Teaching experiences in medical school and projected confidence in teaching during residency and career plans in medical education.

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by
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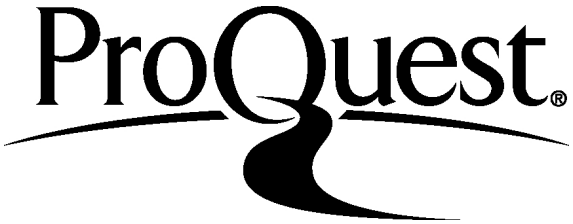

ABSTRACT:

Teaching experiences in medical school and projected confidence in teaching during residency and career plans in medical education.

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Teaching is an important part of being a physician and of being a physician-in-training. Although training to be an effective teacher is already a part of the curricula of many residency programs, it remains unclear what teaching experiences are available to medical students and how these students are affected by these experiences. The aim of this study is to qualify the types of formal and informal teaching experiences that medical students are exposed to and to determine what effect participating in these experiences has on their projected confidence in teaching and their interest in academic medicine and a career in medical education.

To this end we conducted an online, cross-sectional survey of medical students in all years of training at a private northeastern allopathic medical school to assess types of teaching experiences that medical students engage in as well as their attitudes towards teaching. We analyzed the data using ordered logistic regression with both

unadjusted models and models adjusting for potential confounders including demographics, prior teaching experiences and students' self-reported competencies in basic science, clinical knowledge and clinical skills.

Of 472 medical students approached, 203 (43%) completed the survey. A majority of respondents (56%) participated in teaching experiences while in medical school. In both adjusted and unadjusted models, engaging in teaching in medical school was associated with improved confidence in teaching (adjusted OR=3.04; $p<0.001$), as well as an increased interest in a career in medical education (adjusted OR=2.32; $p=0.01$). There was no statistically significant correlation with an interest in a career in academic medicine (adjusted OR=1.14; $p=0.67$), nor in how much the student felt that medical school prepared him or her for teaching in residency (adjusted OR=1.32; $p=0.38$). A large number (33%) of the experiences medical students believe best prepared them for teaching in residency occurred at HAVEN Free Clinic, Yale School of Medicine's student-run free clinic, as well as at the Anatomy Teaching Program (21%), in which medical students teach high school students in the anatomy dissection lab. In free text responses, many students expressed that they believe their training to teach would best be complemented by a combination of formal didactics and enhanced hands-on teaching experiences. Longitudinal cohort studies are necessary to assess actual improved teaching performance in residency.

A majority of students surveyed (56%) participated in teaching experiences in medical school. There is an association between engaging in teaching experiences

and confidence teaching, as well as with increased interest in a career in medical education. Longitudinal studies are necessary to assess whether or not confidence and competence in teaching in residency are affected by teaching experiences in medical school.

ACKNOWLEDGEMENTS:

I feel very proud to have completed this research project as part of earning my degree in medicine from Yale. I became interested in medical education because of the large number of role models I encountered here, especially those faculty and residents who took the time to teach me the art of medicine.

Many people were instrumental in the creation of my thesis and include John Encandela and Gary Leydon at the Teaching and Learning Center. The Medical Education elective, organized by Stephen Holt, Geoffrey Connors and Janet Hafler among others, solidified my interest in the topic of my inquiry. The elective, easily one of the most transformative experiences in my medical education, and the wonderful mentors I met there instilled in me a desire to become a clinician educator.

During the research process, Michael O'Brien was an incredible help in helping me make sense of the statistics involved in the data analysis, and helping me think through some tough research questions. I am very grateful for his help.

I am thankful, above all to Michael Green who helped me build the idea for this project, and who helped me to see it through to its conclusion. His support was constant and his feedback was always timely, constructive and brilliant.

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INTRODUCTION:

The Latin root of the word "doctor" means "to teach." The ability to teach well has long been considered integral to the job of the physician [1]. Throughout their careers, physicians are called upon to impart knowledge about diagnoses, treatments and prognoses to their patients, and performing this task effectively is widely recognized as crucial in delivering quality patient care [2],[3]. Additionally, and equally as important, doctors are charged with the task of teaching their colleagues, residents and medical students on a daily basis. As early as the first year after graduation from medical school, first year residents are expected to teach third and fourth year medical students on their clerkships, sub-internships and electives. This type of resident teaching is different from teaching delivered by medical school teaching faculty, because residents are challenged to teach

(1) Different things (bedside skills and patient management rather than factual knowledge)

(2) In a different way (as near-peer teachers) and

(3) At different times (teaching while on call) [4].

What type of preparation do residents receive in order to face these challenges and to be able to teach their colleagues and their medical students effectively?

Since the 1970s, it has been widely recognized that medical students benefit greatly from having competent resident-physician teachers, who contribute over a third of

the students' teaching [5]. Recognizing the importance of resident teaching and the challenges it presents, many residency program directors have implemented resident-as-teacher programs. A systematic review in 2008 revealed that resident-as-teacher programs in the United States have often included workshops, seminars, lectures and teaching retreats. Survey data has reports that "the percentage of programs offering instruction in teaching skills to residents by specialty is: medicine-pediatrics (88%), pediatrics (80%), internal medicine (65%), psychiatry (62%), family practice (52%), obstetrics and gynecology (38%) and surgery (31%)"[6].

Some of these teaching skills programs have undergone evaluations and have demonstrated improved learning outcomes for medical students, positive changes in attitudes towards teaching among the residents, as well as improved resident knowledge of educational principles involved [7]. A 2001 survey of U.S. residency programs revealed that 740 out of 1,356 (55%) offered formal instruction in teaching skills [8]. Additionally, these programs have been shown to not only improve residents' teaching ability, but also the resident teachers' clinical knowledge, more so than self-study or lectures [9]. As of 2009, resident-as-teacher programs have expanded to include over half of all the residency programs in the United States [10].

While a large volume of the literature has focused on the resident or attending physician as teacher, less attention has been paid to how we can or should prepare

undergraduate medical students for their eventual teaching during residency and beyond.[4, 10-12]

A small but growing body of descriptive literature has explored teaching skills training prior to residency, in medical school or in the pre-med undergraduate years [1]. One review outlined twelve possible rationales for encouraging student teaching and implementing student-as-teacher programs in medical school:

1. To alleviate teaching pressure for faculty.
2. To offer education to students on their own cognitive level.
3. To create a comfortable and safe educational environment.
4. To socialize students in medical school and provide role models.
5. To offer students an alternative motivation as well as another method for studying.
6. To enhance intrinsic motivation in students.
7. To prepare physicians for their future role as educators.
8. To practice peer feedback as part of multi source feedback.
9. To train leadership skills and confidence.
10. To modify the academic medical culture toward embracing education as a core task of healthcare.
11. To sustain medical training programs in severely resource-constrained settings.

12. To offer supervision responsibility to trainees in competency-based postgraduate programs

Additionally, the review confirmed medical students' willingness and enthusiasm to acquire teaching skills. [13]

Despite these rationales, a minority of medical schools have formal student-as-teacher programs (SATs). These SATs often include small-group work, lectures, role-playing and direct observation of teaching activities [8]. Students participate in a variety of teaching roles, including peer tutors [14], standardized patients[15], teachers of physical exam [16] and of problem-based learning modules [17]. Additionally, in a review performed by Pasquinelli in 2008, the authors identified three general contexts exist for student-as-teacher programs in medical school: medical interviewing and physical diagnosis courses, basic science courses, and faculty development courses. The number of students in these programs was generally small, and the programs were not formally assessed for effectiveness [18]. It remains unknown how experiences teaching others in medical school prepares medical students for teaching in residency, since evaluations of these programs are lacking [18].

At the Yale School of Medicine, no formal medical-student-as-teacher program exists for all medical students. The school offers a course once a year entitled the "Medical Education Elective" which is geared towards senior medical students and other

allied health professional students and is intended for a group of 6-10 students. The medical school also offers other teaching opportunities, including paid tutoring opportunities, teaching high school students in the anatomy lab, serving as a standardized patient, and peer-tutor in physical exam practical didactics. No database of these teaching experiences exists, and it is unclear how many students participate in these activities over the course of their time at the medical school.

Statement of Purpose:

The aim of the current study was to enumerate and characterize the types of teaching experiences available to Yale medical students and to evaluate how these experiences correlate with the way that medical students perceive their preparedness for teaching in residency. In particular, we surveyed students to determine if teaching while in medical school was associated with students' confidence in teaching, interest in careers in medical education and academic medicine, and belief that that medical school prepared them for teaching in residency.

Hypothesis:

Our hypothesis was that a variety of teaching experiences are available to the medical student at Yale School of Medicine, and that these types of teaching experiences can range from a one-time tutoring experience to years-long

commitment to teaching, from teaching children to teaching patients and other medical students, and from very hands-on to formal classroom training-to-teach programs. We also hypothesize that students will have a range of prior teaching experiences. We hypothesize that students who teach while in medical school will report higher interest in entering a career in clinical education as well as in academic medicine and that they will feel more confident teaching while in residency. We would expect these students to also feel that medical school prepared them for the challenge of teaching while in residency.

Methods:

Subjects and setting:

We surveyed medical students from all years of training at a private northeast allopathic medical school during the fall and winter of 2014. It was communicated to the students that the surveys were anonymous and that student participation in the survey was completely voluntary. No compensation, monetary or otherwise, was offered to students completing the survey.

Authorship:

I designed the survey with help from my thesis advisor, Dr. Michael Green as well as from Dr. John Encandela, Associate Director for Curriculum and Educator Assessment at the Teaching and Learning Center at Yale University School of Medicine. Mr. Gary Leydon, Associate Director for Technology Services at the Teaching and Learning Center, assisted me in using Qualtrics to design the survey. We reviewed survey results together and devised a plan for statistical analysis with the help of Dr. Michael R. O'Brien, a Robert Wood Johnson Scholar, who also helped me with navigating statistical software. I wrote this paper with helpful revisions from both Drs. O'Brien and Dr. Green.

Design and measurement:

We performed a cross-sectional study using an online survey developed in Qualtrics software®. The 23-item instrument was developed specifically for this study and contained multiple choice, free text, and Likert scale questions. The items included demographics, types of teaching experiences before and during medical school, formal or informal teaching training, self-reported attitudes towards teaching, and self-reported basic science knowledge, clinical science knowledge, and clinical skills competence. A free-text question asked students to brainstorm how their training to teach could best be complemented in medical school.

The independent variable was teaching in medical school (a binary variable). The four dependent (outcome) variables were represented in the following Likert scale questions:

1. How confident are you in your teaching skills?
   (Variable name: Confidence)
2. How much do you feel medical school has prepared you for teaching in residency?
   (Variable name: Medical school teaching preparation)
3. How interested are you in pursuing a career in clinical education? (Variable name: Clinical education)
4. How interested are you in pursuing a career in academic medicine? (Variable name: Academic medicine)

These dependent variables were quantified on a scale from 0-5, with the descriptors "0" being "not at all" and 5 being "very much."

We piloted the survey with 6 medical students in the fourth year medical school class to ensure that the intent of the questions was clear. The final survey instrument was distributed via an email to all medical students in all classes, including MD/PhD candidates.

Analyses:

We determined descriptive statistics on student characteristics and compared students who engaged in teaching in medical school to those who did not using chi-square analysis.

We determined the associations between teaching in medical school and the independent variables via four ordered logistic regression models. The first model was an unadjusted ordered logistic regression. The remaining models included adjustments for potential confounding variables. Model two adjusted for age and gender. Model three added adjustments for teaching experience prior to medical school including both undergraduate and gap-year teaching experiences. Finally, model four added adjustments for self-reported competency in basic science, clinical knowledge and clinical skills. All analyses were conducted with Stata 13.1 statistical software.

Human subjects:

The Yale Human Investigation/Human Subjects Committee granted an exemption from full board review for this study.

Results:

Two-hundred-three of 472 (43%) students completed the survey. The characteristics of these students appear in Table 1. Of the students surveyed, 47% were female, 40% were pre-clinical and 60% were post-clinical students (third, fourth years and beyond). These numbers roughly correspond to the demographic distribution of Yale medical students. Comparing students who engaged in teaching to those who did not, small but statistically significant differences were found in most categories.

Students who engaged in teaching were more likely to be in the clinical (versus pre-clinical years). They were more likely to have had experience teaching prior to medical school (whether in their undergraduate years or in a gap year between undergraduate and medical school), and overall, had greater self-reported competences in the basic sciences (e.g. anatomy, physiology, biochemistry), clinical knowledge (for example, internal medicine, neurology, obstetrics/gynecology or other disciplines), and clinical skills (for example, history taking and physical exam, patient procedures).

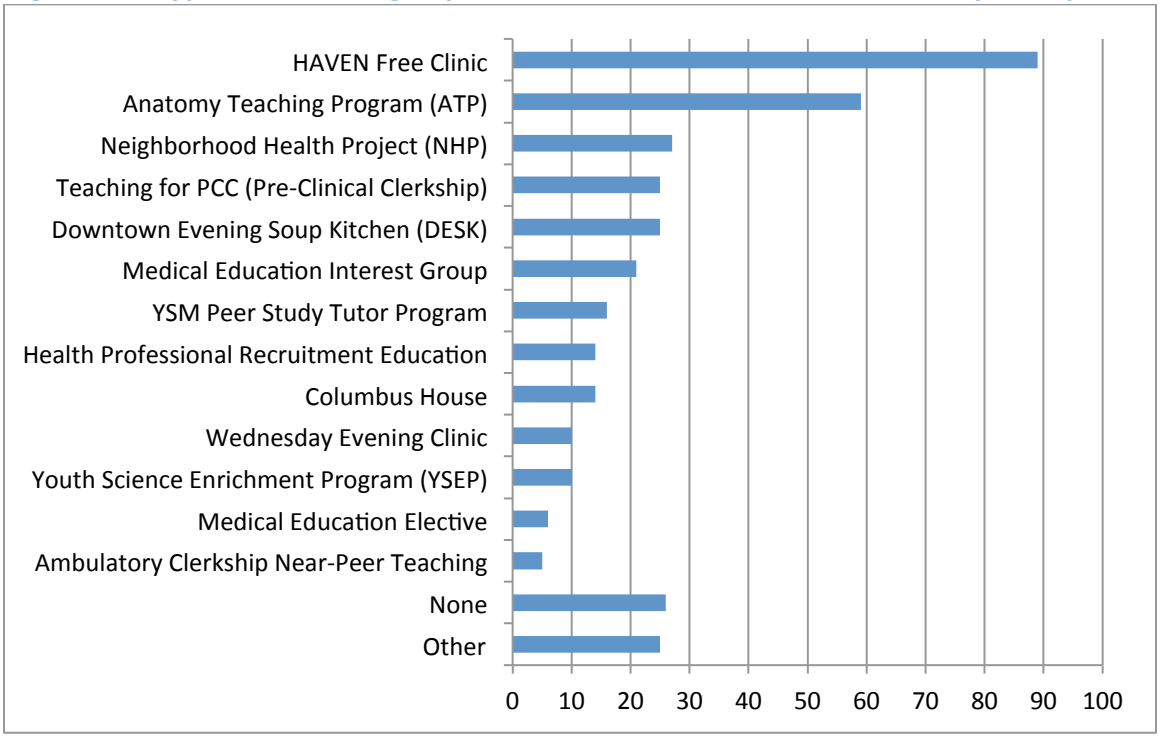
Table 1 – Characteristics of students that did and did not teach in medical school

	Total; mean (sd); n (%)	Medical students that did not teach in medical school (n=77)	Medical students that taught in medical school (n=99)	P-Value
Age	26.0 (2.72)	25.3 (2.70)	26.5 (2.81)	0.01
Female	84 (46.93)	34 (44.74)	49 (49.49)	0.532
Preclinical	78 (40.41)	45 (58.44)	26 (26.26)	> 0.001
Clinical	115 (59.59)	32 (41.56)	73 (73.74)	
No undergrad teaching experience	31 (15.82)	19 (24.68)	8 (8.16)	0.003
Undergrad teaching experience	165 (84.18)	58 (75.32)	90 (91.84)	
No gap year teaching experience	59 (53.15)	29 (59.18)	25 (50.00)	0.359
Gap year teaching experience	52 (46.85)	20 (40.82)	25 (50.00)	
No prior to med school teaching experience	24 (12.18)	14 (18.18)	7 (7.14)	0.026
Prior to med school teaching experience	173 (87.82)	63 (81.82)	91 (92.86)	
Competency in basic sciences	3.62 (0.86)	3.44 (0.92)	3.75 (0.80)	0.07
Competency in clinical knowledge	3.45 (0.94)	3.21 (0.95)	3.66 (0.99)	0.02
Competency in clinical skills	3.72 (0.92)	3.50 (0.96)	3.90 (0.86)	0.04

One-hundred-seventy-seven (88%) of students participated in teaching experiences prior to medical school and 97 (55%) participated in teaching experiences while in medical school. One hundred and seven (60%) of respondents received either formal or informal training for teaching (lectures and courses, or informal learning to teach through friends, colleagues and readings), while 71 (40%) claimed they had no training of any kind in teaching skills.

Within the subset of students who participated in teaching in medical school, 35% participated in teaching other medical students, 14% taught college students, 24% taught high school students and 9% taught students from K-8. The types and frequencies of these teaching experiences appear in Figure 1.

Figure 1 – Types of teaching experiences in which medical students participate



The largest number of teaching experiences occurred at HAVEN, the medical school's student-run free clinic (n= 89; 49%). Of the students who participated at HAVEN, 24 (30%) were part of the clinic's leadership board, and 28 (35%) were senior medical students in charge of teaching junior medical students.

The second most popular teaching experience was the Anatomy Teaching Program (ATP), a tutoring program in anatomy for high-school students taught by first-year medical students (n=59; 32%). The third most popular teaching experience was the Neighborhood Health Project (n=27; 15%), in which pre-clinical medical students provide glucose and blood pressure screening services for the underserved and homeless in the New Haven community.

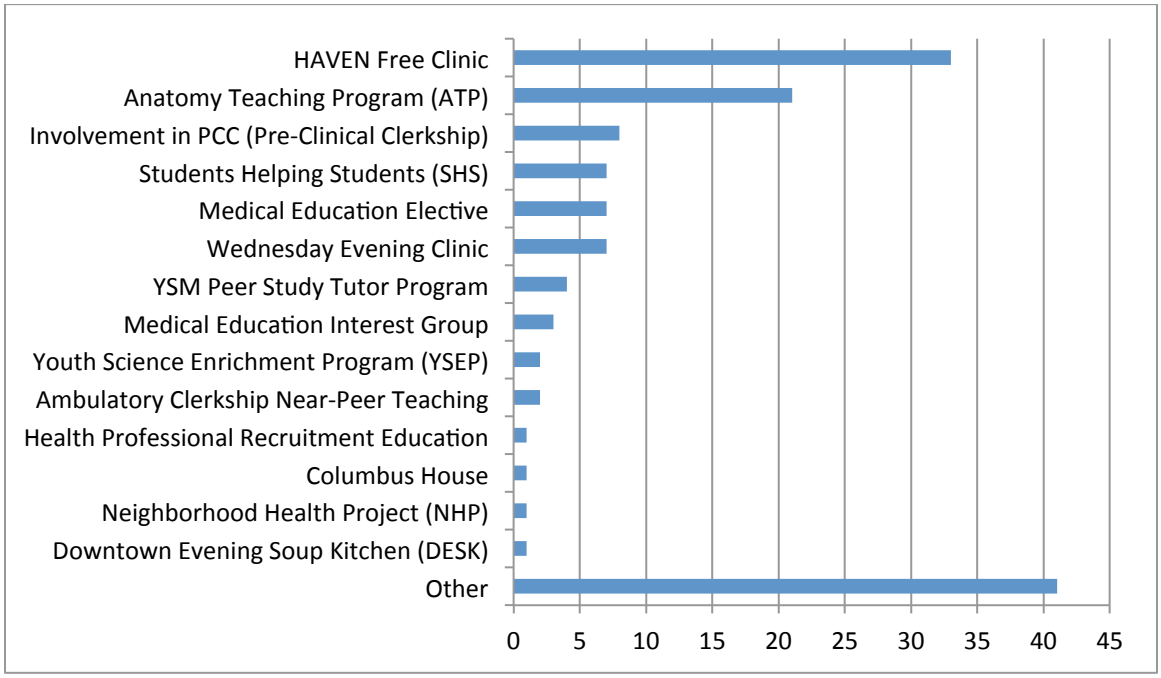
Opportunities to educate other medical students whether as part of the structured curriculum or as extracurriculars (YSM Peer Study Tutor Program and the Ambulatory Clerkship Near-Peer Teaching) together constituted 12% of students' experiences. Opportunities to receive training to teach, as part of a structured elective or through student interest groups (Medical Education Interest Group and Medical Education Elective), constituted 14% of students' experiences. Opportunities to perform health education and provide mentoring opportunities to grade school students in the community (Health Professional Recruitment Education, YSEP) constituted 13% of students' experiences. Some teaching experiences, including DESK (Downtown Evening Soup Kitchen), Wednesday

Evening Clinic and Columbus House, which constituted a combined 27% of students' experiences, were reported to have components of both teaching other medical students as well as teaching of patients.

When students indicated that they participated in "other" experiences, their free-text answers showed participation in experiences as teaching assistants in anatomy, histology and biochemistry courses as well as participation in Students Helping Students (a tutoring program coordinated by second year students for first year students).

Of all those experiences, the largest proportion of students felt that HAVEN prepared them best for teaching in residency (n=33; 24%), followed by 21 (15%) of the students who participated in ATP (please refer to Figure 2). Of the students surveyed, 29% (41) marked "other," indicating that another experience prepared them best, and when prompted, many wrote that serving as a teaching assistant in medical school classes, watching residents, experiences on their sub-internships, as well as experiences in their laboratory research years were helpful in developing skills necessary for teaching in residency.

Figure 2 – The experience that medical students feel most prepared them for teaching in residency



Students who engaged in teaching in medical school had higher confidence in teaching (OR=3.04; p<0.001) and more interest in pursuing careers in medical education (OR= 2.32; p=0.013). There were no statistically significant associations with how much the students believed that medical school prepared them for teaching in residency (OR=1.32; p=0.380) or their interest in pursuing careers in academic medicine (OR=1.14; p=0.672) These associations remained when adjusting for demographic factors, year in medical school, prior teaching experience in their gap-years or their undergraduate college years, as well as self-reported competency in basic sciences, clinical knowledge and clinical skills. The various four models used in the ordered logistic regressions to analyze the survey data are explained in Table 2.

Table 2 – Association between teaching in medical school to various self-reported outcome measures.

	How much do you feel that medical school has prepared you for teaching in residency? (OR, p-value)	How important a role do you think educating others will have in your career? (OR, p-value)	How interested are you in pursuing a career in academic medicine? (OR, p-value)	How confident are you in your teaching skills? (OR)
Model 1	2.166 (p = 0.007)	2.905 (p = <0.001)	1.934 (p = 0.022)	3.275 (p = <0.001)
Model 2	2.103 (p = 0.013)	2.962 (p = 0.001)	1.657 (p = 0.092)	3.331 (p = <0.001)
Model 3	2.036 (p = 0.019)	2.731 (p = 0.002)	1.55 (p = 0.152)	3.014 (p = <0.001)
Model 4	1.55 (p = 0.154)	2.381 (p = 0.009)	1.288 (p = 0.428)	2.817 (p = 0.001)

Of the students who said that they taught while in medical school, 43% (61) stated that they engaged in teaching or tutoring other medical students., while 17% (24) stated that they taught or tutored college students, 30% (42) taught or tutored high school students and 11% (15) taught or tutored students from K-8.

In a free-text question, the students were asked how they think their training to teach could best be enhanced in medical school. Their comments clustered into a few categories. Students believed that "online modules" as well as "teaching workshops" could be helpful, while others stated that "hands-on experience teaching your peers" as well as "having better role models" would serve them best. Several students pointed out that "teaching is best taught through practice and good mentors (i.e. good teachers) who lead by example." A handful of students suggested that training to teach programs should be a "mandatory component" of the curriculum, while others stressed that interested students should be given "optional opportunities for practice." A formal analysis of the free text was beyond the scope of our study.

DISCUSSION:

Teaching is an important part of being a good physician. Formal training in teaching increasingly occurs during a physician's residency years, even as early as during internship. However, for some physicians-to-be, the practice of teaching begins in medical school, a time when medical students are often in the position to teach pre-

med and grade school students, each other as well as patients. Indeed, several studies have shown that medical students are able to serve as effective teachers to their peers and a growing body of literature is now dedicated to the merits of medical student teaching of other medical students, termed "near peer teaching."

Near-peer teaching:

At the University of Adelaide in Australia, Nelson et al. devised a near-peer teaching program in which student-learners reported that medical student "near-peer teachers" had a positive effect on the learner including improved communication skills, enhanced clinical skills, as well as consolidation of knowledge and organizational skills [19]. At the University of California, a "near-peer" teaching experience was developed in which senior medical students who had enrolled in a radiology elective taught components of the core radiology curriculum to first-year medical students. The first-year student learners stated that they enjoyed having the senior medical students as instructors, that the student teachers were sufficiently knowledgeable about the subject matter and that they were useful supplements to their own learning. This study, however, did not assess whether students enrolled in the course performed better on objective knowledge tests [20]. As part of a study performed at the Brighton and Sussex Medical School, Jackson and Evans created a near-peer teaching program in which fourth year medical students taught tutorials to supplement the medical school's cardiovascular and pulmonary physiology modules. The course was extremely well attended (by 94 out of 138 first year

students at the school), and drop-out rates were minimal. Importantly, students did better on the qualifying exams as compared to students in previous years, when the near-peer tutorials were not available [21]. Thus, it appears that near-peer teaching has a positive effect on student learning according to subjective and objective outcome measures.

Perhaps one of the most important reasons why near-peer teaching is effective is the cognitive and social congruence that exists between the teacher and learner in this dyad. Cognitive congruence describes how the near-peer teacher and his or her student share a similar knowledge base and similar experiences. This "congruence" allows a peer teacher to use a language that the learner understands in order for concepts to be able to be explained at a level appropriate to the learner. Lockspeiser continues to describe that even in situations where the near-peer teacher is just several years ahead in their training, the cognitive distance is present, and the "cognitive incongruence" reappears. Furthermore, the learners and peer-teachers often also share similar societal roles, explaining why student-learners often can feel more at ease with their peer-teachers than with more senior clinicians. Little evidence exists to ascertain what the optimal educational distance between learner and near-peer teacher should be [22].

Because 43% of medical students who teach are in fact, teaching or tutoring other medical students, it would appear that near-peer teaching is a significant part of the way that students at the Yale School of Medicine learn. It would be important in

future studies to assess how effective this teaching is and how these near-peer teaching experiences shape the attitudes and skill sets of the near-peer teachers.

How teaching affects the teacher:

Other than the quality of teaching that students can deliver, we are interested in this study on the effect that teaching has on the teacher. Only a few studies explore this aspect of near peer teaching. Weiss et al., in a randomized control trial of pediatric residents, found that teachers of a prescribed set of didactic materials were able to retain information more effectively than those who simply listened to the material [9]. In fact, it has become a common adage that "to teach is to learn twice." In a study done with medical residents, it was concluded that residents who teach have increased enthusiasm for teaching and greater job satisfaction. Furthermore, the research found that resident involvement in teaching activities has a positive effect on residents' communication skills and on patient outcomes [4]. In a systematic review of peer teaching in the undergraduate medical setting, it was found that peer teaching increases students' confidence in their own clinical practice and that peer teaching improves knowledge acquisition as well as development of both clinical and leadership skills [23].

Despite the growing interest in developing undergraduate medical teaching curricula, no consensus currently exists on what these programs should look like. Several systematic reviews have been done to attempt to characterize the literature

on undergraduate training programs. Marton et al, revealed three types of opportunities that develop the teaching skills of medical students: peer teaching programs, teaching workshops and outreach programs (programs in which medical students teach members of the community). All of these opportunities improved the self-perceived teaching skills of participants, but there was a notable lack of performance feedback for the teaching participants. Only two out of the twenty articles included in the review reported objective outcomes.[24]

Our study:

The goal of our study was to determine how experiences in teaching while in medical school affects students' confidence in teaching, their interest in careers in clinical education, their interest in careers in academic medicine, and as well as how much they felt that medical school prepared them for teaching in residency. We were also interested in enumerating the types of teaching experiences available at Yale School of Medicine and soliciting the students' views on how these experiences could be enhanced and extended.

The survey data show that a majority of students participated in teaching while in medical school, including mentoring/teaching while working at the school's student-run free clinic and small-group teaching as part of a high-school anatomy immersion program, among other opportunities. Furthermore, our research suggests that student exposure to teaching opportunities in undergraduate medical

curricula is correlated with confidence in teaching and interest in a career path in clinical education.

It is worth noting that there appeared to be positive correlations between teaching in medical school and all of the dependent variables in the unadjusted analysis. However, only confidence in teaching and interest in careers in education remained significant after adjusting for variables including age, gender, prior teaching experience as well as self-reported competency in basic science, clinical knowledge and clinical skills. In Table 1, we see that while gender appears to have no confounding effect ($p=0.532$), age does appear to be unevenly distributed among those who have and have not had teaching experience ($p=0.01$). This is to be expected as students who are older are more likely to have had teaching experiences while in medical school. With the Model 2 ordered logistic regression, age and gender were taken into account as possible confounders, and we discovered that there was no correlation between teaching in medical school and student interest in careers in academic medicine. Model 3 accounts for prior to medical school teaching experience, which was a possible confounder we identified and attempted to control for. With Model 4, we controlled for all the above variables as well as self-reported competency in basic science, clinical skills and clinical knowledge. The reason that self-reported competencies were believed to be a possible confounder was that these increased competencies in those fields were likely to be independently correlated to the independent variable (teaching in medical school) and the dependent variable (the various outcome effects). The

reason that self-reported competencies were believed to be a confounder was that these increase competencies were likely to be independently correlated to the independent variable (teaching in medical school) and the dependent variable.

The final odds ratios revealed that, while students who taught had higher confidence in teaching, they did not feel that medical school prepared them for teaching in residency (OR: 1.55; p: 0.154). This result is perhaps counterintuitive. Students who participate in teaching while in medical school would be expected to have higher confidence in teaching in residency. However, students who taught in medical school, may not necessarily feel that it was medical school itself which prepared them for teaching in residency – that is to say, these students may have felt that the medical school administration did not have courses and experiences embedded in the curriculum which made the students feel prepared for teaching in residency. The wording of the question highlights the question of agency.

In the final adjusted odds ratio, it was also found that students who taught while in medical school were more likely to think that educating others would play a role in their careers (OR: 2.381; p: 0.009). However, these students were not more likely to state that they were interested in a career in academic medicine (OR: 1.288; p: 0.428). Careers in academic medicine often involve teaching, which makes the discrepancy puzzling. One possibility is that medical students at early points in their training may not understand that teaching is an important part of working in many academic centers. In fact in a study performed by Amorosa et al. it was discovered

that many first year medical students do not have an awareness that teaching is an important component of a career in medicine, and that it was only after students had taught medicine-related material that they made the explicit connection between teaching and being a physician[25]. It is possible that students' misunderstanding of the relationship between teaching and medicine extends to their perception of academic medicine. It is clear, whatever the explanation, that teaching while in medical school can shape the way that a student thinks of his or her own career trajectory within medicine.

Student-as-teacher programs:

Some schools offer elective programs to train students how to teach, including concentrations and courses in medical education[8], [26]. What percentage of medical students across the country participate in these opportunities is currently unknown. In 2013, the major accrediting bodies that oversee medical student and resident training in the United States, the Liaison Committee on Medical Education (LCME) and the Accreditation Council for Graduate Medical Education (ACGME) have declared that all medical trainees should be proficient at teaching. Despite this, very few medical schools have incorporated training to teach as a mandatory part of the curriculum for all their enrolled medical students[27]

In the absence of school-wide training to teach programs, students are left to participate in the experiences that are available at their home institutions, such as

near-peer teaching, teaching electives and tutoring sessions described and quantified in our survey.

Teaching in a student-run free clinic:

As mentioned in the results section, 24% of students surveyed said that HAVEN Free Clinic was the experience that prepared them most for teaching in residency. The HAVEN Free Clinic is a student-run primary care clinic partnered with Fair Haven Community Health Center (FHCHC) and Yale University, which operates in the Fair Haven community just east of downtown New Haven. It opened its doors in 2005 and since then the clinic has seen over 5000 patients. Patients are seen by teams of senior medical students overseeing junior medical students with guidance from faculty attendings. Opportunities for teaching include senior students teaching junior students at the bedside, directors of departments (e.g. Reproductive Health, Education, Social Services Departments) teaching volunteers that they oversee in their own departments as well as in other departments, and junior medical students teaching undergraduates (often pre-medical students working in ancillary roles). Students engage in teaching patients as part of delivering clinical treatment as well as part of patient education curricula [28].

Of the students surveyed, 7% said that working at the Wednesday Evening Clinic, another free clinic staffed by students, was the experience that prepared them most for teaching in residency. The Wednesday Evening Clinic is an integrated medical

student clinic that offers a longitudinal primary care experience to upper level senior medical students as well as to MD/PhD students in their research years. Opportunities for teaching include teaching new volunteers as well as teaching patients as part of delivering appropriate clinical treatment [29].

A randomized control trial performed at the medical faculty of Goethe-University in Frankfurt, Germany sought to determine whether teaching done by medical students at student-run free clinics was effective. The trial showed that students who were exposed to peer-led teaching at their student-run free clinic performed better on tests gauging their medical knowledge and clinical skills than those who were not exposed to peer-led teaching [30].

Together, 31% of students at Yale Medical School cited work at a free clinic as crucial to their development as educators. Perhaps learning to teach in the clinical setting, which presents a unique set of challenges (space and time constraints, pressures of simultaneous patient care provision, etc.) could help the student teacher recall his or her teaching experiences and apply them when teaching in similar settings in residency. The role of context in medical education, which posits that learning in the clinical context may be helpful for later recall is garnering increased support in the literature on medical education[31, 32]. It remains to be investigated whether learning to teach in a clinical context makes for more confident and more competent teachers.

Anatomy Teaching Program:

Of the students surveyed, 21% stated that ATP (The Anatomy Teaching Program) was the teaching experience in medical school that they felt would prepare them best for teaching in residency. The Anatomy Teaching Program was founded in 1993 by teachers at Career High School with the help of one of Yale School of Medicine's core anatomy teaching faculty, Dr. William Stewart. First and second year medical students meet every two weeks for two sessions to teach anatomy to high school students.

The anatomy curriculum has been much-explored topic in the field of medical education. Reciprocal peer teaching, where students alternate roles as teacher and learner, has been implemented in many medical school teaching curricula, especially in anatomy courses. Studies of these programs have shown that students enjoy and value the opportunities to teach their peers in the dissection lab [33-35]. One study showed that medical students felt that they would be better able to communicate with patients and their colleagues in their future careers after participating in teaching in peer teaching in the anatomy lab [36]. To the best of the author's knowledge, no literature exists studying the effects of medical student teaching of high school students in the anatomy lab on the student teacher. As the program is one of the school's most popular outreach programs, further research would be beneficial to investigate the impact that this teaching has, not only on the high school student learners but on the medical student teacher.

The Medical Education Elective:

The Medical Education elective was created in 2013 by members of the Teaching and Learning Center at Yale in conjunction with several members of the Yale School of Medicine Class of 2013. The syllabus for the course delineates the aims of the elective clearly. The purpose of the rotation is to "introduce medical students to their role as teacher before they begin residency and to better prepare them for this role." The course uses "didactic lectures, observation, group exercises, and teaching activities with the help of a diverse and talented set of faculty in order to facilitate the development of the knowledge, skills and attitudes necessary to help our students develop their experience and identity as teachers as they transition from medical school into residency." Evaluation is built into the course through student self-reflection and verbal and written feedback from peers and faculty. Additionally, each student is required to complete a set of four observed structured teaching encounters (OSTEs) at the end of the course.

In their free-form responses, many students referred to the Medical Education course as one of the experiences that best prepared them for residency. Analysis of the evaluations done by students that completed the Medical Education elective was outside the scope of the study. However, comparing attitudes towards medical education before and after the course in these students, as well as assessing projected confidence in teaching in these students could help guide future curricular development. Could a course like this benefit a larger proportion of the medical school class? Perhaps an abbreviated version of the course could be piloted during

capstone course in the fourth year that takes place as part of the curricula of many medical schools as a way to prime students for teaching prior to beginning their internship year.

Opportunities for curricular improvement:

At the end of the survey, students were asked how training to teach could be improved in medical school. In their free-text responses, many students reported that "online modules" – whether mandatory or optional – could be a useful resource in providing basic knowledge of teaching techniques. Others believed that "lectures and small group" instruction integrated into the curriculum could serve to complement their experiences. A larger number felt that more "hands-on experiences" where teaching skills could be practiced could be beneficial, and some of these students indicated that combining practical experiences with a more "formal teaching curriculum" could be helpful. Students wrote that they would feel more prepared for teaching in residency if they had a combination of formal teaching experiences with improved or enhanced hands-on experiences teaching. This data could suggest that providing more high-quality teaching experiences and didactics could improve interest in teaching and confidence in teaching in residency.

Liabilities of student-teaching:

One concern shared by physicians and physician-educators with regards to medical student teaching is whether the student is both proficient enough in the material he or she is teaching and skilled in the craft of teaching, thus "reduc[ing] the potential for negative role modeling or other harmful behaviors" [37]. In a systematic review of peer teaching, mostly positive outcomes of peer teaching were found, but negative aspects were also identified, including "poor student learning if personalities or learning styles are not compatible" and if students spend "less time with their clinical instructors" [23]. In one study from the Queen Mary and Westfield College in London, a peer tutoring program in biochemistry was created in order to address shortages in staff, namely shortages in their faculty academic tutor program. Whereas the student learners stated that the were happy with their peer tutors, finding them "easier to relate to" and "competent enough to answer their questions," they were nonetheless "perceived to be less effective than academic tutors [faculty] in terms of biochemical knowledge answer questions." The academic tutors themselves felt that the peer tutors lacked the experience to address issues raised in tutorials [38]. In another study performed at the University Medical Center in Utrecht, Holland, physicians created a near-peer teaching program at the medical school and then asked student-learners to evaluate their peer teachers. The student learners listed many strengths of the peer teachers, but listed several weaknesses. Several participants commented that the peer tutors "have less knowledge than faculty members," as well as "less clinical experience." They also commented that

they “seemed more nervous” and were eager to “explain difficult questions” which was seen as a weakness in that the peer teachers did not allow the student learners to arrive at the answers on their own [39].

Overall, it is difficult to assess whether or not the liabilities of peer teaching outweigh the benefits. It is logical to assume, however, that exposing students to the challenges of teaching through hands-on experiences and ensuring that they are equipped to handle these challenges through workshops or lectures on teaching could be an effective way of preparing students for teaching in residency.

Limitations of our study:

One limitation of this study is that it is a cross-sectional analysis and neither the directionality nor causality of the associations can be determined. The survey was completed by 43% of students (n=203). However, when we compared the demographic traits of our respondents as compared to the demographic traits of students who attend Yale School of Medicine, no stark differences arose. Our respondent group was 47% female, while the entirety of the Yale School of Medicine is 46% female. Our respondent group was 40% pre-clinical, corresponding to the entirety of the Yale School of Medicine, which is also 40% preclinical. Our respondent group had a mean age of 26, which corresponds with the mean age at the Yale School of Medicine, which is also 26. A formal qualitative analysis of free-text questions was not performed. Additionally, it is unclear to what extent the

teaching experiences and students' attitudes toward teaching at this medical school are generalizable to the experiences and attitudes of students at other medical schools in the United States. Furthermore, the research asks about perceived confidence in and attitudes towards teaching, but does not assess actual resident teaching competence of YSM graduates.

Opportunities for further research:

Further studies are needed to assess how student participation in existing teaching experiences could be enhanced and how new programs could be created to increase students' knowledge of teaching principles as well as their confidence in teaching. Similar investigations are necessary at other medical schools in the United States to ascertain the reproducibility of this data. Longitudinal research is needed to further assess the effects of different types of undergraduate medical teaching experiences on quality of resident teaching.

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