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RESEARCH REPORT

# "A whole new perspective on how the body fits together"—An evaluation of a cadaver laboratory experience for high school students

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## Abstract

The Center for Anatomy and Physiology Education has hosted interactive human cadaver laboratory tours for local high schools (ages 14–18) and undergraduate university students since 2014 to expose students to healthcare careers. Students receive information on the history of body donation and healthcare careers and observe human anatomy on prosections and with isolated organs. The goal of this study was to evaluate students' perceptions of the anatomy laboratory tours and their impact on students' interests in healthcare careers. Students completed pre- and post-tour questionnaires. Responses were analyzed using thematic analysis and linguistic inquiry. Of the 261 students who completed pre-tour questionnaires, 204 (78%) completed the post-tour questionnaire. Before the tour, students anticipated learning about human anatomy and expected to only see but not touch a cadaver. Most students expressed excitement and/or nervousness. A few students viewed the laboratory tour as an opportunity to test if they could see themselves in a healthcare career. After the tour, most students indicated that the tour either met or exceeded their expectations. Students found the laboratory tour to be educational and interesting and were surprised by the opportunity to interact with the donor. Numerous students expressed an increased interest in healthcare careers after the tour. Overall, students perceived the tour as an engaging experience that improved their anatomical knowledge and reinforced/increased their interest in healthcare careers. Academic institutions can positively impact local students by implementing an anatomy tour, sharing access to their in-house human cadaver laboratory, and recruiting instructors to share their anatomy expertise.

**KEYWORDS**
gross anatomy education, laboratory tour, public outreach, science communication

## INTRODUCTION

Factors that motivate high school (ages 14–18) students to learn science include inspiring teachers, their career interests, and collaborative and hands-on learning activities (Bryan et al., 2011). Activities that assist students in connecting science content to prospective careers, like visits from professionals in science, technology, engineering, and mathematics (STEM) fields, and field trips to institutes of higher education that offer STEM training, may positively impact high school students' interests in pursuing careers in science (Bryan et al., 2011). The formation of partnerships between the community and institutes of higher education that aim to improve students'

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academic performance, increase their knowledge of healthcare careers, and supplement teachers' knowledge and pedagogy, has been posited as a strategy to increase the entrance of rural and underrepresented minorities into healthcare careers (Alexander, 2001; Patterson & Carline, 2006). Furthermore, research has demonstrated that the public has a poor understanding of their own bodies (Taylor et al., 2018). For example, while the public can generally correctly identify that the brain is located within the skull, they understand little about its function (Taylor et al., 2018). This, coupled with an overestimation of the public's anatomical knowledge by the medical profession (Kelly & Haidet, 2007), has spurred calls for anatomists to continue educating the public through outreach events (Taylor, 2020). Anatomists are well-situated to offer the public engaging and hands-on outreach events to improve students' knowledge of healthcare careers and education, support science teachers' curricular goals, and increase the public's anatomical knowledge.

University-based outreach programs that invite community members into the gross anatomy laboratory for hands-on learning experiences have been described in the literature and vary considerably in their intended goals, implementation, and evaluation. Many one- and multi-day residential and non-residential educational programs hosted by medical academic institutions, called "mini-medical schools" (MMSs; Connolly & Hinshaw, 2016), incorporate gross anatomy laboratory experiences into their curricula. The goals of these programs include increasing participants' knowledge of biomedical content, exposing participants to different healthcare occupations and professionals, and showcasing institutional and hospital facilities (Wallace et al., 2015; Connolly & Hinshaw, 2016; Briskey et al., 2017; Atance et al., 2018). Expected outcomes for participants include increased knowledge about healthcare occupations and biomedical content, increased interest in pursuing a career in healthcare, and increased ability to pursue a career in healthcare (Winkleby, 2007; Karpa et al., 2015; Wallace et al., 2015; Derck et al., 2016; Briskey et al., 2017; Atance et al., 2018). Some programs that include experiences in the gross anatomy laboratory specifically target students in underserved and rural areas or who are underrepresented in medicine in an effort to decrease barriers to higher education in these communities and create a pipeline for students to enter careers in healthcare (Henderson et al., 2015; Karpa et al., 2015; Derck et al., 2016; Atance et al., 2018).

Whereas the goals and outcomes of MMS programs are well documented, the impact of participants' experiences in the gross anatomy laboratory or with anatomical specimens specifically during the programs is scarcely reported. High school student participants of the two-week-long Careers in Health and Medical Professional Program (CHAMPS) at Cleveland State University reported that hands-on experience in the gross anatomy laboratory offered during the program was one of "the best methods of learning in the program" (Wallace et al., 2015). Similarly, a majority of the middle school (ages 11–13) and high school student participants of the University of Calgary's Cumming School of Medicine one-day MMS identified the gross anatomy laboratory as their favorite experience of the program (Henderson et al., 2015).

Outreach programs that offer community visits to gross anatomy laboratories and that are not part of larger, comprehensive, biomedical curricula present an opportunity to investigate the specific impacts of gross anatomy laboratory experiences on their participants. Anatomy laboratory-based outreach programs' goals are to expose high school and undergraduate university students to health professions and health professional education (Healy, 2011; Zhang et al., 2016; Meyer et al., 2018; Wines, 2019), provide educational opportunities for underserved students (Meyer et al., 2018; Wines, 2019), foster curiosity about human anatomy and pathology through active learning and hands-on experience (Zhang et al., 2016; Wines, 2019; Reed, 2020), increase health literacy (Meyer et al., 2018), and inform the public about whole body donation programs for education and research (Healy, 2011). At the Federal University of Health Sciences of Porto Alegre in Brazil, exemplary dissections completed by undergraduate students are temporarily displayed each year in the "Museum of Anatomy," which members of the general public may visit, with the intended purpose being to inform them about the university's body donation program (da Rocha et al., 2020). While the goals of anatomy laboratory-based outreach programs are well publicized, the effectiveness of these programs in achieving these goals is minimally documented.

The West Virginia School of Osteopathic Medicine's (WVSOM) anatomy laboratory tour program consists of a highly structured two-hour visit, in which high school students rotate through seven stations in the laboratory with WVSOM student teachers who facilitate interaction with cadaveric donors and materials, anatomical models, and radiographic images. In post-session surveys, most participants reported an increase in anatomy knowledge and about osteopathic medicine and an increased interest in pursuing a healthcare career. Participants were particularly impacted by their interactions with WVSOM student teachers and suggested there be more student teachers in future iterations of the program (Wines, 2019).

A similar program, established at Thomas Jefferson University, invites high school students taking either biology or anatomy and physiology classes to attend a one-day "Anatomy and Pathology Workshop" in which university faculty and health professional students deliver anatomy and pathology lectures followed by interactive review sessions in the gross anatomy laboratory intended to mimic preclinical medical education. After the experience, participants performed better on an anatomy and pathology post-examination than a pre-examination, expressed excitement and interest in anatomy and pursuing medical education, and identified both faculty and health profession student instructors as professional role models (Zhang et al., 2016).

Other outreach initiatives utilize anatomical specimens, and not whole cadavers, to engage the public with anatomical content. The Partners in Health Sciences Program (PIHS) was established at the University of Arkansas Medical School to equip teachers of Pre-kindergarten (PreK; age 4) to Grade 12 (age 18) students with supplemental knowledge and resources to enhance current science curricula and provide timely education about health topics (Burns, 2002). Training courses orient teachers to the resources

they are given to use with their classes, which include illustrated syllabi, plastic models, and laminated photos of normal and pathological human specimens, among other resources. Plastinated organs are made available for teachers to learn, too. This "train and equip" model has been customized to supplement education about body systems and health topics relevant to different age groups: the "Healthy Hearts" PIHS Program was developed for teachers of PreK to Grade 3 (age 8) to teach their students about the cardiovascular system and heart disease (Burns, 2008) and the "Healthy Lungs" PIHS Program aims to assist middle school (ages 11–13) teachers in their effort to prevent the onset of cigarette smoking in their students through education about the respiratory system and the impacts of smoking on the lungs (Burns, 2012).

In the United Kingdom (UK) and the United States (US), anatomy experts have performed live dissections of animal hearts and brains for paying audiences at bars and taverns in an effort to increase the public's knowledge of these organs in their own bodies. Data collected from audiences before and after the demonstrations revealed misconceptions about human anatomy as well as areas in which greater understanding was achieved (Sanders & Philp, 2019; Sanders et al., 2022).

This study investigates participants' overall feelings about a gross anatomy laboratory tour program and evaluates the effectiveness of the program in achieving its goal to stimulate interest in healthcare careers. Data were collected using pre-questionnaires prior to attending the tour, and post-questionnaires after the tour. The following research questions are addressed: (1) How do attendees perceive the Indiana University School of Medicine's (IUSM) anatomy laboratory tours prior to and after experiencing them, and how do these perceptions change, if at all, after experiencing the anatomy laboratory tours? and (2) How do attendees' emotions differ prior to and after experiencing the anatomy laboratory tours?

## MATERIAL AND METHODS

### Study setting

The Department of Anatomy, Cell Biology, and Physiology at Indiana University School of Medicine (IUSM) created an outreach program called the Center for Anatomy and Physiology Education (IU-CAPE) in 2012 to provide educational resources for local educators and to engage high school and university students in anatomy, physiology, and health professions education.

Whole-body donors utilized for IU-CAPE programming and all educational endeavors across the state of Indiana are provided through the Anatomical Education Program (AEP), (IUSM, 2022). The program is administered by IUSM for the acquisition and distribution of donors, as well as the formulation of standards for donated human remains. Donations to the AEP are used for the purpose of advancing medical education which is interpreted broadly to include education to transmit knowledge, skills, and values of a health profession (Cooke et al., 2006), such as to meet the health needs of the population. This scope extends beyond the education of medical doctors to health professionals, pipeline, and outreach programs that serve to meet the growing healthcare needs of the state and to build motivation for and awareness of health careers for students from disadvantaged and rural backgrounds (Jopson et al., 2020).

Since 2014, IU-CAPE has offered anatomy laboratory tours to authorized educational organizations for students high school-aged and above. Teachers of anatomy and physiology, biology, human body systems, or similar courses at high schools near and around central Indiana contact IU-CAPE to schedule anatomy tours. Anatomy courses in Indiana high schools are recommended for junior (age 17) and senior (age 18) level students and courses are held to academic standards for course framework and content by the Indiana Department of Education (IDE, 2013). As such, the goal of the anatomy laboratory tours is not to deliver anatomical content but to expose students to potential careers in healthcare and increase awareness of medical school among students in rural communities in Indiana.

Anatomy laboratory tours typically are 2 h in length and consist of an introductory presentation on the history of anatomy, cadaveric dissection, whole-body donation, and specific details about the scope of the AEP for medical education in Indiana. This presentation serves to situate the students to understand the necessity of a willed body program in light of millennia of ethical transgressions from medical and anatomical educators in search of bodies for dissection (Ghosh, 2015; Comer, 2022; Organ & Comer, 2022). Students learn of the first dissections being performed on executed criminals, to graverobbing and body snatching, followed by the Burke and Hare anatomical scandal, and end with a discussion of the Uniform Anatomical Gift Act and the willed body program at IUSM (Rosner, 2010; Ghosh, 2015, 2022; Brenna, 2022). The goal of this historical framing is to humanize the donors and promote respect for the donor and the whole-body donation process. The presentation concludes with information about healthcare professions, highlighting the careers that typically utilize cadaveric dissection to deliver anatomy content during training (e.g., medicine, physical therapy, nursing, etc.).

The remaining hour and a half of the tour are spent in the gross anatomy laboratory with demonstrations of dissected cadavers, human and animal skeletal materials, pathology specimens, and human organs. Students are oriented to the laboratory and protocols, including the prohibition of photography of cadavers or any cadaveric materials and the importance of treating all donors with the utmost respect. Gloves are provided for all students to wear to encourage interaction with cadaveric and skeletal specimens.

Students rotate through a variety of stations that are led by faculty or PhD students in the Anatomy and Physiology Education Track program at IUSM. The number of stations depends on the number of students in the touring group and the availability of faculty and students to lead the stations. However, students are placed into groups no larger than 15 students to promote interactivity and engagement at each station. The topic for each station is typically systemic and common areas include: the musculoskeletal system of

a donor, the nervous system which includes the brain, spinal cord, and eye, the digestive system of a donor, and the skeletal system that compares human and non-human bones. Station leaders discuss the content that relates to their station, but promotes engagement by asking questions to the students and encouraging them to ask any questions they may have. Students spend on average 20 min per station and then rotate to a new station so that they have an opportunity to visit each station in the allotted tour time.

## Data collection

Participants for this study included high school students enrolled in an anatomy course that attended an IUSM anatomy laboratory tour during an 8-month period from April to November of 2018. Students were most often in their junior and senior years of high school. No demographic information was collected from the students, but details about the schools' population and performance were recorded by the Indiana Department of Education (IDE, 2021).

Data for this study were collected through pre- and post-visit questionnaires (Figure 1). A link to an electronic consent form was sent to the teachers of the touring students to distribute to the students prior to arriving on campus for their anatomy laboratory tour. Students under the age of 18 were required to have their consent form also signed by a parent or guardian. Only students who completed the consent form were eligible to participate in the pre- and post-questionnaires. The pre-questionnaire was paper-based and distributed to students prior to beginning the tour. It consisted of four free-response questions asking about students' expectations of the tour, career interests, and feelings about the upcoming laboratory tour. A link to an electronic post-questionnaire was emailed to teachers immediately after the tour to distribute to their students and also consisted of four free-response questions asking if the tour met their expectations, the impact of the tour on their career interests, and feelings about their visit. Electronic consent forms and post-questionnaires were collected using REDCap© (REDCap Consortium, Nashville, TN). Participants were asked to provide a unique identifier to match pre- and post-questionnaires.

## Data analysis

Closed-ended questionnaire items were summed and categorized into percentages of respondents. Open-ended free-response questions were analyzed using Linguistic Inquiry and Word Count (LIWC) Program (Pennebaker et al., 2015a) which calculates the percentage of words and analyzes the psychological state of the responses. The LIWC is a text analysis application that counts the frequency of words and categorizes them into a variety of categories, including standard language categories and psychological processes (e.g., emotions, cognition, perceptions, drives, etc.; Pennebaker et al., 2015b). The LIWC has been used to measure emotional expression (Kahn et al., 2007), analyze dreams (Bulkeley & Graves, 2018), medical student performance evaluations (Isaac et al., 2011), medical students' reflective essays (Lin et al., 2016), and emotional talk in narratives of memorable professionalism dilemmas (Rees et al., 2013, 2015).

Pre-Questionnaire

1. Is this your first time visiting a cadaver lab? (select one)
   a. Yes.
   b. No. How many times have you visited a cadaver lab?
2. Briefly describe what you expect from this visit. (What do you expect to see? To learn? To feel? Etc.)
3. What job/career interests you at this point in your life? (Be as descriptive as possible and include as many interests as you'd like.)
4. Please use the space below to provide any additional thoughts or feelings you have about today's visit to the cadaver lab. (Are you nervous? Excited? Disinterested? Etc.)

Post-Questionnaire

1. Did you visit to the Gross Anatomy/Cadaver lab meet your expectations? (select one)
   a. Yes, the visit met my expectations.
   b. No, the visit **exceeded** my expectations! Please elaborate:
   c. No, the visit **did not** meet my expectations. Please elaborate:
2. What about your visit surprised you?
3. Please describe your level of interest in pursuing a health or allied health field **after** your visit to the IUSM Gross Anatomy/Cadaver lab. (How have your interests changed? Has your interest in a health career increased? Decreased? Etc.)
4. Please use the space below to provide any additional thoughts, feelings, or feedback regarding your visit. (Did you enjoy your visit? Was it interesting? Scary? Educational? Etc.)

**FIGURE 1** Pre- and post-questionnaires.

Tausczik and Pennebaker (2010) claim that language is the most reliable way of conveying emotions and thoughts in a way that others can understand. The degree to which people express emotion can indicate how one is coping with an event and the potential impact of that event on their future. Linguistic inquiry and word count program is capable of accurately identifying emotion in the language in response to positive and negative emotional events (Khan et al., 2007; Tausczik & Pennebaker, 2010) and in narratives of the memories of intense emotional events that occurred years ago because they are thought about frequently (Bohanek et al., 2005). Considering the emotions that may arise in students when interacting with a donor cadaver, the following categories were evaluated using the LIWC program: authenticity, affective (e.g., positive and negative emotions), perceptual (e.g., seeing, hearing, and feeling), and biological (e.g., body and health). Results in these categories were compared to quantities for an average expressive writing sample presented by Pennebaker et al. (2015b) in *The Development of Psychometric Properties of LIWC2015* publication.

While the LIWC was used to categorize and count words in the aforementioned linguistic categories, thematic analysis of free responses was used to provide additional context to the quantitative results (Braun & Clarke, 2013). First, all open-ended responses were reviewed to familiarize the analyst (A.S.C.) with items of potential interest that relate to the research questions. The complete dataset of open-ended responses was then openly coded, allowing the data to drive the coding process from the bottom up. Lastly, the coded excerpts were organized into named themes and subthemes based on their relationships to one another.

All data collected were de-identified and stored in a secure database. The Institutional Review Board of Indiana University approved this study (IRB #1803755251).

## RESULTS

Thirteen schools took part in an anatomy laboratory tour during the study time period and were invited to participate in the study. A total of 261 pre-questionnaires and 204 post-questionnaires were completed by student participants in the IU CAPE anatomy laboratory tour. Participating schools were private and public and ranged from large suburban (5000+ students) to small community-based high schools (250 students). The average distance of travel for the touring schools to get to IUSM, Indianapolis was 42 miles (range of 4 to 98 miles).

The results of the linguistic inquiry of the pre- and post-questionnaire responses can be found in Tables 1 and 2, respectively. The percentage of total words that match each of the selected categories is provided and can be compared to an average expressive writing sample (Pennebaker et al., 2015b). Compared to the expressive writing sample, most of the values for analytical thinking are higher on the pre-questionnaire and equal to those values on the post-questionnaire, reflecting logical thinking. The values for Clout are equal to or above the average expressive writing sample on most items in the questionnaires, except for questions on career interests and additional throughs on the pre-questionnaire which suggests more tentative and anxious responses. Emotional Tone was higher in both questionnaires compared to the average expressive writing sample but was lower in the pre-questionnaire suggesting lower emotionality or different levels of ambivalence prior to the anatomy tour experience (Pennebaker et al., 2015a).

### Pre-questionnaire

Most respondents (87%) indicated this tour was their first experience visiting a cadaver laboratory. Additionally, six respondents (2%) indicated that they had visited a cadaver laboratory previously (The remaining 11% of respondents did not complete this questionnaire item.). As revealed in the thematic analysis, numerous respondents expected to learn about human anatomy (52%) and see (but not touch or interact with) a cadaver (66%). Several respondents also anticipated learning about cadaveric dissection (22%) and hoped to gain insight into the medical or graduate school experience (12%) and their self-perceived fit within those programs (4%). Numerous respondents (66%) reported they were already interested in a healthcare career prior to the laboratory tour. The remaining respondents were either interested in non-healthcare STEM careers (8%), non-STEM careers (3%), or were still unsure of their desired career (17%). However, LIWC indicated career interest responses on the pre-questionnaire were not highly authentic.

The LIWC found high amounts of positive and negative emotions when respondents provided additional thoughts about the anatomy laboratory tour on the pre-questionnaire. Common expressions were excitement (80%), nervousness (45%), or both in anticipation of the laboratory tours. Multiple respondents mentioned that their excitement was due to positive reviews from previous tour attendees: “I'm very excited to be able to visit this lab. I have heard good reviews from students who came here last year” and “I heard that everyone who visited last year really enjoyed the visit, so I have been really looking forward to this visit.”

### Post-questionnaire

A total of 204 visiting students (78% of pre-questionnaire respondents) completed the electronic post-questionnaire after the laboratory tour. Most post-questionnaire respondents indicated in a close-ended questionnaire item that the cadaver laboratory experience either met (77%) or exceeded (22%) their expectations. When asked to elaborate on their expectations, 47 of the 204 (23%) post-questionnaire respondents provided additional free-response comments. Thematic analysis revealed that a large portion of these respondents appreciated the opportunity to not only see cadavers and isolated organs (28%), but touch and feel them as well (30%). One respondent stated, “When I came in, I did not think we would get to interact so much with the cadaver. We

**TABLE 1** Results of the linguistic inquiry and word count analysis of pre-questionnaire responses.

| LIWC domain | What do you expect to see? To learn? To feel? (%)[a] | What job/career interests you at this point in your life? (%)[a] | Additional thoughts? Are you nervous? Excited? Disinterested? (%)[a] | Average expressive writing Sample[b], (%)[a] |
|---|---|---|---|---|
| Analytic thinking | 79.41 | 72.31 | 36.94 | 44.88 |
| Clout | 38.00 | 28.44 | 21.41 | 37.02 |
| Authenticity | 25.07 | 38.93 | 59.16 | 76.01 |
| Emotional tone | 43.27 | 55.39 | 68.34 | 38.06 |
| Positive emotion | 1.95 | 4.20 | 24.05 | 2.57 |
| Negative emotion | 0.72 | 0.30 | 7.36 | 2.12 |
| Anxiety | 0.23 | 0.03 | 7.19 | 0.50 |
| Anger | 0.00 | 0.00 | 0.02 | 0.49 |
| Sadness | 0.04 | 0.00 | 0.03 | 0.50 |
| Perceptual processes | 6.05 | 1.28 | 3.01 | 2.38 |
| Seeing | 4.50 | 0.06 | 1.98 | 0.80 |
| Hearing | 0.02 | 1.16 | 0.05 | 0.48 |
| Feeling | 1.05 | 0.05 | 0.52 | 0.92 |
| Biological processes | 7.13 | 20.05 | 1.32 | 2.59 |
| Body | 6.11 | 0.23 | 0.78 | 0.69 |
| Health/Illness | 1.09 | 18.68 | 0.40 | 0.93 |

[a]Indicates percentage of total words in response.

[b]Based on Pennebaker et al. (2015b); LIWC, Linguistic inquiry and word count (Pennebaker et al., 2015a); The LIWC application counts the frequency of words in each of a variety of standard language and psychological process categories (domains) in a writing sample; the number in each cell represents the percentage of words in all participants' responses to a given question that were classified into each LIWC domain.

**TABLE 2** Results of the LIWC analysis of post-questionnaire responses.

| LIWC domain | Did the tour meet your expectations? (%)[a] | What about your visit surprised you? (%)[a] | Interest in health or allied health field after the tour? (%)[a] | Additional thoughts and feedback? (%)[a] | Average expressive writing Sample[b], (%)[a] |
|---|---|---|---|---|---|
| Analytic thinking | 44.08 | 53.66 | 58.37 | 39.53 | 44.88 |
| Clout | 35.89 | 41.60 | 15.64 | 38.44 | 37.02 |
| Authenticity | 53.49 | 38.58 | 76.25 | 57.59 | 76.01 |
| emotional tone | 58.87 | 62.28 | 83.14 | 82.13 | 38.06 |
| Positive emotion | 4.02 | 4.76 | 7.34 | 12.33 | 2.57 |
| Negative emotion | 1.22 | 0.84 | 0.39 | 1.01 | 2.12 |
| Anxiety | 0.21 | 0.10 | 0.15 | 0.72 | 0.50 |
| Anger | 0.03 | 0.04 | 0.04 | 0.09 | 0.49 |
| Sadness | 0.16 | 0.02 | 0.03 | 0.06 | 0.50 |
| Perceptual processes | 5.61 | 4.93 | 1.10 | 3.78 | 2.38 |
| Seeing | 2.93 | 2.41 | 0.48 | 1.17 | 0.80 |
| Hearing | 0.08 | 0.02 | 0.13 | 0.14 | 0.48 |
| Feeling | 1.93 | 1.95 | 0.28 | 1.11 | 0.92 |
| Biological processes | 2.45 | 5.20 | 5.19 | 2.04 | 2.59 |
| Body | 2.02 | 4.61 | 0.64 | 1.04 | 0.69 |
| Health/Illness | 0.32 | 0.66 | 4.40 | 0.43 | 0.93 |

[a]Indicates percentage of total words in response.

[b]Based on Pennebaker et al. (2015b); LIWC, Linguistic inquiry and word count (Pennebaker et al., 2015a); The LIWC application counts the frequency of words in each of a variety of standard language and psychological process categories (domains) in a writing sample; the number in each cell represents the percentage of words in all participants' responses to a given question that were classified into each LIWC domain.

were able to manipulate it far beyond what I thought we would be able to do." These results are supported by the LIWC results which found high expectations in the Seeing domain of Perceptual Processes across both questionnaires, whereas the value in the Feeling domain of Perceptual Processes was higher on the post-questionnaire.

After their visit, 37% of post-questionnaire respondents felt they had learned much more than they expected from the experience. As one student mentioned, "I expected to see cadavers, but I learned so much more than what I was expecting to and really enjoyed seeing the bodies in a 3D experience rather than just reading from a textbook." Additionally, several students were impressed by the laboratory facilities (4%) and the expertise of the tour leaders (6%).

When asked about the most surprising aspect of the tour, numerous post-questionnaire respondents indicated in their open-ended responses that they found the opportunity to interact with the cadaver (23%) as well as the resulting physical characteristics of the anatomical structures such as size, weight, or texture (26%) to be the most surprising. Many were also surprised by how the real anatomical structures differed from what they had previously seen or learned in textbooks. One student described: "I was genuinely surprised by the appearance of different organs. Prior to the visit, I had only seen the different organs through diagrams and models, and believed that the heart was about the size of a knuckle and the brain the size of two. However, I was surprised when I actually saw the brain, heart, and uterus because the sizes were different from what I imagined, and the weight of the bones and lungs were a lot lighter than I expected."

The thematic analysis also showed that several post-questionnaire respondents were surprised by how much they had learned about the human body (14%) and about the history of anatomy and dissection (11%). In regard to comfort in the laboratory, some were surprised by how comfortable they felt (11%), while others were surprised by how uncomfortable they felt (3%) during the laboratory tour. The LIWC found a greatly reduced amount of negative emotion in the post-questionnaire while the amount of positive emotional words remained higher than the expressive writing sample average.

Afterward, most post-questionnaire respondents reported the laboratory tour either increased (47%) or maintained (31%) their existing interest in a healthcare career. Some remained uninterested in a healthcare career (12%), while others were still uninterested, but are now more open to the idea of a career in healthcare or biomedical sciences (4%). The LIWC found responses about interests in a healthcare career on the post-questionnaire to be highly authentic and comparable to the average expressive writing sample. A few students (2%) were still unsure of their desired careers at this time. One student also indicated they were now interested in a career in anatomy education.

In the extra space provided, 160 post-questionnaire respondents (78% of the total post-questionnaire respondents) shared additional comments regarding their thoughts, feelings, and feedback about the visit. The majority enjoyed their visit to the cadaver laboratory (54%) and found the experience interesting and engaging (53%). Several respondents also thought the tour was educational and informative (38%) and appreciated the opportunity to participate in this experience (14%). One student stated: "It was fascinating to see real human models to help better my understanding of human anatomy. I always say that learning human anatomy through cat dissections is like learning car mechanics on a motorcycle, there are enough similarities but still different enough to be confusing and frustrating. It was a privilege to visit the lab and it was an experience I will tell stories about for years to come."

Several post-questionnaire respondents (18%) also expressed varying degrees of discomfort with seeing or interacting with the cadavers. In contending with mortality in a young donor, one student stated, "It was scary. When we viewed the [young] woman and I saw her nails were still painted, I could only think about how she had a life, dreams, a future, but now none of that will happen. I didn't expect to feel the way that I did during this study."

Upon comparing the language used by the students when referring to the cadaveric donors in the questionnaires, students were far more likely to refer to the donors as "dead bodies" in the pre-questionnaire compared to the post-questionnaire (59 and 21 instances, respectively).

## DISCUSSION

This study investigating high school students' perceptions of the IU anatomy laboratory tour indicates that students experience high amounts of positive and negative emotions prior to their experiences in the gross anatomy laboratory, but experience mostly positive emotions upon completion of the tour. Additionally, students reported an increase in anatomy knowledge and reaffirmed or increased interest in a health profession's career. While the tour met or exceeded students' expectations, the experience of being able to interact with and feel the donor was a memorable and significant aspect of the tour. These results characterize the impact of participation in an anatomy laboratory-based outreach initiative on high school students and offer a unique view of participants' feelings about the experience through the collection of pre- and post-tour data. Furthermore, these results demonstrate the value of in-person, hands-on anatomy outreach in providing participants with a memorable and meaningful educational experience, a controlled environment in which they can explore humanistic values and attitudes toward death and dying, and the opportunity to actively participate in one aspect of health professional education. As medical educators worldwide begin to consider how adjustments made to content delivery and clinical training due to Covid-19, such as the reduction or suspension of in-person lectures and discussions and the increased use of online technology (Lee et al., 2021), can or should persist beyond the end of the pandemic, the impact of in-person anatomy outreach, which was mostly suspended during the pandemic (Dueñas et al., 2021), should not be overlooked.

## Perceived increase in anatomy knowledge

Students, who were all currently enrolled in anatomy and physiology, biology, human body systems, or similar courses, reported feeling more educated about human anatomy after attending the tour, supporting similar findings by Wines (2019), which reported that attendees to gross anatomy laboratory-based outreach program perceived an increase in anatomy knowledge after their tour. Zhang et al. (2016) evaluated the anatomy and pathology knowledge of attendees to an anatomy laboratory-based workshop utilizing pre- and post-workshop multiple-choice examinations and reported an increase in anatomy knowledge after the workshop. Though evaluating tour attendees' change in anatomical knowledge after the tour was not within the scope of this study, attendees' perceived increase in anatomical knowledge may have important implications for their health literacy and health behaviors.

The United States Centers for Disease Control and Prevention (CDC) defines health literacy as "the degree to which individuals have the ability to find, understand, and use information and services to inform health-related decisions and actions for themselves and others" (CDC, 2021). In general, low levels of health literacy are associated with negative health outcomes (Berkman et al., 2011) whereas higher levels improve one's ability to make personal health decisions through greater health and medical knowledge and the use of vocabulary to improve patient-provider communication (Baker, 2006; Nutbeam et al., 2018, Nutbeam, 2019). Studies that assess the relationship between health literacy and health outcomes often only "address a limited set of conceptual dimensions of health literacy" (Jordan et al., 2011; Haun et al., 2014), but there is evidence to suggest that educational activities that include disease-specific anatomy and pathology education, like that, conveyed during anatomy laboratory tours, can improve adult patients' understanding of their condition and facilitate more open and productive communication with their physicians (Smith et al., 2008; Bernhard et al., 2016).

All students who participated in this study were adolescents and their perceived increase in anatomy knowledge after the tour may uniquely impact their health behaviors now and in the future. A systematic review conducted by Fleary et al. (2018) synthesized research examining the relationship between the health literacy and health behaviors of adolescents and found that, in general, adolescent health literacy has a significant positive correlation with health-promoting behaviors (e.g., nutrition and exercise behaviors, smoking behaviors, and stress management). Moreover, the onset of behavior patterns that can result in negative health outcomes in adulthood often occurs during adolescence (O'Connell et al., 2009; Catalano et al., 2012). Fresh and plastinated normal and pathological cadaveric materials have been utilized to equip teachers of children and adolescents with the knowledge to educate their students about the impact of lifestyle and behaviors on anatomical structures and function (Burns, 2008, 2012), but cadaver laboratory tours provide first-hand interactions with the destructive consequences of poor lifestyle choices and behaviors and may encourage students to take preventative measures to protect their health. Moreover, students could relay this experience to their loved ones to positively impact their health behaviors, too (Abrams et al., 2021), similar to how in some cultures youth will assist their family members by translating medical language into their native language and helping make medical decisions (Katz, 2014). While the goal of the anatomy laboratory tours is not to specifically address health literacy, study participants' self-reported increase in anatomical knowledge through exposure to healthy and pathological cadaveric materials and discussions with anatomy educators demonstrates their utility in improving health knowledge. However, more research is needed to understand the short- and long-term impacts anatomy laboratory tours can have on health literacy in adolescents.

## Hands-on learning in anatomy outreach

Memorable and impactful experiences in science outreach programs often relate to doing hands-on, experiential activities such as performing gel electrophoresis (Clark et al., 2016), chemistry experiments (McClure et al., 2020), and computer programming (Mano et al., 2010). While most students expected that they would see a cadaver, experiences like being able to touch the cadaver and hold a human heart or human brain created a more meaningful and memorable experience for the students as noted in the thematic analysis and by the increase in the Feeling domain of the LIWC analysis. These results are consistent with those reported by Wallace et al. (2015), in which participants of a university-based STEM and Health pipeline program reported that hands-on experiences, which included field trips, discussions led by health professionals, and learning sessions in the gross anatomy laboratory, were recalled as being the best methods of learning in the entire program. While not all institutions may be able to offer anatomy tours with cadaveric material, others report high student engagement with non-human anatomic materials (Reed, 2020), indicating the hands-on aspect of the learning experience may be more important than the material source.

## Interest in healthcare careers

The majority of visiting students also reported the laboratory tour experience either maintained or increased their existing interest in pursuing a healthcare career. Studies have demonstrated that engaging with cadaver dissection, prosections, and isolated organs can increase students' interest in health professions careers (Zayas & McGuigan, 2006; Achilly, 2017; Byram et al., 2020). Students expressed awe at the first-hand experience of anatomy and pathology, which could serve as a defining moment that sparks a life-long fascination with the health sciences. While academic achievement and aptitude can be strong motivators for pursuing a specific career field, critical experiences like these may ultimately motivate students to pursue a specific career (Holden et al., 2014). Even when students have strong aptitudes for math and science, they may not pursue a STEM major or career due to a lack of interest in the

subject. Fascination with medical sciences has even been shown to be a more significant driver for pursuing a healthcare career than the perceived social duty to become a healthcare provider (Dorph et al., 2018). Therefore, it is important to not only prepare students academically for healthcare careers but also spark their interests through exciting, impactful experiences. While one-time activities like the laboratory tour experience may not leave as lasting an impression as other long-term, comprehensive programs, they can still serve as meaningful first steps toward further healthcare career exploration (Holden et al., 2014).

Now more than ever, students must be encouraged to pursue healthcare careers to address the significant shortage of healthcare professionals across the United States. Over 54% of the US population's primary care needs remain unmet (Kaiser Family Foundation, 2020), with roughly 20% of the population residing in designated Healthcare Professional Shortage Areas (HPSA; Zayas & McGuigan, 2006). Marion County, the location of Indiana University School of Medicine-Indianapolis and several of the visiting high schools, is designated as a high-needs demographic area with a health professional shortage areas (HPSA) score of 6 on a scale of 0 to 25, with higher numbers indicating greater need (HRSA, 2022a). Several medical facilities within Marion County have also received HPSA scores ranging between 21 and 22 (HRSA, 2022a). Any HPSA with a score of 5 or above is authorized for the assignment of government-assigned healthcare professionals to help alleviate the shortage (HRSA, 2022b). As the projected physician shortage in the US is expected to grow (IHS Markit Ltd., 2020), it's becoming more important to encourage youth to pursue healthcare careers in order to address the nationwide shortage of healthcare professionals.

Additionally, healthcare professional shortages are more pronounced in poor urban and rural communities with large populations of racial/ethnic minorities (Zayas & McGuigan, 2006). Medical students who identify as racial/ethnic minorities are significantly more likely to plan to practice medicine in these medically underserved communities and, upon graduation, many remain in the same state in which they completed their medical education (AAMC, 2019a, b). Therefore, institutions located in HPSAs should consider providing outreach like the anatomy laboratory tours to high school students to encourage exploration and pursuit of healthcare careers. These students, if they pursue careers in healthcare, may be more likely to remain in-state, serve their local communities, and reduce the healthcare professional shortage (Saha et al., 2000; Cohen et al., 2002).

## Learning humanistic values

After participating in the anatomy laboratory tour, several students demonstrated greater humanistic values such as empathy and appreciation for life and mortality. The cadaver laboratory is often where many students have their first encounter with the realities of death and dying (Abrams et al., 2021). As such, the first experience with a cadaver may evoke difficult or complex emotional responses, particularly when the individual was closer to the student in age or retained distinctly human features like nail polish or tattoos (Rizzolo, 2002; Robbins et al., 2008; Abrams et al., 2021). The IU-CAPE laboratory tour students provided responses with a highly emotional tone before and after the tour and expressed strong emotions toward a female donor in her twenties. While these initial reactions may involve more negative emotions such as fear, stress, and anxiety, multiple studies, including this study, have found that students typically worked through these emotions and still considered the experience valuable (Romo Barrientos et al., 2019). Further, navigating emotions encourages students to confront the concept of mortality and empathize with the struggles associated with illness and death (Ghosh, 2017; Abrams et al., 2021).

This early introduction to death and mortality by way of cadaveric anatomy may be particularly beneficial for students who are interested in pursuing a healthcare career. Due to the nature of healthcare and its proximity to death and illness, some students must learn to manage their death anxiety, the "negative emotional reaction provoked by the anticipation of a state in which the self does not exist" (Tomer & Eliason, 1996). For those who experience it, this fear of death can negatively impact mental health (Furer & Walker, 2008), work capacity (Ulla et al., 2003), burnout (Melo & Oliver, 2011), and perceptions of dying patients (Peters et al., 2013), thereby diminishing patient care. The human cadaver laboratory can serve as a safe, controlled environment where students who experience death anxiety can begin working through their fear of death with the support of instructors and peers as opposed to the fast-paced, high-stakes clinical environment. In a study by Dickinson et al. (1997), 54% of first-year undergraduate medical students experienced less death anxiety after completing a dissection-based gross anatomy course, 28% experienced increased death anxiety, and 18% experienced no change. Moreover, in the laboratory, instructors can highlight the importance of respect for cadaveric donors and reassure students that emotional responses to the cadaver are normal and not a sign of "weakness" (Rizzolo, 2002).

Finally, these results demonstrate a subtle shift in the terminology the visiting students used in reference to the donors. In the pre-questionnaire, students more frequently used the phrase "dead bodies" to refer to the donors, whereas in the post-questionnaire, students used the term "cadaver" more frequently. While both terms are still dehumanizing, the term "cadaver" is slightly more respectful and suggests a more clinical view of the donor (cold and detached, yet technical and scientific) whereas "dead bodies" suggests a view of the donor as disgusting or diseased.

Particularly in undergraduate medical student populations, a similar shift in the language used to refer to cadaveric donors is associated with lasting impacts on professionalism, empathy, and morality. The term "donor" humanizes the subject and evokes positive connotations of selflessness and generosity whereas terms like "cadaver", "corpse", or "dead bodies" objectify the subject and elicit varying degrees of negative connotations such as morbidity, crime, and disgust (Weeks et al., 1995). As such, encouraging students to use the term "donor" instead of more negative terminology and modeling that language during instruction can significantly influence

how students think and act in the cadaver laboratory. Medical students who used more technical, detached terminology were found to have a more specimen-like view of the donor and experience less emotional and moral distress during dissection. Conversely, students who preferred more person-minded language often held more humanistic views toward the donor and were more concerned with respectful and empathetic treatment (Goss et al., 2019). Therefore, although "donor" is widely considered the most respectful and humanizing term, a transition from "dead bodies" to "cadaver" suggests a subtle shift in respectful language after the tour (Weeks et al., 1995; Rizzolo, 2002).

## Limitations of the study and future directions

While the introductory presentation was a consistent feature of each tour, experiences in the gross anatomy laboratory differed dramatically between student groups depending on several factors: number of touring students, availability of graduate students and faculty to lead stations, number of stations, time spent at each station, the timing of the tour in the semester (e.g., prosected donors were regionally dissected so those students touring later in a semester would see more anatomy than those earlier in the semester), and availability of donors with anatomical variances and pathology. However, the overall favorability of the results suggests that students find the laboratory tours to be a positive and influential experience, regardless of the particular content that is presented. This suggests that anatomy educators at other institutions could implement anatomy laboratory tours using our basic laboratory tour template and modify it for the resources they have available. Features of the tour that transcended the content discussed at each station included the ability to physically contact donors, having a dedicated educator at each station to present material, and covering a variety of anatomical and clinical content. Perceptions of the introductory presentation were mixed, primarily due to some students believing the presentation was too long and took away from time spent in the laboratory. However, a presentation discussing whole-body donation is important to promote respect for donors and to reduce anxiety in students, many of whom are seeing a dead body for the first time.

Participating students were able to attend an anatomy laboratory tour through a field trip offered by their teachers and approved by their schools. Students' ability to attend a tour is dependent entirely on the school's ability to provide transportation for students to travel to Indianapolis. Therefore, school systems with limited resources are less likely to be able to attend a laboratory tour due to costs and issues with transportation. Indeed, the majority of touring schools were not from economically disadvantaged systems. While individual demographic data on students were not collected, each of the touring schools had an ethnic white majority. The relative heterogeneity in economic status and ethnicity in the touring schools likely represents a lack of diversity in the student responses, limiting the generalizability of these results to low-income and minority students. A future direction of CAPE is to host a monthly "science night" (Burns, 2002) by bringing a version of the anatomy laboratory tour to high schools in the Indianapolis area, in an effort to reach minority students who may not have the resources to attend an on-campus tour.

This study is also limited by the questionnaire instruments and methods of data collection. Pre-questionnaires were filled out in person and on paper prior to beginning the laboratory tour. Students often used short, incomplete sentences in the free-response sections, likely demonstrating reduced engagement with the questionnaire. This likely explains the low levels of authenticity and clout on the pre-questionnaire. Despite this, it was important to survey the students just prior to the experience to gauge their immediate emotions and expectations. Further, although the post-questionnaire was sent to teachers immediately following the tour, students took up to one week to complete the online questionnaire. With a longer delay in completing the questionnaire, students may have lost some details about their experiences and feelings about the tour. However, student open responses were much longer and had higher levels of authenticity compared to pre-questionnaire questions suggesting students were providing honest and personal accounts of their feelings, particularly as they related to an interest in a health professions career (Pennebaker et al., 2015a). This is consistent with other literature that demonstrates LIWC can appropriately identify emotional language from narratives of memories of emotional events years after (Bohanek et al., 2005).

While this study demonstrates that high school students who attended an anatomy laboratory tour expressed increased interest in a healthcare career, this was cross-sectional and did not track students longitudinally to determine whether they went to college and declared a pre-professional major. A future direction of this study would be to track touring students longitudinally to determine the percentage who enter a health professional career.

## CONCLUSIONS

Gross anatomy laboratory tours provided high school students with an engaging, educational, and interactive experience that they believed improved their anatomical knowledge. An impactful tour experience may be able to improve health literacy as well as foster an interest in healthcare or medical science careers.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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