SURVIVAL REPORT

Brain Tumour Registry of Canada (BTRC): Survival Report 2010 - 2015

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Executive Summary

This report provides the most comprehensive survival rate information on all primary brain and other central nervous tumours (herein referred to as primary brain tumours) among Canadians available to date and complements an incidence report published by the Brain Tumour Registry of Canada in May 2019 (Smith, Yuan, Walker & Davis, 2019). This report includes net survival rates for all primary brain tumours diagnosed between 2010-2015 in four Canadian provinces (Alberta, British Columbia, Manitoba, Ontario) representing 67% of the Canadian population. Net survival estimates are stratified by tumour site, malignant and non-malignant primary tumours, and by sex and age at diagnosis.

The net survival rates for all primary brain tumours at 1- and 5-years post-diagnosis was 0.77 and 0.64, respectively. This estimate includes 36% of brain tumours that are malignant and 64% that are non-malignant. The net survival rates for all primary malignant brain tumours at 1- and 5-years post-diagnosis was 0.52 and 0.25, respectively. The net survival rates for non-malignant brain tumours were higher for 1- and 5-years post-diagnosis at 0.91 and 0.85, respectively. Rates were similar between males and females and were highest among those diagnosed at younger ages, declining as age at diagnosis increased. Glioblastoma, the most common malignant tumour, continues to have an extremely poor prognosis (0.07 at 5 years). Conversely, meningioma, the most common non-malignant tumour, was associated with relatively good prognosis (0.87 at 5 years)

Patients with "*unclassified*" tumours consistently have poor survival rates, a finding that merits further exploration. However, these estimates should be interpreted with caution given the potential heterogeneity of tumour types in this category. Accurate surveillance estimates are dependent on accurate diagnosis data in cancer registries. It is our hope that these data will encourage and support histology specific basic science and clinical studies while providing evidence to guide advocacy and policy stakeholders in a joint effort to improve patient outcomes. We anticipate providing subsequent reports for all of Canada.

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1. Introduction

The Brain Tumour Registry of Canada (BTRC) has been established to ensure that every brain tumour in Canada is counted. Our goal is to provide high quality comprehensive estimates of incidence and survival rates for all primary brain and other central nervous system (CNS) tumours, including malignant and non-malignant tumours. These estimates are reported for subsets of the population defined by important patient characteristics, to better understand the patterns of occurrence and survival by tumour site, histology, sex, age, region and over time. This report describes net survival up to 5-years post-diagnosis as a complement to previously reported incidence rates that can be found at https://braintumourregistry.ca. This work has been generated through a continuing collaboration with four provincial cancer registries providing survival data from 2010-2015.

Data on survival are needed to inform clinical decision-making, support planning for research and policy development. As data accumulate over time, these baseline rates will become increasingly informative.

Our appreciation is extended to every individual that this information represents and to every cancer registry staff member whose work is reflected in this report.

2. Background

The current report is an in-depth compilation of cross provincial survival data reflecting the population experience in four provinces (Alberta, British Columbia, Manitoba, Ontario) for all primary brain tumours diagnosed between 2010 and 2015.

Brain tumours have among the worst net survival of all cancer types diagnosed among Canadians (Ellison, 2019). Brain tumours are a heterogeneous group of neoplasms, with a high degree of variation in prognosis across categories of histology and behavior. Clinical studies characterize prognosis in relatively controlled environments providing evidence of patient outcomes in the context of optimal care. Population surveillance studies, such as this one, provide some indication of patient outcomes in a real-world setting. This information can support decision makers as they work to understand and improve outcomes in population subgroups who are not achieving survival rates experienced in clinical studies.

To date, population-based estimates of brain tumour survival in Canada include patients with malignant tumours as information on non-malignant tumours has not been available until recently. This report extends beyond previous estimates of Brain and CNS cancers as it uses a broader definition

of primary brain tumours that incorporates additional sites and behaviors.

Plans are progressing to expand future surveillance reports to include incidence and survival information from all provinces and territories in Canada.

3. Methods

Ethics approval for this project was granted by Health Research Ethics Board of Alberta Cancer Committee. Each province completed local ethics approval or accepted the Alberta, ethics and facilitated data sharing agreements between their organization and the University of Alberta. Data were prepared and securely transferred by cancer registry staff to the central data analytic team at the University of Alberta.

3a: Brain and Other CNS Tumour Definition and Classification

Primary brain tumours (malignant and non-malignant) were defined as brain and other CNS tumours occurring at the following ICD-O3 sites: C700-C709, C710-C719, C720-C729, C751-C753, and C300. Tumours were classified into topography groups, based on ICD-O-3 topography codes, and histology groups based on both ICD-O-3 histology codes and ICD-O-3 behaviour codes. Topography and histology groups were based on classifications used in the CBTRUS report (Ostrom et al., 2016) and our previous incidence report (Appendix A and B). Tumours located in the brain that were incongruent with CBTRUS classification due to a combination of histology and behaviour codes were placed in a new histology category "not classified in CBTRUS". For example, codes 8010/0; 8050/1 were placed in this group. The ICDO-3 codes used to specific histological categories are shown in the incidence report, Appendix A. As patient numbers in this category are quite small, they will be reported in the tables but not discussed further.

3b. Data Collection

Patients diagnosed with all primary brain tumours registered in the four provincial cancer registries (Alberta, British Columbia, Manitoba, Ontario) between 2010 and 2015 were identified within each registry and data files, as approved, were shared with project analysts at the University of Alberta.

3c. Data Management

Multiple provincial datasets were combined into one file and all data elements were harmonized to facilitate calculating standardized estimates.

Data harmonization and analysis was conducted using SAS 9.4. Patients who were diagnosed and died on the same day, and patients that were classified as having a

diagnostic confirmation as "death certificate only" or "autopsy only" were excluded from the report (n=400) as they do not contribute to the survival profile. Patients with multiple primaries were not excluded from the analysis, as such we are presenting inclusive estimates.

3d: Data Analysis

Net survival reflects the probability of brain tumour survival in the absence of other causes of death. In other words, this estimate reflects the probability of survival that would be observed where the condition of interest (in this case primary brain tumours) is the only possible cause of death. Net survival estimates were selected to provide an estimate of patient outcomes that takes into consideration the experience of this patient population relative to the general population. Further, net survival estimates minimize biases that are present under certain circumstances in the more traditional survival estimates (Perme, Stare & Estve 2012).

A SAS macro written by Paul Dickman (Dickman 2011) and adapted to calculate Pohar-Perme net survival by Ron Dewar (Cancer Care Program of Nova Scotia Health Authority) was used. Life tables from CANSIM were used from 2010-16 and matched to the data by age, sex, year of diagnosis and province of diagnosis (Canadian Socio-Economic Information Management System [CANSIM] Table: 13-10-0114-01). Life table data was not available after 2016, so 2016 life table data was extended to the end of the followup period. These life tables were used to adjust for survival variation by age, sex, diagnosis year and province of diagnosis.

Estimates are not standardized by age using brain cancer standard populations from ICSS or Canadian data because those standard populations are dissimilar to the distribution of ages for the specific histologies examined in this report. While these estimates reflect current survival estimation methodology, they are not directly comparable to crude, relative or net survival estimates provided elsewhere within Canada or from other countries. Furthermore, the results in this report differ from CBTRUS results because the data are relatively recent, and over a short time period, limiting the follow-up and sample size.

Net survival estimates by tumour location for all primary brain tumours are presented using ICD-O-3 topography code groupings (Smith, Yuan, Walker & Davis, 2019). Estimates by tumour histology using CBTRUS and ICCC groupings (Steliarova-Foucher, Stiller, Lacour,

Kaatsch 2005) are shown for malignant and non-malignant tumours separately broken down by sex and age. Data are shown for specific groupings and not major groupings as shown in the incidence report. Minor groupings were exclusively used because major groupings would mask important variation in survival estimates. This decision reflects the prognosis in these categories being quite different, a pattern not readily reflected in summary estimates.

Age groupings were changed from the previous report and ICCC classifications were used in pediatric patients to reduce sparse data. Adult patients, ages 20 or older at diagnoses, are categorized by younger (20-54 yrs) and older (55+) age groups. Childhood tumours include those diagnosed under age 20. Tables for children use the ICCC histology classification (Steliarova-Foucher, Stiller, Lacour, & Kaatsch, 2005).

To ensure high quality estimates, all estimates based on less than 50 cases were suppressed. To ensure confidentiality of individuals underlying these data, point estimates are censored (not shown) in tables when the product of the estimate and number of patients alive at the start is less than 5. All counts were rounded to the nearest 5 as per guidelines from Statistics Canada (CCR, 2019).

4. Results

There were a total of 31,167 individuals diagnosed with primary brain tumours between 2010 and 2015, whose information is a part of their provincial cancer registry system. Survival rate information is reported in three sections; tumour site (location) by age group; malignant tumours by histology, sex and age group and non-malignant tumours by histology, sex and age group.

4a. Survival Rates by Tumour Site

Overall and site specific net survival rates for primary brain tumours in adults and children are shown in Tables 1 and 2. The percent malignant at each site is reported to help interpret the variation in rates across the sites.

Tumour behavior will explain some of the variation in these survival estimates so the following sections present malignant (4b) and non-malignant (4c) net survival rates separately.

As shown in Figure 1, overall primary brain tumour survival rates are lower in adults than in children. While survival rates are generally similar by site for children and adults; higher survival rates

are apparent in children than adults for temporal lobe, frontal lobe, cerebrum and "other locations within the brain" groupings.

In adults, tumours located within the cerebrum and lobes of the brain (C71.0-C71.4) have lower survival rates than other locations within the CNS (Figure 2 and Table 1). For example, at 1-year the expected survival of adult patients with a tumour located in the cerebrum, frontal lobe, temporal lobe, parietal lobe, occipital lobe, or other brain is less than 60% of that expected in the adult general population. Cranial nerve tumours were the only site where survival improved after 2-years. Three tumour locations have survival rates over 90% at five years after diagnoses. These locations (cranial, pituitary and craniopharyngeal duct, spinal cord and cauda equina) reflect 25% of the adult and 20% of the children in this population.

In children, the probability of surviving 1-year after diagnoses is over 90% with the exception of tumours in the brain stem and cerebrum. Variation in survival rates across tumour sites in children is not as great as in adults (Figure 2 and Table 2)

Figure 1: 5-year survival curves for adults (20+) and children (0-19) with malignant and non-malignant. brain and CNS tumours.

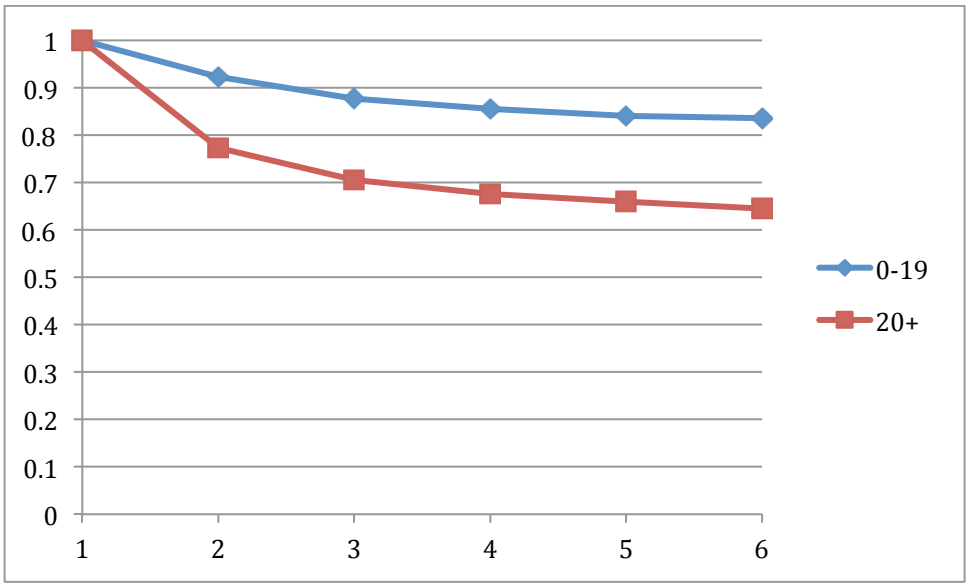
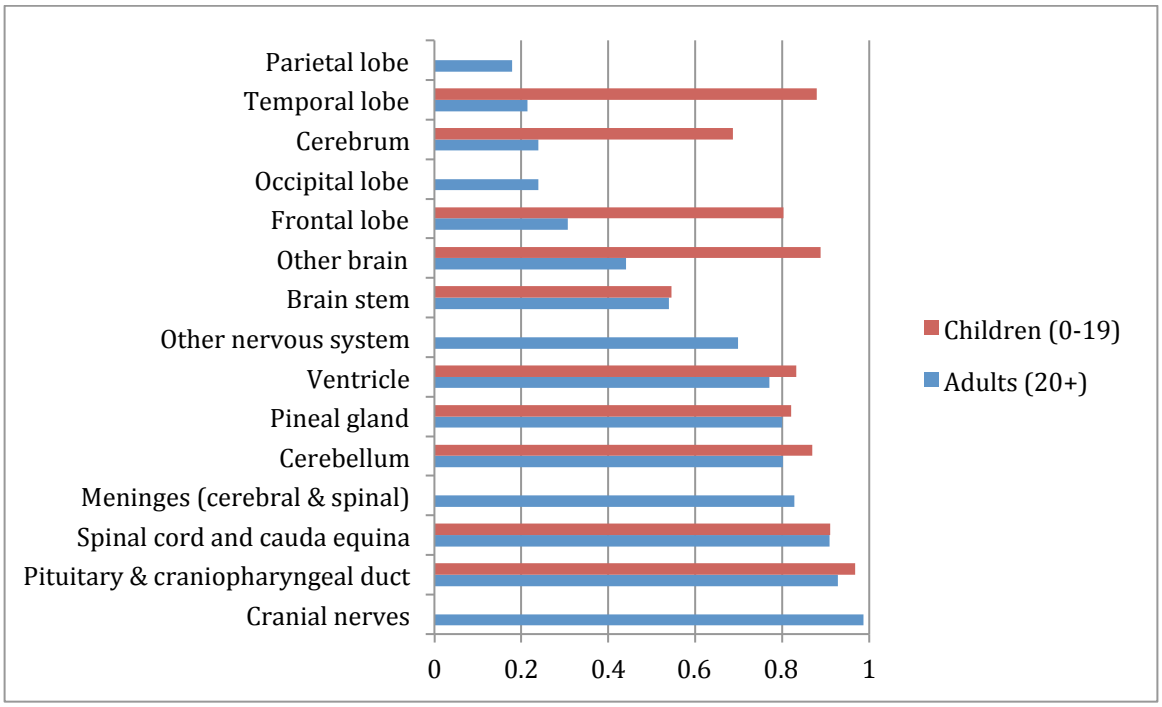


Figure 2: Survival at 5-years for adults (20+) and children (0-19) with malignant and non-malignant brain and CNS tumors by site.



4b. Survival rates for malignant brain tumours by sex, age group and histology.

The pattern of declining survival rates over time is the same in males and females (Figure 3). Declining survival rates with increasing age is apparent over the 5-year time period (Figure 4).

Survival rates for malignant primary brain tumours in adults are shown by histology in Table 3-5 and Figure 5. Glioblastoma, with the largest number of cases, has the lowest survival at all times post diagnosis compared to other tumours. Survival rates are also quite low in the "unclassified tumour" category. Conversely, pilocytic tumours, rare among adults, have the highest survival rates at all times post diagnosis. While there is no overall difference in survival rates by sex, 2 exceptions are present when assessed within histology. Males with meningioma have poorer survival rates than females (0.47 vs 0.60 at 5 years) while males with malignant glioma NOS have a better survival rate than females (0.38 vs 0.31 at 5 years). All other survival rate contrasts are <5% across the sexes at 5 years (Table 4). A pattern of declining survival rates by increasing age group is consistent across histologies and time periods (Table 5).

Survival rates for malignant primary brain tumours by histology in children shown in Table 6. The category of "other gliomas" has the lowest survival rate in children at all time periods (Table 6).

Among adults with malignant brain tumours the overall net survival rates are 0.52 at 1-year, 0.36 at 2-years and 0.25 at 5-years. Among children with malignant brain tumours the overall net survival rates are higher at 0.87 at 1 year, 0.79 at 2 years and 0.74 at five years compared to adults (Figure 4). Rates in adult males and adult females are similar at 0.25 at 5-years post diagnosis.

Figure 3: 5-year survival curves for adults (20+) with malignant brain and CNS tumours by sex

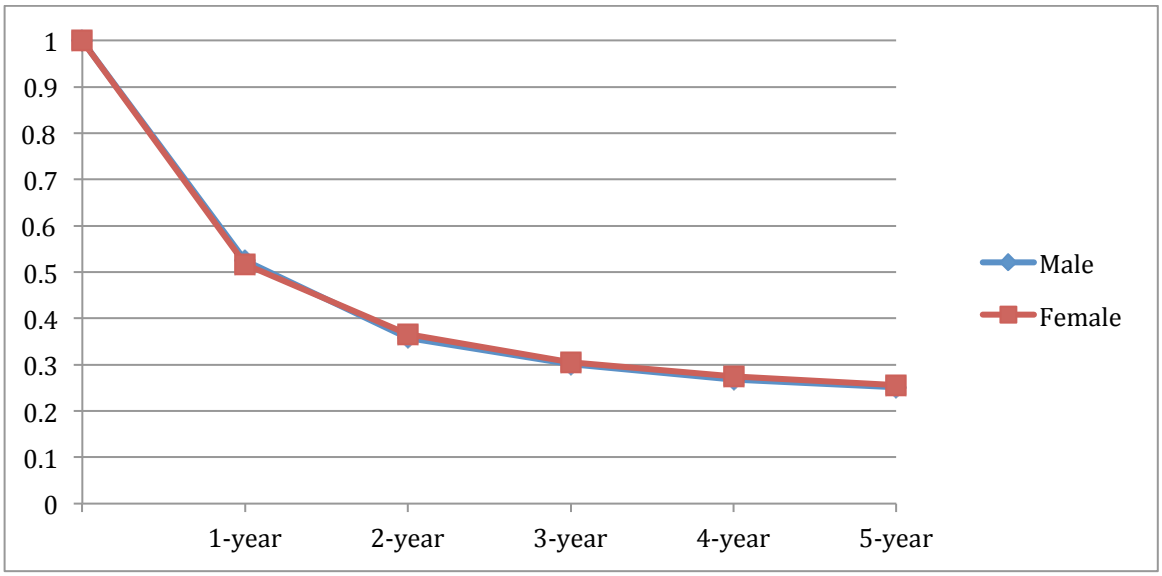


Figure 4: 5-year survival curves for adults (55+), young adults (20-54), and children (0-19) with malignant brain and CNS tumours by age category

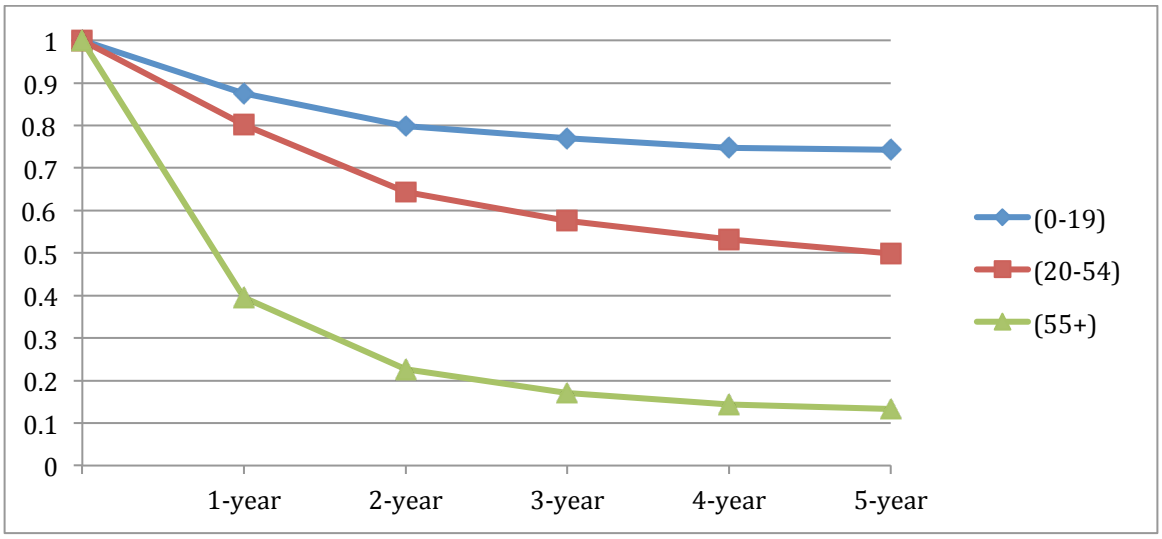


Figure 5: 5-year survival for adults (20+) with malignant brain and CNS tumors by histology.

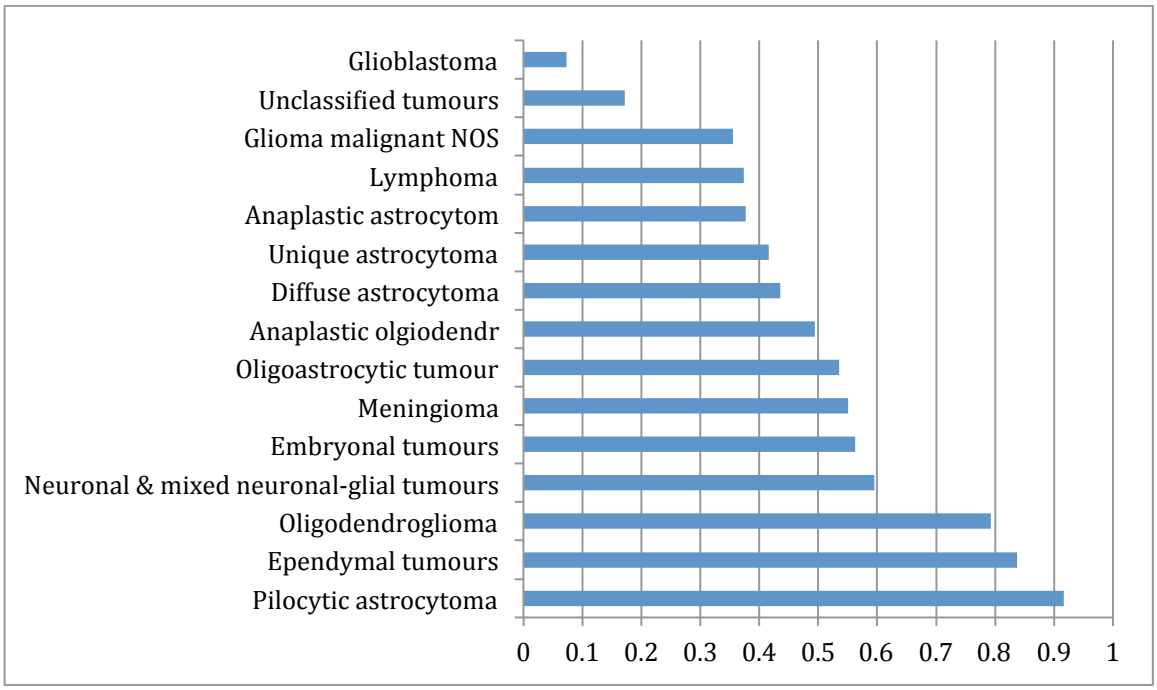
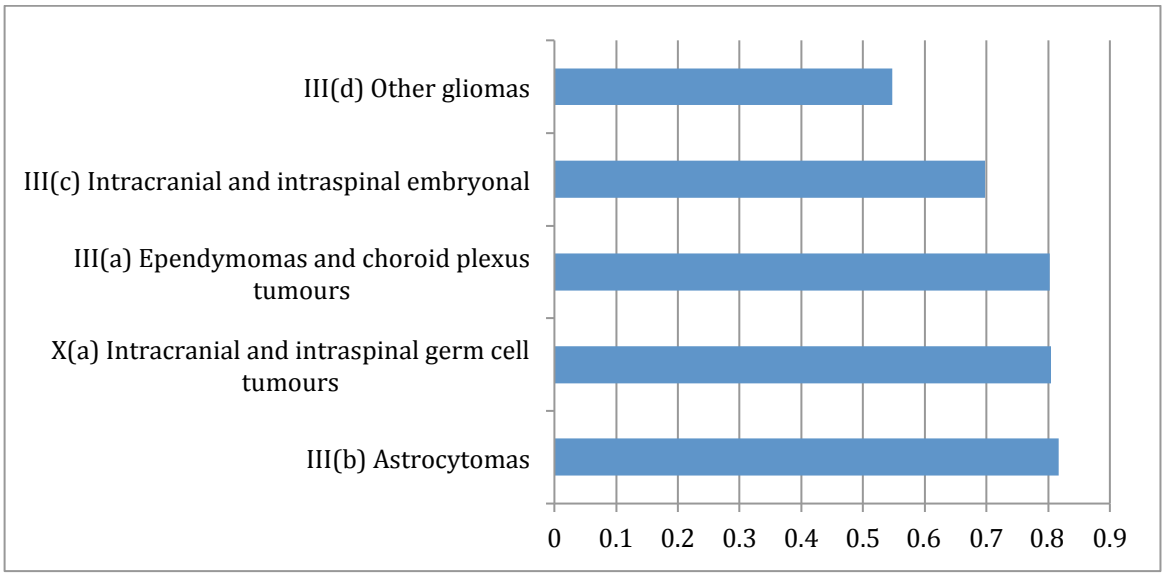


Figure 6: 5-year survival for children (0-19) with malignant brain and CNS tumours by ICCC histology.



4c. Survival Rates for non-malignant tumour by sex, age group and histology.

As shown previously in Tables 3 and 7, survival rates are higher for non-malignant than malignant tumours. The pattern of declining survival rates over time is similar in males and females with non-malignant tumours (Figure 7). A pattern of declining survival rates with increasing age is also apparent in non-malignant tumours over the 5 year time period (Figure 8), although the decline over time is more modest.

Survival rates for non-malignant primary brain tumours in adults are shown by histology in Table 7-9 and Figure 9. Meningiomas are the largest group of non-malignant tumours and present with a 5-year survival rate of 0.87, which is slightly lower in males (0.84) than females (0.88). Rates are substantially higher in young adults (0.95) than older adults (0.83) with meningiomas. Unclassified tumours are the second largest category of non-malignant tumours and this group has the lowest survival rate (0.65). Rates for unclassified tumours are lower in males (0.60) than females (0.68) and decline from 0.86 in young adults to 0.57 is older adults.

Survival rates for non-malignant primary brain tumours by histology in children are shown in Table 10 and Figure 10. All survival rates are 95% or higher.

5. Discussion

There are a number of methodological considerations to consider with respect to the survival rates presented. The Pohar-Perme method for estimating net survival rates is a relatively new method that was developed to reduce biases inherent with alternative approaches. Comparison of estimates can be accomplished if the same methods have been used. However, the lack of standardization to an external reference (by age) limits the ability to compare these estimates to other population estimates . However, within this report, estimates can be compared with each other.

As our collaborative efforts to ensure complete registration of all primary brain tumours began with 2010 data, complete case counts could not be assured from earlier years. As such, data on new cases from 2010-2015 are included in this report making with follow up through September of 2018 at the latest. As such, the 5-year estimates reported here are based on limited follow-up information.

Figure 7: 5-year survival curves for adults (20+) with non-malignant brain and CNS tumours by sex

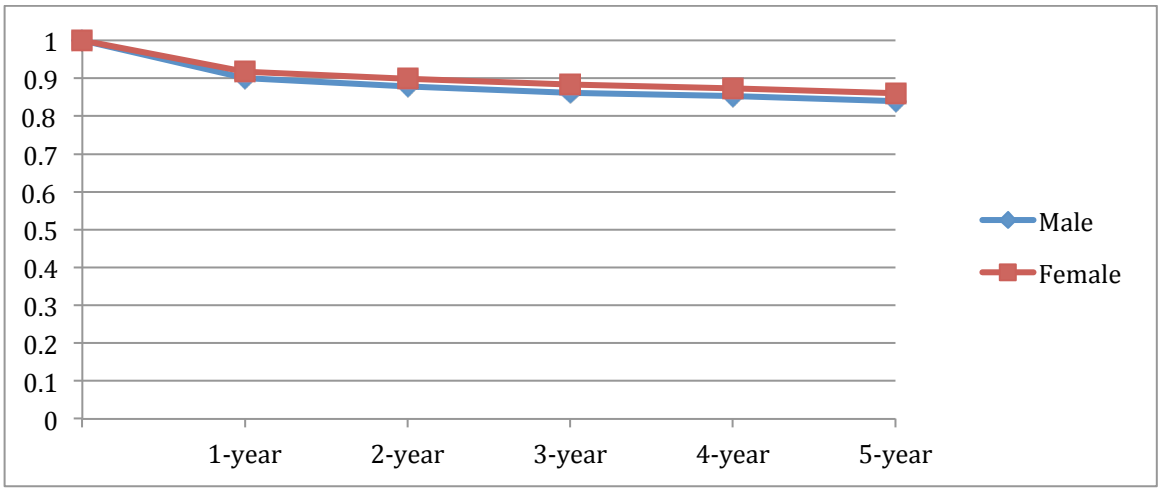


Figure 8: 5-year survival curves for adults (55+), young adults (20-54), and children (0-19) with non-malignant brain and CNS tumours by age-group

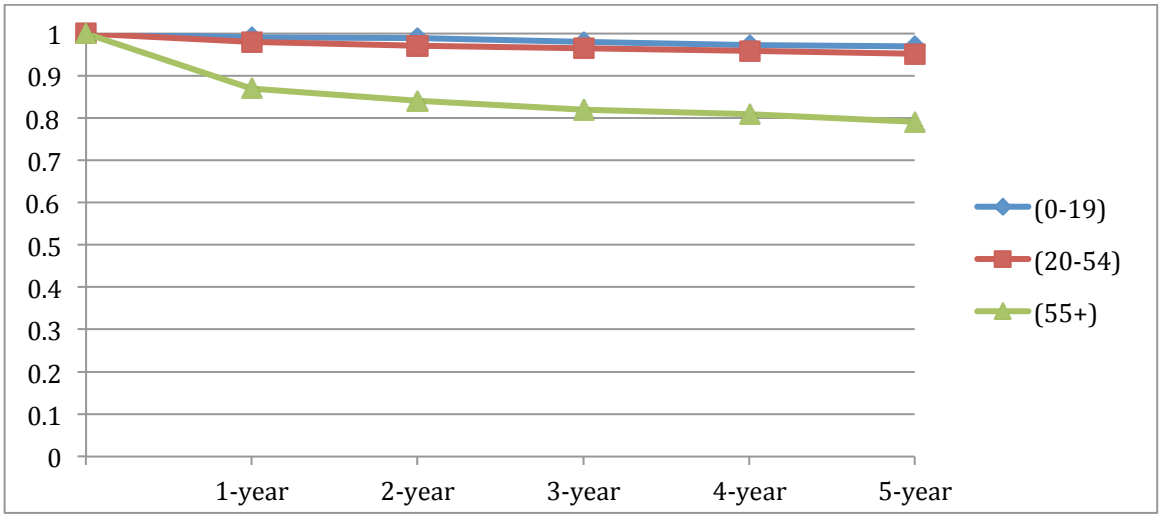


Figure 9: 5-year survival for adults (20+) with non-malignant brain and CNS tumours by CBTRUS histology.

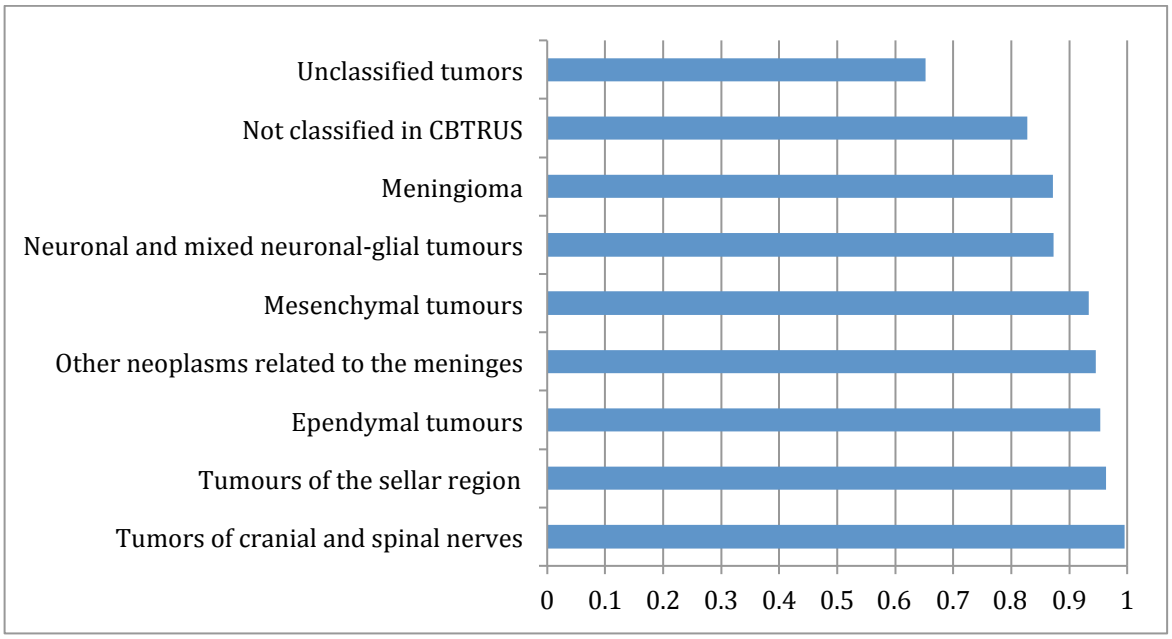
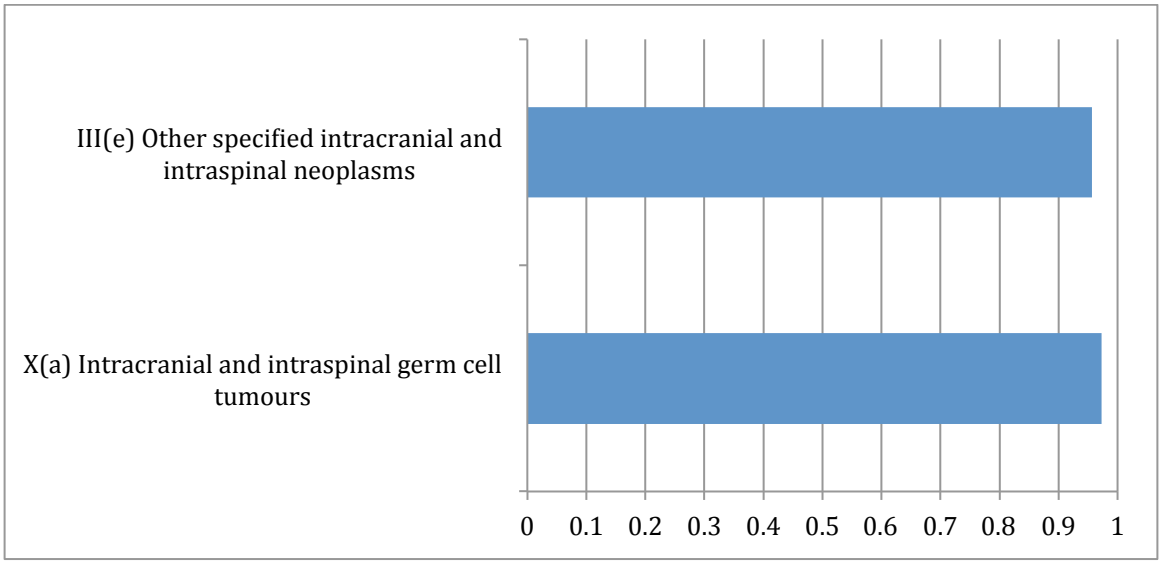


Figure 10: 5-year survival for children (0-19) with non-malignant brain and CNS tumours by ICCC histology.



As data accumulate, rates can be calculated for longer follow-up intervals. This will be particularly important for understanding survival patterns for the non-malignant tumours.

For consistency with other brain tumour surveillance information we elected to group tumours by site and histology using schemas provided by the Central Brain Tumor Registry of the United States. As the Canadian population reflects approximately 1/10th of the US population were not able to be reported due to sparse numbers.

The low survival rates for patients in the unclassified category of tumours are of concern and it is important to understand whether this a real or artifactual finding. As noted in our incidence report this category includes a large number of patients (twice the proportion reported by CBTRUS) and we suspect that older and female patients are more likely to fall into this category than other demographic groups. If so, survival estimates of all groups may not be accurately reflected here. Additionally, the potentially heterogeneous nature of the tumours included in this category complicate accurate interpretation of these estimates. It is also possible that these tumours are unclassified for legitimate clinical reasons.

This report reflects 4 provinces representing 67% of the Canadian population. As more provinces are included over time, estimates for rare tumour types (not included here) will become available.

To date, available Canadian data primarily reflected malignant brain tumours and did not include the non-malignant brain tumours reported here. Our grouping of malignant tumours include C75.1, C75.2, C75.3 and C30.0 as reported by CBTRUS so that these estimates for malignant brain tumours are not exactly comparable to available Canadian Cancer Statistics (CCS) estimates (Canadian Cancer Statistics Advisory Committee 2019). However, to determine how reliable our estimates were, we estimated age standardized 5-year survival using the CCS classification for "Brain and CNS" tumours. Our results were 0.22 for all patients, 0.24 for females and 0.21 for males. These numbers are very similar to the 5-year survival for those with brain and CNS tumours reported in the 2019 CCS report, with survival rates of 0.23 for all patients, 0.24 for females and 0.22 for males. These

results should be placed in the context of what detailed Canadian data we do have. Malignant brain tumour survival rates (2004-2008) are better for males than females up to age 75 years (Ellison 2016). Improvements in overall survival of these tumours are modest from 1992 to current is 2.1% (Ellison 2019). These improvements have been the largest in the 15-44 year olds (Ellison 2019).

We anticipate that the information in this initial survival report will support researchers as they plan histologic specific clinical studies. It is hoped that this evidence may also guide advocacy and policy decisions and create focused questions to be addressed within the neurooncology community. Over time we anticipate extending reports to include information on all primary brain tumours from all provinces.

6. Concluding Comments

This report includes the most comprehensive survival rate estimates on all primary brain and other CNS tumours in the Canadian context available to date. The validity of this information is supported given that patterns observed are similar to those reported elsewhere. In general, malignant tumours have lower survival rates than non-malignant tumours, there are few differences in survival rates by sex and survival rates decline as age at diagnosis increases. Some uncertainty in the estimates arises from the large number of cases (19%) that are "unclassified", and sparse data for some categories. Some limitations of this report relate to the absence of molecular marker information which has become important for creating homogenous tumour categories and relates to prognosis.

7. Acknowledgements

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