

Insomnia in adult survivors of childhood cancer: a report from project REACH

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Abstract

Purpose Insomnia is a common problem affecting cancer survivors even years after completion of therapy. Childhood cancer survivors may be at particular risk due to vulnerability to the effects of treatment and medical late effects which impact normal sleep development. Using an indicator of clinically significant insomnia (sleep efficiency), we examined a group of adult survivors of childhood cancer to (1) describe clinical insomnia rates, (2) identify physical and psychological correlates of insomnia, and (3) investigate the frequency with which sleep issues were evaluated during a cancer survivorship medical visit.

Methods A total of 122 adult survivors of childhood cancer completed standard measures of sleep, psychological distress, and health-related quality of life. Medical records of the 75 survivors with a survivorship medical visit on the day of self-report measure completion were reviewed for documentation of sleep-related issues.

Results Twenty-eight percent of participants endorsed sleep efficiency below 85 %, indicating clinically significant insomnia. Insomnia was associated with poor physical health and anxiety but not with demographic or cancer treatment variables. Medical providers failed to document sleep in visit notes for 67 % of patients with self-reported insomnia.

Conclusions A significant proportion of adult survivors of childhood cancer report insomnia, which is associated with physical and psychological health. Few survivors with insomnia discuss this issue with oncology providers during survivorship care. There is a clear need to screen for insomnia in

this population. Patients and providers should take greater responsibility for discussing sleep issues and seeking out proper treatment referrals when it is identified.

Keywords Insomnia · Sleep disorder · Childhood cancer · Cancer survivorship · Quality of life

Introduction

Cancer patients experience many physical and emotional challenges that can lead to the development of insomnia [1]. Physical symptoms such as pain, nausea, and fatigue, as well as worries about upcoming procedures or treatment outcomes can interfere with normal sleep patterns [2, 3]. Furthermore, hospitalizations often bring with them a variety of factors (e.g., constant light and noise, separation from family, frequent awakenings) known to disrupt sleep [4, 5]. Not surprisingly, more than half of cancer survivors report that cancer was either the cause of their sleep difficulties or further aggravated existing sleep issues [6]. Cancer survivors are more likely than the general population to report insomnia symptoms [7, 8], with over 50 % reporting some form of sleep dysfunction [9–11]. In particular, childhood cancer patients are particularly vulnerable to developing sleep problems both during and following treatment [10, 12–15]. These young patients are often in the phase of life where they are still developing good sleep habits, overcoming fears of the dark, etc., making their sleep more vulnerable to being disrupted. Similarly, they may have not fully developed the cognitive and emotional capacities to successfully process the stressors of the cancer experience [12, 16], leading to maladaptive coping strategies that can result in disrupted sleep [17].

Even after successful completion of cancer therapy, these sleep issues often persist if left untreated. As long as 5 years following treatment, up to half of adult survivors of childhood

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cancer continue to report insomnia symptoms [10, 13, 14, 18]. Unresolved insomnia is associated with a host of physical and psychosocial sequelae, including pain, fatigue, depression, anxiety, disrupted family functioning, and general quality of life decrements [19–21]. Furthermore, the relationships between insomnia and these sequelae are often bidirectional. Health problems such as pain and anxiety can interfere with sleep, and poor sleep can exacerbate fatigue, anxiety, and depression symptoms and interfere with individuals' attempts to manage their physical health problems [22, 23].

Given the many health and well-being implications of insomnia, the National Cancer Institute has specifically encouraged patients to report “trouble sleeping” to their medical providers [24]. The limited research about whether this recommendation is followed is disheartening. Research in the primary care setting indicates that there is a clear lack of communication about sleep-related issues; over 70 % of patients with insomnia do not bring it to their medical provider's attention [25, 26], and fewer than one in four medical providers documented their patients' sleep history [27]. While there has been limited research on the reporting of insomnia specifically in oncology settings, these findings from primary care suggest that insomnia is generally an underreported and undertreated condition in medical care.

Several research studies have investigated the prevalence, correlates, and negative impact of insomnia among adult cancer survivors [6, 9, 28], but comparatively, less is known about insomnia in the growing population of adult survivors of childhood cancer. Previous studies of insomnia in this group of survivors have indicated that they commonly report sleep problems [10, 13], but it is not clear from these findings how often these symptoms may warrant clinical intervention. Literature reviews have indicated that a notable challenge in interpreting the existing literature evaluating insomnia in cancer survivors has been the varied definitions of what constitutes insomnia (or sleep disturbances), ranging from the endorsement of only a single sleep dysfunction item, to meeting cutoff scores on a variety of sleep measures (e.g., the Pittsburgh Sleep Quality Index or the Insomnia Severity Index), to a full diagnosis using DSM-IV-TR criteria [9, 29–31]. This is important because sleep problems occur across a range of severity, and the presence of symptoms alone is of limited utility for clinicians in determining whether an individual's insomnia symptoms require treatment. To focus on the problem of clinically significant insomnia, we utilized the most commonly used metric of insomnia by cognitive behavioral sleep experts in their treatment: sleep efficiency. Calculated as the ratio of total time asleep, compared to total time in bed, sleep efficiency provides the patient and provider with straightforward and meaningful information about both sleep latency and sleep continuity difficulties on the same metric. Clinicians often target a sleep efficiency goal of at least 85 % by the end of treatment [32], and recent literature

suggests that a sleep efficiency below 85 % is a predictor of survival in advanced breast cancer patients [33]. Thus, we aimed to better understand the impact of clinically significant insomnia in a sample of adult survivors of childhood cancer by defining insomnia using a criterion of sleep efficiency below 85 %. Specifically, we sought to (1) describe the prevalence of clinically significant insomnia, (2) identify the association of insomnia with cancer treatments and physical and psychological health outcomes, and (3) investigate the frequency with which sleep issues were evaluated during survivorship medical visits.

Methods

Participants

Participants in the current study were drawn from project Research Evaluating After Cancer Health (REACH), a longitudinal cohort study of 800 cancer survivors followed in one of several specialized long-term follow-up clinics within a single cancer center (e.g., [34]). To be eligible for project REACH, survivors had to have been diagnosed with cancer prior to the age of 21, be at least a year posttreatment, 2-years postdiagnosis, and able to complete forms independently in English. Enrolled survivors completed annual self-report surveys of health outcomes, either in person or through the mail. The study was approved by the cancer center's Institutional Review Board.

For this analysis, participants were drawn from the cohort of adult survivors of childhood cancer followed in a survivorship clinic focusing on the long-term care of survivors of childhood cancer. This clinic serves survivors of all childhood cancer diagnoses, except those diagnosed with a central nervous system tumor, who are followed in a separate neuro-oncology outcomes clinic. Of 189 eligible survivors, 139 completed a study packet. However, 17 did not include complete sleep data and were not included in these analyses. These 17 survivors did not differ from those who did complete sleep data on demographic or disease-specific measures. Of the 122 participants who completed study questionnaires, 75 completed them on the same day as their survivorship medical visit, and 47 completed by mail. These 122 survivors were an average of 31.0 years old (range=20.0–48.9 years), with slightly more females (57.3 %) than males. Our sample was more likely to be unmarried (65.6 %), have at least a college level education (65.6 %), and have a household income of at least \$50,000 (73.0 %). The primary cancer diagnosis included leukemias (32.0 %), lymphomas (31.1 %), sarcomas (18.0 %), and other solid tumors (18.9 %). Survivors were an average of 20.5-years postdiagnosis (range=4.7–48.0 years).

Measures

Pittsburgh Sleep Quality Index [30] The Pittsburgh Sleep Quality Index (PSQI) is a commonly used 19-item self-report measure of sleep quality and disturbances over the past 1-month time period. Participants are asked to report their bed time, wake time, and total hours of actual sleep. Sleep efficiency was calculated by dividing the participant's self-reported total number of hours of sleep by their total time in bed. The individual items of the scale also generate a global sleep score, as well as several component scores. The PSQI has been used previously in adult survivor of childhood cancer populations [10].

Short Form-12 [35] The Short Form-12 (SF-12) is a 12-item measure which evaluates health-related quality of life and has demonstrated reliability and validity [35]. The SF-12 provides both a physical and mental health summary score, as well as 8 subscale scores (physical function, role physical, bodily pain, general health, vitality, social function, role emotional, and mental health). It has been used extensively in the cancer literature, including among adolescent and young adult cancer survivors [34], and in sleep literature for this group [10].

Brief Symptom Inventory-18 [36] The Brief Symptom Inventory-18 (BSI-18) is an 18-item tool designed to evaluate psychological distress. It is a measure that has been used to document functioning in adolescent and young adult cancer populations, including those which have examined sleep-related issues [37]. The BSI-18 was scored following the published manual to yield gender-specific *t* scores based on a community sample. The anxiety and depression scales were used in these analyses.

Medical history Electronic medical records were reviewed for all participants to collect their cancer history. In addition, participants endorsed chronic health conditions from a checklist of common medical issues on their study questionnaires. Please refer to Table 1 for the complete list of medical comorbidities included.

Survivorship medical visit note review Electronic medical records for the 75 participants who attended a cancer survivorship medical appointment on the same day they completed their study questionnaires were further examined for documentation of sleep-related issues. A cancer survivorship medical appointment was defined as an in-person medical appointment with a nurse practitioner or a medical doctor for the purposes of reviewing the patient's medical history, to examine for any new onset medical issues including late effects of cancer treatment and to monitor for cancer recurrence. For this group, the note for their cancer survivorship medical appointment was searched using an electronic text search function for

Table 1 List of potential medical comorbidities in alphabetical order

| | | |
|------------------------|---------------------------|------------------------|
| Angina | Asthma | Atrial fibrillation |
| Carotid artery surgery | Cataract | Chronic bronchitis |
| Colitis | Congestive heart failure | Coronary heart disease |
| Diabetes | Diverticulitis | Emphysema |
| Epilepsy/Seizures | Gallstones | Glaucoma |
| Gout | Hepatitis | High blood pressure |
| Hip fracture | Joint replacement | Kidney infections |
| Kidney stones | Liver condition | Macular degeneration |
| Migraines | Neurofibromatosis | Osteoporosis |
| Pacemaker implant | Peripheral artery disease | Pulmonary embolus |
| Stroke | Thyroid problem | Ulcer |
| Vertebral fracture | Other conditions | |

the presence of the keywords “sleep” or “insomnia.” Subsequently, to ensure that this electronic search did not miss documentation of sleep-related issues, a study author reviewed all medical records individually. Medical notes for those participants who had medical visits on prior to or after the day they completed self-report measures were not reviewed because of concern that changes in their symptoms or presentation could account for differences between self-report symptoms and sleep problems documented in their medical records.

Statistical analyses

We calculated descriptive statistics to describe the sample's demographic, medical, and mental health characteristics. A participant was characterized as experiencing insomnia if their sleep efficiency (calculated from the PSQI) was below 85 % in keeping with standard practice for evaluating insomnia in behavioral interventions [32]. Participants with and without insomnia were compared across sleep-related variables, including time taken to fall asleep, total sleep time, use of sleep medication ($\geq 1 \times / \text{week}$), and daytime somnolence ($\geq 1 \times / \text{week}$) using logistic analyses. Similarly, the relationships of insomnia to demographic, medical, and psychosocial variables were evaluated using logistic regression analyses. Finally, we reported the rates of documentation of sleep in the medical notes of patients who completed questionnaires on the same day as their survivorship visit.

Results

Sleep

The adult survivors of childhood cancer in our sample took an average of 20.2 min to fall asleep (range=0–120 min, standard

deviation (SD)=14.7 min) and slept an average of 7.3 h per day (range=4.5–10.0 h, SD=1.1 h). Mean sleep efficiency for all participants was 89.9 %, with a range from 50.0 to 100.0 %. Thirty-four survivors (27.9 % of the sample) reported a sleep efficiency below 85 % and were classified as having insomnia. Mean sleep efficiency for those with insomnia was 76.1 % (SD=8.3 %). Those classified as having insomnia took longer to fall asleep (26.5 vs 17.7 min, $p<0.01$) and slept for fewer hours (6.7 vs 7.5 h, $p<0.001$; Table 2). Survivors with insomnia were not significantly more likely to take sleep medication at least once per week, although they were more likely to endorse daytime somnolence at least once per week ($p<0.05$). Those who were experiencing insomnia reported poorer overall sleep quality on the PSQI ($p<0.01$).

Physical and psychosocial correlates of sleep

Survivors with insomnia were similar to those with no insomnia across demographic and cancer treatment variables including cancer diagnosis, time since diagnosis, and cancer therapies received (Table 3). In contrast, several indicators of physical and mental health differed between survivors with and without insomnia (Table 3). Specifically, survivors who reported insomnia were more likely to report lower physical

functioning on the SF-12 physical health summary score ($p<0.05$) and lower general health and role emotional functioning on the SF-12 subscales ($p<0.05$; Fig. 1). Survivors with insomnia were also more likely to report the presence of two or more physical comorbidities ($p<0.05$; odds ratio (OR)=2.4), more likely to report receiving medication for anxiety ($p<0.01$; OR=3.4), and reported greater anxiety on the BSI-18 anxiety scale ($p<0.05$).

Medical documentation of sleep

Visit notes for the 75 participants with a cancer survivorship clinic visit on the same day they completed their study questionnaires were reviewed electronically for documentation of sleep-related issues. The sleep efficiency for these 75 participants did not differ significantly from study participants who completed their questionnaires by mail ($p>0.50$). Neither the keyword sleep nor insomnia was present in 50 of the 75 survivorship visit medical notes (66.7 %). Of these 75 participants, 21 were classified as having insomnia by self-report (sleep efficiency <85 %). The notes for 7 (33.3 %) of these 21 participants with insomnia included documentation of either sleep or insomnia. Of these 7 notes, one included a provider recommendation for how to address insomnia symptoms (Fig. 2). A subsequent validation of our keyword search by

Table 2 Sleep-related variable information by presence of insomnia (85 % sleep efficiency cutoff)

| | No. | <i>n</i> No insomnia (% or SD) | <i>n</i> Insomnia (% or SD) | Statistical significance | OR |
|---|------------|--------------------------------|-----------------------------|--------------------------|-------------|
| Time taken to fall asleep (min) | 122 | 17.7 (14.5) | 26.5 (13.2) | .003 | .96 |
| Total sleep time (h) | 122 | 7.5 (1.1) | 6.7 (1.1) | <.001 | 2.11 |
| Sleep medication (≥1×/week) | 122 | | | .26 | |
| Yes | 12 | 7 (8.0 %) | 5 (14.7 %) | | .50 |
| No | 110 | 81 (92.0 %) | 29 (85.3 %) | | Ref |
| Daytime somnolence (≥1×/week) | 122 | | | .03 | |
| Yes | 4 | 1 (1.1 %) | 3 (8.8 %) | | .12 |
| No | 118 | 87 (98.9 %) | 31 (91.2 %) | | Ref |
| Pittsburgh Sleep Quality Index | 122 | | | | |
| Total score | 122 | 3.4 (2.2) | 7.3 (3.1) | .009 | .94 |
| Item #5a (cannot get to sleep within 30 min) | | | | <.001 | |
| Not during the past month | 57 | 50 (56.8 %) | 7 (20.6 %) | | Ref |
| <1×/week | 36 | 26 (29.5 %) | 10 (29.4 %) | | .36 |
| 1–2×/week | 20 | 7 (8.0 %) | 13 (38.2 %) | | .08 |
| ≥3×/week | 9 | 5 (5.7 %) | 4 (11.8 %) | | .18 |
| Item #5b (middle of the night or early morning awakening) | | | | .003 | |
| Not during the past month | 40 | 32 (36.4 %) | 8 (23.5 %) | | Ref |
| <1×/week | 31 | 28 (31.8 %) | 3 (8.8 %) | | 2.33 |
| 1–2×/week | 34 | 18 (20.5 %) | 16 (47.1 %) | | .28 |
| ≥3×/week | 17 | 10 (11.4 %) | 7 (20.6 %) | | .36 |

OR odds ratio

Odds ratios that differ significantly from 1.0 are shown in bold

Table 3 Demographic, cancer, and health-related descriptive information categorized by presence of insomnia (85 % sleep efficiency cutoff)

| | No. | <i>n</i> No insomnia (% or SD) | <i>n</i> Insomnia (% or SD) | P | OR |
|-----------------------------------|------------|--------------------------------|-----------------------------|-------------|-------------|
| Demographic | | | | | |
| Age (years) | 122 | 30.7 (8.1) | 31.8 (7.3) | .50 | |
| Gender | 122 | | | .31 | |
| Male | 52 | 35 (39.8 %) | 17 (50.0 %) | | Ref |
| Female | 70 | 53 (60.2 %) | 17 (50.0 %) | | 1.51 |
| Marital status | 122 | | | .47 | |
| Married/living as married | 42 | 32 (36.4 %) | 10 (29.4 %) | | Ref |
| Single/widowed/divorced/separated | 80 | 56 (63.6 %) | 24 (70.6 %) | | .73 |
| Education | 122 | | | .73 | |
| <College graduate | 42 | 29 (33.0 %) | 13 (38.2 %) | | Ref |
| College graduate | 53 | 38 (43.2 %) | 15 (44.1 %) | | 1.14 |
| Postgraduate | 27 | 21 (23.9 %) | 6 (17.6 %) | | 1.57 |
| Household income | 107 | | | .91 | |
| <\$50,000 | 18 | 13 (16.5 %) | 5 (17.9 %) | | Ref |
| \$50,000–99,999 | 42 | 32 (40.5 %) | 10 (35.7 %) | | 1.23 |
| >\$100,000 | 47 | 34 (43.0 %) | 13 (46.4 %) | | 1.01 |
| Cancer-related | | | | | |
| Primary diagnosis | 122 | | | .89 | |
| Leukemia | 39 | 28 (31.8 %) | 11 (32.4 %) | | Ref |
| Lymphomas | 38 | 28 (31.8 %) | 10 (29.4 %) | | 1.10 |
| Sarcomas | 22 | 16 (18.2 %) | 6 (17.6 %) | | 1.05 |
| Other solid tumors | 23 | 16 (18.2 %) | 7 (20.6 %) | | .90 |
| Time since diagnosis (years) | 122 | 20.0 (9.1) | 21.7 (8.1) | .34 | |
| Recurrence | 122 | | | .75 | |
| Yes | 16 | 11 (12.5 %) | 5 (14.7 %) | | .83 |
| No | 106 | 77 (87.5 %) | 29 (85.3 %) | | Ref |
| Chemotherapy | 122 | | | .68 | |
| Yes | 109 | 78 (88.6 %) | 31 (91.2 %) | | .76 |
| No | 13 | 10 (11.4 %) | 3 (8.8 %) | | Ref |
| Radiation therapy | 122 | | | .27 | |
| Yes | 88 | 61 (69.3 %) | 27 (79.4 %) | | .59 |
| No | 34 | 27 (30.7 %) | 7 (20.6 %) | | Ref |
| CNS-directed radiation therapy | 122 | | | .76 | |
| Yes | 37 | 23 (29.5 %) | 11 (32.4 %) | | .88 |
| No | 85 | 62 (70.5 %) | 23 (67.6 %) | | Ref |
| Surgery | 122 | | | .79 | |
| Yes | 49 | 36 (40.9 %) | 13 (38.2 %) | | 1.12 |
| No | 73 | 52 (59.1 %) | 21 (61.8 %) | | Ref |
| Physical health | | | | | |
| Total medical comorbidities | 122 | | | .04 | |
| 0–1 | 85 | 66 (75.0 %) | 19 (55.9 %) | | Ref |
| 2 or more | 37 | 22 (25.0 %) | 15 (44.1 %) | | 2.40 |
| Mental health | | | | | |
| BSI-18 depression (T-score) | 122 | 45.3 (7.1) | 47.1 (9.1) | .13 | .97 |
| BSI-18 anxiety (T-score) | 122 | 44.8 (7.3) | 48.2 (9.2) | .03 | .95 |
| Medication for anxiety (ever) | 122 | | | .003 | |
| Yes | 34 | 18 (20.5 %) | 16 (47.1 %) | | 3.40 |
| No | 88 | 70 (79.5 %) | 18 (52.9 %) | | Ref |
| Quality of life | | | | | |

Table 3 (continued)

| | No. | <i>n</i> No insomnia (% or SD) | <i>n</i> Insomnia (% or SD) | P | OR |
|---------------------------------------|------------|--------------------------------|-----------------------------|------------|-------------|
| SF-12 mental health (Summary score) | 113 | 51.1 (7.6) | 49.4 (10.7) | .36 | 1.02 |
| SF-12 physical health (Summary score) | 113 | 54.2 (6.6) | 50.7 (9.8) | .03 | 1.06 |

OR odds ratio

Odd ratios that differ significantly from 1.0 are shown in bold.

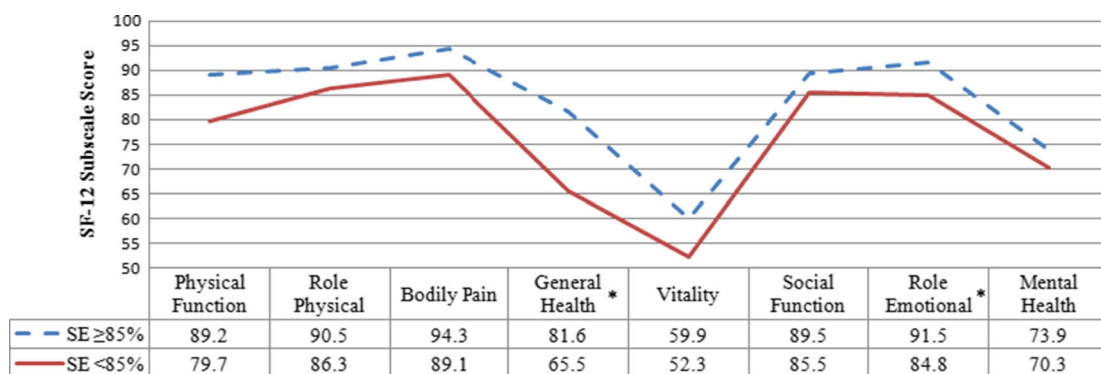
manual review did not identify any additional notes which discussed sleep-related issues and used a term other than sleep or insomnia.

Discussion

Insomnia can be conceptualized along a continuum [38] and has been identified in the existing literature from the presence of a single insomnia-related symptom to a clinical sleep disorder defined by psychiatric nosology [9, 29]. With such a wide range of definitions, it can be extremely difficult to compare findings across studies or to put these findings into a clinical context. In this study, we chose to define insomnia based upon a clinical criterion that guides the cognitive behavioral treatment for insomnia: a sleep efficiency below 85 %. This approach makes clear that the significant proportion of survivors reporting insomnia in our sample (27.9 %) are not simply experiencing minor disruptions in their sleep but are living with symptoms significant enough to warrant active treatment for insomnia. While prevalence rates for insomnia previously reported in this population have varied, our finding that 27.9 % of survivors experience clinically significant insomnia is generally consistent with the existing literature [10, 13, 14, 18].

The lack of association between insomnia with cancer-specific variables such as diagnosis and treatment history was unexpected but is consistent with a previous study that also found that the majority of cancer variables had little or no

association with sleep problems [10]. As expected, insomnia was associated with indicators of poor physical health in our sample. Although no single medical comorbidity was associated with insomnia, the presence of two or more physical comorbidities and poorer overall physical quality of life (SF-12) were associated with a sleep efficiency below 85 %. This may indicate that while many patients have the ability to withstand a certain amount of physical insult without compromised sleep, there is a tipping point for the impact of poor physical health on insomnia. Furthermore, poor psychological health was also associated with insomnia. Elevated anxiety scores (BSI-18), lower role emotional scores (SF-12; indicating greater functional limitations due to emotional problems), and a history of prescription medication for anxiety were more common in survivors with insomnia. Associations between physical and psychological health with insomnia have been extensively documented in the existing literature [39], and our findings confirm that oncology providers should have a heightened index of suspicion for insomnia in survivors who present with physical or psychological comorbidities. Moreover, while we know that medical comorbidities are risk factors for the development of insomnia, what is less commonly recognized is that sleep problems may exacerbate many of the physical ailments that can, in a vicious cycle, precipitate insomnia [40]. Thus, medical providers should consider the bidirectional nature of the relationship between insomnia with physical health in their interventions, as the treatment of insomnia can help to improve physical symptoms, and improvement in physical health symptoms may also improve sleep [41].



**p* < .05

Fig. 1 Mean scores on SF-12 comparing by presence of insomnia (<85 % sleep efficiency cutoff)

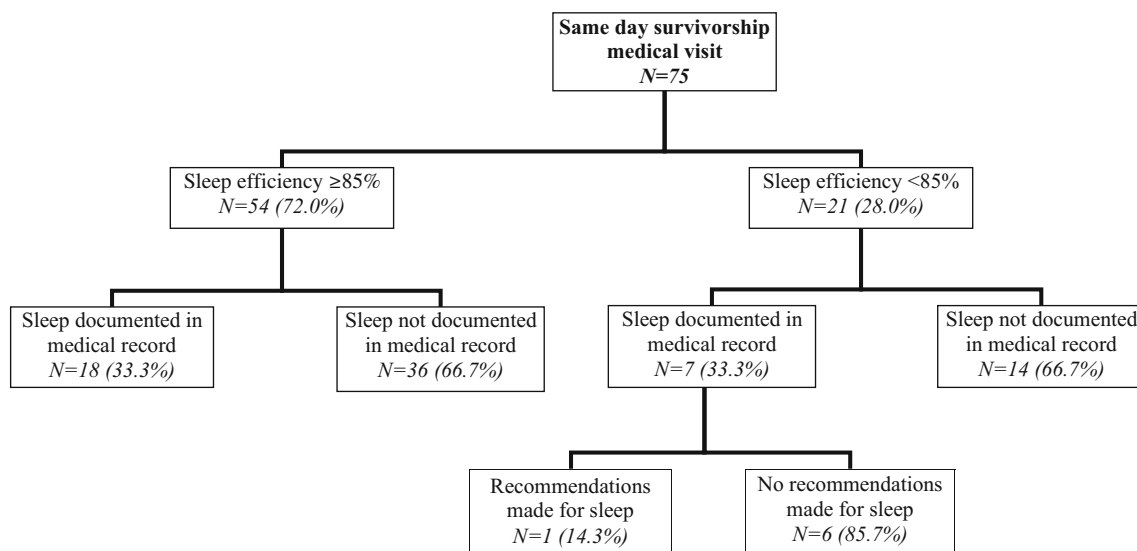


Fig. 2 Medical record documentation of sleep in participants with a medical survivorship visit on the same day as study questionnaire completion ($n=75$)

Despite National Sleep Foundation and National Cancer Institute recommendations for patients to discuss sleep problems with their medical providers [24, 25], two out of every three adult survivors of childhood cancer who endorsed insomnia on a self-report measure in our study did not discuss this issue with their medical providers, despite having a comprehensive cancer survivorship visit that very same day. The survivorship visit presents a valuable opportunity for health screening and interventions [42], but our results indicate that there is a clear gap in the communication about sleep-related issues between the cancer patient and their medical providers. Although this finding is concerning, it is consistent with research in primary care settings which also suggests that very few patients suffering from insomnia consult with medical providers about their sleep problems [25, 26]. The disconnect between patients and providers on the discussion of insomnia may be the result of barriers on both sides of the examination table. Patients often suffer through the daytime consequences of insomnia, reporting that they would prefer to avoid taking medication to resolve their sleep-related issues, and are unaware of treatment alternatives such as cognitive behavioral therapy for insomnia. On the other side, providers report a lack of knowledge about the assessment and treatment of sleep disorders [26, 43].

Study limitations and future directions

We acknowledge several limitations in our current study. Our sample is from a single cancer center and was relatively well-educated and affluent. Thus, they may not be representative of all adult survivors of childhood cancer. In addition, we focused on a single, clinically relevant, aspect of insomnia (sleep efficiency), measured at one time point. Thus, our report of insomnia prevalence and its covariates may differ if other

insomnia criteria were applied (e.g. the use of DSM-5 criteria) [44] and also preclude any causal inferences about the etiology of the insomnia from being made. To confirm and extend our findings, other relevant information about the survivor's sleep (e.g., measures of daytime function, sleep diaries, or objective measures of sleep) would be useful in future studies to confirm and extend our findings. However, we believe that the use of a widely accepted clinical criterion of sleep efficiency provides important information about the prevalence of clinically significant insomnia in this group. Finally, we did not evaluate survivors who were previously diagnosed with a central nervous system tumor. Limited literature, and our own clinical experience, indicates that this group of cancer survivors may present with other comorbid sleep disorders, including obstructive sleep apnea and central sleep apnea [45], and should be examined independently. We have initiated a study of survivors of pediatric central nervous system tumors, in order to address their sleep issues more comprehensively.

Despite these limitations, we believe that our findings contribute new information to the literature on insomnia in childhood cancer survivors. The prevalence of clinically significant insomnia in adult survivors of childhood cancer is worrisome and indicates that insomnia should be a late effect that is actively monitored by oncology providers. In particular, those who report physical or psychological comorbidities should receive special attention toward the possibility of insomnia issues, both because these health symptoms may be causing the insomnia and also because treatment for insomnia may itself improve physical and psychological health outcomes [41]. To address these issues, oncology providers may need to evaluate their current screening practices for sleep disorders and their resources for providing patient education and treatment referrals. Unfortunately, current guidelines for the long-term care of childhood cancer do not directly

address insomnia [46]. However, the addition of structured queries about common sleep disorders as part of survivorship medical care, or psychosocial screening, and providing survivors with patient education materials about insomnia are all simple steps that could increase awareness and detection of insomnia in cancer survivors. For medical providers caring for cancer survivors, learning about local resources for evaluation and treatment of insomnia will be important for supporting appropriate referrals for those affected. Identifying sleep specialists who can assess a range of sleep disorders and deliver effective interventions will be critical [47]. For insomnia in particular, cognitive behavioral treatment has been shown to be highly effective in randomized trials compared to pharmacological treatment and is recommended by the American Academy of Sleep Medicine as part of first-line insomnia treatment [48]. Untreated insomnia can significantly diminish an individual's physical and emotional functioning. Taking the necessary steps to first increase identification of insomnia and then to provide empirically supported treatment has the potential to significantly benefit the health and overall quality of life for adult survivors of childhood cancer.

Conflict of interest Eric S. Zhou and Christopher J. Recklitis declare that they have no conflicts of interest and no disclosures to declare.

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