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An Observational Study of the Impact of Attendance on Pre-Clinical Undergraduate Medical Education Performance

Luke Yeager*, Steele Valenzuela, Miguel Marino, Patricia A. Carney

Department of Family Medicine, Oregon Health & Science University, Portland, Oregon, USA

***Corresponding author:** Luke Yeager, Fourth Year Medical Student, Department of Family Medicine, Oregon Health & Science University, Portland, Oregon, USA. Tel: +15037563905; Email: yeagerl@ohsu.edu

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Abstract

Background: With the availability of online lecture recordings and other online information, pre-clinical medical students now have access to many course materials without being physically present in the classroom.

Objectives: To conduct an in-depth assessment of whether or not high versus moderate physical attendance affects performance in the context of pre-clinical medical education at an allopathic medical school in the Pacific Northwest.

Methods: In this observational retrospective cohort study, a self-administered survey was used to assess high versus moderate self-reported attendance (≥80% vs. <80%). This information was linked to student examination scores, stratified by subject-matter block (Fundamentals of Medicine; Blood & Host Defense; Skin, Bone & Musculature; Cardiopulmonary & Renal; Hormones & Digestion; Nervous System & Function; and Developing Human) and learning session type (large group sessions, clinical skills lab, science skills lab, and anatomy sessions). Multiple linear regression models were performed to test the association between attendance and component scores, controlling for statistically significant demographic and educational factors.

Results: Of 139 eligible participants, 106, provided information for analyses (76%). Of 130 session types and assessment score combinations tested, 123 instances (94.6%) were not associated with any significant relationships between attendance and performance at ≥80%. In six instances, greater attendance was associated with an improved component score. In one instance, less attendance was associated with an improved component score.

Conclusion: Attendance at ≥80% was not consistently associated with improved assessment scores. It is reasonable to conclude that complete attendance alone is not beneficial to performance for a vast majority of educational sessions.

Keywords: Assessments; Attendance; Online lecture recordings; Performance; Undergraduate medical education

Introduction

While attending lectures during the pre-clinical years of medical school has traditionally been viewed as standard educational practice [1] the availability of online lecture recordings and live streaming now allows access to all lecture materials without necessitating physical presence in the classroom. However, there is controversy over the utility of recorded lectures substituting for classroom attendance [1,2]. Some argue that lecture recordings allow for improved learner flexibility and enhanced learning [1,3]. Conversely, some tend to view attendance as serving an important function in the profession socialization process [2]. Such perspectives view absenteeism as having a negative impact on lecture effectiveness and professional development [2]. At least one study found that students consider lecture recordings to be an adequate substitute for classroom attendance [2]. Another study found that students perceive recorded lectures to improve their speed of knowledge acquisition, along with their ability to focus on the material and learn more [1]. Yet another study found that students' self-reported decisions for choosing recordings over attendance are motivated by individualized learning preferences and needs, with the ultimate goal being to maximizing learning [3].

These motivations are congruent with adult learning theory, which suggests that as an individual matures, the motivation to learn becomes more internal and self-directed, with adult

learners preferring to discover knowledge for themselves, also known as experiential learning, rather than depending on others [4]. However, students who did report choosing attendance over recordings were motivated by a desire to show professionalism and respect for the instructor and to interact with their classmates [1]. These findings highlight differing viewpoints regarding the function and importance of attendance in pre-clinical medical education. Given the existence of digital educational innovations coupled with existing controversies, there is growing interest in understanding current student attendance behaviors [1,3,5].

Only a small number of studies have specifically examined the relationship between attendance and performance. However, methodological limitations in these studies suggest a need for further research. Two studies focused on the relationship between attendance in class and online lectures only, and found no impact on standardized national licensing examinations [5,6]. Another study measured medical students' clinical performance after just three lectures conducted either in person or via a recorded lecture group and found that both were equally effective [7]. A randomized trial with 12 students attending a live lecture and 17 students exposed to a digital lecture on an internal medicine clinical rotation found that recordings were a suitable substitute for live lectures when comparing student examination performance [8].

While these studies collectively suggest that attendance may be neutral to performance, several methodological issues could have affected study findings, such as student participants being in different phases of medical school (pre-clinical and clinical), sample sizes often being small, different outcome variables being measured, approaches involving a single class or lecture, or attributing students to study groups using student choice rather than randomization.

To overcome many of these limitations, we conducted a detailed examination, using a robust retrospective cohort study design, of how pre-clinical classroom attendance of medical students affected the attainment of medical knowledge, as assessed by several methodological approaches. We assessed attendance in large group lectures, clinical skills labs, science skills labs, and anatomy labs for all classes considered part of the pre-clinical curriculum (18 months) at Oregon Health & Science University (OHSU) and tested the relationship between attendance and performance on a comprehensive set of assessments that included five component scores: 1) Weekly multiple choice exams (quizzes), 2) mini-clinical skills exams, 3) final block exams, 4) NBME final exam, and 5) Clinical science and skills exam.

Methods

Study Setting

OHSU is Oregon's only allopathic medical school and it enrolls approximately 140 students annually. Attendance policies vary according to educational session. For example, attendance at large group lectures were expected but not required, as lecture recordings and live streaming of large group sessions were available to students. Attendance at clinical skills labs, science skills labs, and anatomy labs was required, as there was neither live streaming nor recordings of these sessions. Absent students had access to online materials discussed in the sessions, such as study guides and reading assignments, but not the discussion or experiences that occur in real time. Attendance was not specifically tracked in any required or non-required sessions.

Study Design and Participants

The study design was an observational retrospective cohort study with eligibility criteria for participants including enrollment at OHSU's School of Medicine in the matriculating class of 2014, which included 139 eligible participants, all of whom were invited to take part. The study was introduced to eligible students during class time and via e-mail in January 2015. Students were informed that the study would involve completing a brief survey on attendance, which would be linked to their test score data. Students who did not wish to take part could opt out of the study, and we did not pull their data or administer the survey to them. OHSU's institutional review board approved all study activities (IRB # 15599).

Data Collection

To assess attendance (predictor variable) and student's demographic and educational characteristics (potential confounders), we administered a web-hosted survey to medical students who completed the pre-clinical portion (first 18 months) of medical school at OHSU. The survey, which took 10 minutes to complete, was administered in February 2016 at a time that did not conflict with other common survey administrations. More specifically, the survey assessed attendance according to the percentage of different types of class sessions attended (large group sessions, clinical skills lab, science skills lab, and anatomy sessions) across the seven subject blocks in the pre-clinical program, which (in chronological order) were: Fundamentals; Blood & Host Defense; Skin, Bone & Musculature; Cardiopulmonary & Renal; Hormones & Digestion; Nervous System & Function; and Developing Human. Of note, anatomy sessions did not occur in the Fundamentals or Blood & Host Defense subject blocks, but did occur in all other blocks. The response categories for attendance included attended ≥80% of sessions, attended between 79%-60%, 40%-59%, 20%-39% or <20% of sessions. Demographic data collected on the survey included age, gender identity, race, ethnicity, undergraduate GPA, educational program (MD, MD/PhD etc.) and MCAT score. Undergraduate GPA included overall GPA and science specific GPA. MCAT scores included the overall score and stratification by subject type (verbal reasoning, physical sciences, and biological sciences).

The outcome variables included five component scores for each of the above seven subject blocks. Component 1 was the mean of multiple choice exams, which occurred weekly for each block for a total of 68 weeks. Component 2 was the mean of mini-clinical skills exams with standardized patients, which occurred approximately every other week for a total of 34 weeks. Component 3 was a final exam for the respective subject block, which was written by school of medicine faculty and occurred once at the end of the block. Component 4 was another final exam for the respective subject block, which was comprised of items pulled from a pool of retired National Board of Medical Examiners (NBME) questions that allowed students to compare their scores to national norms. The selection of questions from the retired question pool was also done by school of medicine faculty. Component 5 was another clinical exam for each respective block that encompassed anatomy, science skill (histology/pathology/microbiology) and an additional clinical skills exam. These five components represented comprehensive scores for pre-clinical performance at OHSU.

Data on all consenting student examination scores were pulled from OHSU's student portfolio system, called Research & Evaluation Data for Educational Improvement (REDEI). Responses to the attendance survey were then linked to student performance on all component scores in each block using a 'token system,' where a unique identifier was generated to link student responses to outcome variables. This token identifier replaced student names creating an anonymous de-identified link between survey responses and students' assessment scores for analyses.

Data Analyses

Summary statistics consisted of frequency distributions for all study variables, which was done to guide the analytic approach. Variables on attendance were collapsed to create meaningful sized groups. For MCAT scores, we created the following categories: 6-9, 10-11, and ≥12. Analysis of variance was used to compare the component score means among various demographic and educational groupings.

Aggregate attendance data were calculated for all subject blocks and session types. We then identified instances where attendance significantly affected component scores across all subject blocks and session types. Attendance responses were grouped into two categories for each classroom session type. Those who attended ≥80% of sessions and those who attended <80%. This cut point was chosen based on the distribution of attendance responses, creating two comparable sample-group sizes. For each of the five component assessment scores, a mean score was calculated according to each attendance category across all session types and subject blocks. Thus, there were two mean scores, one each for the two attendance groups (students with ≥80% and <80% attendance), for a total of 130 session type, subject block, and component score combinations. A set of multiple linear regression models were performed to test the association between attendance and component scores controlling for statistically significant demographic and educational factors, including age, sex, race, educational program, undergraduate GPA and MCAT score. This identified statistically significant differences of component mean scores between attendance pairings. Lastly, we used these multiple linear regression models to estimate adjusted mean component scores by attendance groups. Our null hypothesis was that there would be no association between attendance and component scores. We performed all data analyses using R version 3.3.3 and all tests were two-tailed with the alpha set at 0.05 to determine statistical significance.

Results

Of the 139 eligible study participants, 115 responded to the survey (82.7%). Of these, 9 provided incomplete information and were excluded, leaving 106 completed survey responses (76.3%) for use in analysis. The mean age of students was 27.2 years (standard deviation [SD] was 3.2), and the age range was 23-41 (Table 1). A slight majority of students were male (53.8) and the majority were white (79.2) with 4.7% Hispanic representation. The majority of participating students (94.3%) were in the MD only program (Table 1), the mean undergraduate GPA was 3.73 (SD=0.19) with a mean science GPA 3.68 (SD=0.24). The physical science mean of participating students MCAT score was 10.5, the verbal reasoning mean was 9.9, and the biological sciences mean was 10.8 with an overall MCAT score mean of 31.4. Demographic and educational factors that were significantly associated with component scores included: age, race, undergraduate GPA, and MCAT score (Table 1).

Overall Summary Scores for Core Foundations in Medicine Blocks*						
	Total N (%)	Component 1 Weekly MCE Quizzes	Component 2 Mini-Clinical Skills	Component 3 Final Block Exam	Component 4 NBME Final Exam	Component 5 Clinical Science & Skills Exam
Overall	106 (100.0)	86.2 (5.0)	91.8 (6.0)	84.9 (6.5)	86.1 (7.6)	88.1 (6.0)
Demographic Characteristics						
Mean Age in Years (SD*)	27.2 (3.2)	-	-	-	-	-
Range	[22.8 - 40.5]	-	-	-	-	-
Age Group 1; [22.8 – 25.3]	33 (31.1)	**86.9 (5.2)**	92.5 (6.0)	**86.0 (6.7)**	**87.1 (8.0)**	**89.4 (5.5)**
Age Group 2; [25.4 – 27.7]	32 (30.2)	**86.1 (4.9)**	91.4 (6.0)	**84.9 (6.3)**	**86.6 (6.8)**	**87.8 (5.8)**
Age Group 3; [27.9 – 40.5]	32 (30.2)	**85.9 (4.6)**	91.8 (5.8)	**84.2 (6.5)**	**85.3 (7.6)**	**87.5 (6.1)**
Unknown	9 (8.5)	**84.8 (5.4)**	91.0 (6.8)	**83.1 (5.7)**	**83.7 (7.8)**	**86.4 (6.8)**
Sex						
Male	57 (53.8)	86.2 (4.8)	91.8 (6.0)	84.7 (6.6)	86.6 (7.4)	88.0 (6.1)
Female	49 (46.2)	86.1 (5.3)	91.9 (6.1)	85.1 (6.4)	85.6 (7.7)	88.1 (5.8)
Race						
White	84 (79.2)	**86.4 (5.0)**	**92.0 (6.0)**	**85.2 (6.6)**	**86.5 (7.3)**	**88.2 (5.8)**
Black	1 (0.9)	**82.8 (2.0)**	**87.8 (7.8)**	**80.1 (4.0)**	**76.8 (4.4)**	**83.0 (5.7)**
Asian or Pacific Islander	16 (15.0)	**85.6 (4.6)**	**91.5 (6.4)**	**84.1 (5.8)**	**85.1 (8.1)**	**88.4 (6.2)**
American Indian/Alaska Native	1 (0.9)	**79.5 (4.1)**	**85.6 (5.9)**	**81.5 (8.2)**	**75.1 (5.6)**	**79.0 (8.8)**
Unknown	4 (3.8)	**85.2 (6.4)**	**92.0 (5.0)**	**83.3 (7.4)**	**86.9 (7.4)**	**87.7 (4.8)**
Ethnicity						
Non-Hispanic	101 (95.3)	**83.5 (5.2)**	90.6 (6.6)	**81.7 (7.2)**	**80.6 (8.7)**	**85.7 (8.1)**
Hispanic or Latino	5 (4.7)	**86.3 (5.0)**	91.9 (6.0)	**85.0 (6.4)**	**86.4 (7.4)**	**88.2 (5.8)**
Educational Characteristics						
Educational Program						
MD Only	100 (94.3)	86.1 (5.0)	91.8 (6.1)	84.8 (6.6)	86.0 (7.6)	88.0 (6.0)
MD/MPH	2 (1.9)	88.4 (5.0)	92.2 (4.8)	87.7 (4.1)	90.7 (4.5)	90.2 (4.2)
MD/PhD	4 (3.8)	86.3 (4.0)	92.9 (5.4)	85.8 (5.8)	86.2 (7.2)	88.4 (5.8)
Undergraduate GPA						
Overall; Mean (SD)	3.73 (0.19)	-	-	-	-	-
Group 1; [2.97 – 3.65]	28 (26.4)	**85.4 (4.8)**	**90.8 (6.2)**	**83.6 (6.4)**	**84.3 (7.5)**	**86.5 (6.4)**
Group 2; [3.66 – 3.83]	28 (26.4)	**85.6 (4.9)**	**91.5 (6.4)**	**84.6 (6.8)**	**85.8 (8.0)**	**88.1 (5.8)**
Group 3; [3.84 – 4.00]	28 (26.4)	**87.4 (4.6)**	**92.9 (5.4)**	**86.0 (6.2)**	**87.7 (6.8)**	**89.8 (5.3)**
Unknown	22 (20.8)	**86.3 (5.6)**	**92.2 (6.0)**	**85.5 (6.4)**	**86.8 (7.6)**	**87.9 (5.8)**
Science GPA; Mean (SD)	3.68 (0.24)	-	-	-	-	-
Group 1; [3.00 – 3.60]	26 (24.5)	**85.3 (5.3)**	91.2 (6.5)	**83.4 (6.6)**	**84.3 (7.7)**	**86.5 (6.3)**
Group 2; [3.61 – 3.85]	26 (24.5)	**85.8 (4.5)**	91.3 (6.2)	**84.6 (6.5)**	**85.3 (7.9)**	**87.7 (6.0)**
Group 3; [3.86 – 4.00]	25 (23.6)	**86.6 (4.7)**	92.3 (5.8)	**86.0 (6.0)**	**88.2 (6.7)**	**89.7 (5.4)**
Unknown	29 (27.4)	**86.8 (5.3)**	92.5 (5.6)	**85.5 (6.6)**	**86.7 (7.3)**	**88.4 (5.7)**

MCAT Score						
Physical Science; Mean (SD)	10.5 (1.6)	-	-	-	-	-
Group 1; [6 – 9]	23 (21.7)	**85.2 (5.3)**	91.3 (6.2)	**84.4 (6.8)**	**84.9 (7.8)**	**87.1 (6.2)**
Group 2; [10 – 11]	45 (42.5)	**86.3 (4.7)**	91.8 (6.0)	**84.7 (6.3)**	**85.8 (7.5)**	**87.9 (6.1)**
Group 3; [12 – 15]	21 (19.8)	**88.5 (4.4)**	92.7 (5.8)	**86.6 (6.3)**	**89.7 (6.1)**	**89.7 (4.9)**
Unknown	17 (16.0)	**84.3 (4.9)**	91.5 (6.2)	**83.8 (6.6)**	**84.1 (7.7)**	**87.8 (6.1)**
Verbal Reasoning; Mean (SD)	9.9 (1.5)	-	-	-	-	-
Group 1; [6 – 9]	33 (31.1)	**86.0 (5.2)**	91.9 (5.7)	**84.4 (6.7)**	**86.2 (7.6)**	88.3 (5.6)
Group 2; [10 – 11]	43 (40.6)	**86.8 (4.8)**	92.1 (6.1)	**85.4 (6.5)**	**86.5 (7.6)**	88.1 (6.2)
Group 3; [12 – 15]	13 (12.3)	**87.1 (4.7)**	91.2 (6.6)	**85.7 (5.4)**	**87.2 (6.7)**	87.7 (6.0)
Unknown	17 (16.0)	**84.3 (4.9)**	91.5 (6.2)	**83.8 (6.6)**	**84.1 (7.7)**	87.8 (6.1)
Biological Sciences; Mean (SD)	10.8 (1.6)	-	-	-	-	-
Group 1; [6 – 9]	14 (13.2)	**85.7 (5.7)**	91.3 (6.6)	**83.3 (7.1)**	**83.5 (7.9)**	**86.4 (6.3)**
Group 2; [10 – 11]	49 (46.2)	**86.2 (4.9)**	91.7 (6.1)	**85.0 (6.4)**	**86.0 (7.8)**	**87.7 (6.1)**
Group 3; [12 – 15]	26 (24.5)	**87.5 (4.4)**	92.6 (5.6)	**86.2 (5.9)**	**89.0 (5.7)**	**89.8 (4.9)**
Unknown	17 (16.0)	**84.3 (4.9)**	91.5 (6.2)	**83.8 (6.6)**	**84.1 (7.7)**	**87.8 (6.1)**
Overall; Mean (SD)	31.4 (3.1)	-	-	-	-	-
Group 1; [19 – 29]	23 (21.7)	**85.3 (5.5)**	91.8 (5.8)	**83.3 (7.1)**	**84.4 (7.6)**	**87.5 (6.0)**
Group 2; [30 – 32]	41 (38.7)	**85.7 (4.9)**	91.6 (6.0)	**84.7 (6.6)**	**85.6 (7.9)**	**87.4 (6.1)**
Group 3; [33 – 39]	26 (24.5)	**88.3 (4.3)**	92.8 (5.9)	**86.8 (5.7)**	**89.4 (5.7)**	**89.9 (5.3)**
Unknown	16 (15.1)	**84.8 (4.5)**	90.9 (6.6)	**84.2 (5.8)**	**84.2 (7.7)**	**87.5 (5.9)**

*All Blocks Combined

Bold text indicates that a p-value<0.05 was identified using an analysis of variance model indicating difference among group means are statistically significant.

Table 1: Demographic and Educational Characteristics of Student Participants According to Summary Component Scores.

Table 2 shows the distribution of self-reported attendance according to the seven subject blocks in the pre-clinical program (in chronological order). Attendance at large group sessions had the greatest decline, with 75% of students reporting they attended ≥80% of sessions in the first subject block (Fundamentals) to 23% and 28% of students attending ≥80% of large group sessions in the last two blocks (Nervous System & Function and Developing Human, respectively). Clinical skills lab attendance dropped from 96% (Fundamentals) to 69% (Developing Human) of students reporting they attended ≥80% of sessions. Science skills lab attendance dropped from 93% (Fundamentals) to 69% (Developing Human) of students reporting they attended ≥80% sessions. Anatomy sessions had the best attendance, though it did decline from 91% (Skin, Bones & Musculature) to 82% (Developing Human) of students reporting they attended ≥80% sessions.

	0-19%	20-39%	40-59%	60-79%	≥80%
Fundamentals					
Large Group Sessions	5 (4.7%)	5 (4.7%)	5 (4.7%)	11 (10.4%)	80 (75.5%)
Clinical Skills Lab	0	0	2 (1.9%)	2 (1.9%)	102 (96.2%)
Science Skills Lab	0	0	2 (1.9%)	5 (4.7%)	99 (93.4%)
Blood & Host Defense					
Large Group Sessions	9 (8.5%)	3 (2.8%)	7 (6.6%)	13 (12.3%)	74 (69.8%)
Clinical Skills Lab	0	0	2 (1.9%)	3 (2.8%)	101 (95.3%)
Science Skills Lab	0	1 (0.9%)	2 (1.9%)	5 (4.7%)	98 (92.5%)
Skin, Bones & Musculature					
Large Group Sessions	12 (11.3%)	8 (7.5%)	10 (9.4%)	12 (11.3%)	64 (60.4%)
Clinical Skills Lab	0	0	3 (2.8%)	5 (4.7%)	98 (92.5%)
Science Skills Lab	0	1 (0.9%)	5 (4.7%)	4 (3.8%)	96 (90.6%)
Anatomy Sessions	0	1 (0.9%)	3 (2.8%)	6 (5.7%)	96 (90.6%)
Cardiopulmonary & Renal					
Large Group Sessions	17 (16.0%)	11 (10.4%)	16 (15.1%)	16 (15.1%)	46 (43.4%)
Clinical Skills Lab	0	1 (0.9%)	4 (3.8%)	6 (5.7%)	95 (89.6%)

Science Skills Lab	0	3 (2.8%)	3 (2.8%)	7 (6.6%)	93 (87.7%)
Anatomy Sessions	0	1 (0.9%)	2 (1.9%)	6 (5.7%)	97 (91.5%)
Hormones & Digestion					
Large Group Sessions	33 (31.1%)	14 (13.2%)	14 (13.2%)	12 (11.3%)	33 (31.1%)
Clinical Skills Lab	0	2 (1.9%)	4 (3.8%)	14 (13.2%)	86 (81.1%)
Science Skills Lab	3 (2.8%)	3 (2.8%)	5 (4.7%)	12 (11.3%)	83 (78.3%)
Anatomy Sessions	0	1 (0.9%)	3 (2.8%)	11 (10.4%)	91 (85.8%)
Nervous System & Function					
Large Group Sessions	50 (47.2%)	15 (14.2%)	8 (7.5%)	9 (8.5%)	24 (22.6%)
Clinical Skills Lab	3 (2.8%)	5 (4.7%)	10 (9.4%)	14 (13.2%)	74 (69.8%)
Science Skills Lab	7 (6.6%)	5 (4.7%)	9 (8.5%)	8 (7.5%)	77 (72.6%)
Anatomy Sessions	3 (2.8%)	3 (2.8%)	8 (7.5%)	7 (6.6%)	85 (80.2%)
Developing Human					
Large Group Sessions	49 (46.2%)	11 (10.4%)	6 (5.7%)	10 (9.4%)	30 (28.3%)
Clinical Skills Lab	5 (4.7%)	11 (10.4%)	9 (8.5%)	8 (7.5%)	73 (68.9%)
Science Skills Lab	8 (7.5%)	9 (8.5%)	6 (5.7%)	10 (9.4%)	73 (68.9%)
Anatomy Sessions	6 (5.7%)	1 (0.9%)	5 (4.7%)	7 (6.6%)	87 (82.1%)

Table 2: Level of Attendance According to Block and Type of Educational Session (n=106). Frequency counts (row %) reported.

Table 3 shows the adjusted mean component scores for the seven subject blocks in the pre-clinical program. In 123 of the 130 (94.6%) session type and mean component score combinations tested, we found no statistically significant differences between attendance groups and performance (Table 3). In six (5.4%) instances, we found ≥80% attendance was associated with an improved component score relative to <80% attendance. In one instance, we found <80% attendance was associated with a statistically improved component score relative to ≥80% attendance. These instances are described in detail below.

Adjusted Means Block Summary Scores by Level of Attendance						
	Totals N (%)	Component 1 Weekly MCE Quizzes	Component 2 Mini-Clinical Skills	Component 3 Final Block Exam	Component 4 NBME Final Exam	Component 5 Clinical Science & Skills Exam
	106 (100.0)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Fundamentals						
Overall (Unadjusted Means)		86.6 (4.5)	98.5 (2.9)	84.5 (5.9)	83.2 (8.4)	91.1 (4.1)
Large Group Sessions						
<80%	26 (24.5)	85.3 (1.6)	97.9 (1.1)	82.5 (2.1)	81.7 (2.9)	90.6 (1.5)
≥80%	80 (75.5)	85.3 (1.5)	98.4 (1.0)	82.7 (2.0)	80.7 (2.8)	91.1 (1.4)
Clinical Skills Lab						
<80%	4 (3.8)	85.8 (2.7)	100.4 (1.8)	80.0 (3.5)	81.9 (5.0)	92.9 (2.5)
≥80%	102 (96.2)	85.3 (1.4)	98.1 (1.0)	82.8 (1.9)	81.0 (2.7)	90.8 (1.4)
Science Skills Lab						
<80%	7 (6.6)	86.9 (2.3)	100.2 (1.6)	84.6 (3.0)	83.7 (4.2)	89.5 (2.2)
≥80%	99 (93.4)	85.3 (1.4)	98.2 (1.0)	82.6 (1.9)	81.0 (2.7)	90.9 (1.4)
Blood Host & Defense						
Overall (Unadjusted Means)		85.4 (4.4)	96.3 (4.5)	85.0 (6.4)	84.6 (7.7)	85.0 (7.5)
Large Group Sessions						
<80%	32 (30.2)	84.3 (1.6)	91.4 (1.5)	85.2 (2.3)	83.2 (2.7)	81.5 (2.6)

≥80%	74 (69.8)	84.2 (1.6)	91.3 (1.4)	83.9 (2.2)	82.7 (2.6)	81.8 (2.5)
Clinical Skills Lab						
<80%	5 (4.7)	86.1 (2.6)	90.8 (2.4)	87.1 (3.7)	79.3 (4.4)	86.0 (4.2)
≥80%	101 (95.3)	84.1 (1.5)	91.4 (1.4)	84.3 (2.1)	83.1 (2.5)	81.4 (2.4)
Science Skills Lab						
<80%	8 (7.5)	85.6 (2.2)	91.6 (2.0)	86.5 (3.2)	83.6 (3.8)	82.6 (3.6)
≥80%	98 (92.5)	84.2 (1.5)	91.3 (1.4)	84.3 (2.1)	82.9 (2.5)	81.6 (2.4)
Skin, Bones, & Musculature						
Overall (Unadjusted Means)		88.6 (4.6)	92.1 (3.4)	86.5 (5.9)	86.6 (6.4)	85.1 (5.6)
Large Group Sessions						
<80%	42 (39.6)	84.2 (1.5)	90.4 (1.1)	86.2 (2.1)	82.6 (2.1)	82.9 (1.9)
≥80%	64 (60.4)	84.8 (1.5)	90.0 (1.1)	86.6 (2.1)	80.3 (2.1)	83.6 (1.8)
Clinical Skills Lab						
<80%	8 (7.5)	85.7 (2.0)	90.6 (1.4)	89.2 (2.7)	83.5 (2.7)	83.9 (2.4)
≥80%	98 (92.5)	84.1 (1.5)	90.0 (1.1)	85.3 (2.1)	80.5 (2.1)	83.0 (1.9)
Science Skills Lab						
<80%	10 (9.4)	85.5 (1.9)	90.8 (1.4)	87.7 (2.6)	82.7 (2.6)	82.3 (2.3)
≥80%	96 (90.6)	84.2 (1.5)	90.0 (1.1)	85.9 (2.1)	80.9 (2.1)	83.6 (1.8)
Anatomy Sessions						
<80%	10 (9.4)	84.1 (2.0)	89.5 (1.4)	87.4 (2.7)	79.3 (2.7)	83.7 (2.4)
≥80%	96 (90.6)	84.7 (1.5)	90.3 (1.1)	86.2 (2.1)	81.9 (2.1)	83.1 (1.8)
Cardiopulmonary & Renal						
Overall (Unadjusted Means)		85.1 (5.1)	93.5 (3.3)	81.3 (5.1)	85.8 (8.1)	90.8 (5.0)
Large Group Sessions						
<80%	60 (56.6)	82.6 (1.7)	91.8 (1.1)	77.1 (1.7)	78.6 (2.6)	90.6 (1.7)
≥80%	46 (43.4)	82.8 (1.8)	92.3 (1.2)	76.1 (1.8)	78.7 (2.7)	89.6 (1.8)
Clinical Skills Lab						
<80%	11 (10.4)	83.9 (2.0)	91.3 (1.4)	77.5 (2.0)	80.3 (3.1)	90.2 (2.0)
≥80%	95 (89.6)	82.0 (1.7)	92.3 (1.2)	76.3 (1.7)	77.8 (2.7)	90.3 (1.8)
Science Skills Lab						
<80%	13 (12.3)	82.9 (2.0)	90.8 (1.3)	77.3 (2.0)	80.3 (3.0)	90.6 (2.0)
≥80%	93 (87.7)	82.6 (1.7)	92.6 (1.2)	76.5 (1.7)	77.8 (2.7)	90.1 (1.7)
Anatomy Sessions						
<80%	9 (8.5)	82.9 (2.2)	91.8 (1.5)	78.2 (2.2)	80.7 (3.4)	89.7 (2.2)
≥80%	97 (91.5)	82.6 (1.7)	92.0 (1.2)	76.2 (1.7)	77.9 (2.7)	90.5 (1.7)

Hormones & Digestion						
Overall (Unadjusted Means)		88.3 (5.2)	86.3 (5.7)	87.4 (6.5)	86.7 (7.6)	87.8 (5.6)
Large Group Sessions						
<80%	73 (68.9)	85.1 (1.8)	84.1 (1.9)	85.9 (2.2)	80.9 (2.5)	**82.0 (1.8)**
≥80%	33 (31.1)	87.4 (1.9)	85.2 (2.0)	87.3 (2.3)	81.6 (2.6)	**85.1 (1.9)**
Clinical Skills Lab						
<80%	20 (18.9)	85.4 (2.1)	83.3 (2.2)	86.4 (2.6)	80.8 (2.9)	81.1 (2.1)
≥80%	86 (81.1)	86.0 (2.8)	84.7 (1.8)	86.4 (2.2)	81.4 (2.4)	83.5 (1.8)
Science Skills Lab						
<80%	23 (21.7)	86.4 (2.1)	83.0 (2.1)	86.0 (2.5)	82.6 (2.8)	81.6 (2.1)
≥80%	83 (78.3)	85.8 (1.8)	84.8 (1.8)	86.5 (2.2)	80.9 (2.4)	83.4 (1.8)
Anatomy Sessions						
<80%	15 (14.2)	85.0 (2.3)	84.0 (2.4)	84.9 (2.8)	81.0 (3.1)	81.1 (2.3)
≥80%	91 (85.8)	86.0 (1.7)	84.5 (1.8)	86.6 (2.2)	81.2 (2.4)	83.3 (1.8)
Nervous System & Function						
Overall (Unadjusted Means)		83.6 (4.9)	88.2 (4.4)	84.0 (8.3)	85.0 (7.4)	87.0 (5.3)
Large Group Sessions						
<80%	82 (77.4)	**82.3 (1.6)**	88.1 (1.4)	80.8 (2.7)	80.3 (2.4)	82.8 (1.7)
≥80%	24 (22.6)	**85.4 (2.0)**	89.8 (1.7)	84.1 (3.3)	80.3 (2.9)	85.2 (2.1)
Clinical Skills Lab						
<80%	32 (30.2)	81.7 (1.8)	87.7 (1.5)	81.3 (2.9)	81.1 (2.5)	82.2 (1.8)
≥80%	74 (69.8)	83.0 (1.7)	88.6 (1.5)	80.6 (2.8)	79.6 (2.5)	83.5 (1.8)
Science Skills Lab						
<80%	29 (27.4)	82.4 (1.8)	87.8 (1.5)	81.6 (2.9)	**82.1 (2.5)**	82.4 (1.8)
≥80%	77 (72.6)	82.5 (1.8)	88.6 (1.5)	80.3 (2.8)	**78.7 (2.4)**	83.3 (1.8)
Anatomy Sessions						
<80%	21 (19.8)	80.9 (1.8)	87.6 (1.6)	80.9 (3.0)	78.5 (2.6)	**81.0 (1.9)**
≥80%	85 (80.2)	83.5 (1.7)	88.6 (1.5)	80.9 (2.9)	81.5 (2.5)	**84.1 (1.7)**
Developing Human						
Overall (Unadjusted Means)		85.5 (4.5)	87.9 (5.2)	85.4 (5.2)	90.9 (4.3)	89.7 (4.6)
Large Group Sessions						
<80%	76 (71.7)	82.7 (1.4)	85.2 (1.7)	83.6 (1.7)	87.8 (1.3)	**86.9 (1.6)**
≥80%	30 (28.3)	83.7 (1.6)	85.8 (1.8)	84.1 (1.9)	88.4 (1.4)	**89.1 (1.7)**
Clinical Skills Lab						
<80%	33 (31.1)	84.0 (1.5)	85.1 (1.8)	83.7 (1.9)	88.1 (1.4)	87.0 (1.7)
≥80%	73 (68.9)	82.5 (1.4)	85.5 (1.7)	83.8 (1.7)	87.9 (1.3)	88.1 (1.6)

Science Skills Lab						
<80%	33 (31.1)	83.9 (1.5)	85.7 (1.8)	83.6 (1.9)	88.0 (1.4)	86.6 (1.7)
≥80%	73 (68.9)	82.6 (1.4)	85.2 (1.7)	83.8 (1.7)	87.9 (1.3)	87.9 (1.6)
Anatomy Sessions						
<80%	19 (17.9)	81.6 (1.7)	**82.7 (1.9)**	83.1 (2.1)	86.9 (1.6)	**84.5 (1.8)**
≥80%	87 (82.1)	83.3 (1.4)	**86.1 (1.6)**	83.9 (1.7)	88.2 (1.3)	**88.3 (1.5)**

Note: **Bold** indicates that a p-value<0.05 was identified using multiple linear regression and the difference between means are statistically significant. A set of multiple linear regression models were performed to test the association between attendance and component scores controlling for statistically significant demographic and educational factors, including age, sex, race, educational program, undergraduate GPA and MCAT score. Adjusted means were estimated from the multiple linear regressions.

Table 3: Adjusted Mean Component Scores According to Type of Educational Session in the Seven Subject Blocks in the Pre-clinical Program.

There were 3 instances (8.6%) where ≥80% attendance in large group sessions was associated with improved performance and 32 instances (91.4%) where no association was found (Table 3). These included Component 1 (weekly quizzes) in the Nervous System & Function Block and Component 5 (Clinical Science & Skills Exam) in both the Hormones & Digestion Block as well as the Developing Human Block. For clinical skill lab there were no significant relationship between attendance (≥80% versus <80%) and performance for any of the 35 session type and component score combinations tested (Table 3). For clinical science skills lab, there was one instance (2.9%) where decreased attendance was associated with improved performance. This involved Large Group Sessions in Hormones and Digestion. For anatomy sessions, there were three instances where attendance was associated with improved performance and 22 instances where no association was found (Table 3). The three instances included Component 2 (mini-clinical Skills) and 5 (Clinical Science & Skills Exam) in the Developing Human Block, and Component 5 (Clinical Science & Skills Exam) in the Nervous System & Function Block.

Discussion

To our knowledge, this is the most comprehensive analysis conducted to date on the relationship between attendance and performance in the pre-clinical years of undergraduate medical education. We studied greater than 75% of an entire medical school class undertaking a pre-clinical curriculum that is 18 months in length. Our results highlight several important findings. First, attendance tends to wane at varying degrees over the course of pre-clinical training, despite the fact that institutional attendance policies required attendance for many session types. We did find that attendance at sessions that were not required drops off at a much faster rate than sessions that are required. This finding may be due to either cumulative fatigue that erodes attendance even for required sessions over the course of training or that students determine what they need to do to succeed, an experience that cannot be dictated by an institutional policy.

Our primary finding was that for the vast majority of educational sessions (>94%), attending <80% of the sessions was not associated with improved test scores for all of the seven subject blocks in the pre-clinical program. This held true for all four classroom session types: large group, clinical skills, science skills, and anatomy sessions. The lack of a clear relationship between attendance and performance is congruent with conclusions of prior studies [2,4,7,8]. However, as previously discussed, the prior studies had several methodological issues that may have influenced their findings. Our study is unique in that we conducted a robust analysis of a large cohort-based sample of medical students undertaking the pre-clinical phase of medical school, and we included a comprehensive set of outcome variables or medical school assessments as part of this study. In addition, we adjusted our analyses for possible confounders.

Our findings suggest that, at the level of attendance at ≥80%, no significant association exists between pre-clinical attendance and performance in medical school, a finding that appears to be consistent with experiential or adult learning theory, with just a few exceptions. These exceptions are interesting to consider. The type of content involved in the exception areas (Hormones & Digestion, Nervous System & Function, and the Developing Human) coupled with the type of sessions affected may be influencing the specific examination components. We had assumed that the types of educational sessions reinforced each other in terms of content, but this might not be the case. For example, the finding that higher attendance at anatomy sessions resulted in three instances associated with improved performance occurred with Component 2 (mini-clinical Skills) and Component 5 (Clinical Science & Skills Exam) in the Developing Human Block and the

Nervous System & Function Block. Though only 3 events, it may be that certain content is better conveyed using different types of educational approaches, resulting in improved scores. The single finding that higher attendance resulted in worse performance is also interesting to consider. This occurred in the Science Skills Lab educational session for the Nervous System & Function Block as measured by the NBME Final Exam. It may be that there was a mismatch between the content taught in this session and the exam items chosen for assessment. It might also be that the complexity of the material or the way it was delivered affected students' performance on this exam component.

In any case, we have learned that studying attendance is complex. All medical students do not adhere to attendance policies and even when not required, many medical students find benefits from attending as has been reported elsewhere. It is highly likely that it will not be possible for medical students to succeed without some level of physical attendance, though this will deserve future study. However, the findings from this study should inform both medical schools leaders and medical students about educational policies on attendance. The availability of online lecture materials has changed access to educational materials. It may be beneficial for medical schools to create policies that take into account these changes. Also, it may be helpful for medical students to consider these findings when planning their personal attendance pattern and the manner in which they best learn. Our findings suggest that students who benefit from accessing online resources rather than attending class can have some confidence that doing so will not affect their performance on exams.

This study has several notable strengths. Firstly, the survey response rate was high, indicating that our sample accurately represented the medical school class investigated at OHSU. Additionally, this study included comprehensive assessments and was robust in its analyses. It captured self-reported attendance data through the entirety of the pre-clinical medical school curriculum and analyzed it using all administered assessments. It also stratified this analysis across all classroom session types and subject blocks. Lastly, it adjusted for confounders that may have affected performance unrelated to attendance.

Limitations include that this study represented just one medical school, that attendance was assessed using self report, which may be affected by recall bias, as the students were surveyed shortly after the conclusion of all their pre-clinical studies. At that time, they recorded attendance habits from memory over the previous 18 month period, which may have measurement error related to recall bias. Another limitation involves the inability to control for lecture content between attendance and non-attendance groups. We assumed content was the similar for both groups. However, if a divergence occurred in the content between that received with physical attendance and that received from online resources, then variability in test scores between attendance groups might be better explained by the difference in content and not attendance itself. This might be another explanation for the few instances in our results when attendance did appear to confer a benefit on assessments. The aim of this particular study was to investigate the relationship between physical attendance and performance, not the variability of content between online and in-person resources.

In summary, we found that ≥80% attendance was not consistently associated with improved performance. The few instances when it was might best be explained by differences in the content of the respective experiences or the types of educational sessions or examination items selected for the component scores. Therefore, it may be reasonable to conclude that attendance at <80% alone is neither beneficial nor harmful to performance as long as the content of class is still accessible to the student. This suggests that strict attendance policies may be of little, if any, utility in improving performance outcomes. It also suggests online recordings are a suitable substitute for in-person lectures. A curriculum using online recordings as the primary mode of education, instead of an adjunct to in-class lecture, may result in similar performance outcomes.

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