Expanding Knowledge and Exposure to Aerospace Medicine by Creating a Medical Student Curriculum

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BACKGROUND: Aerospace Medicine is a small medical specialty. With the increasing need for aircraft pilots, continued low Earth orbit NASA operations, and the emergence of commercial spaceflight, there is a necessity for recruiting and educating the next generation of Aerospace Medicine specialists. This study was designed to create and validate a short Aerospace Medicine curriculum.

METHODS: Medical students at the University of Texas Medical Branch were recruited to attend a series of six 1-h meetings covering Aerospace Medicine career options and key Aerospace Medicine topics. A survey addressing student demographics, interest in a career in Aerospace Medicine, and knowledge of key Aerospace Medicine topics was administered at the beginning and end of the curriculum. Interest in pursuing a career in Aerospace Medicine pre- and postcurriculum was compared with an independent *t*-test. The knowledge-based portion of the survey was also evaluated using an independent *t*-test.

RESULTS: There were 23 participants who were recruited and filled out the initial survey and 15 participants who attended the final meeting and filled out the postcurriculum survey. Mean interest in pursuing a career in Aerospace Medicine did not change significantly (75.45% before involvement in the curriculum and 83.08% after participation). Knowledge of foundational Aerospace Medicine topics increased from 64.25% before involvement in the curriculum to 73.33% at the end of the study. There was an average of 12 participants at each meeting.

DISCUSSION: This demonstrates the utility of this curriculum as an educational tool for medical students. Future efforts will focus on dissemination of the curriculum nationally and internationally.

KEYWORDS: aerospace medicine, education, teaching, career advice.

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The Aerospace Medical Association (AsMA) states that Aerospace Medicine "concerns the determination and maintenance of the health, safety, and performance of persons involved in air and space travel."[1] Careers in Aerospace Medicine are diverse, exciting, and offer a range of research and clinical experiences in both military and civilian settings. There are few Aerospace Medicine residencies in the United States. The Air Force, Army, and Navy have residency programs, and there is one civilian residency offered at the University of Texas Medical Branch. The Mayo Clinic also offers a civilian Fellowship in Aerospace Medicine. In total, approximately three to four civilian Aerospace Medicine trained physicians graduate each year. Most Aerospace Medicine specialists are employed by the military, the Federal Aviation Administration (FAA), or the National Aeronautics and Space Administration (NASA). There are many career options available, including the growing field of commercial spaceflight. Though Aerospace Medicine is an exciting and growing field, there is a paucity of exposure to the discipline and its key topics in U.S. medical schools. Given new legislation, this is concerning.

The FAA Extension, Safety, Security Act was signed into law in 2016 and contains a rule called BasicMed. BasicMed has created an educational gap necessitating that all medical students should have exposure to Aerospace Medicine. Medical school

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curricula do not teach the unique physiological considerations and occupational hazards required to properly assess the medical fitness of an aviator, yet untrained physicians can now medically certify pilots to fly. Recreational pilots with a valid U.S. driver's license and history of an FAA medical certificate after July 14, 2006, are eligible for BasicMed (note that the aircraft cannot be more than 6000 lb, carry more than five passengers, or be hired for profit). Under the BasicMed rule, these pilots need only fill out a medical questionnaire (FAA Form 8700-2)[5] and be examined by a state-licensed physician.[4] Any physician conducting exams under BasicMed is required to attest that the individual is free of medical conditions that would interfere with their ability to "safely operate" an aircraft. Allowing untrained physicians to medically certify pilots may increase the likelihood that patients with significant medical conditions are inappropriately cleared to fly. Further, under the BasicMed rule, untrained physicians are unknowingly exposing themselves to increased liability when certifying these pilots. The onus is on physicians providing medical clearance to maintain the safety of the national airspace. All medical students should therefore have exposure to Aerospace Medicine and know how to seek appropriate professional consultation, since they may be asked to certify an aviator in the future.

Fortunately, more than half of medical students are open to career suggestions.[10] NASA offers an Aerospace Medicine clerkship in April and October each year, but space is limited.[8] The University of Texas Medical Branch (UTMB) Aerospace Medicine Residency hosts a one-month Principles of Aviation and Space Medicine course annually in the summer,[11] but again space is limited, particularly for medical students. Early exposure to Aerospace Medicine during medical school could increase interest in this growing field.

The primary public resources to learn about the careers and principles of Aerospace Medicine include AsMA, the Aerospace Medicine Student and Resident Organization (AMSRO), and the FAA.[7] The FAA provides free aviation physiology references and offers some related in-person classes.[3,12] These resources are informative, but having a deployable curricular package that an interested student at any medical school could use to explore the field would fill a gap. The purpose of this pilot study was to test whether a short Aerospace Medicine curriculum could increase interest in the field of Aerospace Medicine as well as teach key Aerospace Medicine foundational principles.

METHODS

Survey Instrument

The study received status 1 exemption from the UTMB Institutional Review Board. An online survey was designed, using Redcap software, to assess interest and knowledge in Aerospace Medicine.[6] The first section of the survey asked demographic questions and assessed likelihood of pursuing a career in Aerospace Medicine on a sliding scale of 0–100%. The second section of the survey assessed understanding of training and career opportunities in Aerospace Medicine. The final section of the survey assessed knowledge of common Aerospace Medicine foundational topics with 14 multiple choice questions and 2 true/false questions. The survey was piloted with faculty and residents in Aerospace Medicine at UTMB and changes were made according to feedback prior to finalization.

Subject Recruitment

The UTMB Office of Educational Development granted permission for dissemination of the survey to medical students with the following restrictions: the students were required to initiate recruitment and it could not be through official UTMB processes (e.g., no posting on class notice boards, UTMB daily announcements, recruitment via email, etc.) Thus, recruitment occurred in two forms.

1) 1st and 2nd year UTMB medical students posted preapproved (by the IRB and Office of Educational Development) advertisements on their class Facebook pages in advance of each meeting. These postings included a link to the survey.
2) Snowball sampling via word of mouth between medical students.

Design

Six meetings were held weekly at noon on Tuesdays from March through April 2019 at UTMB. The third lecture, Decompression Illness, was presented a second time due to poor turnout. (It conflicted with an exam for the first-year medical students. Four students attended the meeting time that presented a conflict and six attended the second offering of the presentation for a total turnout of 10 students). The meetings and their objectives can be found in **Table I**. Meetings lasted 1 h and included pizza for the students.

At the beginning of each meeting, the survey link was displayed for the students and it was requested that, if students had not already taken the survey from the link posted on Facebook, they complete the survey prior to the start of the lecture. At each meeting the number of students in attendance was documented. After each meeting, students completed an evaluation of that meeting. All meeting evaluations contained identical questions. These were aggregated for qualitative feedback for the curriculum. At the final meeting, all students in attendance were asked to complete the same survey they had completed prior to the curriculum, with one additional question: "How many Aerospace Medicine lunch time lectures did you attend this academic year?" (Answers: 0, 1–2, 3–4, 5–6.)

Statistical Analysis

SAS 9.4 software was used for statistical analysis.[9] Likelihood scores for pursuing a career in Aerospace Medicine pre- and postcurriculum were compared with an independent *t*-test. The precurriculum data was found to approximate a normal curve based on skew, kurtosis, and variance specifications in SAS, but the postcurriculum data was not as well approximated. Thus, a nonparametric Wilcoxon rank sum test was also run as a sensitivity analysis, which yielded very similar results to the *t*-test.

Table I. Curriculum Meeting Details.

MEETING NUMBER	PRESENTATION TITLE	OBJECTIVES OF THE PRESENTATION
1	Aerospace Medicine: Sounds Cool, but What Is It?	1. Understand what the field of Aerospace Medicine involves.
		2. Understand why Aerospace Medicine is a unique and important field.
		3. Understand how to pursue training and board certification in Aerospace Medicine.
		4. Be aware of where Aerospace Medicine is practiced.
		5. Become familiarized with who practices Aerospace Medicine and typical career opportunities within the field.
2	Aerospace Medicine Environments	1. List, in order, the layers of the Earth's atmosphere.
		2. Know the altitude and significance of Armstrong and Karman lines.
		3. Identify unique problems associated with operations at high altitudes.
		4. Understand treatment options for altitude-related medical issues.
		5. Identify unique problems associated with operations in hot and cold temperatures.
		6. Understand treatment options for temperature-related medical issues.
		7. Identify preventive measures to avoid medical problems associated with heat, cold, and altitude exposures.
3	Decompression Illness	1. Write and understand Boyle's Law.
		2. Understand and be able to state Henry's Law.
		3. Know the diagnoses encompassed in "Decompression Illness."
		4. Explain the differences between hypobaric and hyperbaric exposure in terms of risk of decompression.
		5. Know the treatment for decompression illness.
4	Acceleration and Spatial Disorientation	Acceleration Objectives:
		1. Know what a "G" is.
		2. Understand the directions of the vectors of acceleration on the human body (the "left hand rule").
		3. Be aware which direction of acceleration is tolerated best by the human body.
		4. Understand the progression of symptoms to G-induced loss of consciousness (G-LOC).
		Spatial Disorientation Objectives:
		1. Be aware of the three types of spatial disorientation.
		2. Understand common runway illusions due to size and shape constancy and their effect on landing glideslope.
		3. Be familiar with the graveyard spiral.
		4. Be familiar with the head-up illusion.
		5. Be familiar with the Coriolis illusion.
5	Accident Prevention, Aeromedical Disposition, & Toxicology	Accident Prevention Objectives:
		1. Understand the scope of commercial air travel worldwide.
		2. Understand the scope of aviation accidents in the United States.
		3. Be familiar with preventive strategies for aviation accidents.
		4. Be familiar with strategies to protect aircraft occupants during accidents.
		Aeromedical Disposition Objectives:
		1. Know what an AME does and how to find a local AME.
		2. Know the lengths of time of issuance for 1st, 2nd, and 3rd Class Medical Certificates for U.S. pilots.
		3. Know where to access the FAA Guide for Aviation Medical Examiners.
		4. Be aware of the 15 specifically disqualifying medical conditions.
		Toxicology Objectives:
		1. Understand the concept of potency of toxins.
		2. Be familiar with the clinical scenario and manifestations of exposure to the following toxins: hydrazine and chromium.
6	Space Physiology	1. Understand physiological adaptations to space flight.
		2. Be aware of current physiological issues in Aerospace Medicine.
		3. Understand the purpose of countermeasures.
		4. Understand the purpose of analogs.

Questions from the second and third sections of the survey (the final 19 questions) were scored and given a percentage correct value. This data was well approximated to a normal curve. Pre- and postcurriculum percentage correct scores for these questions were compared with an independent *t*-test to assess for a change in knowledge regarding Aerospace Medicine careers and salient topics in the field. For all statistical analysis, an alpha level of 0.05 was used.

RESULTS

A total of 23 participants were recruited and filled out the initial precurriculum survey, and a total of 15 participants attended the final meeting and filled out the postcurriculum survey. Demographics are depicted in **Table II**. Mean initial likelihood of pursuing a career in Aerospace Medicine did not change significantly with the implementation of the curriculum. Interest in pursuing a career in Aerospace Medicine was 75.45% (SD 21.77%) before involvement in the curriculum, and 83.08% (SD 14.45%) after participation ($P = 0.28$ *t*-test, $P = 0.22$ Wilcoxon rank sum). There was also not a significant increase in AsMA (17.4%/20%) and AMSRO (13.0%/13.3%) memberships pre- and postcurriculum. The mean percentage of correct questions covering key Aerospace Medicine topics was 64.25% (SD 12.51%) before involvement in the curriculum and it increased to 73.33% (SD 10.75%) at the end of the study ($P = 0.027$). There was an average of 12 participants at each meeting (13, 10, 10, 12, 10, 14, respectively, at the 6 meetings). All participating students attended at least half of the meetings.

Qualitative data from the evaluations of individual sessions was collected and aggregated. Overall, students who filled out these evaluations were very positive about the curriculum.

DISCUSSION

This short Aerospace Medicine curriculum was validated with a medical student population at the University of Texas Medical Branch. It resulted in a statistically significant increase in awareness of Aerospace Medicine career opportunities and knowledge of foundational topics evidenced by an increased score on the final 19 questions of the survey from a mean score of 64.25% before involvement in the curriculum to 73.33% after the curriculum ($P = 0.027$). Likelihood to pursue a career in Aerospace Medicine among medical students at UTMB was unchanged (75.45% before to 83.08% after the curriculum, $P = 0.28$). There was no increase in memberships of AsMA and AMSRO as a result of the curriculum. There could be several reasons for this, including cost and the shorter 6-wk timeline of the curriculum. Students may also have considered that joining AsMA and/or AMSRO would be more advantageous later in the year (i.e., after the AsMA Annual Meeting so that the membership would last through the next meeting).

This study had notable limitations. UTMB has an Aerospace Medicine track for medical students as well as an Aerospace Medicine Residency. Medical students with existing knowledge and interest in the field may, therefore, self-select to enroll at UTMB. Selection bias was present in the study design for participation in the curriculum (only those who saw the posting on the class Facebook page or were referred by friends via word-of-mouth were eligible to attend), as well as the surveys and the postlecture evaluations.

The most significant limitation of this study pertains to recruitment. The initial design planned for in-person recruitment of first and second-year medical students. This was planned as an announcement at the beginning or end of medical school core curricular lectures, in which the survey link would be displayed, and the upcoming Aerospace Medicine curriculum lecture date, location, and time would be announced. Following the proposed curriculum, there would be an additional in-person announcement to complete the postcurriculum survey. This method of recruitment was preferred because it would have served two important purposes: 1) ensuring students were in their first or second year of medical school (limiting possible exposure to Aerospace Medicine through the Aerospace Medicine track in clinical years); and 2) allow for recruitment of a larger sample size (the entire classes of first and second-year medical students).

The limitation placed by the Office of Educational Development mandating that recruitment be initiated by medical students and not through official UTMB processes (i.e., no posting on notice boards, or email recruitment, etc.) severely inhibited the scientific merit of this study. Due to these restrictions, recruitment occurred only through first and second-year medical student class Facebook pages and by word-of-mouth. This was likely responsible for the small pre- and postcurriculum sample sizes in this study. It may have also augmented selection bias. It also

Table II. Characteristics of Participants.

	PRE-CURRICULUM	POST-CURRICULUM
Participants	23	15
Male	15 (65.2%)	11 (73.3%)
Female	8 (34.8%)	4 (26.7%)
Year in Training		
1st Year Medical Student	11 (47.8%)	7 (46.7%)
2nd Year Medical Student	8 (34.8%)	7 (46.7%)
3rd Year Medical Student	1 (4.3%)	0
4th Year Medical Student	1 (4.3%)	0
Other	2 (8.7%)	1 (6.7%)
Undergraduate Major		
Biological Sciences	17 (74%)	13 (86.7%)
Engineering, Math, and Physics	3 (13%)	1 (6.7%)
Arts, Humanities, Language, and Psychology	3 (13%)	1 (6.7%)
Member of Aerospace Medicine Track at UTMB	17 (73.9%)	14 (93.3%)
Aware of UTMB Aerospace Medicine Residency Program	22 (95.7%)	14 (100%*)
Member of Aerospace Medical Association (AsMA)	4 (17.4%)	3 (20%)
Member of Aerospace Medicine Student and Resident Organization (AMSRO)	3 (13.0%)	2 (13.3%)
Past Formal Training in Aerospace Medicine	0	0
Percent Likelihood of Pursuing Career in Aerospace Medicine	75.45%	83.08%

* 1 person did not answer.

allowed for students from medical school classes outside of the first and second year to attend.

The approval process for the Institutional Review Board and the Office of Educational Development resulted in significant delays in the initiation of the study. It was condensed from its originally planned 6 mo (one lecture monthly) to 6 wk (one lecture weekly). This condensed schedule may have affected turnout.

The location of the lectures may have posed a barrier for attendance for medical students, as indicated by one comment in the qualitative feedback from the individual lecture evaluations. The curriculum was presented approximately a 10-min walk from the normal medical school lecture venues.

An independent *t*-test, as opposed to a paired *t*-test, was used for statistical analyses because the data was not paired. Data was anonymous and nonidentifiable and thus there was no way of pairing.

This pilot study indicates that our Aerospace Medicine curriculum for medical students is a successful method of increasing awareness of Aerospace Medicine career opportunities and knowledge of foundational topics in the field. This curriculum could start to fill the gap in Aerospace Medicine training for medical students in the face of the BasicMed rule. Additionally, the trend of increased interest in pursuing a career in Aerospace Medicine shows promise that the curriculum could also serve as a method of recruitment to the field. With the commercialization of space travel and NASA's push to return to the Moon by 2024, more Aerospace Medicine physicians will inevitably be needed.[2] Future directions for this work include broadcasting the curriculum to a broader audience. Dissemination is planned to take place in a phased roll-out of broadcasts via AMSRO and AsMA.

This study also demonstrates the feasibility of initiating an Aerospace Medicine curriculum or interest group. Recruitment for this study had limitations, as previously stated, because a survey was being used to validate the curriculum. Without this barrier, interest building at other institutions should be more straightforward. Recommendations for recruitment include: 1) a centralized meeting location that is close to the medical school and convenient for the students; 2) a meeting time that is convenient for students and does not interfere with other activities of interest; 3) providing food at meetings; and 4) advertising for meetings via multiple avenues: social media, written announcements in the medical school buildings, email, and word-of-mouth.

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