Psychosocial, Neuropsychological, Academic, and Social Outcomes in Pediatric Solid Tumor Survivors: An Exploratory Parent-Reported Study

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Article

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Highlights

What are the main findings?

- Pediatric solid tumor survivors showed frequent parent-reported psychosocial, neuropsychological, academic, and social difficulties after treatment.
- CNS tumor survivors had greater late-effect burden, but family educational level and family structure were also associated with adjustment outcomes.

What is the implication of the main finding?

- Survivorship follow-up should integrate medical, neuropsychological, educational, and family-context screening.
- Exploratory socio-cultural indicators may help identify families needing additional support, even within publicly funded healthcare systems.

Abstract

Background/Objectives: Long-term psychosocial/neurocognitive sequelae are frequently observed in survivors of pediatric cancer and adversely affect quality of life in adulthood. Although clinical predictors are well established, the contribution of familial, cultural, and socio-economic factors has received less attention. **Methods:** Between November 2022-January 2023, 93 survivors parents of pediatric patients with solid tumors including 38 individuals with central nervous system (CNS) tumors, completed a specifically designed 60-item questionnaire. Outcomes were evaluated across four domains—psychological, neurocognitive, academic, and social—along with a broad range of potential predictors encompassing demographic, clinical, family-related, cultural, socio-economic, and premorbid characteristics. Statistical analyses included Fisher's exact test and non-parametric methods. **Results:** New-onset or aggravated internalizing symptoms were reported in 53% of survivors, externalizing behaviors in 32%, neurocognitive impairments in 45%. Academic difficulties were identified in 32%, with 25% requiring an Individualized-Education-Plan. Social challenges affected 30% of participants and were more prevalent among CNS tumor survivors, who also demonstrated greater functional losses and rehabilitation needs. Lower parental educational attainment was associated with externalizing symptoms ($p = 0.039$), whereas household income, parental occupation, and residential setting were not. Premorbid psychological or learning difficulties were strong predictors of adverse outcomes (all $p < 0.01$). Older paternal age was protective for relational and academic functioning, while having more siblings was linked to increased cognitive risk. **Conclusions:** Psychosocial and neurocognitive late effects remain common among pediatric cancer survivors. Educational background and premorbid vulnerabilities appear more influential than economic factors, supporting the need for targeted neuropsychological surveillance and family-centered screening strategies.

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1. Introduction

Advances in pediatric oncology have led to a substantial increase in long-term survival, shifting clinical and research attention toward the late effects of cancer and its treatment. Among these, psychosocial, neuropsychological, academic, and social difficulties are increasingly recognized as major determinants of long-term functioning and quality of life in childhood cancer survivors [1–6]. These difficulties may persist into adolescence and adulthood, influencing educational attainment, interpersonal relationships, and social participation, sometimes to a degree comparable to or exceeding that of physical sequelae [7–12]. A large body of literature has documented the role of medical factors—such as tumor location, surgical excision, treatment intensity, exposure to radiotherapy, and neurological complications—in shaping neurocognitive and psychosocial outcomes [5,11,13–16]. Survivors of central nervous system (CNS) tumors, in particular, have consistently been shown to be at increased risk for cognitive impairment, emotional difficulties, academic decline, and social maladjustment. In parallel, individual and family-level variables, including parent–child communication, attachment quality, illness awareness, and coping strategies, have been identified as important protective or risk-modifying factors [17–28]. In contrast, broader socio-cultural and socioeconomic determinants have received comparatively less attention within pediatric oncology research. In the general pediatric population and in children with acquired brain injuries, socioeconomic conditions—particularly parental education—are robustly associated with cognitive development, emotional regulation, and adaptive functioning [30,31]. However, their role in pediatric cancer survivorship remains less clearly defined, especially when family educational background, cultural context, and structural characteristics are considered alongside traditional economic indicators such as income or occupation [5,11,16,28–34]. Moreover, most existing evidence derives from North American or Northern European settings, limiting the generalizability of findings to other healthcare and cultural contexts.

Understanding how family, cultural, and socioeconomic variables interact with medical factors is therefore essential for the development of equitable and targeted survivorship care models. In clinical practice, these contextual determinants may influence access to cognitive stimulation, educational support, emotional scaffolding, and rehabilitation services, thereby shaping long-term adjustment trajectories beyond disease-related risk alone.

Within this framework, the present study focused on a cohort of survivors of pediatric solid tumors, including CNS tumors, followed at a specialized oncology center. The objectives were twofold: (i) to describe psychological, neuropsychological, academic, and social outcomes after completion of therapy, and (ii) to explore their associations with family, cultural, and socioeconomic characteristics, as well as premorbid vulnerabilities. We hypothesized that family educational level and pre-existing psychological or scholastic difficulties would be associated with less favorable post-treatment outcomes, whereas traditional socioeconomic indicators and demographic variables would play a more limited role.

2. Materials and Methods

In the study period (November 2022–January 2023), an anonymous, purpose-built 60-item questionnaire was administered to parents of survivors who had completed therapy and were attending routine follow-up at our pediatric outpatient clinic (Supplementary material 1). The instrument was designed by a multidisciplinary team of psychologists, oncologists, and statisticians to collect information on socio-cultural, educational, and family variables that are not adequately covered by existing validated tools. Using multiple validated Italian scales (e.g., for anxiety, depression, cognition) would have substantially increased respondent burden and jeopardized

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feasibility across settings, potentially introducing non-response bias and limiting inclusiveness (especially for lower-literacy participants).

Most items are single-item factual or categorical indicators, for which internal consistency metrics (e.g., Cronbach's α) are not appropriate. The psychological/cognitive items were included as brief contextual indicators, not as diagnostic measures. Several items were conceptually adapted from established Italian instruments assessing family functioning and socio-economic background (e.g., ISTAT and Ministry of Education surveys) to ensure cultural and linguistic appropriateness. Formal psychometric validation was not performed, as the primary aim of the study was exploratory and descriptive.

The instrument was purpose-built to (i) characterize four outcome domains (psychological, neuropsychological, social and academic, Supplementary Table 1) and (ii) record potential determinants drawn from six conceptual areas (demographic, clinical, family, cultural, socio-economic and premorbid characteristics, Supplementary Table 2). The questionnaire was divided into six thematic sections addressing: (i) patient demographics and clinical history, (ii) family composition and parental characteristics, (iii) socio-economic background, (iv) perinatal and developmental history, (v) schooling and extra-curricular activities, and (vi) psychological and behavioral functioning. Items were mainly dichotomous (yes/no) or categorical, allowing respondents to indicate the presence or absence of specific conditions both before and after cancer diagnosis. This design enabled the identification of cross-sectional associations as well as qualitative trajectories of change (e.g., emergence, persistence, or resolution of a given problem). Operational definitions and coding rules for all questionnaire items including are provided in the Supplementary material 2.

The sections addressing psychological, academic, and social outcomes were completed by parents based on their direct observation of the child's behavior and functioning in everyday contexts.

We summarized continuous variables by medians and inter-quartile ranges and categorical variables by counts and percentages. Associations between candidate determinants and each outcome, and between treatment/disease consequences/outcomes and tumor type (brain vs. other) were examined with Pearson's chi-squared or Fisher's exact test for categorical data and with the Wilcoxon–Mann–Whitney or Kruskal–Wallis test for ordinal or continuous data, selecting the statistic that matched the number of comparison groups and the data distribution. Given the sample size (n = 93) and the large number of potential determinants, we limited inference to bivariate associations to avoid overfitting and low events-per-variable in multivariable models. Due to the exploratory purpose of the work, we retained a two-sided significance level of 0.05 without correcting for multiple comparisons and results should be interpreted as descriptive and hypothesis-generating. All analyses were performed in R (version 4.1.2).

3. Results

The distribution of variables potentially associated with psychological, neurocognitive, social, and academic difficulties is presented in Supplementary Tables 3–5, while the results of association analyses are shown in Table 1.

Table 1. "Heatmap" of significant relationships between considered factors and outcomes.

	OUTCOME							
	Psychological Profile		**Social profile**		**NPS profile**		**School profile**	
	Internalizi problems	Externalizi problems	Relation problem s	Social proble ms	NPS proble ms	Adapti resourc es	Need for PEI or PDP	Scho mar ks

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Demographic and clinical factors								
Age at evaluation								0.005
Gender	0.022							
Position/job								
Age at diagnosis	0.037							0.002
Time elapsed since diagnosis			0.076			0.051	0.041	
Type of tumor				0.034				0.030
Tumor site				0.004		0.007		
Oncological treatment								0.032
Consequences' severity		0.005		0.001	0.035	0.039		0.001
Rehabilitation needs	0.080				0.025	0.058	0.040	
Awareness about disease								
Communication timing about						0.058		0.019
Information requested about								
Family, cultural and economic								
Mother's age			0.054					0.079
Father's age	0.035		0.013					0.048
Parents marital status			0.030					
Presence of siblings					0.019			0.087
Number of siblings					0.005			
Birth order among siblings					0.077			
Family educational level		0.039		0.080				
Populousness of residence place								
Geographical residence								
Mother's job								
Father's job								
Family income sources								
Financial benefits for child's							0.030	
Premorbid problems								
Pre-perinatal problems								
Previous internalizing problems	0.009	0.071	0.030	0.024		0.045	0.018	0.006
Previous externalizing problems	0.002	<0.001	0.031					0.028
Previous relational problems	0.002	0.024	<0.001	<0.001				0.034
Previous social problems	0.004		<0.001			0.008		0.020
Previous psychological		0.030	0.079					0.048
Previous extra-curricular								
Previous NPS problems					0.006			
Previous academic problems								0.003
Previous NPS evaluation								
Previous support scholastic path	0.011							
Previous adaptive resources				0.062		<0.001		0.004
Previous socio-economic		0.048						
Previous traumatic experiences								

Abbreviations: NPS, neuro-psicological; PEI, piano educativo individualizzato (Individualized Education Plan); PDP, piano didattico personalizzato (Personalized Didactic Plan).

A total of 93 survivors were enrolled, with questionnaires completed by their parents. The patient cohort comprised 49 males (53%) and 44 females (47%). At the time of assessment, the median

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age was 16.2 years (IQR 10.9–20.5). The median time elapsed since diagnosis was 52.5 months (IQR 27.9–76.8), and the median age at diagnosis was 11.8 years (IQR 6.0–15.5). Most participants were students (78, 84%), while 9 (10%) were employed and 5 (5%) were unemployed. Thirty-eight survivors (41%) had been treated for central nervous system (CNS) tumors and 55 (59%) for non-CNS solid tumors. Treatment had consisted of combined surgery, chemotherapy, and radiotherapy in 29 cases (31%), surgery plus chemotherapy in 19 (20%), surgery alone in 24 (26%), and alternative treatments or follow-up only in 20 (23%). Fourteen patients (15%) had not been informed of their cancer diagnosis, whereas 71 (76%) received information during the acute phase and 8 (9%) after treatment completion. Subsequently, 76 survivors (83%) requested additional information about their illness, and 71 (77%) sought clarification regarding diagnostic or follow-up procedures. No functional sequelae were reported in 43 participants (47%); impairments involving one domain were noted in 41 (45%), and two domains in 8 (9%). Academic difficulties ranged from none (53/93, 58%) to four domains affected (1/93, 1%). Physical rehabilitation had been prescribed to 33 survivors (36%), and neuropsychological rehabilitation to 20 (22%).

According to parental reports, comparing post-treatment status with pre-diagnosis functioning, new or aggravated difficulties emerged across multiple areas. Relationship problems were described in 14 of 90 survivors (16%), social participation issues in 27 of 90 (30%), and discontinuation of at least one extracurricular activity in 33 of 87 (38%) (Figure 1).

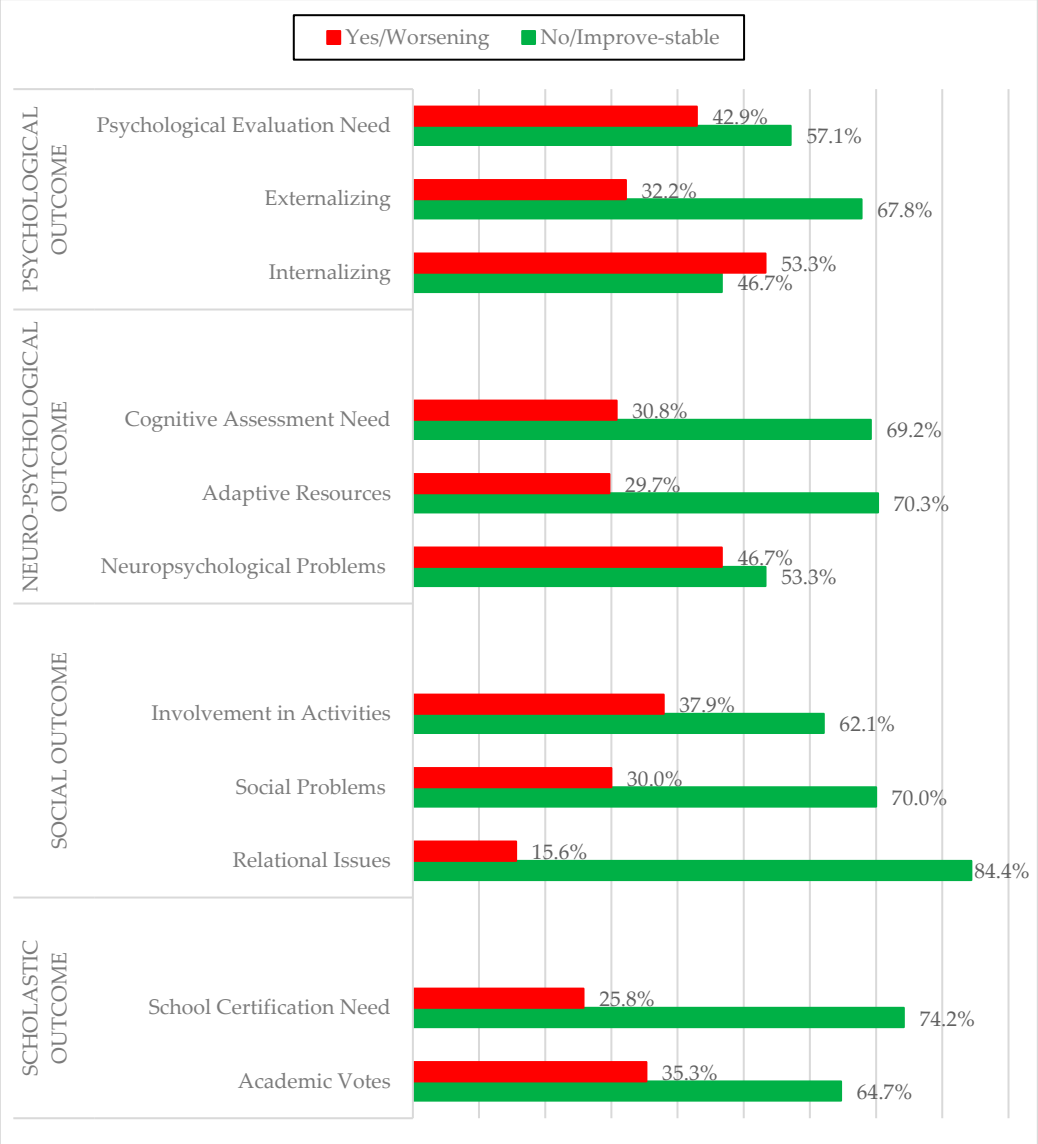

Figure 1. Psychological evaluation and cognitive assessment need and outcomes worsening after disease.

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These observations were based on parental qualitative comparisons rather than prospective longitudinal assessments.

Exploratory analyses indicated links between family or socio-demographic characteristics and reported outcomes. Among the 29 survivors exhibiting externalizing behaviors, 21 (71%) belonged to families with low-to-medium parental educational levels, compared with 8 (29%) from highly educated households ($p = 0.039$; Figure 1). No other socio-economic indicators—including household income, parental occupation, municipality size, or geographic region—showed significant associations, despite similar descriptive patterns (all $p > 0.10$).

Median paternal and maternal ages were 51.0 years (IQR 46.0–56.8) and 49.5 years (IQR 44.0–55.0), respectively. Higher paternal age was associated with fewer relational difficulties ($p = 0.013$) and showed a borderline association with academic stability ($p = 0.048$).

Sibling structure also appeared relevant. Newly identified cognitive-adaptive impairments were observed in 28% of only children, 50% of those with one sibling, and 65% of those with two siblings ($p = 0.005$), whereas academic decline did not differ significantly according to sibling number ($p = 0.087$). Relational difficulties were more frequent among children of separated or divorced parents compared with those from intact families (73% vs. 10%; $p = 0.030$). Pre-existing psychological symptoms or lower baseline academic performance were strong predictors of post-treatment difficulties (all $p < 0.01$).

Comparisons between CNS and non-CNS survivors are detailed in Tables 2 and 3.

Table 2. Significant differences between brain tumor and no brain tumor patients.

	Brain tumor patients N = 38	**No brain tumor patients** N = 55	**P**
Oncological treatment			0.001
Surgery + CT + RT	16 (42.1%)	13 (23.6%)	
Surgery + CT	1 (2.6%)	19 (34.5%)	
Surgery only	10 (26.3%)	14 (25.5%)	
Other/none	11 (28.9%)	9 (16.4%)	
Consequences' severity (aesthetic problems, motor/sensorial problems, language and learning difficulties)			0.022
0	15 (39.5%)	28 (51.9%)	
1	16 (42.1%)	25 (46.3%)	
2	7 (18.4%)	1 (1.9%)	
Learn and language issues			0.007
0	15 (39.5%)	38 (70.4%)	
1	13 (34.2%)	13 (24.1%)	
2	6 (15.8%)	3 (5.6%)	
3	3 (7.9%)	0 (0.0%)	
4	1 (2.6%)	0 (0.0%)	
Rehabilitation needs			0.031
0	20 (52.6%)	39 (72.2%)	
1	15 (39.5%)	8 (14.8%)	
2	3 (7.9%)	7 (13.0%)	
Cognitive rehabilitation need (psychomotricity treatment, speech therapy, neuropsychological rehabilitation)			0.001

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0	24 (63.2%)	48 (88.9%)	
1	6 (15.8%)	6 (11.1%)	
2	5 (13.2%)	0 (0.0%)	
3	3 (7.9%)	0 (0.0%)	
Psychological and educational intervention need			0.033
0	23 (60.5%)	44 (81.5%)	
1	10 (26.3%)	9 (16.7%)	
2	5 (13.2%)	1 (1.9%)	

Abbreviations: CT, chemotherapy; RT, radiotherapy.

Table 3. Association between tumor site and outcome.

		Brain tumor patients	No Brain tumor patients	p
Psychological outcome				
	Onset/worsening of internalizing problems	22 (57.9%)	26 (50.0%)	0.650
	Onset/worsening of externalizing problems	15 (39.5%)	14 (26.9)	0.441
	Need for psychological assessment	22 (57.9%)	17 (32.1%)	0.025
Neuro-psychological outcome				
	Onset/worsening of neuropsychological disorders	22 (57.9%)	20 (38.5%)	0.178
	Reduction of adaptive resources	13 (43.3%)	9 (20.5%)	0.007
	Need for neuro-psychological assessment_	7 (18.4%)	2 (3.7%)	0.047
Social outcome				
	Onset/worsening of relational problems	7 (18.4%)	7 (13.5%)	0.786
	Onset/worsening of social problems	18 (47.4%)	9 (17.3%)	0.004
	Limitation of attendance of extra-curricular activities	13 (38.2%)	20 (37.7%)	0.095
Scholastic outcome				
	Onset/worsening of academic performance problems _	16 (47.1%)	14 (27.5%)	0.179
	Need for personalized concessions/facilitations to support scholastic path (as PEI and PDP)	11 (31.4%)	12 (22.2%)	0.471

Multimodal treatment was more common in CNS tumors (42% vs. 24%; p = 0.001). Severe functional sequelae were reported more frequently among CNS survivors (18% vs. 2%; p = 0.022), as were overall rehabilitation needs (47% vs. 27%; p = 0.031). Overall, neuropsychological impairments were reported in 45% of participants, with reduced adaptive resources in 30%. Only 10% underwent formal neuropsychological evaluation after treatment. Academic decline affected 32% of survivors,

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and 25% required an Individualized Education Plan or Personalized Didactic Plan. Social integration difficulties were significantly more common in CNS survivors (47% vs. 16%; p = 0.004), as was loss of adaptive resources (43% vs. 21%; p = 0.007). Structured neuropsychological assessment was prescribed and completed more frequently in the CNS group (18% vs. 4%; p = 0.047). Internalizing symptoms—such as anxiety, depression, withdrawal, or somatization—were newly reported or worsened in 48 survivors (52%), including 22 CNS patients (58%) and 26 non-CNS patients (50%) (p = 0.650). Externalizing behaviors—such as irritability, oppositionality, hyperactivity, or conduct problems—were observed in 29 participants (31%), 15 with CNS tumors (40%) and 14 with non-CNS tumors (27%) (p = 0.441). Scholastic decline showed no significant difference between groups (CNS 47% vs. non-CNS 28%; p = 0.179).

In summary, CNS survivors experienced a greater overall burden of late effects, influencing which risk factors reached statistical significance. Associations between internalizing symptoms and sex, age, and paternal age observed in the full cohort were no longer present after exclusion of CNS cases. A similar attenuation was observed for behavioral outcomes, where correlations evident in the total sample disappeared in analyses restricted to non-CNS survivors.

Conversely, two relationships became evident when CNS cases were excluded. Among the 55 non-CNS survivors, a longer treatment course was a significantly associated to reduced adaptive resources (p = 0.005), and older age at questionnaire completion inversely associated with new relational problems (p = 0.044).

Taken together, these findings outline a complex pattern of associations between medical, socio-demographic, and family variables and psychosocial outcomes after pediatric cancer. CNS tumor survivors exhibited the highest burden of late effects across domains, consistent with the greater treatment intensity and neurotoxicity typically associated with these conditions. However, socio-cultural and family-related factors—particularly parental education and family structure—also appeared to influence adjustment trajectories, suggesting that psychosocial vulnerability is not solely determined by clinical severity.

The observed variability across domains and subgroups underscores the multidimensional nature of survivorship in pediatric oncology. These exploratory data therefore highlight the need for integrated follow-up models that combine medical, neuropsychological, and socio-cultural perspectives. The implications of these findings will be further discussed in the next section.

4. Discussion

The present study explored psychosocial, neuropsychological, and academic outcomes in a cohort of pediatric cancer survivors, focusing on the role of family and socio-cultural factors. As expected, survivors of brain tumors reported the highest burden of late effects across domains, consistent with previous literature emphasizing the neurocognitive and psychosocial vulnerability of this group [5,11,15,16]. However, our findings also suggest that post-treatment adjustment is not solely determined by medical factors, but is meaningfully shaped by family-related and educational resources.

One of the most relevant findings was the association between lower parental educational level and increased externalizing behavioral problems. Unlike income, occupation, or residential area, parental education emerged as the only socioeconomic indicator significantly associated with outcome. This observation aligns with evidence from developmental and neuropsychological research highlighting parental education as a proxy for cognitive stimulation, health literacy, and capacity to navigate complex care and educational systems [28,29,35–38]. Importantly, this association was observed within a publicly funded healthcare system, suggesting that equal access to medical care does not fully mitigate the influence of educational disparities on psychosocial adjustment [9,18,19].

Family structure also appeared to play a role. Relational difficulties were more frequently reported among survivors from separated or divorced families, supporting previous findings that family instability may exacerbate vulnerability during and after pediatric illness. Additionally,

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premorbid psychological and scholastic difficulties were strong predictors of post-treatment problems across domains, reinforcing the notion that cancer-related stressors often interact with pre-existing vulnerabilities rather than acting in isolation. An original and exploratory finding was the apparent protective association between older paternal age and both relational and academic stability [23,24]. While this result should be interpreted cautiously, it may reflect greater emotional maturity, stability, or caregiving resources associated with older parenthood. Similar mechanisms have been hypothesized in studies examining family adaptation to chronic pediatric conditions, but this observation warrants confirmation in larger samples. Consistent with prior literature, CNS tumor survivors showed higher rates of neuropsychological difficulties, loss of adaptive resources, and social integration problems compared with survivors of non-CNS solid tumors [5,11,13–16]. Notably, only a minority of survivors underwent formal neuropsychological assessment after treatment, despite a substantial proportion showing difficulties in everyday functioning. This gap underscores the need for systematic neuropsychological follow-up, particularly for CNS survivors, but also highlights that non-CNS survivors may experience significant difficulties that risk being overlooked. Several limitations must be acknowledged. The questionnaire used in this study was purpose-built and not formally validated, and outcomes were based on parental report rather than standardized assessments. The cross-sectional design limits causal inference and relies on retrospective comparison with pre-diagnosis functioning, which may be subject to recall bias. In addition, the sample size constrained statistical power and precluded multivariable modeling, and the exploratory nature of the analyses increases the risk of type I error. Finally, the exclusion of hematological malignancies reflects the clinical focus of the center and limits generalizability.

5. Conclusions

Despite the above described limitations, this study provides preliminary evidence that family educational background, family structure, and premorbid functioning are relevant correlates of psychosocial and neuropsychological outcomes in pediatric cancer survivorship. These findings support an integrated model of follow-up care that combines medical surveillance with systematic assessment of family and socio-cultural resources. Future research should employ validated instruments, longitudinal designs, and multicenter samples to clarify causal pathways and to determine whether the observed patterns extend across different healthcare and cultural contexts. In conclusion, survivorship care in pediatric oncology should extend beyond disease-related risk stratification to include structured evaluation of family educational and relational resources. Such an approach may facilitate earlier identification of vulnerable survivors and support the development of personalized, equitable interventions aimed at optimizing long-term quality of life [40].

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org.

Author Contributions: Conceptualization: PG, AA, MM, FB**;** Data curation: all authors**;** Formal analysis: PG, AA, FB, MM**;** Investigation: LC, ON, VB, ES, MT, MM**;** Methodology: AA, PG, FB, MM**;** Project administration: MM**;** Resources: MM**;** Software: FB**;** Writing – original draft: AA, FB**;** Writing – review & editing: PG, FB, MM.

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Informed Consent Statement: Informed consent forms were provided and signed by parents and/or patients.

Data Availability Statement: Data available on request from the authors.

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