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The potential utility of parent-reported attention screening in survivors of childhood cancer to identify those in need of comprehensive neuropsychological evaluation

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Background. Survivors of childhood cancer are at risk for neuropsychological late effects, yet identifying those in need of evaluation and obtaining needed services can be challenging for the medical team. Finding time- and cost-effective screening measures that can be used to identify children in need of evaluation is a clinical priority. Our objective was to investigate the association between parent-rated attention problems and related neuropsychological impairments in childhood cancer survivors as a means of identifying those at high risk for difficulties.

Methods. Cognitive and psychosocial data of survivors who completed neuropsychological evaluations were retrospectively abstracted. Parents of 70 survivors of pediatric cancer (mean age, 11.6 years) completed the Conners Parent Rating Scale and the Child Behavior Checklist. Children also completed a measure of intellectual functioning. The 18 symptoms of inattention and hyperactivity were abstracted from the Conners questionnaire, and participants were classified according to whether or not they met attention deficit/hyperactivity disorder (ADHD) symptom criteria (≥6 inattentive symptoms).

Results. Survivors who met symptom criteria for ADHD (27%) demonstrated greater impairments in IQ and working memory, but not processing speed, than survivors who did not. Meeting ADHD symptom criteria was also associated with greater externalizing and social problems but not more internalizing symptoms. ADHD symptom screening was associated with low sensitivity (range = 26.3%–69.2%) but stronger specificity (range = 75.0%–82.7%) for neuropsychological difficulties.

Conclusion. Parental ratings of attentional symptoms may be a useful way to screen survivors who may be in need of a full neuropsychological assessment.

Keywords: ADHD, attention problems, late effects, neurocognition, neuropsychological screening, pediatric cancer survivors.

It is well known that survivors of acute lymphoblastic leukemia (ALL) and brain tumors are at increased risk for the development of neurocognitive late effects due to their disease and treatment.[1,2] There is a wide range of difficulties experienced by survivors of CNS-impacting cancers as a group (particularly survivors of brain tumors), including visual and verbal episodic memory, visual-motor integration, executive functioning, and some mental health symptoms.[1,2] The most frequently described neurocognitive late effects, however, pertain to IQ, working memory, and processing speed.[3–5] The severity of these late effects has been found to be greatest for pediatric patients who were treated at a young age and with therapies that impact the central nervous system (eg, intrathecal methotrexate, cranial radiation, and neurosurgery).[6,7] Not only do deficits in neurocognitive ability impact intellectual and academic functioning, they can also lead to reduced quality of life that includes higher rates of failure to achieve milestones such as marriage, independent living, and employment.[8,9] Given these implications, it remains critical to work

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towards improving neurocognitive evaluation and interventions for survivors.

The nature of neurocognitive impairment observed in survivors of childhood cancer presents a unique conceptual challenge to researchers, clinicians, and educators. As researchers have refined the cognitive phenotype in survivors, many have also sought to compare the late effects profile to the frameworks of other known cognitive or developmental disorders. Such efforts serve to facilitate understanding of survivors' deficits and to better direct the search for effective interventions. One frequently referenced model is attention deficit/hyperactivity disorder, predominantly inattentive type (ADHD-In). ADHD-In is a developmental disorder characterized by pervasive and impairing difficulties with inattention, concentration, and distractibility that have been observed consistently over time and across settings beginning in early childhood.[10] Working memory deficits, delays in processing speed, and executive dysfunction are also associated with ADHD-In.[10–12] A significant body of literature has documented attention problems in survivors of both ALL and brain tumors,[13–18] which supports this conceptual model. Broadly speaking, survivors of brain tumors demonstrate high rates of attention problems and associated impairments, particularly when they have been treated with cranial radiation[19] or have been treated for hydrocephalus.[20–22] Attentional difficulties have been documented for survivors of numerous tumor types, including medulloblastoma,[5] ependymoma,[23] low-grade astrocytoma,[24] pilocytic astrocytoma,[22] and craniopharyngioma.[25] Notably, increased rates of attentional difficulties have been documented even in survivors of ALL who have no global intellectual, memory, or academic deficits.[13,26] Further, research has also suggested that 70% of survivors' functional impairment at school and other settings can be accounted for by their attention problems.[27]

Because of the prevalence of attention problems, performance-based measures and rating scales of attention are often included in neuropsychological evaluations of survivors of childhood cancer. Best practice guidelines from the Children's Oncology Group[28] recommend, at minimum, a comprehensive neuropsychological evaluation at entry into long-term follow-up for all survivors who have the potential to be at risk for neurocognitive late effects (most predominantly survivors of ALL and brain tumors). Reevaluation is then recommended based on clinical need and the anticipated trajectory for the emergence of late effects. However, it is often difficult to comply with these recommendations due to limitations of practice (eg, insurance, long waiting lists, and family reluctance). As such, it is important to evaluate efficient and economical methods for identifying those patients who are at heightened risk for neurocognitive late effects and would thus benefit from a comprehensive evaluation.

Prior studies have suggested that the use of parent-reported questionnaires may be a quick and feasible means for screening a large group of patients for neurocognitive concerns.[29] Specifically, Patel et al[29] evaluated the utility of a broad-based measure of emotional and behavioral functioning to identify attention problems in survivors of brain tumors. They found that elevated ratings of inattention on this measure were predictive of greater attention problems on more objective, laboratory-based measures.[29] However, they did not evaluate the predictive validity of their attention measure to other measures of neurocognitive functioning that are typically impaired in survivors, including working memory and processing speed tasks. Furthermore, their sample was limited to survivors of brain tumors and did not include patients with ALL, who are also at risk for attention deficits.[26] Therefore, as a logical extension of previous work in this area, we aimed to clarify the association between survivors' clinically significant attention problems and other neuropsychological difficulties (ie, working memory, processing speed, behavioral outcomes). Broadband, parent-completed rating scales, which include items designed to measure ADHD symptoms, have been shown to reliably distinguish between children with and without ADHD as well as children with and without working memory deficits.[30,31] Such rating scales have also been used previously in the research literature to characterize the attention profile of survivors of ALL and brain tumors.[32–34] If parent-rated attention problems can reliably predict broader neuropsychological late effects in survivors, parental ratings may help clinicians triage survivors so that resources are allocated to those who are in need of comprehensive evaluations. This may be particularly relevant for survivors of ALL, who may not evidence global declines in cognitive functioning but do demonstrate attention problems.[1,13,26] Our first hypothesis was that survivors' difficulties with attention would be predictive of lower scores on performance-based tasks of global intellectual functioning, processing speed, and working memory. Our second hypothesis was that the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (DSM-IV)[35] ADHD-In symptoms, as rated by parents, would identify survivors experiencing specific neurocognitive and psychosocial dysfunction.

Materials and Methods

We conducted a retrospective review of the neuropsychological records of 70 patients, aged 5–18 years, who had completed therapy at least 1 year previously for either ALL or a brain tumor.

Participants and Procedures

Following approval from the institutional review board, cognitive and psychosocial data were abstracted from the medical records of survivors of pediatric cancer assessed within the Pediatric Neuropsychology Clinic of a large academic medical center in the Southeastern United States. Routine neuropsychological evaluations were a standard of care for all patients with brain tumors and ALL at this institution, and thus the current sample is representative of the larger population. Participants were eligible if they were diagnosed with either ALL or a brain tumor, were off treatment for at least 1 year, were medically stable at the time of evaluation, and their parent or guardian had completed a version of the Conners Parent Rating Scale[36,37] at the time of evaluation. We elected to include a heterogeneous sample of survivors of both brain tumors and ALL, given the high prevalence of attention problems present in each group and to be consistent with prior literature that has reported the prevalence of ADHD symptoms in survivors.[32,33] The sample used in the current study included 70 survivors of CNS-impacting pediatric cancer (55.7% male; 84.3% Caucasian): 47 survivors of brain tumors and 23 survivors of ALL. At the time of evaluation, survivors were, on average, 11.6 years of age (SD$\pm$3.61, range, 5.8–18.2 years) and 4.6 years off treatment (SD$\pm$2.86, range, 1–12 years). See Table 1 for all demographic and treatment information.

Table 1. Demographic and treatment information for all survivors ($n = 70$)

	M ± SD	Range	*N* (%)
Age (years)	11.55 ± 3.61	5.8–18.2	
Age at diagnosis (years)	5.57 ± 3.50	0.3–15.0	
Years off treatment	4.26 ± 2.86	1.0–11.9	
Sex			
Male			39 (55.7)
Female			31 (44.3)
Race			
Caucasian			59 (84.3)
African-American			3 (4.3)
Hispanic			4 (5.7)
Biracial			4 (5.7)
Cancer Diagnosis			
ALL			23 (32.9)
Medulloblastoma			8 (11.4)
Ependymoma			11 (15.7)
Pilocytic Astrocytoma			9 (12.9)
Other Brain Tumor			19 (27.1)
Cancer Treatment			
Neurosurgery			39 (55.7)
Chemotherapy			48 (68.6)
Cranial Radiation			33 (47.1)
Bone Marrow Transplant			6 (8.6)

Abbreviations: ALL, acute lymphoblastic leukemia; M, mean; SD, standard deviation.

Table 2. Attention deficit/hyperactivity disorder symptom counts from the DSM-IV[35] as abstracted from the Conners rating scale.[36,37] Specifically, the presence of a symptom was defined as a score of 2 ("pretty much") or 3 ("very much") on the Conners, while the absence of a symptom was defined as a score of 0 ("not at all") or 1 ("just a little").

	Survivors (Total *N* = 70)	
	N	%
Inattentive Type*	**19**	**27.1**
Fails to give close attention to details/makes careless mistakes	33	47.1
Has difficulty sustaining attention in tasks or play activities	17	24.3
Does not seem to listen when spoken to directly	24	34.3
Does not follow through on instructions and fails to finish schoolwork or chores	27	38.6
Has difficulty organizing tasks and activities	28	40.0
Avoids or dislikes tasks that require sustained mental effort	28	40.0
Loses things necessary for tasks or activities	16	22.9
Easily distracted by extraneous stimuli	21	30.0
Forgetful in daily activities	28	40.0
Hyperactive/Impulsive Type*	**5**	**7.1**
Often fidgets with hands or feet or squirms in seat	9	12.9
Leaves seat in classroom or in other situations	9	12.9
Runs about or climbs excessively	5	7.1
Has difficulty playing or engaging in leisure activities quietly	7	10.0
Is often "on the go" or often acts as if "driven by a motor"	7	10.0
Often talks excessively	18	25.7
Often blurts out answers before questions have been completed	13	18.6
Often has difficulty awaiting turn	8	11.4
Often interrupts or intrudes on others	19	27.1

Abbreviations: ADHD, attention deficit/hyperactivity disorder; DMS-IV, *Diagnostic and Statistical Manual of Mental Disorders, 4th Edition*.
*Number of patients meeting diagnostic criteria based on questionnaire data. DSM-IV criteria requires presence of at least 6 symptoms.
Note. Three survivors met symptom criteria for Combined Type.

Measures

Conners Parent Rating Scale

Parents completed one of 2 versions of the Conners Parent Rating Scale (CPRS): the revised edition[36] ($n = 40$, 57.1%) or the third edition[37] ($n = 30$, 42.9%). The CPRS is a well-known, widely used, parent-report measure of attention problems that employs a Likert response scale ranging from 0 (symptom never occurs) to 3 (symptom occurs very often). Sensitivity and specificity of this measure for differentiating children with ADHD from those without ADHD exceeds 90%.[31,36] To evaluate ADHD symptoms in our sample, we abstracted items reflecting the 18 core symptoms of ADHD (9 Inattentive Type [In] and 9 Hyperactive/Impulsive Type [HI]) as defined by the DSM-IV[35] from each version of the measure. Of note, the items are very similar across CPRS versions. In keeping with prior literature,[36,37] ratings of either 2 (often) or 3 (very often) were considered symptomatic, and ratings of either 0 (never) or 1 (occasionally) were considered asymptomatic (see Table 2 for the individual items). Internal consistency of the DSM-IV In and HI symptoms was strong for our sample (Chronbach's $\alpha = 0.91$ and 0.86, respectively).

Child Behavior Checklist

The Child Behavior Checklist (CBCL)[38,39] is a widely used, parent-report measure of a child's emotional, behavioral, and psychosocial functioning. Parents respond to a number of open-ended and forced-choice questions, and subscales are computed for several areas of impairment. The Internalizing Problems, Externalizing Problems, and Social Problems subscales were used for analyses and were available for 92.8% ($n = 65$) of the sample.

Wechsler Scales of Intelligence

As this study included participants within a wide age range, survivors were assessed using the age-appropriate version of the Wechsler Scales, the most widely used measures of intelligence for children and adults. Specifically, the Wechsler Intelligence Scale for Children – Fourth Edition[40] (WISC-IV, ages 6–16 years), the Wechsler Adult Intelligence Scale – Third Edition[41] (WAIS-III, ages ≥16 years), and the Wechsler Abbreviated Scale of Intelligence[42] (WASI, ages ≥ 6 years) were used. The majority of patients (58.6%, $n = 41$) completed the WISC-IV. From each version, the Full-Scale IQ score was used ($n = 68$; not available for 2 children younger than 6 years at the time of evaluation), as well as the Working Memory and Processing Speed Index scores when applicable ($n = 51$).

Statistical Analyses

Analyses were completed to compare survivors who met DSM-IV symptom criteria (ie, those with ≥ 6 ADHD-In symptoms; $n = 19$) and those who did not meet the criteria (ie, those with ≤ 5 symptoms; $n = 51$) on measures of neurocognitive ability (ie, IQ, working memory, and processing speed) and parent-reported psychological functioning (ie, Internalizing Problems, Externalizing Problems, and Social Problems subscales from the CBCL). To evaluate our first hypothesis, we used multivariate analysis of variance (MANOVA) procedures. MANOVA procedures were used when analyzing subscales from the same measure to account for shared variance and to minimize the probability of type I error. Finally, binary logistical regression was used to assess if medical (age at diagnosis, years off treatment, treatment with cranial radiation, and diagnosis [ALL or brain tumor]) or demographic (current age, sex) variables predicted whether or not survivors met ADHD symptom criteria. For our second hypothesis, we computed the number of participants who exhibited deficits on the neurocognitive and psychosocial outcomes. Specifically, those who received standard scores < 85 for Full Scale IQ, Working Memory Index, or Processing Speed Index of the Wechsler scales were classified as having dysfunction in that domain. For psychosocial outcomes, we used the recommended clinical cutoff values for the CBCL Internalizing and Externalizing (≥ 64) and Social Problems (≥ 70) scales. We then calculated sensitivity, specificity, positive predictive power, and negative predictive power statistics for all neurocognitive and psychosocial outcomes based on whether or not participants had significant parent-reported ADHD symptoms. Analyses were completed with SPSS version 22.

Results

ADHD Symptoms

The percentage of parent-endorsed DSM-IV symptoms is provided in Table 2. Survivors of both ALL and brain tumors met DSM-IV symptom criteria for ADHD-In (defined as the presence of at least 6 of 9 symptoms) at rates considerably higher than would be expected in the general population (9%[43]; ALL, 26.1%; brain tumor, 27.7%). The most common symptoms exhibited by survivors included: "fails to pay close attention to details" (47.1%), "does not follow through/fails to finish schoolwork" (38.6%), "has difficulty organizing tasks or activities" (40.0%), "avoids tasks that involve sustained effort" (40.0%), and "is often forgetful" (40.0%).

ADHD Symptoms and Neurocognitive Functioning

Regarding our first hypothesis, a MANOVA indicated a significant difference between survivors with and without clinically significant ADHD-In symptoms on measures of neurocognitive functioning (Wilks $\Lambda = 0.80$; $F[3, 44)] = 3.55$; $P = .02$). Specifically, survivors who met ADHD-In symptom criteria had poorer working memory ($P = .008$) and lower IQs ($P = .02$) than survivors who did not meet symptom criteria, although there was no difference between groups on processing speed ($P = .57$; see Table 3).

With regard to parent-reported psychosocial functioning, a second MANOVA also revealed significant differences between groups (Wilks $\Lambda, = 0.70$; $F[7, 57] = 3.57$; $p < .001$). Specifically, survivors who met ADHD-In symptom criteria demonstrated greater parent-reported Externalizing Problems ($p < .001$) and Social Problems ($P = .01$) than survivors who did not. There were no differences between groups with regards to Internalizing Problems ($P = .19$; see Table 3).

Exploratory analyses were completed to determine the potential association between medical variables and ADHD symptoms in the sample of survivors. There was no significant effect for any medical or demographic variable, including diagnosis (ALL vs brain tumor), time since diagnosis, age at diagnosis, treatment with radiation therapy, or sex. See Table 3 for means and confidence intervals.

As may be seen in Table 4, ADHD symptom screening was associated with generally low sensitivity for both neurocognitive (range, 26.3%–40.0%) and psychosocial (range, 44.4%–69.2%) outcomes. Specificity, in contrast, was much stronger (range, 75.0%–82.7%). Similarly, whereas positive predictive power tended to be low (range, 22.2%–50.0%), negative predictive power tended to be higher (range, 65.0%–91.5%) for individual outcomes. Finally, we also examined the sensitivity and specificity of ADHD screening to accurately predict survivors with clinically significant dysfunction on one or more measures of neurocognitive or psychosocial functioning. Whereas ADHD-In screening was still associated with relatively low sensitivity (37.5%), both specificity (86.2%) and positive predictive power (78.9%) were adequate.

Discussion

The objective of this paper was to evaluate the utility of parental reports of attention problems as a mechanism for identifying those survivors of CNS-impacting pediatric cancers who may be experiencing related neurocognitive or psychosocial deficits. Prior work[29] suggested that subjective ratings of attention predicted scores on performance-based measures of attention in survivors, but there is less information about how DSM-IV ADHD ratings relate to other areas of neurocognitive functioning (eg, working memory, processing speed) or psychological functioning (internalizing or externalizing problems) in this population. Results indicated that survivors meeting ADHD-In symptom criteria had lower IQ and working memory scores, as well as more externalizing and social problems, than survivors without significant ADHD symptoms. There were no differences between groups in processing speed or parental ratings of internalizing problems. Despite these observed differences, screening for ADHD-In symptom criteria was associated with rather weak sensitivity and positive predictive power for specific areas of neurocognitive and psychosocial dysfunction. Specificity and negative predictive power of this screening approach was stronger, however.

At a group level, survivors with high levels of ADHD-In evidenced a pattern of poorer neurocognitive and psychosocial functioning. In this way, parent-reported ADHD symptoms may be thought of as a potential indicator of additional difficulties that would be best assessed in the context of a neuropsychological

Table 3. Comparison of survivors meeting versus not meeting *Diagnostic and Statistical Manual of Mental Disorders, 4th Edition*[35] attention deficit/hyperactivity disorder, predominantly inattentive type symptom criteria

	Without ADHD Symptoms M ± SD/ *N* (%)	With ADHD Symptoms M ± SD/ *N* (%)	Mean Difference (95% CI)	*P*
Neurocognitive Outcomes[a]	*N* = 37	*N* = 11		
IQ	98.4 ± 14.93	85.6 ± 14.75	12.8 (2.4, 23.2)	.02
Working Memory	98.5 ± 14.23	84.8 ± 14.81	13.7 (3.8, 23.6)	.008
Processing Speed	88.4 ± 12.66	86.0 ± 11.08	2.4 (−6.1, 10.9)	.57
Psychological Outcomes[b]	*N* = 47	*N* = 18		
Internalizing Problems	54.0 ± 10.68	58.2 ± 13.27	−4.2 (−10.5, 2.1)	.19
Externalizing Problems	46.4 ± 9.47	59.8 ± 11.87	−13.4 (−19.0, −7.8)	<.001
Social Problems	58.0 ± 7.96	64.0 ± 9.6	−6.0 (−10.7, −1.3)	.01
Demographics	*N* = 51	*N* = 19		
Male sex	26 (51.0%)	13 (68.4%)	−17.4% (11.1, 40.4)	.19
Age	11.9 ± 3.61	10.7 ± 3.56	1.2 (−0.7, 3.1)	.24
Medical Variables	*N* = 51	*N* = 19		
Brain Tumor diagnosis	34 (66.7%)	13 (68.4%)	−1.7% (−26.0, 25.0)	.10
Age at Diagnosis (years)	5.9 ± 3.48	4.6 ± 3.48	1.3 (−0.6, 3.2)	.18
Years off Treatment	4.1 ± 2.62	4.6 ± 3.47	−0.5 (−2.0, 1.0)	.53
Cranial Radiation	25 (49.0%)	8 (42.1%)	6.9% (−20.8, 32.3)	.61

Abbreviations: ADHD, attention deficit/hyperactivity disorder; DMS-IV, *Diagnostic and Statistical Manual of Mental Disorders, 4th Edition*.
[a]Standard Scores: M = 100, SD = 15.
[b]T-scores: M = 50, SD = 10.
*Participants meeting diagnostic criteria based on questionnaire data. DSM-IV criteria require presence of at least 6 symptoms.

evaluation. The relatively low sensitivity of this approach indicates that such screening may be less reliable for detecting specific neuropsychological problems on an individual basis. This means that, if patients fail to meet ADHD symptom criteria, the clinician should *not* assume that no neuropsychological late effects are present, particularly if survivors, parents, or teachers are reporting struggles in the classroom, difficulties getting along with others, mood symptoms, or problems completing activities of daily living efficiently or competently. Even so, when survivors have significant ADHD-In symptoms, it is quite likely that they will also evidence a meaningful deficit in at least one other domain upon further testing. Moreover, the adequate specificity of this approach suggests that ADHD-In screening may be particularly useful for deferring the need for full neuropsychological assessment in children who are less likely to have significant dysfunction in these areas. This may be particularly important for families who lack the resources to pay out-of-pocket costs associated with neuropsychological evaluation or who are unable to take time off work to accompany a child to one or more lengthy appointments.

It is important to note that most survivors will not meet full diagnostic criteria for ADHD, and we do not advocate that survivors be given an ADHD diagnosis indiscriminately based on parental ratings alone. Indeed, several investigators have recently expressed concern about assigning a diagnosis of ADHD to survivors of pediatric cancer who exhibit a similar pattern of symptoms.[32,33,44] Specifically, both Kahalley et al[32] and Krull et al[33] determined that the majority of survivors of pediatric brain tumors and ALL do not meet strict diagnostic criteria for primary or secondary ADHD-In, and that rates of the disorder are similar to those observed in normally developing populations (ie, about 9%[43]). In spite of this, past research has suggested that many of the interventions and school-based services designed for children with ADHD may also be efficacious for survivors,[50] and both pharmacological and nonpharmacological approaches derived from the ADHD population have been adapted for survivors with generally positive results.[34,51–54] As such, while the diagnosis of ADHD-In may not be appropriate for many survivors, the presence of attention problems in the majority of survivors and the utility of similar services and interventions are certainly applicable.

Importantly, ADHD-In symptoms are not necessarily related to other neurocognitive processing difficulties experienced by some survivors of pediatric brain tumors. Specifically, problems with long-term visual episodic memory,[3] long-term verbal episodic memory,[45] and visual motor integration[46] have been documented in the literature, and our battery did not include evaluation of these processes. In addition, we did not assess for impairments in executive functioning, which have been documented in both survivors of ALL and brain tumors[45,47,48] and also co-occur with ADHD.[12] It is therefore unknown whether or not elevated levels of parent-reported ADHD symptoms are associated with performance-based deficits in these areas. Therefore, because we do not yet know how ADHD screening is associated with other domains of neuropsychological functioning that can be affected by cancer treatment, we would caution against using such screening in isolation of other interview or questionnaire approaches when difficulties with episodic memory, visual-motor processing, or integration are suspected. Finally, processing speed deficits, which are a prevalent and early finding in survivors who go on to develop a broader range of neurocognitive late effects,[49] were not predicted by significant ADHD symptoms

Table 4. Sensitivity, specificity, positive predictive power and negative predictive power associated with using attention deficit/hyperactivity disorder symptoms to predict rates of neuropsychological dysfunction

	Without ADHD Symptoms* *N* (%)	With ADHD Symptoms* *N* (%)	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
Neurocognitive Outcome						
Full Scale IQ[a] < 85	9 (18.0)	6 (33.3)	40.0% (17.4–67.1)	77.4% (63.4–87.3)	33.3% (14.4–58.9)	82.0% (68.1–90.1)
Working Memory Index[a] < 85	7 (18.9)	4 (33.3)	36.4% (12.4–68.4)	78.9% (62.2–89.9)	33.3% (11.3–64.6)	81.1% (64.3–91.5)
Processing Speed Index[a] < 85	14 (35.0)	5 (45.4)	26.3% (10.1–51.4)	81.3% (63.0–92.1)	45.5% (18.1–75.4)	65.0% (48.3–78.9)
Psychological Outcome						
Internalizing Symptoms[b] T ≥ 64	8 (17.0)	8 (44.4)	50.0% (25.5–75.4)	79.6% (65.2–89.3)	44.4% (22.4–68.6)	83.0% (68.6–91.9)
Externalizing Symptoms[b] T ≥ 64	4 (8.5)	9 (50.0)	69.2% (38.9–89.6)	82.7% (69.2–91.3)	50.0% (26.7–73.2)	91.5% (78.7–97.2)
Social Problems[b] T ≥ 70	5 (10.6)	4 (22.2)	44.4% (15.3–77.3)	75.0% (61.4–85.2)	22.2% (7.3–48.1)	89.4% (76.1–96.0)

Abbreviations: ADHD, attention deficit/hyperactivity disorder; NPV, negative predictive power; PPV,positive predictive power
*Number of participants meeting diagnostic criteria based on questionnaire data. DSM-IV criteria require presence of at least 6 symptoms.
[a]Wechsler IQ and Index scores have a mean of 100 and SD of 15. Frequencies presented are the number of participants with scores 1 SD or lower than the mean.
[b]Child Behavior Checklist Scores have a mean of 50 and SD of 10. Frequencies presented are the number of participants with T scores at or above the recommended clinical cutoff of 64 (Internalizing and Externalizing symptoms) or 70 (Social Problems).

in our sample. Unfortunately, there is a lack of validated rating scales that measure impairments related to processing speed, and thus this is likely to be a domain that is difficult to evaluate without performance-based testing.

Results presented here should be considered in light of limitations. As noted above, our sample of 70 survivors was clinic-referred and thus may reflect children with greater neurocognitive and psychosocial difficulties than those who do not present for evaluation. This may be the most likely explanation for the different percentages of children meeting symptom criteria in our sample as compared with Kahalley[32] and Krull[33] (26%–27% vs. 9%–10%). With that said, it is relevant to examine attentional symptoms in children who are presenting with problems as well as those who are not demonstrating difficulties. Relatedly, our sample was drawn from a clinically derived database of patients referred for evaluation. As such, assessment batteries were determined based on clinical need rather than to answers empirical research questions. Therefore, we were limited in the measures that were available to us, and there were differences in sample size across various measures. Finally, we included a very heterogeneous sample of survivors of both ALL and brain tumors. This limited our ability to examine the association between ADHD symptoms and numerous medical and treatment variables unique to survivors of brain tumors (eg, tumor location, presence of hydrocephalus, radiation dose, and type).

In conclusion, despite some shortcomings, the DSM-IV symptoms of ADHD-In provide a mechanism for screening survivors of CNS-impacting cancers for deficits that may indicate the need for a comprehensive neuropsychological evaluation. Specifically, given the financial constraints of many families, the often inadequate insurance coverage for evaluations, and the limited availability of pediatric neuropsychology providers in many communities, the burden may be on physicians to justify the necessity of comprehensive evaluations for individual patients. The utility of screening instruments becomes more salient in this context. ADHD symptom inventories are easily and freely accessible online[55] and are familiar to most professionals, including nurses and physicians. Parents could complete ratings of the 18 DSM-IV ADHD symptoms in a waiting-room setting, and a symptom count could be ascertained in less than a minute by clinic staff. Such measures could thus be feasibly given to all patients during routine medical appointments, and then referrals could be made for comprehensive evaluations based on the results. This may also have research implications, particularly for large, cooperative group studies, in which collection of performance-based neuropsychological measures can be problematic.[56] Further studies are needed to empirically and prospectively validate our finding that ADHD-In criteria distinguish between 2 differing neurocognitive and psychological profiles in survivors of CNS-impacting cancer. Future work should also address whether or not broadband screening measures, which include items evaluating both ADHD-In symptoms and a wider range of externalizing, internalizing, academic, and social functioning, may do an even better job of predicting those survivors who will manifest performance-based neurocognitive deficits and clinically significant mental health problems. Ultimately, while the DSM-IV ADHD-In profile does not capture all of the strengths and weaknesses typically seen in survivors of brain tumors and ALL, it may help clinicians make more efficient decisions about the need for clinical referrals.

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