The Long-term Impact of Preclinical Education on Medical Students' Opinions About Radiology[1]

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Rationale and Objectives. It has been previously shown that integrating radiology teaching into the first year of medical education has an immediate positive effect on medical students' attitudes toward the practice of radiology. The purpose of this study is to determine whether these changes in attitude persist through the clinical years of training and whether preclinical exposure to radiology has a long-term effect on medical students' opinions about radiology and radiologists.

Materials and Methods. The first-year medical curriculum at the University of Pittsburgh School of Medicine was revised between the 2003 and 2004 academic years, with 2.5 hours of additional radiology lectures integrated into the existing preclinical coursework. Additionally, radiology consult sessions were integrated into problem-based learning sessions. An initial survey was administered in the preclinical years of training to assess first-year medical students' attitudes toward radiology before and after the changes to the curriculum. A follow-up survey was administered before graduation to determine whether the changes in attitude revealed in the first survey persisted throughout the remaining years of training, and to assess students' opinions about negative radiologist stereotypes. Students who had undergone the revised curriculum were compared to students who had undergone the traditional curriculum.

Results. There were statistically significant differences between the two graduating classes in terms of interest in, and perceptions of, the field of radiology. At graduation, students exposed to the revised preclinical curriculum with a greater exposure to radiology had a greater interest in radiology as a discipline and were more likely to have taken senior electives in radiology. These graduating students were also less likely to agree with negative stereotypes about radiologists.

Conclusions. Dedicated medical student teaching from an academic radiologist during the first year of medical school has a positive, long-lasting effect on medical students' attitudes toward radiology. The prevalence of negative stereotypes about radiologists among graduating medical students can be reduced by appropriate teaching of radiology in the preclinical years of medical school.

Key Words. Medical student education; radiology education; problem-based learning.

In a traditional North American medical school curriculum, radiology is not formally taught until the clinical years of training (the third and fourth years of medical school) (1). Radiology is sometimes introduced during the preclinical years as a peripheral element in anatomy or organ pathology courses, but dedicated lectures are unusual (2). Even in the clinical years, radiology is not commonly part of the core curriculum, but is instead usually offered as an elective in the final year, after many medical students have already decided on a specialty. Medical students' main exposure to radiology may come only at the hands of clinicians, instead of radiologists, and may be relegated to occasional reviews of radiographic findings from patients on the clinical services.

Because of the late exposure to radiology, medical students may not recognize that they have an interest in the

Acad Radiol 2008; 15:1331–1339

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doi:10.1016/j.acra.2008.03.015

specialty until late in their training (3). It may be too late to engage in radiology research or to spend time with radiologists and learn more about the specialty. Some students who would otherwise pursue a career in radiology might not know enough about the specialty to consider it in their decision-making. And perhaps of greatest concern, medical students who have not been exposed to radiology may be more likely to harbor negative stereotypes about radiologists after they have completed their training (4). Such misconceptions could contribute to antagonism between clinicians and radiologists, promote turf battles, and prevent unified action between physician specialties on shared political issues.

Previous research on medical student teaching in radiology has focused on the short-term results of radiologist involvement (5), on the acquisition of knowledge skills (6), or on the impact on career choice (7). An immediate boost in knowledge level has been documented after preclinical radiology teaching, and short-term improvements in medical students' attitudes toward radiology have been shown (5,8), but there has been no previous work that documented the long-term effects of early radiologist involvement on medical students' attitudes toward radiology. To justify the substantial time expenditure required of radiologists for medical student teaching, improvements in medical student attitudes toward radiology should last at least throughout the training years.

In a previous publication, we documented the immediate effects on medical students' knowledge of, and attitude toward, radiology when dedicated radiology teaching was incorporated into first-year medical student coursework (5). The purpose of the present research is to determine whether these improvements in attitude persisted throughout the remaining years of medical school training and to determine whether negative stereotypes about radiologists among graduating medical students can be mitigated by exposure to radiology in the preclinical curriculum.

MATERIALS AND METHODS

Changes to Medical School Curriculum

First-year students at the University of Pittsburgh School of Medicine take classes in basic science (eg, medical anatomy, microbiology, genetics, immunology) and pathophysiology (eg, neuroscience, cardiology) as well as courses in patient care (eg, ethics, medical interviewing, medical decision-making). Although occasional radiographs might be used to emphasize a clinical teaching point, these courses have traditionally been taught without input from radiologists.

Between the 2003 and the 2004 academic years, changes were made to two courses (medical anatomy, neuroscience) to provide greater exposure to radiology. Medical anatomy is a 7-week course taught in September and October of the first year. A 1-hour radiology lecture was added in the first week of the course, focusing on radiologic modalities and techniques, as well as radiologic anatomy. Additionally, a 45-minute radiology consult session, which focused on relevant anatomy and appropriate utilization of imaging, was added to each of the four problem-based learning (PBL) modules (9,10). The PBL modules were supplemented with complete cross-sectional patient examinations, presented with the same Picture Archiving and Communication System interface used in the clinical setting (11). Neuroscience is an 8-week course beginning in February of the first academic year. Three half-hour radiology lectures focusing on radiologic neuroanatomy and neurovascular anatomy, as well as frequently encountered pathology, were added to the second week of the course. Additionally, a 1-hour radiology consult session to review pertinent case-based imaging findings was provided with each of the three PBL modules. In both courses, the radiology consult sessions consisted primarily of student-directed discussions, interspersed with brief didactic monologs. All of these lectures and consult sessions were taught by the same academic radiologist (B.F.B.). The total amount of additional course time devoted to radiology was 8.5 hours.

No changes were made to the radiology teaching provided elsewhere in the curriculum. During the core clinical rotations, occasional lectures are provided by various radiologists from the appropriate subspecialty. During the fourth year, dedicated radiology electives are offered to interested students.

The Class of 2007 was in their first year of medical school during academic year 2003, and thus received the traditional curriculum. This class served as our control group. The Class of 2008 was in their first year of medical school during academic year 2004, and thus received the new curriculum. This class served as our experimental group. Many medical students at the University of Pittsburgh School of Medicine participate in medical or clinical scientist training programs, which delay their graduation, and some students delay their graduation for personal reasons. Only students who completed their medical

school education in exactly 4 years were included in our analysis.

Medical Student Survey

A survey was developed to measure medical students' opinions about radiology (Appendix 1). In Part I of the survey, five multiple-choice questions focused on attitudes toward radiology. In Part II of the survey, seven Likert-type questions evaluated students' agreement with stereotypes about radiologists. Some of the statements in Part II were worded such that agreement indicated an unfavorable view of radiologists, and some were worded such that agreement indicated a favorable view of radiologists (12). The survey was offered twice: the "preclinical" survey was administered at the end of the first year of medical school (shortly after exposure to the two different curricula); the "graduation" survey was administered in December of the final year of medical school (after career decisions had been made). Some of the questions were repeated between the first and second surveys to evaluate trends in attitude, but other questions were offered only in the second survey because the students would not have had time to formulate mature opinions early in their training. The complete results of the first survey have been previously reported (5); only those responses pertinent for comparison with the later results are included in the present analysis.

Administration of the surveys was approved by the Medical School Curriculum Committee after review by the Steering Committee. Participation in the surveys was voluntary. The surveys were administered online, and could be completed either at home or at school. Incomplete surveys were discarded.

To invite participants, a bulk e-mail was sent to the entire medical student class. One week later, a second bulk e-mail was sent as a reminder. One week after that, personalized e-mails were sent to every student who had not yet responded to the survey. One week after that, a second personalized e-mail was sent, warning that the survey was closing soon. One week after that (4 weeks after the initial email), the survey was closed. There was no response threshold for closing the surveys. This procedure was followed for all four administrations of the survey: Class of 2007 preclinical, Class of 2007 graduating, Class of 2008 preclinical, and Class of 2008 graduating.

Statistical Analysis

In Part I of the survey (the section on attitudes toward radiology), the answers to each question constituted an ordered, categorical data set. The distribution among the five ordered categories was not necessarily expected to be parametric, so nonparametric statistical tests were selected. The Mann-Whitney rank-sum test was applied to each of the attitude questions, comparing Class of 2007 with Class of 2008. Where appropriate, comparisons were made between the preclinical and graduation time points within a class.

In Part II of the survey (the section on radiologist stereotypes), a conventional 5-point Likert scale was used to assess agreement with various statements about radiologists. The seven individual Likert scores were combined to create a summed Likert score for each student. (If the Likert statement was worded to be favorable to radiologists, the Likert scale was reversed, so that a smaller number on the Likert scale always reflected an unfavorable opinion) (12). Because the summed Likert scores followed a normal distribution, the two groups of students were compared with Student's *t*-test.

A P value $< .05$ was considered significant for all comparisons. When interpreting the results of the multiple Mann-Whitney comparisons, a Bonferroni correction was applied to this threshold.

RESULTS

The matriculating Class of 2007, which was exposed to the traditional curriculum, had 146 students (74 female, 72 male). Of these 146 students, 112 (77%) graduated in 4 years and could be included in this study. Eighty-seven of the 112 students (78%) completed the preclinical survey; 96 of the 112 students (86%) completed the graduation survey. Six of these 112 students (5%) applied to radiology residencies.

The matriculating Class of 2008, which was exposed to the curriculum with integrated radiology, had 149 students (76 female, 73 male). Of these 149 students, 103 (69%) graduated in 4 years and could be included in this study. Ninety-one of the 103 students (88%) completed the preclinical survey; 87 of the 103 students (84%) completed the graduation survey. Five of these 103 students (5%) applied to radiology residencies.

The Class of 2008 recalled being exposed to more radiology in their preclinical years (Fig 1a), but there was no substantial difference in the two groups' recollection of the amount of radiology taught to them in the clinical years (Fig 1b). Students in the Class of 2008 were more likely to take a radiology elective than their counterparts

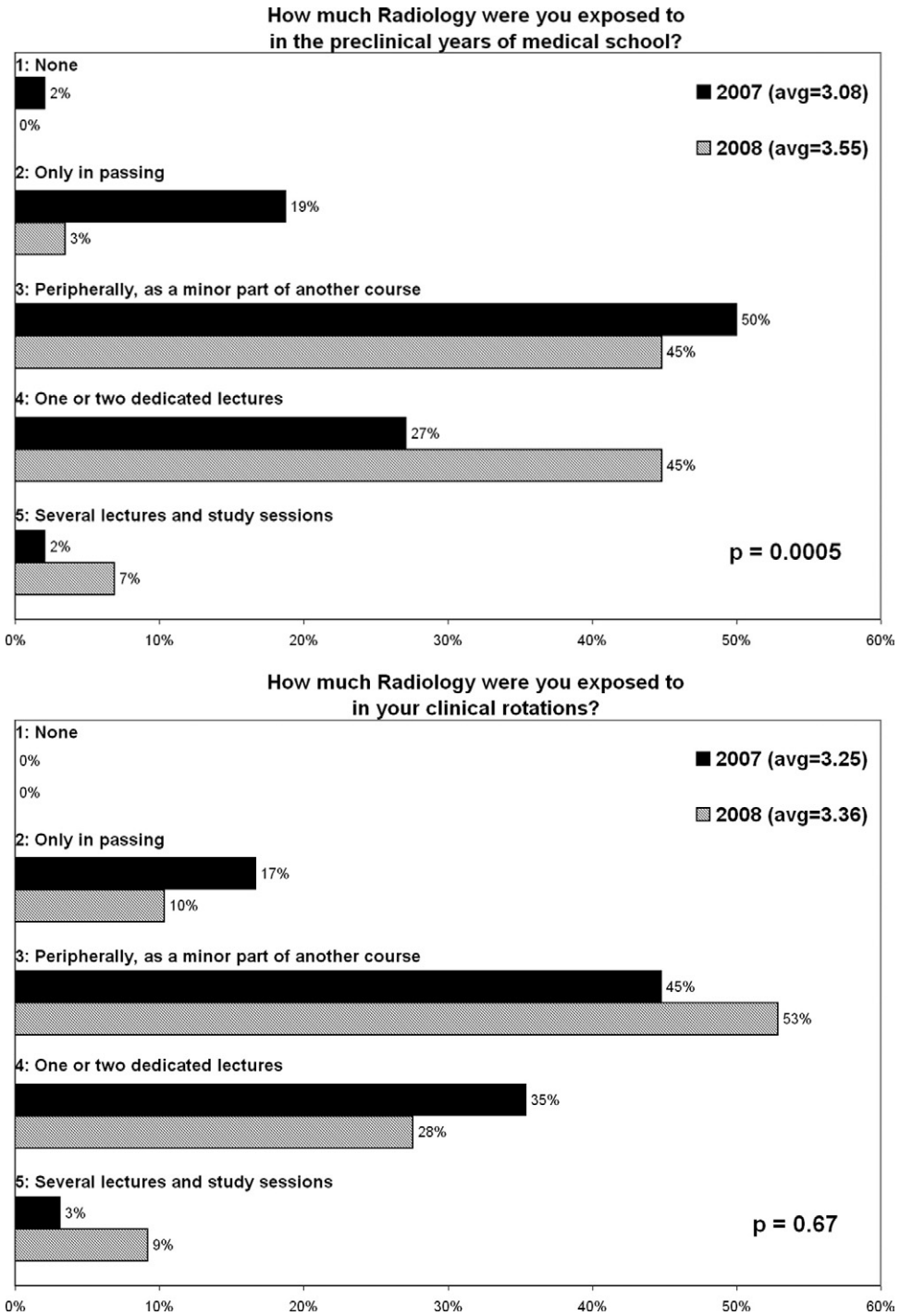

Figure 1. Survey responses for Class of 2007 (no formal radiology) and Class of 2008 (new curriculum). avg: average; grad: graduating; preclin: preclinical. (*Fig 1 continues*).

in the Class of 2007 (Fig 1c), although this effect did not reach statistical significance after Bonferroni correction.

Compared to the Class of 2007, the Class of 2008 was more likely to feel that radiology as a discipline was interesting (Fig 1d). This difference between groups was present both in the preclinical years and at graduation, although the magnitude of the effect was lessened by the time they graduated. There was a slight increase in interest between the pre-

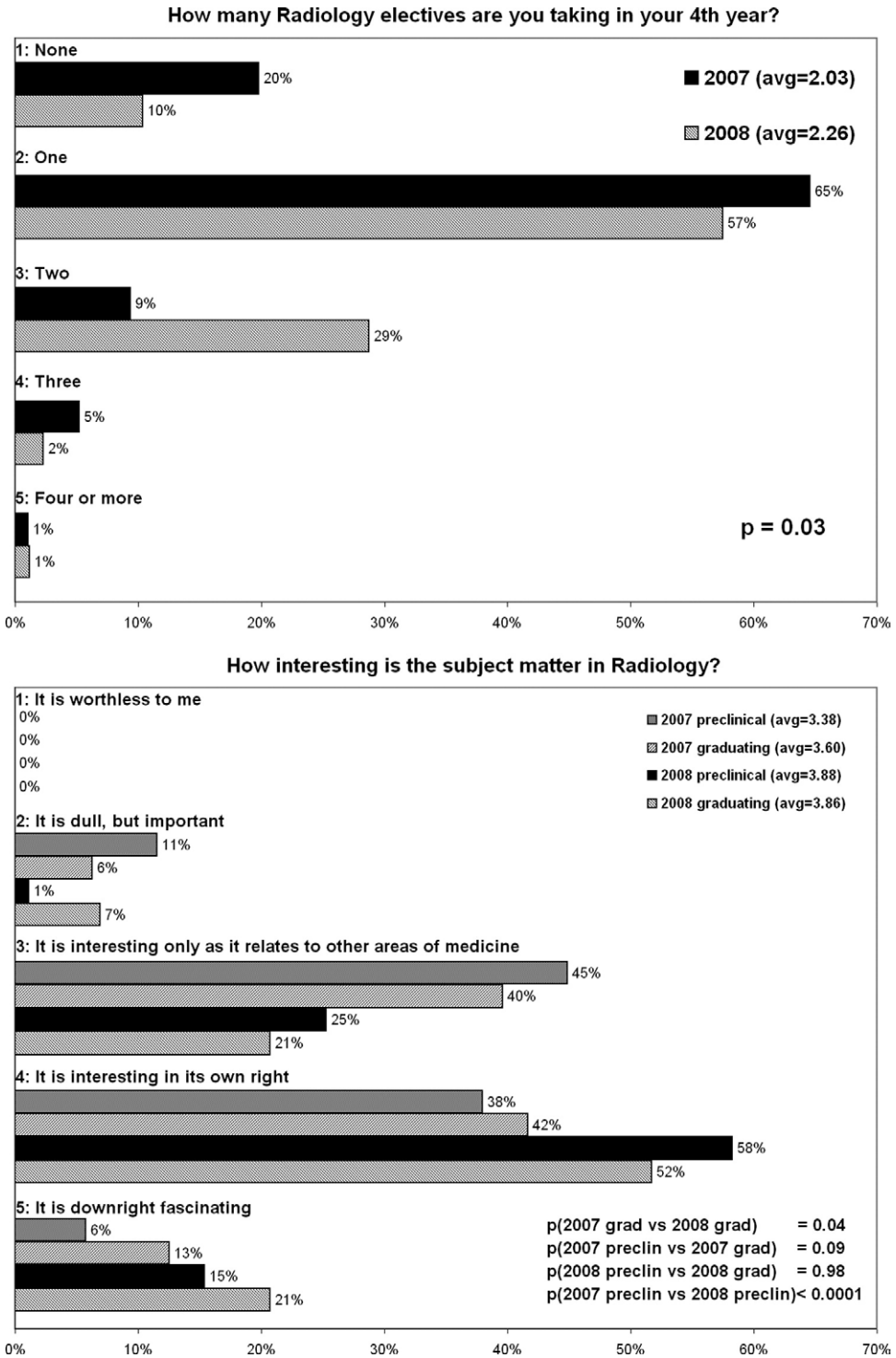

Figure 1. (*continued*).

clinical and graduation surveys from both classes, but these differences did not reach statistical significance.

Comparing the preclinical surveys, the Class of 2008 was more likely to feel that radiology had a large impact on other areas of medicine. By graduation, however, this difference was substantially smaller (Fig 1e). After Bonferroni correction, neither of these comparisons was considered statistically significant, but they did represent a

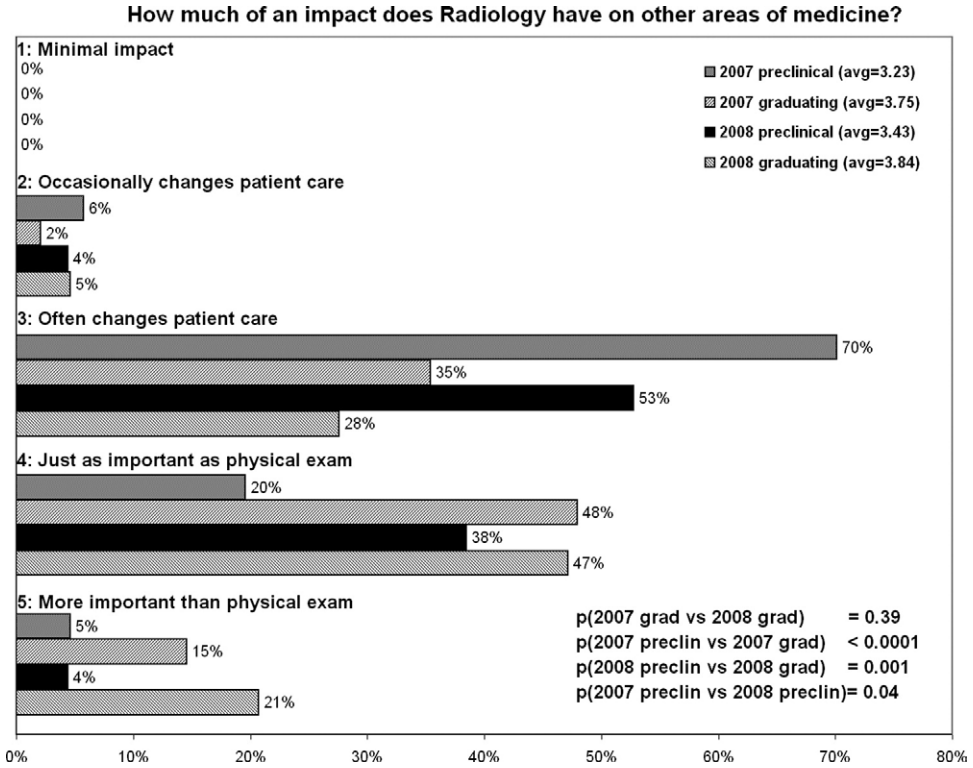

Figure 1. (*continued*).

Table 1
Graduating Medical Students' Opinions about Radiologist Stereotypes

Statement	Class of 2007	Class of 2008	Difference
Radiologists have almost no patient contact.	2.39	2.45	0.06*
Radiologists work about as many hours as physicians in other nonsurgical specialties.†	3.29	3.21	–0.08*
Clinicians can interpret radiologic images almost as accurately as radiologists.	3.85	4.08	0.23*
Radiologists' compensation (salary) is fair when compared to other physicians.†	3.21	3.32	0.11
Radiology residency is easier than other residencies.	2.59	2.90	0.31*
Radiologists are exposed to a worrisome amount of radiation over the course of their careers.	3.67	3.67	0.00
The workload in radiology is less demanding than in other medical specialties.	2.67	2.94	0.27*
Summed Likert	20.67	21.51	0.84*

Values are the average response on Likert scale of 1: strongly agree; 2: agree; 3: neutral; 4: disagree; 5: strongly disagree.
*A more favorable attitude from Class of 2008.
†The Likert was scale reversed for summation. Comparing the summed Likert scores, $P < .05$.

statistical trend. After they had completed their clinical training, both classes felt that the impact of radiology on other areas of medicine was greater than they had thought in their preclinical years.

There was a statistically significant difference in graduating medical students' opinions about radiologist stereotypes (Table 1). The largest differences were in response to the statements, "Radiology residency is easier than other residencies," and "The workload in radiology is less demanding than in other medical specialties" and "Clinicians can interpret radiologic images almost as accurately as radiologists." For almost every question, the Class of 2008 had a more favorable opinion of radiologists than the Class of 2007. The only exception was the statement "Radiologists' compensation (salary) is fair when compared to other physicians," for which the Class of 2007 had a marginally more favorable opinion.

DISCUSSION

This research demonstrates that radiology teaching in the preclinical years of medical school has a substantial positive impact on medical students' attitudes toward radiology that persists throughout the reminder of medical school training.

Graduating medical students who have been through a preclinical curriculum that incorporates radiology instruction find radiology itself to be more interesting than their counterparts who receive less formal radiology teaching, despite the fact that neither group recalls a greater amount of radiology teaching in the clinical years.

Students who have been exposed to radiology early in their preclinical training are more likely to take radiology electives in their final year of medical school, which would likely reinforce the favorable attitudes toward radiology that were instilled in the preclinical years. Anecdotally, students with an awareness of radiology early in their training are also more likely to spend time observing in radiology reading rooms and to participate in radiology research during their medical school years.

Early in their training, medical students are often taught that history-taking and physical examination are essential to making diagnoses, and that laboratory data such as radiology plays only a minor confirmatory role. Early exposure to radiology education can provide students with a more realistic view of the role of radiology, but clinical experience in the third and fourth years of training has an even greater impact on attitudes about the relative importance of these diagnostic elements.

Graduating medical students who have been exposed to radiology in their preclinical years are less likely to believe negative stereotypes about radiologists. This may be a result of positive personal interactions with radiologist-teachers, or a greater awareness of the role of radiologists during their clinical training.

It is unclear whether early exposure to radiology makes students more likely to pursue a career in radiology (the number of students entering radiology residencies in this cohort is too small to make meaningful comparisons, and year-to-year fluctuations in the desirability of radiology residency positions further complicates the issue) (7). However, encouraging students to pursue radiology as a career is only one potential benefit of medical student education in radiology. Perhaps of greater importance is the impact on non-radiologist physicians, on whom radiologists depend for referrals and for collegial professional interactions. Non-radiologist physicians who have a better understanding of what radiologists can add to patient care, and who are not burdened by negative stereotypes about radiologists, will be more likely to promote positive interactions and to make more appropriate use of diagnostic tests. Another benefit is the potential to reduce negative interactions, such as turf battles (4).

Direct radiologist involvement in medical student education is necessary to achieve the benefits depicted in this study (13). Although clinicians will sometimes incorporate radiologic images into medical student teaching, radiologists are better able to answer the in-depth questions that medical students frequently raise, and radiologists are less prone to interpretive errors that may confuse students and reduce their respect for radiology.

Didactic teaching requires a substantial time commitment from academic radiologists. Although the medical students were exposed only to an additional 8.5 hours of radiology teaching, the time to revise the curriculum and prepare the lectures was considerably greater. This time commitment may not be rewarded by the departmental administration (14). Furthermore, increasing demands for time slots within the medical curriculum may make it difficult for radiologist-educators to give didactic lectures (15). The popularity of PBL modules has provided an opportunity for radiologists to participate in medical student education without the burdensome preparation that didactic lectures often entail (9,16). PBL modules require that students research topics of interest surrounding a fictitious patient presentation. Radiologists who are explicitly available to answer questions about the radiologic components of the case can contribute with very little preparation (17). Web-based teaching platforms also provide a way to educate medical students without ongoing time commitments (11,18). However, we have found that a live teacher is often more engaging for students and can put a familiar face on the practice of radiology, which may have an important impact on the changes in attitude documented in this study.

There are several potential limitations to this study. There might be an underlying trend toward increasing interest in radiology because of confounding factors other than the curriculum changes at our medical school. Anecdotal evidence from radiology interest groups and applications to residency, however, suggest that interest in radiology has been robust and steady over this period. Response bias is a potential limitation of any survey data. Our response rates of 78%–88% are extremely high for sur-

vey data, however, so response bias is unlikely to have a major effect. Although we have demonstrated that changes in attitude persist throughout medical school, there are no data to show that the effect is permanent through residency and early career stages. Nonetheless, these attitudes are at least resilient to any negative input that might come from non-radiologist physician-educators during medical school itself, suggesting that some effect is likely to persist even longer.

The exclusive use of didactic lectures and PBL teaching sessions may have actually reduced the effectiveness of the radiology teaching in this study. More interactive, participatory methods of teaching radiology could elicit even greater interest from preclinical students (11).

In conclusion, dedicated medical student teaching from an academic radiologist during the first year of medical school has a positive, long-lasting effect on medical students' attitudes toward radiology. The prevalence of negative stereotypes about radiologists among graduating medical students can be reduced by teaching radiology in the preclinical years of medical school.

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APPENDIX 1

Medical Student Survey

Surveys was administered to medical students during their preclinical training, and again shortly before graduation. * = questions that were compared between the preclinical and graduation surveys.

Part I: Opinions

1. How much radiology were you exposed to in the preclinical (first and second) years of medical school?
   a. None
   b. Only in passing
   c. Peripherally, as a minor part of another course
   d. 1 or 2 dedicated lectures
   e. Several lectures and study sessions
2. How much radiology were you exposed to in your clinical rotations (excluding dedicated radiology electives)?
   a. None
   b. Only in passing
   c. Peripherally, as a minor part of another course
   d. 1 or 2 dedicated lectures
   e. Several lectures and study sessions
3. How many radiology electives are you taking?
   a. None
   b. One
   c. Two
   d. Three
   e. Four or more
4. How interesting is the subject matter in radiology?*
   a. It is worthless to me
   b. It is dull, but important
   c. It is interesting only as it relates to other areas of medicine
   d. It is interesting in its own right
   e. It is downright fascinating

5. How much of an impact does radiology have on other areas of medicine?*
   a. Minimal impact
   b. Occasionally changes patient care
   c. Often changes patient care
   d. Just as important as physical exam
   e. More important than physical exam

Part II: Stereotypes about Radiologists

For each of the following statements, indicate whether you strongly agree, agree, are neutral, disagree, or strongly disagree.

Radiologists have almost no patient contact.

Radiologists work about as many hours as physicians in other nonsurgical specialties.

Clinicians can interpret radiologic images almost as accurately as radiologists.

Radiologists' compensation (salary) is fair when compared to other physicians.

Radiology residency is easier than other residencies.

Radiologists are exposed to a worrisome amount of radiation over the course of their careers.

The workload in radiology is less demanding than in other medical specialties.