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RESEARCH ARTICLE

Immunology Education

Current Status of Immunology Education in U.S. Medical Schools

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ABSTRACT

Immunology is an integral component of undergraduate medical education because of its critical role in many disease processes. Due to the complexity of the subject, the best practice of immunology education in the undergraduate medical curriculum has not been extensively discussed. This study intended to determine the current status of immunology education in U.S. medical schools with the hope of providing insight into curriculum design pertaining to this subject. Immunology curriculum information was collected from the curriculum Web pages of 199 U.S. medical schools, including multiple campuses. Data pertaining to the setting of immunology education such as subjects that are co-taught with immunology, timing of courses, credit hours, and integration level were recorded in Microsoft Excel for analysis. Of 199 U.S. medical schools studied, 174 posted curriculum information related to immunology online. For course settings, 59 (33.9%) offer immunology with microbiology, 42 (24.1%) offer immunology as part of a foundational sciences course, and 18 (10.3%) offer immunology as a stand-alone course. Ten programs (5.7%) have immunology fully integrated in system-based curriculum. Of 119 medical schools that provide information regarding timing, 94 (71.9%) provide immunology education in year 1 of the curriculum, 16 (9.2%) in year 2, and 9 (5.2%) in both years 1 and 2. Differences exist in allopathic versus osteopathic programs in the immunology curriculum setting. Credit hour data were not complete due to inconsistent availability. Our data suggest that immunology education in U.S. medical schools lacks consensus. Continued discussion on best practices of immunology education across U.S. medical schools is recommended. *ImmunoHorizons*, 2022, 6: 864–871.

INTRODUCTION

Immunology is a foundational medical science that analyzes microscopic interactions within the human body and how they synergistically act to mount responses against various infectious agents, toxins, and environmental stressors, or lead to pathological disease states (1). This discipline has lent itself to the expansion of pharmacological treatments to prevent or actively treat various human diseases, as well as the growth of several medical specialties, such as rheumatology, oncology, neurology, allergy medicine, and transplant medicine, among others (2–7). Previously common diseases, such as measles and polio, have been eradicated following the understanding of the immune system and the study of vaccines (8). Other prominent contributions of immunology in the clinical setting include the usage of mAbs for autoimmune and endocrine pathologies, chimeric Ag receptor T cell therapies for oncological treatment, allergy treatments, and many others (9, 10).

As more pathologies and diseases are researched, their ties to immunologic origins have become clearer, highlighting the importance of immunology within medical education (11). Although earlier study has indicated that medical students find immunology abstract and difficult to learn, a firm foundation in this discipline is required for the proper clinical diagnosis and treatment of several diseases (11). The National Board of Medical Examiners and the National Board of Osteopathic Medical Examiners recognize the significance of immunology in understanding disease pathology and clinical

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diagnosis, as well as its role in improving patient outcomes. As such, immunology comprises of 6–11% of questions on the United States Medical Licensing Examination Step 1 (12). Although the National Board of Osteopathic Medical Examiners does not have similar data for immunology questions, the master blueprint for the Comprehensive Osteopathic Medical Licensing Examination of the United States (13) and board preparatory materials all suggest immunology as an important component in undergraduate medical education.

Predating the 21st century, medical immunology was delivered as a standalone, multiweek course concurrently with other disciplines such as physiology, microbiology, and pathology, based on the standardized 4-y format of medical education established by Johns Hopkins University in 1910 (14). With the advent of the first organ system–based undergraduate medical curriculum established by Case Western Reserve University in 1950, the nature of medical immunology education still did not change (14). It covered the theoretical basis of the reticulocyte system and the governance of the body in the face of an infection, and it featured didactics on the limited immune-based pathologies established at the time (11). Teaching tools such as case-based learning had not been popularized yet, and, as such, didactics featured fewer clinical presentations that reiterated the clinical significance of immunology (11). Based on student surveys, this caused lower retention rates of course material for senior and exiting medical students (11). As the field of immunology expanded and evolved, medical immunology curricula have been reformatted and diverged between schools to reflect these changes. With the growing emphasis on immunology for clinical applications, as well as current medical licensing examinations reflecting that emphasis, it is necessary to analyze the current status and evolution of medical immunology curriculum and course content delivery.

To date, literature evaluation has not revealed a comprehensive review of the emerging patterns of immunology education within U.S. medical schools. With the changing landscape of immunology and medical education in general, we intended to conduct a comprehensive review of medical immunology education across all U.S. medical schools. This study can inform the current status of immunology curricula and further support the establishment of any standardization or patterns across U.S. medical school immunology education.

MATERIALS AND METHODS

In this study, there was an initial total consensus of 192 allopathic and osteopathic U.S. medical institutions. This set of 192 institutions includes 155 allopathic programs offering Doctor of Medicine degrees that have received full, preliminary, or provisional accreditation status from the Liaison Committee on Medical Education, and 37 osteopathic programs offering Doctor of Osteopathic Medicine degrees that have received full or preaccreditation status from the Commission on Osteopathic College Accreditation. Several of the osteopathic medical schools have multiple teaching campuses, with each campus functioning as its own unique curricular entity. For this study, any teaching location of a medical school that offers a unique curriculum was counted as one single entity. Thus, to account for these multicampus osteopathic medical institutions, the total number of osteopathic medical programs was corrected from 37 to 44; this in turn brought the total number of programs analyzed from $n = 192$ to a final sample size of $n = 199$. For this study, only U.S. schools within the 48 contiguous states and Alaska and Hawaii were assessed.

The Web site of each medical school was examined between July 2021 and December 2021. The admissions Web page of each medical school was explored to determine how many medical schools either require or recommend immunology as prerequisite coursework prior to matriculation. The curriculum Web page was explored to determine the presence of curriculum information. When applicable, the student handbook, academic bulletin, or course catalog containing the curriculum was also explored. To account for variable terminology, key words such as “immunology,” “immunity,” “immune,” and “host defense” were searched for in the curriculum Web sites or the documents mentioned above. The following information was gathered and compiled into a comprehensive database: institution name, medical degree granted, institution location, institutional funding (i.e., public or private), course information pertaining to immunology education, including course title, course description, and curriculum sequencing (when immunology is offered within a respective curriculum), course setting (when immunology is offered as a core course, or integrated as part of another course), and course credits. Data were collected in Microsoft Excel and analyzed.

The statistical analysis, which includes χ^2 tests, a Fisher exact test, and z score proportion tests, was performed using the R statistical language (15) at an α level of 0.05. The code used for these tests is available upon request.

Institutional Review Board exemption was determined by the Sam Houston State University Institutional Review Board for this study.

RESULTS

In our study, we included 199 U.S. medical school programs, including multiple teaching campuses that offer different undergraduate medical education curriculum in the analysis. Among the programs being investigated, there is a mix of both allopathic and osteopathic public and private institutions (Table I).

To identify whether immunology is required or recommended for matriculation of medical school, minimum academic requirements and lists of required prerequisite courses were explored on the admission Web site of each program. Nine out of 155 allopathic medical schools specifically require upper division biology science courses (not including biochemistry) as a minimum requirement. Among those nine schools, six recommend immunology for their required upper division course. Regardless of the minimum requirement listed on the Web site, a total of

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TABLE I. Breakdown of 199 U.S. medical schools including multiple campuses that are included in study

Medical Schools	Allopathic	Allopathic with Immunology Curriculum Data Online	Osteopathic	Osteopathic with Immunology Curriculum Data Online
Public	93	76	7	6
Private	62	56	37	36

26 allopathic programs (16.8%) recommend immunology as a prerequisite. For osteopathic medical programs, 2 out of 44 require upper division biology science courses, and, among those, 1 recommends immunology as a prerequisite. Regardless of the minimum requirement, a total of 11 osteopathic medical programs (25%) recommend immunology as a prerequisite. Overall, only 18.6% of all U.S. medical schools suggest immunology as a prerequisite for medical school matriculation, but none enforces the completion of the course as a mandatory prerequisite for matriculation.

When curriculum information was searched on each school's Web site, we found that 81.7% of public allopathic medical schools post the immunology curriculum information online, as compared with 90.3% of private allopathic medical schools; in comparison, 85.7% of public osteopathic and 97.3% private osteopathic medical schools post the immunology curriculum information online (Table I). Overall, 174 U.S. medical schools out of 199 (87.4%) have curricular information regarding the immunology education setting available on their published curriculum Web sites. The comprehensive analysis of course setting data revealed four major types of curriculum settings for immunology, including 1) a combination with other subjects, 2) part of a foundational sciences course, 3) a stand-alone course, or 4) integration throughout a fully system-based curriculum. Microbiology, hematology, pathology, and rheumatology are the major subjects that are co-taught with immunology courses combined with other subjects. Immunology co-taught with microbiology is the predominant setting for medical immunology education, followed by integration within foundational sciences courses. The number and percentage of medical schools offering each type of curriculum setting are presented in Table II. Some schools present two types of immunology education in the curriculum, for example, one in foundational science and one in an integrated course. The course title varies among different medical schools. For example, for immunology offered in combination with microbiology, several course titles were identified as follows: "medical microbiology and immunology," "host defense," "invaders and defenders," "infection and immunity," and so forth. Course descriptions were carefully reviewed to confirm the setting of the course when available.

To evaluate whether the setting of immunology education varies in different types of medical schools, statistical tests were performed to examine the relationship between allopathic and osteopathic medical schools and public and private medical schools across the top four types of immunology curriculum settings (Table III). First, a χ^2 test was performed, but it was found that the expected values for "combined with microbiology and hematology" and "stand-alone" for osteopathic schools were <5, which violates the assumption that the data follow a χ^2 distribution. A two-sided Fisher exact test, which does not require expected values >5, was then performed and found a significant result with $p = 0.031$. Barring selection effects, the curriculum setting for immunology instruction likely depends on whether the medical school is allopathic or osteopathic. Post hoc pooled two-sample z score proportion tests were performed to determine whether any of the four curriculum settings had statistically significant differences between the proportion of allopathic and osteopathic schools. Using a two-sided null hypothesis with a Bonferroni correction, only one of the four curriculum settings, that is, "combined with microbiology," was found to be significantly different between allopathic and osteopathic schools, with $z = 2.59$, $p = 0.0095$. Another χ^2 test was performed to examine the relationship between public and private medical schools across the four curriculum settings. While the expected values did not violate the assumptions of the test, the result was not significant, that is, χ^2 $(3, n = 136) = 3.0$, $p = 0.40$.

A total of 119 medical schools provide information regarding the timing of immunology education on their curriculum Web pages. Among them, 94 (71.9%) provide immunology education in year 1 of the curriculum, 16 (9.2%) in year 2, and 9 (5.2%) in both years 1 and 2. When the top four immunology

TABLE II. Various curriculum settings for immunology education in U.S. medical schools

Types and Ranking of Curriculum Setting	No. of Programs (% out of 174 medical schools that have curriculum information online)
Combined with microbiology	59 (33.9)
Part of foundational sciences courses	42 (24.1)
Stand-alone course	18 (10.3)
Combined with microbiology and hematology	17 (9.8)
Combined with hematology	15 (8)
Integrated in fully system-based curriculum	10 (5.7)
Combined with pathology	10 (5.7)
Combined with rheumatology, skin and musculoskeletal system	8 (4.6)
Combined with other topics	4 (2.3)

TABLE III. Comparison of top four types of curriculum setting of immunology in U.S. medical schools

Top Four Types of Immunology Curriculum Setting	Allopathic, *n* (%)	Osteopathic, *n* (%)	Public, *n* (%)	Private, *n* (%)
Combined with microbiology	51 (38.6)	8 (19)	29 (35.4)	30 (32.6)
Part of foundational sciences courses	30 (23)	13 (31)	17 (20.7)	25 (27.2)
As a stand-alone course	10 (7.6)	8 (19)	8 (9.8)	10 (10.9)
Combined with microbiology and hematology	11 (8.6)	4 (9.5)	10 (13.4)	6 (6.5)

curriculum settings were analyzed, most medical schools offer them in the fall semester of the first-year curriculum. For the setting of a stand-alone course, more schools offer this type in the spring semester of the first year. A variation in timing was found, with some schools delivering the course during two semesters and some offering it in the second year of their curriculum (Table IV).

Credit hour data for immunology courses were collected when available. However, there are a large number of medical schools that do not publish such data on their curriculum Web sites. We were unable to gain an accurate and comprehensive view on this aspect. A proposed immunology curriculum structure for undergraduate medical education (Fig. 1) will be presented below.

DISCUSSION

Our data show that only 18.6% medical schools, both allopathic and osteopathic, recommend taking an upper-division immunology course for applicants applying to medical school, whereas courses such as genetics and biochemistry are emphasized as prerequisite requirements on medical school application portals. This indicates that immunology is currently not emphasized as equally important for incoming medical students compared with its science counterparts. In addition to immune-related disorders and immunotherapies, immunology has found renewed relevance in mainstream media considering controversy over the safety and efficacy of vaccines and the prevention of spread for novel viruses such as COVID-19. Medical students should not only be knowledgeable about the social impact of these conversations, but they should also demonstrate an intricate understanding of the pathophysiology that surrounds these discussions. A firm foundation of immunology is vital in clinical practices and patient care when discussing wellness and disease prevention with patients. Engaging in conversations with patients as such requires a firm understanding in foundational science concepts that are typically delivered in the preclerkship years of medical school. Considering the complexity of immunology and the lack of comparable baseline knowledge of incoming medical students, we believe a study on the current status of immunology education in medical schools would provide insights to support the development of recommendations on how to structure and standardize immunology education in undergraduate medical curriculum in U.S. medical schools.

As suggested by our study, attempting to definitively outline best practices for the delivery of immunology education in medical curriculum is challenging due to the varying approaches of medical institutions in the rollout and assessment of the topic. Differences among medical schools in the timing of an immunology course, the repetition of immunology concepts throughout preclinical years, and the combination of fields of study (e.g., microbiology, hematology) with immunology reveal discrepancies as well as trends of how to approach teaching this subject.

Teaching a singular subject in medicine in isolation has become increasingly less common, as the more modern "systems-based approach" has been adapted in the last few decades (16). Although some topics in medicine undoubtedly need a singular focus during medical school, the increasing need for less length of time in preclinical years and the ever-growing information each medical student is required to know make teaching topics in isolation challenging. Intersecting fields of study to enhance learning and build connections for students assist in the integration of vast concepts within biomedical sciences (16). As our data suggested, immunology is commonly combined with other foundational science topics such as microbiology, pathology, and hematology when offered in medical school curriculum. Among the schools assessed in our research, microbiology appears to be the most common subject co-taught with immunology. From immune evasion to host defense to protective immunity, using microbiological pathogens to introduce immunology concepts is an intuitive means of connecting concepts of these two disciplines (17). The interweaving of these two topics is helpful, because understanding one requires knowledge of the other. The effectiveness of integrating two courses stems from shared core concepts and interrelated objectives. Closely

TABLE IV. Timing of top four types of curriculum setting of immunology in U.S. medical schools

	Year 1 (%)				Year 2 (%)		
Top Four Types of Immunology Curriculum Setting	Fall	Winter	Spring	Fall and Spring	Fall	Fall and Spring	Both Years (%)
Combined with microbiology	44.5		35.8	4.5	8.7	4.3	2.2
Part of foundational sciences courses	95		5				
As a stand-alone course	35.3	11.8	52.9				
Combined with microbiology and hematology	50		18.7		31.3		

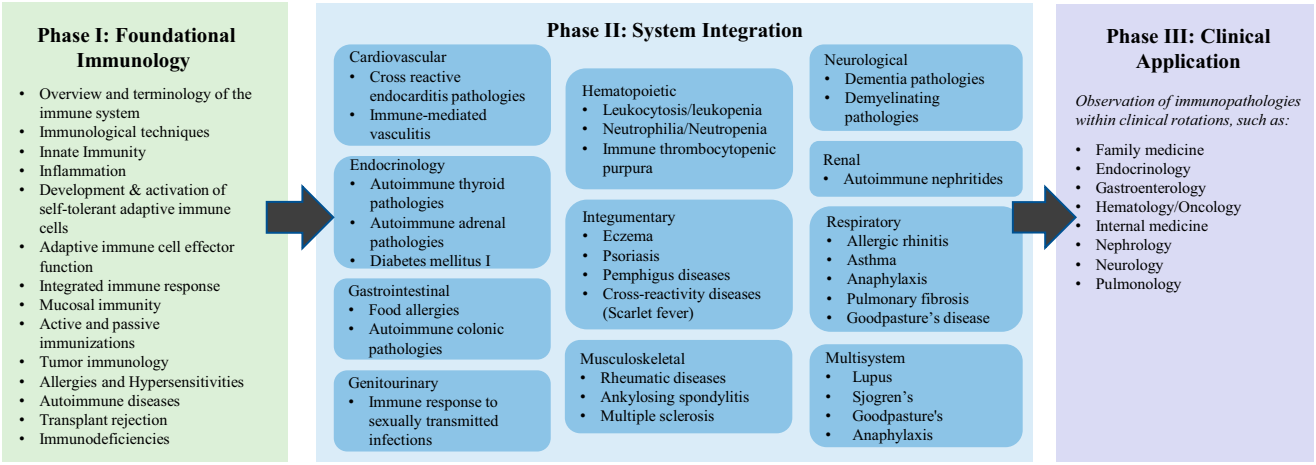

FIGURE 1. A proposed immunology curriculum structure for undergraduate medical education.

The multiphasic approach to this curricular structure for immunology is grounded in two learning theories, cognitivism and constructionism. The order and spaced repetition of immunological concepts within this triphasic model allows for appropriate knowledge acquisition and content reinforcement (cognitivism); the sequence of introducing foundational immunology, then applying it in the context of individualized organ systems courses, before recapitulating the material within clinical settings provides students opportunities to sequentially build and expand their disciplinary knowledge (constructionism).

following the combination of immunology and microbiology is the embedding of immunology within foundational sciences courses.

Embedding immunology within a foundational science course is another predominant type of curriculum setting. Although we were not always privy to every topic and method of teaching involved in these comprehensive courses due to the limited description in course catalogs, it is evident that the topic of immunology is taught in parallel with a variety of basic science subjects in these courses. Although the integration of immunology in broad and overarching courses may help students gain focused knowledge, it also may come at the sacrifice of proficiency in each subject individually included within the prescribed curriculum due to limited time and integration. We found that the curriculum setting for immunology instruction likely depends on whether the medical school is allopathic or osteopathic, with a significant higher percentage of allopathic medical schools offering immunology combined with microbiology. Although not statistically significant, there is a higher percentage of osteopathic medical schools that offer immunology as part of a foundational science course. More investigation is needed to separate possible differences in curriculum structure and the confounding variable of when the medical school was established. Newer institutions usually develop their curricula from scratch and may follow the general trend of curriculum design compared with more established institutions. Because osteopathic schools tend to be younger in comparison with allopathic schools, this may demonstrate differences in curricular approaches that are not related to the school being of allopathic or osteopathic persuasion.

Although it is evident that clinical integration exists when immunology is offered in a fully system-based curriculum, the prevalence of the integration within medical immunology courses was not assessed from our primary evaluation of the data. Emphasis on integrating clinical approaches and patient cases with foundational sciences has become increasingly evident in medical education, addressing concerns on how the medical education community can better prepare students for applying knowledge in their field of work (17). Assessment for immunology on both licensing examinations requires study of the subject in both foundational concepts and application within medical specialties (12, 13).

Among the 119 medical schools that have information regarding the timing of immunology education on the curriculum Web page, most institutions have elected to teach immunology within the first year, often in the fall semester. Due to the foundational nature of immunology, it is most likely taught at the beginning of medical school since several concepts within organ system courses require a working knowledge of the immune system. Introducing immunology in the first year of curriculum helps create a foundational knowledge base that students can use to synthesize concepts taught in later system courses. However, medical students typically do not have much exposure to the practice of medicine within the first semester and may not draw connections to the immunology topics learned and actual practice. Implementing an immunology course within the second year may reaffirm its critical nature in clinical application and increase retention but may delay the understanding of some systems if they are introduced earlier than immunology. Only a few schools dedicate specific time for immunology in both year 1 and year 2 of preclinical classes. The benefit of repeating information for students could potentially help students identify gaps in their knowledge (18); however, as curriculum in medical school has

trended to become more condensed in preclerkship courses, the lack of time may not make repetition a viable option (19).

Noting the necessity for comprehensive guidelines for immunology education at the collegiate level, several collaborative studies have been done to define core content and develop curricular components pertaining to this subject. Academic curriculum subcommittees of the Association of Medical School Microbiology and Immunology Chairs developed a series of core learning objectives for medical microbiology and immunology in 2009 (20). The learning objectives developed from this project served as a base reference for a multi-institution collaboration for a national curriculum reform for medical microbiology and immunology courses (21). Recently, the American Association of Immunologists published an outline of foundational concepts and subtopics necessary for undergraduate students to learn from an immunology course (22). The common aim of these studies was identifying a means of standardizing immunology education so that educators and students can benefit from the assurance that a common curriculum is attained regardless of the university one attends. Although the focus of previous studies was on content, the sequence and integration of immunology in medical curriculum are also important. Using Delphi or modified Delphi methods as described in both Association of Medical School Microbiology and Immunology Chairs and American Association of Immunologists reports, immunology content experts may develop a structured curriculum outline to ensure a comprehensive and integrative coverage of immunology in medical school education.

A proposed curriculum structure is presented in Fig. 1 using multiple resources (12, 20, 22–24). Although this figure does not suggest a single best curricular practice for immunology, because there is wide variation between medical program curricula, it provides a template of when to introduce students key topics of immunology to improve their learning outcomes. The multiphasic approach to this curricular template is grounded in two learning theories, cognitivism and constructionism, which are well recognized for their use within basic science and clinical curricular development (25). Cognitivism posits that students' knowledge acquisition is influenced by the order in which a curriculum is presented to them, and that learners can modify their knowledge (schemata) through cognitive processes such as insight, memorization, and information processing. This new knowledge is then reinforced through repeated and spaced memory retrieval and use (18, 25). Constructivism, alternatively, posits that learners acquire and build knowledge on a scaffolding of their current understanding of that subject, and then construct new knowledge based on their experiences and their biopsychosocial development at the period of time that the knowledge is acquired (25). Our proposal is based heavily on these two learning theories. The first phase of the model creates a contextual immunological foundation for medical students and introduces them to broader concepts within the discipline from a basic science standpoint. The second phase of the model emphasizes reinforcement of immunological concepts within the context of organ systems courses, allows students to build on their existing knowledge of immunological processes, and adds clinical presentations to their repertoire of immunological knowledge. The third phase of the model recapitulates concepts from the first and second phases of the model, and it allows students to solidify their understanding of immunopathology within the clinical setting. The list of topics recommended in each section of the model is not exhaustive and provides examples of pathologies and topics appropriate to that domain of medical curricula, based on common immunopathologies and concepts categorized in medical board examination blueprints and associated review books. From a cognitivist perspective, the order and spaced repetition of immunological concepts within this triphasic model allows for appropriate knowledge acquisition and content reinforcement; from a constructivist perspective, the sequence of introducing students to the foundation of immunology, then applying it in the context of individualized organ systems courses, before recapitulating the material within clinical settings, provides students ample opportunities to sequentially build and expand their disciplinary knowledge. Medical programs that are able to both cover the immunological concepts during preclinical years and reiterate them throughout clinical years would most likely benefit students and encourage continued learning and concept retention.

Although this study focuses on the curricular aspect of medical immunology education, teaching methodology should also be considered for optimal student learning outcomes. Immunology is a complex subject that integrates concepts from cellular biology, biochemistry, anatomy, and genetics (26). With the wide, integrative nature of this discipline, educators have found that students learn immunological concepts best using active learning practices, where the focus of learning sessions moves away from the lecturer and toward student engagement with the course content (26). Some examples of potential active learning tools to engage with students to improve their learning outcomes include pre-lecture readings and quizzes to prime their mind for knowledge acquisition, clicker questions to maintain engagement during lectures, and providing students with audio and visual resources for knowledge consolidation following lectures (26). These learning practices are not exhaustive and can be adapted and integrated within a wide range of immunology curricula within various medical programs.

Additional investigation into how schools determine student readiness and expertise in immunology would help identify assessment tools that could be more widely available. The University of North Carolina Medical School utilizes a preassessment tool, PRIME Immunology, for their immunology course that not only identifies where students are in their understanding of immunology concepts, but also functions as a learning platform offering self-paced videos, a question bank, and flashcards of "Immunology Language" (27). Understanding how these programs help in student success is an important dynamic to underscore that some innovations do not require curricular change. Instead, some learning enhancements can be the addition of extracurricular resources. An expansion of this project can look further into how these course

extensions and experiences may propel student retention and learning.

At this time, there is also a significant lag in the amount of educational research being pursued within the field of immunology compared with other subjects, such as anatomy, microbiology, and neurosciences (28). As the presence of autoimmune disease, cancer, and new biologics continues to increase, the study of immunology and processes related to the topic will continue to underscore its growing importance. Educational research in immunology, which focuses on curriculum design and delivery, is important in helping medical students as well as the general public understand its importance within the field of medicine and beyond.

Our study has several limitations. First, we used publicly available data on each medical school's Web site regarding their immunology course, obtained by surveying designated curriculum Web pages, course catalogs, and student handbooks, when available. However, not all of these online resources provided a comprehensive overview of the immunology courses specifically offered at that school, including the duration of the course, credit hours, and when the course is taught, among other factors. In some cases, integrated immunology lectures in other courses might not be apparent due to the fact that not all medical schools list their entire course list online. Additionally, although our study analyzed the structure and sequencing of medical immunology courses within various undergraduate medical school curricular settings, information on course learning objectives and topics could not been obtained. This information can often be found in course syllabi, which were not publicly available online for most institutions surveyed within this study. Another limitation with our study includes the dynamic nature of medical school education. Certain schools, as we observed, vary their curriculum on an annual basis. For this reason, trends observed across undergraduate medical immunology curricula at the time of this study (2021–2022) may vary in the future. No comparison can be made as to which immunology curriculum setting is more effective because there is no published performance data on standardized assessments for immunology in medical schools.

Future direction of this study includes gathering syllabi data from individual institutions regarding their immunology courses to accrue a more comprehensive picture of the structure of immunology courses offered at respective institutions. Additionally, surveys can be used to assess the content coverage and integration in each undergraduate medical immunology curriculum to ascertain deficiencies and surpluses within respective curricula. This information, along with consulting a panel of content experts as outlined in the Delphi approach, can be used to create a curriculum plan that can standardize the undergraduate medical immunology curricula.

Through comprehensive evaluation of immunology education in undergraduate medical curriculum through program Web sites, it is evident that medical immunology, although taught in every U.S. medical school, is delivered in a variety of modalities. Variations were noted in terms of whether medical immunology was delivered as a stand-alone course or integrated with another topic or within a foundational sciences course. Additional variances were noted in terms of when immunology was delivered within curricula, as well as the duration of time the course was taught. Further evaluation is needed to assess topics covered within immunology and relevant courses and draw a consensus toward an outline of topics as well as curriculum structure that can be used to standardize undergraduate medical immunology across U.S. medical schools, to allow all medical students equal opportunities in their medical immunology education.

DISCLOSURES

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