# Economic Burden and Associated Factors Influencing Out-of-Pocket Expenditures for Patients Undergoing Elective Cranial Surgery in a Public Tertiary Hospital.

***Single center Observational hospital based cross sectional study***

Mehari Wale (PGY 5)

Advisors: Dr. Thomas Bogale and Dr. Tsegazeab Laeke

Research submitted to the Department of Surgery, Neurosurgery Unit, Addis Ababa University College of Health Sciences

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**ACRONYM**

UHC - Universal health coverage

LMICs - low- and middle-income countries

TASH - Tikur Anbessa specialized Hospital

WHO - World Health Organization

OOP - Out-of-Pocket

USD - United States Dollar

CBHI - Community-Based Health Insurance

SHI - Social Health Insurance

## INTRODUCTION

### Background

Achieving universal health coverage (UHC) by 2030, as enshrined in the United Nations Sustainable Development Goals, promises access to quality essential healthcare, medicines, vaccines, and financial safeguards for all. [1] however access to life-saving surgeries remains elusive for a staggering 5 billion people, with low and middle income countries ( LMICs) bearing the brunt of this crisis. In these regions, a mere 10% have adequate access to safe, timely, and affordable surgical care.[2]

While some may view surgical care as a luxury, untreated surgical conditions in LMICs inflict immense human and economic costs. Critical surgical care, a crucial player in tackling both old and new health challenges, has been relegated to a low priority. To maximize health gains and economic growth, the new era of global health must prioritize affordable surgical care in LMICs. Its benefits, spanning all ages and health categories, will empower youth, reduce mortality and disability, and ultimately fuel development.[2]

Every year, 33 million people suffer financial catastrophe due to out-of-pocket payments for surgery and anesthesia, highlighting the critical need for protection against such crippling healthcare expenses. Global health and development organizations, along with the World Bank and World Health Organization (WHO), are prioritizing financial risk protection within Universal Health Coverage (UHC), aiming for 100% coverage against catastrophic health expenses by 2030.[2] This is particularly crucial as high out-of-pocket payments remain the dominant form of healthcare financing in many regions like Ethiopia, leaving an estimated 150 million facing financial ruin due to medical costs each year. [2]

Patients in Ethiopia's heavy reliance on Out-of-Pocket (OOP) spending for accessing healthcare. A staggering one-third of total healthcare costs fall on households, one of the highest rates globally. This creates an immense burden, forcing many Ethiopians to delay or forgo needed medical care. The consequences are dire, particularly for the poor. They are three times more likely to face catastrophic OOP expenses, 40% of their income. This means they often must choose between healthcare and basic necessities, pushing them deeper into poverty. Coping

mechanisms are equally harsh. Selling assets, relying on family support, or taking loans are common, further straining already vulnerable families.[3]

As a sustainable healthcare financial risk protection strategy, Ethiopia is implementing two types of health insurance systems: Community-Based Health Insurance (CBHI) and Social Health Insurance (SHI). CBHI primarily targets the informal sector like farmers, students and people who have no permanent employment, while SHI covers those in the formal sector people who has permanent employment status in government or non-government organization. Notably, both insurance schemes currently only provide coverage for healthcare services received at government healthcare providers.[4]

Research indicates that in Ethiopia, CBHI enrollment has reached 45.5% of the target households.[5] While these improvements are evident, the extent of financial protection, particularly for tertiary care requiring significant resources (such as neurosurgery), remains unclear. Many Ethiopian government hospitals lack the resources to provide such specialized care, directly or indirectly mandating patients to cover their care out-of-pocket.

Brain and central nervous system tumors are significant global health concerns due to their high mortality rate, economic burden, and impact on quality of life. Ranking 19$^{th}$ among the most common cancers and 12$^{th}$ among the deadliest, these tumors are a major contributor to the global disease burden.[6]  Yet, the 2030 ambitious goal faces a more formidable opponent in neurological disorders, which burden healthcare systems, individuals, communities, and economies with mounting costs and lost productivity.[3]

While neurosurgery has recently gained traction on the global platform, its history is relatively brief. To convincingly demonstrate the global importance of neurosurgical interventions, more work and research are necessary, particularly regarding accessibility, cost-effectiveness, and prevention of neurosurgical pathologies.[7]

**Statement of the problem**

Neurosurgical procedures rely heavily on technology, requiring extensive pre operative workup intra operative resources and often leading to prolonged hospital stays due to potential neurological complications, even when performed successfully.[7] This directly and indirectly increases out-of-pocket expenses for patients, severely impacting already fragile financial

security in low-income countries like Ethiopia, where healthcare coverage is limited. Brain tumor and trauma surgeries carry the highest treatment costs compared to other neurosurgical procedures, in middle-income and low-income countries.[8, 9]

Despite rapid advancements, Ethiopian neurosurgery faces critical hurdles in achieving sustainable development to a high-quality healthcare. A survey and public data analysis revealed several challenges: workforce disparities, diverse caseloads, limited access to services, and incomplete infrastructure.[8, 9] Unfortunately, most research, recommendations, and planned interventions pay insufficient attention to the financial burden borne by patients seeking neurosurgical services.

**Significance of the study**

Despite the likelihood of significant financial burden of neurosurgical procedures, particularly in Ethiopia, data specific to treatment costs, out-of-pocket expenses, and associated factors within our setting remains limited. This research aims to bridge this gap by establishing a baseline for further studies. It will focus on the economic burden on patients who have undergone elective cranial surgeries and explore the factors that influence the financial impact on these individuals.

This research investigated the financial burden of elective cranial surgeries in Ethiopia, and thereby carries potential to impact various stakeholders within the neurosurgical landscape. It can equip neurosurgeons with cost awareness, fuel their advocacy for improved resources, and guide future research. Hospital administrators can leverage the findings for financial planning, develop targeted financial assistance programs, and inform policy recommendations. Supporting staff can be better equipped to counsel patients, streamline processes, and advocate for internal improvements. Finally, policymakers can gain insights to inform healthcare financing reforms, resource allocation decisions, and public health initiatives aimed at improving access to affordable neurosurgical care. By addressing the specific needs and perspectives of each stakeholder group, this research has the potential to drive positive change in the Ethiopian neurosurgical system.

## LITERATURE REVIEW

Yoon et al.'s study paints a concerning picture of the financial burden associated with cranial neurosurgery. Examining data from nearly 7,000 patients between 2013 and 2016, the authors reveal a significant increase in out-of-pocket (OOP) spending, even when accounting for inflation.[10] The average OOP cost ballooned to $698, with commercially insured patients facing an even steeper climb, averaging nearly double that amount. Additionally, the study identifies specific procedures, like craniotomies for pain, tumors, and vascular lesions, as incurring particularly high OOP costs. Perhaps most alarmingly, patients with out-of-network insurance face an even greater financial strain. While limited to a single institution, this study shines a light on the substantial financial burden shouldered by cranial neurosurgery patients. Its findings raise critical questions about the affordability of such essential medical care and highlight the urgent need for policy interventions that can alleviate the financial strain on patients seeking cranial neurosurgery.[10]

A recent observational study explored the financial burden of treating adult neuro-oncological patients (specifically those with meningioma or glioma) in a large Brazilian hospital. By analyzing hospital records from 2016 to 2019, the research aimed to estimate the direct cost of specialized care for these patients. The findings revealed an average cost per hospitalization of US$4,166, with the operating room and intensive care unit representing the most significant expenses. Notably, 17.5% of patients developed infections, primarily during emergency procedures, and the overall mortality rate reached 12.7%, with most deaths occurring in emergency situations. This study sheds light on the significant financial challenges associated with neuro-oncological care in developing countries, offering valuable data for resource allocation and cost-effectiveness analyses.[9]

A Ugandan study by Anderson et al. revealed a nearly half of surveyed discharged patients from a regional hospital were already in extreme poverty, with surgery plunging an additional 15% deeper. Alarmingly, 31% faced "catastrophic expenditure," exceeding 10% of their annual income on healthcare. This financial burden triggered harsh coping mechanisms like borrowing, selling possessions, and even job loss. While limited to one hospital, the study exposed the harsh

economic impact of surgery, with median direct medical expenses reaching $118 for non-cesarean surgeries (including only 3% neurosurgical). However, a lack of details on specific neurosurgical procedures and their cost range limits a complete understanding of the financial burden for neurosurgical patients.[11]

Nguyen et al.'s 2010 study unveils the harsh reality of financial burden associated with injuries in Vietnam. Hospitalized patients face an average out-of-pocket cost exceeding $270, with burns and complex surgeries further straining wallets. While health insurance provided some relief, its impact wasn't statistically significant across specific expenses like surgery, diagnostics, or medications. Notably, head injuries incurred an average out-of-pocket cost of $287.30, with surgery, diagnostics, and medications being the main culprits. Although the study was limited to a single hospital and conducted in 2010, it underscores the critical need for interventions beyond just health insurance to address this issue. Additionally, the lack of data on implant costs, particularly relevant for procedures like hydrocephalus treatment, emphasizes the need for further research that comprehensively captures the financial burden of injuries in Vietnam.[12]

A community-based cross-sectional study was conducted among 182 individuals who had undergone surgical procedures in a rural area of Ethiopia. The study assessed the financial burden of surgical care, including direct and indirect costs, and the prevalence of catastrophic health expenditure. The findings revealed that direct medical and non-medical costs constituted 44.6% and 33.2% of the total expenditure, respectively. A significant proportion of households, 69.2% at the 10% threshold and 45.6% at the 25% threshold, experienced catastrophic health expenditure. To cope with these costs, households resorted to asset sales and borrowing, exacerbating their financial situation. These results highlight the urgent need for policy interventions to mitigate the financial burden of surgical care and protect vulnerable populations.[13]

## OBJECTIVE OF THE STUDY

### General Objective:

This study aims to comprehensively assess the economic burden and catastrophic health expenditure associated with elective cranial surgeries in a public tertiary hospital setting, identifying key factors contributing to this burden.

### Specific Objectives:

- To quantify the average total cost of elective cranial surgery, including both direct and indirect costs.
- To estimate the average direct medical costs incurred by patients undergoing elective cranial surgery.
- To estimate the average indirect costs incurred by patients due to elective cranial surgery.
- To measure the proportion of patients experiencing catastrophic health expenditure because of elective cranial surgery.
- To identify demographic, clinical, and socioeconomic factors associated with catastrophic health expenditure for elective cranial surgery.
- To assess the coping mechanisms used by patients to finance the costs of elective cranial surgery.

## MATERIALS AND METHODS

### Study area

The study area will be Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia, the largest tertiary referral hospital in the country. The hospital is a pioneer in neurosurgical services and training, currently housing 18 fixed adult neurosurgical beds, shared pediatrics beds, and shared intensive care unit beds. [14] Based on unpublished hospital annual reports from 2023, the hospital performed, on average, 583 emergency and non-emergency brain and spine surgeries, with the majority being brain surgeries. Additionally, the hospital managed approximately 4,737 clinic visits in the same year.

### Study design and period

This study will employ a cross-sectional observational design to investigate the economic burden and associated factors influencing catastrophic out-of-pocket expenditures for patients undergoing elective cranial surgery at Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia, from May 1, 2024, to August 30, 2024.

### Population

**Source Population:**
All adult patients who underwent elective cranial surgery were discharged from Tikur Anbessa Specialized Hospital (TASH) between May 1 and August 30, 2024.

**Study Population:**
Selected adult patients who underwent elective cranial surgery and were discharged from TASH during the specified study period will be included in the study.

### Inclusion and exclusion criteria

**Inclusion criteria**

- Adult patients who underwent cranial surgery and discharged at TASH public tertiary hospital within the specified timeframe
- Adults aged 18 years or older.
- Able to understand and provide informed consent to participate in the study.

- Willing and able to participate in interviews

**Exclusion Criteria**

- Patients who underwent other neurosurgical procedures besides elective cranial procedure.
- Patients who are diagnosed with cognitive impairment or other mental health conditions that hinder their ability to participate accurately.
- Patient who in the hospital before discharge
- Patients without sufficient fluency in the language of the study instruments or interviews.
- Patients who lack legal decision-making capacity or are unable to provide informed consent.
- Sample size and Sampling techniques.

**Sample size determination**

The study population included patients who underwent elective cranial surgeries from May to August 2024. Based on historical data from 2023, an estimated 72 surgeries were expected during this period, averaging 18 surgeries per month.

A sample size of **n'**= 61 patients was calculated using a finite population formula. This calculation considered a **p** = 45.6% estimated proportion of patients experiencing catastrophic health expenditure, a 95% confidence level, and a **e** = 5% margin of error.[13]

$$\text{Unlimited population: } n = \frac{z^2 \times \hat{p}(1-\hat{p})}{\varepsilon^2} \qquad \text{Finite population: } n' = \frac{n}{1+\frac{z^2 \times \hat{p}(1-\hat{p})}{\varepsilon^2 N}}$$

A total of 56 patients were enrolled, resulting in a response rate of 91%.

**Study Variables**

**Dependent variable**

- Catastrophic out of pocket health expenditures
- Out of pocket expenditure

**Independent variable**

- Sociodemographic characteristics
- Type, Duration of Surgery
- Type of Brain Tumor ( malignant or non-malignant)
- Complication
- Duration of admission
- Duration of ICU admission
- Duration of pre-op stay
- Insurance Status

**Operational definition**

- **Direct Medical Costs:** Costs directly related to medical care, including hospital charges, physician fees, medications, diagnostic tests, and imaging.
- **Direct Non-Medical Costs**: Expenses incurred as a direct consequence of illness or treatment, such as transportation, food, and accommodation.
- **Indirect Costs:** Economic losses due to illness, like lost wages and productivity.
- **Out-of-Pocket (OOP)** Health Spending: Health spending paid by individuals, excluding pre-payments, reimbursements, and indirect costs such as lost wages.
- **Catastrophic Health Care Expenditure**: Out-of-pocket health spending exceeding a certain percentage of total household consumption. For this study, a 25% threshold is primarily used as the definition of catastrophic health expenditure. However, this research mentioned that the proportion of households experiencing catastrophic health expenditure will also be calculated using a 10% threshold.
- **Consumption Expenditure**: Total household expenditure on food and non-food items. Food expenditure includes consumption of own-produced food and purchased food items. Non-food expenditure encompasses housing, utilities, transportation, clothing, healthcare, education, and other items. All expenditure data is annualized and converted to a 30-day timeframe for comparability.
- **Elective Cranial Procedure:** Any neurosurgical procedure involving tumors, vascular abnormalities, or functional neurological disorders, scheduled as either elective, and performed with or without craniotomy (Trans nasal).

## Data collection and procedure

### Data collection tool, methods and pre-testing

Data was collected from discharged patients using a combination of open-ended and closed-ended questionnaires administered via face-to-face interviews or telephone calls. The questionnaire was adapted after some modification after a comprehensive review of relevant literature from WHO, Ethiopia and Uganda.[13] [11, 15, 16]

To ensure standardized data collection, a digital registry format was developed using Kobo Toolbox. Additionally, data was extracted from hospital admission/discharge records, patient cards, operation logbooks, and insurance registries.

The data collection instrument was initially prepared in English and then translated into Amharic, the primary language. To guarantee clarity and accuracy, a pre-testing phase was conducted on a representative sample of 5% of the total sample size.

### Data collectors, supervisors and collection procedure

Data collection was conducted by trained medical students and resident doctors. Prior to data collection, a training session was provided to ensure consistency and accuracy in data collection procedures.

Data was collected from discharged patients during their first post-operative clinic follow-up, typically two weeks post-surgery. For patients unable to attend the clinic, telephone interviews were conducted. Data collection commenced only after patients were clinically stable and willing to provide information. In cases where patients were unable to provide information, next-of-kin were contacted as an alternative source of data.

The principal investigator monitored the data collection process to ensure adherence to the study protocol.

### Data quality assurance

5% of the data collection forms were randomly selected and cross-checked with the corresponding coded patient or information source.

**Data processing, interpretation and analysis**

All analyses were conducted using SPSS Version 27. A p-value of $<0.05$ was considered statistically significant. Descriptive statistics was employed to summarize the sociodemographic, economic, and clinical characteristics of the sample. The distribution of catastrophic out-of-pocket expenditures was assessed.

To explore potential associations between catastrophic out-of-pocket expenditures and various factors, bivariate analyses were conducted. Given the small sample size, the Shapiro-Wilk test was used to assess the normality of continuous independent variables, including age, duration of surgery, distance from the hospital, and length of admission. As most variables displayed non-normal distributions, data were log-transformed before logistic regression were applied to compare these continuous independent variables with the categorical dependent variable, catastrophic healthcare expenditure.

**Ethical clearance**

Ethical clearance was obtained from the Institutional Review Board (IRB) at the College of Health Sciences, Addis Ababa University. Informed consent was obtained from each patient prior to the interview, and participants were informed of their right to withdraw consent at any time.

To ensure patient confidentiality, all data extracted from medical records and interviews underwent a standardized de-identification process. Data was securely stored in a password-protected central registry, accessible only to the primary investigator. All data storage and transmission adhered to established institutional and regulatory protocols. Data was used solely for the purposes of this study, in compliance with ethical guidelines and informed consent.

## RESULT

### Socio Demography

The study included a total of 56 participants, representing a 91% of the 61 expected response rate from our calculated sample size. This group was evenly divided between genders, with 50% (28) female and 50% male participants. The average age of our participants was 39 years old, ranging from 18 to 67 years. A significant majority, 82.1%, came from three specific regions: Addis Ababa (32.1%), Oromia (32.1%), and Amhara (17.9%).

**Table 1 Socio Demographic Characteristic of Patients**

| | | N (%) |
|---|---|---|
| **Age in Years** | 39 (±13) | |
| **Sex** | Female | 28 (50%) |
| | Male | 28 (50%) |
| **Region** | Oromia | 18 (32.1%) |
| | Addis Ababa | 18 (32.1%) |
| | Amhara | 10 (17.9%) |
| | SNNP | 3 (5.4%) |
| | Central Ethiopia Regional State | 2 (3.6%) |
| | Tigray | 1 (1.8%) |
| | South Ethiopia Regional State | 1 (1.8%) |
| | Somali | 1 (1.8%) |
| | Harar | 1 (1.8%) |
| | Central Ethiopia Regional State | 1 (1.8%) |

### Peri-Operative Stay

The average hospital stay for our patients was 26 days, with a range of 4 to 98 days and standard deviation of 20 days. The average preoperative stay of the study population was 16.23 days with a range of 1 to 60 days and standard deviation of 15.44 days. Majority of patients (54) were admitted to the neurosurgical ward pre-operatively, with only two requiring pre-operative ICU admission. Post-operatively, the average hospital stay was 9.89 days, with a standard deviation of

11.5 days and a range of 2 to 60 days. A significant portion of patients (51.7%, or 29) were transferred to the ICU immediately post-operatively and then subsequently to the ward. The length of Post-OP ICU stay ranged from 1 to 45 days.

**Surgical treatment and pathology**

The most common tumor types were meningioma (32.1%, 18 patients), pituitary macroadenoma (23.2%, 13 patients), and high-grade glioma (10.7%, 6 patients). The most frequently used surgical approach was pterional craniotomy (23.2%, 13 patients), followed by trans nasal transsphenoidal surgery (23.2%, 13 patients). Other approaches included posterior fossa approach (12.5%, 7 patients, divided into 2 suboccipital craniotomies, 1 far lateral approach, and 4 retrosigmoid approaches), bifrontal craniotomy for frontal skull base (5.4%, 3 patients), and convexity craniotomy (35.7%, 20 patients).

In 60.4% of cases, according to the intra operative surgeon's note, gross total resection was achieved, while 19.6% of cases involved safe maximal resection. For non-tumor pathologies, there were 2 aneurysm clippings, 3 cavernoma resections, 2 nidus resections for arteriovenous malformations, and 1 microvascular decompression.

The average duration of surgery was 266 minutes, ranging from 70 to 480 minutes, with a standard deviation of 91 minutes. Overall, 23.2 % of patients (13) experienced complications, with the most common being new Neurologic Deficit new (3 patients), infection (3 patients), and venous thromboembolism (3 patients). Ten patients had medical comorbidities, with arterial hypertension being the most common (5 patients). Few patient had overlap complications (e.g. Infection with DVT)

**Table 2 Perioperative and Clinical Data of Patient**

| | | N | Frequency |
|---|---|---|---|
| **Duration of Surgery in min** | | 266 (±91) | |
| **Tumor Histology** | Meningioma | 18 | 32.1% |
| | Pituitary Macroadenoma | 13 | 23.2% |
| | High Grade Glioma | 6 | 10.7% |
| | Cavernoma | 3 | 5.4% |
| | Medulloblastoma | 2 | 3.6% |
| | Craniopharyngioma | 2 | 3.6% |
| | Arteriovenous malformation | 2 | 3.6% |
| | Aneurysm | 2 | 3.6% |
| | Vestibular schwannoma | 1 | 1.8% |
| | Trigeminal neuralgia | 1 | 1.8% |
| | Rathke's cleft cyst | 1 | 1.8% |
| | Pilocytic astrocytoma | 1 | 1.8% |
| | Metastasis | 1 | 1.8% |
| | Epidermoid | 1 | 1.8% |
| | Colloid cyst | 1 | 1.8% |
| | Central neurocytoma | 1 | 1.8% |
| | Sum | 56 | 100% |
| **Surgical Approach** | Pterional craniotomy | 13 | 23.2% |
| | Endoscopic TSS | 9 | 16.1% |
| | Fronto parietal craniotomy | 7 | 12.5% |
| | Parietal craniotomy | 5 | 8.9% |
| | Frontal craniotomy | 5 | 8.9% |
| | Retrosigmoid craniotomy | 4 | 7.1% |
| | Microscopic TSS | 4 | 7.1% |
| | Bifrontal craniotomy | 3 | 5.4% |
| | Sub occipital craniotomy | 2 | 3.6% |

| | | | |
|---|---|---|---|
| | Occipital craniotomy | 2 | 3.6% |
| | Temporal craniotomy | 1 | 1.8% |
| | Far lateral craniotomy | 1 | 1.8% |
| | Sum | 56 | 100.0% |
| **Extent of Resection** | Gross total resection | 34 | 60.7% |
| | Safe maximal resection | 11 | 19.6% |
| | Subtotal resection | 4 | 7.1% |
| | Resection of AVM nidus | 2 | 3.6% |
| | Clipping | 2 | 3.6% |
| | Near total | 1 | 1.8% |
| | Microvascular decompression | 1 | 1.8% |
| | Decompression | 1 | 1.8% |
| | Sum | 56 | 100.0% |
| **Complication*** | No complication | 45 | 80.4% |
| | CSF leak | 3 | 5.4% |
| | DVT with or without PTE | 3 | 5.4% |
| | Infection | 3 | 5.4% |
| | Hormonal dysfunction | 1 | 1.8% |
| | Neurologic deficit | 1 | 1.8% |
| | Congestive Heart Failure | 1 | 1.8% |
| **Comorbidity** | None | 46 | 82.1% |
| | Arterial Hypertension | 5 | 8.9% |
| | HIV | 2 | 3.6% |
| | Type 2 Diabetes Meletus | 2 | 3.6% |
| | Ischemic Heart Disease | 1 | 1.8% |
| | Sum | 56 | 100.0% |

** Single Patient may have more than one complication*

**Socioeconomic data of the patient**

Average house hold size of the study participants was  5 people. In terms of employment status, 15 patients were permanently employed, 21 were farmers or self-employed, and 20 were either students, unemployed, or dependent on others for income.

Regarding health insurance coverage, 29 (51.8%) of respondents had Community-Based Health Insurance (CBHI), while 24(42.9%) had no health insurance coverage. The remaining 3(5.4%) had other forms of insurance (2 with military insurance and 1 with police insurance). It's important to note that the data for these 3 fully insured patients was excluded from the out-of-pocket expenditure calculations, as their insurance fully covered their medical expenses.

**Consumption expenditures**

Average household expenditure per month was 20,194 Birr (approximately 354 USD) with a standard deviation of  23589.73 (413USD). This expenditure was primarily allocated to food, accounting for 36.8% of the total monthly budget. A relatively small portion, 4.2%, was spent on healthcare. The remaining 59% was directed towards other essential expenses such as education, transportation, and housing.

**Cost of Surgery**

The total neurosurgical care cost for all 56 patients, including both direct and indirect expenses (and insurance coverage, where applicable), averaged 147,142.7 Birr (2,581 USD), with a standard deviation of 111,438.20 Birr (1,955 USD). The costs ranged from 25,250.00 Birr (443 USD) to 608,500.00 Birr (10,675 USD).

For CBHI-insured patients, the average total cost, including direct, indirect expenses, and insurance coverage, was 145,641.8 Birr (2,555 USD).

For the 24 non-insured patients, the estimated total surgical cost, including direct and indirect costs, was 139,235.2 Birr (2,443 USD).

However, this figure includes lost wages. A detailed analysis of out-of-pocket and catastrophic expenditure will be presented in the following section.

**Table 3 Cost of Surgery**

| | | Mean in Birr (USD) | SD in Birr | Max in Birr | Mini n Birr |
|---|---|---|---|---|---|
| **Overall Average cost of surgery (56)** | | 147,147.70 2,581.53 (USD) | 111,438.20 | 608,500 | 25250 |
| | Direct Medical Cost | 78280.28 (1,373.33 USD) | 57027.23 | 296560.5 | 24000 |
| | Direct non-medical cost | 18179 (318.92 USD) | 14099.64 | 54000 | 1000 |
| | Indirect Cost | 50683.04 (889.17 USD) | 80662.17 | 500000 | 0 |
| **Overall Average cost of surgery CBHI Insured (29)*** | | 145,641.80 (2555 USD) | | | |
| **Overall Average cost of surgery for Non-Insured (24)** | | 139,235 (2442 USD) | | | |
| **1 USD = 57 BIRR** | | | | | |
| **** 3 patients are excluded because thy have different kind of insurance*** | | | | | |

**Catastrophic Health Expenditure and Out-of-Pocket Payments**

The mean out-of-pocket expenditure (OOPE) for both CBHI-insured and uninsured patients was 88,342.37 Birr (1,548.11 USD), with a standard deviation of 59,571.98 Birr (1,044.95 USD). From this the direct medical expenditure share 79% of the expenditure while the direct non medical expenditure shares 21% of the expenditure.

For the 29 CBHI-insured patients, the mean OOPE was 95,710.72 Birr (1,679.13 USD), with a standard deviation of 72,094.50 Birr (1,264.81 USD). In contrast, the 24 uninsured patients had a

mean OOPE of 79,438.96 Birr (1,393.68 USD) and a standard deviation of 39,302.85 Birr (687.77 USD).

94.3% of all 53 patients incurred catastrophic out of pocket expenditure using a 10% income threshold. When the threshold was raised to 25%, 73.6% of patients still faced catastrophic expenditure.

For CBHI-insured patients, 93.1% and 75.9% experienced catastrophic costs at the 10% and 25% thresholds, respectively. Similarly, for uninsured patients, 95.8% and 70.8% faced catastrophic expenditure at the respective thresholds.

**Table 4 Out of Pocket Expenditure**

| | | **Mean in Birr** | **SD** |
|---|---|---|---|
| **OOPE in Birr (N=53)** | **Total OOP** | 88,342.37 | 59,571.98 |
| | **Direct Medical** | 69790.47 (79%) | |
| | **Direct non-medical** | 18,551.9 (21%) | |
| **Catastrophic OOPE 10 percent cut off (N=53)** | 50 (94.3%) | | |
| **Catastrophic OOPE 25 percent cut off (N=53)** | 40 (73.6%) | | |

Households adopted various strategies to manage the financial burden of healthcare. Borrowing money was reported by 69.8% of households, while 37.7% resorted to selling assets. Job loss affected 18.9% of households, and 26.4% reported keeping their children from school to assist with household responsibilities as a coping mechanism.

**Table 5 Household Way of Adaptation**

| | | N(%) |
|---|---|---|
| **Sell asset (N=53)** | No | 33(62.3) |
| | Yes | 20(37.7) |
| **Borrow money (N=53)** | No | 16(30.2) |
| | Yes | 37(69.8) |
| **Lost job (N=53)** | No | 43(81.1) |
| | Yes | 10(18.9) |
| **Stop sending children school (N=53)** | No | 39(73.6) |
| | Yes | 14(26.4) |

For the categorical independent variable of comorbidity status, patients with comorbidities were significantly more likely to incur catastrophic healthcare expenditures (75%) compared to those without comorbidities (73.3%). This difference was statistically significant ($p = 0.01$). However, after categorizing histological type, surgical approach, complications, gender, and insurance status, these variables were not found to be significantly associated with healthcare expenditure ($p > 0.05$ for all variables).

**Table 6 bivariate analysis.**

| | | **Catastrophic Health care Expenditure** | | **P value** |
|---|---|---|---|---|
| | | No | Yes | |
| **Sex** | Female | 22.2% (6) | 77.8% (21) | 0.498 |
| | Male | 30.8% (8) | 69.2% (18) | |
| **Address** | Addis Ababa | 18.8% (3) | 81.3% (13) | 0.693 |
| | Outside Addis Ababa | 29.7% (11) | 70.3% (26) | |

| | | | | |
|---|---|---|---|---|
| **Comorbidity** | No | 26.7% (12) | 73.3% (33) | **0.01** |
| | Yes | 25% (2) | 75% (6) | |
| **Histology** | Non-Malignant | 27.3% (12) | 72.7% (32) | 0.098 |
| | Malignant | 22.2% (2) | 77.8% (7) | |
| **Skull base Craniotomy** | No | 22.6% (7) | 77.4% (24) | 0.565 |
| | Yes | 31.8% (7) | 68.2% (15) | |
| **Post OP Complication** | No | 26.2% (11) | 73.8% (31) | 0.473 |
| | Yes | 27.3% (3) | 72.7% (8) | |
| **Insurance Status** | NO CBHI | 29.2% (7) | 70.8% (17) | 0.171 |
| | CBHI | 24.1% (7) | 75.9% (22) | |

To normalize the skewed distribution of out-of-pocket expenditure data, a log transformation was applied. Subsequently, an independent t-test was conducted to compare the means of the transformed expenditure between different categorical groups: Sex, Address, Comorbidity, Histology, Skull Base, Craniotomy, Post-Operative Complications, and Insurance Status. While the sample population indicated that females, non-Addis Ababa residents, individuals with comorbidities, malignant histology tumors, skull base approaches, and insured patients incurred higher out-of-pocket expenses, the lack of statistical significance precludes generalization of these findings to the broader study population. None of the categorical variables exhibited a statistically significant difference in out-of-pocket expenditure across their respective categories.

**Table 7 independent t-test**

| | | N | Mean | SD | Levene's sig | t-test Sig |
|---|---|---|---|---|---|---|
| **Sex (53)** | Male | 26 | 1.6301 | 0.4 | 0.564 | 0.275 |
| | Female | 27 | **1.7638** | 0.47 | | |
| **Address (53)** | Addis Ababa | 16 | 1.6870 | 0.37 | 0.328 | 0.774 |
| | outside Addis Ababa | 37 | **1.7254** | 0.47 | | |
| **Comorbidity (53)** | No | 8 | 1.6736 | 0.41 | 0.177 | 0.33 |
| | Yes | 45 | **1.8394** | 0.6 | | |
| **Histology (46)** | Non-Malignant | 37 | 1.6440 | 0.38 | 0.287 | 0.632 |
| | Malignant | 9 | **1.7189** | 0.57 | | |
| **Skull base Craniotomy (53)** + | No | 31 | 1.6891 | 0.38 | 0.028* | 0.862 |
| | Yes | 22 | **1.7119** | 0.52 | | |
| **Post OP Complication (53)** | No | 42 | 1.6955 | 0.46 | 0.745 | 0.921 |
| | Yes | 11 | 1.7105 | 0.38 | | |
| **Insurance Status (53)** | NO CBHI | 24 | 1.6521 | 0.41 | 0.67 | 0.489 |
| | CBHI | 29 | **1.7371** | 0.46 | | |

*** Equal Variances not assumed**

**+ Excluding Vascular Lesions**

Pearson correlation analysis was performed to assess the relationship between out-of-pocket expenditure and the continuous variables: Age, Duration of Surgery, Duration of Admission, Household Size, and Annual Income. After addressing outliers and skewness in the independent variables, correlation analysis was conducted using log-transformed out-of-pocket expenditure. A

strong negative correlation (Pearson Correlation -0.852, p=0.00) was observed between patient income and out-of-pocket expenditure, indicating a significant inverse relationship. Conversely, no statistically significant correlations were found between out-of-pocket expenditure and the other independent variables.

**Table 8 Pearson Correlation**

| | **Out of pocket Expenditure** | |
|---|---|---|
| | Pearson Correlation | Sig. |
| **Age** | -0.03 | 0.818 |
| **Duration of Surgery** | -0.094 | 0.509 |
| **Duration of Admission** | 0.063 | 0.652 |
| **Household Number** | 0.13 | 0.105 |
| **Annual Income** | **-0.852** | **0.00** |

## DISCUSSION

This study is the first to comprehensively investigate the financial burden, out-of-pocket expenditure, and catastrophic healthcare costs associated with adult patients undergoing cranial surgery in Ethiopia. While previous studies have explored the costs of general surgical procedures, this research fills a significant gap by focusing specifically on the financial implications of neurosurgical interventions.[3, 13, 15, 17] By analyzing a three-month dataset of patients referred to the Neurosurgery Unit at Tikur Anbessa Specialized Hospital from various regions of Ethiopia. The study contributes to the limited body of knowledge on neurosurgical costs in Sub-Saharan Africa and other low- and middle-income countries.[11, 12, 18]

The study achieved a 91% response rate, with a balanced gender distribution and a relatively young age profile of 39 years old. Most elective cranial procedures performed were for non-malignant tumors, primarily meningiomas and pituitary macroadenomas. A slight disproportionate preference for skull base approaches was observed, likely due to Tikur Anbessa Hospital being the sole government institution currently performing such surgeries in Ethiopia.[19] These findings align with a study conducted at the same institution over one year, which studied the perioperative care of 153 adult cranial surgeries with a mean age of 36.7 years. The most common procedures in this previous study were meningioma and pituitary macroadenoma.[20]

The average admission duration was approximately one month, with two weeks spent waiting for surgery post-admission. The average post-operative length of stay (LOS) was 10 days, which is comparable to the meta-analysis findings for low-income countries (10 days) and higher than that of high-income countries (5 days).[21] Even though the post-operative LOS is comparable to other low- and middle-income countries, the pre-operative waiting time after admission is significantly longer. This prolonged waiting time can be attributed to factors such as limited operating room availability (one operating table per day) and the high demand for intensive care unit beds, which are shared with other departments.

The average surgery duration was 4-5 hours, potentially influenced by the inclusion of transnasal pituitary surgeries, which typically require less time. The incidence of postoperative

complications was 18%, consistent with previous findings in similar settings.[20] It's important to note that this study did not include patients who died in the hospital. However, based on meta-analyses, neurosurgical complication rates can range from 5% to 28%.[22]

This study found that 94.3% and 73.6% of patients incurred catastrophic health expenditure when using 10%- and 25%-income thresholds, respectively. While there is no direct comparison for neurosurgical patients, previous studies on catastrophic healthcare expenditure in Ethiopia have reported lower rates for general medical care. For instance, one study found that 40% of patients experienced catastrophic expenditure at a 10% threshold, while another reported 17.4% exceeding the 10% threshold.[3, 15] Additionally, a study focusing on surgical procedures in Ethiopia, excluding neurosurgery, found that 69.2% and 45.6% of households incurred catastrophic expenditure at 10% and 25% thresholds, respectively. [13]A Sub-Saharan study on pediatric surgery reported a 39.9% rate of catastrophic healthcare expenditure.[17]

Our findings are consistent with the above studies and are further supported by a Ugandan study, which found that 93% of neurosurgical patients experienced catastrophic financial burden at a 10% threshold.[23] These results underscore the significant financial burden imposed by neurosurgical procedures, particularly in low-income countries like Ethiopia, compared to other types of medical or surgical care.

This study assessed the total cost of neurosurgery, which includes direct and indirect costs. The average direct cost, encompassing both direct medical and direct non-medical direct cost, was approximately 96,460 Birr (USD 1,700). But, considering indirect costs, which amounted to 50,683.04 Birr (USD 889.17), the overall average cost of surgery can reach up to147,147.70 Birr (USD 2,581.53). For comparative purposes, this study will primarily focus on the average direct cost of surgery. A study conducted in Sub-Saharan Africa estimated the cost of neurosurgical procedures in Uganda, particularly for brain tumor excision, at $1,221. [9] Our study indicates a higher cost of neurosurgical procedures compared to this Ugandan study. While no specific studies have been conducted on neurosurgical costs in Ethiopia, general surgical costs have been estimated at around $815, including both medical and non-medical expenses. [24]This further highlights the substantial financial burden associated with neurosurgical procedures in developing countries. While our study's findings align with the trend of high neurosurgical costs in developing countries, it's important to note that these costs can vary significantly across

different regions and healthcare systems. For instance, in developed countries, the average cost of neurosurgery can range from several thousand to tens of thousands of US dollars. [25]

The mean out-of-pocket expenditure (OOPE) for the patients was 88,342.37 Birr (1,548.11 USD), From this the Direct medical expenditure share 79% of the expenditure and direct non-medical expenditure shares 21% of the expenditure. This also showed the one fifth of out of pocket cost is used for patient transportation, food and accommodation. Which has a comparative finding with other researchers.[9, 11, 17]

The study also found that regardless of insurance status, patients incurred comparable out-of-pocket expenses. CBHI-insured patients, the mean OOPE was 95,710.72 Birr (1,679.13 USD). Research conducted in Vietnam on trauma expenditure and multicentric studies on pediatric surgery has shown that health insurance can mitigate out-of-pocket expenses.[12, 17] This can be attributed to two reasons the fact that community-based health insurance primarily covers expenses directly provided by the hospital. However, a significant portion of direct medical costs, including imaging, medications, and laboratory investigations, are often not covered by insurance and must be borne by patients themselves. As a result, patients, regardless of insurance status, are compelled to cover these expenses independently. The other reason is some of the patients acquire the CBHI when they cannot cover the health care cost.

The study also tried to find any factor associator between different factors in relative to catastrophic out of pocket. The study found that patients with co morbidity has statistically significant association. Even though the studies have not been done in surgical patients, a study in Debre tabor Ethiopia, Hypertension, which is the most common comorbidity in our study, was found high compared to the national *per capita* health expenditure. [26]

The study found a strong negative correlation ($r = -0.852$, $p = 0.00$) between income level and out-of-pocket expenses. This suggests that patients with higher incomes were less likely to face high out-of-pocket or catastrophic healthcare expenditures. Conversely, individuals from the poorest quintile were significantly more likely to experience such financial burden. This finding aligns with a meta-analysis on the burden of household out-of-pocket healthcare expenditures in Ethiopia, which revealed that low-income households had a threefold higher likelihood of catastrophic expenditure.[3]

The study also revealed that patient households employed various coping strategies to manage the financial burden of healthcare. Two-thirds of respondents resorted to borrowing, while 40% sold assets. Additionally, 20% of respondents experienced job loss, and 25% reported keeping their children out of school to assist with household responsibilities. These coping mechanisms are commonly reported in other studies in Ethiopia.[13, 17, 18]

While patient age, sex, duration of admission, duration of surgery, type of histology, and post-operative complications did not exhibit statistically significant associations with out-of-pocket expenditure, this may be attributed to the high prevalence of catastrophic expenditure and potential limitations in sample size and statistical power. The effect sizes of these variables on the outcome might be relatively small, making them difficult to detect statistically.

## CONCLUSION

This study put effort to comprehensively investigate the overall cost, financial burden, out-of-pocket expenditure, and catastrophic healthcare costs associated with adult cranial surgeries in Ethiopia. By focusing specifically on neurosurgical interventions, this research addresses a significant gap in existing literature.

The findings underscore the substantial financial burden imposed on patients and their families, particularly in the context of neurosurgical procedures. Compared to other types of healthcare interventions within the same setting, neurosurgical patients appear to face a disproportionately higher level of catastrophic health expenditure. This is evident from the high cost of neurosurgical surgery when compared to general surgical procedures or other medical conditions.

The analysis of patient demographics, clinical characteristics, and treatment modalities provides valuable insights into the factors influencing healthcare costs. Notably, comorbidity and income level were identified as statistically significant predictors of catastrophic expenditure. Additionally, factors such as long admission times, high rates of postoperative complications, limited service availability, and insurance systems, even if not statistically significant, likely contribute to the financial burden on patients and their families.

A significant proportion of neurosurgical patients impose a financial and social burden on patients and their families, often forcing them to adopt detrimental coping mechanisms such as selling assets, withdrawing children from school, and borrowing money. These actions can have long-lasting negative consequences for households.

### Limitation of the Study

- Data collection was restricted to a specific period, potentially limiting the representativeness of the results.
- The study excluded pediatric patients, limiting the understanding of the financial impact of neurosurgery on this specific demographic.
- Conducting the study at a single institution may limit generalizability to other healthcare settings with varying cost structures and patient populations.
- The limited sample size and high prevalence of catastrophic expenditure may have constrained the ability to identify detailed associations between variables

## RECOMMENDATION

To mitigate the financial burden of neurosurgery, a multi-faceted approach is necessary. Neurosurgeons should prioritize transparent communication with patients about costs and explore cost-effective treatment options. Patients should be aware of the high cost of neurosurgical procedures and explore options like health insurance and government assistance programs. Early medical attention and adherence to treatment plans can help prevent complications and reduce overall costs. Hospital administrators should streamline processes, collaborate with insurers, and ensure the availability of needed laboratory and imaging services. Additionally, efforts to reduce hospital stay, such as early mobilization and discharge planning, can help lower costs. Policymakers should expand health insurance coverage, increase healthcare funding, strengthen primary care, and prioritize low-income households.

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