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# A nationwide, population-based study of school grades in practical and aesthetic subjects of children treated for a brain tumour

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## Abstract

**Background:** Children treated for a brain tumour often need extra support in school because of late-appearing side effects after their treatment. This is the first study that explores how these children perform in the five practical and aesthetic (PRAEST) subjects Home and consumer studies, Physical education and health, Art, Crafts and Music.

**Methods:** In this nationwide population-based study of data from the Swedish Childhood Cancer Registry and Statistics Sweden, we included 475 children born between 1988 and 1996, diagnosed with a brain tumour before their 15th birthday. We compared their grades in PRAEST subjects to those of 2,197 matched controls. We also investigated if there were any differences between females and males, children diagnosed at different ages, and children with high- or low-grade tumours.

**Results:** The odds for failing a subject were 2-3 times higher for females treated for a brain tumour compared to their controls in all five PRAEST subjects, whereas there were no significant differences between the males and their controls in any subject. Survivors had lower average grades from year nine in all PRAEST subjects, and females differed from their controls in all five subjects, while males differed in Physical education and health, and Music. Age at diagnosis had a significant effect on the average grade in Crafts, but not any other subjects or failing a grade. Being treated for a high- or a low-grade tumour grade had no significant effect at all on the results.

**Conclusions:** Children treated for a brain tumour, especially females, are at risk of lower average grades or failing PRAEST subjects and may need extra support, as these subjects are be important for their well-being and future skills.

## Key messages

**What is already known on this topic?**

- Children treated for a brain tumour are at high risk of cognitive and other late effects that may affect their school performance.
- Compared to controls they often perform worse in theoretical school subjects such as first or second language, and mathematics.
- Very little is known about their performance in practical and aesthetic subjects

**What this study hopes to add?**

- The odds to fail a PRAEST subject were two to three times higher for females treated for a brain tumour compared to controls.
- Survivors, both females and males, had lower average grades from year nine in all practical and aesthetic subjects, compared to controls.
- Children treated for a brain tumour may need extra support in school, not only in theoretical subjects, but also in practical and aesthetic subjects.

## Introduction

As the survival rates of children treated for a brain tumour (hereafter termed paediatric brain tumour survivors, abbreviated PBTS) have improved during the latest decades, to about 80% [1] and as a consequence, the number of PBTS attending school have increased. However, PBTS may face different kinds of difficulties in school, as they typically suffer from cognitive late effects such as difficulties with verbal memory, language and attention [2], IQ decline over time [3], psychosocial difficulties, as well as depression or anxiety disorders [4]. Especially children treated at a younger age and female PBTS appear to be at risk of academic difficulties [5–7]. PBTS may also have limitations in physical performance affecting everyday life [8].

To our knowledge, this is the first study focusing on the performance PBTS of in the practical and aesthetic (PRAEST) subjects Home and consumer studies (equivalent to the subject Home Economics), Physical education and health, Art, Crafts and Music. Previous studies of PBTS' school performance have mainly focused on theoretical subjects, such as mother tongue, mathematics and foreign language [5–7,9]. These studies have shown a greater risk of lower school grades for PBTS compared to controls. Only a few studies have included the subjects Physical education [7,9,10] or Art/Music [11], despite that activities included in PRAEST subjects likely are valuable for essential skills and general well-being. For example, physical activity in the form of adventure-based training reduced fatigue and enhanced self-efficacy and quality of life among children treated for different types of cancer[12]. Other studies have shown that active video gaming improved PBTS motor coordination and activities of daily living [13,14] and that group training promoted white matter and hippocampal recovery and improved reaction time [15]. The school subject Home and consumer studies teaches basic daily life skills[16] and thus prepares for independent living, which is of particular importance as

many PBTS struggle with late effects affecting their daily life[17,18]. A review of studies from Australia and the United Kingdom have shown that teaching in, and through, aesthetic subjects may have positive effects, such as promoting social interaction, better study results and increased self-confidence [19,20]. Yet, the quality of the art program is important Aesthetic activities are also often used during hospital episodes to make it possible for patients to express feelings and fears, and to offer coping strategies [21–23]. In summary, PRAEST subjects are important for physical activity, practical skills and may contribute to positive results in school and general well-being. However, we have found no studies that highlight PBTS' performance in PRAEST subjects, despite the presumed importance and benefits.

## Aim and research questions:

Our aim was to explore the grades from spring term the last term of compulsory school in Sweden (year nine) in the mandatory practical and aesthetic (PRAEST) school subjects, for 475 PBTS and 2,197 matched controls. Our research questions were:

- How many of the children treated for a brain tumour fail the different PRAEST subjects Home and consumer studies, Physical education and health, Art, Crafts and Music, compared to controls?
- Are there any differences between females and males, age at diagnosis or tumour grade (high- or low-grade) for the risk of failing a grade?
- How do children treated for a brain tumour perform in school, as judged by their average grades in the PRAEST subjects from the final year of compulsory school, compared to controls?
- Are the PRAEST grades different between females and males, and do they vary depending on age at diagnosis or tumour grade (high- or low-grade)?

## Methods

A total of 475 children born between 1988-1996 and treated for a brain tumour before their 15th birthday were identified from The Swedish Childhood Cancer Registry[24] and matched to and 2,197 controls (Figure 1) [6]. Children with relapses were included, but not children with any other cancer forms. PBTS were not eligible as controls and each control only appears for one PBTS. Of the PBTS, 97% were at least one year post-diagnosis when their school grades were abstracted. We deducted information about the numbers of PBTS with high- (WHO III-IV) or low-grade (WHO I-II) tumours from the Swedish Childhood Cancer Registry. From Statistics Sweden [25] we obtained information about grades, about the number of students with Swedish as their first or second language, and parents' education. The PBTS and the controls were comparable, as we found no statistically significant differences between the numbers of males and females in the groups, Swedish as their first or second language, or parents' education (Table 1) [6] . Children included in this study typically started in a preschool class at age six, school at age seven, and attended the full nine years of compulsory school. In most schools, grades were given for the first time in the spring term year eight. Until 2012, the Swedish grade system was based on a three-step scale, G = pass, worth 10 points, VG = pass with distinction, worth 15 points, and MVG = pass with special distinction, worth 20 points. If the student failed a subject because a lot of absence or because they did not obtain the defined goals in the subject, 0 points were given. The five PRAEST subjects are mandatory and make up around one third of all the subjects in the Swedish curriculum for the compulsory school years one to nine [16]. As in Lönnerblad et al. (2019), the age groups regarding age at diagnosis that we refer to follow the Swedish school system. Ages 0 to 5 comprise the years before compulsory school, ages 6 to 9 the so-called preschool year plus the early years (one to three) of compulsory school, and ages 10 to 14 the middle and last

years (four to nine) of compulsory school. The children graduate and get their final grades their ninth year of compulsory school, typically at age fifteen or sixteen, and these are the grades we analysed in the current study.

**--- Insert Figure 1 about here---**

**Figure 1** Inclusion and exclusion criteria PBTS and controls [6]

**TABLE 1** Characteristics of PBTS (n = 475) and controls (n = 2,197) [6]

| | **PBTS** n = 475 | **Controls** n = 2,197 | **Pearson's Chi-square** |
|---|---|---|---|
| **Females** | 230 (48.4%) | 1,059 (48.2%) | p=0.931 (n.s.) |
| **Males** | 245 (51.6%) | 1,138 (51.8%) | |
| **Age at diagnosis** | | | |
| **Females** | | | |
| 0-5 years | 82 (35.6%) | | |
| 6-9 years | 51 (22.2%) | | |
| 10-14 years | 97 (42.2%) | | |
| **Males** | | | |
| 0-5 years | 87 (35.5%) | | |
| 6-9 years | 66 (26.9%) | | |
| 10-14 years | 92 (37.6%) | | |
| **Tumor grade** | | | |
| Low | 383 (80.6%) | | |
| High | 92 (19.4%) | | |
| **Mothers' education** | | | p=0.245 (n.s.) |
| Low (school year 1-9 or less) | 36 (7.6%) | 219 (9.9%) | |
| Medium (school year 10-12)* | 236 (49.7%) | 1,091 (49.7%) | |
| High (higher education) | 201 (42.3%) | 881 (40.1%) | |
| No information about education | 2 (0.4%) | 6 (0.3%) | |
| **Fathers' education** | | | p=0.284 (n.s.) |
| Low – (school year 1-9 or less) | 82 (17.3%) | 353 (16.1%) | |
| Medium (school year 10-12)* | 229 (48.2%) | 1,156 (52.6%) | |
| High (higher education) | 54 (32.4%) | 660 (30.0%) | |
| No information about education | 10 (2.1%) | 28 (1.3%) | |
| **Swedish** | | | p=0.396 (n.s.) |
| As first language | | 450 (94.7%) | 2,101 (95.6%) |
| As second language | | 25 (5.3%) | 96 (4.4%) |

*Until 1994 school year 10-12 could be two or three years.

## Statistical methods

We used IBM SPSS versions 25 and 26 and R version 3.6.0 for statistical analyses. P-values below 5% were considered statistically significant. Non-significant results are marked n.s. For comparison between the background variables of cases and controls, we used Pearson's Chi-square test. Odds ratios with 95% confidence intervals (CIs) for failing in the different subjects comparing PBTS and their controls were calculated using logistic regressions. To investigate whether the sex difference in the proportion failing differed between PBTS and their controls, we added an interaction term between sex and diagnosis to a logistic regression model with the failing in the different subjects as a dependent variable and sex and diagnosis as independent variables. To analyse the differences within the PBTS group for age at diagnosis (0-5 years, 6-9 years or 10-14 years) or tumour type (high- or low-grade), we used logistic regressions. We also adjusted the models for mothers' and fathers' education, respectively. Regarding average grade and differences between PBTS and their controls, we used an independent sample t-test. To investigate whether the sex difference in average grade differed between the PBTS and their controls, an interaction term between gender and diagnosis was added to a linear regression model including average grade as a dependent variable, and sex and diagnosis as independent variables. To analyse the differences within the PBTS group between, age at diagnosis (0-5 years, 6-9 years or 10-14 years) or tumour type (high- or low-grade), we used a linear regression. Average grade (including fail, pass, pass with distinction and pass with special distinction) in the different subjects was used as the dependent variable and age groups and tumour type were used as the independent variables. This model was also adjusted for mothers' and fathers' education, respectively.

## Results

### Failing a subject

PBTS failed to a significantly higher extent the subjects Music, Art, and Physical education and health compared to controls (Table 2). In Crafts and Home and consumer studies there were no statistically significant differences compared to controls. However, female PBTS had two to three times higher odds for failing a subject compared to females in the control group in all PRAEST subjects, whereas the male PBTS did not significantly differ from their controls in any of the subjects (Figure 2). There were statistically significant interaction effects between sex and controls or PBTS in Physical education and health (p=0.035), Art (p=0.011), Crafts (p=0.026) and Music (p=0.007). In these subjects, female PBTS failed to a significantly higher extent than male PBTS compared to the control group. We found no interaction effect in Home and consumer studies. Neither age at diagnosis, nor tumour grade (high or low), had a significant effect on failing a grade for any of the PRAEST subjects for the PBTS (Figure 2), and was still not significant when we adjusted for mothers' and fathers' education.

**Table 2.** Number, percentage and odds ratios (OR) with 95% confidence intervals (CI) for failing the subjects for PBTS vs. controls. Statistically significant interaction effects between sex and PBTS or control, are indicated with *.

| | N (%) PBTS | N (%) Controls | OR (95% CI) | p-value between PBTS and controls |
|---|---|---|---|---|
| **Home and consumer studies** | | | | |
| All | 35 (7.4%) | 112 (5.1%) | | 0.051 n.s. |
| Females | 18 (7.8%) | 38 (3.6%) | 2.28 (1.28-4.07) | 0.005 |
| Males | 17 (6.9%) | 74 (6.5%) | | 0.803 n.s. |
| **Physical education and health*** | | | | |
| All | 51 (10.7%) | 153 (7.0%) | 1.61 (1.15-2.24) | 0.005 |
| Females | 33 (14.3%) | 74 (7.0%) | 2.23 (1.44-3.46) | 0.001 |
| Males | 18 (7.3%) | 79 (6.9%) | | 0.822 n.s. |
| **Art*** | | | | |
| All | 35 (7.4%) | 109 (5.0%) | 1.52 (1.03-2.26) | 0.036 |
| Females | 21 (9.1 %) | 39 (3.7%) | 2.63 (1.51-4.56) | 0.001 |
| Males | 14 (5.7 %) | 70 (6.2%) | | 0.795 n.s. |
| **Crafts*** | | | | |
| All | 29 (6.1%) | 91 (4.1%) | | 0.063 n.s. |
| Females | 17 (7.4%) | 32 (3.0%) | 2.56 (1.40-4.70) | 0.002 |
| Males | 12 (4.9%) | 59 (5.2%) | | 0.854 n.s. |
| **Music*** | | | | |
| All | 50 (10.5%) | 129 (5.9%) | 1.89 (1.34-2.66) | 0.001 |
| Females | 28 (12.2%) | 44 (4.2 %) | 3.20 (1.94-5.26) | < 0.001 |
| Males | 22 (9.0%) | 85 (7.5%) | | 0.423 n.s |

* Statistically significant interaction effect between sex and PBTS or control

**--- Insert Figure 2 about here---**

**Figure 2** Odds ratios and 95% confidence intervals for failing a subject. The lower part of the figure includes only PBTS.

## Average grade

The average grades were significantly different between PBTS and controls in all five PRAEST subjects (Table 3). Female PBTS had significantly lower average grades compared to their controls in all subjects, while male PBTS only had a significantly lower average grades in Physical education and health and Music. The largest differences between PBTS and controls, including both females and males, was in Physical education and health, and the smallest one was in Crafts. There was a statistically significant interaction between sex and PBTS or control only in Art (p=0.0402). In Art, females had a statistically significant higher average grade than males, and this difference was significantly larger in the control group. Neither age at diagnosis nor high- or low-grade tumours was a statistically significant factor for mean grade. Only in the model when we adjusted for fathers' education, age at diagnosis was statistically significant (p=0.0399) in the subject Craft with children diagnosed at age 0-5 performing significantly worse than children treated at age 10-14.

**Table 3.** Average grade with 95% confidence interval (CI) and difference for PBTS vs. controls. Statistically significant interaction effects between sex and PBTS or control are marked with *.

| | Average grade (95% CI) PBTS | Average grade (95% CI) Controls | p-value between PBTS and controls |
|---|---|---|---|
| **Home and consumer studies** | | | |
| All | 12.86 (12.40-13.32) | 13.78 (13.57-13.98) | <0.001 |
| Females | 13.91 (13.21-14.62) | 15.22 (14.94-15.50) | 0.001 |
| Males | 11.88 (11.31-12.45) | 12.43 (12.16-12.70) | 0.093 n.s |
| **Physical education and health** | | | |
| All | 11.74 (11.26-12.21) | 13.79 (13.57-14.01) | <0.001 |
| Females | 11.13 (10.40-11.86) | 13.45 (13.14-13.76) | <0.001 |
| Males | 12.31 (11.70-12.92) | 14.10 (13.79-14.42) | <0.001 |
| **Art*** | | | |
| All | 12.53(12.08-12.98) | 13.37 (13.17-13.57) | <0.001 |
| Females | 13.50 (12.77-14.23) | 14.84 (14.57-15.12) | 0.001 |
| Males | 11.61 (11.09-12.13) | 12.00 (11.74-12.26) | 0.209 n.s. |
| **Crafts** | | | |
| All | 12.80 (12.36-13.24) | 13.67 (13.48-13.86) | <0.001 |
| Females | 13.20 (12.52-13.88) | 14.44 (14.18-14.70) | 0.001 |
| Males | 12.43 (11.86-13.00) | 12.95 (12.68-13.21) | 0.106 n.s. |
| **Music** | | | |
| All | 11.88 (11.41-12.36) | 13.17 (12.97-13.38) | <0.001 |
| Females | 12.35 (11.61-13.09) | 14.12 (13.84-14.40) | <0.001 |
| Males | 11.45 (10.85-12.05) | 12.29 (12.00-12.58) | 0.015 |

* Statistically significant interaction effect between sex and PBTS or control

## Discussion

### Statement of the principal findings

This nationwide, population-based study revealed that the odds for failing a PRAEST subject were two to three times higher for female PBTS compared to their controls for all five subjects, whereas male PBTS did not fail any of the PRAEST subjects more often than their controls. PBTS also had significantly lower average grades in all five PRAEST subjects compared to their controls. When we compared the average grades of female and male PBTS with their controls, females differed from their controls in all subjects, while males only differed in Physical education and health and Music. Age at diagnosis was not a significant factor in any subject for failing. For average grade, age at diagnosis was significant only in one subject, Crafts, when we adjusted for the fathers' education, but not in the unadjusted models or when we adjusted for the mothers' education. Treatment for a high- grade or a low-grade tumour did not have any impact in any subject on average grade or failing.

### Strengths and weaknesses of the study

The major strength of this study is that it is a nationwide, population-based study with grades from almost all children in Sweden born 1988-1996 and diagnosed with a brain tumour before the age of fifteen. We have analysed how this group of PBTS performed in the five different PRAEST subjects compared to their controls, and this is the only study of its kind. We consider that the main limitations are that we have no information about why the included children failed a subject, or if any adaptations in the course work were done for the PBTS. Another limitation are the unknown reasons for missing data, as there are slightly more missing registry data from the PBTS than from the controls. This is discussed in more detail in Lönnerblad et al. (2019).

## Discussing important differences in results

Our results regarding Physical activity and health grades are in line with previous studies by Lähteenmäki, et al. (2007), Ahomäki (2017) and Park (2018), showing that PBTS had a lower average grade and failed to a higher extent than controls in this subject. In our study, both females and males differed more from their controls in Physical activity and health than in the other PRAEST subjects and it was the subject in which the females failed most frequently (14.3% vs. 7.0 % in the control group). The study by Yilmaz et al. (2014) of children treated for different kinds of cancers showed that controls performed better in the two subjects denoted Sports and Art/Music. In our study, Music revealed the second largest difference between PBTS and controls for both females and males, and was the second most common subject where female PBTS failed. Both Physical activity and health and Music can be very noisy which, at least partly, may explain why these two subjects are most affected, as auditory deficits and difficulties such as tinnitus are not unusual [26]. Another explanation could be that motor skills as well as muscle strength may be affected [8,27,28]. This could possibly affect the results in all the PRAEST subjects. As reported in our previous study (Lönnerblad et al, 2019) age at diagnosis was a significant factor for a lower average grade in all three theoretical subjects Mathematics, Swedish and English. However, in the PRAEST subjects age at diagnosis does not seem to be important for average grade or failing. We can only speculate about the reasons of this. One explanation could be that it is easier to find strategies to compensate for cognitive and other late effects in the PRAEST subjects compared to the theoretical subjects; another explanation could be that it is easier to catch up in the PRAEST subjects. A third that there are no standardized tests in these subjects that the teacher have to consider when grading the children. Similarly, having been treated for a high-grade or a low-grade tumour did not have any effect on grades in the risk of failing a

PRAEST subject. The same was true also for Mathematics, Swedish and English (Lönnerblad et al., 2019), contrary to our expectations.

## Possible explanations and implications for clinicians and policymakers

The present study provides novel, important information, demonstrating that PBTS perform worse also in PRAEST subjects compared to controls, not only in theoretical subjects, which is known from previous studies. Given the benefits of the PRAEST subjects, acquiring skills for activities of daily living as well as promoting health and general well-being, the PBTS' higher rate of failing and lower average grades compared to controls is problematic. Adaptations and modifications should be considered to encourage higher participation and better performance, particularly for females. Clinicians, school staff and relatives to PBTS, along with policy makers, should all be included in the discussion about what can be done to ameliorate the negative effects of poor performance in school for PBTS, not only in theoretical but also in the PRAEST subjects.

## Unanswered questions and future research.

Females were two or three times more likely to fail the PRAEST subjects compared to their controls, while this was not seen in males. PRAEST subjects may have a lower status than the more theoretical subjects [22] and it is conceivable that females for strategic reasons deselect the PRAEST subjects in favour of the theoretical subjects Swedish, Mathematics and English, since failing the latter ones precludes qualification for school years 10-12 (upper secondary school/high school). The reason why PRAEST subjects are deselected or why female PBTS fail these subjects to a much higher extent than male PBTS, should be further investigated. As some of PBTS might need additional attention and special educational efforts to fully benefit from PRAEST subjects, future research should look closer into is how the different

subjects could be adapted to enable the PBTS to participate in these subjects to a higher extent and further develop their practical and aesthetic skills.

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## Author's contribution

ML and EB conceived the study. ML collected and analysed the data and wrote the first draft. ML, IVH, KB and EB interpreted the results and critically revised the manuscript. All authors approved the final version.

## Competing interests

None declared.

## Patient and public involvement

No patients were involved in the data collection or in the design of the study.

## Patient consent for publication

Not required.

## Abbreviations

| | |
|---|---|
| PBTS | Pediatric Brain Tumour Survivors |
| PRAEST subjects | Practical and Aesthetic subjects |

## References

1. Gustafsson G, Kogner P, Heyman M. *Childhood Cancer Incidence and Survival in Sweden 1984-2010*.; 2013. http://www.forskasverige.se/wp-content/uploads/ChildhoodCancerIncidenceandSurvivalinSweden1984_2010.pdf.

2. Robinson KE, Kuttesch JF, Champion JE, et al. A quantitative meta-analysis of neurocognitive sequelae in survivors of pediatric brain tumors. *Pediatric Blood & Cancer*. 2010;55(3):525-531. doi:10.1002/pbc.22568

3. Mulhern RK, Merchant TE, Gajjar A, Reddick WE, Kun LE. Late neurocognitive sequelae in survivors of brain tumours in childhood. *The Lancet Oncology*. 2004;5(7):399-408. doi:10.1016/S1470-2045(04)01507-4

4. Bitsko MJ, Cohen D, Dillon R, Harvey J, Krull K, Klosky JL. Psychosocial Late Effects in Pediatric Cancer Survivors: A Report From the Children's Oncology Group. *Pediatric Blood & Cancer*. 2016;63(2):337-343. doi:10.1002/pbc.25773

5. Andersen KK, Duun-Henriksen AK, Frederiksen MH, Winther JF. Ninth grade school performance in Danish childhood cancer survivors. *Br J Cancer*. 2017;116(3):398-404. doi:10.1038/bjc.2016.438

6. Lönnerblad M, van't Hooft I, Blomgren K, Berglund E. A nationwide, population-based study of school grades, delayed graduation, and qualification for school years 10-12, in children with brain tumors in Sweden. *Pediatr Blood Cancer*. October 2019. doi:10.1002/pbc.28014

7. Lähteenmäki PM, Harila-Saari A, Pukkala EI, Kyyrönen P, Salmi TT, Sankila R. Scholastic achievements of children with brain tumors at the end of comprehensive education: a nationwide, register-based study. *Neurology*. 2007;69(3):296-305.

8. Ness KK, Morris EB, Nolan VG, et al. Physical performance limitations among adult survivors of childhood brain tumors. *Cancer*. 2010;116(12):3034-3044. doi:10.1002/cncr.25051

9. Ahomäki R, Harila-Saari A, Matomäki J, Lähteenmäki PM. Non-graduation after comprehensive school, and early retirement but not unemployment are prominent in childhood cancer survivors—a Finnish registry-based study. *Journal of Cancer Survivorship*. 2017;11(2):284-294. doi:10.1007/s11764-016-0574-z

10. Park M, Park HJ, Lee JM, et al. School performance of childhood cancer survivors in Korea: A multi-institutional study on behalf of the Korean Society of Pediatric Hematology and Oncology. *Psycho-Oncology*. 2018;27(9):2257-2264. doi:10.1002/pon.4819

11. Yilmaz MC, Sari HY, Cetingul N, Kantar M, Erermis S, Aksoylar S. Determination of School-Related Problems in Children Treated for Cancer. *The Journal of School Nursing*. 2014;30(5):376-384. doi:10.1177/1059840513506942

12. Li WHC, Ho KY, Lam KKW, et al. Adventure-based training to promote physical activity and reduce fatigue among childhood cancer survivors: A randomized controlled

trial. *International Journal of Nursing Studies*. 2018;83:65-74. doi:10.1016/j.ijnurstu.2018.04.007

13. Sabel M, Sjölund A, Broeren J, et al. Active video gaming improves body coordination in survivors of childhood brain tumours. *Disability and Rehabilitation*. 2016;38(21):2073-2084. doi:10.3109/09638288.2015.1116619

14. Sabel M, Sjölund A, Broeren J, et al. Effects of physically active video gaming on cognition and activities of daily living in childhood brain tumor survivors: a randomized pilot study. *Neuro-Oncology Practice*. August 2016:npw020. doi:10.1093/nop/npw020

15. Riggs L, Piscione J, Laughlin S, et al. Exercise training for neural recovery in a restricted sample of pediatric brain tumor survivors: a controlled clinical trial with crossover of training versus no training. *NEUONC*. August 2016:now177. doi:10.1093/neuonc/now177

16. Swedish National Agency for Education. Curriculum for the compulsory school, preschool class and the leisure-time centre 2011. 2011. https://www.mah.se/upload/Nationella%20%c3%a4mnesprovet/Lgr11%20English.pdf. Accessed November 11, 2019.

17. Kunin-Batson A, Kadan-Lottick N, Zhu L, et al. Predictors of independent living status in adult survivors of childhood cancer: A report from the Childhood Cancer Survivor Study. *Pediatric Blood & Cancer*. 2011;57(7):1197-1203. doi:10.1002/pbc.22982

18. Gunn ME, Mört S, Arola M, et al. Quality of life and late-effects among childhood brain tumor survivors: a mixed method analysis. *Psycho-Oncology*. 2016;25(6):677-683. doi:10.1002/pon.3995

19. All-Party Parliamentary Group on Arts Health and Wellbeing. *Creative Health: The Arts for Health and Wellbeing*.; 2017. https://www.artshealthandwellbeing.org.uk/appg-inquiry/Publications/Creative_Health_Inquiry_Report_2017_-_Second_Edition.pdf. Accessed November 12, 2019.

20. Swedish National Agency for Education. Undervisning och lärande genom sinne, tanke och känsla. 2017. https://larportalen.skolverket.se/LarportalenAPI/api-v2/document/path/larportalen/material/inriktningar/4-specialpedagogik/Grundskola/101_Inkludering_och_skolans_praktik/del_08/Material/Flik/Del_08_MomentA/Artiklar/SP2_1-9_08_01_Sinne.docx. Accessed November 11, 2019.

21. Uggla L, Bonde L-O, Hammar U, Wrangsjö B, Gustafsson B. Music therapy supported the health-related quality of life for children undergoing haematopoietic stem cell transplants. *Acta Paediatr*. 2018;107(11):1986-1994. doi:10.1111/apa.14515

22. Tucquet B, Leung M. Music Therapy Services in Pediatric Oncology: A National Clinical Practice Review. *Journal of Pediatric Oncology Nursing*. 2014;31(6):327-338. doi:10.1177/1043454214533424

23. Lane MR. Arts in Health Care: A New Paradigm for Holistic Nursing Practice. *Journal of Holistic Nursing*. 2006;24(1):70-75. doi:10.1177/0898010105282465

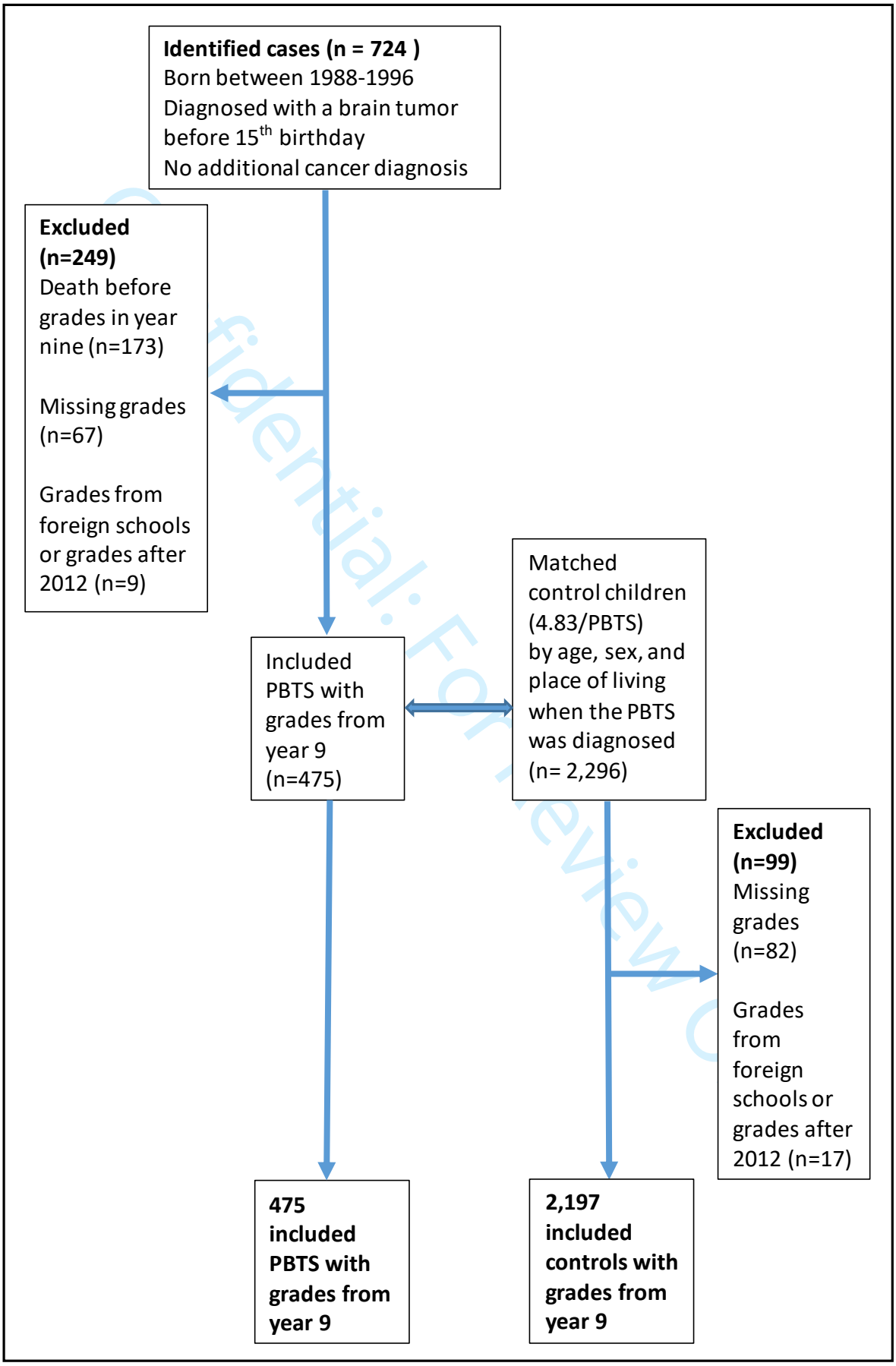
24. National Board of Health and Welfare. Täckningsgrader 2016 -Jämförelser mellan nationella kvalitetsregister och hälsodataregistren. Socialstyrelsen. https://www.socialstyrelsen.se/sok/?q=barncancerregistret. Published 2017. Accessed November 15, 2019.

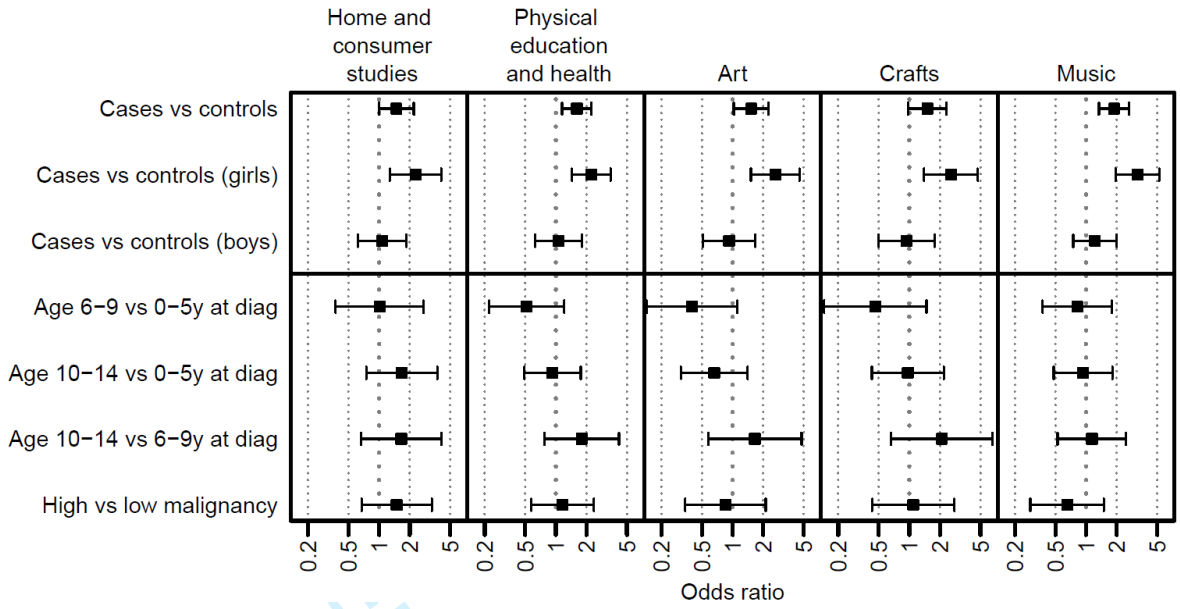
25. Statistics Sweden. About Statistics Sweden. Statistiska Centralbyrån. http://www.scb.se/en/About-us/. Published 2018. Accessed December 12, 2018.

26. Weiss A, Sommer G, Kasteler R, et al. Long-term auditory complications after childhood cancer: A report from the Swiss Childhood Cancer Survivor Study: Weiss et al. *Pediatr Blood Cancer*. 2017;64(2):364-373. doi:10.1002/pbc.26212

27. Zeltzer LK, Lu Q, Leisenring W, et al. Psychosocial Outcomes and Health-Related Quality of Life in Adult Childhood Cancer Survivors: A Report from the Childhood Cancer Survivor Study. *Cancer Epidemiology Biomarkers & Prevention*. 2008;17(2):435-446. doi:10.1158/1055-9965.EPI-07-2541

28. Rueegg CS, Michel G, Wengenroth L, et al. Physical Performance Limitations in Adolescent and Adult Survivors of Childhood Cancer and Their Siblings. Rota R, ed. *PLoS ONE*. 2012;7(10):e47944. doi:10.1371/journal.pone.0047944





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# A nationwide, population-based study of school grades in practical and aesthetic subjects of children treated for a brain tumour

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## Abstract

**Background:** Children treated for a brain tumour often need extra support in school because of late-appearing side effects after their treatment. We explored how this group of children perform in the five practical and aesthetic (PRAEST) subjects Home and consumer studies, Physical education and health, Art, Crafts and Music.

**Methods:** In this nationwide population-based study of data from the Swedish Childhood Cancer Registry and Statistics Sweden, we included 475 children born between 1988 and 1996, diagnosed with a brain tumour before their 15th birthday. We compared their grades in PRAEST subjects to those of 2,197 matched controls. We also investigated if there were any differences between females and males, children diagnosed at different ages, and children with high- or low-grade tumours.

**Results:** The odds for failing a subject were two to three times higher for females treated for a brain tumour compared to their controls in all five PRAEST subjects, whereas there were no significant differences between the males and their controls in any subject. Survivors had lower average grades from year nine in all PRAEST subjects, and females differed from their controls in all five subjects, while males differed in Physical education and health, and Music. Being treated for a high- or a low-grade tumour grade had no significant effect at all on the results.

**Conclusions:** Children treated for a brain tumour, especially females, are at risk of lower average grades or failing PRAEST subjects. All children treated for a brain tumor may need extra support, as these subjects are important for their well-being and future skills.

## Key messages

### What is already known on this topic?

- Children treated for a brain tumour are at high risk of cognitive and other late effects that may affect their school performance.
- Compared to controls they often perform worse in theoretical school subjects such as first or second language, and mathematics.
- Very little is known about their performance in practical and aesthetic subjects

### What this study hopes to add?

- The odds to fail a PRAEST subject were two to three times higher for females treated for a brain tumour compared to controls.
- Survivors, both females and males, had lower average grades from year nine in all practical and aesthetic subjects, compared to controls.
- Children treated for a brain tumour may need extra support in school, not only in theoretical subjects, but also in practical and aesthetic subjects.

## Introduction

The survival rates of children treated for a brain tumour (hereafter termed paediatric brain tumour survivors, abbreviated PBTS) have improved during the latest decades to about 80% [1] and as a consequence, the numbers of PBTS attending school have increased. However, PBTS may face different kinds of difficulties in school, as they typically suffer from cognitive late effects such as difficulties with verbal memory, language and attention [2], IQ decline over time [3], psychosocial difficulties, as well as depression or anxiety disorders [4]. Especially children treated at a younger age and female PBTS appear to be at risk of academic difficulties [5–7]. PBTS may also have limitations in physical performance affecting everyday life [8].

In this study, we focused on PBTS performance in the practical and aesthetic (PRAEST) subjects Home and consumer studies (equivalent to the subject Home Economics), Physical education and health, Art, Crafts and Music (Table 1). Previous studies of PBTS' school performance have mainly focused on theoretical subjects, such as mother tongue, mathematics and foreign language [5–7,9]. These studies have shown a greater risk of lower school grades for PBTS compared to controls. Only a few studies have included the subjects Physical education [7,9,10] or Art/Music [11], despite that activities included in PRAEST subjects likely are valuable for essential skills and general well-being. For example, physical activity in the form of adventure-based training reduced fatigue and enhanced self-efficacy and quality of life among children treated for different types of cancer [12]. Other studies have shown that active video gaming improved PBTS motor coordination and activities of daily living [13,14] and that group training promoted white matter and hippocampal recovery and improved reaction time [15]. The school subject Home and consumer studies teaches basic daily life skills [16] and thus prepares for independent living, which is of particular importance as

many PBTS struggle with late effects affecting their daily life [17,18]. A review of studies from Australia and the United Kingdom have shown that teaching in, and through, aesthetic subjects may have positive effects, such as promoting social interaction, better study results and increased self-confidence [19,20]. Yet, the quality of the art program is important. Aesthetic activities are also often used during hospital episodes to make it possible for patients to express feelings and fears, and to offer coping strategies [21–23]. In summary, PRAEST subjects are important for physical activity, practical skills and may contribute to positive results in school and general well-being. However, we have found no studies that highlight PBTS' performance in PRAEST subjects, despite the presumed importance and benefits.

**Table 1.** Aims of practical and aesthetic subjects cited from the Swedish Compulsory School Syllabuses [24].

| Subject | Aim |
|---|---|
| **Home and consumer studies** | *The subject provides experiences of social community, food and meals, housing and consumer economics, as well as opportunities to experience connections and pleasure in domestic work. The aim is to provide experiences and an understanding of the consequences of daily activities and habits in terms of economics, the environment, health and well-being (p.15).* |
| **Physical education and health** | *The subject aims at developing pupils' physical, psychological and social abilities, as well as providing knowledge of the importance of lifestyle for health (p.19).* |
| **Art** | *The subject aims at developing not only a knowledge of art, but also a knowledge of creating, analysing and communicating visually. It should develop desire, creativity and creative abilities, provide a general education in the area of the arts and lead to pupils acquiring their own standpoint in a reality characterised by huge flows of visual information (p. 9).* |
| **Crafts** | *The subject aims at creating an awareness of aesthetic values and developing an understanding of how choices over material, processing and construction influence a product's function and durability. The subject also aims at providing a knowledge of environmental and safety issues, and creating an awareness of the importance of resource management (p. 77).* |
| **Music** | *The subject /…/ aims at giving each pupil a desire and the opportunity of developing their musical skills and to experience that a knowledge of music is grounded in, liberates and strengthens their own identity, both socially, cognitively and emotionally (p. 35).* |

## Aim and research questions:

Our aim was to explore the grades from spring term the last year of compulsory school in Sweden (year nine) in the mandatory practical and aesthetic (PRAEST) school subjects, for 475 PBTS and 2,197 matched controls. Our research questions were:

- How many of the children treated for a brain tumour fail the different PRAEST subjects Home and consumer studies, Physical education and health, Art, Crafts and Music, compared to controls?
- Are there any differences between females and males, age at diagnosis or tumour grade (high- or low-grade) for the risk of failing a grade?
- How do children treated for a brain tumour perform in school, as judged by their average grades in the PRAEST subjects from the final year of compulsory school, compared to controls?
- Are the PRAEST grades different between females and males, and do they vary depending on age at diagnosis or tumour grade (high- or low-grade)?

## Methods

Children born 1988-1996 and treated for a brain tumour were identified from the Swedish Childhood Cancer Registry and their personal identification numbers were sent from The Swedish Childhood Cancer registry to Statistics Sweden, and matched by Statistics Sweden [25] to about five controls each (Figure 1). PBTS were not eligible as controls and each control only appears for one PBTS. No PBTS or controls could be identified by the investigators. We have only handled coded key numbers and only Statistics Sweden has the key-code. The

Swedish Childhood Cancer Registry includes 94% of all children diagnosed with cancer in Sweden during the years 1984 - 2013[26]. All parents or the children themselves have consented to being included in the registry, from which we also deducted information about the numbers of PBTS with high- (WHO III-IV) or low-grade (WHO I-II) tumours. Children with relapses were included, but not children with any other cancer forms. Of the PBTS, 97% were at least one year post-diagnosis when their school grades were abstracted. From Statistics Sweden we obtained information about grades, number of students with Swedish as their first or second language, and parents' education. We found no statistically significant differences between the numbers of males and females in the groups, Swedish as their first or second language, or parents' education, thus the PBTS and the control groups were comparable (Table 2).

Children included in this study typically started a preschool class at age six, school at age seven, and attended the full nine years of compulsory school. In most schools, grades were given for the first time in the spring term year eight. Until 2011, when a new grading system was introduced, the national Swedish grade system was based on a three-step scale, G = pass, worth 10 points, VG = pass with distinction, worth 15 points, and MVG = pass with special distinction, worth 20 points. This is the official way to enable calculation of average grades in Sweden. [27]. If the student failed a subject because a lot of absence or because they did not obtain the defined goals in the subject, 0 points were given. The five PRAEST subjects are mandatory and make up around one third of all the subjects in the Swedish curriculum for the compulsory school years one to nine [16]. As in Lönnerblad et al. (2019), the age groups at diagnosis that we refer to follow the Swedish school system. Ages 0 to 5 comprise the years before compulsory school, ages 6 to 9 one year in the so-called preschool class plus the early years of compulsory school (school years 1-3), and ages 10 to 14 the middle and last years

(school years 4-9) in compulsory school. The children graduate and get their final grades their ninth year of compulsory school, typically at age fifteen or sixteen, and these are the grades we analysed in the current study.

**--- Insert Figure 1 about here---**

**Figure 1** Inclusion and exclusion criteria PBTS and controls

**TABLE 2** Characteristics of PBTS (n = 475) and controls (n = 2,197) [6]

| | **PBTS** n = 475 | **Controls** n = 2,197 | **Pearson's Chi-square** |
|---|---|---|---|
| **Females** | 230 (48.4%) | 1,059 (48.2%) | p=0.931 (n.s.) |
| **Males** | 245 (51.6%) | 1,138 (51.8%) | |
| **Age at diagnosis** | | | |
| **Females** | | | |
| 0-5 years | 82 (35.6%) | | |
| 6-9 years | 51 (22.2%) | | |
| 10-14 years | 97 (42.2%) | | |
| **Males** | | | |
| 0-5 years | 87 (35.5%) | | |
| 6-9 years | 66 (26.9%) | | |
| 10-14 years | 92 (37.6%) | | |
| **Tumour grade** | | | |
| Low | 383 (80.6%) | | |
| High | 92 (19.4%) | | |
| **Mothers' education** | | | p=0.245 (n.s.) |
| Low (school year 1-9 or less) | 36 (7.6%) | 219 (9.9%) | |
| Medium (school year 10-12)* | 236 (49.7%) | 1,091 (49.7%) | |
| High (higher education) | 201 (42.3%) | 881 (40.1%) | |
| No information about education | 2 (0.4%) | 6 (0.3%) | |
| **Fathers' education** | | | p=0.284 (n.s.) |
| Low (school year 1-9 or less) | 82 (17.3%) | 353 (16.1%) | |
| Medium (school year 10-12)* | 229 (48.2%) | 1,156 (52.6%) | |
| High (higher education) | 154 (32.4%) | 660 (30.0%) | |
| No information about education | 10 (2.1%) | 28 (1.3%) | |
| **Swedish** | | | p=0.396 (n.s.) |
| As first language | 450 (94.7%) | 2,101 (95.6%) | |
| As second language | 25 (5.3%) | 96 (4.4%) | |

*Until 1994 school year 10-12 could be two or three years.

## Statistical methods

We used IBM SPSS versions 25 and 26 and R version 3.6.0 for statistical analyses. P-values below 5% were considered statistically significant. Non-significant results are marked n.s. For comparison between the background variables of cases and controls, we used Pearson's Chi-square test. Odds ratios with 95% confidence intervals (CIs) for failing in the different subjects comparing PBTS and their controls were calculated using logistic regressions. To investigate whether the sex difference in the proportion failing differed between PBTS and their controls, we added an interaction term between sex and diagnosis to a logistic regression model with the failing in the different subjects as a dependent variable and sex and diagnosis as independent variables. To analyse the differences within the PBTS group for age at diagnosis (0-5 years, 6-9 years or 10-14 years) or tumour type (high- or low-grade), we used logistic regressions. We also adjusted the models for mothers' and fathers' education, respectively. Regarding average grade and differences between PBTS and their controls, we used an independent sample t-test. To investigate whether the sex difference in average grade differed between the PBTS and their controls, an interaction term between gender and diagnosis was added to a linear regression model including average grade as a dependent variable, and sex and diagnosis as independent variables. To analyse the differences within the PBTS group between, age at diagnosis (0-5 years, 6-9 years or 10-14 years) or tumour type (high- or low-grade), we used a linear regression. Average grade (including fail, pass, pass with distinction and pass with special distinction) in the different subjects was used as the dependent variable and age groups and tumour type were used as the independent variables. This model was also adjusted for mothers' and fathers' education, respectively.

## Results

### Failing a subject

PBTS failed to a significantly higher extent the subjects Music, Art, and Physical education and health compared to controls (Table 3). In Crafts and Home and consumer studies there were no statistically significant differences compared to controls. However, female PBTS had 2.23 - 3.20 times higher odds for failing a subject compared to females in the control group in all PRAEST subjects, whereas the male PBTS did not significantly differ from their controls in any of the subjects (Figure 2). There were statistically significant interaction effects between sex and controls or PBTS in Physical education and health, Art, Crafts and Music. In these subjects, female PBTS failed to a significantly higher extent than male PBTS compared to the control group. We found no interaction effect in Home and consumer studies. Neither age at diagnosis, nor tumour grade (high or low), had a significant effect on failing a grade for any of the PRAEST subjects for the PBTS (Figure 2), and was still not significant when we adjusted for mothers' and fathers' education.

**Table 3.** Number, percentage and odds ratios (OR) with 95% confidence intervals (CI) and p-values for failing the subjects for PBTS (n=475) vs. controls (n=2197) and p-value for interaction effect between sex and PBTS or control.

| | N (%) PBTS | N (%) Controls | OR (95% CI) | p-value PBTS vs. controls |
|---|---|---|---|---|
| **Home and consumer studies** | | | | |
| All | 35 (7.4%) | 112 (5.1%) | 1.48 (1.0-2.19) | 0.051 n.s. |
| Females | 18 (7.8%) | 38 (3.6%) | 2.28 (1.28-4.07) | 0.005 |
| Males | 17 (6.9%) | 74 (6.5%) | 1.07 (0.62-1.85) | 0.803 n.s. |
| P-value for interaction: 0.063 n.s. | | | | |
| **Physical education and health** | | | | |
| All | 51 (10.7%) | 153 (7.0%) | 1.61 (1.15-2.24) | 0.005 |
| Females | 33 (14.3%) | 74 (7.0%) | 2.23 (1.44-3.45) | 0.001 |
| Males | 18 (7.3%) | 79 (6.9%) | 1.06 (0.62-1.81) | 0.822 n.s. |
| P-value for interaction: 0.035 | | | | |
| **Art** | | | | |
| All | 35 (7.4%) | 109 (5.0%) | 1.52 (1.03-2.26) | 0.036 |
| Females | 21 (9.1 %) | 39 (3.7%) | 2.63 (1.52-4.56) | 0.001 |
| Males | 14 (5.7 %) | 70 (6.2%) | 0.92 (0.51-1.67) | 0.795 n.s. |
| P-value for interaction: 0.011 | | | | |
| **Crafts** | | | | |
| All | 29 (6.1%) | 91 (4.1%) | 1.51 (0.98-2.31) | 0.063 n.s. |
| Females | 17 (7.4%) | 32 (3.0%) | 2.56 (1.40-4.70) | 0.002 |
| Males | 12 (4.9%) | 59 (5.2%) | 0.94 (0.50-1.78) | 0.854 n.s. |
| P-value for interaction: 0.026 | | | | |
| **Music** | | | | |
| All | 50 (10.5%) | 129 (5.9%) | 1.89 (1.34-2.66) | 0.001 |
| Females | 28 (12.2%) | 44 (4.2 %) | 3.20 (1.94-5.26) | < 0.001 |
| Males | 22 (9.0%) | 85 (7.5%) | 1.12 (0.75-2.0) | 0.423 n.s |
| P-value for interaction: 0.007 | | | | |

**--- Insert Figure 2 about here---**

**Figure 2** Odds ratios and 95% confidence intervals for failing a subject. The lower part of the figure includes only PBTS.

## Average grade

The average grades were significantly different between PBTS and controls in all five PRAEST subjects (Table 4). Female PBTS had significantly lower average grades compared to their controls in all subjects, while male PBTS only had a significantly lower average grades in Physical education and health and Music. The largest differences between PBTS and controls, including both females and males, was in Physical education and health, and the smallest one was in Crafts. There was a statistically significant interaction between sex and PBTS or control only in Art. In Art, females had a statistically significant higher average grade than males, and this difference was significantly larger in the control group. Neither age at diagnosis nor high- or low-grade tumours was a statistically significant factor for mean grade. Only in the model when we adjusted for fathers' education, age at diagnosis was statistically significant (p=0.040) in the subject Craft with children diagnosed at age 0-5 performing significantly worse than children treated at age 10-14.

**Table 4.** Average grade and estimated difference with 95% confidence interval (CI) for PBTS (n=475) vs. controls (n=2197) and interaction effect between sex and PBTS or control.

| | Average grade (95% CI) PBTS | Average grade (95% CI) Controls | Estimated difference (95% CI) PBTS - Controls | P-value PBTS - Controls |
|---|---|---|---|---|
| **Home and consumer studies** | | | | |
| All | 12.86 (12.40-13.32) | 13.78 (13.57-13.98) | -0.91 (-1.40 - -0.43) | <0.001 |
| Females | 13.91 (13.21-14.62) | 15.22 (14.94-15.50) | -1.31 (-1.99 - -0.63) | 0.001 |
| Males | 11.88 (11.31-12.45) | 12.43 (12.16-12.70) | -0.55 (-1.20 - -0.92) | 0.093 n.s |
| P-value for interaction: 0.113 n.s. | | | | |
| **Physical education and health** | | | | |
| All | 11.74 (11.26-12.21) | 13.79 (13.57-14.01) | -2.05 (-2.58 - -1.53) | <0.001 |
| Females | 11.13 (10.40-11.86) | 13.45 (13.14-13.76) | -2.32 (-3.07 - -1.57) | <0.001 |
| Males | 12.31 (11.70-12.92) | 14.10 (13.79-14.42) | -1.80 (-2.53- -1.06) | <0.001 |
| P-value for interaction: 0.328 n.s. | | | | |
| **Art** | | | | |
| All | 12.53(12.08-12.98) | 13.37 (13.17-13.57) | -0.85 (-1.32 - -0.37) | <0.001 |
| Females | 13.50 (12.77-14.23) | 14.84 (14.57-15.12) | -1.34 (-2.02- -0.66) | 0.001 |
| Males | 11.61 (11.09-12.13) | 12.00 (11.74-12.26) | -0.39 (-1.00 - -0.22) | 0.209 n.s. |
| P-value for interaction: 0.040 | | | | |
| **Crafts** | | | | |
| All | 12.80 (12.36-13.24) | 13.67 (13.48-13.86) | -0.866 (-1.32- -0.41) | <0.001 |
| Females | 13.20 (12.52-13.88) | 14.44 (14.18-14.70) | -1.24 (-1.89- -0.60) | 0.001 |
| Males | 12.43 (11.86-13.00) | 12.95 (12.68-13.21) | -0.52 (-1.15- -0.11) | 0.106 n.s. |
| P-value for interaction: 0116 n.s. | | | | |
| **Music** | | | | |
| All | 11.88 (11.41-12.36) | 13.17 (12.97-13.38) | -1.29 (-1.78- -0.80) | <0.001 |
| Females | 12.35 (11.61-13.09) | 14.12 (13.84-14.40) | -1.77 (-2.46- -1.08) | <0.001 |
| Males | 11.45 (10.85-12.05) | 12.29 (12.00-12.58) | -0.84 (-1.53- -0.16) | 0.015 |
| P-value for interaction: 0.060 n.s. | | | | |

## Discussion

### Statement of the principal findings

This nationwide, population-based study revealed that the odds for failing a PRAEST subject were two to three times higher for female PBTS compared to their controls for all five subjects, whereas male PBTS did not fail any of the PRAEST subjects more often than their controls. PBTS also had significantly lower average grades in all five PRAEST subjects compared to their controls. When we compared the average grades of female and male PBTS with their controls, females differed from their controls in all subjects, while males only differed in Physical education and health and Music. Age at diagnosis was not a significant factor in any subject for failing. For average grade, age at diagnosis was significant only in one subject, Crafts, when we adjusted for the fathers' education, but not in the unadjusted models or when we adjusted for the mothers' education. High-grade tumours are usually treated with cranial radiotherapy, a modality known to cause cognitive and other deficits, but we did not find any significant impact of tumour grade on average grades or failing any of the subjects.

### Strengths and weaknesses of the study

The major strength of this study is that it is a nationwide, population-based study with grades from almost all children in Sweden born 1988-1996 and diagnosed with a brain tumour before the age of fifteen. We have analysed how this group of PBTS performed in the five different PRAEST subjects compared to their controls, and this is the only study of its kind. To address the issue of patients still undergoing treatment, we performed a sensitivity analysis, excluding all patients less than two years after diagnosis, and this did not have any appreciable impact on the results. We consider that the main limitations are that we have no information about why the included children failed a subject, or if any adaptations in the course work were made for the PBTS to facilitate their participation. In addition, as passing

the PRAEST subjects is not required to qualify for post-secondary school in Sweden, we do not know if PBTS may have dropped any of these subjects voluntary in favour of the theoretical subjects Swedish, Mathematics or English, which are required for qualification. However, as all PRAEST subjects are mandatory, it is not possible for pupils to drop any subject unless the school have given permission to do so. Another limitation is the unknown reasons for missing data, as there are slightly more missing registry data from the PBTS than from the controls. This is discussed in more detail in Lönnerblad et al. (2019).

## Discussing important differences in results

Our results regarding Physical activity and health grades show that PBTS had a lower average grade and failed to a higher extent than controls in this subject, which is in line with previous studies by Lähteenmäki, et al. (2007), Ahomäki (2017) and Park (2018). In our study, both females and males differed more from their controls in Physical activity and health than in the other PRAEST subjects. Female PBTS failed this subject more frequently (14.3% vs. 7.0 % in the control group). The study by Yilmaz et al. (2014) of children treated for different kinds of cancers showed that controls performed better in the two subjects denoted Sports and Art/Music. In our study, Music revealed the second largest difference between PBTS and controls for both females and males, and was the second most common subject where female PBTS failed. Both the subjects Music and Physical activity and health can be very noisy which, at least partly, may explain why these two subjects are most affected, as auditory deficits and difficulties such as tinnitus are not unusual [28]. Another explanation could be that motor skills as well as muscle strength may be affected [8,29,30]. This could possibly affect the results in all the PRAEST subjects. As reported in our previous study (Lönnerblad et al, 2019) age at diagnosis was a significant factor for a lower average grade in all three theoretical subjects Mathematics, Swedish and English. However, in the

PRAEST subjects age at diagnosis does not seem to be important for average grade or failing. We can only speculate about the reasons of this. One explanation could be that it is easier to find strategies to compensate for cognitive and other late effects in the PRAEST subjects compared to the theoretical subjects; another explanation could be that it is easier to catch up in the PRAEST subjects. A third that there are no standardized tests in these subjects that the teacher have to consider when grading the children. Similarly, having been treated for a high-grade or a low-grade tumour did not have any effect on grades in the risk of failing a PRAEST subject. The same was true also for Mathematics, Swedish and English (Lönnerblad et al., 2019), contrary to our expectations.

## Possible explanations and implications for clinicians and policymakers

The present study provides novel, important information, demonstrating that PBTS perform worse also in PRAEST subjects compared to controls, not only in theoretical subjects, which is known from previous studies. Given the benefits of the PRAEST subjects, acquiring skills for activities of daily living as well as promoting health and general well-being, the PBTS' higher rate of failing and lower average grades compared to controls is problematic. Adaptations and modifications should be considered to encourage higher participation and better performance, particularly for females. Clinicians, school staff and relatives to PBTS, along with policy makers, should all be included in the discussion about what can be done to ameliorate the negative effects of poor performance in school for PBTS, not only in theoretical but also in the PRAEST subjects.

## Unanswered questions and future research.

Females were two or three times more likely to fail the PRAEST subjects compared to their controls, while this was not seen in males. However, future larger studies would be

interesting as they could possibly detect a difference also between males, as the difference between male PBTS and controls is much smaller. PRAEST subjects may have a lower status than the more theoretical subjects [22] and it is conceivable that females more often, for strategic reasons, drop the PRAEST subjects in favour of the theoretical subjects Swedish, Mathematics and English, since failing the latter ones precludes qualification for school years 10-12 (upper secondary school/high school). The reasons why PRAEST subjects are dropped or why female PBTS fail these subjects to a much higher extent than male PBTS, should be further investigated. Nevertheless, it is important that both females and males are offered appropriate support and special educational efforts to fully benefit from the PRAEST subjects. Future research should look closer into is how the different subjects could be adapted to enable the PBTS to participate in these subjects to a higher extent and further develop their practical and aesthetic skills.

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## Author's contribution

ML and EB conceived the study. ML collected and analysed the data and wrote the first draft. ML, IVH, KB and EB interpreted the results and critically revised the manuscript. All authors approved the final version.

## Ethical approval and data availability statement

The data that support the findings of this study are available from Swedish childhood cancer registry and Statistics Sweden. Ethical approval for this study was given by the Regional

Ethical Review Board in Stockholm (no. 2017/995-31/5). Restrictions apply to the availability of these data, which were used under license for this study.

## Competing interests

None declared.

## Patient and public involvement

No patients were involved in the data collection or in the design of the study.

## Patient consent for publication

Not required.

## Abbreviations

| | |
|---|---|
| PBTS | Pediatric Brain Tumour Survivors |
| PRAEST subjects | Practical and Aesthetic subjects |

## References

1. Gustafsson G, Kogner P, Heyman M. *Childhood Cancer Incidence and Survival in Sweden 1984-2010*.; 2013. http://www.forskasverige.se/wp-content/uploads/ChildhoodCancerIncidenceandSurvivalinSweden1984_2010.pdf.

2. Robinson KE, Kuttesch JF, Champion JE, et al. A quantitative meta-analysis of neurocognitive sequelae in survivors of pediatric brain tumors. *Pediatric Blood & Cancer*. 2010;55(3):525-531. doi:10.1002/pbc.22568

3. Mulhern RK, Merchant TE, Gajjar A, Reddick WE, Kun LE. Late neurocognitive sequelae in survivors of brain tumours in childhood. *The Lancet Oncology*. 2004;5(7):399-408. doi:10.1016/S1470-2045(04)01507-4

4. Bitsko MJ, Cohen D, Dillon R, Harvey J, Krull K, Klosky JL. Psychosocial Late Effects in Pediatric Cancer Survivors: A Report From the Children's Oncology Group. *Pediatric Blood & Cancer*. 2016;63(2):337-343. doi:10.1002/pbc.25773

5. Andersen KK, Duun-Henriksen AK, Frederiksen MH, Winther JF. Ninth grade school performance in Danish childhood cancer survivors. *Br J Cancer*. 2017;116(3):398-404. doi:10.1038/bjc.2016.438

6. Lönnerblad M, van't Hooft I, Blomgren K, Berglund E. A nationwide, population-based study of school grades, delayed graduation, and qualification for school years 10-12, in children with brain tumors in Sweden. *Pediatr Blood Cancer*. October 2019. doi:10.1002/pbc.28014

7. Lähteenmäki PM, Harila-Saari A, Pukkala EI, Kyyrönen P, Salmi TT, Sankila R. Scholastic achievements of children with brain tumors at the end of comprehensive education: a nationwide, register-based study. *Neurology*. 2007;69(3):296-305.

8. Ness KK, Morris EB, Nolan VG, et al. Physical performance limitations among adult survivors of childhood brain tumors. *Cancer*. 2010;116(12):3034-3044. doi:10.1002/cncr.25051

9. Ahomäki R, Harila-Saari A, Matomäki J, Lähteenmäki PM. Non-graduation after comprehensive school, and early retirement but not unemployment are prominent in childhood cancer survivors—a Finnish registry-based study. *Journal of Cancer Survivorship*. 2017;11(2):284-294. doi:10.1007/s11764-016-0574-z

10. Park M, Park HJ, Lee JM, et al. School performance of childhood cancer survivors in Korea: A multi-institutional study on behalf of the Korean Society of Pediatric Hematology and Oncology. *Psycho-Oncology*. 2018;27(9):2257-2264. doi:10.1002/pon.4819

11. Yilmaz MC, Sari HY, Cetingul N, Kantar M, Erermis S, Aksoylar S. Determination of School-Related Problems in Children Treated for Cancer. *The Journal of School Nursing*. 2014;30(5):376-384. doi:10.1177/1059840513506942

12. Li WHC, Ho KY, Lam KKW, et al. Adventure-based training to promote physical activity and reduce fatigue among childhood cancer survivors: A randomized controlled

trial. *International Journal of Nursing Studies*. 2018;83:65-74. doi:10.1016/j.ijnurstu.2018.04.007

13. Sabel M, Sjölund A, Broeren J, et al. Active video gaming improves body coordination in survivors of childhood brain tumours. *Disability and Rehabilitation*. 2016;38(21):2073-2084. doi:10.3109/09638288.2015.1116619

14. Sabel M, Sjölund A, Broeren J, et al. Effects of physically active video gaming on cognition and activities of daily living in childhood brain tumor survivors: a randomized pilot study. *Neuro-Oncology Practice*. August 2016:npw020. doi:10.1093/nop/npw020

15. Riggs L, Piscione J, Laughlin S, et al. Exercise training for neural recovery in a restricted sample of pediatric brain tumor survivors: a controlled clinical trial with crossover of training versus no training. *NEUONC*. August 2016:now177. doi:10.1093/neuonc/now177

16. Swedish National Agency for Education. Curriculum for the compulsory school, preschool class and the leisure-time centre 2011. https://www.mah.se/upload/Nationella%20%c3%a4mnesprovet/Lgr11%20English.pdf. Accessed November 11, 2019.

17. Kunin-Batson A, Kadan-Lottick N, Zhu L, et al. Predictors of independent living status in adult survivors of childhood cancer: A report from the Childhood Cancer Survivor Study. *Pediatric Blood & Cancer*. 2011;57(7):1197-1203. doi:10.1002/pbc.22982

18. Gunn ME, Mört S, Arola M, et al. Quality of life and late-effects among childhood brain tumor survivors: a mixed method analysis. *Psycho-Oncology*. 2016;25(6):677-683. doi:10.1002/pon.3995

19. All-Party Parliamentary Group on Arts Health and Wellbeing. *Creative Health: The Arts for Health and Wellbeing*.; 2017. https://www.artshealthandwellbeing.org.uk/appg-inquiry/Publications/Creative_Health_Inquiry_Report_2017_-_Second_Edition.pdf. Accessed November 12, 2019.

20. Swedish National Agency for Education. Undervisning och lärande genom sinne, tanke och känsla. 2017. https://larportalen.skolverket.se/LarportalenAPI/api-v2/document/path/larportalen/material/inriktningar/4-specialpedagogik/Grundskola/101_Inkludering_och_skolans_praktik/del_08/Material/Flik/Del_08_MomentA/Artiklar/SP2_1-9_08_01_Sinne.docx. Accessed November 11, 2019.

21. Uggla L, Bonde L-O, Hammar U, Wrangsjö B, Gustafsson B. Music therapy supported the health-related quality of life for children undergoing haematopoietic stem cell transplants. *Acta Paediatr*. 2018;107(11):1986-1994. doi:10.1111/apa.14515

22. Tucquet B, Leung M. Music Therapy Services in Pediatric Oncology: A National Clinical Practice Review. *Journal of Pediatric Oncology Nursing*. 2014;31(6):327-338. doi:10.1177/1043454214533424

23. Lane MR. Arts in Health Care: A New Paradigm for Holistic Nursing Practice. *Journal of Holistic Nursing*. 2006;24(1):70-75. doi:10.1177/0898010105282465

24. Swedish National Agency for Education. *Syllabuses 2000: Compulsory School.* Stockholm: FRITZES; 2003.

25. Statistics Sweden. About Statistics Sweden. Statistiska Centralbyrån. http://www.scb.se/en/About-us/. Published 2018. Accessed December 12, 2018.

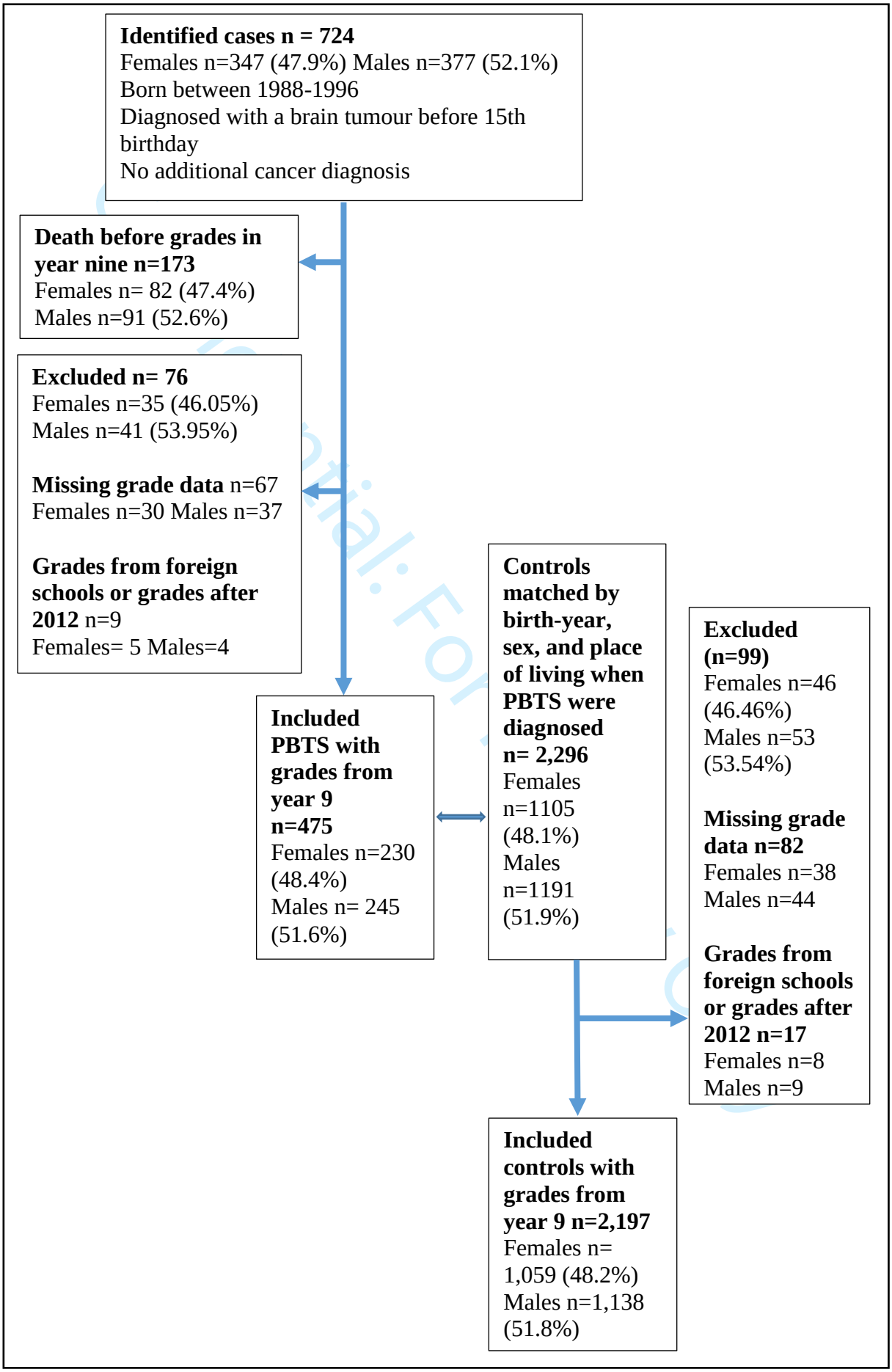
26. National Board of Health and Welfare. Täckningsgrader 2015 -Jämförelser mellan nationella kvalitetsregister och hälsodataregistren. Socialstyrelsen. https://www.socialstyrelsen.se/sok/?q=barncancerregistret. Published 2015. Accessed November 15, 2019.

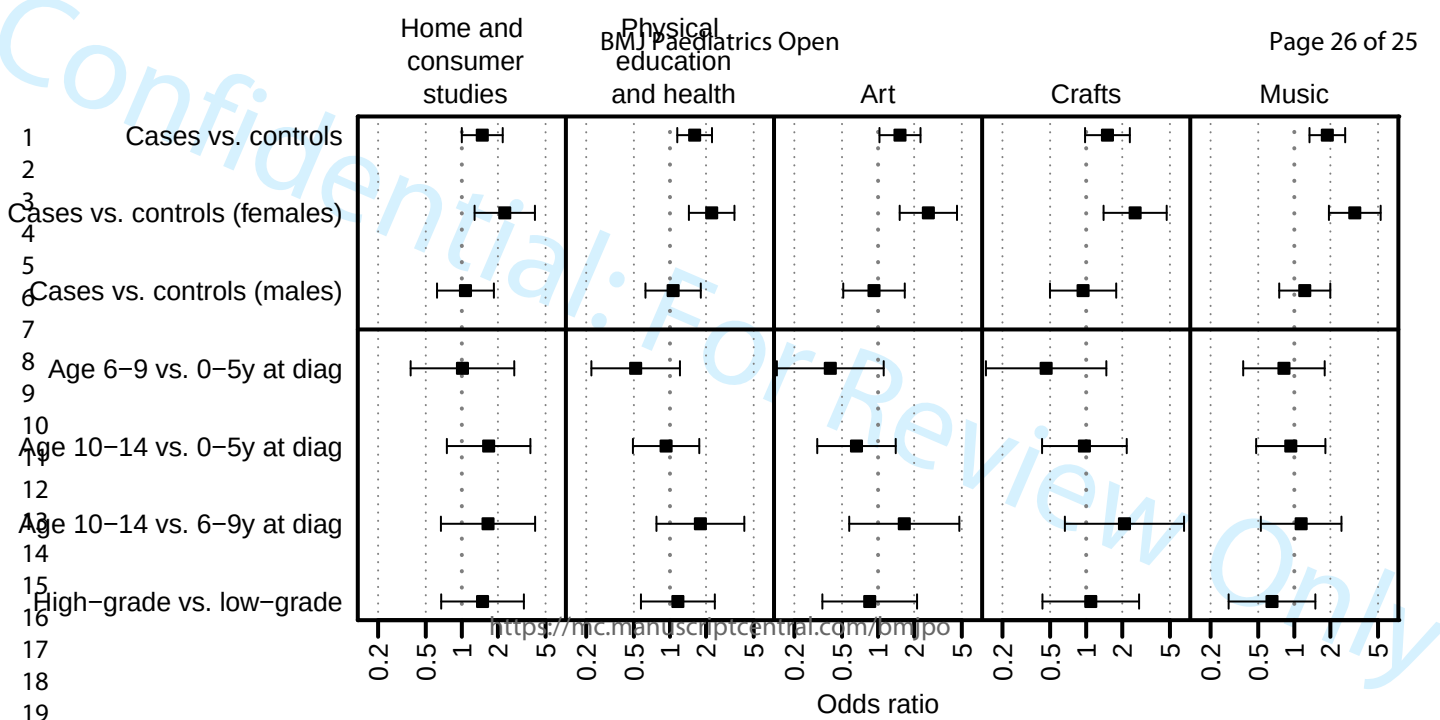
27. Swedish National Agency for Education. Swedish Grades. https://www.skolverket.se/download/18.47fb451e167211613ef398/1542791697007/swedishgrades_bilaga.pdf. Accessed January 8, 2020.

28. Weiss A, Sommer G, Kasteler R, et al. Long-term auditory complications after childhood cancer: A report from the Swiss Childhood Cancer Survivor Study: Weiss et al. *Pediatr Blood Cancer*. 2017;64(2):364-373. doi:10.1002/pbc.26212

29. Zeltzer LK, Lu Q, Leisenring W, et al. Psychosocial Outcomes and Health-Related Quality of Life in Adult Childhood Cancer Survivors: A Report from the Childhood Cancer Survivor Study. *Cancer Epidemiology Biomarkers & Prevention*. 2008;17(2):435-446. doi:10.1158/1055-9965.EPI-07-2541

30. Rueegg CS, Michel G, Wengenroth L, et al. Physical Performance Limitations in Adolescent and Adult Survivors of Childhood Cancer and Their Siblings. Rota R, ed. *PLoS ONE*. 2012;7(10):e47944. doi:10.1371/journal.pone.0047944


Identified cases n = 724
Females n=347 (47.9%) Males n=377 (52.1%)
Born between 1988-1996
Diagnosed with a brain tumour before 15th birthday
No additional cancer diagnosis
Death before grades in year nine n=173
Females n= 82 (47.4%)
Males n=91 (52.6%)
Excluded n= 76
Females n=35 (46.05%)
Males n=41 (53.95%)
Missing grade data n=67
Females n=30 Males n=37
Grades from foreign schools or grades after 2012 n=9
Females= 5 Males=4
Included PBTS with grades from year 9 n=475
Females n=230 (48.4%)
Males n= 245 (51.6%)
Controls matched by birth-year, sex, and place of living when PBTS were diagnosed n= 2,296
Females n=1105 (48.1%)
Males n=1191 (51.9%)
Excluded (n=99)
Females n=46 (46.46%)
Males n=53 (53.54%)
Missing grade data n=82
Females n=38
Males n=44
Grades from foreign schools or grades after 2012 n=17
Females n=8
Males n=9
Included controls with grades from year 9 n=2,197
Females n= 1,059 (48.2%)
Males n=1,138 (51.8%)



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# A nationwide, population-based study of school grades in practical and aesthetic subjects of children treated for a brain tumour

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## Abstract

**Background:** Children treated for a brain tumour (hereafter termed paediatric brain tumour survivors, abbreviated PBTS) often need extra support in school because of late-appearing side effects after their treatment. We explored how this group of children perform in the five practical and aesthetic (PRAEST) subjects Home and consumer studies, Physical education and health, Art, Crafts and Music.

**Methods:** In this nationwide population-based study of data from the Swedish Childhood Cancer Registry and Statistics Sweden, we included 475 children born between 1988 and 1996, diagnosed with a brain tumour before their 15th birthday. We compared their grades in PRAEST subjects to those of 2,197 matched controls. We also investigated if there were any differences between females and males, children diagnosed at different ages, and children with high- or low-grade tumours.

**Results:** The odds for failing a subject were two to three times higher for females treated for a brain tumour compared to their controls in all five PRAEST subjects, whereas there were no significant differences between the males and their controls in any subject. PBTS had lower average grades from year nine in all PRAEST subjects, and females differed from their controls in all five subjects, while males differed in Physical education and health, and Music. PBTS treated for high-grade tumours did neither have significantly different average grades, nor did they fail a subject to a significantly higher extent, than PBTS treated for low-grade tumours.

**Conclusions:** Children treated for a brain tumour, especially females, are at risk of lower average grades or failing PRAEST subjects. All children treated for a brain tumor may need extra support, as these subjects are important for their well-being and future skills.

## Key messages

**What is already known on this topic?**

- Children treated for a brain tumour are at high risk of cognitive and other late effects that may affect their school performance.
- Compared to controls they often perform worse in theoretical school subjects such as first or second language, and mathematics.
- Very little is known about their performance in practical and aesthetic subjects

**What this study hopes to add?**

- The odds to fail a PRAEST subject were two to three times higher for females treated for a brain tumour compared to controls.
- Survivors, both females and males, had lower average grades from year nine in all practical and aesthetic subjects, compared to controls.
- Children treated for a brain tumour may need extra support in school, not only in theoretical subjects, but also in practical and aesthetic subjects.

## Introduction

The survival rates of children treated for a brain tumour (hereafter termed paediatric brain tumour survivors, abbreviated PBTS) have improved during the latest decades to about 80% [1] and as a consequence, the numbers of PBTS attending school have increased. However, PBTS may face different kinds of difficulties in school, as they typically suffer from cognitive late effects such as difficulties with verbal memory, language and attention [2], IQ decline over time [3], psychosocial difficulties, as well as depression or anxiety disorders [4]. Especially children treated at a younger age and female PBTS appear to be at risk of academic difficulties [5–7]. PBTS may also have limitations in physical performance affecting everyday life [8].

In this study, we focused on PBTS performance in the practical and aesthetic (PRAEST) subjects Home and consumer studies (equivalent to the subject Home Economics), Physical education and health, Art, Crafts and Music (Table 1). Previous studies of PBTS' school performance have mainly focused on theoretical subjects, such as mother tongue, mathematics and foreign language [5–7,9]. These studies have shown a greater risk of lower school grades for PBTS compared to controls. Only a few studies have included the subjects Physical education [7,9,10] or Art/Music [11], despite that activities included in PRAEST subjects likely are valuable for essential skills and general well-being. For example, physical activity in the form of adventure-based training reduced fatigue and enhanced self-efficacy and quality of life among children treated for different types of cancer [12]. Other studies have shown that active video gaming improved PBTS motor coordination and activities of daily living [13,14] and that group training promoted white matter and hippocampal recovery and improved reaction time [15]. The school subject Home and consumer studies teaches basic daily life skills [16] and thus prepares for independent living, which is of particular importance as

many PBTS struggle with late effects affecting their daily life [17,18]. A review of studies from Australia and the United Kingdom have shown that teaching in, and through, aesthetic subjects may have positive effects, such as promoting social interaction, better study results and increased self-confidence [19,20]. Yet, the quality of the art program is important. Aesthetic activities are also often used during hospital episodes to make it possible for patients to express feelings and fears, and to offer coping strategies [21–23]. In summary, PRAEST subjects are important for physical activity, practical skills and may contribute to positive results in school and general well-being. However, we have found no studies that highlight PBTS' performance in PRAEST subjects, despite the presumed importance and benefits.

**Table 1.** Aims of practical and aesthetic subjects cited from the Swedish Compulsory School Syllabuses [24].

| Subject | Aim |
|---|---|
| **Home and consumer studies** | *The subject provides experiences of social community, food and meals, housing and consumer economics, as well as opportunities to experience connections and pleasure in domestic work. The aim is to provide experiences and an understanding of the consequences of daily activities and habits in terms of economics, the environment, health and well-being (p.15).* |
| **Physical education and health** | *The subject aims at developing pupils' physical, psychological and social abilities, as well as providing knowledge of the importance of lifestyle for health (p.19).* |
| **Art** | *The subject aims at developing not only a knowledge of art, but also a knowledge of creating, analysing and communicating visually. It should develop desire, creativity and creative abilities, provide a general education in the area of the arts and lead to pupils acquiring their own standpoint in a reality characterised by huge flows of visual information (p. 9).* |
| **Crafts** | *The subject aims at creating an awareness of aesthetic values and developing an understanding of how choices over material, processing and construction influence a product's function and durability. The subject also aims at providing a knowledge of environmental and safety issues, and creating an awareness of the importance of resource management (p. 77).* |
| **Music** | *The subject /…/ aims at giving each pupil a desire and the opportunity of developing their musical skills and to experience that a knowledge of music is grounded in, liberates and strengthens their own identity, both socially, cognitively and emotionally (p. 35).* |

## Aim and research questions:

Our aim was to explore the grades from spring term the last year of compulsory school in Sweden (year nine) in the mandatory practical and aesthetic (PRAEST) school subjects, for 475 PBTS and 2,197 matched controls. Our research questions were:

- How many of the children treated for a brain tumour fail the different PRAEST subjects Home and consumer studies, Physical education and health, Art, Crafts and Music, compared to controls?
- Are there any differences between females and males, age at diagnosis or tumour grade (high- or low-grade) for the risk of failing a grade?
- How do children treated for a brain tumour perform in school, as judged by their average grades in the PRAEST subjects from the final year of compulsory school, compared to controls?
- Are the PRAEST grades different between females and males, and do they vary depending on age at diagnosis or tumour grade (high- or low-grade)?

## Methods

Children born 1988-1996 and treated for a brain tumour were identified from the Swedish Childhood Cancer Registry and their personal identification numbers were sent from The Swedish Childhood Cancer registry to Statistics Sweden, and matched by Statistics Sweden [25] to about five controls each (Figure 1). PBTS were not eligible as controls and each control only appears for one PBTS. No PBTS or controls could be identified by the investigators. We have only handled coded key numbers and only Statistics Sweden has the key-code. The

Swedish Childhood Cancer Registry includes 94% of all children diagnosed with cancer in Sweden during the years 1984 - 2013[26]. All parents or the children themselves have consented to being included in the registry, from which we also deducted information about the numbers of PBTS with high- (WHO III-IV) or low-grade (WHO I-II) tumours. Children with relapses were included, but not children with any other cancer forms. Of the PBTS, 97% were at least one year post-diagnosis when their school grades were abstracted. From Statistics Sweden we obtained information about grades, number of students with Swedish as their first or second language, and parents' education (Table 2) [6].

Children included in this study typically started a preschool class at age six, school at age seven, and attended the full nine years of compulsory school. In most schools, grades were given for the first time in the spring term year eight. Until 2011, when a new grading system was introduced, the national Swedish grade system was based on a three-step scale, G = pass, worth 10 points, VG = pass with distinction, worth 15 points, and MVG = pass with special distinction, worth 20 points. This is the official way to enable calculation of average grades in Sweden. [27]. If the student failed a subject because a lot of absence or because they did not obtain the defined goals in the subject, 0 points were given. The five PRAEST subjects are mandatory and make up around one third of all the subjects in the Swedish curriculum for the compulsory school years one to nine [16]. As in Lönnerblad et al. (2019), the age groups at diagnosis that we refer to follow the Swedish school system. Ages 0 to 5 comprise the years before compulsory school, ages 6 to 9 one year in the so-called preschool class plus the early years of compulsory school (school years 1-3), and ages 10 to 14 the middle and last years (school years 4-9) in compulsory school. The children graduate and get their final grades their ninth year of compulsory school, typically at age fifteen or sixteen, and these are the grades we analysed in the current study.

**--- Insert Figure 1 about here---**

**Figure 1** Inclusion and exclusion criteria PBTS and controls

**TABLE 2** Characteristics of PBTS (n = 475) and controls (n = 2,197) [6]

| | **PBTS** n = 475 | **Controls** n = 2,197 |
|---|---|---|
| **Females** | 230 (48.4%) | 1,059 (48.2%) |
| **Males** | 245 (51.6%) | 1,138 (51.8%) |
| **Age at diagnosis** | | |
| **Females** | | |
| 0-5 years | 82 (35.6%) | |
| 6-9 years | 51 (22.2%) | |
| 10-14 years | 97 (42.2%) | |
| **Males** | | |
| 0-5 years | 87 (35.5%) | |
| 6-9 years | 66 (26.9%) | |
| 10-14 years | 92 (37.6%) | |
| **Tumour grade** | | |
| Low | 383 (80.6%) | |
| High | 92 (19.4%) | |
| **Mothers' education** | | |
| Low (school year 1-9 or less) | 36 (7.6%) | 219 (9.9%) |
| Medium (school year 10-12)* | 236 (49.7%) | 1,091 (49.7%) |
| High (higher education) | 201 (42.3%) | 881 (40.1%) |
| No information about education | 2 (0.4%) | 6 (0.3%) |
| **Fathers' education** | | |
| Low (school year 1-9 or less) | 82 (17.3%) | 353 (16.1%) |
| Medium (school year 10-12)* | 229 (48.2%) | 1,156 (52.6%) |
| High (higher education) | 154 (32.4%) | 660 (30.0%) |
| No information about education | 10 (2.1%) | 28 (1.3%) |
| **Swedish** | | |
| As first language | 450 (94.7%) | 2,101 (95.6%) |
| As second language | 25 (5.3%) | 96 (4.4%) |

*Until 1994 school year 10-12 could be two or three years.

## Statistical methods

We used IBM SPSS versions 25 and 26 and R version 3.6.0 for statistical analyses. P-values below 5% were considered statistically significant. Non-significant results are marked n.s. For comparison between the background variables of cases and controls, we used Pearson's Chi-square test. Odds ratios with 95% confidence intervals (CIs) for failing in the different subjects comparing PBTS and their controls were calculated using logistic regressions. To investigate whether the sex difference in the proportion failing differed between PBTS and their controls, we added an interaction term between sex and diagnosis to a logistic regression model with the failing in the different subjects as a dependent variable and sex and diagnosis as independent variables. To analyse the differences within the PBTS group for age at diagnosis (0-5 years, 6-9 years or 10-14 years) or tumour type (high- or low-grade), we used logistic regressions. We also adjusted the models for mothers' and fathers' education, respectively. Regarding average grade and differences between PBTS and their controls, we used an independent sample t-test. To investigate whether the sex difference in average grade differed between the PBTS and their controls, an interaction term between gender and diagnosis was added to a linear regression model including average grade as a dependent variable, and sex and diagnosis as independent variables. To analyse the differences within the PBTS group between, age at diagnosis (0-5 years, 6-9 years or 10-14 years) or tumour type (high- or low-grade), we used a linear regression. Average grade (including fail, pass, pass with distinction and pass with special distinction) in the different subjects was used as the dependent variable and age groups and tumour type were used as the independent variables. This model was also adjusted for mothers' and fathers' education, respectively.

## Results

### Failing a subject

PBTS failed to a significantly higher extent the subjects Music, Art, and Physical education and health compared to controls (Table 3). In Crafts and Home and consumer studies there were no statistically significant differences compared to controls. However, female PBTS had 2.23 - 3.20 times higher odds for failing a subject compared to females in the control group in all PRAEST subjects, whereas the male PBTS did not significantly differ from their controls in any of the subjects (Figure 2). There were statistically significant interaction effects between sex and PBTS or controls on Physical education and health, Art, Crafts and Music. In these subjects, female PBTS failed to a significantly higher extent than male PBTS compared to the control group. We found no statistically significant interaction effect on Home and consumer studies. Neither age at diagnosis, nor tumour grade (high or low), had a significant effect on failing a grade for any of the PRAEST subjects for the PBTS (Figure 2), and was still not significant when we adjusted for mothers' and fathers' education.

**Table 3.** Number, percentage and odds ratios (OR) with 95% confidence intervals (CI) and p-values for failing the subjects for PBTS (n=475) vs. controls (n=2197) and p-value for interaction effect between sex and PBTS or control.

| | N (%) PBTS | N (%) Controls | OR (95% CI) | p-value PBTS vs. controls |
|---|---|---|---|---|
| **Home and consumer studies** | | | | |
| All | 35 (7.4%) | 112 (5.1%) | 1.48 (1.0-2.19) | 0.051 n.s. |
| Females | 18 (7.8%) | 38 (3.6%) | 2.28 (1.28-4.07) | 0.005 |
| Males | 17 (6.9%) | 74 (6.5%) | 1.07 (0.62-1.85) | 0.803 n.s. |
| P-value for interaction: 0.063 n.s. | | | | |
| **Physical education and health** | | | | |
| All | 51 (10.7%) | 153 (7.0%) | 1.61 (1.15-2.24) | 0.005 |
| Females | 33 (14.3%) | 74 (7.0%) | 2.23 (1.44-3.45) | 0.001 |
| Males | 18 (7.3%) | 79 (6.9%) | 1.06 (0.62-1.81) | 0.822 n.s. |
| P-value for interaction: 0.035 | | | | |
| **Art** | | | | |
| All | 35 (7.4%) | 109 (5.0%) | 1.52 (1.03-2.26) | 0.036 |
| Females | 21 (9.1 %) | 39 (3.7%) | 2.63 (1.52-4.56) | 0.001 |
| Males | 14 (5.7 %) | 70 (6.2%) | 0.92 (0.51-1.67) | 0.795 n.s. |
| P-value for interaction: 0.011 | | | | |
| **Crafts** | | | | |
| All | 29 (6.1%) | 91 (4.1%) | 1.51 (0.98-2.31) | 0.063 n.s. |
| Females | 17 (7.4%) | 32 (3.0%) | 2.56 (1.40-4.70) | 0.002 |
| Males | 12 (4.9%) | 59 (5.2%) | 0.94 (0.50-1.78) | 0.854 n.s. |
| P-value for interaction: 0.026 | | | | |
| **Music** | | | | |
| All | 50 (10.5%) | 129 (5.9%) | 1.89 (1.34-2.66) | 0.001 |
| Females | 28 (12.2%) | 44 (4.2 %) | 3.20 (1.94-5.26) | < 0.001 |
| Males | 22 (9.0%) | 85 (7.5%) | 1.12 (0.75-2.0) | 0.423 n.s |
| P-value for interaction: 0.007 | | | | |

**--- Insert Figure 2 about here---**

**Figure 2** Odds ratios and 95% confidence intervals for failing a subject. The lower part of the figure includes only PBTS.

## Average grade

The average grades were significantly different between PBTS and controls in all five PRAEST subjects (Table 4). Female PBTS had significantly lower average grades compared to their controls in all subjects, while male PBTS only had a significantly lower average grades in Physical education and health and Music. The largest differences between PBTS and controls, including both females and males, was in Physical education and health, and the smallest one was in Crafts. There was a statistically significant interaction between sex and PBTS or control only on Art. In Art, females had a statistically significant higher average grade than males, and this difference was significantly larger in the control group. Neither age at diagnosis nor high- or low-grade tumours was a statistically significant factor for mean grade. Only in the model when we adjusted for fathers' education, age at diagnosis was statistically significant (p=0.040) in the subject Craft with children diagnosed at age 0-5 performing significantly worse than children treated at age 10-14.

**Table 4.** Average grade and estimated difference with 95% confidence interval (CI) for PBTS (n=475) vs. controls (n=2197) and interaction effect between sex and PBTS or control.

| | Average grade (95% CI) PBTS | Average grade (95% CI) Controls | Estimated difference (95% CI) PBTS - Controls | P-value PBTS - Controls |
|---|---|---|---|---|
| **Home and consumer studies** | | | | |
| All | 12.86 (12.40-13.32) | 13.78 (13.57-13.98) | -0.91 (-1.40 - -0.43) | <0.001 |
| Females | 13.91 (13.21-14.62) | 15.22 (14.94-15.50) | -1.31 (-1.99 - -0.63) | 0.001 |
| Males | 11.88 (11.31-12.45) | 12.43 (12.16-12.70) | -0.55 (-1.20 - -0.92) | 0.093 n.s |
| P-value for interaction: 0.113 n.s. | | | | |
| **Physical education and health** | | | | |
| All | 11.74 (11.26-12.21) | 13.79 (13.57-14.01) | -2.05 (-2.58 - -1.53) | <0.001 |
| Females | 11.13 (10.40-11.86) | 13.45 (13.14-13.76) | -2.32 (-3.07 - -1.57) | <0.001 |
| Males | 12.31 (11.70-12.92) | 14.10 (13.79-14.42) | -1.80 (-2.53- -1.06) | <0.001 |
| P-value for interaction: 0.328 n.s. | | | | |
| **Art** | | | | |
| All | 12.53(12.08-12.98) | 13.37 (13.17-13.57) | -0.85 (-1.32 - -0.37) | <0.001 |
| Females | 13.50 (12.77-14.23) | 14.84 (14.57-15.12) | -1.34 (-2.02- -0.66) | 0.001 |
| Males | 11.61 (11.09-12.13) | 12.00 (11.74-12.26) | -0.39 (-1.00 - -0.22) | 0.209 n.s. |
| P-value for interaction: 0.040 | | | | |
| **Crafts** | | | | |
| All | 12.80 (12.36-13.24) | 13.67 (13.48-13.86) | -0.866 (-1.32- -0.41) | <0.001 |
| Females | 13.20 (12.52-13.88) | 14.44 (14.18-14.70) | -1.24 (-1.89- -0.60) | 0.001 |
| Males | 12.43 (11.86-13.00) | 12.95 (12.68-13.21) | -0.52 (-1.15- -0.11) | 0.106 n.s. |
| P-value for interaction: 0.116 n.s. | | | | |
| **Music** | | | | |
| All | 11.88 (11.41-12.36) | 13.17 (12.97-13.38) | -1.29 (-1.78- -0.80) | <0.001 |
| Females | 12.35 (11.61-13.09) | 14.12 (13.84-14.40) | -1.77 (-2.46- -1.08) | <0.001 |
| Males | 11.45 (10.85-12.05) | 12.29 (12.00-12.58) | -0.84 (-1.53- -0.16) | 0.015 |
| P-value for interaction: 0.060 n.s. | | | | |

## Discussion

### Statement of the principal findings

This nationwide, population-based study revealed that the odds for failing a PRAEST subject were two to three times higher for female PBTS compared to their controls for all five subjects, whereas male PBTS did not fail any of the PRAEST subjects more often than their controls. PBTS also had significantly lower average grades in all five PRAEST subjects compared to their controls. When we compared the average grades of female and male PBTS with their controls, females differed from their controls in all subjects, while males only differed in Physical education and health and Music. Age at diagnosis was not a significant factor in any subject for failing. For average grade, age at diagnosis was significant only in one subject, Crafts, when we adjusted for the fathers' education, but not in the unadjusted models or when we adjusted for the mothers' education. High-grade tumours are usually treated with cranial radiotherapy, a modality known to cause cognitive and other deficits, but we did not find any significant impact of tumour grade on average grades or failing any of the subjects.

### Strengths and weaknesses of the study

The major strength of this study is that it is a nationwide, population-based study with grades from almost all children in Sweden born 1988-1996 and diagnosed with a brain tumour before the age of fifteen. We have analysed how this group of PBTS performed in the five different PRAEST subjects compared to their controls, and this is the only study of its kind. To address the issue of patients still undergoing treatment, we performed a sensitivity analysis, excluding all patients less than two years after diagnosis, and this did not have any appreciable impact on the results. We selected two years after diagnosis since very few patients, only those on second or third line treatments, would still be on active treatment. We consider that the main limitations are that we have no information about why the included

children failed a subject, or if any adaptations in the course work were made for the PBTS to facilitate their participation. In addition, as passing the PRAEST subjects is not required to qualify for post-secondary school in Sweden, we do not know if PBTS may have dropped any of these subjects voluntary in favour of the theoretical subjects Swedish, Mathematics or English, which are required for qualification. However, as all PRAEST subjects are mandatory, it is not possible for pupils to drop any subject unless the school have given permission to do so. Another limitation is the unknown reasons for missing data, as there are slightly more missing registry data from the PBTS than from the controls. This is discussed in more detail in Lönnerblad et al. (2019).

## Discussing important differences in results

Our results regarding Physical activity and health grades show that PBTS had a lower average grade and failed to a higher extent than controls in this subject, which is in line with previous studies by Lähteenmäki, et al. (2007), Ahomäki (2017) and Park (2018). In our study, both females and males differed more from their controls in Physical activity and health than in the other PRAEST subjects. Female PBTS failed this subject more frequently (14.3% vs. 7.0 % in the control group). The study by Yilmaz et al. (2014) of children treated for different kinds of cancers showed that controls performed better in the two subjects denoted Sports and Art/Music. In our study, Music revealed the second largest difference between PBTS and controls for both females and males, and was the second most common subject where female PBTS failed. Both the subjects Music and Physical activity and health can be very noisy which, at least partly, may explain why these two subjects are most affected, as auditory deficits and difficulties such as tinnitus are not unusual [28]. Another explanation could be that motor skills as well as muscle strength may be affected [8,29,30]. This could possibly affect the results in all the PRAEST subjects. As reported in our previous

study (Lönnerblad et al, 2019) age at diagnosis was a significant factor for a lower average grade in all three theoretical subjects Mathematics, Swedish and English. However, in the PRAEST subjects age at diagnosis does not seem to be important for average grade or failing. We can only speculate about the reasons of this. One explanation could be that it is easier to find strategies to compensate for cognitive and other late effects in the PRAEST subjects compared to the theoretical subjects; another explanation could be that it is easier to catch up in the PRAEST subjects. A third that there are no standardized tests in these subjects that the teacher have to consider when grading the children. Similarly, treatment for for a high-grade or a low-grade tumour did not have a statistically significant effect on grades in the risk of failing a PRAEST subject. The same was true also for Mathematics, Swedish and English (Lönnerblad et al., 2019), contrary to our expectations.

## Possible explanations and implications for clinicians and policymakers

The present study provides novel, important information, demonstrating that PBTS perform worse also in PRAEST subjects compared to controls, not only in theoretical subjects, which is known from previous studies. Given the benefits of the PRAEST subjects, acquiring skills for activities of daily living as well as promoting health and general well-being, the PBTS' higher rate of failing and lower average grades compared to controls is problematic. Adaptations and modifications should be considered to encourage higher participation and better performance, particularly for females. Clinicians, school staff and relatives to PBTS, along with policy makers, should all be included in the discussion about what can be done to ameliorate the negative effects of poor performance in school for PBTS, not only in theoretical but also in the PRAEST subjects.

## Unanswered questions and future research.

Females were two or three times more likely to fail the PRAEST subjects compared to their controls, while this was not seen in males. However, future larger studies would be interesting as they could possibly detect a difference also between males, as the difference between male PBTS and controls is much smaller. PRAEST subjects may have a lower status than the more theoretical subjects [22] and it is conceivable that females more often, for strategic reasons, drop the PRAEST subjects in favour of the theoretical subjects Swedish, Mathematics and English, since failing the latter ones precludes qualification for school years 10-12 (upper secondary school/high school). The reasons why PRAEST subjects are dropped or why female PBTS fail these subjects to a much higher extent than male PBTS, should be further investigated. Nevertheless, it is important that both females and males are offered appropriate support and special educational efforts to fully benefit from the PRAEST subjects. Future research should look closer into is how the different subjects could be adapted to enable the PBTS to participate in these subjects to a higher extent and further develop their practical and aesthetic skills.

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## Author's contribution

ML and EB conceived the study. ML collected and analysed the data and wrote the first draft. ML, IVH, KB and EB interpreted the results and critically revised the manuscript. All authors approved the final version.

## Ethical approval and data availability statement

The data that support the findings of this study are available from Swedish childhood cancer registry and Statistics Sweden. Ethical approval for this study was given by the Regional Ethical Review Board in Stockholm (no. 2017/995-31/5). Restrictions apply to the availability of these data, which were used under license for this study.

## Competing interests

None declared.

## Patient and public involvement

No patients were involved in the data collection or in the design of the study.

## Patient consent for publication

Not required.

## Abbreviations

| | |
|---|---|
| PBTS | Pediatric Brain Tumour Survivors |
| PRAEST subjects | Practical and Aesthetic subjects |

## References

1. Gustafsson G, Kogner P, Heyman M. *Childhood Cancer Incidence and Survival in Sweden 1984-2010*.; 2013. http://www.forskasverige.se/wp-content/uploads/ChildhoodCancerIncidenceandSurvivalinSweden1984_2010.pdf.

2. Robinson KE, Kuttesch JF, Champion JE, et al. A quantitative meta-analysis of neurocognitive sequelae in survivors of pediatric brain tumors. *Pediatric Blood & Cancer*. 2010;55(3):525-531. doi:10.1002/pbc.22568

3. Mulhern RK, Merchant TE, Gajjar A, Reddick WE, Kun LE. Late neurocognitive sequelae in survivors of brain tumours in childhood. *The Lancet Oncology*. 2004;5(7):399-408. doi:10.1016/S1470-2045(04)01507-4

4. Bitsko MJ, Cohen D, Dillon R, Harvey J, Krull K, Klosky JL. Psychosocial Late Effects in Pediatric Cancer Survivors: A Report From the Children's Oncology Group. *Pediatric Blood & Cancer*. 2016;63(2):337-343. doi:10.1002/pbc.25773

5. Andersen KK, Duun-Henriksen AK, Frederiksen MH, Winther JF. Ninth grade school performance in Danish childhood cancer survivors. *Br J Cancer*. 2017;116(3):398-404. doi:10.1038/bjc.2016.438

6. Lönnerblad M, van't Hooft I, Blomgren K, Berglund E. A nationwide, population-based study of school grades, delayed graduation, and qualification for school years 10-12, in children with brain tumors in Sweden. *Pediatr Blood Cancer*. October 2019. doi:10.1002/pbc.28014

7. Lähteenmäki PM, Harila-Saari A, Pukkala EI, Kyyrönen P, Salmi TT, Sankila R. Scholastic achievements of children with brain tumors at the end of comprehensive education: a nationwide, register-based study. *Neurology*. 2007;69(3):296-305.

8. Ness KK, Morris EB, Nolan VG, et al. Physical performance limitations among adult survivors of childhood brain tumors. *Cancer*. 2010;116(12):3034-3044. doi:10.1002/cncr.25051

9. Ahomäki R, Harila-Saari A, Matomäki J, Lähteenmäki PM. Non-graduation after comprehensive school, and early retirement but not unemployment are prominent in childhood cancer survivors—a Finnish registry-based study. *Journal of Cancer Survivorship*. 2017;11(2):284-294. doi:10.1007/s11764-016-0574-z

10. Park M, Park HJ, Lee JM, et al. School performance of childhood cancer survivors in Korea: A multi-institutional study on behalf of the Korean Society of Pediatric Hematology and Oncology. *Psycho-Oncology*. 2018;27(9):2257-2264. doi:10.1002/pon.4819

11. Yilmaz MC, Sari HY, Cetingul N, Kantar M, Erermis S, Aksoylar S. Determination of School-Related Problems in Children Treated for Cancer. *The Journal of School Nursing*. 2014;30(5):376-384. doi:10.1177/1059840513506942

12. Li WHC, Ho KY, Lam KKW, et al. Adventure-based training to promote physical activity and reduce fatigue among childhood cancer survivors: A randomized controlled

trial. *International Journal of Nursing Studies*. 2018;83:65-74. doi:10.1016/j.ijnurstu.2018.04.007

13. Sabel M, Sjölund A, Broeren J, et al. Active video gaming improves body coordination in survivors of childhood brain tumours. *Disability and Rehabilitation*. 2016;38(21):2073-2084. doi:10.3109/09638288.2015.1116619

14. Sabel M, Sjölund A, Broeren J, et al. Effects of physically active video gaming on cognition and activities of daily living in childhood brain tumor survivors: a randomized pilot study. *Neuro-Oncology Practice*. August 2016:npw020. doi:10.1093/nop/npw020

15. Riggs L, Piscione J, Laughlin S, et al. Exercise training for neural recovery in a restricted sample of pediatric brain tumor survivors: a controlled clinical trial with crossover of training versus no training. *NEUONC*. August 2016:now177. doi:10.1093/neuonc/now177

16. Swedish National Agency for Education. Curriculum for the compulsory school, preschool class and the leisure-time centre 2011. https://www.mah.se/upload/Nationella%20%c3%a4mnesprovet/Lgr11%20English.pdf. Accessed November 11, 2019.

17. Kunin-Batson A, Kadan-Lottick N, Zhu L, et al. Predictors of independent living status in adult survivors of childhood cancer: A report from the Childhood Cancer Survivor Study. *Pediatric Blood & Cancer*. 2011;57(7):1197-1203. doi:10.1002/pbc.22982

18. Gunn ME, Mört S, Arola M, et al. Quality of life and late-effects among childhood brain tumor survivors: a mixed method analysis. *Psycho-Oncology*. 2016;25(6):677-683. doi:10.1002/pon.3995

19. All-Party Parliamentary Group on Arts Health and Wellbeing. *Creative Health: The Arts for Health and Wellbeing*.; 2017. https://www.artshealthandwellbeing.org.uk/appg-inquiry/Publications/Creative_Health_Inquiry_Report_2017_-_Second_Edition.pdf. Accessed November 12, 2019.

20. Swedish National Agency for Education. Undervisning och lärande genom sinne, tanke och känsla. 2017. https://larportalen.skolverket.se/LarportalenAPI/api-v2/document/path/larportalen/material/inriktningar/4-specialpedagogik/Grundskola/101_Inkludering_och_skolans_praktik/del_08/Material/Flik/Del_08_MomentA/Artiklar/SP2_1-9_08_01_Sinne.docx. Accessed November 11, 2019.

21. Uggla L, Bonde L-O, Hammar U, Wrangsjö B, Gustafsson B. Music therapy supported the health-related quality of life for children undergoing haematopoietic stem cell transplants. *Acta Paediatr*. 2018;107(11):1986-1994. doi:10.1111/apa.14515

22. Tucquet B, Leung M. Music Therapy Services in Pediatric Oncology: A National Clinical Practice Review. *Journal of Pediatric Oncology Nursing*. 2014;31(6):327-338. doi:10.1177/1043454214533424

23. Lane MR. Arts in Health Care: A New Paradigm for Holistic Nursing Practice. *Journal of Holistic Nursing*. 2006;24(1):70-75. doi:10.1177/0898010105282465

24. Swedish National Agency for Education. *Syllabuses 2000: Compulsory School.* Stockholm: FRITZES; 2003.

25. Statistics Sweden. About Statistics Sweden. Statistiska Centralbyrån. http://www.scb.se/en/About-us/. Published 2018. Accessed December 12, 2018.

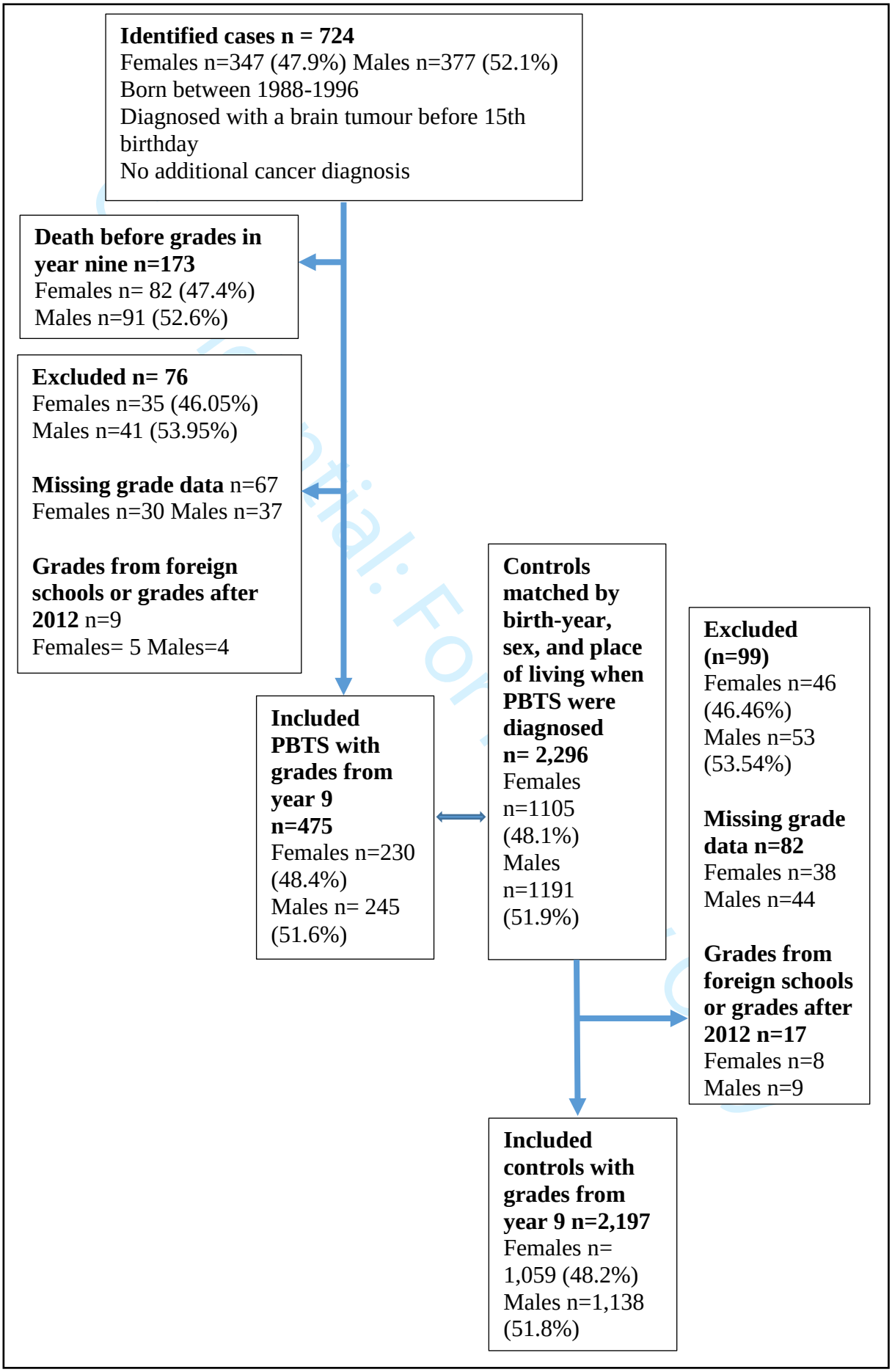
26. National Board of Health and Welfare. Täckningsgrader 2015 -Jämförelser mellan nationella kvalitetsregister och hälsodataregistren. Socialstyrelsen. https://www.socialstyrelsen.se/sok/?q=barncancerregistret. Published 2015. Accessed November 15, 2019.

27. Swedish National Agency for Education. Swedish Grades. https://www.skolverket.se/download/18.47fb451e167211613ef398/1542791697007/swedishgrades_bilaga.pdf. Accessed January 8, 2020.

28. Weiss A, Sommer G, Kasteler R, et al. Long-term auditory complications after childhood cancer: A report from the Swiss Childhood Cancer Survivor Study: Weiss et al. *Pediatr Blood Cancer*. 2017;64(2):364-373. doi:10.1002/pbc.26212

29. Zeltzer LK, Lu Q, Leisenring W, et al. Psychosocial Outcomes and Health-Related Quality of Life in Adult Childhood Cancer Survivors: A Report from the Childhood Cancer Survivor Study. *Cancer Epidemiology Biomarkers & Prevention*. 2008;17(2):435-446. doi:10.1158/1055-9965.EPI-07-2541

30. Rueegg CS, Michel G, Wengenroth L, et al. Physical Performance Limitations in Adolescent and Adult Survivors of Childhood Cancer and Their Siblings. Rota R, ed. *PLoS ONE*. 2012;7(10):e47944. doi:10.1371/journal.pone.0047944


Identified cases n = 724
Females n=347 (47.9%) Males n=377 (52.1%)
Born between 1988-1996
Diagnosed with a brain tumour before 15th birthday
No additional cancer diagnosis
Death before grades in year nine n=173
Females n= 82 (47.4%)
Males n=91 (52.6%)
Excluded n= 76
Females n=35 (46.05%)
Males n=41 (53.95%)
Missing grade data n=67
Females n=30 Males n=37
Grades from foreign schools or grades after 2012 n=9
Females= 5 Males=4
Included PBTS with grades from year 9 n=475
Females n=230 (48.4%)
Males n= 245 (51.6%)
Controls matched by birth-year, sex, and place of living when PBTS were diagnosed n= 2,296
Females n=1105 (48.1%)
Males n=1191 (51.9%)
Excluded (n=99)
Females n=46 (46.46%)
Males n=53 (53.54%)
Missing grade data n=82
Females n=38
Males n=44
Grades from foreign schools or grades after 2012 n=17
Females n=8
Males n=9
Included controls with grades from year 9 n=2,197
Females n= 1,059 (48.2%)
Males n=1,138 (51.8%)