**Long term quality of life outcomes following surgical resection alone for benign paediatric intracranial tumours**

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**Declarations**

Compliance with Ethical Standards

Author contributions: Conception and design: RM, CLM, MDJ. Data collection: SK, RM, CPM, MTF, CM, BP Data analysis: SK, AI. Data interpretation: SK, AI, RM, CPM, DH, MTF, BP, CLM, MDJ. Manuscript writing, revision, and completion: all authors

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interests/competing interests: The authors have no conflicts of interest to declare that are relevant to the content of this article.

Ethical approval**:** This study was approved by the East of England Essex Research Ethics Committee (REC No. 18/EE/0225)

Availability of data: Anonymized data are available (upon reasonable request) from the corresponding author.

Consent for publication: Not required

***Abstract***

**Purpose**Survivors of paediatric intracranial tumours are at increased risk of psychosocial, neuro-developmental, and functional impairment. This study aimed to evaluate long-term health-related quality-of-life (HRQOL) outcomes in patients with benign paediatric brain tumours treated curatively with surgical resection alone.

**Methodology**  
This was a cross-sectional study of patients with benign paediatric intracranial tumours managed with surgery alone between 2000 and 2015. Eligible patients with a minimum of 5-years follow-up after surgery were identified. Validated health-related quality of life (HRQOL) questionnaires were administered: SF-36, QLQ-BN20, QLQ-C30 and PedsQLTM.

**Results**

Twenty-three patients participated (median age at surgery 13 years; range 1-18; 12 male). The most common diagnosis was pilocytic astrocytoma (n=15). Median time from surgery to participation was 11 years(range 6-19). Fourteen patients achieved A-level qualifications and two obtained an undergraduate degree. Twelve patients were employed, eight were studying and three were unemployed or volunteering.

HRQOL outcomes demonstrated significant limitation from social functioning (*p*=0.03) and cognitive functioning (*p=*0.023) compared to the general population. Patients also experienced higher rates of loss of appetite (*p=*0.009) and nausea and vomiting (*p=*0.031).

Ten patients were under transitional teenager and young-adult (TYA) clinic follow-up. TYA patients achieved higher levels of education (*p=*0.014), were more likely to hold a driver’s license (*p=*0.041) compared to patients not followed-up through these services.

**Conclusions**

Childhood brain-tumour survivors have a greater risk of developing psychological, neuro-cognitive and physical impairment. Early comprehensive assessment, specialist healthcare and TYA services are vital to support these patients.

**Introduction**

Intracranial tumours are the second most common neoplasm in children under 15 years of age, with approximately 400 cases diagnosed in the UK each year [1-3]. While most paediatric brain tumours are treated with combinations of surgery, chemotherapy and radiotherapy [4, 5], a proportion are amenable to surgical resection alone which may be curative [6]. Prognosis varies according to histological diagnosis and ranges from less than 5% 5-year survival for diffuse intrinsic pontine glioma, [4] up to over 90% 5-year survival for cerebellar pilocytic astrocytoma [7].

Traditionally, neurosurgical outcomes have focused on surgical and neurological morbidity, and mortality[2, 8]. Paediatric patients experience higher morbidity rates than adults after neuro-oncology surgery, but the existing measures to quantify this have significant limitations[9]. Increasingly, health related quality-of-life (HRQOL) indicators are recognised as important measures of patients’ wellbeing, encompassing not just clinical outcomes, but also functional, neurocognitive and psychosocial aspects [10].

Survivors of paediatric central nervous system (CNS) malignancies have among the highest risks of late mortality (cumulative late mortality at 30 years of 25.8%) of all primary paediatric cancers, alongside an increased risk of tumour recurrence, secondary malignancy and chronic medical conditions[11]. Long term survivors of paediatric brain tumours are also at risk of neurocognitive impairment, with an associated social impact [12-15]. Survivors of paediatric brain tumours are also more likely to have impairment in psychosocial and lifestyle outcomes, including increased difficulties forming peer relationships, increased social difficulties in the school environment, being less likely to drive a car, and reduced employment [6, 8]. A large proportion of this concomitant morbidity may present insidiously, often beyond our traditional 5-year follow-up timeline leading to an underestimation of the true impact of childhood intracranial brain tumours [16].

While the current literature details the long-term effects associated with radiotherapy and chemotherapy [17-20], there are comparatively few studies evaluating the late-effects and long-term outcomes of curative surgery as the sole treatment for paediatric brain tumours [16, 21]. Neurocognitive deficits in survivors of paediatric brain tumours are common, particularly in patients receiving radiotherapy, with significantly lower intelligent quotient (IQ) demonstrated in 5-year survival studies [16, 22]. Similar reports are seen in patients receiving methotrexate chemotherapy, with 40-100% of long-term survivors experiencing deficits in IQ, visuo-spatial perception, learning ability and adaptive behaviours[18]. Moreover, short-term post-operative deficits in cognitive processing, verbal memory, motor outputs and visuospatial control have been identified in patients prior to radiotherapy[11].

Study Objectives

The aim of this study was to evaluate the long-term effects and adverse outcomes encountered by patients treated with curative surgical resection alone for histologically benign paediatric intracranial tumours, and to assess the subsequent impact on health-related quality of life (HRQOL) outcomes.

**Methods**

Study design:

This cross-sectional study was conducted at the Walton Centre NHS Foundation Trust, a tertiary neurosciences hospital, and Alder Hey Children’s NHS Foundation Trust, a large paediatric hospital in the United Kingdom offering a tertiary and quaternary paediatric neuro-oncology surgery service.

Ethical Approval

Ethical approval for this study was provided by the local research committee. An integrated research application system (IRAS) ethics submission was approved by the East of England Essex Research Ethics Committee (REC No. 18/EE/0225).

Patient identification

Patients diagnosed with a benign intracranial tumour aged <18 years between January 2000 to December 2015 (inclusive) were identified through pre-existing medical records held at Alder Hey Children’s NHS Foundation Trust and The Walton Centre NHS Foundation Trust, Liverpool. Patients were eligible to participate if they were aged under 18 years at time of diagnosis, age 16 years or over at the time of consent to participate in the study, had a pathological diagnosis of histologically benign intracranial tumour (including, but not limited to, pilocytic astrocytoma, low-grade glioma, vestibular schwannoma, meningioma), had gross total resection achieved during the course of treatment (defined as macroscopically by the operating surgeon and radiologically on post-operative imaging, which in some cases was achieved after multiple surgeries), had received the surgical treatment of their tumour exclusively at either Alder Hey Children’s NHS Foundation Trust or The Walton Centre NHS Foundation Trust (allowing for initial presentation and shared care management within the regional neurosurgery network). Patients were excluded if they were less than 5 years from time of operation (to exclude patients remaining at risk of tumour recurrence), lacked the capacity to consent to participate in the study themselves (e.g. due to significant neurological deficit or other disease), were treated with adjuvant or neo-adjuvant chemotherapy and/or radiotherapy, had metastatic disease, disease relapse or progression, radiological evidence of pseudoprogression, or secondary neoplastic disease (at any site), had a diagnosis of craniopharyngioma, had cerebral neurological insult (e.g. trauma, meningitis, stroke) prior to presenting with a brain tumour, had a congenital or acquired neurological disease present prior to diagnosis of intracranial tumour (e.g. cerebral palsy, tuberous sclerosis, neurofibromatosis).

Clinicopathological features

A retrospective case note review of eligible cases was performed to collect the following baseline clinical data: diagnosis and tumour grade (according to the WHO classification used at the time of surgery), age at diagnosis, clinical presentation, operative details (including date of surgery, type of surgery, extent of surgical resection), immediate post-operative complications, date of discharge following surgery, length of follow-up, documented long-term problems, tumour recurrence, premorbid health status (including clinical, behavioural and educational diagnoses/problems present prior to tumour diagnosis).

Eligible patients were contacted by letter and invited to participate in the study. Patients giving consent to participate were then asked to complete and return study specific and validated HRQOL questionnaires. A second round of invitation to participate and consent forms was sent to non-responders. If written consent was still not returned, a telephone call was made to patients to confirm receipt of study information and to offer a further opportunity to discuss the study, to optimise patient retention given the rarity of conditions being assessed. No further attempts were made if patients were not contactable. Patients who declined to participate or who could not be contacted were excluded.

Questionnaires

All patients completed a study specific questionnaire identifying level of education, employment status, active medical problems, current medications, and engagement with healthcare professionals. The following four validated HRQOL questionnaires were administered:

General HRQOL was assessed via the 36-item short-form survey (SF-36) across eight domains (physical functioning, limitations from physical health, limitations from emotional problems, fatigue, emotional well-being, social functioning, pain, and a general health score)[23].

Cancer treatment related QOL was assessed via the European Organisation for Research and Treatment of Cancer quality of life questionnaire (EORTC QLQ-C30). Outcomes were evaluated across five functional domains: physical, role, cognitive, emotional, and social, three symptom domains (fatigue, pain and nausea and vomiting), five single additional symptoms (dyspnoea, insomnia, loss of appetite, constipation, and diarrhea) and finally a perceived financial impact and global health status score[24].

A brain tumour specific questionnaire (EORTC QLQ-BN20) consisting of 20 questions evaluated seven symptom domains (headache, seizure, drowsiness, hair loss, itchiness, leg weakness and bladder control) and four functional domains (future uncertainty, motor dysfunction, visual disorder, and communication deficit)[25].

Patients aged 16 years and less than 18 years of age at the time of receipt of consent were also asked to complete the paediatric quality of life inventory (PedsQLTM) which assessed three psychosocial domains (emotional, social, and school functioning) and one physical health score[26].

Data and statistical analysis

Raw data underwent processing as described by the original questionnaire instructions, these were scaled and grouped into the various domains for analysis. Higher mean values represent improved HRQOL outcomes across questionnaires. Mean values and standard deviation (SD) were calculated and compared to normal population reference values provided by each questionnaire publisher or from normative values sourced from current literature[23, 27, 28].

Data from questionnaires was compiled into a database, anonymity was preserved by removing patient identifiable information and maintaining secure storage of all study related documents. Data analysis was conducted using Microsoft Excel (IBM Corp, 2019) and SPSS (Version 25, Windows, Armonk, NY: IBM Corp). Descriptive statistics were conducted, mean values and standard deviations for domains were reported and compared to published normative population values. P values of <0.05 were considered statistically significant, corresponding to a confidence interval of 95%. Patient reported outcome measures were reported following the international society for quality of life (ISOQOL) research guidelines[29].

**Results**

Below a strengthening the reporting of observational studies in epidemiology (STROBE)[30] flow diagram, figure 1, illustrates the recruitment process

Figure 1 – STROBE flow diagram illustrating patient recruitment and exclusion process

Patients’ ineligible excluded (inappropriate tumour histology) (n=10)

Patients meeting inclusion/exclusion criteria (n=69)

Patients identified through medical records

Patients enrolled and invited to participate (n=59)

Patients excluded (declined/unable to contact) (n=5)

Patients anonymised and clinical/questionnaire data collected (n=54)

Patients not responded or incomplete data set excluded (n=31)

Patients included in final data analysis (n=23)

Demographics

Patient demographics are summarised in table 1. Twenty-three patients met the inclusion criteria (see table 1). Median age at surgery was 13 years old (range 1-18), twelve patients were male (52.2%). Median age at study participation was 21 years old (range 17-26).

The commonest presenting symptoms were of raised intracranial pressure (ICP) (69.6%), focal neurological deficit (21.7%) and balance or gait issues (17.4%). Thirteen patients had infratentorial tumours (56.5%). Most tumours arose from the cerebellum (n=11, 47.8%), followed by ventricular lesions (n=5, 21.7%). Pilocytic astrocytoma WHO grade I was the commonest pathology (n=15; 65.2%).

Median length of stay was 7 days, with a range of 3-88 days. Six patients (26.1%) experienced morbidity in the first 7 days post-operatively, whilst ten patients (43.5%) experienced morbidity within the first 30 days post-operatively. Five patients underwent more than 1 operation to achieve complete resection.

Median time from surgery to study participation was 11 years (range 6-19), with median time from surgery to last follow-up 7.5 years (range 3-13). Ten patients (43.5%) reported they were under follow-up in a transitional teenager and young-adult (TYA) clinic, whilst thirteen patients were discharged as children with no further follow-up.

At the time of enrolment in the study, fourteen patients (60.9%) had achieved an A-level qualification, whilst two patients (8.7%) had completed an undergraduate degree. Eight patients were in full-time education, seven were in full-time employment, five were in part-time employment and three were either volunteering or not working. Of those employed, six patients (50%) worked in retail or customer services, three in hospitality (25%), and three patients worked across finance, education or were self-employed (8.3%). Fifteen patients (65%) held a driver’s license, however only twelve (52%) reported driving a car.

The response rate from enrolled, invited patients was 38.98% (n = 23). From our non-responder cohort of thirty-five patients, eighteen were male (51.4%), median age at surgery was 13 years old (range 4-16). Other baseline characteristics were similar to the patients included in the final study analysis.

Quality of life questionnaires

Table 2 summarises the HRQOL results. Compared to normal reference values for the SF-36 questionnaire[27], our cohort demonstrated statistically significant difference in limitation from emotional problems (*p=*0.037), fatigue (*p=*0.016) and social functioning (*p=*0.03). Mean physical functioning (*p=*0.59), limitation from physical functioning (*p=*0.125), emotional well-being (*p=*0.064), pain (*p=* 0.051) and general health (*p=* 0.057) were not statistically significant.

From the EORTC QLQ-C30 and brain tumour specific questionnaire EORTC QLQ-BN20, compared to normative reference values [28], our cohort demonstrated significantly different mean physical functioning (*p=*0.033), cognitive functioning (*p=*0.023), nausea and vomiting value (*p=*0.031) and loss of appetite value (*p=*0.009). However, role functioning (*p=*0.11), emotional functioning (*p=*0.41) and social functioning (*p=*0.31), mean fatigue (*p=*0.141), pain (*p=*0.066), dyspnoea (*p=*0.057), insomnia (*p=*0.058), constipation (*p=*0.349), diarrhoea (*p=*0.131), perceived financial impact (*p=*0.077) and global health status (*p=*0.062) were not statistically significant.

Paediatric questionnaire

Two patients also completed the additional PEDS-QL questionnaire, mean physical health value was 96.9 (SD 4.4) and mean psychosocial health value was 90 (SD 4.7).

TYA analysis

Analysis of those patients who remained under follow-up was performed and compared to those patients who were no longer under follow-up to determine the social outcomes between TYA and non-TYA cohorts. Ten patients (43%) were transitioned into TYA follow-up clinics. In the TYA cohort, 70% of patients achieved an A-level education or higher; 40% were working and another 40% were studying. Compared to non-TYA cohort in which 69.2% achieved an A-level or higher education; 62% were working and 31% were studying. Seventy percent of TYA patients held a driver’s license and 40% were driving, whilst 61.5% of non-TYA patients both had a license and were driving. Comparing mean values between these cohorts; higher education level achieved (*p=*0.014) and having a driver’s license (*p=*0.041) were statistically significant. There were no differences in the rates of employment (*p=*0.135), education (*p=*0.08) or driving (*p=*0.133) between the groups.

**Discussion**

In this cross-sectional study of patients with paediatric brain tumours treated with surgery alone, and who are aged 18 years or over, we have shown that a subset of health related QOL outcomes were significantly reduced across a range of domains including physical functioning, emotional well-being, psychosocial health, symptomatology, education, and employment. Moreover, our study also demonstrated that generally other HRQOL outcomes in patients with paediatric brain tumours treated curatively with surgery alone were similar to the general population.

To date, there is limited research into the long-term effects and QOL outcomes in patients treated with surgical resection alone for benign paediatric intracranial tumours. Most of the published literature is focused on paediatric intracranial malignant tumours which have a major impact on patients’ quality of life [2, 31]. Childhood cancer affects the QOL of the entire family and parents of children with cancer often report more severe illness burden than that perceived by the patients themselves [31-33]. As such child inclusive research, which aids understanding of children's perceptions of their own QOL, is highly beneficial[34]. The aim of this study was to determine the long-term HRQOL outcomes in patients treated with curative surgical resection alone for benign paediatric intracranial tumours. Our study cohort of twenty-three patients had a similar range of presenting symptoms (e.g., raised intracranial pressure in 69.6%), anatomical locations and pathology types (e.g., pilocytic astrocytoma in 65.2%) in keeping with other studies of paediatric brain tumours [35-37]. The median length of inpatient stay was 7 days (range 3-88) in our cohort, which was slightly longer than previous studies of surgically treated paediatric brain tumour patients [38]. Characteristics of our included study cohort was similar to that of the non-responders, moreover, given the patient cohort being studied and rarity of the conditions being assessed, the response rate was appropriate and representative.

Our cohort demonstrated 60.9% of survivors had achieved an A-level qualification whilst only 8.7% went on to pursue a higher-level undergraduate degree. This was much lower than the published national figures in the United Kingdom of 65.6% completing A-level equivalent education and 46.5% obtaining an undergraduate degree[39], although specific reasons for this disparity were not assessed in this study. Previous studies have found that survivors of paediatric brain tumours have increased educational needs and as such may be less inclined to pursue higher education [3, 40]. However, other studies have reported that encouraging reintegration of children after brain tumour treatment into school improves psychosocial development, resilience, overall performance and academic motivation[41]. As such, assessment of academic and psychosocial needs and systematic follow-up of survivors would help to encourage reintegration into education.

From an employment perspective, 52.2% of respondents were employed; 30.4% in full-time and 21.7% in part-time employment. Most patients worked in the service sector (83.3%). Almost half of our cohort reported not driving (48%), the causes of this were not studied. An observational study amongst all types of paediatric brain-tumour survivors describes high rates of unemployment (32%) and numerous factors relating to earlier termination of employment compared to the general population [42]. In our study, patients experienced even higher rates of unemployment, and this highlights the need for a more comprehensive education and welfare system to support these individuals. Current studies evaluating outcomes in brain tumours tend to focus on survival, time to recurrence and QOL indicators following chemo-radiotherapy [43-46]. QOL outcomes and qualitative research are crucial for providing holistic management of these patients, particularly in supporting these patients through transitional years into adulthood.

Our study demonstrated that survivors of paediatric brain tumours suffer from a range of psychosocial issues; this is consistent with current literature [3, 47]. Survivors reported having significant limitation due social functioning, and this negative influence on psychosocial development from early onset oncological disease has been reported in previous studies[47, 48]. During the course of treatment children experience absences from school, social activities and may harbour concerns about future ill health, moreover, stress and vulnerability associated with life-threatening illness and re-adaptation with peer groups increases patients’ level of fear and impairs social development[47].

From HRQOL outcomes, respondents also reported significant cognitive functioning impairment. This has been demonstrated in previous studies of paediatric intracranial malignancy utilising the PedsQL [3]. A long-term cohort study describes brain tumour survivors to have the highest rates of cognitive dysfunction, visual and auditory impairment and are the group most at risk of functional impairment, compared to other cancer survivors[40]. Survivors of paediatric brain tumours can also have increased special educational needs, particularly children diagnosed below 5 years of age, and patients with poorer neuro-cognitive function often end up developing psychological impairment, such as poorer self-worth, emotional blunting and poorer conflict resolution[2]. These patients requires early recognition and support to aid their neurocognitive development[31].

Our study identified long-term survivors also experienced other physical symptoms including increased loss of appetite and nausea and vomiting compared to the normal population. These are established long-term consequences of chemo-radiotherapy regimes [2], but not for surgery alone. We hypothesize that these symptoms are related to a high proportion of posterior fossa tumours within the cohort. They may arise alongside other neuro-psychological impairment such as irritability, worry, nervousness or depression[49], which would benefit from early psychosocial and neurocognitive support.

Previous studies have reported that paediatric brain tumour survivors experience increased limitations from physical capabilities and tend to engage less in physical activity than the age-matched general population [31, 47, 50], Surprisingly, our cohort had improved HRQOL outcomes in domains of physical functioning, fatigue and limitations from emotional health. One explanation for this may be due to almost half of our cohort remaining under follow-up and receiving continued specialist healthcare input. This is supported by other studies that found attendance at follow-up clinic facilitates education, early detection of morbidity and aids health promotion amongst paediatric cancer survivors[51]. Increased physical activity has also been demonstrated to ameliorate morbidity, mortality, and neurocognitive impairment rates in paediatric brain cancer survivors[52]. Moreover, although the understanding and underlying mechanisms of persistent post-treatment physical impairment is limited, survivors with reduced physical capabilities experience poorer psychosocial and neuro-cognitive outcomes[53, 54]. Physical impairment and fatigue have been described as the one of the most important predictors of poor functional status and researchers recommend comprehensive assessment to identify and manage causes of fatigue in long-term survivors of paediatric brain tumours [53-55]

The neurocognitive, psychosocial, and physical deficits in survivors of childhood brain tumours can be subtle and even subclinical, making them difficult to identify within the limited timeframe of the outpatient clinic. In light of these long-term survivorship problems encountered in paediatric populations following treatment for brain tumour, specialist teenager and young adult (TYA) [also referred to as AYA: adolescent and young adult] cancer services have been proposed as the standard of care, to enable access to the multidisciplinary team [19]. The multi-disciplinary team comprises specialist nurses, neurosurgeons, and neuro-oncologists and neuropsychologist, to deliver care to patients transitioning from paediatric to adult services. Over 40% of our patients were under transitional TYA clinic follow-up. Our study was not powered to assess the HRQOL difference between the TYA and non-TYA groups. Studies in other diseases have shown that patient not transitioned from paediatric to TYA services may not fully recognise the long-term consequences of late effects and as a result the impact on health-related QOL outcomes [56]. It has been reported, for example, that patients with gonadal failure do not fully appreciate the inability to conceive and effects of dependence on artificial hormones until adulthood [53]. Furthermore, it has been shown that 73.4% of paediatric cancer survivors suffer from chronic health conditions and these patients are at significantly higher risk of these long‐term conditions becoming life-threatening [40]. Longitudinal studies with serial assessments of HRQOL are necessary to understand how developmental age mediates reported outcomes and influences childhood cancer survivors' holistic responses to treatment-related late effects.

There are several limitations in our study. The study was cross-sectional and conducted across two neuroscience centres sharing a TYA service. The sample size was small, limiting power, and there is likely to be reporting bias – for example, patients who perceive themselves to be well may not have participated. Using multiple HRQOL measures makes it difficult to compare outcomes and to extrapolate conclusions. Finally, the time from end of treatment to study participation varied amongst patients which may impact patient’s perceptions of their treatment and clinical condition.

**Conclusion**

This study provides insight into the long-term outcomes and QOL in survivors of benign paediatric brain tumours managed with surgical resection alone. Children with brain tumours are particularly vulnerable as they undergo treatment during periods of major physical, cognitive, and social development. As a result, childhood brain-tumour survivors have a greater risk of developing psychological, neuro-cognitive, socialisation and physical development challenges. Survivors of childhood brain tumours are likely to benefit from early comprehensive assessment, specialist healthcare and TYA CNS cancer services.

**Appendix 1**

Table 1

|  |  |  |
| --- | --- | --- |
| Baseline patient characteristics (n=23) | | Frequency |
| Gender | Male | 12 |
|  | Female | 11 |
| Age at surgery | Median (range) | 13 (1-18) |
| Age at study participation | Median (range) | 21 (17-26) |
| Length of Stay (days) | Median (range) | 7 (3-88) |
| Presenting Symptoms | Raised ICP | 16 |
|  | Focal Neurological Deficit | 4 |
|  | Incoordination/Balance | 5 |
|  | Seizure | 1 |
|  | Visual deficit | 2 |
| CNS Tentorial Relation | Supratentorial | 10 |
|  | Infratentorial | 13 |
| Tumour Location | Cerebellum | 11 |
|  | Ventricular | 5 |
|  | Pineal | 2 |
|  | Hemispheric | 2 |
|  | Suprasellar | 1 |
|  | Hypothalamic | 1 |
|  | Thalamic | 1 |
| Histology | Pilocytic Astrocytoma Grade I | 15 |
|  | Oligodendroglioma Grade II | 3 |
|  | Schwannoma Grade I | 1 |
|  | Mature Teratoma | 1 |
|  | Astroblastoma | 1 |
|  | Papillary Glioneuronal Tumour Grade I | 1 |
|  | Meningioma Grade II | 1 |
| Under TYA Follow-Up | Yes | 10 |
|  | No | 13 |
| Time from Surgery (Years) | Median (range) | 11 (6-19) |
| Time from Surgery to follow-up (Years) | Median (range) | 7.5 (3-13) |
| Morbidity (0-7 Days) | Yes | 6 |
|  | No | 17 |
| Morbidity (7-30 Days) | Yes | 10 |
|  | No | 13 |
| Education Level | <GCSE | 2 |
|  | GCSE | 5 |
|  | A-Level | 14 |
|  | Undergraduate | 2 |
| Employment | Student | 8 |
|  | Part-time Employment | 7 |
|  | Full-time Employment | 5 |
|  | Volunteer | 1 |
|  | Not Working | 2 |
| Jobs | Retail/Service industry | 6 |
|  | Hospitality | 3 |
|  | Teaching | 1 |
|  | Finance | 1 |
|  | Self-employed | 1 |
| Hold driver’s license | Yes | 15 |
|  | No | 8 |
| Currently driving | Yes | 12 |
|  | No | 11 |

Table 2 – Quality of life questionnaire outcomes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SF-36 | Mean Cohort Value | Cohort SD | Population Mean | Population SD | Significance (p value) |
| Physical Functioning | 85.2 | 27.9 | 70.61 | 24.72 | 0.59 |
| Limitation from Physical Health | 79.3 | 40.3 | 52.97 | 40.78 | 0.125 |
| Limitation from Emotional Health | 73.9 | 30.1 | 65.78 | 40.71 | **0.037** |
| Fatigue | 54.9 | 21.3 | 52.15 | 22.39 | **0.016** |
| Emotional well-being | 68.3 | 15.4 | 70.38 | 21.97 | 0.064 |
| Social functioning | 71.7 | 29.97 | 78.77 | 25.43 | **0.03** |
| Pain | 83 | 27.3 | 70.77 | 25.46 | 0.051 |
| General Health | 68.3 | 26.9 | 56.99 | 21.11 | 0.057 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| EORTC-C30 | Mean Cohort Value | Cohort SD | Population Mean | Population SD | Significance (p value) |
| Physical Functioning | 85.2 | 28.2 | 76.7 | 23.2 | **0.033** |
| Role functioning | 82.6 | 31.97 | 70.5 | 32.8 | 0.11 |
| Emotional functioning | 80.8 | 19.5 | 71.4 | 24.2 | 0.41 |
| Cognitive functioning | 78.3 | 28.2 | 82.6 | 21.9 | **0.023** |
| Social functioning | 82.6 | 33.14 | 75 | 29.1 | 0.31 |
| Fatigue | 23.7 | 26.4 | 34.6 | 27.8 | 0.141 |
| Pain | 20.3 | 31.8 | 27 | 29.9 | 0.066 |
| Nausea and vomiting | 4.3 | 12.5 | 9.1 | 19 | **0.031** |
| Dyspneoa | 10.1 | 18.6 | 21 | 28.4 | 0.057 |
| Insomnia | 26.1 | 31.7 | 28.9 | 31.9 | 0.058 |
| Loss of appetite | 7.2 | 17.3 | 21.1 | 31.3 | **0.009** |
| Constipation | 4.3 | 15.3 | 17.5 | 28.4 | 0.349 |
| Diarrhea | 5.8 | 16.4 | 9 | 20.3 | 0.131 |
| Perceived financial impact | 15.9 | 36.1 | 16.3 | 28.1 | 0.077 |
| Global Health Status | 75 | 29.3 | 61.3 | 24.2 | 0.062 |

|  |  |  |  |
| --- | --- | --- | --- |
| EORTC-BN20 | Mean Cohort Value | Cohort SD |  |
| Future uncertainty | 15.6 | 18.3 |  |
| Motor dysfunction | 14.5 | 23.6 |  |
| Communication deficit | 15.9 | 23.2 |  |
| Headache | 31.9 | 38.2 |  |
| Visual disturbance | 15.5 | 22.4 |  |
| Seizure | 5.8 | 21.7 |  |
| Drowsiness | 14.5 | 26.3 |  |
| Hair loss | 11.6 | 29.2 |  |
| Itchiness | 13 | 24.1 |  |
| Leg weakness | 8.7 | 20.6 |  |
| Bladder control | 1.4 | 7 |  |

**Appendix 2**

Figure 2

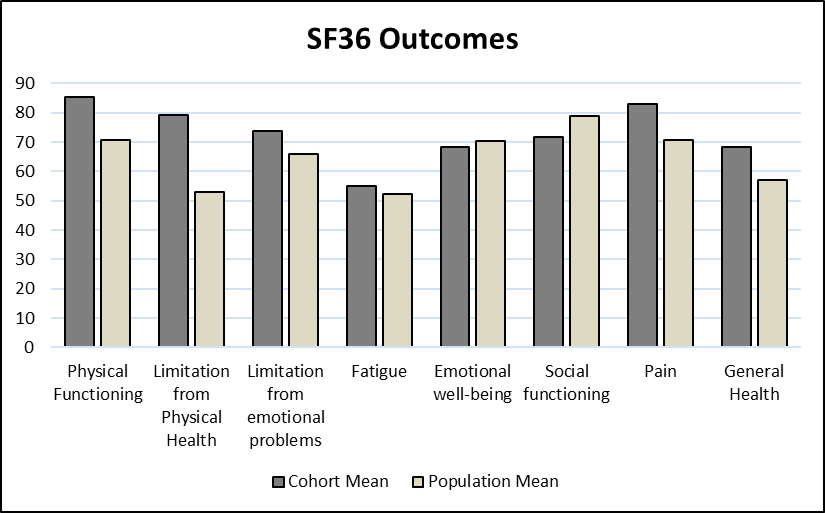


Figure 2 – SF-36 QOL outcomes comparing cohort to population mean values

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Figure 3

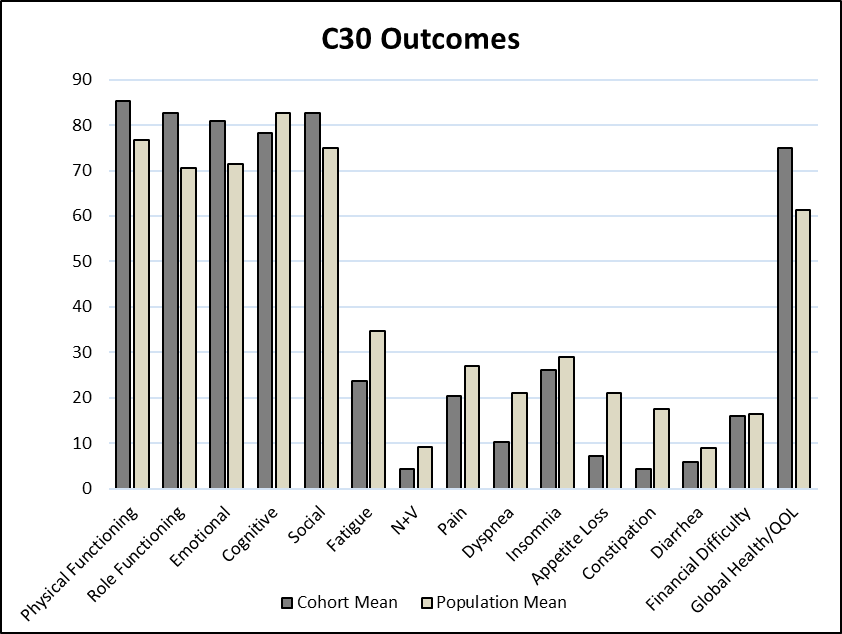


Figure 3 – QLQ C30 QOL outcomes comparing cohort to population mean values

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