COLLEGE OF HEALTH SCIENCES

SCHOOL OF MEDICINE

DEPARTMENT OF ANESTHESIA

SURVIVAL STATUS AND PREDICTORS OF OUTCOME IN PATIENTS WITH BRAIN TUMORS UNDERGOING SURGERY AT BLACK LION SPECIALIZED HOSPITAL, ADDIS ABABA, ETHIOPIA: A RETROSPECTIVE COHORT STUDY

BY

MEBRAHTOM WELDU (BSc IN ANESTHESIA)

A THESIS SUBMITTED TO DEPARTMENT OF ANESTHESIA, SCHOOL OF MEDICINE, COLLEGE OF HEALTH SCIENCES, ADDIS ABABA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE (MSc) IN ANESTHESIA

JUNE, 2025

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MSc Thesis Submission Form

Name of investigator	MEBRAHTOM WELDU (BSc)
Name of Advisor (s)	Ms. MISRAK WOLDEYOHANNES (Ass't Prof.) AND Mr. MULUALEM SITOT (Ass't Prof)
Full title of the research project	Survival status and predictors of outcome in patients with brain tumors undergoing surgery at Black Lion Specialized Hospital, Addis Ababa, Ethiopia: A Retrospective Cohort Study
Duration of project	AUGUST 2024 TO JUNE 2025
Study Area	Black Lion Specialized Hospital, Addis Ababa, Ethiopia
Total Cost of the project	**36067.5 ETB**
Address of investigator	Tel: **+251904874750** Email: mebreselama2022@gmail.com

Advisor's Approval Sheet

This is to certify that the study entitled "Survival status and predictors of outcome in patients with brain tumors undergoing surgery at Black Lion Specialized Hospital, Addis Ababa, Ethiopia: A Retrospective Cohort Study" is submitted in partial fulfillment of the requirements for the degree of Master of Science in Clinical Anesthesia to the graduate program of the college of health sciences of Addis Ababa university and has been carried out by **Mebrahtom Weldu** under my supervision. Therefore, I recommend that the student has fulfilled the requirements and hence with this can submit his thesis to the department.

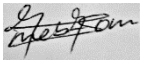
Ms. MISRAK WELDEYOHANNES _____ _____

Name of Advisor Signature Date

Mr. MULUALEM SITOT _____ _____

Name of Co-advisor Signature Date

declare that this MSc proposal is my original work and has not been presented for a degree in any other university and all sources of material used for this thesis proposal have been duly acknowledged.

Name: MEBRAHTOM WELDU Signature:  Date: _____

This MSc research proposal has been submitted for examination with my approval as thesis advisor.

Name: Ms. MISRAK WELDEYOHANNE Name: Mr. MULUALEM SITOT

Signature: _____ Signature: _____

Date: ___/___/_____ Date:___/___/

APPROVAL BY THE BOARD OF EXAMINATION

This is to certify that the thesis prepared by Mebrahtom Weldu entitled: *Survival status and predictors of outcome in patients with brain tumors undergoing surgery at Black Lion Specialized Hospital, Addis Ababa, Ethiopia: A Retrospective Cohort Study* submitted in partial fulfillment of Degree of Master of Science in Anesthesia is approved by the board of examiners as satisfying the recognized criteria for quality and uniqueness in its existing form.

EXTERNAL EXAMINER:

_____ _____ _____

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INTERNAL EXAMINER:

_____ _____ _____

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RESEARCH ADVISORS:

1. Mrs. Misrak (Ass't Prof.) _____ _____

NAME SIGNATURE DATE

2. Mr. Mulualem S. (Ass't Prof.) _____ _____

NAME SIGNATURE DATE

STATEMENT OF DECLARATION

I, Mebrahtom Weldu, confirm that this thesis is my original work and that all ethical standards in research, data collection, analysis, and writing have been upheld. No part of this thesis is plagiarized, and all referenced sources are properly cited. This work is submitted in partial fulfillment of the requirements for a graduate degree at the College of Health Sciences, Department of Anesthesia, Addis Ababa University. Any contributions from others have been appropriately acknowledged. This thesis has not been submitted to any other institution for academic credit. Quotations may be used with proper citation, and permission for extended use must be obtained from the author or thesis advisors.

PRINCIPAL INVESTIGATOR:

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ABBREVIATIONS

BLSH	Black Lion Specialized Hospital
DALYs	Disability-adjusted Life Years
ETB	Ethiopian Birr
GBM	Glioblastoma
GTR	Gross Total Resection
HHGs	High Grade Gliomas
LMICs	Low- and Middle-Income Countries
MRN	Medical Record Number
OS	Overall Survival
PFS	Progress Free Survival

Abstract

Background: Brain tumors are a significant public health concern, contributing to high morbidity and mortality rates worldwide. Primary brain tumors account for about 2% of all malignant neoplasms in adults. In Ethiopia, the incidence of brain tumors is rising, yet comprehensive data on survival outcomes and associated predictors remain limited. Despite the significance of brain tumors, research in this field remains sparse, with very little data on patient outcomes, survival rates, and prognostic factors following surgery.

Objective: The objective of this study was to assess survival status and identify predictors of outcomes in patients with brain tumors undergoing surgical intervention at Black Lion Specialized Hospital from January 2020 to December 2024.

Method: A facility-based retrospective cohort study was conducted among adult patients aged 18 years and older who were diagnosed with primary brain tumors and underwent surgical treatment at Black Lion Specialized Hospital between January, 2020, and December, 2022, with follow-up continuing until December, 2024. Data were extracted from medical records using a structured data extraction tool. Survival analysis was performed to assess time-to-death. Kaplan-Meier survival curves were used to estimate overall survival and compare survival probabilities between groups. To identify predictors of survival and control for potential confounding variables, both bivariate and multivariate Cox proportional hazards regression models were employed. The strength of associations was reported using Adjusted Hazard Ratios with their corresponding 95% Confidence Intervals**.** Variables with a p-value less than 0.05 in the multivariate model were considered statistically significant.

Results: The median survival time was 41 months. In the multivariable Cox regression analysis, significant predictors of mortality included age 55–65 years (AHR = 2.32, 95% CI: 1.54-3.50), malignant tumors (AHR = 2.26, 95% CI: 1.09-4.70), glioblastoma (AHR = 4.14, 95% CI: 1.41-12.22), malignant ependymoma (AHR = 4.38, 95% CI: 1.33-14.42), malignant astrocytoma (AHR = 3.68, 95% CI: 1.20-11.26), medulloblastoma (AHR = 3.99, 95% CI: 1.37-11.58), schwannoma (AHR = 2.93, 95% CI: 1.20-7.14), other benign neoplasms (AHR = 3.61, 95% CI: 1.43-9.17),

WHO Grade II (AHR = 3.19, 95% CI: 1.32-7.73), WHO Grade III (AHR = 5.27, 95% CI: 2.25-12.37), WHO Grade IV (AHR = 6.15, 95% CI: 2.62-14.42), and presence of neurological deficit (AHR = 1.39, 95% CI: 1.02-1.90).

Conclusion: Older age, malignant and high-grade tumors, specific tumor types, and preoperative neurological deficits significantly reduced survival; thus, targeted management strategies and early interventions for high-risk groups are recommended to improve patient outcomes.

Keywords: Brain tumors, survival analysis, Black Lion Specialized Hospital, Ethiopia

1. Introduction

1.1. Background

Brain tumors are a major health concern worldwide, contributing significantly to morbidity and mortality across all age groups[1]. Brain tumors are commonly classified based on their cell of origin, grade, and behavior as benign or malignant. The World Health Organization (WHO) classifies brain tumors into four grades, where Grade I and II are typically considered less aggressive, while Grade III and IV are more aggressive and malignant. Additionally, tumors may be categorized by their origin into primary brain tumors, which originate in the brain, and secondary (metastatic) tumors, which spread to the brain from other parts of the body[2]. Primary brain tumors are a heterogeneous group of benign and malignant tumors arising from the brain parenchyma and its surrounding structures[3].

Primary brain tumors account for about 2% of all malignant neoplasms in adults. The most frequent histopathological types are glioma, meningioma, astrocytoma, glioblastoma, and ependymoma, with a higher prevalence in men[4–6].

Individuals with brain tumors are susceptible to a variety of neurologic and medical side effects from their condition or from its treatment. Surgery is often the primary treatment for brain tumors, and outcomes are shaped by several factors such as tumor type, patient age, and the preoperative condition[7]. Treatment-related consequences include radiation-induced toxicities and side effects from medications such as corticosteroids, antiepileptic drugs, and chemotherapy, whereas underlying neoplasm-related complications include thromboembolic disease, seizures, and peritumoral edema[8].

Globally, advancements in neurosurgical techniques and oncological care have improved patient outcomes in high-income countries. However, in low and middle-income countries, patients with brain tumors often experience delayed diagnoses, limited access to specialized care, and suboptimal treatment outcomes[9].

1.2. Statement of the Problem

Globally brain tumor has an annual incidence of 3.5 cases and an annual mortality of 2.8 cases, per population of 100,000[10]. In a 2018 review, the estimated age-standardized incidence rate of brain tumors was between 6 and 8 per 100 000 people in most of Europe and North America and less than 2 per 100 000 in Sub-Saharan Africa[11].

These tumors are an important cause of morbidity and mortality in both adults and children, often generating severe disabilities and producing high burden in both families and health care systems[3]. Globally, primary brain tumors are responsible for 0.34% of total disability-adjusted life years[12].

In a study done in North America, the median length of survival was 40.9 weeks for patients with recently diagnosed GBMs. The true median length of survival for patients with Grade III gliomas was not reached, although there was a 58% survival rate at 104 weeks. In multivariate analysis, resection rather than biopsy, age 60 years or younger, and a Karnofsky Performance Scale (KPS) score of 70 or greater ($p = 0.0004$) were associated with a prolonged survival time for patients with Grade III or IV gliomas[13].

In Ethiopia, cancer-related research primarily focuses on more common cancers, such as breast and cervical cancer. Despite the significance of brain tumors, research in this field remains sparse, with very little data on patient outcomes, survival rates, and prognostic factors following surgery[14]. Black Lion Specialized Hospital (BLSH) in Addis Ababa, the largest referral hospital in Ethiopia, offers neurosurgical care but lacks comprehensive data on the outcomes of brain tumor patients.

There is a gap in the literature concerning survival status and outcome predictors for brain tumor patients in Ethiopia, especially in the study area. The present study seeks to fill this knowledge gap by exploring the survival status and identifying the key predictors of outcomes in patients undergoing brain tumor surgery at BLSH.

1.3. Significance of the Study

This study is important because it addresses a critical gap in the understanding of brain tumor patient outcomes in Ethiopia. By identifying the factors that influence survival and outcomes following brain tumor surgery, this research was contribute to improving neurosurgical care and treatment protocols in the region. The findings from this study could lead to better resource allocation, improved healthcare strategies, and the development of targeted interventions for brain tumor patients, thus reducing mortality rates.

The study is relevant not only for healthcare professionals but also for policymakers and stakeholders in Ethiopia's healthcare system. It provides scientific evidence that could inform future policies and investments in neurosurgical care and oncology services. Furthermore, the findings have the potential to influence regional strategies for cancer treatment in other LMICs, offering a model for improving brain tumor care in resource-constrained settings. By improving outcomes for brain tumor patients, this study aims to contribute to the overall enhancement of cancer care in Ethiopia and beyond.

2. LITERATURE REVIEW

2.1. Mortality from brain tumor patients after brain surgery

Mortality among patients with brain tumors following surgery varies significantly across tumor types and demographic groups. In an Australian retrospective study investigating primary brain tumor incidence from 2000 to 2008, the age-standardized incidence rate was 11.3 cases per 100,000 person-years, with malignant tumors being more common among individuals aged 65 and older. Despite this, the overall incidence of primary brain tumors remained stable over the study period, with age and tumor malignancy being prominent predictors of mortality[15].

Glioblastoma (GBM) is associated with particularly high mortality rates. A study done in Scott & White Hospital found that the overall survival for GBM patients was markedly low, with racial disparities highlighting the complexity of outcomes. White patients had the highest prevalence of GBM (87.1%) but the lowest survival rates (6.6% vs. 30.1%, $p < 0.01$), while Black patients, with lower prevalence (5.9%), experienced higher survival rates (47.4% vs. 7.3%, $p < 0.01$). Additionally, tumor location influenced survival rates, reflecting the aggressive nature of GBM[16].

Mortality outcomes also differ across other tumor types. For instance, medulloblastomas with high-risk classifications or anaplastic histology are associated with poorer survival. Among patients aged 15 years and older, the 5-year progression-free and overall survival rates were reported at 53.5% and 59.5%, respectively, even with the application of risk-adapted treatments[17]. Grade II meningiomas demonstrate lower mortality when gross total resection (GTR) is achieved, while incomplete resections correlate with shorter progression-free and overall survival[18].

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In a study analyzing survival and prognostic factors of anaplastic glioma, the median overall survival was 15 and 42 months among Anapastic astrocytoma and Anaplastic Oligodendroglioma patients, respectively. Age increments of 10 years implicated a 50% increase in mortality hazards among AA (hazard ratio [HR], 1.49; $P < .001$) and AO (HR, 1.51; $P < .001$) patients. Among AA

patients, radiation (HR, 0.62; P < .001), surgery (vs biopsy; HR, 0.73; P < .001), female sex (HR, 0.87; P = .02), and married status (HR, 0.87; P = .02) were associated with a reduction in the hazard of mortality[20].

A study done in London revealed that the overall survival was 9.2 months. In the multivariate analysis, longer survival was associated with debulking surgery vs. biopsy alone (14.9 vs. 8 months) (HR 0.54 [95% CI 0.41–0.70]), subsequent treatment after diagnosis (HR 0.12 [0.08–0.16]) (standard chemoradiotherapy [16.9 months] vs. nonstandard regimens [9.2 months] vs. none [2.0 months]), tumour MGMT promotor methylation (HR 0.71 [0.58–0.87]), and younger age (hazard ratio vs. age < 50: 1.70 [1.26–2.30] for ages 50–59; 3.53 [2.65–4.70] for ages 60–69; 4.82 [3.54–6.56] for ages 70+)[21].

2.2. Factors affecting mortality

Several factors significantly affect survival outcomes in patients with brain tumors, underscoring the complex interplay of demographic, clinical, and treatment-related variables.

Sociodemographic factors: Age is one of the most critical determinants of survival, with older patients, especially those over 65, facing worse outcomes. Racial disparities also play a role, as observed in GBM studies where survival rates differ across racial groups, reflecting potential genetic, biological, or healthcare access factors[15,16]. Gender differences, although noted, are less consistent in their statistical significance[16].

Tumor Characteristics: Tumor-specific variables such as histopathology, malignancy grade, and tumor location strongly influence survival[16]. Aggressive tumor types, such as high-grade gliomas and anaplastic medulloblastomas, are associated with poorer survival outcomes. In contrast, low-grade tumors and less invasive types generally show better prognoses[19].

Extent of Surgical Resection: The degree of tumor removal has a profound impact on survival, particularly in cases such as GBM and grade II meningiomas. Studies consistently report that extensive resection significantly extends survival compared to partial resection[17,22,23]. Patients with over 98% tumor resection experienced a 13 months (95% CI: 11.4-146 months) significantly higher than 8.8 months(95%CI: 7.4-10.2 months, P<0.0001) for resection below 98%,

emphasizing the importance of aggressive surgical intervention for favorable predictive profiles[22].

Functional Status: Preoperative functional status, often measured by the Karnofsky Performance Scale (KPS), is a key predictor of surgical and overall treatment success. Patients with KPS scores above 70 benefit the most from aggressive surgical interventions, while those with lower scores may not see significant survival gains[22].

Adjuvant Treatments: Tailored adjuvant therapies improve survival, particularly for high-risk medulloblastomas[17]. However, systemic chemotherapy has shown limited efficacy in standard-risk patients, emphasizing the need for individualized treatment strategies[17].

Histopathology: In cases like pineal region gliomas, histopathological grading is a stronger survival predictor than surgical resection extent[19]. These findings suggest that treatment approaches should prioritize tumor-specific characteristics and patient functionality to optimize outcomes.

These findings collectively highlight that survival in primary brain tumors is influenced by multiple factors, including age, tumor type, extent of resection, functional status, and histopathology. Tailoring treatment approaches based on these prognostic indicators could enhance outcomes and provide more personalized patient care in neuro-oncology.

2.2. Conceptual Framework

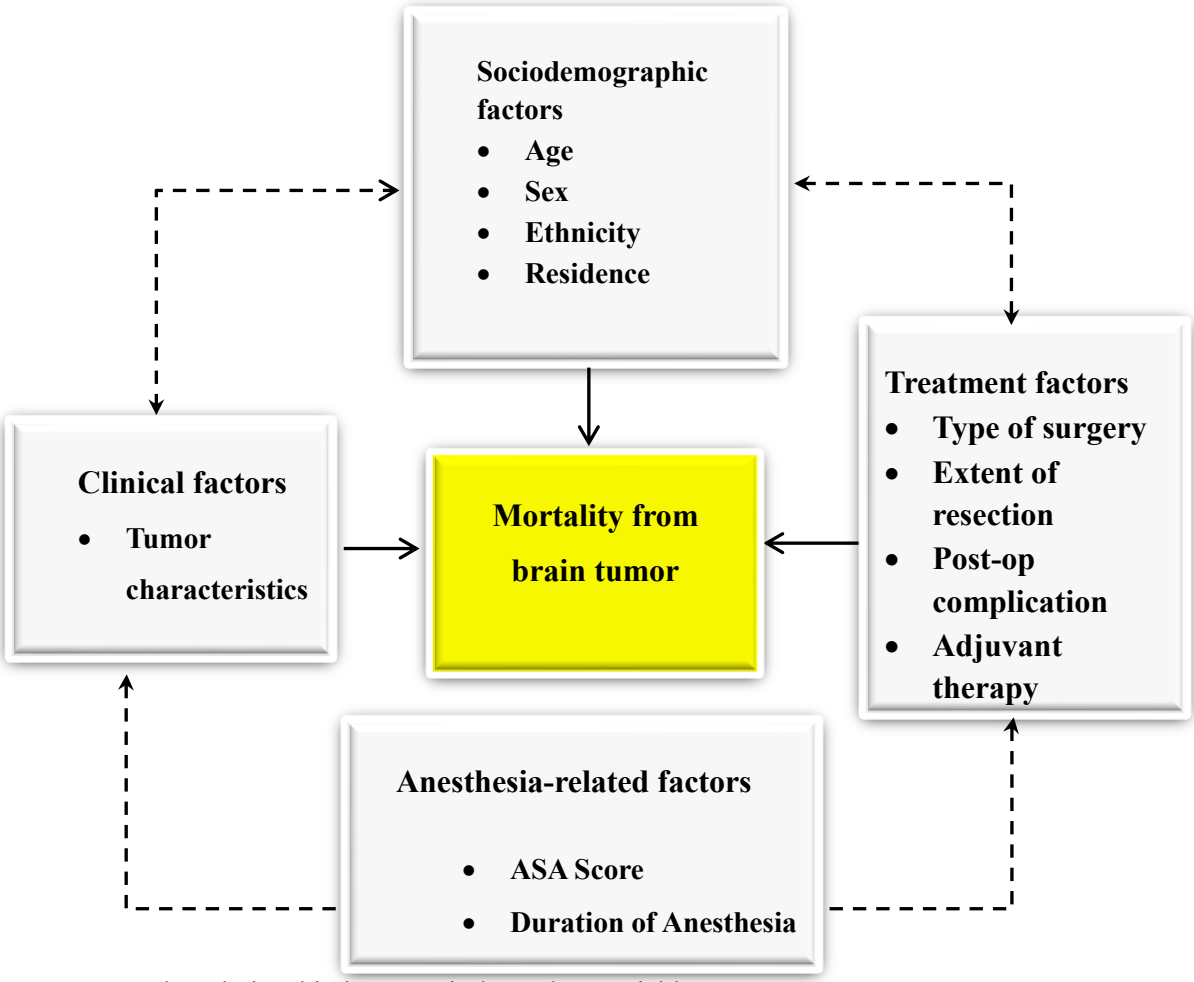

Figure 1: Conceptual Framework Survival status and predictors of outcome in patients with brain tumors undergoing surgery at Black Lion Specialized Hospital, Addis Ababa, Ethiopia adapted from different literatures

3. OBJECTIVES

3.1. General Objective

- To assess survival time and identify predictors of outcome in patients with brain tumors undergoing surgical intervention at Black Lion Specialized Hospital (BLSH) in Addis Ababa, Ethiopia, January 1, 2020, to December 31, 2024.

3.2. Specific Objectives

- To estimate the survival probability of patients with brain tumors undergoing surgical intervention at Black Lion Specialized Hospital.
- To identify predictors associated with mortality among patients with brain tumors at BLSH.
- To fit an appropriate final model that best represents the survival data of patients with brain tumors

4. Methodology

4.1. Study Design

This study employed a facility-based retrospective cohort design to evaluate survival time and identify predictors of outcome in patients with brain tumors undergoing surgery at Black Lion Specialized Hospital in Addis Ababa, Ethiopia.

4.2. Study Area

The study was conducted at the Black Lion Specialized Hospital in Addis Ababa, Ethiopia. BLSH is a prominent teaching hospital and specialized facility in the country dedicated to cancer treatment, including neurosurgery. Addis Ababa, the capital city of Ethiopia, is located at an altitude of 2,355 meters above sea level. The hospital, which began providing services in 1952, has several departments. This hospital is a tertiary facility in the country where brain tumors was treated with neurosurgical intervention, chemotherapy, and radiotherapy. Patients are expected to be referred from various centers across the country.

4.3. Study Period

The study period for this research was encompass a five-year timeframe, specifically from January 1st, 2020, to December 31st, 2024.

4.4. Source and Study Population

4.4.1. Source Population

The source population for this study consists of all adult patients diagnosed with primary brain tumors who have undergone surgical intervention at Black Lion Specialized Hospital (BLSH) in Addis Ababa, Ethiopia.

4.4.2. Study Population

The study population included adult patients aged 18 years and older who were diagnosed with primary brain tumors and underwent surgical treatment at BLSH between January 1, 2020, and December 31, 2022.

4.5. Eligibility Criteria

4.5.1. Inclusion Criteria:

Adult patients aged 18 years and older, diagnosed with primary brain tumors, who underwent surgical intervention for their condition at Black Lion Specialized Hospital (BLSH) during the specified study period, was included.

4.5.2. Exclusion Criteria:

Patients with incomplete medical records or follow-up data, as well as those who received treatment for brain tumors at other facilities prior to their referral to Black Lion Specialized Hospital (BLSH) was excluded from this study.

4.6. Study Variable

4.6.1. Dependent Variable:

- Time to death

4.6.2. Independent Variables:

- *Sociodemographic Factors*: Age at diagnosis, sex, ethnicity, and residence.
- *Clinical Factors*: Tumor characteristics (type, grade and location).
- *Treatment Factors*: Type of surgical intervention, extent of surgical resection, postoperative complications, and adjuvant therapies received.
- *Anesthesia-related factors:* ASA Score and Duration of anesthesia

4.7. Operational definition

Survival time: duration from the date of surgery to the date of death or last follow-up.

Event: refers to the occurrence of death among patients who underwent brain tumor surgery during the study period.

Censored: A participant is considered "censored" if the event did not occur during the follow-up period.

4.8 Sample Size determination

The sample size was calculated using Schonfeld's formula with the following assumptions: α = 0.05, HR = 0.54, $p_x = 0.64$, S_0 = 0.243 and S_1 = 0.045[21]. π_0= 1 - S_0 and π_1= 1 – S_1.

$$d = \frac{(z_{1-\frac{\alpha}{2}} + z_{1-\beta})^2}{p_{x(1-p_x)(\ln(HR))^2}}$$

Where,

d – Number of expected deaths (Events)

p_x – Proportion of patients with debulking surgery

HR – Hazard ratio

S_0 – Survival rate of patients with debulking surgery

S_1 – Survival rate of patients with no debulking surgery

$$d = \frac{(z_{1-\frac{\alpha}{2}} + z_{1-\beta})^2}{p_{x(1-p_x)(\ln(HR))^2}} = \frac{(1.96 + 0.84)^2}{0.64*0.34(\ln(0.54))^2} = \underline{\mathbf{90}}$$

$n = \frac{2d}{\pi_0 + \pi_1} = = \frac{2*90}{0.77 + 0.55} = \underline{\mathbf{137}}$ for each group. This gives a total of **274** sample size.

4.9 Sampling procedure

Data collection involved reviewing patient medical records to extract relevant information. A structured data extraction form was developed to capture: Data was collected by 3 trained nurses familiar with the hospital's record-keeping system. Prior to data collection, a one-day training session ensured consistency in data extraction. Between January 2020 and December 31, 2022, a total of 789 surgeries were performed. Among these, 440 were adult brain tumor cases that

underwent craniotomy. However, 66 cases were excluded due to incorrect medical record numbers, leaving 374 eligible cases enrolled in the cohort. Additionally, 349 cases were excluded because they either fell outside the eligible age range (under 18 or over 65 years) or had diagnoses other than brain tumors.

4.10 Statistical Analysis

Statistical analysis for this study was conducted using R version 4.5, following data entry through Kobo Toolbox. The initial data was converted into a survival format, and assumptions of the Cox proportional hazards model was assessed to evaluate time-dependent relationships among continuous predictors for the final model construction. The results of the study were interpreted using hazard ratios (HRs) derived from the final Cox proportional hazards model. The statistical significance of each predictor was assessed using p-values and 95% confidence intervals (CIs), with a predefined level of significance (α). For categorical variables, initial comparisons were performed using the log-rank test, while continuous predictors were first evaluated through univariate Cox regression analysis**.**

In the final multivariable model, the effect of each covariate on the risk of death following surgery for primary brain tumors was interpreted using hazard ratios, which quantify the relative risk of the event occurring, derived from the survival data analysis.

The following steps was performed during survival data analysis:

Descriptive Statistics Analysis

Descriptive statistics was applied to determine the median survival time of patients with brain tumors, the average age of the study population, and the frequency and percentage distribution by sex, tumor type, and other relevant categories.

Proportionality Assumptions of the Cox Proportional Hazards Model

To assess the proportionality assumption, interactions between continuous predictors and time was tested for significance. A significant interaction would indicate a violation of the Cox model's proportionality assumption. The hazard ratio between a covariate and the baseline hazard should

remain constant over time, indicated by non-overlapping or approximately parallel Kaplan-Meier (KM) survival curves.

$$\frac{h_1(t)}{h_0(t)} = \psi \quad \Rightarrow \quad h_1(t) = \psi h_0(t)$$

Significance Testing for Predictors

Categorical Predictors: The significance of categorical predictors was assessed using the Log-rank test. Only predictors showing significant relationships with survival time was included in the final Cox model.

Continuous Predictors: Univariate analysis was examined each continuous predictor's impact on survival outcomes. Only predictors with a statistically significant association was included in the final model.

Model Building for Outcome Prediction (Mortality)

At a specified significance level ($\alpha = 0.5$), predictors identified as significant in Log-rank and univariate tests was included in the model. Potential interactions between predictors was also be tested, and only significant interactions was retained. The final model's suitability was assessed using a likelihood ratio test (lrtest), comparing models with and without interaction terms to identify the best fit.

Hazard Ratio Interpretation and Model Goodness of Fit

The final Cox proportional hazards model, including significant predictors, was evaluated for its goodness of fit using Cox-Snell residuals. A well-fitting model was showed a cumulative hazard function that aligns closely with the reference line, indicating an accurate representation of the survival data.

Cox Proportional Hazards Regression analysis was identified independent predictors of survival time while controlling for confounding variables. A p-value of < 0.05 was considered statistically significant.

4.11 Data Quality Control and Management

Data was assessed for completeness and consistency by reviewing records and content of patient medical records in the study setting. Only qualified and complete data records which contain the necessary patient information was used for the study. In addition, a pilot test was done on 5% of the sample size to modify the checklist based on already available data and data collectors was recruited and then training was given to the recruited data collectors.

4.12 Ethical Consideration

The Addis Ababa university College of Health Sciences' ethical review committee granted an ethical clearance. No study subjects were directly involved because secondary data was used. However, the information was kept private, the study subjects' names won't be disclosed, and using the information for the study won't pose any risks to the study subjects or the hospital. Consequently, neither the extracted data nor the medical records were used for any other objectives.

4.13 Result dissemination

The results of the study will be presented and disseminated for all responsible individuals and institutions to ensure that the study was conducted formally and to be used by health planners as an input for intervention and further study. Eventually, publications with open access was given consideration for wider distribution.

5. Results

5.1. Sociodemographic characteristics of study participants

Out of 374 participants, 189 (50.5%) had died and 185 (49.5%) were censored. The patients were divided into four age groups. Among participants aged below 35 years, 38 (32.5%) had died and 79 (67.5%) were censored. This age group accounted for 31.3% of the total sample. In contrast, the 35–45-year-old participants had a higher mortality with 29 (53.7%) deaths and 25 (46.3%) censored and accounted for 14.4% of the sample. At 45–55 years, 36 (41.9%) died while 50 (58.1%) were censored, accounting for 23% of the total. The highest mortality in this instance occurred with the age group 55–65 years, where 86 (73.5%) died and only 31 (26.5%) were censored. This age group also accounted for 31.3% of the study population.

Of the 151 total women, 72 (47.7%) were deceased and 79 (52.3%) were censored. Among the men, who made up a larger percentage of the sample (59.6%), 117 (52.5%) were deceased and 106 (47.5%) were censored. On the basis of residential area, city residents accounted for 148 (39.6%) of the study participants, of which 76 (51.4%) were fatal cases and 72 (48.6%) censored. A greater proportion of the study population resided in rural areas (60.4%), but had an equal number of both fatalities and censored cases, 113 (50.0%) each (**Table 1**).

Table 1: Sociodemographic characteristics of patients with brain tumors undergoing surgery at Black Lion Specialized Hospital, Addis Ababa, Ethiopia, 2020-2024(n = 374)

Variable	Category	Status at last contact		Total (%)
		Death (%)	Censored (%)	
Age (Years)	<35	38(32.5)	79(67.5)	117(31.3)
	35-45	29(53.7)	25(46.3)	54(14.4)
	45-55	36(41.9)	50(58.1)	86(23)
	55-65	86(73.5)	31(26.5)	117(31.3)
Sex	Female	72(47.7)	79(52.3)	151(40.4)
	Male	117(52.5)	106(47.5)	223(59.6)
Residence	Urban	76(51.4)	72(48.6)	148(39.6)
	Rural	113(50)	113(50)	226(60.4)

5.2. Clinical and Anesthesia related factors

Among 262 (70.1%) benign tumor patients, 88 (33.6%) were dead and 174 (66.4%) were censored. In comparison, among 112 (29.9%) malignant tumor patients, 101 (90.2%) were dead and 11 (9.8%) were censored, showing much higher mortality in the malignant tumor patients. In meningioma, 45 (30.0%) died and 105 (70.0%) were censored. In astrocytoma (benign), 8 (19.5%) died and 33 (80.5%) were censored. Ependymoma (benign) had 13 (56.5%) deaths and 10 (43.5%) censored, and ganglioglioma had 4 (57.1%) deaths and 3 (42.9%) censored. Other benign tumors had 11 (61.1%) deaths and 7 (38.9%) censored.

Of the malignant tumors, astrocytoma (malignant) had 18 (90.0%) died and 2 (10.0%) censored, ependymoma (malignant) 11 (84.6%) died and 2 (15.4%) censored, glioblastoma 12 (75.0%) died and 4 (25.0%) censored, medulloblastoma 32 (94.1%) died and 2 (5.9%) censored, and GBM 21 (87.5%) died and 3 (12.5%) censored. Of the schwannoma patients, 14 (51.9%) died and 13 (48.1%) were censored.

In WHO Grade I tumor patients, 6 (13.6%) died and 38 (86.4%) were censored. In Grade II, 35 (40.2%) died and 52 (59.8%) were censored. In Grade III tumor patients, 68 (57.1%) died and 51 (42.9%) were censored, while Grade IV tumors had the greatest mortality of 80 (64.5%) deaths and 44 (35.5%) censored. Of 132 total resections, 77 (58.3%) died and 55 (41.7%) were censored. For partial resection, 112 (46.3%) succumbed and 130 (53.7%) were censored.

Of the 226 (60.4%) patients who received radiation therapy, 113 (50.0%) died and 113 (50.0%) were censored. Of the patients with no radiation therapy (148 patients, 39.6%), 76 (51.4%) died and 72 (48.6%) were censored. In 190 (50.8%) patients with neurological deficits, 82 (43.2%) died and 108 (56.8%) were censored. In 184 (49.2%) patients without neurological deficits, 107 (58.2%) died and 77 (41.8%) were censored.

Of hospitalization durations of less than 1 week (42 patients, 11.2%), 28 (66.7%) died and 14 (33.3%) were censored. Of the hospitalized between 1–2 weeks (216 patients, 57.8%), 106 (49.1%) died and 110 (50.9%) were censored. Those who hospitalized for more than 3 weeks (24 patients, 6.4%) had 13 (54.2%) deaths and 11 (45.8%) censored. Of 256 (68.4%) patients with ASA-I score, 111 (43.4%) died and 145 (56.6%) were censored. In ASA-II score (118 patients, 31.6%), 78 (66.1%) died and 40 (33.9%) were censored (**Table 2**).

Table 2: Clinical and Anesthesia related factors of patients with brain tumors undergoing surgery at Black Lion Specialized Hospital, Addis Ababa, Ethiopia, 2020-2024(n = 374)

Variable	Category	Status at last contact		Total (%)
		Death (%)	Censored (%)	
Tumor category	Benign	88(33.6)	174(66.4)	262(70.1)
	Malignant	101(90.2)	11(9.8)	112(29.9)
Tumor type	Meningioma	45(30)	105(70)	105(40.1)
	Astrocytoma(Benign)	8(19.5)	33(80.5)	41(11)
	Ependymoma(Benign)	13(56.5)	10(43.5)	23(6.1)
	Ganglioglioma	4(57.1)	3(42.9)	7(1.9)
	Other Benign	11(61.1)	7(38.9)	18(4.8)
	Astrocytoma(Malignant)	18(90)	2(10)	20(5.3)
	Ependymoma(Malignant)	11(84.6)	2(15.4)	13(3.5)
	Glioblastoma	12(75)	4(25)	16(4.3)
	Medulloblastoma	32(94.1)	2(5.9)	34(9.1)
	GBM	21(87.5)	3(12.5)	24(6.4)
	Schwannoma	14(51.9)	13(48.1)	27(7.2)
WHO grade	I	6(13.6)	38(86.4)	44(11.8)
	II	35(40.2)	52(59.8)	87(23.3)
	III	68(57.1)	51(42.9)	119(31.8)
	IV	80(64.5)	44(35.5)	124(33.2)
Extent of resection	Total	77(58.3)	55(41.7)	132(35.3)
	Partial	112(46.3)	130(53.7)	242(64.7)
Radiation therapy	Yes	16(34.8)	30(65.2)	36(12.3)
	No	169(51.5)	159(48.5)	328(87.7)
Neurological deficit	Yes	82(43.2)	108(56.8)	190(50.8)
	No	107(58.2)	77(41.8)	184(49.2)
Length of stay	< 1 Week	28(66.7)	14(33.3)	42(11.2)
	1-2 Weeks	106(49.1)	110(50.9)	216(57.8)
	>3 Weeks	13(54.2)	11(45.8)	24(6.4)

ASA Score	ASA-I	111(43.4)	145(56.6)	256(68.4)
	ASA score-II	78(66.1)	40(33.9)	118(31.6)
Intraoperative Mannitol use	Yes	119(59.5)	81(40.5)	200(53.5)
	No	70(40.2)	104(59.8)	174(46.5)
Blood loss	1000-2500	171(49)	178(51)	349(93.3)
	≥2500	18(72)	7(28)	25(6.7)
ICU admission	Yes	81(51.3)	77(48.7)	158(42.2)
	No	108(50)	108(50)	216(57.8)
Duration of anesthesia	<4.5	8(72.7)	3(27.3)	11(2.9)
	4.5-6.5	19(28.8)	47(71.2)	66(17.6)
	6.5-8.5	106(81.5)	24(18.5)	130(34.8)
	>8.5	56(33.5)	111(66.5)	167(44.7)

5.3. Overall survival rate of brain tumor patients undergoing surgery

A Kaplan-Meier survival curve was employed to estimate the probability of survival as time progressed in the subjects. The probability of survival at 12 months was 89% (95% CI: 85.9%-92.3%), such that the majority of them were event-free at the one-year follow-up. Survival probability, however, decreased with time significantly. The survival probability at 24 months went down to 57.5% (95% CI: 52.7%-62.7%), and then to 51.5% (95% CI: 46.7%-56.9%) at the 36th month. At the end of the 48-month follow-up, survival probability had reduced to 48.6% (95% CI: 43.7%-54.0%). The overall median survival time of brain tumor patients undergoing surgery was found to be 41 months.

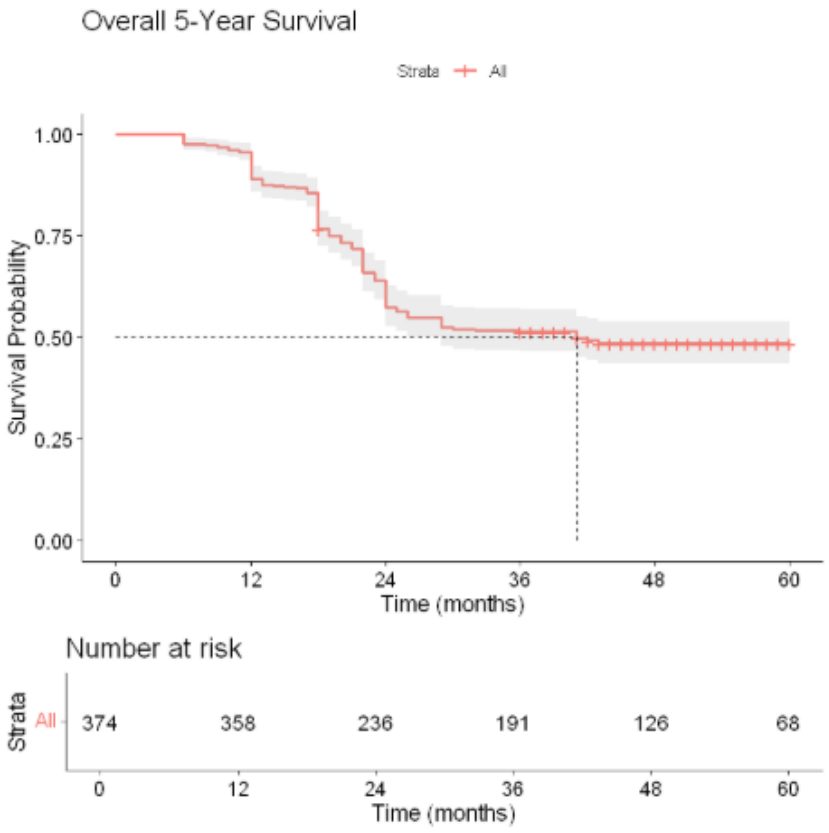

Figure 2: Overall Kaplan-Meier estimation of survival functions of brain tumor patients undergoing surgery in Black Lion Specialized Hospital, Addis Ababa, Ethiopia, 2020-2024

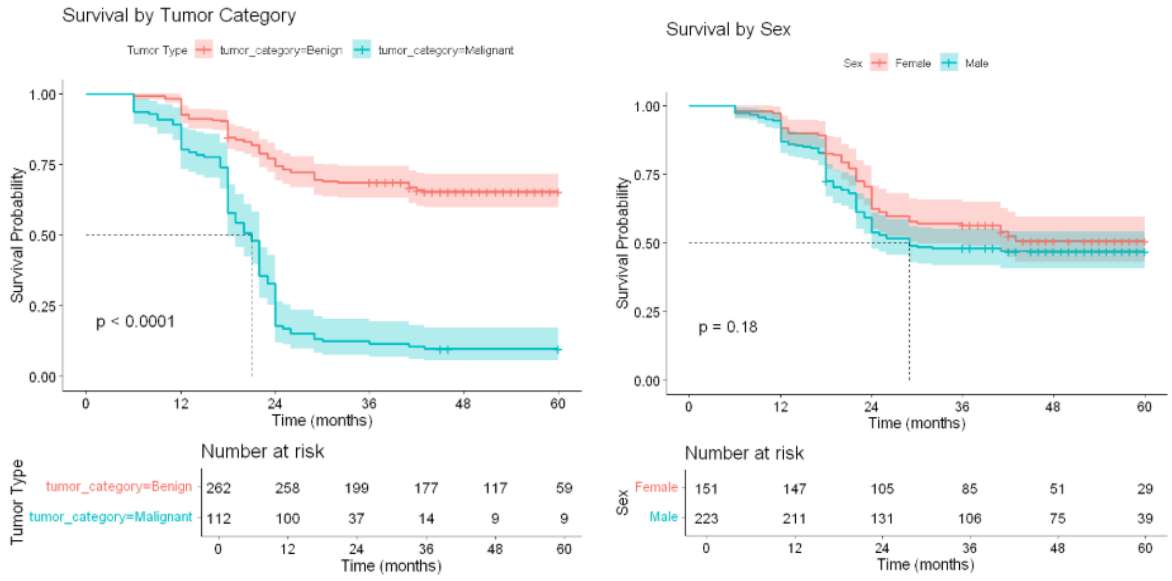

Figure 3: KM survival curves of the two group of sex and tumor category in brain tumor patients undergoing surgery in Black Lion Specialized Hospital, Addis Ababa, Ethiopia: 2020-2024.

5.4. Predictors of brain tumor mortality

To identify independent predictors of time to event in patients with brain tumors after surgery, a multivariable Cox proportional hazards regression model was formulated. Crude hazard ratios (CHR) were first determined using bivariable analysis and those variables with p-values less than 0.25 were included in the multivariable model. In bivariable Cox proportional hazard regression analysis, sex, residence, category of the tumor, type of the tumor, WHO grade, radiation, ASA score, age at surgery, and neurological deficit were significant. Adjusted hazard ratios (AHR) and 95% confidence intervals (CI) were used to measure direction and magnitude of associations. Age at surgery, tumor category, tumor type, WHO grade, and neurological deficit were significant variables for mortality of brain tumor in multivariable Cox proportional hazards model.

Age 55-65 years had 2.32-fold high risk of death compared with those aged below 35 years (AHR = 2.32, 95% CI: 1.54-3.50). Although other age groups (35-45 and 45-55) showed high risks in the bivariable model, their effects were weakened and were statistically non-significant after adjustment for confounders.

Patients with malignant tumors were more than twice as likely to die compared with benign tumors (AHR = 2.26, 95% CI: 1.09-4.70). There was a fourfold risk of death with glioblastoma (AHR = 4.14, 95% CI: 1.41-12.22). Similarly, malignant ependymomas (AHR = 4.38, 95% CI: 1.33-14.42), malignant astrocytomas (AHR = 3.68, 95% CI: 1.20-11.26), and medulloblastomas (AHR = 3.99, 95% CI: 1.37-11.58) were all significantly associated with increased mortality. Additionally, schwannomas (AHR = 2.93, 95% CI: 1.20-7.14) and other benign neoplasms (AHR = 3.61, 95% CI: 1.43-9.17) had a statistically significant elevated risk of mortality.

Patients with WHO Grade II tumors had 3.2 times increased risk of death compared to patients with Grade I tumors (AHR = 3.19, 95% CI: 1.32-7.73). Patients with Grade III tumors were also at increased risk, with over five times increased hazard of death (AHR = 5.27, 95% CI: 2.25-12.37). The highest hazard was among patients with Grade IV tumors, who had over a six-fold increased hazard compared to those who entered with Grade I tumors (AHR = 6.15, 95% CI: 2.62-14.42). Patients entering with a neurological deficit had 39% increased hazard of dying (AHR = 1.39, 95% CI: 1.02-1.90) (**Table 3**).

Table 3: Results of the Bivariable and Multivariable cox regression analysis of brain tumor patients undergoing surgery in Black Lion Specialized Hospital, Addis Ababa, Ethiopia, 2020-2024 (n = 374)

Variable	Category	Bivariable CHR (95% CI)	Multivariable AHR (95% CI)	P-value
Age (Years)	<35	1		
	35-45	1.98 (1.22–3.21)	1.48(0.88-2.49)	0.1
	45-55	1.36 (0.86–2.14)	1.21(0.74-1.96)	0.3
	55-65	3.26 (2.22–4.78)	2.32(1.54-3.5)	0.0001
Sex	Female	1		
	Male	1.23(0.82-0.91)	1.32(0.98-1.89)	0.07
Tumor category	Benign	1		
	Malignant	4.98(3.7-6.69)	2.26(1.09-4.7)	0.03
Tumor type	Astrocytoma(Benign)	1		
	Meningioma	1.64(0.77-3.49)	1.44(0.67-3.13)	0.3
	Glioblastoma	7.35(3.0-18.03)	4.14(1.41-12.22)	0.01
	Ependymoma(Benign)	3.88(1.61-9.37)	2.7(1.06-6.89)	0.02
	Schwannoma	3.4(1.42-8.1)	2.93(1.2-7.14)*	0.01
	Other Benigns	4.16(1.67-10.34)	3.61(1.43-9.17)	0.006
	Ganglioglioma	3.37(1.01-11.2)	2.78(0.77-1.02)	0.08
	GBM	1.97(0.42-4.71)	2.14(0.71-6.42)	0.1
	Medulloblastoma	11.18(5.12-2.44)	3.99(1.37-11.58)	0.01
	Astrocytoma(Malignant)	11.09(4.8-25.63)	3.68(1.2-11.26)	0.01
	Ependymoma(Malignant)	8.98(3.61-22.37)	4.38(1.33-14.42)	0.01
WHO grade	I	1		
	II	3.51(1.48-8.35)	3.19(1.32-7.73)	0.007
	III	5.51(2.39-12.72)	5.27(2.25-12.37)	0.0001
	IV	7.23(3.15-16.59)	6.15(2.62-14.42)	0.0001
Extent of resection	Partial	1		
	Total	0.69(0.52-0.92)	0.76(0.55-1.05)	0.08

Radiation therapy	Yes	0.98(0.73-1.31)		0.1
	No	1		
Neurological deficit	Yes	1.61(1.2-2.14)	1.39(1.02-1.9)	0.04
	No	1		
ASA score	ASA-I	1		
	ASA-II	1.79(1.34-2.39)	1.18(0.86-1.6)	0.3

5.5. Cox-Proportional Hazard Assumption (Cox-PHA) Checking

Using Schoenfeld's Residual

The Cox regression model's proportional hazards assumption was evaluated using graphical inspection of the scaled Schoenfeld residuals. For each covariate included in the multivariable Cox model, scaled Schoenfeld residuals were plotted against follow-up time. A smooth curve was superimposed on each plot to detect any potential time-dependent patterns.

The visual check did not aim to find any systematic shape or deviation from a horizontal line that would indicate whether the effect of a covariate on the hazard could be time-varying. In our analysis, no apparent or systematic linear trend was found between time and the residuals, meaning that the effect of each covariate on the hazard function was approximately constant over the follow-up period.

Based on this graphical assessment, it was concluded that the proportional hazards assumption was not violated for either covariate, and thus the Cox regression model was suitable to be applied in examining the survival data.

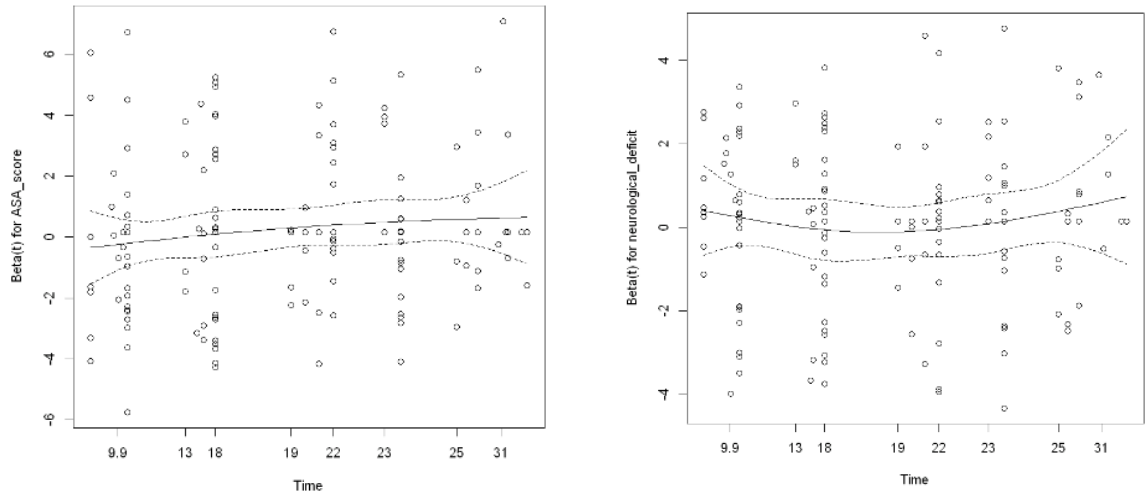

Figure 4: Graphical comparison Cox-PHA for ASA score and neurological deficit in brain tumor patients underwent surgery in BLSH, 2020-2024

6. Discussion

This study assessed the survival time and predictors of outcome among patients with brain tumors undergoing surgical treatment at Black Lion Specialized Hospital, Addis Ababa, Ethiopia, from 2020 to 2024. The overall survival probability was found to be 89% at one year and decreased to 48.6% at four years, with a median survival time of 41 months.

The median survival time in our study is longer than that reported in London[20], which documented a median survival of 9.2 months. This difference could be attributed to the high proportion of benign tumors (70.1%) in our sample, particularly meningiomas, which are known to have better prognoses. Additionally, over 44% of our patients underwent total tumor resection, a factor known to prolong survival.

The current study's finding that malignant tumors such as glioblastoma, medulloblastoma, and malignant astrocytoma were significantly associated with higher mortality is in agreement with the prospective cohort study from USA[16], which showed lower survival rates in patients with high-grade tumors, particularly glioblastoma multiforme. The consistency in findings underscores the aggressive nature of high-grade tumors, even in settings with surgical capacity. However, the slightly lower mortality rate for malignant tumors in our study might reflect the benefit of postoperative follow-up and partial access to radiotherapy at Black Lion Specialized Hospital.

Our finding that older age groups (particularly those aged 55–65 years) had significantly higher mortality is in line with the study done in Australia[15], which also reported poorer outcomes in elderly patients.

Moreover, the association between higher WHO tumor grade and increased mortality is consistent with the findings of [22], which emphasized that WHO Grade IV tumors had the worst prognosis.

7. Strength and Limitation of the study

7.1. Strength

The data collection was facilitated through Kobo Toolbox, a digital platform that enhanced data accuracy, minimized manual entry errors, and ensured efficient data management. The study

utilized advanced statistical techniques, including Kaplan-Meier survival analysis and multivariable Cox proportional hazards regression modeling, which are well-suited for analyzing time-to-event data and adjusting for potential confounding variables. These methods provided robust estimates of survival probabilities and predictors of mortality.

7.2. Limitations

This study had some limitations, which should be considered while interpreting the findings. The first one is that the retrospective design typically relied on data already in the record, and these can be missing, not recorded in a uniform fashion, or vulnerable to entry errors. Therefore, some significant clinical or demographic variables could have been left out or misclassified. Second, selection bias could have been introduced if patients who lacked medical records or follow-up information were excluded. This could possibly decrease the representativeness of the study population and affect the generalizability of the results. Third, important prognostic variables such as molecular markers (e.g., IDH mutation, MGMT promoter methylation), performance status (e.g., Karnofsky Performance Scale) data were not present within the medical records and therefore could not be studied. Additionally, since the study was conducted within one referral hospital, the findings cannot be generalized to other sites within Ethiopia or elsewhere, which may have variations in healthcare facilities, diagnostic resources, and therapy regimens.

8. Conclusion

In conclusion, the overall survival median survival time was 41 months. Age 55-65 years, malignant tumor, tumor type, neurological deficit, and WHO grade of tumor were found to be significant predictors of mortality patients undergoing surgery with brain tumor.

9. Recommendations

First and foremost, early diagnosis and treatment need to be prioritized, especially for individuals in the 55-65 age group, who were found to be at significantly higher risk of mortality.
Facilitating routine screening, referral at an early point from the community, and community awareness could all help towards earlier diagnosis and treatment. Two, cancerous brain tumors must be controlled using an entire multidisciplinary system. This requires cooperation among

neurosurgeons, oncologists, radiologists, and palliative care specialists to bring overall and individualized care.

The WHO grading system needs to be included in regular clinical decision-making, with increasingly aggressive treatment and closer surveillance for those presenting with Grade III and IV tumors. Preoperative assessment of neurological function also needs to be standardized, and as far as possible, those with neurological deficits need to undergo targeted preoperative intervention to enhance resilience and capacity for recovery. Neuro-rehabilitation postoperative services also need to be reinforced to improve recovery and reduce the risk of death for those with deficits.

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11.ANNEXES

11.1. Result Summary

Univariate Cox-PH Analysis

```
Call:
coxph(formula = surv_obj ~ age_at_surgery, data = brain_tumor)

  n= 374, number of events= 189

                      coef exp(coef) se(coef)     z Pr(>|z|)
age_at_surgery35-45 0.6811    1.9761   0.2469 2.758  0.00581 **
age_at_surgery45-55 0.3050    1.3566   0.2326 1.311  0.18987
age_at_surgery55-65 1.1805    3.2561   0.1959 6.025 1.69e-09 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

                    exp(coef) exp(-coef) lower .95 upper .95
age_at_surgery35-45     1.976     0.5060    1.2179     3.206
age_at_surgery45-55     1.357     0.7372    0.8599     2.140
age_at_surgery55-65     3.256     0.3071    2.2178     4.781

Concordance= 0.629  (se = 0.021 )
Likelihood ratio test= 43.92  on 3 df,   p=2e-09
Wald test            = 43.43  on 3 df,   p=2e-09
Score (logrank) test = 47.15  on 3 df,   p=3e-10
```

```
Call:
coxph(formula = surv_obj ~ tumor_category, data = brain_tumor)

  n= 374, number of events= 189

                          coef exp(coef) se(coef)     z Pr(>|z|)
tumor_categoryMalignant 1.6054    4.9800   0.1508 10.65   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

                        exp(coef) exp(-coef) lower .95 upper .95
tumor_categoryMalignant      4.98     0.2008     3.706     6.692

Concordance= 0.67  (se = 0.016 )
Likelihood ratio test= 108.2  on 1 df,   p=<2e-16
Wald test            = 113.4  on 1 df,   p=<2e-16
Score (logrank) test = 136.6  on 1 df,   p=<2e-16

Call:
coxph(formula = surv_obj ~ tumor_type, data = brain_tumor)

  n= 374, number of events= 189

                             coef exp(coef) se(coef)     z Pr(>|z|)
tumor_typeastrocytoma_mal  2.4058   11.0876   0.4276 5.627 1.84e-08 ***
tumor_typebenign_other     1.4249    4.1575   0.4648 3.066  0.00217 **
tumor_typeependymoma_ben   1.3565    3.8824   0.4495 3.018  0.00255 **
tumor_typeependymoma_mal   2.1951    8.9812   0.4655 4.715 2.41e-06 ***
tumor_typeganglioglioma    1.2147    3.3693   0.6128 1.982  0.04745 *
tumor_typeGBM              1.9659    7.1411   0.4175 4.709 2.49e-06 ***
tumor_typeglioblastoma     1.9952    7.3535   0.4576 4.360 1.30e-05 ***
tumor_typemedulloblastoma  2.4142   11.1807   0.3990 6.051 1.44e-09 ***
tumor_typemeningioma       0.4969    1.6435   0.3837 1.295  0.19538
tumor_typeschwannoma       1.2228    3.3965   0.4433 2.759  0.00581 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Multivariable Cox-PH model

```
Call:
coxph(formula = surv_obj ~ sex + age_at_surgery + residence +
    tumor_category + tumor_type + WHO_grade + extent_of_resection +
    radiation_therapy + neurological_deficit + ASA_score, data = brain_tumor)

  n= 374, number of events= 189
```

	coef	exp(coef)	se(coef)	z	Pr(>|z|)
sexMale	0.27947	1.32243	0.15677	1.783	0.074629
age_at_surgery35-45	0.43539	1.54557	0.26754	1.627	0.103653
age_at_surgery45-55	0.24726	1.28052	0.24983	0.990	0.322316
age_at_surgery55-65	0.88209	2.41595	0.21147	4.171	3.03e-05
residenceurban	0.03273	1.03327	0.18956	0.173	0.862910
tumor_categoryMalignant	0.81455	2.25816	0.37784	2.156	0.031099
tumor_typeastrocytoma_mal	1.35932	3.89354	0.57575	2.361	0.018227
tumor_typebenign_other	1.28229	3.60487	0.47508	2.699	0.006952
tumor_typeependymoma_ben	1.04528	2.84420	0.47759	2.189	0.028621
tumor_typeependymoma_mal	1.44866	4.25739	0.61019	2.374	0.017591
tumor_typegangliоglioma	1.12450	3.07868	0.66021	1.703	0.088520
tumor_typeGBM	0.79036	2.20419	0.56280	1.404	0.160222
tumor_typeglioblastoma	1.36313	3.90839	0.55881	2.439	0.014713
tumor_typemedulloblastoma	1.35448	3.87475	0.54683	2.477	0.013251
tumor_typemeningioma	0.38392	1.46803	0.39517	0.972	0.331284
tumor_typeschwannoma	1.13163	3.10070	0.45583	2.483	0.013045
WHO_gradeII	1.20978	3.35276	0.45322	2.669	0.007600
WHO_gradeIII	1.69353	5.43867	0.43627	3.882	0.000104
WHO_gradeIV	1.84004	6.29677	0.43589	4.221	2.43e-05
extent_of_resectiontotal resection	-0.28348	0.75316	0.16529	-1.715	0.086339
radiation_therapyYes	0.33821	1.40244	0.26031	1.299	0.193852
neurological_deficitYes	0.32428	1.38303	0.15969	2.031	0.042290
ASA_scoreASA-II	0.14876	1.16040	0.16261	0.915	0.360267

```
                                exp(coef) exp(-coef) lower .95 upper .95
sexMale                            1.3224     0.7562    0.9726     1.798
age_at_surgery35-45                1.5456     0.6470    0.9149     2.611
age_at_surgery45-55                1.2805     0.7809    0.7847     2.090
age_at_surgery55-65                2.4159     0.4139    1.5962     3.657
residenceurban                     1.0333     0.9678    0.7126     1.498
tumor_categoryMalignant            2.2582     0.4428    1.0768     4.736
tumor_typeastrocytoma_mal          3.8935     0.2568    1.2597    12.034
tumor_typebenign_other             3.6049     0.2774    1.4207     9.147
tumor_typeependymoma_ben           2.8442     0.3516    1.1154     7.252
tumor_typeependymoma_mal           4.2574     0.2349    1.2875    14.078
tumor_typeganglioglioma            3.0787     0.3248    0.8441    11.229
tumor_typeGBM                      2.2042     0.4537    0.7315     6.642
tumor_typeglioblastoma             3.9084     0.2559    1.3072    11.686
tumor_typemedulloblastoma          3.8748     0.2581    1.3267    11.316
tumor_typemeningioma               1.4680     0.6812    0.6766     3.185
tumor_typeschwannoma               3.1007     0.3225    1.2690     7.576
WHO_gradeII                        3.3528     0.2983    1.3792     8.150
WHO_gradeIII                       5.4387     0.1839    2.3128    12.789
WHO_gradeIV                        6.2968     0.1588    2.6797    14.796
extent_of_resectiontotal resection 0.7532     1.3277    0.5447     1.041
radiation_therapyYes               1.4024     0.7130    0.8420     2.336
neurological_deficitYes            1.3830     0.7230    1.0114     1.891
ASA_scoreASA-II                    1.1604     0.8618    0.8437     1.596

Concordance= 0.787  (se = 0.017 )
Likelihood ratio test= 206  on 23 df,   p=<2e-16
Wald test            = 180.9  on 23 df,   p=<2e-16
Score (logrank) test = 226.9  on 23 df,   p=<2e-16
```

11.2. Data Extraction Sheet

S/N	Section 1: Sociodemographic Characteristics	Options	Remark
101	MRN	_____	
102	Age (Years)	_____	
103	Sex	1. Male 2. Female	
104	Residence	1. Urban 2. Rural	
	Section 2: Clinical Information		
201	Tumor type	1. Glioblastoma 2. Astrocytoma 3. Meningioma 4. Other(Specify_____)	

203	WHO grade	1. I 2. II 3. III 4. IV	
204	Extent of resection	1. Partial 2. Total	
205	Neurological deficit at presentation	1. Yes 2. No	
	Section 3: Treatment details		
301	Type of surgical procedure	1. Total resection 2. Partial resection	
302	Radiation therapy	1. Yes 2. No	
303	Date of surgery	_____	
304	Date of last follow-up	_____	
305	Date of death	_____	
	Section 4: Anesthesia-related factors		
401	Duration of anesthesia	1. <4.5 hours 2. 4.5-6.5 hours 3. 6.5-8.5 hours 4. >8.5 hours	
402	ASA Score	1. ASA I 2. ASA II	
403	LOHS		
404	BL	1.1000-2500 mL 2. >2500 mL	
405	Intraoperative Manniol use	1. Yes 2. No	
406	ICU Admission	1.Yes 2. No	
