



Prevalence and Correlates of Worry About Medical Imaging Radiation Among United States Cancer Survivors

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Published online: 5 June 2018

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Abstract

Purpose Cancer survivors undergo lifelong surveillance regimens that involve repeated diagnostic medical imaging. As many of these diagnostic tests use ionizing radiation, which may modestly increase cancer risks, they may present a source of worry for survivors. The aims of this paper are to describe cancer survivors' level of worry about medical imaging radiation (MIR) and to identify patterns of MIR worry across subgroups defined by cancer type, other medical and demographic factors, and physician trust.

Method This cross-sectional study used the 2012–2013 Health Information National Trends Survey of US adults conducted by the National Cancer Institute. The analysis focused on the 452 respondents identifying as cancer survivors. Weighted logistic regression analysis was used to evaluate factors associated with higher MIR worry (reporting “some” or “a lot” of MIR worry).

Results Nearly half (42%) of the sample reported higher worry about MIR. Unadjusted and adjusted logistic regressions indicated higher rates of MIR worry among those with lower incomes, those who self-reported poorer health, and those who completed cancer treatment within the past 10 years. Receipt of radiation treatment was associated with higher MIR worry in unadjusted analysis.

Conclusion Worries about MIR are relatively common among cancer survivors. An accurate assessment of the rates and patterns of worry could aid efforts to improve these individuals' survivorship care and education.

Keywords Radiation · Worry · Medical imaging · National sample · Cancer survivorship

Introduction

Over the past few decades, the number of individuals who have been diagnosed with cancer in the USA has steadily increased. In 2016, 15.5 million living Americans had a history of cancer [1]. These cancer survivors generally undergo repeated diagnostic medical imaging to screen for new and/or recurrent cancer [2]. These enhanced surveillance regimens can help address survivors' worries about developing new primary as well as recurrent disease. Such worries are quite prevalent, with up to 60% of survivors reporting moderate to severe worry about recurrence 1 year after diagnosis [3]. Worries may be intense

prior to scheduled scans, such as screening mammography, given that the tests may show recurrent or new disease [4, 5]. Yet cancer worry may persist long after treatment ends [6], leading to distress and reduced quality of life [3, 7–9]. Predictors of cancer worry in the survivorship context include depression, lower quality of life, being female, younger age, and having more intensive treatment regimens, as well as the presence and severity of physical symptoms [3, 10–12].

There are multiple, diverse theoretical perspectives on how worry about cancer might relate to important protective behaviors such as cancer screening and surveillance [13, 14]. For instance, worry has been proposed to facilitate screening [15–18] in Leventhal's Common Sense Model [15, 16, 18], also called the dual process or parallel response model [17]. This model proposes that cognitive representations of disease drive the development of an action plan for coping with the threat of disease, as well as a parallel plan for coping with emotional reactions to this threat (such as cancer worry). Similarly, the Health Belief Model [19] has been used to justify cancer worry as a facilitator of screening as an aspect of susceptibility or severity beliefs, with measures of cancer

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worry embedded in these constructs [20–24]. A second theoretical premise highlights the potential inhibitory effect of cancer worry on behavior [25–28]. For instance, the Preventive Health Model proposes factors related to screening for colorectal cancer [28] and includes worries about abnormal screening results and physical discomforts of screening as potential barriers for colorectal cancer screening. Alternatively, other theories propose that a moderate level of cancer worry or distress—neither too high nor too low—may optimize screening. This is consistent with Protection Motivation Theory [29, 30] and the Extended Parallel Process Model [31] which both posit a moderating relationship between arousal of fear about illness and efficacy, predicting that fear will lead to protective health behaviors only when beliefs about ability to perform the behavior (self-efficacy) and beliefs about effectiveness of the protective measure itself (response-efficacy) are high. These models are guided by the seminal social psychological framework of Fear Arousing Communications Theory, which suggests that a moderate level of fear arousal is optimal for engagement in health behaviors, too little arousal is seen as promoting denial of risk, and too much arousal may lead to avoidance [32]. In general, the empirical literature provides more support that cancer worry promotes rather than inhibits cancer screening behaviors [13, 14, 33], despite the potential impact of higher levels of cancer worry on distress and poor quality of life. Whether worry about medical imaging radiation (MIR) might influence cancer screening behaviors, and in what direction, has not been directly examined to date.

Many of the tests used in the enhanced surveillance regimens in survivorship care involve ionizing radiation, including CT scans, x-rays, PET scans, and fluoroscopy [34], albeit at low doses. For example, after treatment for early-stage lung cancer, the National Comprehensive Cancer Network recommends surveillance for recurrent and new primary lung cancer including a CT scan of the chest every 6–12 months for the first 2 years and then annually [35, 36]. There is potential for those who have these tests to overestimate their exposure to radiation; for instance, among women in a general population urban health clinic presenting for screening mammogram, 60% overestimated their radiation exposure [37]. The cancer risks associated with MIR are uncertain [38]. Cancer risks associated with MIR are largely based on projections, mostly from atomic bomb survivors, occupational exposures, and other environmental radiation studies [39]. The importance of exposures in determining the use of optimal imaging protocols is dictated by individual patient life expectancies [40]. Nonetheless, the link between ionizing radiation delivered in routine medical workups and cancers such as papillary thyroid carcinoma is well characterized [41]. The uncertainty of cancer risk associated with MIR, paired with widespread negative public associations of

radiation exposure—derived from nuclear reactor accidents and atomic bomb explosions—likely contributes to survivors' worries [42], especially as the number of survivors treated with radiation therapy rises exponentially [43], which may further increase cancer risks [44]. These issues must be adequately addressed in health education efforts for cancer survivors.

There is little research examining the extent to which cancer survivors worry about MIR, specifically. While worry about diagnostic testing has been included in measures of worry in cancer survivor populations, it has not been evaluated as a separate item or construct [45, 46]. In one qualitative study assessing the psychological impact of routine surveillance CT scans in a sample of 70 long-term survivors of adult aggressive lymphoma, concern about radiation exposure was common and led some survivors to feel that they were receiving too many tests [5]. Worries about MIR, especially worries about surveillance for possible second cancers, may be an underappreciated element of the many aspects of cancer worry faced by cancer survivors and may dictate unmet educational needs. Clarifying survivors' level of MIR worry, as well as which subgroups are most worried, may help the survivorship care team to identify patient questions and concerns about MIR associated with surveillance tests, correct misconceptions and intervene to minimize the quality of life impact, and address any barriers to surveillance adherence in cancer survivors.

Thus, ascertaining the rates and patterns of MIR worry for cancer survivors is the overarching goal of this paper. Our study aims are to (1) estimate rates of worry about MIR in the US population of cancer survivors and (2) examine patterns of MIR worry across subgroups of cancer survivors defined by cancer type and by other important medical and demographic factors, as well as level of physician trust, all of which may show important patterns across MIR worry and be relevant to future theoretically driven studies that include moderators of overall worry about cancer and adherence with critical surveillance behaviors in survivorship populations.

Methods

Study Design and Participants

The Health Information National Trends Survey (HINTS, 2013) version 4, cycle 2, is a nationally representative survey that was conducted by the National Cancer Institute via mail between October 2012 and January 2013. Of 12,057 invitees, 3630 participants returned completed surveys (response rate 30%). The current analysis focused on the 452 individuals who responded “Yes” to “Have you ever been diagnosed with cancer?” and for whom complete data on the outcome of interest (worry about MIR) was available.

Measures

Worry About MIR The study-dependent variable was a self-report item measuring the amount of worry about the health harms of MIR utilizing a 4-point response scale (*not at all, a little, some, a lot*). Other items assessed worry regarding other factors, such as chemicals in water and food, and were not examined in the current study.

Demographic Factors Gender, age, race/ethnicity, educational attainment, annual income, whether the participant was born in the USA, subjective health status (*poor, fair, good, very good, excellent*), and health insurance status (*yes versus no*) were all assessed. General anxiety was assessed with the anxiety subscale from the Physician's Health Questionnaire-4 (PHQ-4), with scores ≥ 3 considered suggestive of elevated general anxiety [47].

Cancer Diagnosis and Treatment Participants indicated the type(s) of cancer they had, the type(s) of treatment they underwent (chemotherapy, radiation, surgery, and other), and how long ago they had received their last cancer treatment.

Physician Trust Participants were asked how much trust they would have in cancer information from a doctor (*not at all, a little, some, a lot*).

The specific wording of all measures reported in this study appears at https://hints.cancer.gov/docs/Instruments/HINTS_4_Cycle_2_English.pdf.

Analytic Strategy

All analyses were conducted in R version 3.2.3 using the “survey” package, version 3.30-3, to account for the HINTS complex sampling design. The HINTS sample weight was applied to all analyses to yield nationally representative point estimates. Standard errors were calculated using jackknife repeated replications with the set of replicate weights included with the HINTS data.

Variables were summarized using descriptive statistics. We compared rates of higher worry by cancer diagnosis using Rao-Scott chi-square tests. We were not comfortable treating the four-category ordinal variable as continuous, but we explored other alternatives before deciding to dichotomize our outcome variable. Standard linear regression assumes that the outcome variable is interval scaled, an assumption violated by the four-category ordinal variable. We considered alternatives that utilized all four categories, namely proportional odds regression and multinomial logistic regression. We decided against proportional odds regression because there was strong evidence that the proportional odds assumption did not hold. We decided against multinomial logistic regression because it yields a more complicated model that is considerably more

difficult to interpret. Additionally, the conclusions drawn from our preliminary proportional odds and multinomial logistic regression models were similar to conclusions drawn from the corresponding logistic regression models. Ultimately, we decided to dichotomize our outcome and go with the modeling technique (logistic regression) with the most straightforward interpretation. Logistic regression analysis was conducted and presented as unadjusted (univariable) and adjusted (multivariable) odds ratios with 95% confidence intervals. For the logistic regression analysis, the dependent variable (MIR worry) was dichotomized (*not at all/a little versus some/a lot*) and higher MIR worry was modeled. We dichotomized at *some/a lot* of worry instead of at *a little/some/a lot* because we were interested in evaluating variables associated with *higher* MIR worry instead of *any* MIR worry.

Three multivariable logistic regression models were fit to the data. The first included only the associations between the demographic variables and MIR worry. The second included the physician trust variable dichotomized as *a lot versus not at all/a little/some* in addition to the demographics. The third added treatment type and time since last cancer treatment (dichotomized as *less than 10 years ago versus 10 or more years ago*) to the demographic model.

Results

Characteristics of the Sample

Table 1 reports the descriptive characteristics of the analyzed HINTS sample reporting a history of cancer. The sample was 55% female, predominantly aged 50 and older (mean age = 63), 20% non-white, and highly diverse in educational attainment and income. Most of the cancer survivors had their cancer treated with surgery (76.4%), while 27.6% were treated with radiation and 21.0% with chemotherapy. The most common cancer types were skin (31.74%), breast (16.45%), prostate (13.24%), and cervical (11.05%) cancers (see Table 2).

Rates and Levels of Worry About MIR Among Cancer Survivors

Almost three-quarters of cancer survivors (73.1%, 95% CI 67.5–78.7%) reported worry regarding the health effects of radiation from medical imaging, and 42.4% (95% CI 35.4–49.3%) reported higher levels of worry (i.e., *some* or *a lot*). Specifically, 30.7% (95% CI 24.9–36.6%) reported *a little* worry, 25.5% (95% CI 19.2–31.8%) reported *some* worry, and 16.9% (95% CI 11.9–21.9%) reported *a lot* of worry.

Significantly larger proportions of respondents with breast (56.5%) and lung cancer (75.8%) reported higher worry about MIR compared to survivors of other cancer types (Table 2). Respondents with head/neck cancer, Hodgkin's lymphoma,

Table 1 Descriptive characteristics of cancer survivors

Variable	N (%) ^a
Demographics	
Gender	
Male	196 (45.0%)
Female	256 (55.0%)
Age group	
18–34	15 (5.9%)
35–49	44 (11.8%)
50–64	133 (31.6%)
65–74	123 (24.6%)
75+	133 (26.1%)
Race/ethnicity	
White	339 (80.4%)
Asian	6 (1.4%)
Black	48 (7.8%)
Hispanic	39 (7.7%)
Other	15 (2.7%)
Education	
Less than high school	39 (15.6%)
High school graduate	103 (19.2%)
Some college	148 (39.9%)
College graduate	66 (10.8%)
Post-graduate degree	92 (14.6%)
Income	
\$0 to \$9999	32 (4.1%)
\$10,000 to \$14,999	32 (6.5%)
\$15,000 to \$19,999	33 (8.8%)
\$20,000 to \$34,999	73 (15.3%)
\$35,000 to \$49,999	65 (15.5%)
\$50,000 to \$74,999	75 (18.9%)
\$75,000 to \$99,999	53 (15.2%)
\$100,000 to \$199,999	57 (12.7%)
\$200,000 or more	18 (3.1%)
Born in the USA	
Yes	416 (91.8%)
No	33 (8.2%)
General health self-assessment	
Poor	31 (5.6%)
Fair	82 (17.6%)
Good	150 (34.6%)
Very Good	139 (34.6%)
Excellent	34 (7.5%)
Health insurance	
Yes	410 (92.9%)
No	36 (7.1%)
PHQ-4 anxiety	
Low general anxiety	373 (84.8%)
High general anxiety	58 (15.2%)
Variable group = trust in physician	
Trust in cancer info from doctor	

Table 1 (continued)

Variable	N (%) ^a
A lot	331 (79.8%)
Not at all, a little, or some	116 (20.2%)
Variable group = cancer treatment-related variables	
Age at diagnosis	
Median (Q1–Q3)	53 (42–64)
Years since diagnosis	
Median (Q1–Q3)	8 (3.7–16)
Time since treatment completion	
Still receiving treatment	37 (7.2%)
< 1 year ago	54 (13.9%)
1 to < 5 years ago	104 (28.2%)
5 to < 10 years ago	81 (22.7%)
10+ years ago	122 (28.1%)
Cancer treatment received^b	
Chemotherapy	94 (21.0%)
Radiation	121 (27.6%)
Surgery	322 (76.4%)
Other	61 (10.9%)

PHQ Physician's Health Questionnaire

^a Unweighted frequency and weighted percent

^b Does not total to 100% because many respondents reported receiving multiple treatment modalities

non-Hodgkin's lymphoma, and endometrial cancer also had relatively higher rates of worry about MIR, but these rates failed to reach significance due to small sample sizes. Compared to those with other cancer types, a significantly smaller proportion of respondents with melanoma (21.4%) reported higher MIR worry. Unadjusted (univariable) and adjusted (multivariable) logistic regressions examining associations between higher MIR worry and medical and demographic factors, and level of physician trust, are presented in Table 3.

In the unadjusted models, higher worry about MIR was significantly associated with racial/ethnic minority status, having an annual income lower than \$50,000, lower educational attainment, being foreign-born, and poorer subjective health. With respect to cancer treatment, completion of cancer treatment within the past 10 years and receipt of radiation treatment were significantly related to higher MIR worry. Worry about MIR was not associated with sex, age, health insurance status, elevated general anxiety, or physician trust.

The multivariable demographic model indicated higher rates of MIR worry among those individuals with an annual income lower than \$50,000 and among those who self-reported poorer health. Race/ethnicity, education, and nativity were not significantly associated with MIR worry after adjusting for the other demographic variables. As with the univariable model, completion of cancer treatment more recently (within the past 10 years) was significantly associated

Table 2 Prevalence of higher MIR worry by cancer type

CA type	Total with CA type		Total with higher MIR worry among CA type		<i>p</i> value ^c
	<i>n</i> ^a	Weighted % ^a	<i>n</i> ^b	Weighted % ^b	
Lung	13	3.1	8	75.8	0.029*
Head/neck	12	3.5	6	67.9	0.098 ⁺
Hodgkin's	10	4.8	5	67.5	0.164
Non-Hodgkin	10	2.8	5	64.6	0.083 ⁺
Endometrial	14	4.9	8	57.3	0.356
Breast	82	16.5	40	56.5	0.008*
Prostate	60	13.2	22	39.9	0.830
Skin	138	31.7	50	39.4	0.650
Other	40	8.8	15	32.3	0.365
Colon	30	5.7	10	32.0	0.423
Cervical	43	11.1	14	26.6	0.105
Bladder	10	1.7	3	24.7	0.231
Melanoma	36	8.3	8	21.4	0.031*

CA cancer, MIR medical imaging radiation

^a Unweighted frequency and weighted percent with the given cancer type among 443 respondents with a history of cancer (9 of the total 452 cancer survivors did not report a diagnosis)

^b Unweighted frequency and weighted percent with higher (i.e., “Some” or “A lot”) MIR worry among the respondents with the given cancer type. For reference, the overall weighted percentage of cancer survivors with higher MIR worry was 42.4%

^c Rao-Scott chi-square *p* values. For *p* < 0.05, the proportion of survivors with higher MIR worry differed significantly between those with versus without a history of the given cancer type

⁺ *p* < 0.10; * *p* < 0.05

Table 3 Unadjusted and adjusted logistic regressions examining correlates of higher worry (worry was dichotomized as *none/a little* versus *some/a lot*) about harm from MIR among cancer survivors (*N* = 452)

Variables	Unadjusted OR (95% CI)	Factor <i>p</i> value	Adjusted OR (95% CI)	Factor <i>p</i> value
Demographics^a				
Gender				
Male	1.00 [referent]	0.563	1.00 [referent]	0.166
Female	1.16 (0.7–1.92)		1.59 (0.84–3.04)	
Age				
10-unit increase	0.96 (0.77–1.19)	0.685	0.86 (0.65–1.13)	0.284
Race/ethnicity				
White	1.00 [referent]	< 0.001***	1.00 [referent]	0.271
Black	4.66 (2.1–10.34)***		2.9 (0.76–11.02)	
All other	2.2 (0.87–5.54)		0.9 (0.35–2.31)	
Education				
Less than high school	3.34 (1.2–9.29)*	0.074 ⁺	1.11 (0.32–3.84)	0.685
High school/college grad	1.22 (0.68–2.18)		0.8 (0.45–1.45)	
Post-graduate degree	1.00 [referent]		1.00 [referent]	
Income				
< \$50,000 per year	2.25 (1.44–3.5)***	< 0.001***	1.92 (1.11–3.33)*	0.025*
≥ \$50,000 per year	1.00 [referent]		1.00 [referent]	
Born in the USA				
Yes	1.00 [referent]	0.044*	1.00 [referent]	0.089 ⁺
No	3.44 (1.06–11.11)*		2.68 (0.88–8.15) ⁺	

Table 3 (continued)

Variables	Unadjusted OR (95% CI)	Factor <i>p</i> value	Adjusted OR (95% CI)	Factor <i>p</i> value
General health self-assessment				
Poor-fair	4.79 (2.54–9.04)***	< 0.001***	4.07 (2.06–8.01)***	< 0.001***
Good-excellent	1.00 [referent]		1.00 [referent]	
Health insurance				
Yes	1.35 (0.31–5.84)	0.690	2.35 (0.45–12.19)	0.316
No	1.00 [referent]		1.00 [referent]	
PHQ-4 anxiety				
Low general anxiety	1.00 [referent]	0.267	1.00 [referent]	0.760
High general anxiety	1.83 (0.64–5.26)		1.18 (0.41–3.39)	
Trust in physician ^b				
Trust in cancer info from doctor				
A lot	1.00 [referent]	0.535	1.00 [referent]	0.760
< a lot	1.2 (0.67–2.15)		0.90 (0.45–1.78)	
Cancer treatments ^c				
Time since treatment completion				
Tx > 10 years	1.00 [referent]	0.011*	1.00 [referent]	0.031*
Tx 0–10 years	2.48 (1.27–4.85)*		2.43 (1.12–5.27)*	
Chemotherapy				
Yes	1.53 (0.76–3.06)	0.238	0.84 (0.35–2.02)	0.707
No	1.00 [referent]		1.00 [referent]	
Radiation				
Yes	2.34 (1.37–3.98)**	0.003**	1.97 (0.94–4.14) ⁺	0.083 ⁺
No	1.00 [referent]		1.00 [referent]	
Surgery				
Yes	0.91 (0.56–1.48)	0.709	1.66 (0.69–4.02)	0.267
No	1.00 [referent]		1.00 [referent]	
Other				
Yes	1.27 (0.6–2.68)	0.537	1.58 (0.62–4.04)	0.350
No	1.00 [referent]		1.00 [referent]	

MIR medical imaging radiation, OR odds ratio, CI confidence interval, PHQ Physician's Health Questionnaire

^a The adjusted odds ratios for each demographic variable are adjusted for all of the other demographic variables

^b The adjusted odds ratio for the trust in physician variable is adjusted for all of the demographic variables

^c The adjusted odds ratio for each cancer treatment variable is adjusted for all of the demographic variables and for the other cancer treatment variables

⁺ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

with MIR worry after adjusting for demographics, but the association with receipt of radiation treatment no longer reached the significance threshold ($p = 0.08$).

Conclusion

Almost half of survivors (42%) in the USA have salient concerns about exposure to radiation from medical tests, a fact that mirrors an expanding dialogue about the delivery of radiation via medical imaging in the medical community and the news media [48–51]. Some specific areas of concern were highlighted in a recent study examining cancer patient

perspectives on medical imaging radiation—patients desired more educational information about the rationale for recommendation of one test over another and for the frequency of repeated tests, as well as whether alternatives were available for tests that involved less MIR [51].

Patterns of higher worry (*some* or *a lot*) about medical imaging tests varied across cancer type; survivors of lung, head/neck, lymphoma, endometrial, and breast cancers all had worry prevalence that exceeded 55%. It is possible that the higher levels of MIR worry reported by survivors of these cancers can be attributed to surveillance regimens that include more frequent exposure to MIR and to patterns in radiation therapy and its long-term toxicity risks [43], as well as other

demographic differences in these patient groups that may predispose survivors to higher MIR worry. Alternately, these high levels may be a product of frequent media representations, particularly of breast and lung cancers, which may make these cancers more salient in survivors' everyday lives and thus more worrisome. Additionally, the low levels of worry found among melanoma cancer survivors may be attributed to their perceptions of melanoma as a largely controllable illness with mild consequences and concern [52]. Further, the vast majority of melanomas are diagnosed at an earlier stage, so survivors may undergo less exposure to MIR [53].

Examination of the patterns of MIR worry across the various factors investigated in this study indicates three survivor subgroups for which MIR worry is most prevalent: (1) the underserved, (2) those with poorer subjective health, and (3) those who were treated for their cancer more recently. First, worry about MIR was higher in survivors with lower incomes. This is likely due to the fact that underserved populations have lower health literacy [54] and are slower to absorb new health innovations [55]. A second important study finding is that higher MIR worry was associated with poorer self-reported health. Indeed, survivors who have serious health issues in addition to their histories of cancer [51] may be imaged more frequently and be more aware of potential risks associated with repeated imaging. As such, it is possible that two separate subgroups exist—where low socioeconomic status and limited access to/comprehension of health education resources dictate higher MIR worry, and where those with health concerns (and potentially greater access to health information) may also have higher MIR worry.

A final important study finding is that MIR worry is higher in those survivors who have been treated for their cancer more recently. Compared to patients treated 10 or more years ago, MIR worry was over twice as common in those who were treated for their cancer more recently (see Table 3). This is likely because these survivors' surveillance regimens are more severe during the first few years; thus, the amount of diagnostic imaging required may provoke worry, especially among those unused to long-term surveillance. Additionally, as this subgroup is closer to the experience of cancer and its treatment, its members may be more vigilant about anything that could potentially lead to recurrence.

General anxiety was unrelated to MIR worry in both the unadjusted and adjusted analyses; while our current findings indicate the primary importance of other factors over general anxiety, general anxiety was an important indicator of potential high levels of MIR worry in the general US population [56]. These findings suggest that MIR-specific worry is distinct from general worry.

Given that nearly three-quarters of our sample reported at least a *little* worry about MIR, future research should assess the impact that worries about MIR may have on cancer survivors' quality of life, and investigate whether and how worries about MIR may influence cancer screening behavior. In

particular, theory-driven research examining the role of MIR worry on adherence with cancer screening could potentially clarify under what conditions MIR worry might impede screening. For example, given our findings regarding recency of cancer diagnosis and heightened MIR worry, it might be useful to examine whether such worries may have a diminishing effect on behavior over time. Theory could also inform work to understand whether worry about different issues—such as worry about MIR and worry about recurrence—may predict diverse outcomes, including screening adherence, on the one hand, and distress outcomes, on the other hand, and how this might differ among those treated for different cancers. Another interesting line of research might seek to disentangle worries over diagnostic testing that focus on what the tests might reveal, and worries over the radiation exposure associated with the testing. In addition, given that the highest levels of MIR worry were reported by survivors of breast and lung cancer, future research should assess whether more frequent exposure to MIR among those treated for specific cancer types may account for higher levels of worry. Finally, future studies on this topic could recruit a larger sample of survivors of Hodgkin's lymphoma and endometrial cancer to assess rates of high MIR worry in these populations.

Study Limitations

Study limitations include the single-item measure of MIR worry and the modest study response rate, as well as the cross-sectional nature of the data, which does not allow for examination of cause and effect relationships between the covariates and worry about MIR. Additionally, the modest levels of worry might be normative and/or may represent inflated estimates consistent with initial elevation bias, a response characteristic sometimes observed in subjective reports [57]. With this dataset, we could not test specific health behavior theories, and we could not examine specific health concerns such as cancer recurrence worry, or screening histories. Some of the cell sizes for specific cancer types were quite small, requiring further research for confirmation and elaboration. Full consideration of cancer survivors' myriad concerns about and information needed for medical imaging, including both shorter- and longer-term effects, and other environmental exposures to radiation is necessary to fully address their health and policy implications.

Clinical Implications

An accurate assessment of survivors' concerns about the harms of MIR will aid health and cancer education within survivorship care planning and will guide physicians' communications as they address patients' responses to recommended and ongoing medical imaging. A recent systematic literature review examining quality and content of physician communication of radiation-induced cancer risks revealed that there is currently no consensus regarding who should provide

patients with relevant information, as well as in what specific situations information should be communicated and what that information should be [58]. Clinically, providers should be aware of the potential role of worry in cancer survivors' quality of life and informational needs [7]. This work can help improve educational strategies and thus risk communication and shared decision-making about recommended tests, among cancer survivors as well as their healthcare team. The development of consensus statements and novel educational initiatives within radiology and cancer survivorship fields would help galvanize such efforts. By anticipating patient questions and concerns and correcting misconceptions, the survivorship care team can ease the decision-making process for their patients and minimize the potential of cancer-related worries in general, as well as worries about MIR in particular.

This study contributes to the literature in that it helps clarify the rates and patterns of MIR worry among cancer survivors. Key points and study contributions include our finding that worry about MIR is prevalent among cancer survivors in the USA and highest among those with poorer subjective health, lower income, and more recent cancer treatments. MIR worry is also more common in survivors of breast and lung cancers, relative to other cancer types. Addressing survivors' concerns and educational needs about MIR, in oncology as well as in primary care settings, could support medical imaging adherence and address survivors' MIR concerns.

Acknowledgements We thank Jillisia James for her help in completing this manuscript.

Funding Information We received funding support from the Memorial Sloan Kettering Support/Core Grant (P30 CA008748).

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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