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What are medical students in the United States learning about radiation oncology? Results of a multi-institutional survey

Nicholas G. Zaorsky, M.D.[1], **Talha A. Shaikh, M.D.**[1], **Elizabeth Handorf, PhD**[1], **Gary Eastwick, M.D.**[2], **Adam Hesney, M.D.**[3], **Eli D. Scher, D.O.**[4], **Ryan T. Jones, M.D.**[5], **Timothy N. Showalter, M.D.**[5], **Vladimir Avkshtol, M.D.**[6], **Stephanie R. Rice, M.D.**[7], **Eric M Horwitz, M.D.**[1], **Joshua E. Meyer, M.D.**[1]

(1)Department of Radiation Oncology, Fox Chase Cancer Center, Philadelphia, PA

(2)Temple University School of Medicine, Philadelphia, PA

(3)Jefferson Medical College of Thomas Jefferson University, Philadelphia, PA

(4)Rowan University School of Osteopathic Medicine, Stratford, NJ

(5)Department of Radiation Oncology, University of Virginia School of Medicine, Charlottesville, VA

(6)University of Toledo College of Medicine, Toledo, OH

(7)University of Wisconsin School of Medicine, Madison, WI

SUMMARY

We used an electronic survey to quantify knowledge about radiation therapy among first and fourth year medical students, and primary care physician attendings (PCPs) at 7 academic US hospitals. We found that, although medical knowledge of radiation therapy principles improves from first to fourth years, large knowledge gaps still exist between students, PCPs, and radiation oncology attendings. Basic misconceptions persist among a minority of students and PCPs.

PURPOSE: The purposes are: (1) to assess the exposure that medical students (MSs) have to radiation oncology (RO) during the course of their medical school career, as evidenced by two time points in current medical training (i.e. 1st vs. 4th year; MS1s and MS4s, respectively); and, (2) to assess the knowledge of MS1s, MS4s, and primary care physicians (PCPs) about the appropriateness of RT in cancer management as compared to RO attendings.

METHODS: We developed and beta tested an electronic survey, divided into 3 parts: (1) RO job descriptions, (2) appropriateness of RT, and (3) toxicities of RT. Surveys were distributed to 7 US medical schools. A concordance of >90% (either "yes" or "no") among RO attendings in an

Corresponding Author: Nicholas G. Zaorsky, MD, Department of Radiation Oncology, Fox Chase Cancer Center, 333 Cottman Avenue, Philadelphia, PA 19111, USA. Tel: +1-215-728-2581, Fax: +1-215-214-4038, nicholaszaorsky@gmail.com.
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answer was necessary to determine the "correct" answer; and to compare to other subgroups using a chi-squared test ($p < 0.05$ was significant).

RESULTS: The overall response rate for ROs, MS1s, MS4s, and PCPs was 26%; n: (22 + 315 + 404 + 43)/3,004. RT misconceptions decreased with increasing level of training. More than 1 of 10 MSs did not believe RT alone could cure cancer. Emergent oncologic conditions for RT (e.g. spinal cord compression, superior vena cava syndrome) could not be identified by > 1 of 5 respondents. Multiple non-toxicities of RT (e.g. emitting low-level radiation from the treatment site), were incorrectly identified as toxicities by > 1 of 5 respondents. MS4s/PCPs with an RO rotation in medical school had improved scores in all prompts.

CONCLUSIONS: Although MS knowledge of general RT principles improves from 1st to 4th year, a large knowledge gap still exists between MSs, current PCPs, and ROs. Some basic misconceptions of RT persist among a minority of MSs and PCPs. We recommend implementing formal education in RO fundamentals during the core curriculum of medical school.

INTRODUCTION

Cancer is a frequent cause of morbidity and mortality in the United States and worldwide (1). It is estimated that around 60% of all cancer patients receive radiation therapy (RT) at some point during their disease course (2). However, radiation oncology (RO) is underrepresented in the curricula of most medical schools (3, 4), and it is estimated that only 15% of medical school graduates in the United Kingdom believe they know enough about radiation therapy (5).

As survivorship from cancer continues to increase (6), medical practitioners throughout the world will need to know the basics of RT, its role in the multimodal management of cancers, outcomes, and toxicities. If physicians do not have a basic working knowledge of radiation oncology, potential adverse clinical outcomes may include misdiagnosis and improper treatment of misattributed symptoms (7). While studies have suggested that medical students (MSs) and primary care physicians (PCPs; i.e. internal medicine and family medicine attendings) in the US know little about RO and are not trained in this field in medical school (8–10), and the extent knowledge about RO among these populations has not been quantified to date.

The purposes of this work are: (1) to assess the exposure that medical students (MSs) have to RO during the course of their medical school career, as evidenced by two time points in current medical training (i.e. 1st vs. 4th year; MS1s and MS4s, respectively); and (2) to assess the knowledge of MS1s, MS4s, and PCPs about the appropriateness and the role of RT in cancer management, as compared to RO attendings. We hypothesized that MSs and PCPs have limited knowledge of RO and that medical schools are not adequately training MSs in RO.

METHODS AND MATERIALS

After Institutional Review Board approval, the authors constructed a survey, using consensus recommendations for electronic methods of surveying clinicians (11, 12). The survey evaluated general RT knowledge that the authors felt was important for providers to learn during medical school. The survey was divided into three sections: (1) RO job descriptions, (2) appropriateness of RT, and (3) toxicities of RT. The surveys were beta tested using cognitive interviews (13). Briefly, the authors sat with potential survey-takers (including MS1s, MS4s, PCPs, and ROs) and discussed, question-by-question, the appropriateness of the prompts. In total, 24 cognitive interviews were conducted (n = 6 per group) among eight medical schools with affiliated academic hospitals in the US (Supplemental File 1). Affiliated hospital were selected on the basis of students from these institutions rotating through our Department of Radiation Oncology at our institution, a National Cancer Institute (NCI)-designated National Comprehensive Cancer Network (NCCN) member hospital.

We contacted the corresponding medical school offices of 9 institutions and provided them with: (1) the study synopsis; (2) our completed IRB forms; and (3) the sample survey. We asked institutional officials to use email directories and registrars to provide us with the email lists of potential respondents (MS1s, MS4s, PCPs, ROs; total: 3,004; listed in Supplementary Table 1). Two institutions refused; the remaining 7 provided us the requested information. All MS1s, MS4s, PCPs, and ROs provided were included in our email list. We excluded invalid email addresses.

Email lists with individual addresses were compiled, and surveys with one-time use links were emailed to the respondents using third-party software, similar to methods used in related works (8, 13–15). The survey links were active from October 2013 – March 2014. We sent three email reminders to take the survey to avoid message burden. If an email recipient took a survey using a specific link, he/she was removed from subsequent email reminders. An “unsubscribe” link was provided in every email message. Respondents were able to provide their email addresses if they wanted the results of the survey.

Data were analyzed using frequency tables. A concordance of >90% (either “yes” or “no”) among RO attendings in an answer for each question was necessary to determine the “correct” answer. We ultimately excluded two non-mutually exclusive answer choices (out of 66) and one question because not all ROs agreed on the correct answers.

The correct yes/no response (as determined by RO attendings) was then used to compare the % answering correctly in other subgroups, using a chi-squared test. The following comparisons were made for each question: MS1s vs ROs, MS4s vs ROs, and PCPs vs ROs. We also performed a subset analysis of MS4s and PCPs who stated they completed a RO rotation in medical school, as this group was postulated to have improved understanding of the concepts of RT. For each question, the 95% confidence intervals (CIs) were calculated for the % answering correctly. A p-value of < 0.05 was interpreted as statistically significant between groups.

RESULTS

The characteristics of respondents are listed in Supplementary Table 1. The overall response rate was 26% (783/3004), reporting from seven medical schools. Among the subgroups the response rate was for 44% (22/50) for ROs, 24% (315/1,324) for MS1s, 31% (403/1,295) for

MS4s, and 13% (43/335) for PCPs. Almost all (95%) ROs performed a RO rotation in medical school; compared to 1% of MS1s, 9% of MS4s, and 4% of PCPs. Among MSs, 97% of respondents planned to enter a field besides RO. There were 42 respondents (40 MS4s and 2 PCPs) who had performed a RO rotation during medical school.

Regarding the prompts about the characteristics of a RO (Table 1), 45% of MS1 and 58% of PCPs believed that completion of a *radiology* residency was necessary to become an RO (p =< 0.0001); MS4s and MS4/PCPs with RO rotations in medical school correctly did not believe this to be true. The understanding of a RO's duties improved from MS1 to M4 and PCPs; however, a significant number of respondents in each group believed that ROs "push a button" to deliver RT daily (MS1: 24%, p = 0.009; MS4: 23%, p = 0.01; 19%, p = 0.03). Comparatively, only 12% of MS4s and PCPs who performed a RO rotation in med school believed this to be true (p = 0.06). Additionally, more than 1 of 3 MS1s, MS4s, and PCPs did not believe that ROs were responsible for staging cancer patients (p < 0.01)

Regarding the prompts of appropriateness of RT (Table 2), a significant number of respondents did not believe that RT could be used alone to cure certain cancers (% answering correct of MS1s: 25%, p = 0.007; MS4s: 16%, p = 0.044); comparatively, 98% of MS4s/PCPs who performed an RO rotation in med school correctly believed RT alone could cure cancer. Additionally, a minority of MS1s, MS4s, and PCPs did not believe that "RT could be part of the standard initial management" for treatment of arteriovenous malformations, lymphoma, pancreatic cancer, spinal cord compression from cancer, or superior vena cava syndrome. On the other hand, more than half of respondents incorrectly believed that RT could be used to treat as part of the initial management of kidney cancer. Knowledge of the appropriateness of RT improved from when comparing MS1s to MS4s and MS4s to PCPs (as evidenced by increasing p-values). MS4s/PCPs who performed an RO rotation in medical school were able to identify more conditions (e.g. lung, arteriovenous malformations) where RT could be used as part of the standard initial management.

Respondents incorrectly believed that proton beam therapy was associated with improved outcomes compared to conventional RT for prostate cancer (% answering correct of MS1s: 12%, p < 0.0001; MS4s: 63%, p < 0.0001; PCPs: 21%, p<0.0001; MS4s/PCPs with an RO rotation: 67%, p < 0.0001). Respondent ability to define IMRT as "intensity modulated radiation therapy" increased with level of training, but was still poor compared to RO attendings (% answering correct of MS1s: 48%, p < 0.0001; MS4s: 56%, p < 0.0001; PCPs: 56%, p < 0.0001; MS4s/PCPs with an RO rotation: 83%, p = 0.04). Approximately a quarter of MS1s and MS4s incorrectly believed that RT could not be used for pediatric cancers because of the risk of second cancers and/or developmental defects.

Regarding the toxicity of RT (Table 3), many MS1s, MS4s, and PCPs incorrectly believed that patients emit low level radiation from the treatment site for a brief time after external beam RT (% answering correct of MS1s: 42%, p < 0.0001; MS4s: 51%, p < 0.0001; PCPs: 66%, p = 0.0017); while MS4s/PCPs with an RO rotation did not have this misconception (86%, p = 0.23). As the level of training increased from MS1 to MS4 and to PCP, respondent knowledge of the common side effects of RT for prostate cancer also improved. Surprisingly, many MS1, MS4s, and PCPs incorrectly believed that the risk of developing a radiation-induced cancer after external beam RT was > 2% per year (% answering correct of MS1s: 42%, $p < 0.0001$; MS4s: 61%, $p = 0.0002$; PCPs: 64%, p 0.001); while MS4s/PCPs with an RO rotation did not have this misconception (86%, $p = 0.6$).

DISCUSSION

The knowledge gap about RT among US medical school graduates has not been previously explored to this extent. We performed a multi-institutional survey that included respondents of various levels of medical education: MS1s, MS4s, and PCPs. We found that although student knowledge of general RT principles improves from 1st to 4th year, a large knowledge gap still exists among MSs and current PCPs, when compared to ROs. Some basic misconceptions regarding the benefits and harms of RT persist among a minority of MSs and PCPs. Based on these findings, it seems that fundamental, core concepts in RT have not been disseminated to the broader medical community.

Initiatives to better educate physicians regarding core RT principles should be considered. We found that MS4s/PCPs with an RO rotation in medical school had an improved understanding of RO job descriptions, appropriateness of RT, and RT toxicities when compared to their peers who did not complete a RO rotation. Thus, formal exposure to RO principles within the core curriculum of medical school may help resolve this knowledge gap.

In 1994, the International Union Against Cancer recognized an imbalance between cancer prevalence and the number of oncologists (16). It subsequently advised further integration of oncology in medical school curricula (16–18). However, recent literature has shown that medical student, resident physician, and general practitioner knowledge of core oncology information is relatively low in the United States (19, 20).

The lack of basic RO knowledge among medical school graduates is unfortunate, since RT is widely used in cancer patients and is generally delivered in a multidisciplinary cancer care environment (2). Since patients often seek counsel from physicians outside of oncology, with whom they have a long-standing relationship (e.g. PCPs, pediatricians, gastroenterologists, cardiologists), it is essential that some essential knowledge be disseminated broadly in medicine. Our survey respondents (Supplementary Table 1) commonly planned to pursue internal medicine, family medicine, and obstetrics/gynecology – all fields where longstanding relationships between the provider and patient would be forged.

When prompted about the characteristics of a RO (Table 1), many respondents incorrectly believed that RO is a branch of radiology. Many respondents incorrectly held beliefs that ROs do not stage patients, and that ROs "push a button to deliver RT every day." MS4s and PCPs who had taken a RO rotation in medical school were more likely to answer questions correctly, in comparison to their peers who had not taken such a rotation. From the perspective of representing RO as a medical specialty, as well as attracting the best candidates to the field of RO, there may be much to gain through better representation of RO to MSs.

A minority of MSs and PCPs were also frequently unable to identify situations where RT would be an appropriate treatment (Table 2). For example, 16% of MS4s did not believe that RT alone could be used to cure cancer. In addition, a minority of respondents incorrectly believed that RT could not be part of the standard initial management of lung cancer, lymphoma, or pancreatic cancer. Alternatively, approximately 1 of 3 respondents incorrectly believed that RT could be used as part of the standard initial therapy of kidney cancer. A minority of respondents could not identify emergent oncologic conditions where RT is indicated and ROs should be consulted (e.g. spinal cord compression from cancer, superior vena cava syndrome). On the other hand, many MS1s (88%), MS4s (37%), and PCPs (79%) believed that proton therapy was associated with improved outcomes over conventional RT for prostate cancer – a belief that likely stems from advertisement in the media, rather than the medical literature (21).

From an oncologic perspective, these results are concerning: if a patient presents to an oncologist with lymphoma, that patient would be referred to multiple other oncologic providers, including a RO. Moreover, if a non-oncologist diagnoses an oncologic emergency, the patient should be managed accordingly. For example, if a patient's computed tomography scan in an emergency department were to reveal spinal cord compression from cancer, ROs hastily try to see that patient to start RT, typically on the same day to prevent neurological progression.

A minority of MSs and PCPs were unable to correctly identify toxicities from RT (Table 3). Strikingly, multiple non-toxicities of RT (including emitting low-level radiation from the treatment site, and feeling or sensing RT), were incorrectly identified as potential toxicities by at least 1 out of 5 respondents. Further, a minority of MS1s and MS4s could not correctly identify the common toxicities of RT for prostate cancer; for example, more than 1 of 4 MS4s believed that RT could commonly cause a risk of infection due to bone marrow suppression and second cancer formation. In general, knowledge about the potential toxicities of RT increased with training, from MS1, to MS4, and then to PCP. However, none of these groups scored as well as MS4s or PCPs with a prior RO rotation.

In the US, there is an increasing elderly population, increasing incidence of cancer with age, and increasing survivorship from cancer (6). There has been an increased emphasis on integrating pre-clinical courses in oncology into the medical student curriculum. Medical student-reported outcomes of such initiatives are favorable and effective in helping identify the basics of cancer therapy and laying the foundation for clinical electives in oncology (20).

Moreover, multiple studies have shown that an elective rotation in radiation oncology improves knowledge of the field (8–10, 22), independent of a student's ultimate career path (13). These electives are particularly useful if they contain didactic sessions (e.g. lectures, case discussions, contouring) (8, 23). Unfortunately, few students have the opportunity to participate in such a rotation. In the current work, we found that only 5% of MS4s and PCPs had a previous RO rotation. We noted that these respondents were more knowledgeable about RT: they could identify the characteristics of radiation oncologists; and, more importantly, they could correctly identify the indications for and toxicities of RT. Thus, we recommend implementing an RO course during the core clerkships of medical school as a potential strategy to improve general medical knowledge of RO. Based on our findings, it is clear that basic principles of RT are poorly understood within the broad community of medical professionals, suggesting a need for ROs to better communicate the core principles and indications for RT.

Our work has limitations. First, we did not distribute the survey to all medical schools, including those in the Western US. Second, our response rate was 26%, and if the non-respondents had taken the survey, the % answered correct may have been different. On the other hand, research focused on substantive variables has concluded that response rates are very weakly (if at all) related to the distributions of substantive responses (24, 25); thus, a higher response rate would have likely yielded similar results. Third, we did not survey other medical providers (e.g. cardiologists, gastroenterologists). We focused on internal medicine and family medicine doctors because they typically have long-standing relationships with patients.

CONCLUSION

Although MS knowledge of general RT principles improves from 1st to 4th year, a large knowledge gap still exists between MSs, current PCPs, and ROs. Some basic misconceptions of RT persist among a minority of MSs and PCPs. We recommend that ROs focus on communicating the key aspects of RT to PCPs and colleagues in other specialties, and one promising strategy is a clinical rotation or course in RO during the core curriculum of medical school.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Prompts regarding the characteristics of a radiation oncologist.

Prompt		ROs (n=22)			MS1s (n=315)				MS4s (n=404)				PCPs (n=43)				MS4s or PCPs with RO rotation in med school (n=42)			
		n answering "YES"	n answering "NO"	Agreement	n answering "YES"	% answering correctly	Chi-squared p-value	95% CI	n answering "YES"	% answering correctly	Chi-squared p-value	95% CI	n answering "YES"	% answering correctly	Chi-squared p-value	95% CI	n answering "YES"	% answering correctly	Chi-squared p-value	95% CI
To become a radiation oncologist, one must complete a *radiology* residency		1	21	95%	172	45%	< 0.001	0.40 0.51	80	81%	<0.0001	0.78 0.85	20	58%	<0.0001	0.43 0.73	7	83%	0.16	0.72 0.95
In the treatment of a patient with cancer, radiation oncologists (select all that may apply):	• Perform H/P	22	0	100%	236	75%	0.007	0.70 0.80	363	90%	0.39	0.87 0.93	40	93%	0.70	0.85 1.01	41	98%	0.46	0.87 1.00
	• Stage the patient	22	0	100%	175	56%	< 0.001	0.50 0.61	268	66%	<0.0001	0.62 0.71	26	60%	<0.001	0.46 0.75	33	79%	0.02	0.66 0.91
	• Review films	22	0	100%	284	90%	0.12	0.87 0.93	377	93%	0.68	0.91 0.96	40	93%	0.20	0.85 1.01	42	100%	N/A	0.92 1.00
	• Design RT plan	21	1	95%	303	96%	0.86	0.94 0.98	401	99%	0.02	0.98 1.00	43	100%	0.12	1.00 1.00	42	100%	N/A	0.92 1.00
	• Push a button to deliver RT every day	0	22	100%	76	76%	0.009	0.71 0.81	94	77%	<0.0001	0.73 0.81	8	81%	<0.001	0.70 0.93	6	88%	0.06	0.78 0.98
	• Follow-up with patient	22	0	100%	299	95%	0.28	0.92 0.97	391	97%	0.39	0.95 0.99	41	95%	0.30	0.89 1.02	42	100%	N/A	0.92 1.00

Abbreviations: CI: confidence interval; MS1: first year medical student; MS4: fourth year medical student; PCP: primary care physician; RO: radiation oncologist/oncology; RT: radiation therapy

Note: p-values < 0.05 are in red boxes; others are in green.

Table 2.

Prompts regarding the appropriateness of RT.

Prompt		ROs (n=22)			MS1s (n=315)					MS4s (n=404)					PCPs (n=43)					MS4s or PCPs with RO rotation in med school (n=42)				
		n answering "YES"	n answering "NO"	Agreement	n answering "YES"	% answering correctly	Chi-squared p-value	95% CI		n answering "YES"	% answering correctly	Chi-squared p-value	95% CI		n answering "YES"	% answering correctly	Chi-squared p-value	95% CI		n answering "YES"	% answering correctly	Chi-squared p-value	95% CI	
RT can be used to cure (i.e. not just palliate) certain cancers	• alone	22	0	100%	236	75%	0.007	0.70	0.80	338	84%	0.04	0.80	0.87	37	86%	0.07	0.76	0.96	41	98%	0.47	0.87	1.00
	• with surgery	21	1	95%	264	84%	0.13	0.80	0.88	353	87%	0.16	0.84	0.91	39	91%	0.17	0.82	0.99	40	95%	0.94	0.84	0.99
	• with chemo	21	1	95%	269	85%	0.18	0.81	0.89	343	85%	0.17	0.81	0.88	38	88%	0.38	0.79	0.98	40	95%	0.94	0.84	0.99
Radiation RT can be used as a part of the standard initial management of the following conditions:	• Arteriovenous malformations	22	0	100%	110	35%	<0.0001	0.30	0.40	169	42%	<0.0001	0.37	0.47	19	44%	<0.0001	0.29	0.59	33	79%	0.02	0.66	0.91
	• Breast cancer	21	1	95%	277	88%	0.29	0.84	0.92	342	85%	0.16	0.81	0.88	36	84%	0.17	0.73	0.95	39	93%	0.68	0.81	0.99
	• Kidney cancer	1	21	5%	234	13%	<0.0001	0.10	0.17	216	36%	<0.001	0.31	0.41	24	26%	<0.001	0.13	0.39	18	38%	<0.0001	0.23	0.53
	• Lung cancer	22	0	100%	24	8%	<0.0001	0.09	0.16	317	78%	0.02	0.74	0.82	38	88%	0.10	0.79	0.98	41	98%	0.47	0.87	1.00
	• Lymphoma	22	0	100%	181	57%	<0.0001	0.52	0.63	228	56%	<0.0001	0.52	0.61	30	70%	<0.001	0.56	0.83	31	74%	0.008	0.61	0.87
	• Pancreatic cancer	21	1	95%	229	73%	0.018	0.68	0.78	216	53%	<0.0001	0.49	0.58	22	51%	<0.0001	0.36	0.66	24	57%	0.002	0.42	0.72
	• Prostate cancer	22	0	100%	279	89%	0.09	0.85	0.92	366	91%	0.13	0.88	0.93	39	91%	0.14	0.82	1.0	40	95%	0.3	0.84	0.99
	• Spinal cord compression from cancer	22	0	100%	155	49%	<0.0001	0.44	0.55	289	72%	<0.001	0.67	0.76	32	74%	0.01	0.61	0.87	39	93%	0.19	0.81	0.99
	• Superior vena cava (SVC) syndrome	22	0	100%	90	29%	<0.0001	0.24	0.34	213	53%	<0.0001	0.48	0.58	26	60%	<0.001	0.46	0.75	34	81%	0.03	0.69	0.93
	• Urosepsis	0	22	0%	81	57%	0.006	0.51	0.62	27	82%	0.22	0.78	0.86	0	72%	<0.001	0.59	0.85	1	86%	0.46	0.75	0.96
For prostate cancer, proton therapy is associated with improved outcomes compared to conventional radiation therapy.		0	22	0%	235	12%	<0.0001	0.09	0.16	253	63%	<0.0001	0.58	0.67	27	21%	<0.0001	0.09	0.33	14	67%	0.002	0.52	0.81
IMRT stands for: Intensity modulated radiation therapy		22	0	100%	152	48%	<0.0001	0.43	0.54	225	56%	<0.0001	0.51	0.61	24	56%	<0.0001	0.41	0.71	35	83%	0.04	0.72	0.95
Radiation therapy is never used in pediatric cancers due		0	22	100%	94	70%	0.008	0.65	0.75	84	76%	0.02	0.72	0.80	3	86%	0.01	0.76	0.96	3	93%	0.2	0.81	0.99

Prompt	ROs (n=22)			MS1s (n=315)				MS4s (n=404)				PCPs (n=43)				MS4s or PCPs with RO rotation in med school (n=42)			
	n answering "YES"	n answering "NO"	Agreement	n answering "YES"	% answering correctly	Chi-squared p-value	95% CI	n answering "YES"	% answering correctly	Chi-squared p-value	95% CI	n answering "YES"	% answering correctly	Chi-squared p-value	95% CI	n answering "YES"	% answering correctly	Chi-squared p-value	95% CI
to the high risk of a second cancer and/or developmental defects.																			
Once an area receives radiation, it cannot be radiated again.	1	21	95%	24	90%	0.59	0.86 0.93	37	88%	0.45	0.85 0.91	11	67%	0.01	0.53 0.81	4	90%	0.13	0.82 0.99
Radiation therapy is almost always used for palliation (i.e. to improve symptoms but not to cure).	1	21	95%	64	77%	0.07	0.72 0.81	40	89%	0.41	0.86 0.92	36	84%	<0.001	0.73 0.95	41	98%	0.63	0.87 1.00

Abbreviations: CI: confidence interval MS1: first year medical student; MS4: fourth year medical student; PCP: primary care physician; RO: radiation oncologist/oncology; RT: radiation therapy

Note: p-values < 0.05 are in red boxes; others are in green.

Table 3.

Prompts regarding the toxicity of RT.

Prompt		ROs (n=22)			MS1s (n=315)					MS4s (n=404)					PCPs (n=43)					MS4s or PCPs with RO rotation in med school (n=42)				
		n answering "YES"	n answering "NO"	Agreement	n answering "YES"	% answering correctly	Chi-squared p-value	95% CI		n answering "YES"	% answering correctly	Chi-squared p-value	95% CI		n answering "YES"	% answering correctly	Chi-squared p-value	95% CI		n answering "YES"	% answering correctly	Chi-squared p-value	95% CI	
Patients emit low-level radiation from the treatment site for a brief period after external beam radiation therapy.		0	22	100%	183	42%	<0.0001	0.36	0.47	211	51%	<0.0001	0.47	0.56	18	66%	0.002	0.53	0.79	6	86%	0.23	0.75	0.96
During external beam radiation treatments, patients are able to feel/sense the radiation.		1	21	95%	73	77%	0.041	0.72	0.81	82	81%	0.09	0.77	0.85	13	75%	0.043	0.64	0.87	3	93%	0.68	0.81	0.99
For prostate cancer, the common side effects of radiation therapy typically include (select any of the following):	• Hair loss on the head	0	22	100%	103	67%	0.001	0.62	0.72	45	90%	0.11	0.87	0.93	1	98%	0.51	0.90	1.00	0	0%	0.23	0.92	1.00
	• Urinary urgency or frequency	22	0	100%	193	61%	0.0003	0.56	0.67	296	68%	0.0015	0.64	0.72	48	91%	0.13	0.83	0.98	38	90%	0.68	0.82	0.99
	• Risk of infection due to bone marrow suppression	0	22	100%	151	52%	<0.0001	0.47	0.58	106	76%	0.008	0.72	0.80	6	89%	0.1	0.80	0.97	2	95%	0.3	0.84	0.99
	• Second cancer formation	2	20	91%	135	57%	0.002	0.52	0.63	207	52%	0.0004	0.48	0.57	8	85%	0.45	0.75	0.95	10	76%	0.15	0.63	0.89
	• Neurocognitive impairment	0	22	100%	34	89%	0.1	0.86	0.93	26	94%	0.24	0.92	0.96	2	96%	0.36	0.87	1.00	1	98%	0.46	0.87	1.00
	• Skin redness or tanning	1	21	95%	213	32%	<0.0001	0.27	0.38	326	25%	<0.0001	0.21	0.29	37	30%	<0.0001	0.18	0.43	31	26%	<0.0001	0.13	0.39
After radiation therapy, the risk of developing a radiation-induced cancer (in one's lifetime) is about:	• < 2% per year	22	0	100%	132	42%	<0.0001	0.36	0.47	267	61%	0.0002	0.57	0.66	34	64%	0.001	0.51	0.77	36	86%	0.06	0.75	0.96
	• 5 – 10% per year	0			121					139					14					5				
	• 20 – 30% per year	0			33					13					1					1				
	• 50 – 70% per year	0			2					0					0					0				
	• > 80% per year	0			0					0					0					0				

Abbreviations: CI: confidence interval; MS1: first year medical student; MS4: fourth year medical student; PCP: primary care physician; RO: radiation oncologist/oncology; RT: radiation therapy

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Note: p-values < 0.05 are in red boxes; others are in green.