the length of training considerably. Even so, most schools only required two years of education. At the same time, the previous half-century had seen the development of tertiary medical centers, specialty hospitals and more humane treatment at sanitariums (Flexner, 1910). Still, the level of training and proficiency of American doctors was still inferior to their European colleagues (Flexner, 1910).

In this uneven environment, the need for specific requirements for formal education and qualifications was even more imperative than it had been in the past (Flexner, 1910). Medical Education in the United States and Canada (colloquially known as the Flexner Report), was an extensive review performed by Abraham Flexner, under the commission of the Carnegie Foundation for the Advancement of Teaching. Flexner was a renowned expert on higher education, having previously published an unfavorable appraisal of the current state of higher education (The American College - 1908) (Duffy, 2011). It was under these auspices that the Carnegie Foundation engaged him to perform the same assessment of the methods and means of training physicians, although Flexner had no medical training.

While Flexner noted the first medical schools in the United States (The University of Pennsylvania, Columbia, Harvard, the University of Maryland, and Yale) offered apprenticeships in physic as well as lectures and practical clinical training, as well as early foundations for excellence in medical school and residencies, these first institutes had promising beginnings. Yale had required an independent research thesis for all of their medical graduates for nearly eighty years when the Report was released. However, then Flexner goes on to denigrate one of
the founding institutions in quite unequivocal terms. He states that the proliferation of medical schools which are not initially affiliated to established university systems started in Baltimore. Flexner notes the “so-called medical department of the so-called University of Maryland” disparagingly due to its early lack of university affiliation (Flexner, 1910). However, Maryland’s scholarly history does not demonstrate any of the same underpinnings as many more fraudulent institutions that came (and went) later. In fact, Dr. Davidge (Maryland co-founder, and its first dean) specifically despised “quackery” and established the school in a response to unfounded superstitions about medical dissections (Schimpff & Rapoport, 1992). Further, there is no evidence that free standing postgraduate medical training institutions (for example, Chicago Medical School, now Rosalind Franklin University, founded in 1912, offer an inferior education: by contrast, quite the opposite is true)(Peterson, 2003).

However, there were considerable issues in the current medical system as it stood in the first decade of the 20th century. In fact, the majority of archaic medical training rightly did not survive the coming eras of change and accreditation. Flexner's criticism of the proliferation of private, for-profit institutions in the 19th century with their little education value, with faculty that would “buy” department chairs and academic appointments with financial donations or other incentives was well founded (Flexner, 1910). Further, the structure of the education was disjointed, with little to requirements for completion for the majority of the institutions and the rivalry between these schools for funding, students and prestige in the field led to commercial exploitation (Flexner, 1924).
Despite these challenges, a few physicians still became proficient in this setting. Those with the means to do so sought knowledge first-hand elsewhere, traveling abroad to further their education (Flexner, 1924). As noted previously, there are numerous incidents of American women and other underrepresented minorities in the medical profession traveling to places in the United Kingdom and other parts of Europe, where they were often more accepted into the local communities than they were back at home (Clausen, 1999)(Lujan & DiCarlo, 2019). This would, unfortunately, continue to be a familiar trend well into the 20th century, even as the quality of the education in the United States improved (Laws, 2021).

In response to these deficiencies, Flexner outlined a rigorous, German-inspired, scientifically based curriculum which eventually became the international gold standard for medical education (Duffy, 2011). His recommendations included:

- Development of the pre-medical baccalaureate track
- Appointment of full-time physician professors and faculty (this was not completely realized, as the adjunct clinical professor position is still very prevalent)
- Adherence to empirical methodology in instruction and practice
- Affiliation and institutional management of teaching hospitals
- Encouragement of research activities for faculty and students
- State and federal, as well as professional board regulation of licensure and the establishment of new schools (this would eventually also entail student and resident qualifications, as well as board certification. (Duffy, 2011)
Nonetheless, the overarching objective (and legacy) of the Flexner Reports was to purge non-university affiliated medical schools. These included those founded on methods based on what he believed were pseudoscience (including proven methods of complementary medicine), although most of these had been phased out at the end of last century. This also included the outright prohibition of for-profit medical schools. Thus, it was not only a recommendation to reduce the number of schools (and the populations those schools inadvertently served), but eventually, a requirement for all those remaining (Laws, 2021).

From the beginning of the eighteenth century until the release of the Flexner Report, there were 457 medical schools established in the United States and Canada. There were 155 schools remaining by 1910 (Flexner, 1910). Flexner proposed to reduce the number of schools by 80% to 31 schools, which included only one in all of Canada, one for women and two at HBCU’s. By the mid-1930’s, only 66 institutions remained, which drastically reduced the output of physicians of any means by 65% (Duffy, 2011). The number of active medical students at all levels reduced drastically from 21,000 in 1910, 15,000 in 1910 and as low as 12,000 in 1935 (Duffy, 2011).

However, this extreme decrease did not hold. Following the Second World War, the number of schools increased steadily. By 2021, there were 154 MD schools, 38 DO schools and 17 MD schools in Canada, for a total of 209. This constitutes a nearly 35% percent increase from the “excessive” number criticized by Flexner over a century ago (ACGME, 2015). The overall number of total medical students increased exponentially, as new and existing medical schools expanded their roster to fill a growing dearth of physicians in response to the immense post-war
population growth. In 2021, the enrollment numbers were the highest ever at over 92,000, an over 3-fold increase (AAMC, 2021). Nonetheless, the quality of the institutes today far exceeds even the best examples of the early 20th century. With the structure and guidance of licensing boards, professional society codes of conduct, as well the strict curriculum guidelines of the AAMC, Liaison Committee on Medical Education (LCME) (1942) and the Accreditation Council for Graduate Medical Education (ACGME) (1981), the standards for schools, educators and students are extremely high (AAMC, 2021). This is not in spite of the quantity of centers of higher education, but because of the rigorous and competitive environment.

While The American College had disparaged college curriculums over emphasis on research and attributed the disarray of the undergraduate structure to it, Flexner took a completely different stance when it came to research for physicians (Flexner, 1910). The report defined the foundation concepts for medical rounds and clinical rotations for students. He noted that, inherent in hospital clinical training is research activities on the part of teachers and students to determine the best course to treat patients, as well as how to optimize treatment and develop standards of care (Flexner, 1910). This early focus on research methods went a long way toward the development of the top medical research institutes in the world being located in the United States.

Unintended Consequences of the Flexner Report

The standardization of undergraduate prerequisites as well as the curricula and duration of medical school, and a strong scientific emphasis were just a few of the several changes brought about by Flexner. These improvements to the previously disordered system were
necessary and important. However, one would be remiss if they did not consider Flexner’s inherent biases in terms of gender and race, and how these prejudices were reflected in the reports’ recommendations. The negative consequences of the Flexner Report affected women (assumed by the report to be exclusively White) and minority groups (African American men) disproportionately. Tellingly, there is no mention of any other race or ethnicity in the Flexner report, let alone any of them being women (Bailey, 2017). The far-reaching sequela of this systemic discrimination persists to the modern day (Laws, 2021).

The total of women’s medical schools in 1895 was seven. A decade after the Flexner report, only one remained (Woman’s Medical College of Pennsylvania). This effectively reversed the steady nationwide increases since the middle of the 19th century (Moehling, et al., 2019). In parts of the country, women accounted for up to one-fifth of practicing physicians in the community, and their numbers did not recover until over half a century later (Moehling, et al., 2019). While not specific to the report, the dramatic reduction of medical schools led to many prestigious schools to fracture by gender (where there had not been before), with medical programs only accessible to male applicants. To be fair, Flexner sought to eliminate gender-specific medical training institutions, as he thought that women that met the qualifications should be able to attend any school based on their merit (Flexner, 1910). Over a century later, we are still coping with the aftermath of these disparities (Laws, 2021). Favorably, eventually this population disparity did equalize early in the 21st century, although gender biases are taking longer to expel. For the 2020 cohort of medical school graduates, 52.4% of new physicians were female (AAMC, 2021).
Flexner's bias against African Americans is much more blatant than his opinions about women. Flexner believed that Black physicians (always presumably male) should only serve Black patients, as well as all other minority groups. Due to this fact, he advocated for the systematic reduction of the number of colleges that educated primarily Black physicians and other minority practitioners, regardless of their facilities or their adherence to secular medicine (Bailey, 2017). These endorsements were grounded in Flexner's belief that the primary purpose of minorities in medicine was to emphasize hygiene, rather than treatment modalities. Further, that focus was expressly for the purpose of preventing disease spread to white populations (Laws, 2021). This intolerance led to the closing of five of the seven HSBU medical schools, with Flexner stating that, with the exception of Howard University and Meharry College, the other schools were “in no position to make any contribution of value” to the medical community (Flexner, 1910)(Harley, 2006). These prejudiced views (and the associated dearth of female and minority practitioners) played a substantial role in the suspicious and negative attitudes to medicine (and eventually research as well) in minority communities (Harley, 2006).

Medical Education and Research

Throughout the extensive history of medical education, there have been countless examples of medical students and training institutes being a pivotal aspect of new clinical discoveries. The principles of good clinical practice in research formed the basis of classical Greek Knidian and mathematikoi practitioners and the tenants of the Hippocratic Oath (Turgut, 2011) (Tsiompanou & Marketos, 2013). Galenic philosophy, as well as the hypotheses that Al-Razi, Van Wesen, and Harvey employed to challenge and eventually disprove Galen's
millennia later, was rooted in the spirit of scientific inquiry (Aird, 2011). Both Ibn Al-Baitar in Andalusian Spain and Li Shizhen in Ming China applied empirical investigational techniques to assess common herbal remedies for safety and efficacy (Haque, 2020)(Tsai, 2001). At the foundational institutions in the United States, both faculty and students engaged in noteworthy research for both cowpox and Yellow Fever (Spaulding, 1916) (National Archives, 2016). The development of education-focused hospitals, the first in the United States being associated with the University of Maryland, evolved into the eminent centers of excellence around the country and world (Schimpff & Rapoport, 1992). Research has become an essential aspect of the prestige of medical schools, and the benefits of an academic teaching and research institution include more funding opportunities from both public and private sources, access to the latest technologies and techniques, and high institutional ranking (Burgoyne, et al., 2010).

As emphasized previously, research has been an essential component of medical education throughout history, in activity if not by name. The history of ethical research conduct in the United States begins just over a century ago. The Pure Food and Drug Act was passed in 1906, the first law to regulate ingredients in medications and foods (Swann, 2019). In 1948, the Nuremberg Code was published following the conclusion of criminal proceedings against Nazi physicians who had performed experiments in concentration camps. These experiments were conducted without regard to subject welfare and against their consent. The Code, outlined for the first time the essential principles of voluntary participation and risk benefit assessment for study participation (Pence, 2004). This signaled a distinct turning point in the role and importance of medical research and resulted in the swift integration of research training and ethics into the medical school curricula in the subsequent decades (Harding, et al., 2017).
The first MD/PhD program in the United States was established at Case Western University (formally Western Reserve University) in 1956 (Harding, et al., 2017). In 1964, the NIH-NIGMS established the Medical Scientist Training Program (MSTP) with several pilot programs at prestigious institutions, in recognition of the importance of specialized research training for physician scientists. In 1975, the NIH formed an ongoing endowment to provide funding to students who are accepted into the MSTP program, which provides combined MD/PhD training for prospective clinician scientists who intend to have a primary career focus on academic research (Harding, et al., 2017). In 2018, a comprehensive outcomes study for the MSTP was published (AAMC, 2018). This study yielded a great deal of information about how programming has evolved over the past half century. For instance, average overall annual enrollment increased from 159 to 4,548, with the percentage of female students improving from 1.3% to 50% (AAMC, 2018). It is important to note that only about half of the MD-PhD programs in the United States are MSTP’s. Many other universities also have their own combined courses, including those for DO/PhD’s, and curricula and funding can vary widely (AAMC, 2018).

The LCME provides the standards and requirements for medical school curricula. Concerning research, all students are required to have formal instruction by experienced faculty in research methodology. This includes basic and clinical research, as well as the associated ethical principles and how it relates to patient care (LCME, 2021). This prerequisite enables students to engage in the scholarly community at their university, and to learn valuable scientific, ethical, and analytical skills that can be utilized throughout their medical education and into their careers, both within and outside of the realm of research. While access to formal
training and resources is compulsory, the LCME does not require students to conduct or participate in a specific research project to complete their medical education.

As the LCME requirements are relatively broad in their definition, the majority of schools offer additional elective or required research coursework and experience (AAMC, 2021). There are a myriad of reasons for these additional opportunities. These include early professional networking through collaboration with clinicians, developing a mentorship relationship with eminent physicians and preparation for residency applications and requirements (Velez, et al., 2017). Of even more benefit, however, are the skills imparted to students inherent to research involvement, which are carried over to all aspects of clinical practice. These skills are comprised of complex critical thinking aptitudes, project management expertise as well as engaging and adapting in dynamic situations (Velez, et al., 2017). The LCME Annual Medical School Questionnaire is administered (by LCME) on a yearly basis and tracks institutional modifications in prerequisites and curriculum requirements, including research involvement (LCME, 2021). For instance, in 2013, 49 of the 136 schools surveyed reported that they had research requirements in addition to the LCME guidelines. By 2018, that figure increased to 65 of 147 medical school respondents (AAMC, 2019). Further, many top schools have a much more rigorous research standard as a core part of their curriculum as compared to the minimum LCME requirement.

For example, Harvard, in collaboration with MIT, requires 1st and 2nd year students to take part in basic sciences research, and a 2-month research clerkship to initiate a research project which will continue into their fourth year and beyond if needed (Harvard, 2021). Duke
University School of Medicine has a 10 – 12-month third year scholarly/research requirement (Duke, 2021), the Stanford University School of Medicine offers several pathway courses (Discovery Curriculum) with research/academic foci, extending the coursework an additional 1 – 2 years if needed. Options for medical students include the following:

- **MD + Scholarly Concentration:** 12 Additional credits of subject-specific study and 25% devoted research time
- **MD + In-depth Research Experience:** Scholarly Concentration track with 40% or more devoted research time
- **MD + Master's Degree:** Additional Masters coursework in students’ chosen concentration
- **MD + Berg Scholars:** Fully funded MD with additional Masters of Science in Biomedical Investigation
- **MD + PhD – NIH-Structured Medical Scientist Training Program**

All students select one of these five areas of concentrations, which includes options which comprise of 25% - 40% of required research time, as well as optional Master's Degrees in Biomedical Investigation and a full MSTP MD-PhD track as well (Stanford, 2022). The Yale Medical School curriculum designates half of the third and the entire 4th year to an integrated rotation of electives, specialty internships and research, as well as a research thesis defense (Yale, 2021).

The Michigan State University’s College of Human Medicine’s (MSU-CHM) (which is the setting for my research) current research curricula includes an elective research course that
can be taken in either the first or second year. The required ASK (Applied Skills & Knowledge) scholarly project begins in the third year, when students begin their clinical rotations, and requires that all students engage in the design, development, and implementation of a research or quality improvement project. Students are also welcomed and encouraged to take part in extracurricular research endeavors throughout medical school (MSU CHM, 2022). A graduate certificate program at the MSU College of Human Medicine was recently approved and is scheduled for implementation in Fall 2023. A detailed description of the MSU College of Human Medicine Research Graduate Certificate Program is outlined on page 55 of this dissertation.

It is generally accepted among educators that early and frequent exposure to research is imperative to initiating and sustaining long term interest in research for medical students (Ommering, et al., 2018). Research involvement has become an important selection factor for the most competitive residency programs as well (Burgoyne, et al. 2010) (Chang & Ramnanan, 2015). In fact, the National Resident Matching Programs 2022 report indicates that 74% of MD senior survey respondents averaged 4 research experiences throughout medical school (NRMP, 2022). Further a higher amount of research experiences and abstracts, presentation and publications are associated with higher residency match rates. For example, for the neurosurgical specialty, successful applicants reported 25.5 research publications/presentations are compared to 11.7 for non-matched candidates (NRMP, 2022). These research-orientated students are also more likely to go on to collaborate with other scholars and become clinical investigators themselves (Collier, 2012). For DO seniors, the results are even more varied. There was an average of 2.2 research experiences per respondent (with 88% reporting) noted. For
neurosurgical applicants, matched candidates had an average of 32.6 abstracts, as compared to 7.1 for their unmatched counterparts (NRMP, 2022). IMG (International Medical Graduates) tend to be older, with more research experience in order to bolster their applications, as many residency programs are unwilling or unable to manage the challenges of IMG’s (educational accreditation, visa sponsorship) (NRMP, 2022). Accordingly, they report an average of 6.7 research experiences, with the neurosurgical applicants reporting 73.8 and 52.1 abstracts for matched and unmatched candidates, respectively. Research activities are vital to the ongoing progress of evidence-based medicine, novel medical treatments, and overall improvement in patient care outcomes (Jacob, 2016) (Kazdin, 2008). There are numerous examples throughout history (as noted previously) of how an atmosphere of scientific inquiry improves healthcare. While students are often very motivated to get involved in projects, there is a need for balance between a research interest, a rigorous schedule, and clinical responsibilities, specifically for medical students where intensive research involvement may not be a core requirement of many programs (Burgoyne, et al., 2010). Further, a lack of availability of clinical research mentors can often be a hindrance to early research participation of students (Klowak, et al., 2018).

As noted previously in the literature, physicians who are active in research often report involvement in research early in their education. If, theoretically, it was possible to increase medical student exposure to research earlier in their educational career, then clinical research activity by future physicians would increase as well. In the short time, such an increase in research activity for medical students would be beneficial for a myriad of reasons, from expanding the knowledge and talent pool, to the creation of new evidence and development of innovative ideas, as well as promoting an increased base of interested and engaged mentors for
students. Of note, what qualifies as research, or scholarly, activity is a broad category, and can be inclusive of outcomes studies to define best practices, local practice/internal chart reviews and observational collaborations, FDA-regulated clinical trials, and federally funded basic sciences research.

In 2010, Siemens, et al, conducted a 33-questionnaire assessment of 327 medical students (2nd and 4th year) to gauge their interest and engagement in research, along with its importance to their education. The three medical schools, Queen’s University, University of Ottawa, and University of Western Ontario all have significant research focus as part of their curricula. A number of barriers to participation in research were identified by the students, including time constraints, mentor availability and experience, sufficient training in formal research methods, and the level of understanding in research methods. Some limitations of this study were the lower response rates (47%), and that the population was limited to three Canadian medical schools (Siemens, 2010).

Klowak took a different approach, assessing student perceptions of their research environments as well as self-assessment of their experiences and skills subjectively. Interestingly, students’ perceptions of themselves and their own research competency had less of an influence on the successful completion of a project than how they perceived the level of experience and involvement of their research mentors (Klowak, 2018). That is, the knowledge of the teacher, methodology, and the approach and attitude of the mentors themselves matter the most to students in terms of research accomplishment. Pathipati reviewed the prevalence, values, and motivations for medical students to take one to two years during their medical
education to pursue research exclusively. In this study, students reported that they pursued additional research internship years for the purposes of improving their resume for competitive specialty residencies (32%), continuing professional development (24%) or pursuing academic interests (23%). (Pathipati, 2016).

Previously established medical research training program modalities (such as those utilized for MD-PhD programs), other specialty certification programs, and direct feedback from students can provide valuable insight when developing a new program for research specialty certification for MD/DO students. Potentially, a certification program could further integrate research into clinical training, streamline student research involvement by establishing a clear structure for connecting with projects and mentors, as well as provide trackable expectations and milestones. (Daelmans, et al., 2018). Additionally, specialty certification encourages collaboration and other useful skills for practice, while maintaining clinical focus. A 2014 analysis by the NIH Physician–Scientist Workforce Working Group reported that 1.5% of all US did indicate that academically-based research is their main professional emphasis (NIH, 2014). In contrast, the AAMC reported in 2021 that 84% of medical students reported participating in research during medical school (AAMC, 2021), and demonstrated scholarly productivity (with an average of 8.1 abstracts, presentations, and publications per student) (NRMP, 2022). This dramatic difference between the number of medical students conducting research, and their productivity, and the low percentage of physician-scientists in the physician workforce, requires additional analysis. Why are students substantially reducing research participation into residency, and what (if anything) should be done about this? Finding answers to this question can have a significant impact, as physician-scientists play a critical role in
developing new treatments, diagnostic procedures, and disease prevention strategies. Well-developed certificate programs, along with other methods of engaging medical students in research, have the potential to improve the number and quality of principal investigators involved in clinical trials and reduce the paucity of physician researchers (Ommering, et al., 2018, NIH, 2014).

Physician-scientists (both dual degree physician PhD's and other physicians who take part in research) are a vital resource in improving the health and well-being of the United States and abroad. They provide an important intermediary between basic research and novel techniques and make those beneficial innovations available to patients (Daniels, 2015). To help determine potential causes for the decreasing numbers of researchers, a number of factors were analyzed. Disconcerting trends that may be detrimental to the development of young physician-scientists that have been identified in the literature should be noted. The average age of new investigators who receive their first NIH Research Project Grant (ROI) has increased from under 38 years old in 1980 to 46 years old (for both MD and MD-PhD investigators) in 2020 (Lauer, 2021). The ROI grant has historically been an indicative first milestone in the career of a biomedical research physician, and a plurality of physicians are opting for a declined research career focus in favor of more lucrative and less academically demanding clinical practices due to these challenges (Daniels, 2015). Additionally, the average percentage of ROI grants awarded has declined for all MD-PhD applicants (40% to 23%) from 1999 to 2012, but even more substantially (27.8% to 15%) for first time applicants (PSW-WG, 2014). In recent years, several medical schools have begun to offer specialty certificates in various areas of concentration, including research, in an attempt to address this issue. The purpose of these additional
pathways is to provide experience and instruction in a student’s chosen area of focus that can be continued into residency and beyond. These programs are varied in terms of requirements and specialties. At MSU CHM, there are currently three active certificate programs: Leadership in Medicine for theUnderserved (LMU), Leadership in Rural Medicine (LRM) and The Medical Partners in Public Health Certificate (MD-PH) (MSU CHM, 2022).

MSU CHM: Human Medicine Research Graduate Certificate

A newly devised Research Certificate Program has been developed by the Michigan State University College of Human Medicine (MSU CHM) faculty and approved, with implementation to begin at a future start date. This program implementation has been delayed due to COVID-19 restrictions and changes in administrative review.

“The Graduate Certificate in Human Medicine Research trains students to possess a special set of knowledge, skills and abilities enabling them to become productive researchers during medical school. Students will engage in rigorous, long-term research experience resulting in high-impact outcomes, positioning them for admittance to research-intensive residency programs and competitiveness for future research funding. The graduate certificate is available to students currently enrolled in the Professional Program in Human Medicine leading to the Doctor of Medicine degree.” (Galbavi, 2019).

The aim of this program is to provide medical students with extended and immersive research experience working with an enthusiastic physician mentor. Students will be required to complete a research portfolio of their experience, participate in presentation activities and manuscript drafting as well as develop a research proposal for suitable for an application for federal funding. While all the modules and courses are available in the MSU CHM curricula, the structure of the program is the novel component. Please see the requirements below
1. Complete 20 hours of Research Online Modules/Quizzes
2. Complete 80 hours of Introduction to Biostatistics Intersession during their professional program requirements
3. Attend five enrichment activities as directed by the program director.
4. Complete 6 to 10 weeks of full-time research activities or its equivalent
   a. Presentation at a regional or national conference is required
   b. Manuscript for publication will be submitted to certificate advisory committee, however publishing of the manuscript is not required due to time constraints.
5. Complete 40 hours of research community involvement as approved by the program director.
6. Complete 12 credits of Research Clerkship.

Some of these are similar exigencies to those of conventional PhD programs. Candidates will be selected on a number of stringent, specialized criteria. These are inclusive of gauging personal research goals and long-term interest. This can be accomplished in part through academic aptitude and analytical skills assessments, but the task of identifying the best students for the program goes beyond these objective means. Students may seek to portray themselves are more engaged in research than they actually are to better position themselves for their future plans, or they may realize they are not interested once they understand the requirements. However, these students shouldn’t be outrightly discouraged or discounted from program application. Rather, a detailed application and interview process would focus on each applicant as an individual. A dynamic set of criteria will be revised following each application and certification cycle to continually refine the best practices for identifying candidates with
potential for long-term research engagement, including input from applicants and alumni, including providing additional support for continuation of projects and progress updates. Research certification must be completed while the student is in medical school but can be initiated at any time. In order to satisfy the requirements, the program should be commenced as early as possible in the MSU CHM program. Also, additional determinants would entail the previous research experience of the applicant as well as their familiarity with research concepts. Ultimately, the objective of the certificate program is to engage students, perpetuate their research involvement and potentially inspire them to become physician scientists in their own right (Galbavi, 2019). My purpose is to ascertain how best to evaluate medical student perceptions of research involvement, and how it can contribute to a pilot research certification program in a research-intensive university setting. Longitudinally, these results may be useful to determine the factors that maintain clinician interest in research beyond medical school. The results of this project will be relayed to the faculty and program directors to potentially facilitate a better understanding of potential certificate seekers.

Theoretical Framework: Survey Design

A quality improvement survey designed to assess the hypotheses below was delineated into five sections. An example is noted in Appendix A. Section one of the survey consisted of the nine demographic questions. Demographics and educational experiences were collected to gain a better understanding of the background of the students (Allen, 2017). A prospective on geographic location and origins was included for a number of considerations, from educational stability and socioeconomic factors, which can have a marked effect on extracurricular scholarly activity, including significant research involvement (Grbic, et al., 2015). This section also
requested the student current specialty/residency preferences, as well as their previous research experiences, and their levels of involvement. As noted previously, research exposure, specifically presentations and publications, can be a deciding factor in selection for the most prestigious and competitive residency specialties. Additionally, certain specialties, such as oncology and neurology are more heavily research focused (Burgoyne, et al., 2010) (NRMP, 2022).

The second section of the survey was comprised of twelve questions about important research principles, and their familiarity with each. These included preliminary project activities like finding a mentor, literature review, protocol development, regulatory submission, and management. It also pertained to knowledge about statistical analysis methodology and abstract and publication preparation. Early fluency in research concepts has been demonstrated in the literature to be indicator of long-term research involvement and success, so these assessments were essential in order to obtain a more complete view of respondent baselines, and how they could change over time and further exposure in a research-intensive university environment (Ommering, et al., 2018)(Velez, et al., 2017).

The third section of the queried respondents about their own research availability, and their individual opinions concerning how long their research projects would take to be completed. The rationale for the time-related questions was that, given that how much time students perceive to have for research could lead to reasonable project scope recommendations for students about the scale of future projects (Klowak, 2018)(Velez, 2017). This means of self-assessment can also help establish realistic expectations for students early in research involvement and avoid disappointing outcomes with research experiences (Daelmans, et al., 2018).
The fourth section of the survey was comprised of questions about the value of research to five distinct areas. These were: residency applications, academic growth, professional development, networking, and improvement in patient’s care. Possessing an understanding of these areas and the role that research plays in each an additional gauging factor in student research exposure, as well as their overall research interest (Klowak, 2018)(Siemen, 2010).

For the fifth and final section, respondents were asked to assess their own personal research interest, in a free-text layout. This format allows for an open forum for respondents to outline their perspectives on research and can provide further insight to determine potential themes and patterns that require further inquiry (Hsieh & Shannon, 2005)

Proposed Research Questions

The proposed research questions are as follows:

1. How does medical student knowledge of concepts and their perceptions about research change following second semester research experiences and electives (research internships, research-day presentations and research intersession), as well as research-intensive university environment?

2. What factors (if any) better predict interest in continuing research participation beyond medical school?

These results may help to guide additions and requirements to the initial research specialty certification curriculum to encourage research interest and engage students and future physician-researchers and principal investigators.
The purpose of my dissertation is to assess how medical students’ knowledge in research changes following their second semester research experiences (research internships, research-day presentations and research elective course).
CHAPTER III

METHODS

Study Hypotheses

It is hypothesized that there will be a statistically significant improvement in the post-test Likert scores (Sections 2 and 4) of the quality improvement survey which is the subject of this dissertation. These questions are specific to research knowledge of concepts, and the perceived importance of research experience.

It is also predicted that there will be a statistically significant increase in the score for each question in Section 3 of the quality improvement survey. These survey questions pertain to the respondent’s perceived availability to participate in research.

Overview of Research Design

A mixed-methods survey was conducted. Quantitative analysis included exploratory analysis and inferential statistics. For the quantitative aspect, nominal data (including gender and ethnicity) will be analyzed using chi-squared testing. Paired-sample t-test (for tests with normal distribution) and Mann-Whitney for non-parametric testing was be used for Likert scale questions. Matrix-type questions with cross tabs may require multiple correspondence analysis (MCA).

Qualitative data assessment methodology will be performed using content analysis theory. Content analysis has been noted to be the optimal analytical tool for evaluating themes,
works and concepts within a given set of text (Silverman, 2015). Open (free text) responses will be assessed both by content, as well as thematically. In terms of content, responses will be color-coded, and a coding dictionary will be generated based on code words, patterns and potential interpretations. For example, if a number of respondents note interested in finding a mentor in the pre-test, but their focus changes to statistical analysis or manuscript development in their post-test, one could interpret that they gained some exposure to these new concepts and were potentially able to connect with a research mentor.

A survey, distributed via email, was selected as the most suitable to contacting as many potential respondents as possible in a timely manner (Ponto, 2015). The mixed-methods design was ideal for multiple choice, Likert scales, and free text responses. Online survey distribution also allowed for subject privacy and anonymity.

Pre- and Post- testing methodology was utilized to determine if there was a measurable effect on respondent knowledge and perceptions following research curricula and activity exposure in the Spring semester. This testing method is ideal for assessing and quantifying these changes (Dellwo, 2010).

Survey Development

A quality improvement survey for student research was administered by the MSU Office of Student Affairs and Services to all medical students. The survey was created with the input of former students, mentors and members of my dissertation committee utilizing Google Forms. There were thirty-one questions in the survey including basic demographics, (age, gender identification, race and ethnicity and last degree completed). There were questions about the
students’ geography, requesting the primary location of the student during primary and secondary schools and undergraduate education. Geographic locations were defined by regions in the United States and international students. Medical school admission is highly competitive, so this data point was deemed to be of interest in an attempt to determine if the overall distance students are willing (or required) to travel to complete their medical education is a factor for medical school selection. Respondents were also asked their specialty preference for residency. The purpose of these questions was to determine if there is a connection between research interest and medical specialty. Research experience, specifically presentations and publications can be a deciding factor in selection for many residency specialties. Next, students were asked about their previous research experience. This included their presentations and publications, and their levels of project involvement. Participants were also asked about twelve important aspects of research and their familiarity with each on a five-point Likert scale (see attached survey) as a section of the 31 questions. Students were asked to assess their research availability (i.e., the number of weekly hours that they could devote to research pursuits given their current academic schedule, as well as their individual opinions concerning how long their research projects would take to be completed. Finally, respondents were invited to share their opinions and concerns about research activities and involvement in three open-ended questions to conclude the survey. The information collected in this section is qualitative and could provide valuable insight into student concerns not covered in the earlier portions of the survey. The quality improvement evaluation survey collection period was conducted from September 28, 2020, to December 31, 2020.
Sampling Frame

416 surveys were sent out to students. Each respondent was assigned a random number to differentiate the surveys without identifiable characteristics. This number was masked from the investigators. For the purposes of this project, this will be considered the “pre-test.”

The purpose of this survey was to evaluate the utility of the current research intersession elective and required internship curricula, as well as the effect of a research intensive university environment. Responses were anonymous, and students were able to opt out if they so decided. This quality improvement project was approved by the Western Michigan University Institutional Review Board in February 2020 and the MSU CHM Office of Medical Education and Professional Development on September 20, 2020.

Exposures

For the post-test portion, the same survey and method of distribution outlined above was utilized, after the following research-specific activities:

- Research/biostatistics intersession: A 4 week, 12 module elective course for first- and second year MSU CHM students. The syllabus and coursework were designed and taught by me and the MSU faculty. My qualifications for leading instruction of this course include over a decade of research student mentorship and extensive coursework, and expertise in core principles of research. The MSU faculty included the directors of student research for MSU CHM, with over a decade each of experience in those roles.
The primary objective is to expose early medical students to the essential skills needed to become productive student researchers and future physician scientists. Skills include:

- How to find a research mentor
- How to formulate a research question
- How to conduct a literature search
- How to design a research protocol
- How to navigate submissions/reviews by the IRB
- How to complete basic biostatistical analysis
- Understand ethical and authorship considerations, and
- How to present and publish your work.

As this course is elective, it’s not required of all students, which could be a confounding factor in the analysis.

- Research internships: Students can engage with research mentors to take part in projects throughout their medical education. While there are no specific requirements for study roles, students are required (as part of ASK) to take part in the design, development, and implementation of a research or quality improvement project. Potential cofounders of this variable could include when did they completed the questionnaire pre- and post-test periods relative to their internship and that this is not a requirement for students.

- Inter-City Research Day: A program of annual, multi-discipline event showcasing the research and scholarly activities of local medical students, residents, clinical fellows and
allied health professional program students. This is often the first abstract and presentation preparation experience for clinicians-in-training and provides valuable research exposure for students. This occurs after the completion of the research elective course, and students are encouraged to attend. A number of Michigan cities where students complete their clinical rotations conduct research days, including East Lansing, Grand Rapids, Southfield and Flint. Similar to the research elective course and internships above, this is also not a requirement for all students.

- Epidemiology intersession: In addition, there is a required first year course that is conducted during the Spring semester, typically before or in tandem with the research elective. The epidemiology course, while not centered on a specific project, is distinctly focused on research methodology and evidence-based medicine. This is an important foundational course of introducing students to important aspects of establishing and maintaining a research project. While this course is required for all students, some more senior students could be several semesters removed from this course.

The random number assignment from the previous survey functions as a correlation number for pairing a comparison set for the post-test for the respondent from that email address, which will be masked from the investigators. Following data formatting (converting individual survey answers into an analyzable spreadsheet), post-tests and comparative data will be analyzed to obtain descriptive and inferential statistical results. This dissertation will survey the same MSU-CHM medical student respondents above to determine if there have been any changes in the pre-test responses concerning research knowledge, attitudes, and desired areas of focus. The
post-test survey period was administered following in the Spring of the 2020-2021 academic year (ending in June 2021), which coincided with the completion of a research/biostatistics elective, epidemiology coursework, research internships and the research presentation days, Respondents could have participated in one or all of these events, although it was not required of survey respondents. Further, some participants may not have any of the above exposures during the survey period, but all students are required to complete the epidemiology course in the second semester of their first year.

Informed Consent Process

The online survey had a brief consent section before the questions. Please see the attachment to review this consent form. As an anonymous survey, participants were not asked to sign the consent form. The survey was estimated to take about 20 – 30 minutes to complete. There were no direct benefits to respondents to who chose to participate, nor were there any risks, other than the possible loss of confidentiality. The anonymized nature of the survey mitigated this risk as much as possible. Participants were allowed withdraw from participation at any time by not completing the survey or responding to the second survey. Any information collected before withdrawal was eligible to be used for study.

Statistical Plan and Rationale

Summary statistics will be calculated for the data. Sections one and three were comprised of nominal data points collected in multiple-choice format with single and multiple answer options. Given that these were non-operable responses, hypothesis testing methodology
will be utilized for analysis. Therefore, it is anticipated that 2x2 tables, frequency distributions chi-squared testing will be used to determine significant differences in the frequency of the given values (Perreault Jr, et al., 1989).

Variable Calculations: Sections two and four were comprised of ordinal data collected using a Likert scale with matrix-style questions. Likert-type was selected due to its utility and its preferable utilization for assessing medical education performance and efficacy (Sullivan & Artino, 2013). Paired-sample t-test (for tests with normal distribution) and Mann-Whitney (for data without a normal distribution) testing was be used for Likert scale questions. Matrix-type questions with cross tabs may require multiple correspondence analysis (MCA). These means of analysis are noted to be most appropriate for evaluation for parametric (t-test) and nonparametric (Mann-Whitney) ordinal data. For data that requires cross tab analysis, MCA may be used as well (Sullivan & Artino, 2013).

Additionally, responses in these two sections will be further stratified into minimal, moderate, and maximal level of research exposures. For section 2, familiarity with research concepts ranges from 1 (Unfamiliar) and 5 (Very Familiar). Therefore, the lowest potential score for this 12 point assessment is 12 and the highest is 60. Descriptive analysis will be determined by the average and standard deviation values. The stratification will be based on the five-number summary, with the moderate including scores between the first and third quartiles. A similar process will be employed for section 4 (minimum 5, maximum 25). These two scores will be combined to determine the respondent’s level of research exposures.
Differences between the pre-test and post-test values for quantitative data will be determined using the t-test, and for nominal data using the \( t^2 \) test. Significance is noted at \( p > 0.05 \). The statistical analysis software that will be utilized will be Minitab 19.

Qualitative data assessment methodology will be performed using content analysis theory. Content analysis has been noted to be the optimal analytical tool for evaluating themes, works and concepts within a given set of text (Green & Thorogood, 2009)(Silverman, 2015). Open (free text) responses will be assessed both by content, as well as thematically. In terms of content, responses will be color-coded, and a coding dictionary will be generated based on code words, patterns and potential interpretations.

Independent variables include the research experiences and exposures (Research Days, elective internships, ASK (Applied Skills & Knowledge) and research elective course) and well the research-intensive university environment at MSU CHM. Dependent variables are Likert scores of perceptions and attitudes as well as residency specialty selection.
CHAPTER IV

RESULTS

Surveys were sent out to 416 active medical students at MSU CHM for the 2020-2021 academic year. The first of these for the pre-test period were distributed on September 26, 2020, with email reminders sent on October 26, 2020 and November 26, 2020. The pretest survey period closed on January 10, 2021. The post-test response interval began on April 23, 2021 with reminders sent on May 15, 2021 and June 15, 2021. The post-test closed on July 1, 2021. There were 121 total respondents for both periods (63 in the pretest, and 58 in the post-test). The response rate for the pre-test was (63/416) 15% of the total population for the pre-test period, (58/416) 13.9% for the paired, post-test period. Responses were paired based on a self-selected anonymous identifier. Following this process, there were 52 unique, paired respondents for the survey. The overall response rate for the paired respondents was (52/416) 12.5%.

Demographics

Age

Respondents were queried on their age range by the senior author to obtain a better understanding of their level of expertise. The age of respondents ranged from groups starting at a minimum 18 to a maximum of 30+ years old. These were grouped as follows: Group 1: 18-21 years old, Group 2: 22-25 years old, Group 3: 26-29 years old, and Group 4: 30+ years old. As expected, there was a slight increase in the pre- and post-test periods. For Group 1, there were two respondents in the pre-test period (3.9%), and one in the post-test cohort (1.9%). The
The largest subset was Group 2, which had 31 in the pre-test cohort (59.6%), and 29 for the post-test (55.8%). Group 3 consisted of 14 respondents in the pre-test period (26.9%), and 13 in the post-test group (25%). For Group 4, five subjects reported being age 30 or older during the pre-test (9.6%), and nine respondents were noted to be in this group in the post-test period (17.3%).

These results adhere relatively closely to the reported age ranges for students in medical school. Per the AAMC, the average age of a first-year medical student is 24 and the median age is 26 overall (AAMC, 2022). Given the age ranges are not specific numbers, the averages are not exact, but are estimated by frequency. Further, this survey did have a larger proportion of respondents over the age of 30 than initially anticipated, although this difference was not noted to be significant \( p = 0.615 \). These results were also in correlation with the education level of our respondents, which was higher than those reported in the literature. The potential implications of these outcomes will be reviewed in the Discussion section of this dissertation.

**Self-Reported Gender and Race/Ethnicity**

Students were asked to self-report their gender and their race/ethnicity to establish the demographic characteristics of the sample population. 30 (57.7%) of respondents were reported to be female, and 20 (38.5%) were males. One respondent identified as non-binary (1.9%), and another student preferred not to disclose their gender. This was unchanged from the pre- to the post-test period. In contrast to more recent AAMC matriculation graduation reports, the gender statistics reported for the medical student participants of this survey were as follows:
• 2018-19 Academic Year (21, 614 respondents)*:
  o Female – 11,160 (51.6%)
  o Male – 10,454 (48.4%)

• 2020-21 Academic Year (22, 647 respondents)*:
  o Female – 12,590 (55.6%)
  o Male – 10,057 (44.4%)

* Non-binary and other respondents (as well as those who preferred not to indicate their selection was not included in either report).

In comparison to the AAMC survey, this questionnaire had a slightly larger proportion of female respondents, and a corresponding decrease in the percentage of male students. Per best-fit analysis, these portions were as expected in comparison to the historical AAMC data. In addition, this questionnaire included options for non-binary respondents, as well as those who chose not to indicate their gender. These options can (and should) be added as responses to surveys of matriculates in order to have the most accurate and inclusive assessment of the student population.

With regards to race/ethnicity, 38 respondents were Caucasian, (73.1%). Asian-American Pacific Islanders (AAPI) consisted of (13.4%), or seven students. African American or Black respondents represented (7.7%) of the sample population, or four students. There was one student of Hispanic/Latino origin (1.9%), one multiracial respondent, and one student who preferred not to disclose their race/ethnicity. In terms of race and ethnicity, AAMC has highly
specific questions and categories for their respondents, with selected combination of races/ethnicities reflected in their reports. Please see a sample of this table for the 2018-2019 and 2021-2022 academic years in Table 1 and 2 below (AAMC, 2022):

Table 1: 2018-19 Academic Year - Selected Combinations of Race/Ethnicity

<table>
<thead>
<tr>
<th>Selected Combinations of Race/Ethnicity</th>
<th>Total</th>
<th>Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Indian or Alaska Native Only</td>
<td>109</td>
<td>0.21%</td>
</tr>
<tr>
<td>American Indian or Alaska Native, Black, or African American</td>
<td>49</td>
<td>0.09%</td>
</tr>
<tr>
<td>American Indian or Alaska Native, White</td>
<td>242</td>
<td>0.46%</td>
</tr>
<tr>
<td>Asian Only</td>
<td>11,216</td>
<td>21.26%</td>
</tr>
<tr>
<td>Asian, Black, or African American</td>
<td>91</td>
<td>0.17%</td>
</tr>
<tr>
<td>Asian, White</td>
<td>979</td>
<td>1.86%</td>
</tr>
<tr>
<td>Black or African American Only</td>
<td>4,430</td>
<td>8.40%</td>
</tr>
<tr>
<td>Black or African American, White</td>
<td>203</td>
<td>0.38%</td>
</tr>
<tr>
<td>Hispanic, Latino, or of Spanish Origin Only</td>
<td>3,296</td>
<td>6.25%</td>
</tr>
<tr>
<td>Hispanic, Latino, or of Spanish Origin, Black or African American</td>
<td>209</td>
<td>0.40%</td>
</tr>
<tr>
<td>Hispanic, Latino, or of Spanish Origin, White</td>
<td>1,561</td>
<td>2.96%</td>
</tr>
<tr>
<td>Native Hawaiian or Other Pacific Islander Only</td>
<td>53</td>
<td>0.10%</td>
</tr>
<tr>
<td>White Only</td>
<td>24,680</td>
<td>46.78%</td>
</tr>
<tr>
<td>White, Other</td>
<td>610</td>
<td>1.16%</td>
</tr>
<tr>
<td>Other</td>
<td>1,166</td>
<td>2.21%</td>
</tr>
<tr>
<td>Multiple Race/Ethnicity Not Listed Above</td>
<td>908</td>
<td>1.72%</td>
</tr>
<tr>
<td>Unknown Race/Ethnicity</td>
<td>1,008</td>
<td>1.91%</td>
</tr>
<tr>
<td>Non-U.S. Citizen and Non-Permanent Resident</td>
<td>1,947</td>
<td>3.69%</td>
</tr>
<tr>
<td>Total Applicants</td>
<td>52,757</td>
<td>100.00%</td>
</tr>
</tbody>
</table>
Table 2: 2021-22 Academic Year - Selected Combinations of Race/Ethnicity

<table>
<thead>
<tr>
<th>Selected Combinations of Race/Ethnicity</th>
<th>Total</th>
<th>Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Indian or Alaska Native Only</td>
<td>105</td>
<td>0.17%</td>
</tr>
<tr>
<td>American Indian or Alaska Native, Black, or African American</td>
<td>70</td>
<td>0.11%</td>
</tr>
<tr>
<td>American Indian or Alaska Native, White</td>
<td>283</td>
<td>0.45%</td>
</tr>
<tr>
<td>Asian Only</td>
<td>13,420</td>
<td>21.51%</td>
</tr>
<tr>
<td>Asian, Black, or African American</td>
<td>149</td>
<td>0.24%</td>
</tr>
<tr>
<td>Asian, White</td>
<td>1,325</td>
<td>2.12%</td>
</tr>
<tr>
<td>Black or African American Only</td>
<td>6,167</td>
<td>9.89%</td>
</tr>
<tr>
<td>Black or African American, White</td>
<td>298</td>
<td>0.48%</td>
</tr>
<tr>
<td>Hispanic, Latino, or of Spanish Origin Only</td>
<td>4,037</td>
<td>6.47%</td>
</tr>
<tr>
<td>Hispanic, Latino, or of Spanish Origin, Black or African American</td>
<td>368</td>
<td>0.59%</td>
</tr>
<tr>
<td>Hispanic, Latino, or of Spanish Origin, White</td>
<td>2,173</td>
<td>3.48%</td>
</tr>
<tr>
<td>Native Hawaiian or Other Pacific Islander Only</td>
<td>41</td>
<td>0.07%</td>
</tr>
<tr>
<td>White Only</td>
<td>25,640</td>
<td>41.10%</td>
</tr>
<tr>
<td>White, Other</td>
<td>795</td>
<td>1.27%</td>
</tr>
<tr>
<td>Other</td>
<td>1,563</td>
<td>2.51%</td>
</tr>
<tr>
<td>Multiple Race/Ethnicity Not Listed Above</td>
<td>1,217</td>
<td>1.95%</td>
</tr>
<tr>
<td>Unknown Race/Ethnicity</td>
<td>2,427</td>
<td>3.89%</td>
</tr>
<tr>
<td>Non-U.S. Citizen and Non-Permanent Resident</td>
<td>2,308</td>
<td>3.70%</td>
</tr>
<tr>
<td>Total Applicants</td>
<td>62,386</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

The respondents for this survey tended to be less demographically diverse than the national statistics from AAMC, but more closely aligned with those in the Midwestern (Great Lakes) region. According the 2020 U.S. Census figures, Caucasian or White respondents account for 74.5% of the Great Lake population. The AAPI, African American or Black, Hispanic/Latino, mixed race and other populations consist of 3.1%, 12%, 8%, 2% and 0.4% respectively of the same region. Regarding the AAMC survey, I appreciate the comprehensive breakdown for their questionnaires. With their large population, it is the ideal means for
collecting this information. Additionally, there is some rationale why the respondents of this survey may closely align with local demographics, which is explored more in depth in the next section.

Geographic Background

In the interest of assessing how geographic background affects choices pertaining to continuing higher education, respondents were asked about their regional origins. This was for both their primary/secondary schools as well as their undergraduate college and university. The results of these two survey questions are noted in Figures 1 and 2 below.

Figure 1: What was the geographic region of your primary/secondary schools?
There are a myriad of reasons why students choose to stay closer to home for medical school, including economic/affordability factors, out-of-state student quota limits. Additionally, there are some state schools that do not admit students from outside the state. Despite these limitations, prospective medical students come from a variety of backgrounds, including their collegiate preparation for their clinical education. The next section considers this aspect of the survey.

Educational History

To gain a better understanding of the students’ scholarly credentials, respondents were questioned about this educational background. While a Bachelor’s degree is a necessary prerequisite for medical school application and acceptance, many students pursue additional post-graduate education, for a multitude of reasons. For example, non-traditional students may
decide to attend medical school after careers in other fields, others may obtain dual degrees to better prepare for their career ambitions. A notable recent trend is for students to spend at least a year after completing their undergraduate degree obtaining research expertise. In some instances, this occurs as a result of an unsuccessful application to medical school. In others, they forgo application until they have additional degrees, graduate certificates, or experience in order to bolster their applications and chances of acceptance. Further, many medical students have also taken a year of research before residency applications, with the same motivations. More on the possible implications of this phenomena will be explored in the next chapter. For this analysis, 41 (78.8%) of the students reported their last completed degree was a Bachelor’s. There were nine respondents (17.3%) with a Master’s degree. One student reported they had a postgraduate certificate, and another had a PhD (1.9%, respectively).

**Time to Devote to Research**

Students were asked for their personal assessments with regard to time management and research activities, a major concern for managing responsibilities. These responses were delineated into groups indicated below.

- Less than 5 hours/week
- 5 - 10 hours/week
- 10 - 15 hours/week
- 15+ hours/week
For the pretest period, 22 respondents (42.3%) indicated they had less than five hours weekly to devote to research. Students who could allocate between five and ten hours to investigational projects amounted to 22 as well. A substantial decrease in the number of respondents was noted for the next two categories. Five students (9.6%) noted that they could spend an average of 10 to 15 hours on research. Only one student (1.9%) responded that they were able to dedicate 15 hours or more to research endeavors. Two students provided multiple answers (Less than 5 hours/week and 5 - 10 hours/week). They score was averaged to 5 hours/week, and classified into their own subcategory, which accounted for 3.8% of the population in order to be included in the analysis.

In the posttest group, the results were similar. The number of students who had five hours or less to dedicate to research was 24 (46.2% of sample). Those who could spend five to ten hours on research projects totaled 20 (38.5%). Somewhat predictably, a similar precipitous trend was noted for students who could devote ten or more hours to research on a weekly basis. Six (11.5%) of respondents noted that they could allocate ten and fifteen hours to studies. Additionally, none of the students indicated that they could allocate 15 or more weekly hours to research. Here again, there was one (1.95%) respondent that indicated multiple answers; (in this instance 5 - 10 hours/week and 10 - 15 hours/week). This was again averaged to 10 hours/week and assigned an additional category to be integrated into the results.

There are a number of reasons that could explain why there was a slight decrease in the average amount of time students estimated that they could spend on research. The student’s current obligations and course load (including preparing for step exams and rigorous rotations)
could certainly play a factor. The amount of time estimated by the student may also be
dependent on the students’ roles and responsibilities in the project. They may indicate less time
because their part actually requires fewer hours of direct activity. Further, the student
responsibilities tend to increase in intensity during the spring semester as compared to the fall.
Additionally, an aftereffect of garnering more clinical and research knowledge is that students
will have a most realistic assessment of the time commitments required for projects once they
have a better understanding of what is entailed in participation.

Residency Preference Selection

To determine the potential future career plans of the students, they were asked about the
specialty/and residency preferences. As this was an unlimited number of responses in each
category, as well as free text field, there was the potential for numerous combinations for
responses. This was by design to get the most complete picture of residency choices, to see how
the number of options changed over time, and if those changes were affected by the research
exposure environment. Once the results were obtained, they were organized into individual
responses, and for three options or less. Four or more selections were broken down into
categories as well. Please see the results for the pre- and post- test periods below, as well the
corresponding USMLE Step 2 Clinical Skills score and 2022 Residency Match Rate for
individually listed specialties:
Table 3: Residency Specialty Selections by Respondents (Pre-Test)

<table>
<thead>
<tr>
<th>Specialty Represented</th>
<th>Total</th>
<th>Percentage</th>
<th>Avg. USMLE Step 2 Score</th>
<th>2022 Match Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency Medicine</td>
<td>4</td>
<td>7.69%</td>
<td>247</td>
<td>95.1%</td>
</tr>
<tr>
<td>Emergency Medicine, Internal Medicine</td>
<td>3</td>
<td>5.77%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Family Medicine</td>
<td>2</td>
<td>3.85%</td>
<td>241</td>
<td>97.2%</td>
</tr>
<tr>
<td>Radiology</td>
<td>2</td>
<td>3.85%</td>
<td>233</td>
<td>96.3%</td>
</tr>
<tr>
<td>Family Medicine, Neurology</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Psychiatry, Neurology</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Emergency Medicine, Pathology, Internal Medicine</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>General Surgery</td>
<td>1</td>
<td>1.92%</td>
<td>250</td>
<td>90.4%</td>
</tr>
<tr>
<td>Obstetrics/Gynecology, Pediatrics</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Emergency Medicine, Obstetrics/ Gynecology</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Cardiology, Gastroenterology, Internal Medicine</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>ENT, Emergency Medicine</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Cardiothoracic surgery</td>
<td>1</td>
<td>1.92%</td>
<td>246</td>
<td>71.6%</td>
</tr>
<tr>
<td>Cardiothoracic Surgery, General Surgery, Obstetrics/ Gynecology</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Family Medicine, Internal Medicine, Rheumatology</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Dermatology, Endocrinology</td>
<td>1</td>
<td>1.92%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dermatology, Ophthalmology, Oncology/Hematology</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>General Surgery, Internal Medicine, Obstetrics/ Gynecology</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Internal Medicine</td>
<td>1</td>
<td>1.92%</td>
<td>249</td>
<td>98.2%</td>
</tr>
<tr>
<td>Psychiatry, Radiology</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Pediatrics</td>
<td>1</td>
<td>1.92%</td>
<td>250</td>
<td>99.1%</td>
</tr>
<tr>
<td>Emergency Medicine, Family Medicine</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Emergency Medicine, Family Medicine, Internal Medicine, Psychiatry</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Undecided</td>
<td>2</td>
<td>3.85%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>4 Specialties</td>
<td>6</td>
<td>11.54%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>4 Specialties (Emergency Medicine Included)</td>
<td>2</td>
<td>3.85%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>5 Specialties (Emergency Medicine Included)</td>
<td>3</td>
<td>5.77%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>6 Specialties</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>6 Specialties (Emergency Medicine Included)</td>
<td>3</td>
<td>5.77%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>7+ Specialties</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>7+ Specialties (Emergency Medicine Included)</td>
<td>4</td>
<td>7.69%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
<td>100.00%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Post-Residency Fellowship is Required or Strongly Recommended*
Table 4: Residency Specialty Selections by Respondents (Post-Test)

<table>
<thead>
<tr>
<th>What specialty are you interested in pursuing? (check all that apply)*</th>
<th>Total</th>
<th>Percentage</th>
<th>Avg. USMLE Step 2 Score</th>
<th>2022 Match Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency Medicine</td>
<td>7</td>
<td>13.46%</td>
<td>247</td>
<td>95.1%</td>
</tr>
<tr>
<td>Emergency Medicine, Internal Medicine</td>
<td>3</td>
<td>5.77%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Orthopaedics</td>
<td>2</td>
<td>3.85%</td>
<td>256</td>
<td>87.4%</td>
</tr>
<tr>
<td>General Surgery</td>
<td>2</td>
<td>3.85%</td>
<td>250</td>
<td>90.4%</td>
</tr>
<tr>
<td>Pediatrics</td>
<td>2</td>
<td>3.85%</td>
<td>250</td>
<td>99.1%</td>
</tr>
<tr>
<td>Plastic Surgery</td>
<td>1</td>
<td>1.92%</td>
<td>257</td>
<td>97.1%</td>
</tr>
<tr>
<td>Radiology</td>
<td>1</td>
<td>1.92%</td>
<td>253</td>
<td>96.3%</td>
</tr>
<tr>
<td>Family Medicine</td>
<td>1</td>
<td>1.92%</td>
<td>241</td>
<td>97.2%</td>
</tr>
<tr>
<td>Psychiatry</td>
<td>1</td>
<td>1.92%</td>
<td>242</td>
<td>89.5%</td>
</tr>
<tr>
<td>Internal Medicine, Obstetrics/ Gynecology</td>
<td>2</td>
<td>3.85%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Family Medicine, Obstetrics/ Gynecology, Psychiatry</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Anesthesiology, Internal Medicine, Undecided</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Family Medicine, Neurology, Psychiatry</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Dermatology, Endocrinology</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Cardiology, Internal Medicine</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Dermatology, Ophthalmology, Oncology/Hematology</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Emergency Medicine, Family Medicine</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Family Medicine, Obstetrics/ Gynecology</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>General Surgery, Obstetrics/ Gynecology</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Family Medicine, Pediatrics</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Obstetrics/ Gynecology</td>
<td>1</td>
<td>1.92%</td>
<td>249</td>
<td>86.1%</td>
</tr>
<tr>
<td>General Surgery, Internal Medicine, Oncology/Hematology</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Anesthesiology, Neurosurgery, Plastic Surgery</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Anesthesiology, Internal Medicine, Pediatrics</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Obstetrics/ Gynecology, Pediatrics</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Emergency Medicine, Gastroenterology, Obstetrics/ Gynecology</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Pathology, Physical Medicine &amp; Rehabilitation</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Emergency Medicine, Obstetrics/ Gynecology</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>4 Specialties (Emergency Medicine Included)</td>
<td>3</td>
<td>5.77%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>5 Specialties</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>5 Specialties (Emergency Medicine Included)</td>
<td>5</td>
<td>9.62%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>6 Specialties</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>7+ Specialties (Emergency Medicine Included)</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Undecided</td>
<td>1</td>
<td>1.92%</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
<td>100.00%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Post-Residency Fellowship is Required or Strongly Recommended
In the pre-test period, there were 32 permutations for the responses, with an average of 3.6 specialty selections each. Students that selected Emergency Medicine (EM) as at least one option amounted to 11 respondents (34.4%). For the post-test, 34 combinations, but a slight decrease in overall median number of residency choices (3 each). There were eight students (23.5%) who selected EM as a potential residency option. It was also the most commonly selected option in both groups (23 in the pre-test, and 19 in the post-test group). The total number of selections also drops by nearly 30% from 174 to 124 between the two periods. The frequency of each selection is noted in Figure 3:

Figure 3: Residency Selection Frequency
A few interesting trends were noted in the findings above. To begin with, EM was the most common selection, and one of the more competitive residency placements in terms of research. Considering all residencies, the match difficulty for EM is noted as moderate, with over 95% of MD and 93% DO applicants matching for the 2022 cycle (AAMC, 2022). A distinguishing characteristic of EM residencies is the prevalence of scholarly tracks. At current 80% of EM residencies include a research requirement in the curricula. Jordan et al reported in 2018 that 72% of EM programs that responded to their survey offered such pathways, and most residents take part if such programs are available. The majority graduates reported a number of advantages to their tracks, including future academic career resources, opportunities access to active and involved mentors (Jordan, et al, 2018).

By comparison, neurosurgery is consistently ranked as one of the most difficult residencies to match into. The requirements are well understood to be very rigorous, but also there are a fraction of positions available compared to the majority of other specialties. For instance, there were 2665 total spots in the EM match in the 2022 cycle, and 232 (8.7% of the EM total) for neurosurgery over the same period. The successful match rate for neurosurgery for 2022 was 85.1% for both MD's and DO's. When reviewing the research requirements for the 107 programs, 59 (55.1%) programs indicated at least a year was allocated specifically for research/scholarly activities while another 34 programs noted less than 12 month or an integrated research approach, for a total of 86.9% of residencies reported specific research requirements (Karsy, et al., 2018).
There are few other key distinctions between these two clinical fields, especially when it pertains to availability for research activities. To begin with, EM residencies are three years in duration (without additional specialization) and neurosurgery programs are a minimum of seven years long. This difference allows for more time to be allocated to research and other academic areas of interest, especially in programs with a strong research emphasis. By contrast, EM residents have less time to devote to research, making integrated and extracurricular projects even more vital (Jordan, et al, 2018).

Research Experience Stratification (Section 2: Research Familiarity)

In order to classify respondents into stratifications based on their research knowledge/experience, the Likert scores in Sections 2 and 4 were utilized. These responses needed to be converted to numerical value for both sections. Please see this conversion below in Table 4a for Section 2.

Table 5: Likert Score Conversion (Section 2)

<table>
<thead>
<tr>
<th>Responses</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unfamiliar</td>
<td>1</td>
</tr>
<tr>
<td>Aware, Not Familiar</td>
<td>2</td>
</tr>
<tr>
<td>Neither Unfamiliar or Familiar</td>
<td>3</td>
</tr>
<tr>
<td>Somewhat Familiar</td>
<td>4</td>
</tr>
<tr>
<td>Familiar</td>
<td>5</td>
</tr>
</tbody>
</table>

For respondents with two answers, the average was used, and rounded upward for the total exposure score. For example, if a 3 and 2 were selected, this was averaged to 2.5. If they had
an average score of 42.5, this was rounded up 43 and stratified accordingly. For this section, pre-
test ranges for each classification were delineated into three groups. Low importance grading
was defined by any score of 26 or less. Moderate scores were noted between 27 and 47, with a
mean of 37 (standard deviation of 11). High scores were 48 or higher. The lowest score response
was 16 and the highest was 69, resulting in a range of 44. The post-test scoring ranges were as
follows: low familiarity was 35 of less, the midrange was 36 to 50 (average of 44, standard
deviation 8), and high score were 51 or higher. The range decreased to 32, with a low of 28 and a
high of 60. This total was then added to the research importance grading noted in the next
section.

Another way of viewing these scores is to consider the characteristics of the lowest and
highest scoring respondent. The respondent with a score of 16 reported no research experience,
and little to no familiarity with research concepts. They also had completed a Bachelor’s degree
prior to medical school. By contrast, the respondent with the score of 60 reported 1st author
experience, numerous presentations, and was very familiar with all aspects of research. Further,
their education level before medical school was PhD, so these results were not surprising, and
atypical for this group.

However, while the highest scoring respondents score remained static, the lowest
scoring respondent’s score improved to 47.5 following exposure. A paired t-test was performed
on the pre- and post- scores to assess this change for all subjects over time. For this section, the
improvement in scores between the two timepoints was noted to be statistically significant \( p < 0.05 \).
Research Experience Stratification (Section 4: Research Importance)

Similar to Section 2, Section 4 required the translation of alpha-descriptive responses to numeric values. This is noted below:

Table 6: Likert Score Conversion (Section 4)

<table>
<thead>
<tr>
<th>Responses</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unimportant</td>
<td>1</td>
</tr>
<tr>
<td>Somewhat Unimportant</td>
<td>2</td>
</tr>
<tr>
<td>Neither Unimportant nor Important</td>
<td>3</td>
</tr>
<tr>
<td>Somewhat Important</td>
<td>4</td>
</tr>
<tr>
<td>Important</td>
<td>5</td>
</tr>
</tbody>
</table>

As was done for the research familiarity section, the mean of the two values was used for students with more than one response, and this number was rounded up for the total score. For the pre-test, the ranges for each stratification for the research importance group were defined as follows: low exposures were any total less than and including 16, with the midrange being between 17 and 23. Any score rated at 24 or over was considered a high familiarity, this was calculated based on an average of 20.25 (rounded to 20) and a standard deviation of 4.06 (adjusted to 4). The range was 19.5, with the lowest score being 5.5 (rated at 6) and the highest 25.

As previously, the lowest and highest scoring respondents are characterized by certain traits. The lowest scoring respondent’s research experience consists of regional presentations, other authorship, and a publication acknowledgement. Additionally, their qualitative responses
are focused on finding a research project and a mentor. Further, they noted that they have five or less hours a week to dedicate to research activities. In this group, there were nine respondents who scored the maximum of 25. All of these subjects reported that they were able to devote between 5 and 15 hours to research. Their research experience varied from international presentations and first or other authorship in a peer-reviewed journal to regional/state abstracts and posters. Also of note, the lowest score improved to 21 in the post test period.

For the post-test period, the results were similar, with a low range from 12 to 17, a midrange from 17 to 23, and 24 or higher for high scores. The total range was 16, with the lowest score being 12 and the highest 25. A paired t-test was also conducted. In this case, the results were not deemed significant \( p = 0.308 \).

Sections 2 and 4: Total Exposure and Stratification

From these results, an overall exposure score was generated, combining the total scores for all questions for each respondent. These scores were stratified into exposure gradings as well. Please the table with these results below:
Table 7: Research Score Stratification (Total Exposure)

<table>
<thead>
<tr>
<th>Stratification (Total Exposure)</th>
<th>Pre-Test Count</th>
<th>Post-Test Count</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Pre-Test (≤ 45) (Lowest: 31.5)</td>
<td>10</td>
<td>8</td>
<td>-2</td>
</tr>
<tr>
<td>• Post-Test (≤ 56) (Lowest: 46)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Medium</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Pre-Test (46 - 71)</td>
<td>35</td>
<td>36</td>
<td>+1</td>
</tr>
<tr>
<td>- Post-Test (57 - 73)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>High</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Pre-Test (≥ 72) (Highest: 85)</td>
<td>7</td>
<td>8</td>
<td>+1</td>
</tr>
<tr>
<td>- Post-Test (≥ 74) (Highest: 85)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td>52</td>
<td>52</td>
<td>*</td>
</tr>
</tbody>
</table>

The senior author hypothesized that overall scores would increase. Additionally, the medium score stratification was predicted to be the largest group, encompassing at least 50% of the total respondent with normal distribution. The results are a larger percentage than theorized, accounting for 69% of the total respondents. Therefore, the low and high scores were both lower portions of the responses than anticipated but were evenly distributed in the post-test model. The means difference between the pre- and post-testing period was also noted to be statistically significant \((p < 0.05)\) with a pre-test average exposure score of 57.57 (58) and a post-test mean of 64.74 (65), a difference of 7.17 (7) points.

Qualitative Analysis

The qualitative component of this analysis consisted of three, free-text questions assessing student perceptions about the attitudes, experiences and expectations of research. A thematic,
content analysis assessment was performed, coding responses into keywords, themes, frequency of occurrence and potential interpretations. This provided valuable insights that were complementary to the qualitative results. A coding chart was utilized to examine the student feedback. These responses were delineated into the following sub-sections:

- Categorization
- Keywords/Phrases
- Themes
- Frequency of Mentions
- Interpretations

By sorting the comments in this way, I was able to gain a better understanding of student ideals, possible motivations, and areas where there were opportunities for further education. Please see the tables below: which served as my codebooks.
Table 8 – Quantitative Analysis Codebook- Ideal Research Experience

<table>
<thead>
<tr>
<th>Categorization</th>
<th>Area of interest</th>
<th>Research Type</th>
<th>Mentor Involvement</th>
<th>Diversity of Experience</th>
<th>Timing Flexibility</th>
<th>Project Impact</th>
<th>Residency Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specialty</td>
<td>Specific medical specialties noted (from demographics section): - Dermatology - Orthopaedics - OB/GYN Focus Scope of interest Field of practice</td>
<td>Study Models/: - Clinical - Pre-Clinical - Bench (work) - Laboratory Levels of Evidence - Prospective - Randomized - Controlled - Retrospective - Case series - Case study</td>
<td>Mentor Teacher Descriptive terms: - Interested - Passionate - Engaged - Respected</td>
<td>All aspects Comprehensive Inclusive Specific to one area of research - Regulatory/IRB - Statistics/analysis - Presentations - Publications</td>
<td>Time management Scheduling Busy Flexibility</td>
<td>Impact Effect on the world Making a difference Bearing on patient care</td>
<td>Residency Applications Placement Competitive</td>
</tr>
<tr>
<td>Keywords/phrases</td>
<td>- Applicability to future plans Student desire to know more about a medical specialty to make their residency decisions</td>
<td>Students are interested in making professional connections with mentors, even early in</td>
<td>A variety of experiences in the different aspects of research are important to students</td>
<td>Students are concerned about integrating their research experiences into their projects</td>
<td>Students have a longitudinal view of the importance of their research projects</td>
<td>Students are concerned about how their research experiences will affect their residency applications</td>
<td></td>
</tr>
<tr>
<td>Interpretation</td>
<td>Before exposure, students are more concerned with research in their own areas of interest</td>
<td>Students maintain a strong interest and preference in the type of research they prefer to take part in</td>
<td>Early on, students are focused on finding an ideal mentor</td>
<td>Students demonstrate interest in all components of research studies, and the ability to conduct a project independently.</td>
<td>Student concerns about time management may decrease after exposure to research intensive environment.</td>
<td>This small proportion in this category does not change meaningfully over time, but it does decrease.</td>
<td>The role of resident applications plays a smaller role in the type of project students prefer than anecdotally reported</td>
</tr>
</tbody>
</table>
Table 9 – Quantitative Analysis Codebook- Most Important Aspect of Research

<table>
<thead>
<tr>
<th>Categorization</th>
<th>Area of interest</th>
<th>Skill Development/ Diversity of Experience</th>
<th>Project Impact</th>
<th>Publishing/ Presenting Sharing Result with Others</th>
<th>Positive Experience</th>
<th>Mentor Involvement</th>
<th>Residency Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specialty Specific medical specialties Focus Scope of interest Field of practice</td>
<td>Specialty Specific medical specialties Focus Scope of interest Field of practice</td>
<td>All aspects Comprehensive Inclusive Specific to one area of research - Regulatory/ IRB - Statistics</td>
<td>Impact Effect on the world Making a difference Bearing on patient care</td>
<td>Publishing Manuscript Presentations Peer- Reviewed Abstracts Conferences Meetings</td>
<td>Encouraging Good experience Positive</td>
<td>Mentor Teacher Descriptive terms: - Interested - Passionate - Engaged - Respected</td>
<td>Residency Applications Placement Competitive</td>
</tr>
<tr>
<td>Keywords/ phrases</td>
<td>Applicability to possible professional trajectory Student desire to know more about medical specialties to make their residency</td>
<td>An understanding of a variety of research principles is valuable to medical students.</td>
<td>Student have a longitudinal view of the importance of the projects that they take part in</td>
<td>While not the most important aspect, positive experiences are part of what student seek when taking part in</td>
<td>A variety of experiences in the different aspects of research are important to students</td>
<td>Students are concerned about how their research experience will affect their residency applications</td>
<td></td>
</tr>
<tr>
<td>Themes</td>
<td>Pre: 8 Post: 5 Small decrease</td>
<td>Pre: 9 Post: 36 Nearly no change</td>
<td>Pre: 9 Post: 4 Notable decrease</td>
<td>Pre: 6 Post: 2 Notable decrease</td>
<td>Pre: 5 Post: 4 Nearly the same</td>
<td>Pre: 9 Post: 6 Slight decrease</td>
<td></td>
</tr>
<tr>
<td>Frequency of mentions</td>
<td>Students prefer projects in areas of interests. Respondents have a longer term view of research participation</td>
<td>Respondents express interest in research familiarity in the pre-test.</td>
<td>Fewer mentions are noted in the post-test, but may have also prioritize the importance of presentations differently.</td>
<td>Respondents would like a good experience with research, especially in the pre-test period.</td>
<td>Students remain focused on finding an ideal mentor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interpretation</td>
<td>Students have contemporary views of importance of research experiences to residency applications.</td>
<td>This large proportion of responses is maintained from the pre to the post test period.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 10– Quantitative Analysis Codebook- What would you like to know?

<table>
<thead>
<tr>
<th>Categorization</th>
<th>Impact on Residency Application</th>
<th>Funding and grant application</th>
<th>Publication/Publication guidance</th>
<th>Time management strategies</th>
<th>Regulatory/IRB</th>
<th>Getting Started/Opportunities</th>
<th>Statistics and Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keywords/phrases</td>
<td>Students are concerned about how their research experience will affect their residency applications</td>
<td>Respondents would like a better understanding of the possible funding mechanisms</td>
<td>Students want to know about sharing the results of their projects with their colleagues/academic community.</td>
<td>Respondents are focused on learning the best practices to be able to participate in research projects given their numerous other responsibilities</td>
<td>Medical students want to know more about the regulations and ethical concerns inherent in research activities.</td>
<td>Students are enthusiastic early on about getting started on projects and what resources are available to them.</td>
<td>Respondents have an interest in the process of statistical analysis.</td>
</tr>
<tr>
<td>Themes</td>
<td>Pre: 1 Post: 1 No change from pre- to</td>
<td>Pre: 2 Post: 1</td>
<td>Pre: 12 Post: 9 Slight decrease</td>
<td>Pre: 5 Post: 3 Slight decrease</td>
<td>Pre: 5 Post: 6</td>
<td>Pre: 30 Post: 15 Notable decrease</td>
<td>Pre: 6 Post: 4 Very slight decrease</td>
</tr>
<tr>
<td>Frequency of mentions</td>
<td>The lower response rate in both testing period shows that these students have few questions about how research effects their residency</td>
<td>The minimal rate noted here demonstrates that students place a lower priority for obtaining more information about funding for projects.</td>
<td>A good proportion of students mentioned an interest in learning more about presenting/publishing research results.</td>
<td>Students may obtain a better grasp on how to manage their schedules with research projects following exposures.</td>
<td>Some students noted sustained interest in how the regulatory and review process of research applies to their projects.</td>
<td>Strong response, with a drop in mentions pre- to post-test.</td>
<td>There was some mention, but not as strong as expected from anecdotal examples.</td>
</tr>
<tr>
<td>Interpretation</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
Several valuable insights were obtained regarding student perceptions of research. For instance, the ideal experience for respondents was pertaining to their field of interest, which is somewhat counter to what is reported in the literature (Klowak, et al., 2018). That noted, the research exposures may have facilitated more research involvement regardless of specialty, due to the availability of projects and mentors. Interest in broad-based skill development and diversity of experience declines between the pre and the post-test timepoints. Ideally, this is due to a better understanding of research principles and their roles in research projects. Concerning the most important aspects of research, respondents indicated that they have a good grasp of the imperative of research to medicine and practice. These numbers remain consistent over the pre- and post-test period. For the third qualitative question, a common theme was that the research-intensive environment helps students to focus on their goals, and better assess what’s missing in their knowledge base. Further, student prioritization of research experiences in relation to their residency applications can be a source of motivation but can also be a driving factor to lifelong interest.
CHAPTER V

DISCUSSION

The results demonstrate the complexity of the problem, and how a multifaceted approach is the best means of approaching the challenges associated with encouraging ongoing research involvement for medical students. The shortage of dedicated physician scientists, as well as practice physicians who engage in research, is a global problem, and the solutions needed to address the vital portion of the physician workforce can come from a number. In terms of percentages of research-specific doctors, the increases needed are reasonable. Further, other physicians who engage in research as a smaller proportion of their practice can and will continue to make a substantial impact. Therefore, the challenge is not insurmountable, once the factors that best distinguish future clinical researchers are better identified.

The results of this survey indicate that there are number of discernments gained with regards to the qualities that best characterize medical students who are the most knowledgeable and experienced when it comes to research. Also, there are factors that help determine which of those most likely to continue to be in engaged throughout residency and into practice. While gender and ethnicity dynamics do not play a substantial role in research interest and exposure, students do tend to be older, and have higher levels of education.

There are number of publications analyzing the impressions and experiences of medical students, as well as a few which seek to determine predictive factors for medical school research involvement. However, these surveys did not include pre- and post-testing or qualitative
components. Additionally predictive aspects were not scoped for research activities beyond medical school into practice, which is the secondary goal of this dissertation. To the knowledge of the author, this integrated, mixed methods, comparative study is a novel approach to the challenges of medical student research involvement, and the first of its kind to be reported in the literature.

In 2011, Seimens reported on the effect of age on the career plans of physicians, and the role of research on those plans. Utilizing similar data collection methods as this analysis, their results provided valuable insight on the motivations of students who participate in research (Seimens, et al., 2010). A primary objective of this study was to analyze student knowledge of research, including critical thinking skills that can be used in other applications, how to read and interpret literature and statistics. Additionally, as noted previously in the literature, medical student involvement fosters an ongoing interest in academic research.

While this study is more than a decade old, it does provide some valuable insight in how the challenges of previous research curricula helped to guide and inform the numerous changes to medical education programs in the intervening years. For instance, a main concern that was noted in the results of this study was the lack of research-specific coursework, the paucity of time for students to take part in projects as well as the availability of knowledgeable and engaged mentors. It’s a fair statement to note that while there has been a great deal of improvement to the research curricula for most programs, the problems pertaining to time management and mentors persist, and are require more complex and institution-specific solutions to address. Further, these same issues are prevalent throughout residency.
Balancing research involvement with a rigorous schedule is still a priority for students, and one of the benefits of compulsory research involvement is that there is specific time designated in the curricula for study activities and responsibilities. Anecdotally, there has been some evidence of positive feedback from students as a result of the change in medical school coursework. However, mandatory involvement in research can also be a double-edged sword, creating negative feelings about research if the student has other areas of interest, or if the experience is unsatisfactory. Moreover, the intensive and challenging coursework and clinical rotations of medical school often allows for very limited availability (five hours or less weekly) to devote to research projects, including finding a research mentor.

Access to knowledgeable mentors is an ongoing challenge for many medical schools. The professional responsibilities of physicians are immense, so working research and students into that schedule can be very daunting for many attending clinicians. Here, past research experience often plays a large role in which doctors mentor physicians-in-training and residents. Many universities use research experience to gauge who best to mentor students, sometimes offering scholarly resources and benefits to physicians. For example, in an effort to mitigate the problems associated with a lack of clinical mentors, MSU CHM have started a new initiative to recruit and retain competent and involved mentors, in an attempt to determine the best means and methods to maintain a robust roster of research physicians.

The Siemens study was conducted under similar conditions to this one, but with a few key differences. While Seimens, used comparable methods for data collection and analysis, this was without the benefit of pre- and post- testing or qualitative assessment component. Further
in comparison to our results, there was more inconsistency in their study. Our population reported higher levels of research exposures and experiences, as well as elevated skills. Most notably their survey was conducted over a decade and a half previously. In the intervening years, the number of medical schools who reported research requirement in their curricula to the LCME during their annual questionnaire increased from 15 in 2005 to over 80 by 2020 (AAMC, 2021). Further, the characteristics of successful applicants to competitive residency programs also changed to some extent.

Contemporaneously, another analogous survey was conducted halfway around the world in New Zealand. Following a successful pilot project of paper-administered questionnaires to assess student research interest, a single time frame follow-up e-mail survey was conducted (669 respondent, 44.8% response rate) to determine if there was any predictive characteristics that determine if certain students would be more engaged in research (Alamri, et al., 2021). The results of their regression analysis yielded similar results assessment, and others found in the literature. Students who reported being involved in research earlier in medical school or during their undergraduate education had more publications and presentations than others in their same year without such experiences. They also noted that they would be more inclined to remain involved into residency and as a part of their future career plans. These respondents also tended to be older, with a higher post-graduate education level. When queried about what residency specialty they preferred, those with the most research engagement were less inclined to be interested in internal/family med specialities. This was similar to the survey results for this study, and many others before it. (Ranieri, et, al., 2016).
Geographic Factors

In terms of location, many students select to stay close to home regionally. For this survey, 69% of respondents reported that they completed their undergraduate education in the Great Lakes region. Also, 67% stated that they had attended the majority of secondary education in this same location. Over the same time period, the AAMC noted that 60.2% of matriculants had remained in their home states for medical school (AAMC, 2022). There are numerous reasons supporting this rationale. Students make their choice for medical based on program prestige (including research) and areas of focus, as well as local climate and atmosphere. A fair percentage of students apply to as many programs as possible and attend wherever they are accepted. Still others prefer to go to school in close proximity to family and other support systems. Another consideration that has taken precedence in recent decades is the cost of medical school. In-state, public medical school annual tuition rates can be as much as 40% lower than that of out-of-state public medical schools, or private schools (in-state of out-of-state). Further, the graduating class of physicians in 2021 are burdened by an average of $200,000 of college loans (Copello, 2021). Even with the lowest student loan rate of 6% compounded annually, these loans can increase from 238,203 (3 years of residency) to 283,704 (5 years of residency plus an additional fellowship year). The potential of another year off taken to gain research experience can cost the student an extra $12,000 to $18,000 or more under the current amortization system (Boutros, et al., 2022). The benefit of integrating research into the medical school curricula and maintaining that interest throughout residency and intro practice can not only be beneficial for the research community at large, but also may help to reduce the overall debt load for newly practicing physicians. In order to help stem the flow of clinicians who
migrate away from research, the NIH offers tuition support for educational programs (like MSTP) as well as loan repayment/forgiveness programs which can cover up to $50,000.00 annually in an effort to recruit and retain clinical investigators and scientists (Garrison & Ley, 2022).

Additionally, this undue financial burden may have additional unintended consequences for students when determining their specialization. Very competitive residencies are often associated with the specialties with the highest annual salaries. These placements also necessitate substantial research involvement from successful candidates. This often results in a substantial time and financial investment, as well as a further push toward these highly specialized fields. Unfortunately, it has also led to shortages in less competitive specialties including internists and family medicine. Due to this equivocation, research involvement is often considered “a means to an end”, and more of an obligation than a worthwhile scholarly pursuit. In addition, research activities in tandem with practice can be thought of as unnecessary “pet projects” distracting from seeing patients, and in many cases, meeting insurance coverage requirements.

Education

With regards to education, there were more respondents with post-graduate degrees and certifications than hypothesized. In comparison to the AAMC figures, the percentages were very similar (25% for AAMC respondents and 21.1% for this survey). Although it’s important to note that the AAMC questionnaire asks more specific questions about the reasoning behind the additional education, querying if students who pursue graduate education medical schools did
so to improve their odds of getting into medical school. However, it was also notable that the largest portion of AAMC respondents (over 42%) who indicated they did not immediately enroll in medical school spent the years between pursuing other careers and gaining research experience.

This same trend follows into medical school as more students take time off from the traditional MD/DO track and get involved in additional research experiences outside of the curricula. These students often take it upon themselves for similar reasons as outlined for getting into medical school. However, the objective is now acceptance to even more competitive residences. In the past, this time was often under structured, with the main purpose being to publish and present. Not surprisingly, the limited scope of this environment is not always conducive to continuing in research, being viewed as more of means to an end. Fortunately, programs are recognizing and offering solutions, with dual degree courses and a choice of academic pathways, as well as extracurricular certifications.

Programs such as these can help with the burden of locating and getting involved in projects and provide necessary resources and structure. Additionally, guided pathways with evidence-based coursework and reliable faculty and mentors can increase the benefits and odds of quality research experiences and exposures that lead to enduring research interest. Further, integrated and tandem degrees are by their nature less time consuming (as well as less financially arduous).

Moreover, there can be considerable concerns with the interruption of the typical MD or DO track for research purposes in terms of skills and competencies. In 2006, a survey of such
effects was conducted at Mayo Clinic Medical School, encompassing 302 former students from 1997 to 2004. Of these, 44 respondents reported taking at least a year off between the second and third year of medical school. For those who only took a year off, there was no discernable effect noted concerning medical board scores or residency performance (clerkship honors) (Dyrbye et al., 2006). However, for there was a notable reduction in both these metrics for students who took three or more years away from medical school for research endeavors. Paradoxically, these lower scores and competencies had a deleterious effect on residency applications, which was often the rationale for taking the off in the first place (Dyrbye et al., 2006). That noted, there are numerous advantages to taking short research externships. This time away from the rigors of medical school allows the students to develop and build analytical skills, promotes research interest and career options for the future. For shorter terms, residency competitiveness improves as well (Dyrbye et al., 2006). Students who take a research year are often directly involved in project mechanisms, including grant application and funding processes, regulatory requirements, and manuscript development and publications. Additionally, the academic and institutional aspects allow the students to engage with a network of colleagues and resources, making connections in the research community. These contacts can prove to be invaluable for future research projects as attendings.

In the last decade, the AAMC has made changes in research curricula requirements that encourage program flexibility. Medical schools have added dynamic coursework pathways as options for students to complete their academic requirements. Others now offer complementary degree programs (MBA, MHA, MPA and JD) and certifications, to integrate research and scholarly experiences into the medical school track. Before 2020, the United States Medical
Licensing Examination (USMLE) consisted of three Steps with four exams in order to become a licensed MD in the United States. The Step 1 exam is taken in the 2nd year and consists of multiple choice questions assessing foundational medical concepts. Step 2 was previously two examinations, one evaluating clinical skills (Step 2 CS) and the other clinical knowledge (Step 2 CK). Taken in the 3rd year, the Step 2 CK score is pivotal to residency rank choice. The third exam (Step 3) is taken at the end of the 4th year and assesses medical application of clinical concepts. With the 2022 decision to make Step 1 pass/fail, and this discontinuation of Step 2 CS (Clinical Skills) in 2020, the importance of the Step 2 CK (Clinical Knowledge) score will inevitably increase, and research will more likely become more important to residency selection in the coming match cycles.

The lessons that can be gained by future physicians in these environments cannot be overestimated. Positive experiences in research can and does encourage continued involvement into clinical practice (Rivero-Müller & Nees, 2019). Additional approaches that can be considered are the role of research education during medical school on improving other critical thinking skills, and how to keep student engaged in the curricula. This necessitates fresh approaches to research education coursework and encouraging more student involvement in the academic and development process of research ideas, not just data collection once a project is already underway. Instructors and mentors should be challenged to transition away from simple memorization and more toward practical application and critical thinking. An example of this is the recent research requirement change at MSU CHM. In the past, research involvement was more loosely defined as were the scholarly requirements. More recently, the curriculum has been modified to more exacting parameters. Specifically, student engagement must begin from project
initiation, from the hypothesis discovery and protocol development process, regulatory/IRB application, and approval as well as data collection and analysis (MSU-CHM, 2022). The objective here is that students are exposed to all aspects of research and can feel true ownership with their projects. They also often work in groups of two to five students, forming their own small research community along with their mentors. These networks also help to encourage engagement and accountability.

Residency Selection/Exposure

The aforementioned criteria of Step 2 CK scores and research experiences define the available options for residency for the vast majority of medical students. For the 2022 cycle, the average Step 2 CK score for matched candidates was 247. For the same cycle, a median of 8.1 research experiences (abstracts, presentations, and publications) were reported for matched MD’s (NRMP 2022). A more in-depth representation of this relationship, as well as the 2022 Match rate for each specialty, is noted below.
Eight of the eleven specialties with a match rate of less than 90% matched candidates with 12.2 research experiences or more. Two residencies with higher match rates (plastic surgery and vascular surgery) averaged 28.5 and 12.4 respectively. Therefore, it follows that
respondents who are interested in the most competitive residencies would mostly likely have the highest stratification scores for this survey as well. A subset of the specialties with the highest frequency of selection in the post-test period, as well as a few of those of most competitive residencies are outlined in Table 10 below.

Table 12: Post-Test Stratification, Step 2 CK Statistics, and Match Scores of Residency Specialty by Frequency of Selection

<table>
<thead>
<tr>
<th>Frequency Of Selection</th>
<th>Specialty</th>
<th>Average USMLE Step 2 CK Score</th>
<th>Average Abstracts, Presentations, and Publications for Matched MD’s</th>
<th>2022 Match Rate</th>
<th>Stratification Score (Post-Test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Emergency Medicine</td>
<td>247</td>
<td>5.1</td>
<td>95.1%</td>
<td>64.3</td>
</tr>
<tr>
<td>14</td>
<td>Internal Medicine</td>
<td>249</td>
<td>6.9</td>
<td>98.1%</td>
<td>66.3</td>
</tr>
<tr>
<td>11</td>
<td>Obstetrics/Gynecology</td>
<td>249</td>
<td>6.8</td>
<td>86.1%</td>
<td>63.4</td>
</tr>
<tr>
<td>9</td>
<td>Family Medicine</td>
<td>241</td>
<td>4.1</td>
<td>97.2%</td>
<td>63.9</td>
</tr>
<tr>
<td>7</td>
<td>* General Surgery</td>
<td>250</td>
<td>8.6</td>
<td>90.4%</td>
<td>69.8</td>
</tr>
<tr>
<td>6</td>
<td>* Orthopaedics</td>
<td>256</td>
<td>16.5</td>
<td>87.4%</td>
<td>80.5</td>
</tr>
<tr>
<td>6</td>
<td>Pediatrics</td>
<td>245</td>
<td>5.6</td>
<td>99.1%</td>
<td>61.3</td>
</tr>
<tr>
<td>6</td>
<td>* Psychiatry</td>
<td>242</td>
<td>6.2</td>
<td>89.5%</td>
<td>68.7</td>
</tr>
<tr>
<td>4</td>
<td>* Neurosurgery</td>
<td>252</td>
<td>25.5</td>
<td>85.1%</td>
<td>71.5</td>
</tr>
<tr>
<td>3</td>
<td>* Plastic Surgery</td>
<td>257</td>
<td>28.5</td>
<td>91.7%</td>
<td>68.3</td>
</tr>
</tbody>
</table>

*Red indicates that a Post-Residency Fellowship Required/Strongly Recommended (Match Rate <92%)

Those specialties which have the lowest match rates (less than 92%, highlighted in red above), have the higher stratification scores for the post-test period. However, as above, there’s not a simple line correlating all specialties in this way. For instance, obstetrics/gynecology has an 86.1% match rate, but a lower stratification score (and associated research experiences) in
comparison. Still, with exceptions such as this taken into account, certain characteristics define an exemplary candidate, well-positioned to match into the residency (and individual program) of their preference. By utilizing these two tables, as well as the previously reported results, a clear picture of the ideal applicant for highly competitive residencies comes into focus. Those with high Step 2 CK scores, numerous research experiences, as well competencies and strong program recommendations have the best chances for success.

On-Ramps and Pathways

The significant improvement observed in the pre- and post- test comparison reinforces not only the importance of research exposure, but also that the experience be multimodal in nature. The four difference exposures range from required and elective coursework to scholarly conferences and extracurricular research. A flexible myriad of approaches has been noted, both in this study and in the literature to be the ideal means of encouraging students to engage and maintain research interest. In the longer view, it may also prove to have the same utility beyond medical school. The disparity in the quantity of physician-scientists in comparison to previous years, and the limitations to recruiting new practitioners are current and future challenges for the research community. The Physician-Scientist Workgroup responded to this concern with a number of pilot programs to encourage more doctors to get involved in research. The objectives for these new procedures are the following (PSW-WG, 2014):

- Support in residency for research projects
- Establishment and maintenance of national research/institutional research networks
- The implementation of on-ramps at all stages of training
This checklist could be modified and utilized for medical student research exposure. In fact, many medical schools have used similar methods to guide their research training curricula. However, the limitations of resident research and other physician-scientist programs are similar to those in medical school and were actually mirrored in the results of this study. Specifically, the length of time required for training, the rigors of competitive program constraints and the availability of resources (both facilities and mentors) are prevalent for both residency and medical school.

A literature review conducted by Hall, et al., in 2016 analyzed the common themes on the topic of research training in medical education. These includes the length of time needed for training, as well as to continue into practice, a paucity of women and minorities, leading to lower likelihoods for academic appointment and advancement, residency competitiveness, and the overall cost of medical education (Hall, 2016)(Harden, 2018). These are very similar to the findings of this study. The recommendations from this analysis include:

- Protected time for research outside of clinical duties.
- Annual evaluation of impact of program support, mentoring and leadership opportunities
- Active faculty networks
- On-ramps throughout all phases of medical education

I feel that this latter recommendation is the most pivotal. Research on-ramps provides numerous entry points to involvement that can be utilized by the student. This publication actually included a visual representation of how to use on ramps to encourage students to get
involved (and stay involved) in research. I have modified this model to incorporate the early findings of this project, and other academic changes that have occurred in the intervening years. Please note the depiction in Figure 4 below.

Figure 4: Research On-Ramps in Medical Education
This flowchart provides a useful tool to help guide programs, as well as gauge student progress. Additionally, flexible courses that allow for progressive advancement at student discretion (i.e., a certification that can lead to a tandem post-graduate degree, and even to concurrent PhD) could lead to an increase in physician scientists, as occurred in Norway.

Lessons from Abroad

The outcomes of this survey can be utilized in tandem with lessons from abroad. Norway offers an excellent longitudinal example of the successes and challenges of a nationally implemented (and funded) medical student research development curriculum. A shortage of academic physicians in Norway prompted the establishment of the Medical Student Research Program (MSRP) in 2002. The objective was to encourage medical students to engage in research both during their education and as an essential part of their practice. The coursework requirements are like those of a traditional PhD program, without the dissertation process, to be initiated between and 2nd and 3rd year (of six total years) of medical school (Hunskaar, 2009). Students are, however, encouraged to take another year to complete the PhD coursework for a dual degree. The entire course is fully funded nationally. Also, the program participants consist of over 10% of the total number of Norwegian medical students. A per-capita comparison in the United States would have over 2,200 MD-PhD students (compared to 709 reported for 2022).

Early evaluations in 2007 and 2009 reported on some of the achievements and deficits of the program. The MSRP accomplished its goal to encourage students to engage in research, and recruitment of such students continued in the subsequent years. Additionally, the need for research “translators” that is, counselors who are able to connect students with scientists, clinicians and patients was identified. A few years into the program, research navigators were
added to the structure, functioning in the same capacity as that of a doctoral advisor. This mentor follows students throughout the program, providing assistance, resources, and support (Müller & Solberg, 2017).

A survey to specifically assess not only the program completion, but also what the overall effect was on the total number of MD-PhD graduates. This study reviewed all MSRP candidates from 2006 (the first year of alumni) to 2014, comparing them to a control group of traditional MD students. The results were very encouraging. Over the course of the first 12 years, the number of MD-PhD graduates increased dramatically (over ten-fold) in contrast to the MD only group (Jacobsen, et al., 2018). Even those who did not go on to complete the PhD program reported increased research involvement in practice, and more academic focus for students still in training.

Finally, 20 years after the inception of the MSRP, a comprehensive assessment was conducted, amalgamating the data from the 2007 and 2015 surveys, along with another questionnaire. The results had continued to improve, actual recruitment met and exceeded expectations in terms of the number of physician scientists graduated compared to pre-program projections and MD comparison groups. Three-quarters of active students responded that they planned to continue through the PhD course. There was a significant increase noted in the number of publications by enrollees and alumni: from 35 in 2006 to 107 in 2015 (Sandvei, et al., 2022). Survey respondents did however note the paucity of (and need for) more guidance in the later stages of the program. Mentorship and guidance issues are a common theme and shortfall.
in student research involvement and was noted in this study which is the subject of this dissertation.

These lessons and solutions on how to encourage students to participate in research programs offer fresh perspectives and ideas on how to address a similar shortage of physician scientists here at home. The transition of many programs to coursework pathways, dual degrees, and integrated research experiences are all potential means of resolving this shortage. I think that Norway’s MSRP’s approach with optional routes to completion should also be given consideration. Certification programs might function in the same way, allowing students a lower-intensive research experience, with the option to pursue further study if they decide to. Another important distinction of the Norwegian program is that it is entirely covered financially, as is the majority of undergraduate and medical education at the public universities (Hunskaar, 2009).

Limitations

This project had a number of limitations. The survey population was constrained to a single medical school in the Midwestern United States. The response rate was considerably lower than initially anticipated (12.5% response rate as compared to the senior authors predicted 40%) initially projected. This resulted in a very small relative sample set (0.23% of the total) when compared to the 22,562 matriculants reported by AAMC over the same period (AAMC, 2022)
In order to maintain study anonymity, the decision was made not to ask students which year of training they were in. In hindsight, it would have been useful to compare how student perceptions of research may change over the course of medical school. Future surveys will include this datapoint, as well as a much larger population to maintain respondents’ privacy. Additionally, the age ranges selected for respondents did not allow for calculation of the average overall age for respondents, and frequencies were used to compare to AAMC datasets. Specifically, the low end age range included respondents 18 to 21, although the small percentage was most probably the highest number (21) in this range. Future surveys will ask for the specific age of the respondents as well. The primary confounding variable is that not all students received the same exposures at the same timepoints or configurations. That is, some students had one or more of the exposures. However, the researchers were able ensure that all respondents did complete at least one: the epidemiology course required all first year students in the Spring semester. In an effort to encompass all of the potential exposures, an encompassing term was established as “research-intensive environment”, as described throughout this manuscript.

An event outside of this project also had a limiting effect on survey distribution as well. The COVID-19 pandemic necessitated that all communications with students was limited to electronic means for several months. Therefore, elective surveys (such as the one that is the subject of this dissertation) were postponed for several months from being reviewed and implemented. Therefore, the initial timelines (January to March and May to August 2020) needed to be altered to entail Fall 2020 and Spring 2021. Further, with students transitioned to remote coursework, their email count increased exponentially, and they may have experienced
survey and email fatigue. This may also help to account for the low response rate. Also, initially, the dissertation plan included a mentor interview component, but due to scheduling and COVID-19 restriction conflicts these interviews were not able to be completed within the data collection timeframe. Conducting qualitative interviews of current and past students, as well as for active mentors is planned as a follow-up study subsequent to this project.

There were a number of challenges of pre- and post- test matching as well. Students selected their own ID’s, which they had to remember for months. Future projects will include an unblinded distribution study member, who would only be responsible for correlation. Additionally, during the survey analysis, a potential voluntary response bias was identified. That is, the students who were more inclined to be involved in research may have been more likely to take part in the survey.

Moreover, my bias as a research professional and mentor in orthopaedics for medical students should be mentioned as well. A portion of my career is matching students with physician mentors and assisting them with research projects. Being in orthopaedics, the research opportunities, and connections with the surgeons (some of whom are also residency faculty) with are highly in demand with students who are interested in this specialty. Therefore, it’s important to note that research is an area of interest and expertise for me, and that I foster a very strong belief in the importance of research in medicine. However, I think that this experience is actually a strength, due to my strong experience and adherence to research ethics. I also took specific mitigating steps to ensure that I could not identify the respondents, in case they were any of the students that I was working with in a mentorship capacity.
Conclusion

To conclude, there seems to be no shortage of potential conduits to address the challenge of engaging and maintaining medical student research participation. Having a better understanding of how students perceive research, both in general as well as their own personal role is essential for advancing curricula and programs that support and encourage prospective physician scientists. A promising starting point is to identify the key characteristics of students who are most likely to actively participate in research both in medical school and beyond. Once that profile is understood, the experiences and exposures of those students can be used as a template to optimize research involvement for future students.

Also, the results of this study could be used to create a short checklist of best practices. This can be utilized to help ensure that the most effective plan for developing and sustaining research education programs for students. These recommendations could include:

- A pathway of on-ramps to research involvement all throughout the educational course, with early exposure being the first objective,
- A mentorship outreach and long-term communication plan that identifies the needs and expectations of all parties throughout the course of the project,
- Flexible sessions for attaining research skills, including interactive drop-in workshops in a variety of formats where students can learn in a low-risk environment; and
- A periodic, systematic review to evaluate the effectiveness of these processes and potential gaps in knowledge.
Furthermore, these initiatives would need to foster an atmosphere that is not just research intensive, but research advancing, that is, the program’s curricula should actively encourage that students continue their involvement in research, emphasizing the benefits and responsibilities of doing research into residency and practice. Additionally, integrated programs should be utilized whenever possible, reducing the time and financial burdens on an already rigorous academic schedule.
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