Current Problems in Diagnostic Radiology 48 (2019) 17–21

Current Problems in Diagnostic Radiology

journal homepage: www.cpdrjournal.com

Trainee Knowledge of Imaging Appropriateness and Safety: Results of a Series of Surveys From a Large Academic Medical Center

Thaddeus D. Hollingsworth, MD[a,*], Richard Duszak Jr., MD, FACR[a], Arvind Vijayasarathi, MD, MBA, MPH[a], Rondi B. Gelbard, MD[b], Mark E. Mullins, MD, PhD, FACR[a]

[a] Department of Radiology and Imaging Sciences, Emory University School of Medicine, Atlanta, GA
[b] Department of Surgery, Emory University School of Medicine, Atlanta, GA

Objective: In order to provide high quality care to their patients and utilize imaging most judiciously, physician trainees should possess a working knowledge of appropriate use, radiation dose, and safety. Prior work has suggested knowledge gaps in similar areas. We aimed to evaluate the knowledge of imaging appropriateness, radiation dose, and MRI and contrast safety of physician trainees across a variety of specialties.
Methods: Between May 2016 and January 2017, three online surveys were distributed to all interns, residents, and fellows in ACGME accredited training programs at a large academic institution over two academic years.
Results: Response rates to three surveys ranged from 17.2% (218 of 1266) for MRI and contrast material safety, 19.1% (242 of 1266) for imaging appropriateness, to19.9% (246 of 1238) for radiation dose. Overall 72% (509 of 706) of survey respondents reported regularly ordering diagnostic imaging examinations, but fewer than half (47.8%; 470 of 984) could correctly estimate radiation dose across four commonly performed imaging studies. Only one third (34%; 167 of 488) of trainees chose appropriate imaging in scenarios involving pregnant patients. Trainee post-graduate year was not significantly correlated with overall radiation safety scores, and no significant difference was found between radiation safety or appropriate imaging scores of those who participated in a medical school radiology elective vs. those who did not. A total of 84% (57 of 68) of radiology trainees and 43% (269 of 630) of non-radiology trainees considered their knowledge adequate but that correlated only weakly correlated to actual knowledge scores ($p<0.001$). Most trainees (73%, 518 of 706) agreed that more training in these areas would have beneficial effects on patient care.
Conclusions: Knowledge gaps pertaining to appropriateness and imaging safety exist among many trainees. In order to enhance the value of imaging at the population level, further work is needed to assess the most appropriate method and stage of training to address these knowledge gaps.

Introduction

A central role of physicians has long been that of diagnostician. The diagnostic process has been viewed as an iterative process of information gathering and interpretation, with the selection and ordering of diagnostic tests being a critical step in the diagnostic pathway.[1] Imaging often plays a critical role in this process. Advances in imaging technologies and accessibility have greatly increased the use of diagnostic imaging in recent decades but there may be important knowledge gaps among physician trainees when it comes to ordering these tests. Physician knowledge of the costs of imaging has been widely studied,[2] but the extent of their knowledge of other factors such as exposure to ionizing radiation, intravenous contrast, and possible interactions with implantable devices is poorly understood.

Multiple prior studies have assessed physicians' knowledge of radiation risks at various stages of physician education and in multiple practice settings. Generally, physicians across many specialties and levels of training have performed poorly on surveys assessing their understanding of radiation dose, safety, and potential hazardous effects.[3-17] Similar results have been seen with respect to physicians' knowledge of magnetic resonance imaging (MRI) and contrast material-related safety, as well as diagnostic imaging appropriateness.[18,19] In the academic setting, physician trainees (ie, interns, residents, and fellows) should possess a working knowledge of associated risks and appropriateness of these tests to provide high-quality and high-value care, and to address any concerns with their patients.[4,20] Importantly, they continue to order those studies after training, when they begin to practice independently.

The purpose of this study was to evaluate the knowledge of physician trainees across a variety of clinical specialties regarding several key topics related to ordering diagnostic imaging examinations. These include appropriateness, radiation dose, and both MRI and contrast safety considerations. We also sought to assess trainees' perceptions of the adequacy of their education in these important areas.

*Reprint requests: Department of Radiology and Imaging Sciences, Emory University Hospital, 1364 Clifton Road NE, Atlanta, GA 30322.
E-mail address: tdholli@emory.edu (T.D. Hollingsworth).

https://doi.org/10.1067/j.cpradiol.2017.10.007
0363-0188/

Methods

This study was formally evaluated by our university's Institutional Review Board and was granted exempt status before deployment of the first of 3 separate surveys.

Study Population

The population for this study included all trainees enrolled in Accreditation Council for Graduate Medical Education accredited internships, residencies, and fellowships at our university between May 2016 through January 2017. The surveys were distributed via the Graduate Medical Education (GME) Office's official list server.

Survey Instrument

Our survey design and format was based upon recently published studies distributed to physician trainees regarding the cost of imaging.[2,21] The diagnostic appropriate use content was adapted from the American College of Radiology's (ACR) Appropriateness Criteria.[22-25] The radiation safety content was adapted from open source material such as the ACR Relative Radiation Level Scale,[26] which rates relative effective doses of examinations in simple terms, as well as the Radiology Society of North America's Radiation Biology for Diagnostic and Interventional Radiologists Syllabus.[27] The MRI and contrast material safety content was adapted from the ACR guidance document on MR safe practices[28] and the ACR Manual on Contrast Media.[29] Our survey instruments are available in Appendix C.

The first segment of our surveys queried respondents regarding the following demographic information: training program specialty, year and level of training, estimated number of diagnostic imaging studies ordered per week, prior medical school radiology elective, and whether they received focused education related to the survey topic during medical school or postgraduate training. Additionally, we asked respondents to rate their level of perceived knowledge on each respective topic on a 5-point Likert scale, and whether they felt additional education at the medical school level in this area would be beneficial to their practice. The specific knowledge assessment questions for each survey can be found in Appendix C1-3.

Survey Distribution

The surveys were created and distributed via SurveyMonkey.com (SurveyMonkey LLC, Palo Alto, CA), a web-based survey platform. An initial e-mail with a hyperlink was distributed to all trainees subscribed to the GME list sever in May of 2016, and 3 reminder emails were sent during the 6 weeks that the survey remained open. Subsequent surveys were distributed in a similar manner in October of 2016 and January of 2017. To incentivize trainees to participate, the opportunity to enroll into a raffle to win 1 of ten $50.00 Amazon.com gift cards for each of the surveys, or the option to enroll in each gift card raffle without survey completion, was provided using departmental research funds.

Data Analysis

The statistical analysis employed was partially derived from prior studies assessing physician trainee knowledge of the costs of diagnostic imaging.[2,21] Answers to the demographic questions (eg, postgraduate year [PGY], training program, and self-perceived adequacy of knowledge) were summarized by frequencies.

For the diagnostic imaging appropriateness survey, correct responses to 4 clinical vignettes were summed to provide imaging appropriateness score. Answers to the radiation safety portion of the survey were coded as dichotomous responses (correct vs incorrect). The total number of correct responses per participant were summed to provide a radiation safety knowledge score (number of correct responses out of a total of 8 questions). A mean radiation safety knowledge score was calculated across the study sample and various subgroups. Incorrect responses pertaining to radiation dose or risk assessment were further categorized into over and underestimates. For the MRI and contrast material safety survey, credit for correct response to question on devices considered to be MRI safe was assigned as 1 point for selection of the correct response divided by total number (out of 5 devices) selected, such that 0.5 points were awarded if respondent chose the correct device as well as one other device (1 correct of 2 selected). The other 4 questions were coded as dichotomous responses receiving 1 point for each correct response. Survey score was determined by summation of points from each question (out of a total of 5 questions).

Independent *t*-test used to compare mean scores between groups. Pearson correlation coefficient, r, used to test correlation between PGY status and survey scores, as well as for correlation between number of imaging examinations ordered per week and imaging score. Spearman correlation coefficient, ρ, used to test for correlation between trainee perceptions of knowledge adequacy vs survey score.

Multiple subgroups were analyzed individually by comparing their survey scores. Radiology trainees were compared with nonradiologists, and those respondents reporting prior education on respective subject or participation in a medical school radiology elective were compared with those who reported no prior education and no medical school radiology elective, respectively.

Data analysis was performed using Excel 2016 (Microsoft, Redmond, WA) and statistical analysis was performed using GNU PSPP (Free Software Foundation, http://fsf.org/), as well as Social Science Statistics' Spearman rho calculator (www.socscistatistics.com/tests/spearman/Default.aspx).

Results

Of 1238 to 1266 trainees, 17.2%-19.9% responded to 3 surveys. Mean response rate among the surveys was 18.7%. Survey specific response rates and basic demographics of survey respondents are illustrated in Table A1.

Imaging Frequency

Among all respondents, 72% (509/706) reported ordering diagnostic imaging examinations in their regular practice. Among those ordering examinations, the mean number of studies ordered per week was 12.2 (±16.4). Appropriate imaging score was very weakly associated with the number of examinations that the respondent requested per week ($r = 0.15$, $P = 0.022$). Among nonradiology trainees, number of examinations ordered per week was slightly more associated with appropriate imaging ($r = 0.18$, $P = 0.010$). The number of examinations requested per week did not significantly correlate with radiation safety score ($r = 0.01$, $P = 0.880$), or MRI and contrast-related safety score ($r = -0.06$, $P = 0.379$).

Imaging Appropriateness

Almost half (48%;115/242) of trainees reported that they had not heard of ACR Appropriateness Criteria, and only 9% reported regular use of that tool. As can be seen in Figure B2, fewer trainees chose appropriate imaging in scenarios involving pregnant patients.

Radiation Safety

Just under half (47.8%; 470/984) of radiation dose estimates across 4 commonly performed imaging studies were correct. Among incorrect estimates for studies delivering ionizing radiation, 76% (355/469) underestimated radiation dose. Approximately 18% (45/246) of all respondents believed that MRI delivers ionizing radiation. As illustrated in Figure B1, respondents underestimated rather than overestimated relative radiation dose of the chest computed tomography (CT) to a chest radiograph, lifetime relative risk of cancer from a CT, as well as the background lifetime incidence of all cancers in the United States.

MRI Safety

Nearly one-third (29%; 64 of 218) of trainees did not understand that an MRI magnetic field remains on even when a scanner is not in use. Trainee responses for implants considered to be generally MRI safe can be seen in Figure B3.

Contrast Material Safety

Contrast-induced nephropathy was correctly defined by only 38.5% of trainees (84 of 218), whereas 29% (64 of 218) correctly identified risks for nephrogenic systemic fibrosis in the setting of gadolinium-based contrast media administration. Only 48% (104 of 218) chose the most appropriate first-line therapy, route, and dose for an acute severe allergic type reaction after iodinated contrast administration.

Training Level

PGY level of the trainee was not significantly correlated with appropriate imaging score ($r = 0.01$, $P = 0.986$), overall radiation safety score ($r = 0.10$, $P = 0.11$), or MRI and contrast safety score ($r = 0.06$, $P = 0.358$).

Radiology vs Nonradiology Trainees

Radiology trainees tended to score higher regarding appropriate imaging, averaging 76% ± 24%, ($n = 17$) compared with 67% ± 23%, ($n = 225$) for nonradiology trainees, however, this was not statistically significant ($P = 0.119$). Radiology trainees achieved significantly higher radiation safety scores (51% ± 19%, $n = 35$) than nonradiology trainees (37% ± 17%, $n = 211$) ($P = 0.000$), as well as significantly higher MRI and contrast-related safety scores (64% ± 15%, $n = 18$) as compared to nonradiology trainees (39% ± 20%, $n = 200$) ($P = 0.000$).

Radiology Elective

Trainees who had participated in radiology electives had higher MRI and contrast-related safety scores (44% ± 24%, $n = 119$) than those who did not (37% ± 20%, $n = 94$) ($P = 0.022$); however, MRI and contrast safety scores among nonradiology trainees who participated in a radiology elective (41% ± 20%, $n = 104$) were not significantly higher than those who did not, (37% ± 20%, $n = 93$) ($P = 0.188$). No significant difference was found between appropriate imaging score of those who participated in a radiology elective (70% ± 24%) and those who did not (66% ± 22%) ($P = 0.145$), nor between radiation safety scores (38% ± 18%, $n = 110$) of those who participated in a radiology elective and those who did not, (36% ± 16%, $n = 101$) ($P = 0.512$).

Prior Formal Education

No significant difference was found between those reporting prior formal education regarding respective topics during medical school and those who did not for appropriate imaging score (67% ± 23%, $n = 186$ vs 71% ± 22%, $n = 56$) ($P = 0.283$), radiation safety score (38% ± 17%, $n = 122$ vs 37% ± 18%, $n = 89$) ($P = 0.772$), nor for MRI and contrast safety score (44% ± 22%, $n = 86$ vs 39% ± 20%, $n = 127$) ($P = 0.084$).

Trainee Self-Perceived Knowledge

When asked to rate the adequacy of their subject knowledge, 88% (15/17) of radiology trainees and 50% (110/222) of nonradiology trainees considered their knowledge of appropriate use of diagnostic imaging to be adequate, as compared to 86% (30/35) radiology trainees and 45% (96/211) nonradiology trainees for radiation safety, and 75% (12/16) of radiology trainees and 32% (63/197) of nonradiology trainees for MRI and contrast safety, with an average across all subjects of 84% (57/68) among radiology trainees and 43% (269/630) among nonradiology trainees. Knowledge adequacy among trainees regularly requesting diagnostic imaging examinations was 53%, 47%, and 34% with regard to appropriate imaging, radiation safety, and MRI and contrast-related safety, respectively, (98/185, 85/182, and 51/150, respectively), with an average across all subjects of 45% (234/517).

Trainee perception of knowledge adequacy weakly correlates to appropriate imaging score ($\rho(240) = 0.271$, $P < 0.001$), radiation safety score, ($\rho(246) = 0.237$, $P < 0.001$), and CT and MRI safety score ($\rho(213) = 0.234$, $P < 0.001$).

Desire for Training

A majority of respondents agreed that it would be beneficial to have received more education about appropriate imaging (77%; 186/242), radiation safety (68%; 167/246), and MRI and contrast material safety (76%; 165/218).

Discussion

In our series of surveys of postgraduate physician trainees across a variety of specialties in a large academic health system, we found that most trainees report regularly requesting diagnostic imaging examinations for their patients. However, considerable knowledge gaps among trainees exist in several important areas that should be considered when selecting and requesting these examinations.

Selection of appropriate diagnostic imaging examinations is a critical step in the diagnostic pathway, however, trainees demonstrate widely variable knowledge of appropriate imaging, particularly pertaining to imaging pregnant patients. Given that less than 10% of trainees currently report regular use of ACR Appropriateness Criteria, embedded clinical decision support in the ordering process may be a useful way to improve patient care.

Overall, trainees appear to be poorly prepared to assess and discuss radiation risks with patients. There is a tendency of trainees to underestimate both background lifetime incidence of cancer and relative risk of developing a malignancy from CT examinations, which is consistent with the 2015 review by Lam et al.[30]

Trainee knowledge of implants that are generally safe to image with MRI was particularly interesting. For example, it is concerning to see that 56% of trainees believe all intracranial aneurysm clips to be MRI safe, and up to 39% believe that cochlear implants are MRI safe. Although this knowledge gap among trainees may not pose a

great risk to patients with proper screening techniques in place, what may be more concerning is the general perception that remote orthopedic hardware is not typically safe to image. Since trainees are responsible for selection and ordering of diagnostic examinations, the misconception that orthopedic hardware precludes patients from MRI likely prevents, or at least delays, many patients from getting valuable diagnostic imaging.

Knowledge of contrast material-related safety was generally poor among nonradiology trainees. It is not surprising that radiology trainees performed better in this area given residency specific training. The apparent correlation between MRI and contrast safety score and participation in a radiology elective seems to be confounded by radiology trainees' scores, as this was the topic with the greatest disparity between radiology and nonradiology trainee scores, with radiology trainees outscoring nonradiology trainees by 25%, as compared to 14% for radiation safety, and 9% for appropriate imaging.

Radiology trainees report much higher knowledge adequacy than nonradiology trainees across all topics examined, most markedly pertaining to MRI and contrast-related safety, in which only 32% of nonradiology trainees report adequate knowledge to care for their patients. Although radiology trainees receive more dedicated instruction in these areas, it is very concerning that only 45% of trainees regularly ordering diagnostic examinations feel adequately prepared to do so.

With regard to imaging frequency, the slightly higher correlation between number of examinations ordered per week and appropriate imaging score among nonradiology trainees vs all trainees makes sense in the context that radiology trainees do not regularly order diagnostic imaging. However, radiology trainees had higher overall appropriate imaging scores possibly owing to cumulative time spent reading and interpreting these tests compared to nonradiology trainees.

A majority of trainees agree that more training in these areas would have beneficial effects on patient care, however, further work is needed to assess the most appropriate method and stage of training to address these knowledge gaps, as no significant knowledge improvement was seen between prior formal training or PGY year.

Limitations

Limitations to this study include limited survey response rate, averaging 18.7% over all 3 surveys, with decreasing response rates for each successive survey, likely signaling an element of survey fatigue.[31] Survey distribution across different academic years, resulting in a slightly different study population for the radiation safety survey as compared to the other 2 surveys, may limit direct comparison of these groups. Self-reporting of number of imaging examinations ordered and prior formal training may not be an accurate method of measuring these, as "formal training" may have different connotations among trainees and some may have received similar training but not have considered it to be formal training.

Conclusion

Although a majority of physician trainees regularly order diagnostic imaging examinations, considerable knowledge gaps exist in important areas pertaining to judicious and safe use of diagnostic imaging. To enhance the value of imaging at the population level, further work is needed to assess the most appropriate method and stage of training to address these knowledge gaps, particularly with regard to radiation risk assessment, MRI and contrast-related safety, as well as with regard to imaging of pregnant patients.

Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at doi:10.1067/j.cpradiol.2017.10.007.

References

1. Balogh EP, Miller BT, Ball JR, eds. Improving Diagnosis in Health Care, Washington, D.C: National Academies Press; 2015, https://doi.org/10.17226/21794.
2. Vijayasarathi A, Duszak R, Gelbard RB, et al. Knowledge of the costs of diagnostic imaging: A survey of physician trainees at a large academic medical center. J Am Coll Radiol 2016;13(11):1304–10, https://doi.org/10.1016/j.jacr.2016.05.009.
3. Ratnapalan S, Bona N, Chandra K, et al. Physicians' perceptions of teratogenic risk associated with radiography and CT during early pregnancy. AJR Am J Roentgenol 2004;182(5):1107–9, https://doi.org/10.2214/ajr.182.5.1821107.
4. Sadigh G, Khan R, Kassin MT, et al. Radiation safety knowledge and perceptions among residents: A potential improvement opportunity for graduate medical education in the United States. Acad Radiol 2014;21(7):869–78, https://doi.org/10.1016/j.acra.2014.01.016.
5. Friedman AA, Ghani KR, Peabody JO, et al. Radiation safety knowledge and practices among urology residents and fellows: Results of a nationwide survey. J Surg Educ 2013;70(2):224–31, https://doi.org/10.1016/j.jsurg.2012.10.002.
6. Krille L, Hammer GP, Merzenich H, et al. Systematic review on physician's knowledge about radiation doses and radiation risks of computed tomography. Eur J Radiol 2010;76(1):36–41, https://doi.org/10.1016/j.ejrad.2010.08.025.
7. Wong C, Huang B, Sin H, et al. A questionnaire study assessing local physicians, radiologists and interns' knowledge and practice pertaining to radiation exposure related to radiological imaging. Eur J Radiol 2012;81(3):e264–8, https://doi.org/10.1016/j.ejrad.2011.02.022.
8. McBride JF, Wardrop RM, Paxton BE, et al. Effect on examination ordering by physician attitude, common knowledge, and practice behavior regarding CT radiation exposure. e1. Clin Imaging 2012;36(5):455–61, https://doi.org/10.1016/j.clinimag.2012.01.001.
9. Boutis K, Fischer J, Freedman SB, et al. Radiation exposure from imaging tests in pediatric emergency medicine: A survey of physician knowledge and risk disclosure practices. J Emerg Med 2014;47(1):36–44, https://doi.org/10.1016/j.jemermed.2014.01.030.
10. Foley SJ, Evanoff MG, Rainford LA. A questionnaire survey reviewing radiologists' and clinical specialist radiographers' knowledge of CT exposure parameters. Insights Imaging 2013;4(5):637–46, https://doi.org/10.1007/s13244-013-0282-4.
11. Borgen L, Stranden E. Radiation knowledge and perception of referral practice among radiologists and radiographers compared with referring clinicians. Insights Imaging 2014;5(5):635–40, https://doi.org/10.1007/s13244-014-0348-y.
12. Singh RK, McCoubrie P, Burney K, et al. Teaching medical students about radiation protection—What do they need to know? Clin Radiol 2008;63(12):1344–9, https://doi.org/10.1016/j.crad.2008.06.010.
13. Bosanquet DC, Green G, Bosanquet AJ, et al. Doctors' knowledge of radiation—A two-centre study and historical comparison. Clin Radiol 2011;66(8):748–51, https://doi.org/10.1016/j.crad.2011.03.009.
14. Kada S. A study of general practitioners' knowledge of ionizing radiation from diagnostic imaging examinations. Qual Prim Care 2010;18(6):391–7.
15. Bosanquet DC, Green G, Bosanquet AJ, et al. Doctors' knowledge of radiation—A two-centre study and historical comparison. Clin Radiol 2011;66(8):748–51, https://doi.org/10.1016/j.crad.2011.03.009.
16. Poot JD, Hartman MS, Daffner RH. Understanding the US medical school requirements and medical students' attitudes about radiology rotations. Acad Radiol 2012;19(3):369–73, https://doi.org/10.1016/j.acra.2011.11.005.
17. Brenner DJ, Hall EJ. Computed tomography—An increasing source of radiation exposure. N Engl J Med 2007;357(22):2277–84, https://doi.org/10.1056/NEJMra072149.
18. Sheng AY, Castro A, Lewiss RE. Awareness, utilization, and education of the ACR Appropriateness Criteria: A review and future directions. J Am Coll Radiol 2016;13(2):131–6, https://doi.org/10.1016/j.jacr.2015.08.026.
19. Leschied JR, Knoepp US, Hoff CN, et al. Emergency radiology elective improves second-year medical students' perceived confidence and knowledge of appropriate imaging utilization. Acad Radiol 2013;20(9):1168–76, https://doi.org/10.1016/j.acra.2013.05.011.
20. Iwashyna TJ, Fuld A, Asch DA, et al. The impact of residents, interns, and attendings on inpatient laboratory ordering patterns: A report from one university's hospitalist service. Acad Med 2011;86(1):139–45, https://doi.org/10.1097/ACM.0b013e3181fd85c3.
21. Vijayasarathi A, Hawkins CM, Hughes DR, et al. How much do common imaging studies cost? A nationwide survey of radiology trainees. Am J Roentgenol 2015;205(5):929–35, https://doi.org/10.2214/AJR.14.14167.
22. Mosher TJ, Kransdorf MJ, Adler R, et al. ACR Appropriateness Criteria acute trauma to the ankle. J Am Coll Radiol 2015;12(3):221–7, https://doi.org/10.1016/j.jacr.2014.11.015.
23. Daffner RH, Weissman BN, Wippold II FJ, et al. ACR Appropriateness Criteria® suspected spine trauma. American College of Radiology.
24. Sudakoff GS, Rosen MP, Rybicki FJ, et al. ACR Appropriateness Criteria ® , Blunt Abdominal Trauma. Reston, VA: American College of Radiology; 2012.

25. Douglas AC, Wippold FJ, Broderick DF, et al. ACR appropriateness criteria headache. J Am Coll Radiol 2014;11(7):657–67, https://doi.org/10.1016/j.jacr.2014.03.024.
26. Cody DD, Becker M, Geise RA, et al. ACR Appropriateness Criteria® Radiation Dose Assessment Introduction. Available at: https://www.acr.org/~/media/ACR/Documents/AppCriteria/RadiationDoseAssessmentIntro.pdf?db=web. American College of Radiology. Accessed 9/28/2017. per https://www.acr.org/Quality-Safety/Appropriateness-Criteria/Citation-Info
27. Hedrick WR, Mahesh M. Radiation Biology for Diagnostic and Interventional Radiologists. Radiological Society of North America 2007.
28. Kanal E, Barkovich AJ, Bell C, et al. ACR guidance document on MR safe practices: 2013. J Magn Reson Imaging 2013;37(3):501–30, https://doi.org/10.1002/jmri.24011.
29. Ellis JH, Cohan RH, Davenport MS, et al. ACR Manual on Contrast Media. Version 10.3. Available at: https://www.acr.org/Quality-Safety/Resources/Contrast-Manual. Accessed 9/28/2017
30. Lam DL, Larson DB, Eisenberg JD, et al. Communicating potential radiation-induced cancer risks from medical imaging directly to patients. Am J Roentgenol 2015;205(5):962–70, https://doi.org/10.2214/AJR.15.15057.
31. Porter S, Whitcomb M, Weitzer W. Multiple surveys of students and survey fatigue. New Dir Institutional Res 2004;2004(121):63–73, https://doi.org/10.1002/ir.101.