INTRODUCTION

Since the first report of the novel coronavirus outbreak in late December of 2019, infection with Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) has spread rapidly across the globe (Zhu et al., 2020). The Coronavirus Disease 2019 (Covid-19) outbreak was declared a global pandemic in March of 2020 (WHO, 2020). This incited a rapid and widespread movement to reduce the spread of the virus, through stay-at-home orders, social distancing, limiting gatherings, business closures, and wearing face coverings in public (Ağalar & Engiın, 2020; Czeisler et al., 2020; Govindasami, 2020; Kulkarni et al., 2020). Numerous

No cuts, no buts: Satisfaction of first-year medical students with a hybrid prosection-based model for learning gross anatomy during the Covid-19 pandemic

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Abstract

Few realized the extent of disruption that the Covid-19 global pandemic would impose upon higher anatomical education. While many institutions were obliged to adopt a fully-remote online model, the New York Institute of Technology College of Osteopathic Medicine strove to develop a curriculum that would allow medical students to receive an in-person anatomy education. A hybrid model that emphasized learning from prosected cadavers and self-study stations was implemented, with the remainder of the students’ time directed toward studying at home. Through an anonymous survey aimed at gleaning student satisfaction, this study demonstrates that this hybrid prosection-based anatomy course aligned with student preferences both assuming no health risk (64.6% agreed) and given the current risk of contracting Covid-19 (78.5% agreed). Generally, students felt that their education was equal to that of previous years (Likert scale = 3.24 ± 1.05), fostered an appreciation for anatomy (4.56 ± 0.59), promoted teamwork (4.13 ± 0.85), and prepared them for practical examinations (4.18 ± 0.74). Linear mixed-effect models demonstrated that specific differences in results could be attributed to students’ preconceived preferences toward student-led dissections and to past medical training. Importantly, most students “disagree” (1.97 ± 1.00) that they were concerned about the risk of exposure to Covid-19 during in-person anatomy laboratory sessions. Areas requiring improvement were identified by the model, including the provision of access to the cadavers outside of the regularly scheduled laboratory times (3.89 ± 1.08). These findings should be utilized when designing future gross anatomy courses in response to the “new normal”.

KEYWORDS
Covid-19 prosection, dissection, gross anatomy education, medical education, osteopathic medical education, student satisfaction
sectors have been significantly impacted by this pandemic, one of which is medical education (Evans et al., 2020; Franchi, 2020; Longhurst et al., 2020; Pather et al., 2020; Ross et al., 2021). Within a short period of time, schools were tasked with devising and implementing curricula that adhered to government restrictions surrounding the pandemic to maintain the health and safety of their students and faculty, while continuing to provide high quality education (Evans et al., 2020; Longhurst et al., 2020; Pather et al., 2020; Iwanaga et al., 2021; Ross et al., 2021). Consequently, much of students’ medical training became virtual (Evans et al., 2020; Franchi, 2020; Longhurst et al., 2020; Singal et al., 2020; Iwanaga et al., 2021).

Within New York State, medical schools were allowed to reopen on June 22nd, 2020 with appropriate precautions in place (NYSDOH, 2020). Despite the early allowance of in-person learning compared to other institutions for higher education, numerous obstacles prevented medical schools from being able to follow their previous curricula (Franchi, 2020; Iwanaga et al., 2021). For example, schools with predominantly student-driven gross anatomy dissections were obliged to modify this course due to time and space constraints [but see Ross et al. (2021)]. Once again, the value of in-person anatomical dissection is questioned against the convenience of virtual learning. This value has previously been debated, where some claim the experience as more of a ‘rite of passage’ for medical students and that anatomy can be learned without cadaveric dissection (McLachlan et al., 2004; McLachlan & Bere, 2004; McMenamin et al., 2018). Other opinions focus on the idea of the cadaver as the students’ first patient or their first teacher, emphasizing its impact on the development of students’ empathy and professionalism (Ghosh, 2017; Flack & Nicholson, 2018; Evans & Pawlina, 2020; Souza et al., 2020). However, despite technological advances that allow for a more virtually-based curriculum (Mathiowetz et al., 2016), cadaveric-based dissections are still regarded as the most effective method of learning anatomy (Granger, 2004; Winkelmann, 2007; Ghosh, 2017; Franchi, 2020; Ross et al., 2021; Zibis et al., 2021). The Covid-19 pandemic presented a new challenge to develop an alternative and safe anatomy curriculum that remains equally effective as those from previous years (Franchi, 2020; Iwanaga et al., 2021; Ross et al., 2021). In this study, students were surveyed at a single medical institution to determine their opinions on in-person anatomical education and satisfaction with learning anatomy through instructor-led dissections as opposed to student-driven dissections in the context of the current pandemic.

Global hybrid anatomy learning changes during the Covid-19 pandemic

Anatomy educators worldwide were forced to adjust their learning plans for gross anatomy laboratory due to Covid-19 (Alsafi et al., 2020; Smith & Pawlina, 2020; Tucker & Andersen, 2020; Bockers et al., 2021; Harrell et al., 2021; Papa et al., 2022). As such, several studies have sought to summarize both the common impacts of the Covid-19 pandemic upon anatomical teaching and student perceptions of these adjustments. For example, a survey of 20 anatomy educators by Harmon et al. (2021) reported that common impacts of the pandemic upon anatomical education included: (1) a reduction in the number of in-person lectures; (2) a reduction in the use of cadaveric material; (3) an increase in the use of computer-based assessments; and (4) an increased reliance upon digital teaching resources. These observations are supported by data presented by Attardi et al. (2022), reporting that, across 191 educators, the proportion of in-person lectures dropped from 88% to 24% while computer-based assessments rose from 4% to 56%.

Such changes had a significant impact upon student learning. At the University of Zagreb School of Medicine, students reported a significant increase in the number hours per day spent studying anatomy (5.59 ± 2.46 vs. 4.09 ± 1.52, P < 0.001) during the pandemic (Banovac et al., 2021). This was substantiated by a survey of medical students from 39 medical schools across the United Kingdom, where students also reported a significant increase in hours of study (Dost et al., 2020). However, the proportion of students who felt they could easily assess their progress during anatomy classes fell from 73.44% to 39.57% (Banovac et al., 2021). Similar concerns as to the effect of the pandemic upon their medical education were reported at the University of Malta (Cuschieri & Calleja Agius, 2020), wherein a high proportion of students reported anxieties over detrimental effects to their studies (46.51%) and examinations (77.90%). While students at several institutions favored online lectures over in-person classes, as lectures could be repeated multiple times, preserved more time to review materials, and allowed students to get ahead of the lecture schedule (Banovac et al., 2021; Shahrvini et al., 2021; Yoo et al., 2021), remote learning was associated with both an increase in distractions that hindered time management (Dost et al., 2020; Singal et al., 2021) or resulted in digital fatigue (Shahrvini et al., 2021).

In addition to altering teaching strategies, the nature of anatomical assessment also required modification. Student perceptions of online anatomical examination techniques reported by Sadeesh et al. (2021) describe high levels of variance in student satisfaction, largely as a product of question type. For example, while 60.1% of students stated a preference for online viva voce questions of osteology, radiology and embryology, only 31.6% of students preferred the online delivery of anatomical spotter cards, with several noting the difficulty of identifying specific structures from photographs (Sadeesh et al., 2021).

Finally, the experiences of medical educators themselves are reported for several institutions. Across 359 respondents in China (Cheng et al., 2021), only 29% of educators estimated that online teaching enabled students to achieve most or all of their intended learning outcomes. Many teachers also expressed concerns over the effectiveness, integrity, and impartiality of conducting online examinations. Moreover, medical educators in the United Kingdom and Republic of Ireland (n = 24) reported that remote teaching hindered student–student (66.7%) and student-tutor (52.6%) engagements.
Context of pre-pandemic anatomical education at New York Institute of Technology College of Osteopathic Medicine-Old Westbury Campus

Historically, the gross anatomy laboratory at the New York Institute of Technology College of Osteopathic Medicine-Old Westbury Campus (NYITCOM) has featured a student-driven, dissection-based curriculum, in which students participated in twice-weekly, four-hour sessions under the supervision of Faculty and Academic Medicine Scholars (third-year medical students enrolled in a dual-degree program). Groups of seven to eight students performed dissections on their assigned cadaver during each session. There were 81 scheduled laboratory hours per student divided amongst 27 distinct laboratory sessions. Various textbooks (e.g., Grant’s Dissector, Moore’s Clinically Oriented Anatomy) were available as reference materials at all times in the laboratory, alongside iPads, 3rd Generation, 16GB (Apple Corp., Cupertino, CA) installed with Essential Anatomy 5 application (3D4Medical, Dublin, Ireland). Anatomical models, articulated skeletal casts, and casts of individual bones were available as well. Students were provided live prosection demonstrations during the anatomy laboratory sessions that were recorded and posted on the school’s online learning management system for later viewing. Students also retained access to the anatomy laboratory to review the cadavers any time outside of the laboratory sessions while the campus was open, unless another class was in session. In-person review sessions were held at the discretion of the anatomy faculty and Academic Medicine Scholars and averaged approximately 50 hours total throughout the entire course.

Practical examinations consisted of two sessions; the first was conducted in-person using pinned cadavers, with typically two questions per cadaver, as well as tagged bones and radiological imaging. Students rotated through multiple question stations and were allocated one minute per station. Students could not return to a station once the minute for that station had concluded. Students typed their answers into their own school-provided iPad through a secure interface created in ExamSoft (ExamSoft Worldwide, Dallas, TX). Questions on the in-laboratory portion of the examinations consisted of anatomical structure identification on cadavers or in medical imaging. The second section of the practical examinations occurred in the lecture hall with proctors present and consisted of a total of 50 multiple choice and fill-in-the-blank questions. These questions typically involved topics relating to innervations and anatomical actions and relationships. An additional smaller component of students’ anatomy course grading was derived from quizzes that were administered during each laboratory session to a subset of tables; the material for these quizzes comprised topics from the previous laboratory session.

Context of post-pandemic anatomical education at New York Institute of Technology College of Osteopathic Medicine-Old Westbury Campus (revised curriculum)

Under the revised curriculum, students were assigned into cohorts that were each on campus for only one day per week. This ensured that, if students were exposed to Covid-19, only one section would have to isolate. All laboratory activities were consolidated into this single day, and as a result, the time spent in the anatomy laboratory for each student was reduced to two hours. As this reduced schedule did not allow students to both perform dissections and review anatomical material, a prosection-based course was implemented. Under this curriculum, there were 13 distinct laboratory sessions; 12 were conducted in-person and one was completely remote. This resulted in a total of 24 hours of in-person laboratory time and an additional one-to-two hours of instructor-led remote learning. Each week, six stations were set up in the anatomy laboratory; two were instructor-led stations (at which one anatomy faculty member and one Academic Medicine Scholar were present) and four were self-study stations. One prosected cadaver was set up at each station, with the exception of one self-study station, which was considered a radiology station. Groups of three to four students were assigned to each station at the beginning of the session. Every seventeen minutes, students rotated to the next station until they completed the laboratory session (approximately 1 hour and 52 minutes). The majority of content was covered at the two instructor-led stations, with the activity stations designed to reinforce the content and allow students to work through material that was considered easier by the faculty. Of note, the total number of anatomical structures that were covered by the revised curriculum was reduced by approximately 25% relative to the pre-pandemic curriculum due to the posed time restrictions in the laboratory precipitated by the pandemic. Students did not retain access to the anatomy laboratory outside of their scheduled sessions.

Learning activities and covered answer sheets were provided at each self-study station. For example, one self-study station asked the students to review the branches of the celiac trunk on the provided cadaver (Electronic Supplemental Material “Self-study_Example” and “Self-study_Key”). After navigating the activity, students were able to review their answers. To assist with the identification of structures, various anatomy textbooks and electronic resources (similar to those described above) were available as reference material.

When students were off-campus, access was provided to multiple learning resources. These included pre-recorded prosection videos with embedded pre-laboratory quizzes, digital anatomical guides including NetAnatomy (Scholar Educational Systems, Inc., Crofton, MD; Walsh et al., 2021) and Complete Anatomy (3D4Medical/Elsevier B.V., Dublin, Ireland), and access to online textbooks such as Grant’s Dissector (Tank, 2012), Grant’s Atlas of Anatomy (Agur & Dalley, 2009), and Clinically Oriented Anatomy (Moore et al., 2018). For cases in which a student was absent from a laboratory session, he or she completed a virtual anatomy activity utilizing Complete...
Anatomy (Motsinger, 2020), (for example, see Supplemental File “Virtual-anatomy_Example”). A faculty member also met with students virtually who were unable to attend laboratory sessions to work through the material. Virtual review sessions were held for all students prior to practical examinations and were hosted by the Academic Medicine Scholars with a faculty advisor present. These sessions averaged two hours each.

A total of three practical examinations were held remotely via ExamSoft throughout the semester and consisted of a total of 50 multiple choice and short answer questions aligned to the learning objectives for the laboratory sessions. Questions were based on either high-quality cadaveric images screenshots from Complete Anatomy (Motsinger, 2020), or images from online textbooks.

Objectives of the study

To understand the impact of this novel curriculum upon the educational experience of the medical students, the present study assesses levels of student satisfaction with various aspects of the course and assesses the hypothesis that the transition to a hybrid teaching model would increase student perceptions of the curriculum, as observed in other institutions. Further, the study elucidates which components of the hybrid learning experience are most, and least, appealing to students of anatomy—critical information for developing future anatomy courses in a hybrid setting. Further, this study also assesses the comfort of medical students in participating in a hybrid course model in the midst of this global pandemic.

MATERIALS AND METHODS

Survey and participants

A one-time, anonymous, online survey consisting of twenty-six questions (thirty-three with follow-ups) (Electronic Supplemental Material “Survey”) was distributed via email to the entire first-year class in the Doctor of Osteopathic Medicine (DO) program at NYITCOM, which comprised 319 students (Class of 2024). No exclusion criteria were applied, as all students participated fully in all elements of the hybrid curriculum. These medical students completed their laboratory course in human gross anatomy in December of 2020. The initial date of survey administration was January 6th, 2021—students had one month to complete the survey and received weekly reminder emails until February 6th, 2021. Anonymous online surveys were prepared and administered using the REDCap secure web application (Vanderbilt University, Version 11.3.0, Nashville, TN) (Harris et al., 2009). Completion of the survey was not compulsory, and no incentives for completion were offered.

The survey first established basic demographic information, including age, sex, ethnicity, place of residence, and enrollment in the Foreign Medical Graduate (i.e., a four-year Doctor of Osteopathic Medicine program for foreign physicians seeking to practice medicine in the United States). Questions then focused on student satisfaction with various aspects of the revised curriculum, including the in-person instruction by the anatomy faculty, the amount of time provided to review the cadavers, and the external resources provided by the school. All questions related to satisfaction were formatted using a five-point Likert scale (1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree; Table S1).

Students were also asked pandemic-related questions, including their ideal method of learning anatomy assuming no health risk, their ideal learning method in their current context, and their level of concern regarding risk of infection with Covid-19. The final question of the survey provided students with a free text box in which they could provide any commentary on their satisfaction with the course. Prior to dissemination of the survey to the students, the proposed study was submitted to the Education Research Data Committee (ERDC) at NYITCOM, where it received Institutional Review Board (IRB) exemption status (BHS1596).

Statistical analysis

Reliability of the survey instrument was assessed by Cronbach’s alpha coefficient (Sokal & Rohlf, 2012), following Attardi et al. (2022) and Shahrvini et al. (2021). Reliability was confirmed with an alpha of 0.71 (see Supporting Information for full test data).

Responses were assessed using a series of logistic ordinal regression models. Ordinal logistic regression is form of statistical analyses that assesses the relationship and relative impact between various explanatory variables and an ordinal response variable (e.g., Likert scale survey). Such statistical testing provides a conservative approach of identifying primary causal relationships while accounting for potential confounding variables (Sokal & Rohlf, 2012). Analyses were conducted on fourteen of the total thirty-three questions (Table S2). The responses were converted to factors for all analyses. Foreign Medical Graduate Program status, anatomy session, sex, age, ethnicity, individuals residing in primary residence, and previous gross anatomy experience were included in the models as fixed effects. As many studies have demonstrated that a student’s preconceived notions about gross anatomy often influence their perception of the course overall (Kerby et al., 2011; Jayakumar et al., 2020; McWatt et al., 2021), students’ response to “Assuming no health risk to yourself or others, what would be your ideal method of learning anatomy?” was also included as an additional fixed effect in the model.

As there is considerable debate (Winship & Mare, 1984; Kampen & Snybedouw, 2000) about how to treat ordinal predictor variables (e.g., age category), four separate logistic ordinal regression models (Tables S2–S5) were constructed. Two of these models treated “age” and “number of people in residence” as categorical variables, while two of these models treated “age” and “number of people in residence” categories as continuous variables. Furthermore, two of these models analyzed full categorization of “previous gross anatomy experience”, while two other
models simplified previous anatomy course experience as either a "yes or no" response. To compare models, Akaike's information criterion (AIC) was used: a metric which measures the goodness of fit of an estimated model and provides an operational way of trading off the complexity of an estimated model against how well the model fits the data, with lower AIC scores reflecting a better model fit (Burnham & Anderson, 2001).

In certain instances, a single participant provided a particular response (e.g., one participant preferred not to provide an age) that artificially weighted the models. These responses (three total) were excluded from the final analyzed dataset. All data were analyzed using the statistical software R, version 4.1 (R Foundation for Statistical Computing, Vienna, Austria) via the package 'rms' (Harrell, 2021).

RESULTS

A total of 144 first-year osteopathic medical students completed the survey, yielding a 45.14% response rate. Cohort characteristics and summary statistics are provided in Tables 1 and 2, respectively. Simplifying previous anatomy course as a "yes or no" response and treating both age and number of people in residence categories as continuous in ordinal logistic regression models (Table S2) resulted in the lowest Akaike's information criteria values (Tables S2–S5).

We found that the health risk associated with the Covid-19 pandemic significantly influenced students' preferred learning mode (Table 2). Assuming no health risk, most student respondents (64.6%) favored a hybrid learning model using prosections with human cadavers, 34.7% favored completely in-person sessions with student dissections, and one student (0.7%) favored a completely remote online learning model (Figure 1). However, in light of the health risk at the time of the Fall 2020 semester, a relatively greater proportion (78.5%, up from 64.6%) of student respondents selected a hybrid learning model using prosections, a relatively reduced proportion (16%, down from 34.7%) selected completely in-person sessions with student dissections, and a relatively greater proportion (5.6%, up from 0.7%) of student respondents selected a completely remote online learning model. Despite an increased preference for hybrid learning, students "agree" (3.89±1.08) that they would have liked to have access to the cadavers outside the regularly scheduled in-person laboratory time (Table 2).

We also found that concerns about the risk of Covid-19 infection during in-person anatomy sessions were low. Most students "disagree" (1.97±1.00) that they were concerned about this risk (Table 2). It should be noted, however, that this response was strongly influenced by whether students were enrolled in the Foreign Medical Graduate Program (average Foreign Medical Graduate Program response = 2.86±1.35; average other response = 1.87±0.91; Figure 2).

The hybrid learning model was deemed favorable for prompting teamwork and an appreciation for anatomy. Respondents "strongly agree" (4.56±0.59) that the hybrid learning model fostered an appreciation by students for human anatomy, and "agree" (4.13±0.85) that this model promoted teamwork during in-person weekly sessions. Students were "very satisfied" (4.67±0.65; 1 = very unsatisfied; 2 = unsatisfied; 3 = neutral; 4 = satisfied; 5 = very satisfied) with the faculty and Academic Medicine Scholar instruction during in-person weekly sessions (Table 2). Indeed, these demonstrations were considered the most helpful aspect of the curriculum for learning anatomy for 46.85% of respondents.

Satisfaction with self-guided study stations was mixed. Overall, student respondents (n = 143) were "satisfied" (3.52±1.01) with the self-guided activity stations, yet 33.33% of respondents considered these self-study stations the least helpful aspect of the curriculum for learning anatomy. Perception of these self-guided stations was significantly influenced by both enrollment in the Foreign Medical Graduate Physicians Program (average Foreign Medical Graduate Program response = 4.43±0.65; average other response = 3.79±0.94; Figure 2) and their ideal modality for learning anatomy assuming no health risk (hybrid = 3.79±0.94; fully in-person = 3.36±0.85). Finally, student respondents (n = 143) were "satisfied" (4.28±0.85) with the external resources provided to them by the NYITCOM anatomy instructors.

Finally, the hybrid learning model did not negatively affect students overall feeling of preparedness for examination. Students felt that the hybrid learning model "prepared" (4.18±0.74; 1 = very unprepared; 2 = unprepared; 3 = neutral; 4 = prepared; 5 = very prepared) them for practical examinations (Figure 2). Students also believed their hybrid anatomy education was "neutral/equal" (3.24±1.05; 1 = strongly disadvantaged; 2 = disadvantaged; 3 = neutral/equal; 4 = advantaged; 5 = strongly advantaged) compared to traditional anatomy education in previous years (Table 2). This response was significantly influenced both by enrollment in the Foreign Medical Graduate Program (average Foreign Medical Graduate Program response = 4.00±1.11; average other response = 3.14±1.01; Figure 2) and by their ideal modality for learning anatomy assuming no health risk (hybrid = 3.62±0.87; fully in-person = 2.52±0.97; Figure 2).

DISCUSSION

Overall perceptions of the hybrid model

Student perception of the hybrid prosection-based anatomical curriculum was largely positive. This structure aligned with student educational preferences both assuming no health risk and given the current health risk associated with Covid-19. Generally, students felt that their education was equal compared to previous years, and those enrolled in the Foreign Medical Graduate Physicians Program felt advantaged as opposed to disadvantaged. Inclusion of Foreign Medical Graduate Program students provides a unique perspective as these students have experienced a complete medical curriculum in the past, including gross anatomy, and thus have first-hand knowledge with which to compare their experience to a traditional anatomical education.
### TABLE 1 Cohort characteristics of the students that responded to the online survey

| Cohort characteristic | Variable                                      | n (%)         |
|-----------------------|------------------------------------------------|---------------|
| Foreign Medical Graduate Program | Yes                                             | 16 (11.11)    |
|                       | No                                              | 128 (88.89)   |
| Anatomy session       | Section 1                                       | 10 (6.94)     |
|                       | Section 2                                       | 14 (9.72)     |
|                       | Section 3                                       | 35 (24.31)    |
|                       | Section 4                                       | 18 (12.50)    |
|                       | Section 5                                       | 21 (14.58)    |
|                       | Section 6                                       | 12 (8.33)     |
|                       | Section 7                                       | 16 (11.11)    |
|                       | Section 8                                       | 16 (11.11)    |
| Sex                   | Male                                            | 53 (36.80)    |
|                       | Female                                          | 90 (62.50)    |
|                       | Prefer not to answer                            | 1 (0.69)      |
| Age                   | 18–24 years                                     | 94 (65.28)    |
|                       | 25–34 years                                     | 37 (25.69)    |
|                       | 35–44 years                                     | 10 (6.94)     |
|                       | 45–54 years                                     | 2 (1.39)      |
|                       | Prefer not to answer                            | 1 (0.69)      |
| Ethnicity             | Asian or South Asian                            | 60 (41.67)    |
|                       | Black or African American                       | 6 (4.17)      |
|                       | Hispanic or Latino                              | 4 (2.78)      |
|                       | Middle Eastern                                  | 10 (6.94)     |
|                       | Mixed or Multiple                               | 3 (2.08)      |
|                       | White                                           | 53 (36.80)    |
|                       | Prefer not to answer                            | 8 (5.56)      |
| Individuals residing in your primary residence | One (i.e., I lived by myself)                    | 16 (11.11)    |
|                       | Two (i.e., I lived with one other person)       | 19 (13.19)    |
|                       | Three (i.e., I lived with two other people)     | 31 (21.53)    |
|                       | Four or more (i.e., I lived with three or more individuals) | 75 (52.08) |
|                       | Prefer not to answer                            | 3 (2.08)      |
| Which best describes the residents of your household? | Family with at least one person over the age of 65 years and/or was immunocompromised | 24 (19.20) |
|                       | Family and no one that was over the age of 65 years and/or was immunocompromised | 52 (41.60) |
|                       | Medical or graduate student                     | 34 (27.20)    |
|                       | Other                                           | 3 (2.40)      |
| Previous gross anatomy course | Yes—at another institution                      | 38 (26.39)    |
|                       | Yes—at NYIT/NYITCOM                             | 7 (4.86)      |
|                       | No                                              | 96 (66.67)    |
|                       | Not sure                                        | 3 (2.08)      |
| Previous anatomy course cadaver-based | Yes                                              | 22 (48.89)    |
|                       | No                                              | 23 (51.11)    |

*Note: Number of participants (n = 144).*

*Abbreviations: NYIT, New York Institute of Technology; NYITCOM, New York Institute of Technology College of Osteopathic Medicine.*
The preference for a hybrid model even assuming no health risk was surprising, as cadaveric dissection is generally considered not only a rite of passage, but also the most effective method of anatomical education (Granger, 2004; Winkelmann, 2007; Ghosh, 2017; Franchi, 2020; Ross et al., 2021; Zibis et al., 2021). Students may prefer a hybrid model because it allows them to spend more time studying at home, easing the adjustment to medical school (Cuddy et al., 2013; Kinirons et al., 2019; McWatt et al., 2021). Nevertheless, in spite of the given health risk posed by Covid-19, students still preferred to retain some form of in-person cadaveric learning in the form of prosections. These in-person sessions, albeit shorter than in previous years, allowed students to directly ask questions, engage in small-group problem solving activities, and have face-to-face interactions with peers and instructors.

Most importantly, students did not express significant concerns over the risks of Covid-19 infection during these in-person sessions. This feeling of safety was not influenced by age, ethnicity, or sex; however, students enrolled in the Foreign Medical Graduate Program expressed greater concern about their exposure to Covid-19 than the broader student sample.

One unanticipated but noteworthy observation of the revised prosection-based anatomy curriculum was the reduction of cadavers required to successfully carryout the course. In total, only 11 cadavers were required to teach 319 medical students, compared

### TABLE 2

| Question/statement                                                                 | Mean (± SD) |
|------------------------------------------------------------------------------------|-------------|
| 1. How satisfied are you with faculty and academic medicine scholar instruction during in-person weekly sessions? | 4.67 (±0.65) |
| 2. How satisfied are you with the amount of time spent at the instructor-led stations during in-person weekly sessions (i.e., 17 min per station)? | 3.83 (±1.11) |
| 3. How satisfied are you with the self-guided activity stations during in-person weekly sessions? (n = 143)* | 3.52 (±1.01) |
| 4. How satisfied are you with the amount of time spent at the self-guided activity stations during in-person weekly sessions (i.e., 17 min per station)? (n = 142)* | 3.63 (±0.92) |
| 5. How satisfied are you with external resources provided by NYITCOM anatomy? | 4.28 (±0.85) |
| 6. Assuming the current health risk (i.e., infection with SARS-CoV-2), I would have liked access to the cadavers outside of the regularly scheduled laboratory-time. (n = 143)* | 3.89 (±1.08) |
| 7. The NYITCOM anatomy course promoted teamwork during in-laboratory weekly sessions. (n = 143)* | 4.13 (±0.85) |
| 8. The NYITCOM anatomy course fostered my appreciation for human anatomy | 4.56 (±0.59) |
| 9. At any point in NYITCOM Anatomy Laboratory, were you concerned about your health (i.e., infection with SARS-CoV-2 due to exposure in the laboratory)? | 1.97 (±1.00) |
| 10. Compared to previous years, what do you believe about your current anatomy education? | 3.24 (±1.05) |
| 11. How prepared did you feel for the anatomy practical examinations? | 4.18 (±0.74) |
| 12. How satisfied are you with the virtual laboratory activities that utilize Complete Anatomy? (n = 93)* | 3.95 (±0.88) |

Note: Total number of participants (n = 144).

*For some questions, all 144 participants did not provide a response and in these instances, a revised n is provided. Data were collected based on the five-point Likert scale, following scale was used: for questions 1 to 5 and 12 (1 = very unsatisfied; 5 = very satisfied); for questions 6 to 9 (1 = strongly disagree; 5 = strongly agree); for question 10 (1 = strongly disadvantaged; 5 = strongly advantaged); and for question 11 (1 = very unprepared; 5 = very prepared).

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**Figure 1** Bar graph depicted percentage of students' responses regarding health risk in taking anatomy laboratory classes at New York Institute of Technology College of Osteopathic Medicine. Number of participants (n = 144).
with an average of 42 cadavers over roughly equivalent cohort sizes in previous years. Thus, prosection-based courses (either hybrid or fully in-person) may represent a viable and satisfactory alternative during times when the availability of cadavers is limited.

Weaknesses of a hybrid educational model

While the revised curriculum was generally well-received, two deficiencies were frequently noted: (1) lack of access to the cadavers outside the regularly scheduled in-person laboratory times, and (2) the composition of the self-study stations. Extracurricular access to cadavers was limited to reduce potential unaccounted transmission events between students (Yu & Yang, 2020), and to prevent cadaveric prosections from drying out. However, 69.2% of respondents either agree or strongly agree that they would have appreciated access to the cadavers outside the scheduled laboratory time despite the current health risk. One possible solution would be to create supervised “prosection access” times where specific anatomy sections are allowed timed entry to the laboratory.

The purpose of the self-study stations, meanwhile, was to stimulate curiosity and foster more direct self-engagement, which has been linked to improved retention and retrieval of information (Slavin, 1996; Mayer, 2004; Dolmans & Schmidt, 2006). However, other work suggests that students appreciate (Verhoeven et al., 2002; Kirschner et al., 2006) and demonstrate a greater recall of anatomical knowledge (Kooloos et al., 2012) with strictly-guided stations because they allow students to focus their attention more easily on the essentials of the session. Thus, one future compromise could be to provide more direct instructions for the self-guided activities [e.g., “Study the insertions of the extensor tendons. Use your atlas or one of the prosected specimens” versus “Study the insertion of extensor tendons and discuss how these tendons acts on the distal interphalangeal joints”; example from Kooloos et al. (2012)]. More time and cost-intensive interventions include increasing the number of instructors per session, to ensure at least one instructor is present at each station to help direct students through station activities.

The foreign medical graduate program

Participation in the Foreign Medical Graduate Physicians Program frequently affected student responses, both with reference to perceptions of the curriculum itself and to the risk of Covid-19 infection during in-person sessions. Specifically, Foreign Medical Graduate Physicians reported a more positive perception of self-study stations, and a greater concern over the risk of Covid-19 infection during in-person anatomy sessions. While the limited sample \( n = 16 \) of students enrolled in the Foreign Medical Graduate Program makes any particular conclusion tenuous, greater concern about the transmission of Covid-19 could reflect their previous medical training and thus greater awareness of the
risks posed to their health. Individuals enrolled in the Foreign Medical Graduate Program also tended to be older and have a greater number of individuals residing in their household; both factors are known to influence behaviors in response to Covid-19 (Li et al., 2020; Nepomuceno et al., 2020). However, neither of these variables were found to be independently significant within our logistic ordinal regression models. With regards to their perceptions of self-guided study, meanwhile, it is possible that the previous experiences in medicine and medical education of the Foreign Medical Graduate Physicians enabled them to draw more independent conclusions from the material directly, without the presence of an instructor.

Virtual anatomy resources

Multiple learning resources were made available for students to use while away from campus, including digital anatomical guides such as NetAnatomy and Complete Anatomy. Previous studies that have demonstrated that, despite their utility, such online programs provide significantly lower rates of self-perceived learning and satisfaction (Hale et al., 2009; Paechter et al., 2010; Mathiowetz et al., 2016; Franchi, 2020). There is also a steep learning curve associated with using these programs for both teachers and students (Doubleday et al., 2011), with many students finding it difficult to manipulate models and focus on structures of interest (Attardi & Rogers, 2015; Attardi et al., 2016), thus further bringing into question their usefulness in times as challenging as a pandemic (Franchi, 2020). However, it should be noted that, of the respondents that selected external resources as the most helpful aspect of the curriculum for learning anatomy, access to NetAnatomy was the most frequent response (Table 2). Unlike the more sophisticated three-dimensional models and animations available in some virtual resource packages, NetAnatomy is a website that uses two-dimensional images that are similar to what the students might experience in the anatomy laboratory because the dissections are well-done, but not flawless. Additionally, the images are organized in a way that guides the students through the dissection and important structures. While users are able to simply look through the labeled structures, additional text and highlighted tips are also available for students to orient themselves and distinguish different structures. Perhaps most relevant to the students, there is not an overwhelming amount of information for every structure, which is often a complaint that arises when using three-dimensional atlases (Doubleday et al., 2011; Attardi et al., 2016; Mathiowetz et al., 2016). A quiz feature also allowed students to test their anatomical knowledge. Finally, NetAnatomy highlights any anomalies in the dissected cadavers. While in certain circumstances this may be confusing for the students, NetAnatomy provides a detailed description of the illustrated anomaly and an explanation of the normal anatomy. As recognition of variation is an oft-cited criticism of online anatomical platforms (Mathiowetz et al., 2016), this is a welcome and valuable addition that likely contributes to positive perceptions of this particular platform.

Limitations of the study

The present study was limited by a number of factors. First, the students at NYITCOM are subject to receiving numerous survey invitations throughout the year, leaving them susceptible to "survey fatigue". Students with "survey fatigue" may opt out of taking a survey at all, or simply click through it without providing thoughtful responses. This can lower the response rate and decrease the validity of the responses, respectively. Students may also have been deterred from taking this survey because they were expected to take a similar anatomy course evaluation questionnaire administered by the NYITCOM anatomy department at the immediate end of the course. These surveys were distinguished in the email invitation; however, the limitation of students’ using their discretion to read the entire email still existed.

Secondly, having completed the gross anatomy course approximately one month prior to the administration of the survey left a small, but notable possibility for recall bias in the students’ responses. Furthermore, it should be noted that authors, A.F.S. and B.J.B., participated in the student-driven dissection-based anatomy curriculum from previous years at NYITCOM. Thus, a small potential for bias existed when drafting the survey questions, although every attempt was made to design neutral, non-leading questions.

Further, this study was limited to a single institution in New York State, which has a considerably greater rate of compliance with Covid-19 mitigation behaviors than other regions within the United States (NYSDOH, 2020); thus, the recommendation for hybrid dissection-based anatomical education is strictly dependent upon proper compliance with Covid-19 mitigation behaviors and a relatively low transmission rate in the region of interest.

A final limitation to consider is that, with the nature of the pandemic inciting rapid change in virtually every sector including anatomy education, the collection of objective data was not the focus of this study; however, it is important to note that subjective data does hold value considering the survey population comprises the future of healthcare in the United States.

CONCLUSIONS

This study has demonstrated that the hybrid anatomy curriculum described above—which shifted away from traditional student-driven cadaver-based dissections and toward dissection-based learning—was received favorably by first-year medical students in light of the current pandemic. Overall, this course aligned with student preferences for anatomical education both assuming no health risk and given the current health risk of contracting Covid-19. Potential options for improving the curriculum where students felt comparatively dissatisfied should be explored, including access to the cadavers outside of the scheduled laboratory times and the composition of the self-study stations.

A crucial aspect of the modified anatomy curriculum was the maintenance of student safety during in-person anatomy
laboratory sessions. It is proposed that, with proper safety protocols in place, medical schools should consider implementing a-progression-based gross anatomy curriculum, inclusive of access to pilot-tested online anatomical platforms, in order to provide high-quality education to their students during both the pandemic and its potential sequelae. This would ameliorate concerns regarding viral exposure from fully in-person dissection-based sessions as well as provide a better, more gratifying alternative to a completely virtual anatomy course. Institutions are also encouraged to adapt their curricula to the specific needs and desires of their student body and administration, and to continue to enhance their provision of quality anatomical education to future physicians regardless of the status of the pandemic.

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CONFLICTS OF INTEREST

The authors have no other conflicts of interest to report.

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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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