

Trajectories of health behaviors across early childhood cancer survivorship

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Abstract

Objective: The majority of childhood cancer survivors develop at least one late effect subsequent to treatment (eg, cardiovascular disease and obesity). Consistent engagement in recommended health behaviors may mitigate some of these conditions. Researchers have identified early survivorship as a teachable moment, yet few studies have examined positive health behaviors during this period.

Methods: Families of children with cancer (ages 5-17) were initially recruited following a diagnosis or relapse of cancer. Three years post diagnosis, survivors ($n = 82$, $M_{\text{age}} = 13.3$, $SD = 3.7$) and their mothers ($n = 103$, $M_{\text{age}} = 41.1$, $SD = 7.6$) completed a questionnaire assessing exercise, dietary, and sleep patterns among survivors. A follow-up assessment was conducted 2 years later. Mixed models tested change in health behavior over time.

Results: At 3- and 5-year post diagnosis, mother and self-report indicated that few survivors engaged in appropriate levels of low-intensity exercise, fruit/vegetable intake, and dairy consumption. However, most survivors engaged in recommended levels of high intensity exercise, fast food restriction, and sleep. Health behaviors remained stable over time, except for mother report of sleep duration, which decreased ($b = -0.6$, $P < 0.001$). Brain tumor diagnosis predicted a larger decrease in self-report of sleep duration compared with other diagnoses ($P = 0.04$). Income predicted fast food intake such that higher income was associated with decreased intake over time, whereas lower income was associated with increased intake ($P = 0.04$).

Conclusions: During early survivorship, several health behaviors fell short of expectations for exercise and diet and did not improve upon reaching 5-year post diagnosis. Providers should evaluate survivors' health behaviors, including sleep, early and often, intervening when necessary.

KEYWORDS

cancer, healthy lifestyle, oncology, psychosocial, survivors, survivors of childhood cancer, survivorship

1 | INTRODUCTION

Five-year survival rates for childhood cancer now exceed 80%, and the population of survivors of childhood cancer continues to grow

exponentially, with numbers approaching 400 000 in the United States.¹ These survival rates come at a cost, as multimodal treatments can have a significant impact on the developing child. According to some estimates, up to 95% of these survivors may experience at least

one late effect from treatment, such as pulmonary conditions, obesity, and cardiovascular disease.^{1,2} Thus, minimizing these late effects is a crucial step toward optimizing the long-term quality of life of childhood cancer survivors.

Positive health behaviors, such as exercising often, eating a well-balanced diet, and getting ample sleep, may reduce risk for certain metabolic and cardiovascular conditions among both the healthy population and survivors.³⁻⁵ Given the importance of preventing cancer recurrence and late effects, engagement in these health behaviors may be particularly important for survivors. Yet, cancer and its treatment can compromise positive health behaviors. Side effects, such as nausea, vomiting, changes in taste, limited mobility, and fatigue may undermine diet, physical activity, and sleep. Later, as children enter survivorship, poor habits may linger—particularly if children exhibit late effects that limit physical functioning.^{6,7} However, little research has documented how positive health behaviors change between the end of treatment and early survivorship.

Childhood cancer survivors across age groups typically have comparable or lower dietary and physical activity patterns relative to the healthy population and fall short of national lifestyle guidelines.⁷⁻¹⁵ A review of 26 studies concluded that survivors demonstrate low levels of physical activity and fruit and vegetable intake, and most do not meet health behavior recommendations.¹⁶ Limited research has evaluated dairy and fast food intake, but adherence to dairy guidelines also appears poor.^{12,15,17} Children undergoing treatment for cancer may report poor sleep quality (eg, disrupted, restricted sleep), and a subset experience sleep disorders.¹⁸⁻²⁰ Such issues may persist well into survivorship.^{18,19,21,22} Thus, many long-term survivors of childhood cancer display inadequate patterns of diet, exercise, and sleep—despite the importance of positive health behaviors in the prevention of late effects and recurrence.

Early survivorship is a critical period for establishing positive health behaviors. However, most health behavior research has relied on data from adults who survived childhood cancer—focusing on health-compromising behaviors five or more years after diagnosis.²³ Such studies with young survivors may be subject to bias due to an overreliance on parent report or single informants.¹⁶ Few studies examining health behaviors in childhood cancer survivors have used longitudinal designs to clarify when and why health behaviors are poor. In cross-sectional studies, survivors who are adolescents or young adults (AYA), of lower socioeconomic status, and black typically demonstrate worse health behaviors.^{8,9,12,14,16,24} Diagnoses of leukemia or central nervous system (CNS) malignancy, as well as receipt of CNS-directed treatment, may also predict worse health behaviors.^{7,14,16,18,19,24} Whether or not these same variables predict health behavior change is poorly understood. Thus, research has yet to examine changes in health-promoting behaviors among contemporary cohorts during early survivorship—a critical transition point in the cancer continuum when providers can engage families in follow-up care.

Given these methodological gaps, we aimed to longitudinally examine the positive health behaviors (ie, diet, exercise, and sleep) of childhood cancer survivors during early survivorship compared with national guidelines. Adherence to guidelines were informed by recommendations from a variety of organizations. We prioritized the use of cancer-specific, measurable guidelines (ie, The American Cancer

Society and the Children's Oncology Group) when available but consulted resources from the US government agencies (the US Department of Agriculture and the Center for Disease Control), as well as previous research, when needed.²⁵⁻²⁹ Considering developmental expectations and observed differences across age groups in this population, we expected health behaviors to worsen over time, as participants aged into adolescence/young adulthood.^{9,22} Age, income, diagnostic type, and treatment type (CNS vs non-CNS directed treatment) were examined as potential predictors of health behavior change across early survivorship.

2 | METHODS

2.1 | Participants and procedures

Data are part of a larger, longitudinal study investigating coping and family communication in the context of childhood cancer.³⁰ Eligible participants were the following: (a) ages 5 to 17, (b) diagnosed with new or relapsed cancer, (c) English speaking, and (d) without preexisting developmental delay. Following Institutional Review Board (IRB) approval (IRB05-00039; IRB09-00135), study staff at two large pediatric institutions in the United States identified children from cancer registries and recruited them in clinic. Children and their parents provided written informed consent and assent (ages 10-17) to participate. Families received paper surveys to complete and return. Children aged 10 and older completed questionnaires and were offered assistance if needed. Compensation was provided for participation. At initial enrollment, 336 families of participated (M = 2.5 months post diagnosis, SD = 2.0 months). A majority of children were newly diagnosed at enrollment, although a subset had a relapsed diagnosis (n = 37, 11%). For this manuscript, health behavior data from parents and children at three (M = 41.0 months post diagnosis, SD = 3.8 months) and 5 years (M = 63.3 months post diagnosis, SD = 5.2 months) was included.

At 3 years post diagnosis, 16% (n = 55) of children had died. Of the 281 remaining families, 47 pilot families were not approached at this time due to a lag in funding. Thus, 54% (n = 127) of approached families participated, and 47% (n = 111) had complete data for the current study (103 mothers, 82 children). Mothers and children were, on average, 43.1 years old (SD = 7.6) and 13.3 years old (SD = 3.7), respectively.

At 5 years post diagnosis, four additional children had died, and pilot families were included at this time point. Of the 277 approached families, 52% (n = 145) participated, and 43% (n = 120) had complete data (104 mothers, 111 children). One hundred sixty-nine families had at least one family member who completed a health behavior questionnaire at either follow-up and were included in analyses. Nearly all of these participants (n = 157; 93%) were off treatment, with an average of 3.73 years (SD = 1.28).

Demographic characteristics (ie, survivor gender, survivor race, family income, diagnostic type, treatment type, and treatment status) were not significantly different for participants and those who chose not to participate at each time point. However, participants whose

initial study diagnosis was a relapsed diagnosis were less likely to participate at either time point ($P = 0.001$).

2.2 | Measures

Mothers reported family demographic characteristics (eg, marital status, education, and income), and diagnosis and treatment information was collected via medical chart abstractions. Health behaviors were measured (per mother and self-report) via a health behavior questionnaire designed for this population and adapted from the Youth Risk Behavior Surveillance System questionnaire (YRBS).³¹ Questions evaluated the frequency of each health behavior over the previous week. Items similar to the YRBS formatting and scales evaluating dairy intake, fast food intake, and sleep duration were also created. Participants rated the number of days in the previous week survivors engaged in each health behavior on a scale of 0 to 7 days. Sleep duration was assessed via an open-ended response indicating hours slept per night. Health behavior achievement criteria are displayed in Table 1. Criteria were derived from the recommendations of a variety of institutions and guided by previous research.^{7,25-29}

2.3 | Data analysis plan

Changes in health behaviors over time were analyzed using mixed models with the PROC MIXED procedure in SAS for mother and self-reports separately.³² First, change in each health behavior outcome was analyzed with a statistical model that included time as a repeated measures factor. Second, models examined demographic and medical factors (age, income level, diagnosis type, CNS-directed treatment) as predictors of change in health behavior outcomes from 3- to 5-year follow-up. As this procedure accounts for missing data, all available data were used in the mixed model analyses (see Table 2

for sample sizes). With $n = 79$ as the smallest possible sample size, we had approximately 80% power—sufficient to detect moderate to large effects, with $\alpha = 0.05$ for two-tailed tests.

3 | RESULTS

3.1 | Survivor health behavior achievement of recommendations

Using our criteria for health behavior recommendations (presented in Table 1), we calculated the percentage of survivors who met health behavior recommendations at both 3- and 5-year follow-up. One mother's sleep duration response was removed as it seemed unreasonable (ie, 19 h per night). At 3-year follow-up, both mother and self-reports demonstrated that few survivors (11-37%) met recommendations for low intensity exercise, fruit and vegetable intake, and dairy intake (see Table 2). However, most survivors (63-73%) met recommendations for high intensity exercise, fast food intake, and sleep for their age group.

At 5-year follow-up, achievement of health behavior recommendations largely remained stable. Few survivors (17-36%) met recommendations for low intensity physical activity, fruit and vegetable intake, and dairy intake (see Table 2). Again, most survivors (52-73%) reported recommended levels of high intensity physical activity, fast food intake, and sleep for their age group.

Concordance between mother and self-report of survivor health behavior was strong. Responses were significantly and positively correlated at both time points ($r = 0.23-0.62$, $P < 0.05$), and two-tailed, paired t tests found no significant differences between mother and self-report ($P = 0.25-0.97$). At 3-year follow-up, children on and off treatment reported similar health behaviors with two exceptions. At 3 years post diagnosis, participants on treatment consumed less fast

TABLE 1 Health behavior recommendation criteria

Health Behavior	Question	Achievement Criteria
Low intensity exercise	"During the past 7 days, how many days did you/your child participate in a physical activity for at least 30 minutes that did not make you/your child sweat and breathe hard (e.g. fast walking, slow bicycling, skating, pushing a lawn mower, or mopping floors)?"	The American Cancer Society recommends that survivors engage in 60 min of low intensity exercise at least 5 d per wk. ²⁶
High intensity exercise	"During the past 7 days, how many days did you/your child exercise or participate in a physical activity for at least 30 minutes that made you/your child sweat and breathe hard (e.g. basketball, soccer, running, swimming laps, fast bicycling, fast dancing, or similar aerobic activities)?"	The American Cancer Society recommends that survivors engage in 30 min of high intensity exercise at least 3 d per wk. ²⁶
Fruit/vegetable intake	"During the past 7 days, how many days did you/your child eat at least five fruits or vegetables per day?"	The Children's Oncology Group recommends that survivors consume at least 5 servings of fruits and/or vegetables each day. ²⁷
Dairy intake	"During the past 7 days, how many days did you/your child have at least three servings of milk or dairy products per day?"	The US Department of Agriculture recommends that youth consume at least 3 servings of milk or dairy products each day. ²⁸
Fast food intake	"During the past 7 days, how many days did you/your child eat fast food or take-out?"	Prior research recommend that youth consume fast food or take-out less than 3 d per wk ²⁵
Sleep duration	"During the past 7 days, on average, how many hours per night did you/your child sleep?"	The Center for Disease Control recommends 9-12 h of sleep per night for school-aged children, 8-10 h per night for adolescents, and 7 or more hours per night for young adults. ²⁹

Use of cancer-specific guidelines were used, when available. If unavailable, United States resources and prior research were consulted.

TABLE 2 Sample size, mean, and SD of health behaviors compared with recommendations

Health Behavior	Three Years Post Diagnosis						Five Years Post Diagnosis					
	Mother Report			Survivor Report			Mother Report			Survivor Report		
	n	Met Recommendations n (%)	M (SD)	n	Met Recommendations n (%)	M (SD)	n	Met Recommendations n (%)	M (SD)	n	Met Recommendations n (%)	M (SD)
Low intensity exercise	103	30 (29)	3.34 (2.28)	81	25 (31)	3.53 (2.43)	102	37 (35)	3.02 (2.19)	111	35 (32)	3.17 (2.16)
High intensity exercise	103	65 (63)	2.86 (2.47)	81	52 (64)	3.04 (2.57)	104	54 (53)	3.29 (2.38)	110	70 (63)	3.18 (2.23)
Fruit/vegetable intake	103	11 (11)	3.21 (2.23)	82	14 (17)	3.30 (2.39)	103	22 (21)	3.64 (2.46)	110	19 (17)	3.37 (2.40)
Dairy intake	103	38 (37)	4.52 (2.46)	82	28 (34)	4.09 (2.64)	104	37 (36)	4.63 (2.36)	111	32 (29)	4.25 (2.40)
Fast food intake	103	68 (66)	2.09 (1.39)	82	57 (70)	2.02 (1.55)	104	74 (71)	2.09 (1.46)	111	81 (73)	1.91 (1.31)
Sleep duration	103	72 (73)	8.55 (1.70)	79	47 (60)	8.08 (1.62)	104	45 (52)	7.87 (1.23)	107	50 (54)	7.89 (1.66)

As each health behavior was examined separately, we used the maximum n for mother and survivor data for all analyses. [Correction added on 19 November 2018, after first online publication: The high intensity and low intensity exercise labels at the first column of the table were misplaced. This has been corrected in this version.]

food ($P = 0.046$) and reported more sleep ($P = 0.024$). Correlations revealed that time since completion of treatment was unrelated to health behaviors.

3.2 | Health behavior change over time

Health behavior outcome variables were analyzed separately for mother and self-report to analyze change over time. Contrary to our expectations, mixed model analyses revealed that health behaviors remained stable across early survivorship. Sleep duration significantly decreased by approximately 36 minutes per night per mother report ($b = -0.60$, $P < 0.001$).

Tested predictors of health behavior change included child age, mother-reported family income level, diagnosis type, and treatment type. Most predictors were nonsignificant (see Table 3). Brain tumor diagnosis predicted a significant decrease in self-report of sleep duration compared with other diagnoses ($b = -2.20$, $P = 0.04$), evidencing a decrease of 132 minutes of sleep per night, whereas other diagnostic groups demonstrated minimal change (ie, a 15-20 min decrease or increase in sleep duration). However, as few children in this sample were brain tumor survivors (see Table 4), this finding should be viewed cautiously.

Although fast food intake remained stable, family income predicted differential change in fast food intake, per both mother ($b = -0.25$, $P = 0.04$) and self-report ($b = -0.31$, $P = 0.04$). Survivors at the lowest income level (less than \$25 000 annually) increased fast food intake slightly. In contrast, survivors at the highest income level (more than \$100 000 annually) decreased fast food intake in the previous week by about 1 day.

4 | DISCUSSION

As children diagnosed with cancer enter survivorship, clinicians or family members may expect to see improvements in health behaviors. However, engagement in positive health behaviors is perhaps complicated due to late effects (eg, fatigue and musculoskeletal problems) and developmental changes as survivors age and evidence normative declines in health behaviors.^{6,21,33} This study examined the trajectories of several key health behaviors during the transition off treatment to long-term survivorship, an often understudied yet critical period in the cancer continuum. Survivors in this study achieved recommendations for high intensity exercise, fast food intake, and sleep, but low intensity exercise, fruit and vegetable intake, and dairy intake fell short of established guidelines. Furthermore, given that health behaviors remained stable and did not vary as a function of time posttreatment, the lack of improvement from 3 to 5 years post diagnosis is concerning.

Achievement of recommended levels of physical activity was moderate for high intensity exercise and poor for low intensity exercise. Reviews report that approximately 50% of survivors or less achieve recommendations for physical activity and/or exercise.^{7,9,16} Although few studies have specifically reported low- and high-intensity physical activity levels in survivors of this age group, our finding of more survivors meeting recommendations for high inten-

TABLE 3 Regression coefficients for predictors of health behaviors

Reporter	Predictor	Low Intensity Exercise			High Intensity Exercise			Fruit/vegetable Intake			Dairy Intake			Fast Food Intake			Sleep Duration			
		b	t	P	b	t	P	b	t	P	b	t	P	b	t	P	b	t	P	
Mother	Child age	-0.076	-0.81	0.419	0.011	0.08	0.881	0.011	0.15	0.881	-0.021	-0.26	0.792	0.033	0.71	0.479	0.011	0.15	0.881	
	Family income	0.109	0.42	0.678	-0.066	-0.31	0.759	-0.066	-0.31	0.759	-0.276	-1.26	0.210	-0.258	-2.07	0.041	-0.066	-0.31	0.759	
	Diagnostic type																			
	Leukemia	0.332	0.41	0.683	0.595	0.90	0.373	0.595	0.9	0.373	0.470	0.66	0.509	0.351	0.86	0.394	0.595	0.9	0.373	
	Lymphoma	-0.268	-0.3	0.764	1.123	1.52	0.132	1.123	1.52	0.132	-0.010	-0.01	0.990	0.471	1.02	0.308	1.123	1.52	0.132	
	Brain tumor	-1.444	-0.97	0.335	2.017	1.63	0.107	2.017	1.63	0.107	-1.465	-1.1	0.272	0.216	0.28	0.777	2.017	1.63	0.107	
	Other solid tumor	0.000	...	...	0.000	...	...	0.000	...	...	0.000	...	...	...	...	...	0.000	...	...
	Treatment (CNS vs non-CNS)	0.870	1.33	0.187	0.886	1.62	0.109	0.886	1.62	0.109	0.792	1.35	0.180	0.186	0.55	0.585	0.886	1.62	0.109	
	Survivor	Child age	-0.071	-0.64	0.522	-0.012	-0.12	0.906	-0.072	-0.76	0.449	-0.147	-1.27	0.208	-0.002	-0.03	0.980	-0.010	-0.17	0.862
		Family income	0.331	1.42	0.162	0.336	1.54	0.131	-0.194	-0.82	0.414	-0.286	-1.12	0.266	-0.318	-2.04	0.044	0.165	1.21	0.232
Diagnostic type																				
Leukemia		-0.895	-1.04	0.302	-0.100	-0.12	0.903	-0.384	-0.49	0.622	-0.698	-0.77	0.444	-0.191	-0.35	0.727	-0.507	-1.21	0.231	
Lymphoma		-0.438	-0.49	0.628	0.081	0.10	0.924	-1.220	-1.51	0.135	-0.812	-0.85	0.395	-0.317	-0.55	0.580	-0.596	-1.37	0.177	
Brain tumor		-0.571	-0.31	0.754	-1.357	-0.81	0.419	-1.750	-1.05	0.297	-1.597	-0.86	0.391	-1.399	-1.27	0.208	-2.200	-2.67	0.001	
Other solid tumor		0.000	...	...	0.000	...	...	0.000	...	...	0.000	...	...	0.000	...	...	0.000	...	...
Treatment (CNS vs non-CNS)		-0.364	-0.52	0.603	0.047	0.07	0.943	0.494	0.77	0.442	0.867	1.18	0.240	0.285	0.65	0.515	-0.203	-0.57	0.570	

Abbreviation: CNS, central nervous system.

TABLE 4 Participant demographic characteristics^a

Variable	Three Years Post Diagnosis	Five Years Post Diagnosis
Survivor mean age (SD)	13.3 (3.9)	...
Survivor age range	7 to 21	...
Survivor gender		
Male (%)	56 (51)	57 (48)
Female (%)	53 (49)	62 (52)
Survivor race		
White (%)	93 (85)	104 (88)
Black (%)	11 (10)	11 (9)
Native American/other (%)	5 (5)	4 (3)
Family income		
\$25 000 or under (%)	26 (25)	23 (22)
\$25 000 to \$50 000 (%)	21 (20)	28 (26)
\$50 000 to \$75 000 (%)	24 (23)	23 (21)
\$75 000 to \$100 000 (%)	13 (13)	17 (17)
\$100 000 or more (%)	19 (19)	16 (14)
Cancer diagnosis		
Leukemia (%)	41 (38)	43 (36)
Lymphoma (%)	30 (27)	31 (26)
Brain tumor (%)	5 (5)	8 (7)
Other solid tumor (%) ^b	33 (30)	37 (31)
Type of treatment		
CNS-directed treatment (%)	55 (50)	61 (51)
Chemotherapy (%)	105 (95)	116 (98)
Radiation (%)	35 (32)	39 (33)

Abbreviation: CNS, central nervous system.

^aDemographics presented reflect children from all families with complete survivor or mother data.

^bOther solid tumors include sarcoma diagnoses, as well as neuroblastoma and Wilms tumor.

sity exercise than for low intensity exercise contradicts previous findings.^{10,11} Survivor engagement in organized sports, dance, or other physically intense activities perhaps explains this observation in a primarily school-aged sample. Stability of health behaviors in the current study is consistent with some research in healthy populations³⁴ but differs from findings of declining physical activity in adult survivors over 5 years from treatment in the St. Jude Childhood Cancer Survivor Study.³⁵ It is likely that adherence to physical activity guidelines remains moderate in early survivorship and then declines as survivors age into adulthood. However, the factors examined in our study did not predict a change in physical activity in early survivorship, despite correlational findings in prior research.⁹ This may be due to timing. Particularly for children who remained in the same developmental age group, this 2-year window may be too brief for significant changes to emerge.

Dietary findings were generally consistent with prior research with this population, as few survivors were adherent to recommendations of five servings of produce and three servings of dairy daily.^{11,12,15,17} While dietary patterns often worsen as healthy children enter adolescence and young adulthood, those of our sample remained stable over

a 2-year period.³⁶ Generally, sociodemographic and medical factors failed to predict changes in adherence to dietary guidelines in our sample. However, survivors from higher-income families decreased their fast food consumption over time, while survivors from lower-income families slightly increased fast food intake. Post hoc analyses found that this difference may be explained by higher income families consuming more fast food than lower income families at 3 years post diagnosis. Taken together, our results may reflect a catch-up period for survivors as fast food consumption increases for lower income families and becomes more similar to national trends.²⁵ Overall, these findings add to a growing body of literature from adult survivors, indicating that many younger childhood cancer survivors do not meet dietary recommendations. This is concerning, as the intake of nutrient-dense, health-promoting fruits and vegetables, and dairy products could mitigate risk for late effects, such as secondary malignancies, osteopenia, and cardiometabolic disorders.

Most survivors achieved the recommended amount of sleep per night for their age group, replicating a study with pediatric brain tumor survivors.³⁷ It is noteworthy that survivors' sleep significantly decreased over time according to their mothers, which mirrors findings of continued poor sleep quality as survivors mature.^{20,21} We found a greater decrease in sleep duration among brain tumor survivors relative to other diagnoses, according to self-report. This observation may be explained by circadian changes specific to brain malignancies but should be viewed cautiously given our small sample of brain tumor survivors.^{18,19} Together, these observations are troubling, as restricted sleep duration is associated with obesity and obesogenic changes in hormones and physical activity.⁵

Overall, we found few demographic or medical factors that distinguished trajectories of change in health behaviors over a 2-year period. This may be due to the longitudinal nature of these data and factors such as the timing of assessments and the nature of selected predictors. Various medical factors not explored in the current study (eg, younger age at diagnosis, longer treatment length, lower health care utilization, and higher presence/severity of late effects) may serve as effective predictors of health behavior decline.^{9,23} Based on previous research, psychological constructs including beliefs about health self-efficacy, health protection, and cognitive competence may predict health behavior change in childhood cancer survivors.^{13,16,38} Future studies should evaluate such constructs and their associations with health behavior change among this population.

4.1 | Study limitations

There are several other study limitations to consider. Participant attrition between enrollment and follow-up studies reduced sample size and power. Moreover, the sample is mostly white, with proportionally fewer brain tumor survivors. While multiple informants provided similar health behavior data, they were collected via subjective report on single items. We recruited fathers of survivors, but the small sample prohibited inclusion in this paper. Larger and more diverse samples of survivors should be followed—perhaps over a longer period of time. Future studies should include objective data (eg, food diaries and

actigraphy) when possible. The use of both objective and multi-informant subjective measures of health behavior would provide more information and may have greater sensitivity to detect changes over time.

Despite limitations, this is the first longitudinal study examining the positive health behaviors of a broad age range of childhood cancer survivors across early survivorship. Use of multiple informants and evaluation of fast food and dairy intake in this population adds to the existing literature. As this study expands our understanding of when health behaviors among childhood cancer survivors are suboptimal, research should continue to address why this is the case. Such work will inform interventions tailored to this high-risk population. Our findings evidence that young survivors do not appear to improve health behaviors post diagnosis without intervention. Existing interventions for young survivors typically target physical activity, with most findings demonstrating moderate, short-term success.^{10,16,39} The current study demonstrates that efforts aimed at improving dietary quality are also necessary. Interventions should especially target periods of transition within the developmental or cancer continuums, taking advantage of “teachable moments” during treatment or early survivorship to prevent the persistence of unhealthy habits into adulthood.

4.2 | Clinical implications

Ideally, clinical efforts should focus on improving family education and providing effective interventions to address the deficits this study and others have identified. However, many survivors are lost to long-term follow-up, and a recent review reported that primary care physicians found survivorship guidelines unclear and inconsistent.⁴⁰ Regular communication between providers and families, as well as the development of an efficient, valid screener of health behaviors, would bring greater attention to this issue. Psychosocial providers play a key role in working with children at the greatest risk. Although survivors in this sample achieved recommendations for several positive health behaviors, intervention may be necessary for youth who are obese, hypertensive, or evidence chronically poor habits. Ultimately, additional research, coupled with improvements in evidence-based care, is needed to increase engagement in positive health behaviors in early survivorship and thus improve long-term quality of life.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest to disclose.

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