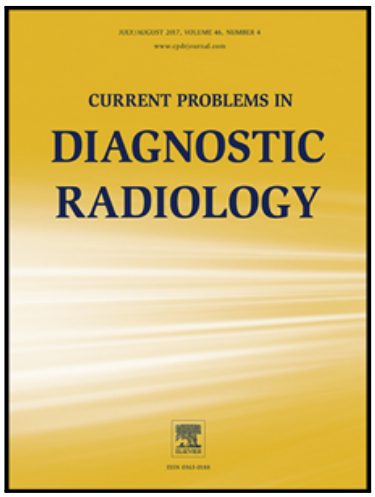

Medical Student Perspectives on the Impact of Artificial Intelligence on the Practice of Medicine.

Christian J. Park , Paul H. Yi , Eliot L. Siegel

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Current Problems in Diagnostic Radiology

Medical Student Perspectives on the Impact of Artificial Intelligence on the Practice of Medicine.

--Manuscript Draft--

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	Paul H. Yi, MD
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Manuscript Region of Origin:	North America
Abstract:	Introduction Concerns about radiologists being replaced by artificial intelligence (AI) from the lay media could have a negative impact on medical students' perceptions of radiology as a viable specialty. The purpose of this study was to evaluate United States of America medical students' perceptions about radiology and other medical specialties in relation to AI. Methods An anonymous, web-based survey was sent to 32 radiology interest groups at USA medical schools. The survey was comprised of 6 questions assessing medical student perceptions of AI and its potential impact on radiology and other medical specialties. Responses were voluntary and collected over a six-month period from November 2017 to April 2018. Results A total of 156 students responded with representation from each year of medical school. Over 75% agreed that AI would have a significant role in the future of medicine. Most (66%) agreed that diagnostic radiology would be the specialty most greatly affected. Nearly half (44%) reported that AI made them less enthusiastic about radiology. The majority of students (57%) obtained their information about AI from online articles. Thematic analysis of free answer comments revealed mostly neutral comments towards AI, however, the negative responses were the strongest and most detailed. Conclusion USA medical students believe that AI will play a significant role in medicine, particularly in radiology. However, nearly half are less enthusiastic about the field of radiology due to AI. As the majority receive information about AI from online articles, which may have negative sentiments towards AI's impact on radiology, formal AI education and medical student outreach may help combat misinformation and help prevent the dissuading of medical students who might otherwise consider the specialty.
Suggested Reviewers:	
Opposed Reviewers:	

Cover Letter

Current Problems in Diagnostic Radiology

May 28, 2020

Dear Managing Editor,

We are pleased to submit our manuscript entitled "Medical Student Perspectives on the Impact for Artificial Intelligence on the Practice of Medicine" for consideration for publication in *Current Problems in Diagnostic Radiology*.

As Artificial Intelligence (AI) becomes more prevalent in the field of medicine, particularly in radiology, our study wanted to evaluate what effect this was having on medical students and their choice of career (residency) path. In this study, we surveyed medical students across the United States about their perspectives on AI's impact on the practice of medicine, in general, and on radiology, specifically. We found that medical students were not only aware of the developments of AI in medicine, but that their perceptions of AI affect their vision of the future of medicine and subsequently their choices of residency moving forward (in particular, negatively towards radiology).

We confirm that this manuscript has not been published elsewhere and is not under consideration by another journal. All authors have approved the manuscript and agree with its submission to Current Problems in Diagnostic Radiology. The authors have no conflict of interest, financial or otherwise.

Please do not hesitate to contact me if you need any other materials or information. Thank you again for consideration to publish our work in *CPDR*.

Sincerely,

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Highlights

- Medical students are aware of the potential applications of Artificial Intelligence (AI) in the field of medicine.

- However, they remain wary about potential reduction or replacement of physicians, particularly in radiology. This is due to misinformation about AI's role, capabilities and use cases from the media or well-meaning mentors.

- Formalized AI education must be implemented into medical student curricula not only to retain the best talent in radiology but also to prepare future physicians to harness this incredible technology.

Medical Student Perspectives on the Impact of Artificial Intelligence on the Practice of Medicine.

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Results:

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Conclusion:

USA medical students believe that AI will play a significant role in medicine, particularly in radiology. However, nearly half are less enthusiastic about the field of radiology due to AI. As the majority receive information about AI from online articles, which may have negative sentiments towards AI's impact on radiology, formal AI education and medical student outreach may help combat misinformation and help prevent the dissuading of medical students who might otherwise consider the specialty.

Keywords: Artificial Intelligence, Deep Learning, Education, Medical Student, Residency

Disclosures: No relevant disclosures for all authors.

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Medical Student Perspectives on the Impact of Artificial Intelligence on the Practice of Medicine.

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Medical Student Perspectives on the Impact of Artificial Intelligence on the Practice of Medicine.

Abstract

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Keywords: Artificial Intelligence, Deep Learning, Education, Medical Student, Residency

Disclosures: No relevant disclosures for all authors.

Main Body

Introduction:

Interest and research in Artificial Intelligence (AI) has increased dramatically over the last decade[1] with billions of dollars projected to be spent towards Deep Learning (DL), in particular.[2] As deep learning has become increasingly applied to medical image analysis, prominent computer scientists have made ominous predictions about the future of radiology, ranging from DL algorithms being able to outperform radiologists in image interpretation[5] to calls to "stop training radiologists now[4]". Such sentiments have unsurprisingly been covered heavily by the lay media, both within medical and technology niches[5] and more broadly in mainstream outlets.[6]

Such negative assessments of the future of radiology in relation to AI and DL might be expected to cause medical students to have an unfavorable view of the future of radiology as a specialty to enter. In fact, studies performed in Canada and Europe have shown that AI may be significantly impacting the way that medical students approach their choice of specialty in a negative manner[7 8]. In response, a recent editorial has proposed that radiology educators should proactively address these concerns and view AI and DL as an opportunity recruit medical students to a field that will interface intimately and collaboratively with these exciting technologies.

Although the perceptions of medical students towards radiology in relation to AI have been evaluated in both Canada and Europe[7,8], no such study has been performed in the USA. The purpose of this study was thus to evaluate the perceptions of medical students about radiology and other medical specialties in relation to AI.

Methods:

Survey Administration & Participants

We conducted a survey of medical students in the USA from November 2017 to April of 2018 titled "Artificial Intelligence and the Future of Medicine," with the goal of evaluating perceptions towards radiology and other medical specialties in relation to AI. We sent our survey in the form of a browser-based, anonymous questionnaire (SurveyMonkey.com, North America) to thirty-two radiology interest groups at medical schools across the United States chosen to provide a representative mix of medical schools from different regions and which had a contact email listed on the Internet (**Appendix**). We sent a web link to our questionnaire to the student representative of each interest group, which was then sent out to all members of the interest group. Over the course of the survey period, reminders were sent to complete the survey with an internal mechanism from SurveyMonkey to prevent multiple responses from a single participant.

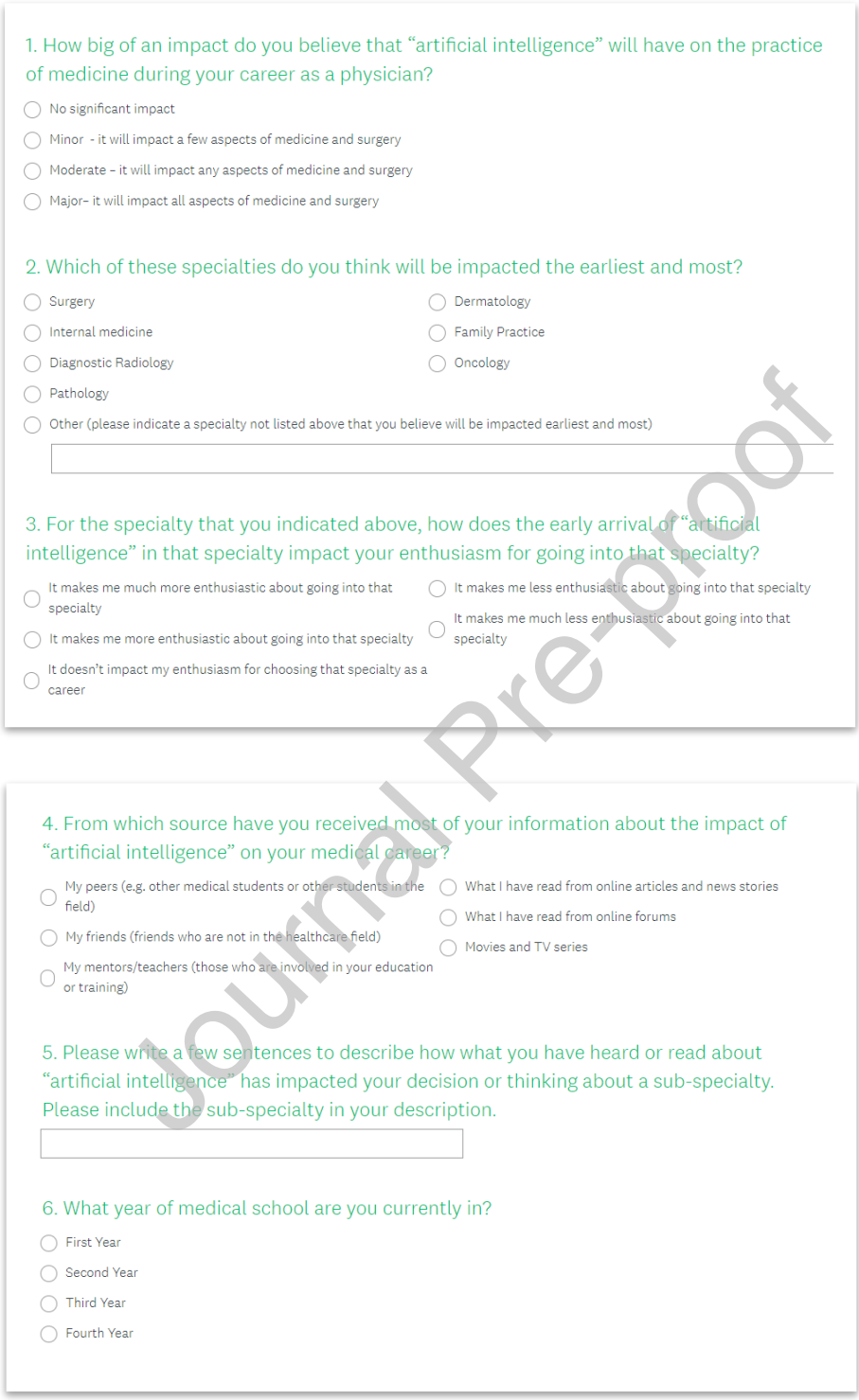
Institutional review board approval was not required as this study did not involve any patients. Participation in this survey was completely voluntary and had no effect on the students' curricular activities. Respondents were informed on the nature of the survey being used for

research and that they would remain completely anonymous due to the nature of the survey method. Furthermore, no identifying information was recorded at any time during this study, ensured by the design of the survey on SurveyMonkey.

Survey Content

Our survey questionnaire was comprised of five multiple choice questions and one free response. The survey format and questions are provided in **Figure 1.** The first question asked about the medical students' perceptions towards AI on their future careers as physicians. The second and third questions asked about their opinion on which medical specialty would be impacted the earliest and most by AI and how AI impacts their enthusiasm for choosing that specialty for their career. The fourth question asked about the primary source of information the students used to obtain information about AI and medicine. The fifth question was a free-response question for students to share any thoughts they had on the impact of AI on their decision-making for specialty choice. The sixth and final question asked students for their current year in medical school. Likert-type scales were used where appropriate. After the initial drafting of the survey, all survey questions and potential responses were reviewed and revised by a fourth-year medical student to ensure clarity and ease-of-understanding.

Figure 1.



1. How big of an impact do you believe that "artificial intelligence" will have on the practice of medicine during your career as a physician?

- ○ No significant impact
- ○ Minor - it will impact a few aspects of medicine and surgery
- ○ Moderate – it will impact any aspects of medicine and surgery
- ○ Major– it will impact all aspects of medicine and surgery

2. Which of these specialties do you think will be impacted the earliest and most?

- ○ Surgery
- ○ Internal medicine
- ○ Diagnostic Radiology
- ○ Pathology
- ○ Dermatology
- ○ Family Practice
- ○ Oncology
- ○ Other (please indicate a specialty not listed above that you believe will be impacted earliest and most)

3. For the specialty that you indicated above, how does the early arrival of "artificial intelligence" in that specialty impact your enthusiasm for going into that specialty?

- ○ It makes me much more enthusiastic about going into that specialty
- ○ It makes me more enthusiastic about going into that specialty
- ○ It doesn't impact my enthusiasm for choosing that specialty as a career
- ○ It makes me less enthusiastic about going into that specialty
- ○ It makes me much less enthusiastic about going into that specialty

4. From which source have you received most of your information about the impact of "artificial intelligence" on your medical career?

- ○ My peers (e.g. other medical students or other students in the field)
- ○ My friends (friends who are not in the healthcare field)
- ○ My mentors/teachers (those who are involved in your education or training)
- ○ What I have read from online articles and news stories
- ○ What I have read from online forums
- ○ Movies and TV series

5. Please write a few sentences to describe how what you have heard or read about "artificial intelligence" has impacted your decision or thinking about a sub-specialty. Please include the sub-specialty in your description.

6. What year of medical school are you currently in?

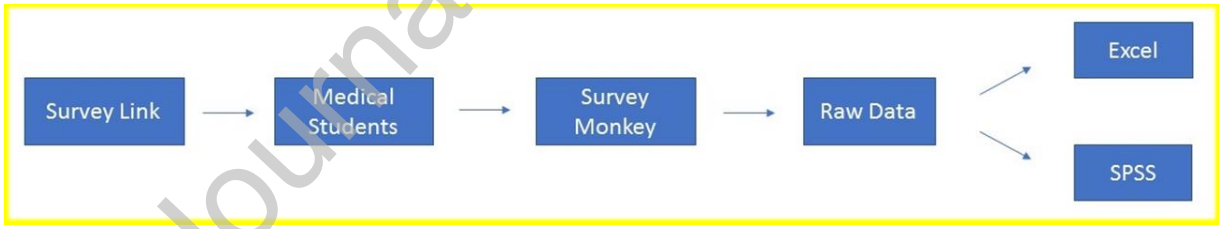
- ○ First Year
- ○ Second Year
- ○ Third Year
- ○ Fourth Year

Data Analysis

Raw data was exported from Survey Monkey and statistical analysis was performed utilizing SPSS (IBM Corporation, Armonk, NY) using a standard workflow design (**Figure 2**). Differences in responses between medical school years were compared in binary fashion using Chi-Squared and Mann-Whitney-Wilcox tests.

Free text responses were reviewed and summarized thematically by two of the study authors (one fourth-year medical student and one attending radiologist). Additionally, all free-text responses were classified by sentiment into one of three categories: AI having a negative impact on a given specialty, AI having a positive impact on a given specialty, and AI having neutral/no impact on a given specialty.

Figure 2. Survey Collection and Analysis Process Flowchart.

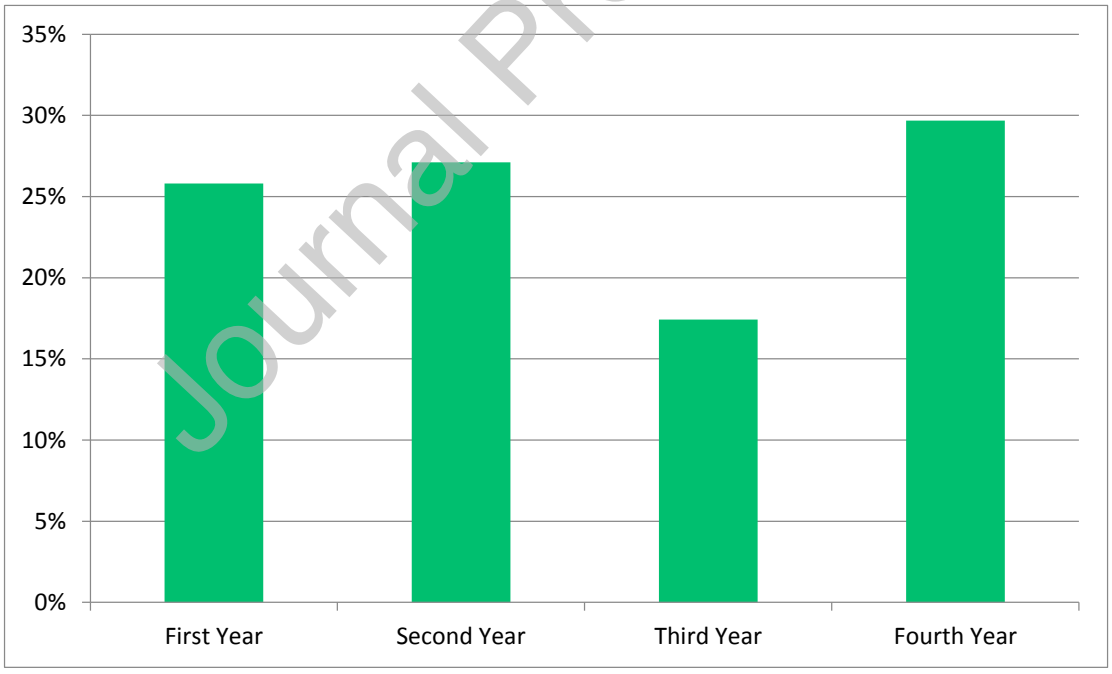


Results:

Survey Respondent Summary

There was a total of 156 responses with a very high survey completion rate of 95.4% (of all students who started the survey). There was representation from students from each year (M1: 25.8%, M2: 27.1%, M3:17.4%, M4:29.7%) of medical school (Figure 3).

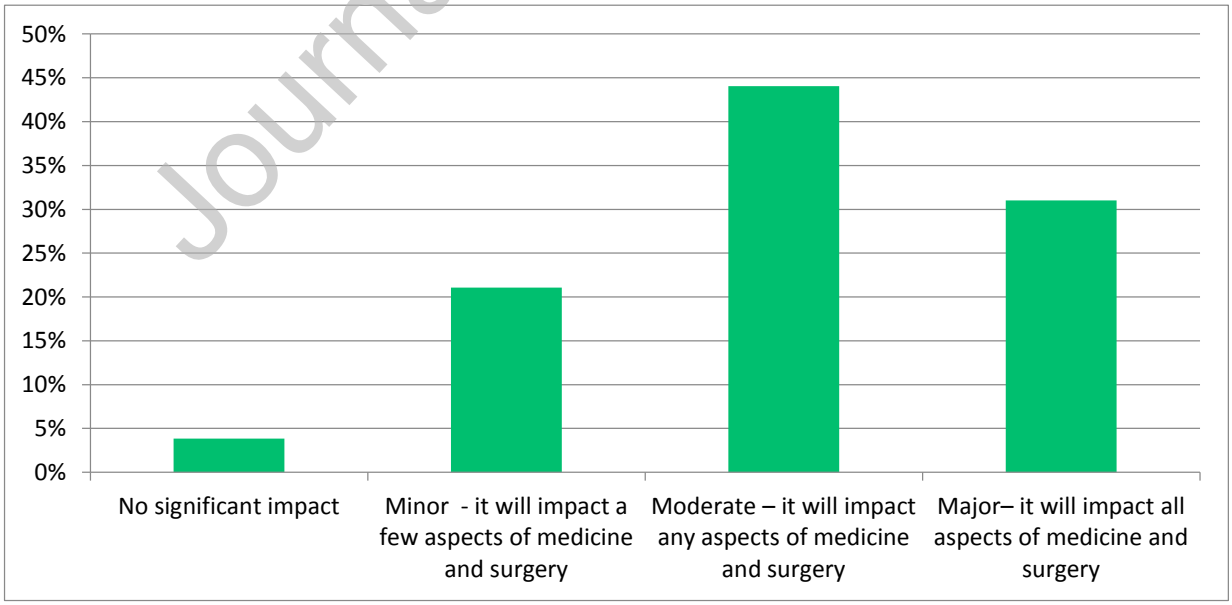
Figure 3. Results for the question "What year of medical school are you currently in?"



The effect of AI on the practice of medicine during their career

Over 75% of students revealed that they believed AI would have a moderate-to-major effect on medicine during their careers (**Figure 4**). A small minority (1.9%) reported that AI would play no part in the future of medicine. On sub-analysis by medical school year, first-year medical students were more likely to believe that AI will have a profound impact on medicine than fourth-year medical students(M1 = 82%, M4 = 65%, p=0.038). No other significant differences were observed in responses between medical school years.

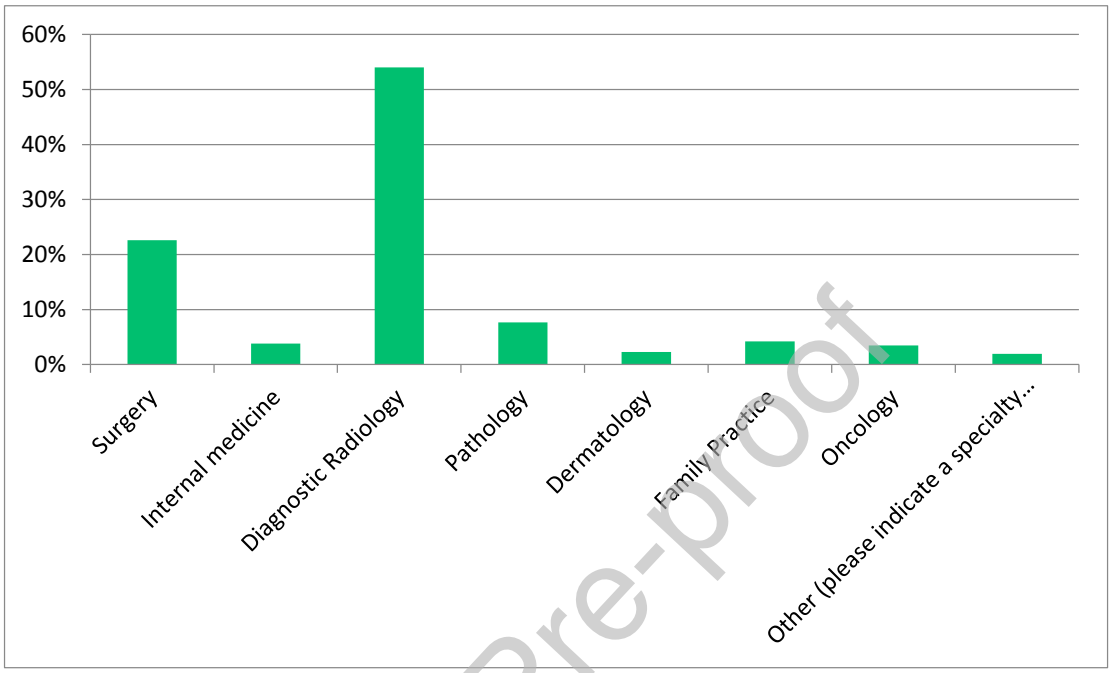
Figure 4. Results for the question "How big of an impact do you believe that "artificial intelligence" will have on the practice of medicine during your career as a physician?"



Specialty Impacted Earliest by AI

With regards to the specialty that would be impacted the earliest and most by AI, the majority of students (66%) answered “Diagnostic Radiology” with “Surgery” a distant second at 13.4%, followed by “Pathology” at 7.7% (**Figure 5**). Other specialties were represented in smaller proportions and “write-in” specialties added by students included “anesthesia” and “emergency medicine.” A significant difference was found between M1 vs M4 students (M1 = 73%, M4 = 27%, p=0.008) for their selection of radiology. No other significant differences were identified.

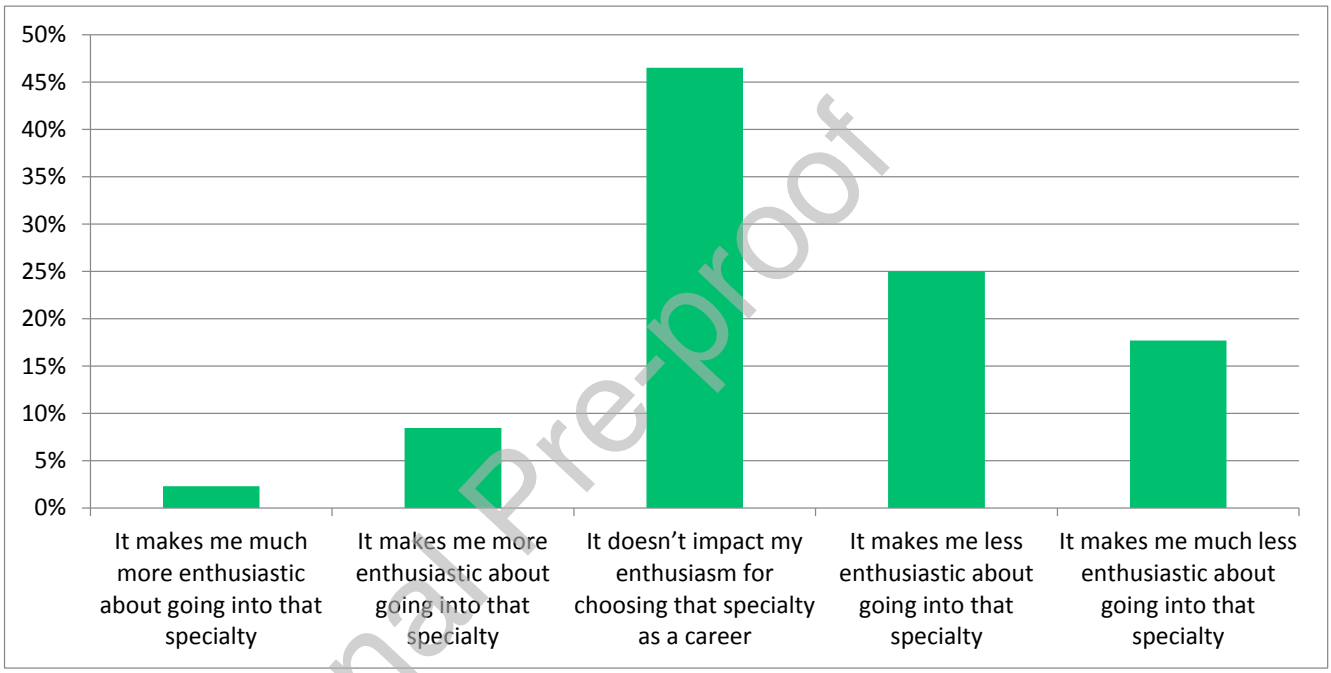
Figure 5. Results for the question "Which of these specialties do you think will be impacted the earliest and most?"



Attitudes towards specialty due to potential impact of AI

With regards to the specialty the respondents indicated in the preceding question, 45% of students responded that their belief about AI's earliest and most impacted specialty (most often radiology) did not affect their enthusiasm for the field, while 44% of students indicated that it would make them less or much less enthusiastic about that specialty (**Figure 6**). There were no significant differences found between groups.

Figure 6. Results for the question "For the specialty that you indicated above, how does the early arrival of "artificial intelligence" in that specialty impact your enthusiasm for going into that specialty?"



Sources of Information

With regards to the students' source for obtaining information on AI and its relationship to medicine, the majority (57%) received their knowledge about AI from online articles and news stories while the second popular choice of 18% of respondents received their information from mentors. No significant differences were found between response groups.

Free Answer/Comment Section

A total of 116 free-text responses were recorded and analyzed thematically. Thirty were negative (26%), twenty-seven were positive (23%) and fifty-nine responses were neutral/no impact (51%). The most frequently encountered entry was about "radiology" as a specialty, which appeared in 27% of all responses total. Students remarked about "AI programs that have learned to interpret chest radiographs with an accuracy rate at or better than current radiologists" as well as "Google's machine learning prowess." Negative responses included concerns that AI would result in "doom for diagnostic radiology," "AI will take over all interpretation of imaging, EKG's and anything else not acquired from an H&P," and "artificial intelligence could potentially make radiologist(s) obsolete." There was even some dark humor, with one student saying that "a mentor of mine told me that radiology is Blockbuster and AI is Netflix."

Discussion:

Due to anecdotal reports of medical student concerns regarding AI's influence on the future practice of medicine as well as sentiments from both medical professionals and the lay media that have predicting deleterious effects of AI on the viability of diagnostic radiology, we investigated whether there could be a negative impact of AI on medical students' perceptions of the field. Although medical student perceptions of AI's impact on radiology have been studied in Canada and Europe[7,8], no similar study has been performed in the USA. Therefore, we surveyed USA medical students about their perceptions of AI's impact on radiology and other medical specialties. Students felt that AI would have a profound impact in medicine and

chose radiology as the most likely to be impacted. The negative comments in the free response section were more specific, detailed and knowledgeable, indicating a range of sentiments related to radiology in relation to AI.

We found that the vast majority of medical students were aware of the arrival of AI and are concerned about the impact that it will have on their future practice. As three quarters of respondents answered that they believed their medical careers would be significantly impacted by AI, this seems to confirm that medical students are indeed profoundly impacted by media and articles regarding AI in medicine. Historically, sweeping technological changes have affected medical students' decisions regarding their career direction[9]. Given that first year medical students seem to believe that AI will have a stronger impact than their fourth year counterparts, one can surmise that this may shape the way in which medical students select their fields of choice for residency. In regard to specialty, almost five times the number of total respondents selected radiology to be the earliest and most impacted by AI compared to surgery. This likely reflects the volume of information regarding the potential integration and utility of AI into radiology, as well as the respondents being members of radiology interest groups.

Interestingly, of the respondents who chose radiology to be the most significantly impacted, 44% said that it would reduce their enthusiasm. This is a similar proportion compared to a recent survey that was performed in Europe[8], which found that less than half (44%) of respondents responded that this would reduce enthusiasm for the field of radiology, a

sentiment that was echoed in a recent survey of Canadian medical students in which 48.6% stated that AI caused them to feel anxious regarding a career in radiology[7]. The significance of this is not to be understated in that half of potential candidates to the specialty feel as though there is limited opportunity due to an emerging technology such as AI. These sentiments have the potential to create downstream effects such as reduction in recruitment to the field of radiology or even medicine as whole.

The free form comments regarding the specialty first impacted by AI were particularly interesting, as they provide a window into the thoughts of medical students. While there were some truly enthusiastic comments that seemed to convey the possibilities being offered by AI, the majority of the positive comments were relatively lukewarm and vague. Comments such as "supplement our knowledge and abilities," "assist with evaluating radiology images" and "help radiologists" are certainly hopeful, although understandably lacking in specific details of how AI might be utilized in the future. This is in stark contrast to the negative comments, in which many cited specific examples and articles to support their prediction of the demise of radiologists at the hands of AI. This likely reveals the relative paucity of supportive lay media articles compared to the relatively abundancy of negative press. The overall takeaway from the negative effect responders was that AI is something that will take away opportunity from practitioners of that particular field - many commented that it would lead them to choose another specialty path.

Limitations of the study:

There were number of limitations with our study, one of which the relatively small sample size of students compared the total number of medical students in the United States, as well as likely self-selection of students that the survey was provided to. Because the survey responses were received from students in radiology interest groups, there was certainly a factor of self-selection in the survey responses, as students interested in radiology may be more up to date with relevant hot topics in radiology, such as AI. Additionally, it could be argued that the wording of the questions could be considered biased despite our efforts to avoid bias, in the sense that they may have suggested the presence of an impact on medical practice by AI. For example, many of the survey questions ask, "what impact," perhaps subtly implying there should be some sort of change. To what degree this may have affected the responses is hard to gauge. Finally, there were a limited number of questions on our survey, because we assumed our completion rate would be inversely related to the number of questions on the survey and we believed a high (although the 95% was higher than anticipated) completion rate per survey taken was important.

Conclusion:

The continued misperception of AI as a replacement for radiologists is much more of a threat than the development and integration of AI into the practice of diagnostic imaging, as our study suggests that it may erode medical student enthusiasm for the field. This has to potential to reduce incoming talent into the field and ultimately results in a "brain drain." Radiology has always been at the forefront of technology utilization and education in medicine – MRI, CT, and

PACS to just name a small sample. Similarly, AI (and associated data science principles) should be integrated into medical education curricula to enable students to take advantage of this technology as well as dispel any incorrect notions about AI's deleterious effects on the field.

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Appendix

List of Contacted Radiology Interest Groups
Boston University
University of Pennsylvania
University of Alabama Birmingham
University of Washington
Howard University College of Medicine
University of Arkansas for Medical Sciences
University of Michigan
Wayne State University Medical School
University of Arizona
Wake Forest School of Medicine
University of Maryland
University of Colorado
Stanford University
University of California San Francisco
University of California Los Angeles
Northwestern University
University of California San Diego
Emory University
University of North Carolina
University of Central Florida
Yale School of Medicine
University of California Davis
Vanderbilt University School of Medicine
University of Massachusetts School of Medicine
Duke University
University of Texas
Ohio State University School of Medicine
Thomas Jefferson University School of Medicine
Louisville University School of Medicine
Einstein University
Johns Hopkins University School of Medicine
Harvard University School of Medicine