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Out-of-pocket expenditure for neurosurgical care in Uganda: quantifying financial catastrophe and identifying policy pathways to universal health coverage

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Background: Out-of-pocket payments remain the primary source of healthcare financing in many low- and middle-income countries, frequently resulting in catastrophic and impoverishing expenditures. Neurosurgical care is particularly costly due to substantial direct and indirect expenses borne by patients and caregivers, typically with little or no financial protection. This study quantifies these OOP costs, estimates the prevalence of catastrophic and impoverishing health expenditures, and examines their socioeconomic impact to inform equitable surgical financing policies.

Methods: We conducted a cross-sectional study at the two main Ugandan public neurosurgical centers - Mulago National Referral Hospital, Kampala, and Mbarara Regional Referral Hospital, Mbarara. Consecutive patients with confirmed neurosurgical diagnoses were enrolled at discharge or within two weeks post-discharge. Structured surveys captured sociodemographic, clinical and cost data. OOP health payments were direct medical plus direct non-medical payments; total economic burden added indirect costs. Catastrophic health expenditure (CHE) was OOP payments exceeding 10% of annual household consumption expenditure (World Bank) or 40% of it after food costs (WHO). Impoverishment was the change in poverty headcount against the $3.00/person/day line (2021 purchasing power parity). Data was analyzed using R 4.4.2. Ethical approval was obtained from Ugandan and Duke University institutional review boards.

Results: Seventy-six respondents (mean age 39 years; 65% male) were enrolled, mostly at discharge (67%). Traumatic brain injury was the leading diagnosis (65.8%). No participant had health insurance. Median OOP health payments were UGX1.23 million [$351] (direct medical UGX880,000 [$251]; direct non-medical UGX359,000 [$103]); adding indirect costs of UGX125,000 [$36] gave a median total economic burden of UGX1.38 million [$394]. OOP payments exceeded 10% of annual household expenditure in 76.0% of households (95% CI 65.2 to 84.2) and 40% of capacity to pay in 41.2% (30.3 to 53.0). The poverty headcount rose from 50.7 to 62.7% (net impoverishment 12.0%).
Conclusion: Neurosurgical care in Uganda imposes a substantial economic burden on households: three quarters incurred catastrophic expenditure, and one in eight of those not already poor was pushed below the poverty line. These findings highlight the urgent need for financial risk protection, targeted subsidies, and health system reforms to ensure equitable and sustainable access to neurosurgical services.

KEYWORDS
catastrophic healthcare expenditure, financial risk protection, health policy, neurosurgery, out-of-pocket costs, Uganda, universal health coverage

Introduction

Access to affordable and timely surgical care remains a persistent challenge in many low- and middle-income countries (LMICs), where out-of-pocket (OOP) healthcare expenditures contribute significantly to financial hardship among households. OOP health payments constitute a considerable share of national spending, averaging 0.67% of total household final consumption expenditure and 1.65% of gross domestic product (GDP), thereby imposing a substantial burden on families and limiting access to essential health services (1). This financial pressure is particularly acute in the realm of neurosurgery, which requires high-cost, specialized procedures, complex equipment, and often prolonged recovery periods (2). Such specialized care, particularly when required for chronic illnesses, disproportionately affecting low-income populations, frequently results in catastrophic healthcare expenditure (CHE) and can perpetuate cycles of poverty (3).

Uganda, a low-income East African nation with a predominantly rural population, operates with an under-resourced public health system and faces critical gaps in specialized care provision (4). Neurosurgical services are concentrated at only two public tertiary hospitals, Mulago National Referral Hospital (MNRH) and Mbarara Regional Referral Hospital (MRRH), as well as a few private hospitals mostly located in the city (5). This centralization is coupled with systemic limitations such as limited human resources, inadequate surgical equipment, poor geographical access, and frequent shortages of medical supplies (5, 6). Patients often bear the cost and complexity of accessing care, with many traveling long distances and incurring substantial direct medical and non-medical costs, including transportation and lodging, as well as high indirect costs from lost income and prolonged caregiving responsibilities (7). These compounding expenditures place immense strain on household finances, especially in the absence of robust health insurance or effective financial risk protection mechanisms further exacerbating inequities in healthcare delivery (8). Despite the growing burden of neurosurgical conditions in Uganda, limited evidence exists on the full household-level financial burden of accessing neurosurgical care, particularly when direct non-medical and indirect costs are included.

While some studies have explored the financial burden of surgical care in LMICs, most focus narrowly on the in-hospital costs of specific neurosurgical procedures, thereby neglecting the full range of direct and indirect expenditures borne by patients and their caregivers. To address this critical gap, this study systematically quantifies the total direct medical, direct non-medical, and indirect OOP costs incurred by patients receiving specialized neurosurgical care at MNRH and MRRH in Uganda. Additionally, the research assesses the proportion of patients experiencing catastrophic and impoverishing health expenditures and explores the broader socioeconomic impact of neurosurgical illness. By generating evidence on cost-related barriers and the attendant financial consequences, this study aims to inform policy, guide health financing reforms, and advocate for improved financial risk protection and surgical equity in Uganda and similar resource-limited settings.

Methods

Study design and setting

We conducted a cross-sectional study using researcher-administered structured surveys at MNRH in Kampala and MRRH in Mbarara, the only two public facilities in Uganda offering specialized neurosurgical services. MNRH is the largest academic tertiary hospital and serves as a national referral and teaching hospital affiliated with Makerere University. MRRH is a major regional referral center and a teaching hospital affiliated with Mbarara University of Science and Technology. The status of these two hospitals makes them critical sites for assessing the financial burden associated with neurosurgical care (5).

Data collection and bias mitigation

The survey was designed and hosted on Qualtrics *(Qualtrics XM, Provo, UT, USA)*. The survey instrument was first piloted on a group of neurosurgical patients who were not subsequently enrolled in the

main study. Patients were consecutively enrolled at the time of discharge from the neurosurgical wards or within two weeks post-discharge via follow-up clinic visits or phone interviews. This two-week window was implemented to minimize recall bias regarding expenditures. Eligibility required a documented neurosurgical diagnosis and recent discharge. Because enrolment took place at or after discharge, the study population comprises patients who reached one of the two centers and survived to discharge, and all estimates are therefore conditional on accessing and surviving neurosurgical care. When necessary, patients unable to provide informed consent were interviewed through a designated caregiver. To enhance the accuracy of cost reporting, participants were encouraged to verify expenditures against receipts or invoices where these were available; whether verification occurred was not recorded for individual respondents. Participants were also asked whether the patient held any form of health insurance and, if so, what proportion of the costs it covered.

Sample size

Sample size estimates were calculated using the Epitools sample size calculator for proportions, assuming a finite population of patients discharged from the neurosurgical wards during the anticipated study period. Over a typical two-week recruitment window, approximately 50 patients at MNRH and 35 patients at MRRH were expected to be eligible. Assuming a 31% prevalence of CHE from prior literature and setting the confidence level at 95% with a precision of ±5%, the calculated minimum sample sizes were 44 patients from MNRH and 32 patients from MRRH. Therefore, a total sample size of 76 patients was targeted. This sample size was deemed sufficient to provide robust estimates of CHE prevalence and associated OOP expenditure patterns among neurosurgical patients in Uganda.

Data analysis

Data analysis was performed using R version 4.4.2 *(R Foundation for Statistical Computing, Vienna, Austria)*. Analyses and figures were produced with the tidyverse, gtsummary, sf, geodata, ggpattern, patchwork and ragg packages; the Sankey diagram (Figure 1) was produced with networkD3. Descriptive statistics summarized sociodemographic characteristics, clinical diagnoses, and expenditure categories. Medians and interquartile ranges (IQRs) were reported for continuous variables, and frequencies and proportions for categorical variables.

Costs were estimated from the perspective of the patient and their household. The cost boundary comprised payments made by the household for the index neurosurgical admission at MNRH or MRRH, together with transport to that center; payments made at referring health facilities before arrival, and any costs incurred after discharge, were not captured. The reference period for direct medical and direct non-medical payments was the index admission, whereas the reference period for indirect costs was the illness episode, since respondents were asked how many work days had been lost during the illness rather than during the admission alone. Costs were explicitly defined to ensure methodological rigor. Direct medical costs included admission fees, radiological investigations (CT, MRI,

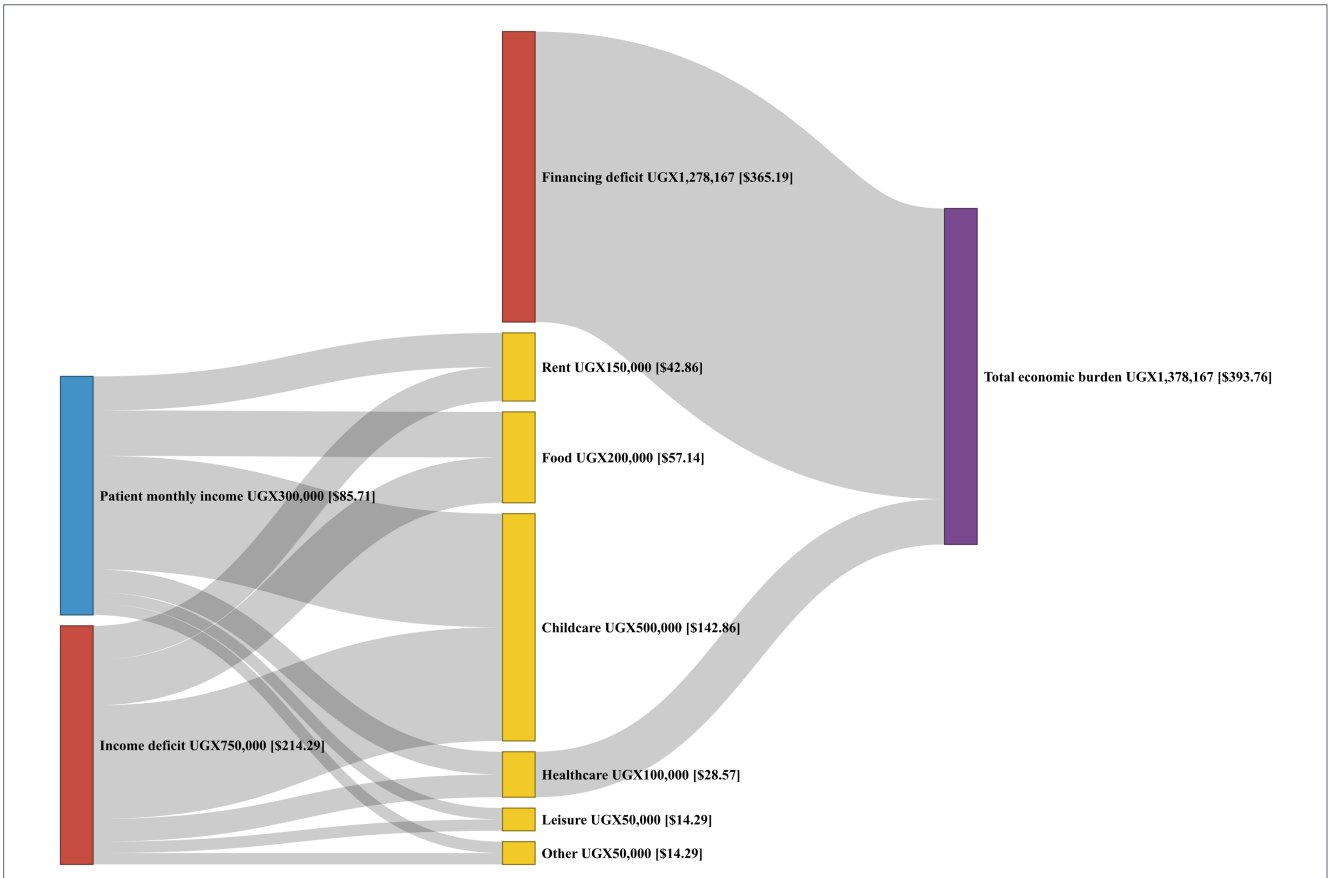

FIGURE 1
Sankey diagram showing flow of median household income, median routine expenditures, and median out-of-pocket costs for neurosurgical care.

ultrasound, X-ray), laboratory tests, medications, surgical consumables, devices/prosthetics, anesthesia, surgery fees, and ICU care. Direct non-medical costs captured transport, food, water, bedding, toiletries, caregiver accommodation and other non-medical expenses. Indirect costs were calculated as income lost due to missed workdays for both the patient and the caregiver, based on self-reported monthly income divided by 30 days and multiplied by the number of days lost ([monthly income ÷ 30] × days lost). Lost time of patients, caregivers and household helpers who reported no earnings, or whose wages were fully compensated, was valued at zero, and no imputation was made for unpaid household production. In a sensitivity analysis, lost days were re-valued at gross domestic product per capita per day (UGX11,908).

$$\text{Total economic burden} = \text{Direct medical cost} + \text{Direct non} - \text{medical cost} + \text{Indirect cost}$$

$$\text{OOP health payments} = \text{Direct medical payments} \times \left(1 - \text{Proportion Covered by Insurance}\right) + \text{Direct non} - \text{medical payments}$$

For consistency, all costs were calculated using a conversion rate of USD $1 = UGX3500 as of August 1, 2025 (9).

Financial catastrophe and impoverishment metrics

Financial consequences were measured using established international thresholds. CHE was defined as either OOP health payments exceeding 10% of annual household consumption expenditure by the World Bank threshold or OOP health payments exceeding 40% of annual household consumption expenditure after food costs by the WHO capacity-to-pay threshold (10, 11).

$$CHE10\% = \frac{Total\ Out-of-Pocket\ Expenditure}{Annual\ Household\ Consumption\ Expenditure} x\,100\%$$

$$CHE40\% = \frac{Total\ Out-of-Pocket\ Expenditure}{Annual\ Household\ Concumption\ Expenditure - Annual\ Food\ Expenditure} x\,100\%$$

Impoverishment was assessed by comparing per-capita daily household consumption with the international poverty line before and after OOP health payments. Per-capita daily household consumption was calculated before payment as annual household consumption expenditure divided by 365 and by household size, and after payment as annual household consumption expenditure minus OOP health payments, divided by 365 and by household size, so that both are measured on the same basis. Each was compared with the World Bank international poverty line for low-income countries of $3.00 per person per day in 2021 purchasing power parity (PPP) dollars, converted using the World Bank PPP conversion factor for private consumption for Uganda (UGX1,315.3 per international dollar, 2021) and inflated to 2025 prices using the consumer price index (factor 1.209), giving UGX4,769 per person per day (9). We report the poverty headcount before and after payment, the net proportion of households pushed below the line, and the mean normalized poverty gap. Prevalence estimates are reported with Wilson 95% confidence intervals. We also report OOP health payments as a share of annual household consumption expenditure, the absolute financing gap, and the burden by quintile of per-capita household consumption expenditure.

$$\frac{Anual\ household\ consumption\ expenditure - OOP\ health\ payments}{360\ x\ Household\ Size} < \text{UGX } 4,769$$

Ethics approval statement

The study protocol received ethical approval from the Duke Health Institutional Review Board (IRB) (Pro00117682), the MRRH IRB (MUST-2025-270), Mulago National Hospital (MHREC 2923), and the Uganda National Council for Science and Technology (HS5875ES).

Results

Patient characteristics and geographical access

A total of 76 respondents were enrolled, with 44 patients from MNRH and 32 from MRRH. Most surveys were conducted at the point of discharge (67%), and over half of the respondents were caregivers (57%). The mean age was 39 years, and the majority were male (65%). Fifty-three participants (69.7%) reported a source of income; only 8 of these (15.1%) were in salaried employment, in the private sector (5), a non-governmental organization (2) or government (1), while the remaining 45 (84.9%) were self-employed or reported other work. Twenty-three participants (30.3%) reported no source of income (Table 1).

Geographically, participants originated from 23 districts in Uganda. Five districts contributed only to MNRH (Arua, Gulu, Kabale, Kaberamaido, Rukungiri) and eight contributed only to MRRH (Hoima, Kabarole, Kumi, Kyenjojo, Luwero, Masaka, Mpigi, Nebbi). The remaining 10 districts supplied both hospitals, accounting for 75% of all participants. Overall, the majority of the patients came from Mbarara (18.4%), Wakiso (9.2%), and Mubende (7.9%) (Figure 2).

Barriers to access were evident in the transport data: only 38.2% of patients utilized formal ambulance services, while private vehicles (30.3%) and commercial transport (23.7%) were frequently used. While 32.9% of the patients experienced transit times of ≤1 h, 42.1% had significant delays of two hours or more (Table 2).

Clinical profile and household economy

The most common primary diagnosis was Traumatic Brain Injury (TBI) (65.8%), followed by Chronic Subdural Hematoma (CSDH) (13.2%) and brain tumor (6.6%). Overall, the median (IQR) admission duration was 5 (4–10) days, similar at both MNRH 5 (4–10) and MRRH 5 (3–10). The duration ranged from 4.0 (3.2–5.8) days for TBI to 45.0 (30–60) days for brain tumor patients (Figure 3; Supplementary Table 1).

TABLE 1 Sociodemographic characteristics of study participants.

Characteristic	Overall $N = 76^1$	MNRH $N = 44^1$	MRRH $N = 32^1$
Survey point			
Clinic	21 (27.6%)	12 (27.3%)	9 (28.1%)
At discharge	51 (67.1%)	32 (72.7%)	19 (59.4%)
Via phone	4 (5.3%)	0	4 (12.5%)
Respondent			
Caregiver	43 (56.6%)	26 (59.1%)	17 (53.1%)
Patient	33 (43.4%)	18 (40.9%)	15 (46.9%)
Age (years), mean (SD)	38.9 (22.6)	39 (19.5)	38 (26.7)
Sex			
Female	27 (35.5%)	13 (29.5%)	14 (43.8%)
Male	49 (64.5%)	31 (70.5%)	18 (56.3%)
Marital status			
Married	42 (55.3%)	26 (59.1%)	16 (50.0%)
Single	12 (15.8%)	7 (15.9%)	5 (15.6%)
Widowed	9 (11.8%)	5 (11.4%)	4 (12.5%)
Separated	2 (2.6%)	2 (4.5%)	0 (0.0%)
Divorced	1 (1.3%)	1 (2.3%)	0 (0.0%)
Minor	10 (13.2%)	3 (6.8%)	7 (21.9%)
Education level			
Not attended school	4 (5.3%)	0	4 (12.5%)
Pre-school	5 (6.6%)	3 (6.8%)	2 (6.3%)
Primary	36 (47.4%)	22 (50.0%)	14 (43.8%)
Secondary	22 (28.9%)	16 (36.4%)	6 (18.8%)
Tertiary	5 (6.6%)	3 (6.8%)	2 (6.3%)
Vocational training	4 (5.3%)	0	4 (12.5%)
Having a source of income	53 (69.7%)	34 (77.3%)	19 (59.4%)
Employment			
Government	1 (1.9%)	0 (0.0%)	1 (5.3%)
NGO	2 (3.8%)	0 (0.0%)	2 (10.5%)
Other	11 (20.8%)	3 (8.8%)	8 (42.1%)
Private	5 (9.4%)	4 (11.8%)	1 (5.3%)
Self-employed	34 (64.2%)	27 (79.4%)	7 (36.8%)

[1]*n* (%); Mean (SD).

The most frequently reported pre-admission total monthly household expenditure was UGX250,000–500,000 ($71–143) in 25% of participants, with educational expenses (UGX500,000 [$143]), food (UGX200,000 [$58]), and rent (UGX150,000 [$43]) accounting for the bulk (Figure 4; Supplementary Tables 2, 3).

Out-of-pocket expenditures and cost drivers

No participant had any form of health insurance (0 of 76), so all costs reported were borne in full by the household. Median OOP health payments were UGX1,227,000 ($351), comprising direct medical payments (median: UGX880,000 [$251]) and direct non-medical payments (median: UGX359,000 [$103]). Adding indirect costs (median: UGX125,000 [$36]) gave a median total economic burden of UGX1,378,167 ($394) (Table 3).

Direct medical expenses were the primary drivers, led by resource-intensive services. Median costs were highest for Intensive Care Unit (ICU) admission (UGX1,600,000 [$457]), devices/prosthetics (UGX1,050,000 [$300]), and MRI scans (UGX700,000 [$200]). Direct non-medical costs were lower, with median expenditures of UGX110,000 [$31] for transport and UGX100,000 [$29] for food. Indirect costs included a median of 5 patient workdays lost (3–10), 6 caregiver workdays lost (4.5–14), with a median total indirect cost of UGX125,000 [$36] (Figure 5). Because catastrophic expenditure and impoverishment were computed on OOP health payments, which exclude imputed lost income, these estimates are unaffected by how lost time is valued; re-valuing lost days at gross domestic product per capita per day changed the median total economic burden only marginally, from UGX1,378,167 to UGX1,385,938.

Catastrophic and impoverishing consequences

OOP health payments exceeded 10% of annual household consumption expenditure in 76.0% of households (57/75; 95% CI 65.2 to 84.2) and 40% of capacity to pay in 41.2% (28/68; 95% CI 30.3 to 53.0); with direct medical payments alone the corresponding figures were 68.0% (51/75) and 27.9% (19/68). Before payment, 50.7% of households (38/75) were already below the international poverty line. After OOP health payments the headcount rose to 62.7% (47/75), a net impoverishing effect of 12.0% (9/75). Among the 38 households already below the line, payments deepened poverty: the mean normalized poverty gap rose from 27.1 to 44.2% of the poverty line. OOP health payments absorbed a median 20.9% of annual household consumption expenditure (IQR 10.9 to 39.8) and exceeded one month of total household expenditure in 60 of 76 households (median financing gap UGX710,000). The burden was strongly graded by household means: from the poorest to the richest quintile of per-capita consumption, the median share of annual expenditure absorbed fell from 87 to 8%, catastrophic expenditure at the 10% threshold fell from 100 to 40%, and at the 40% threshold from 100 to 20%, while the absolute amount paid was similar across quintiles (Supplementary Table 4). Costs also differed by diagnosis: TBI patients ($n = 50$) stayed a median 4 days (IQR 3 to 6) and paid a median UGX1,201,000 ($343), whereas non-TBI patients ($n = 26$) stayed a median 12 days (IQR 7 to 28) and paid a median UGX1,592,500 ($455), so the pooled medians reflect the predominance of TBI in this sample (Supplementary Table 5).

Most households financed this burden primarily through savings (83.3%) and borrowing (65.8%). The median amount borrowed was UGX750,000 [$214]. Notably, 64.0% of households that borrowed incurred interest, with a median interest payment of UGX120,000 [$34]. In addition, 23.7% of households (18 of 76) sold property. Among these 18 households the median estimated value of the property was UGX755,000 [$216] and the median price obtained was UGX700,000 [$200] (Table 4).

Additionally, Figure 1 shows how a median neurosurgical admission creates a substantial shock to household finances. The predominant household expenditures in our cohort were food, education, and rent, which leaves limited disposable income to absorb unexpected health costs. When compared with the median total economic burden

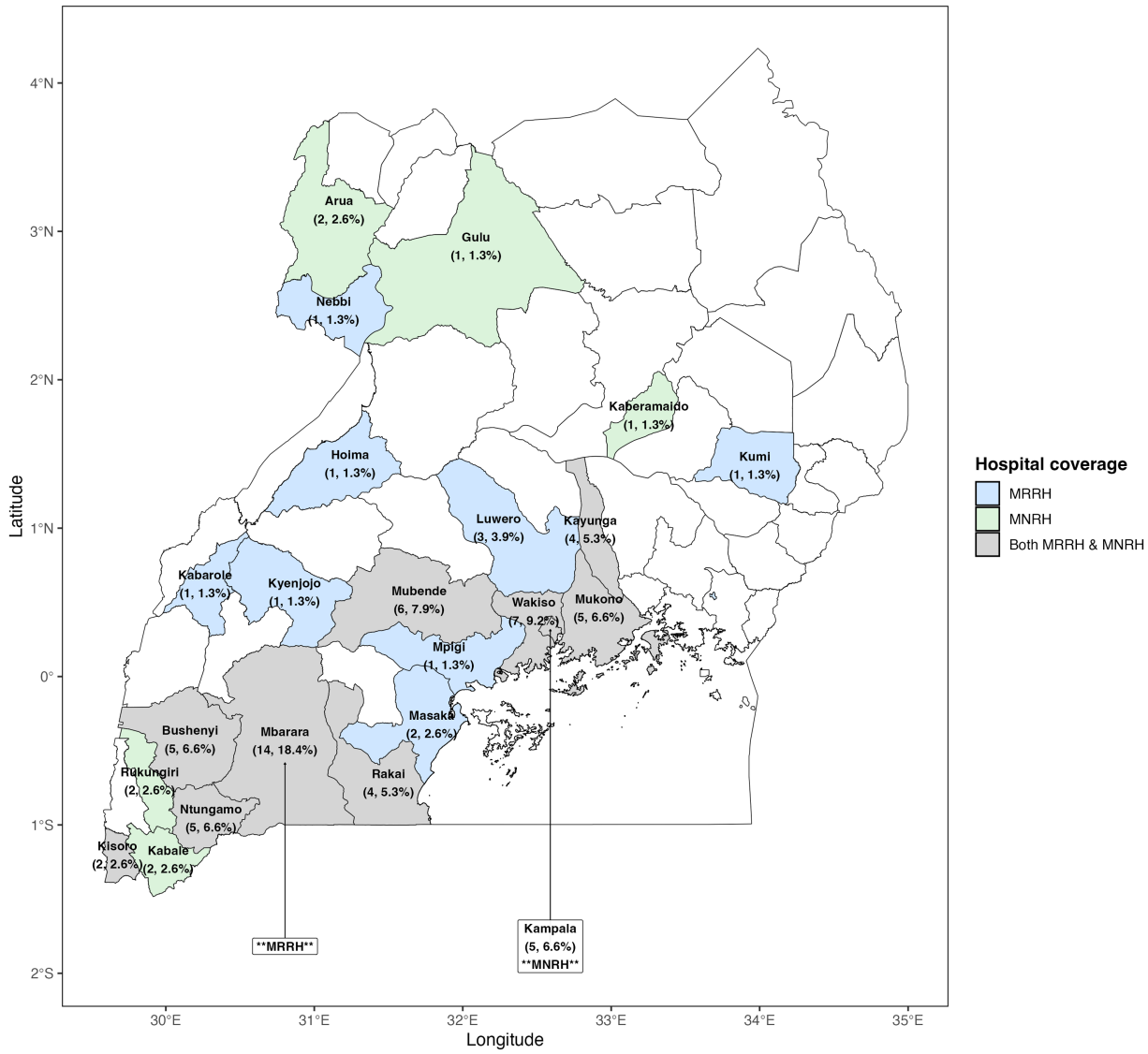

FIGURE 2
Geographic distribution of participants by district and referral hospital.

TABLE 2 Transport mode and transit duration to hospital, overall and by site.

Characteristic	Overall $N = 76^1$	MNRH $N = 44^1$	MRRH $N = 32^1$
Transport type			
Ambulance	29 (38.2%)	23 (52.3%)	6 (18.8%)
Private	23 (30.3%)	14 (31.8%)	9 (28.1%)
Commercial	18 (23.7%)	2 (4.5%)	16 (50.0%)
Motorcycle	5 (6.6%)	4 (9.1%)	1 (3.1%)
Other	1 (1.3%)	1 (2.3%)	0
Transit duration (hours)			
0–0.5	6 (7.9%)	3 (6.8%)	3 (9.4%)
0.5–1	19 (25.0%)	15 (34.1%)	4 (12.5%)
1–2	19 (25.0%)	12 (27.3%)	7 (21.9%)
2–4	23 (30.3%)	12 (27.3%)	11 (34.4%)
>4	9 (11.8%)	2 (4.5%)	7 (21.9%)

[1]*n* (%).

of UGX 1,378,167 (USD $393.76), the Sankey diagram demonstrates that most households experience a large financing deficit that must be covered through borrowing, liquidation of assets, and external support.

Discussion

This study provides one of the first comprehensive assessments of the OOP costs associated with neurosurgical care in Uganda. It offers compelling evidence that specialized neurosurgical care in Uganda is financially devastating for the large majority of patients, establishing that access is currently secured at the cost of catastrophic household expenditure for three quarters of households, and of deeper poverty for those already below the poverty line. The study highlights the multidimensional socioeconomic impact of neurosurgical illness and of getting neurosurgical care.

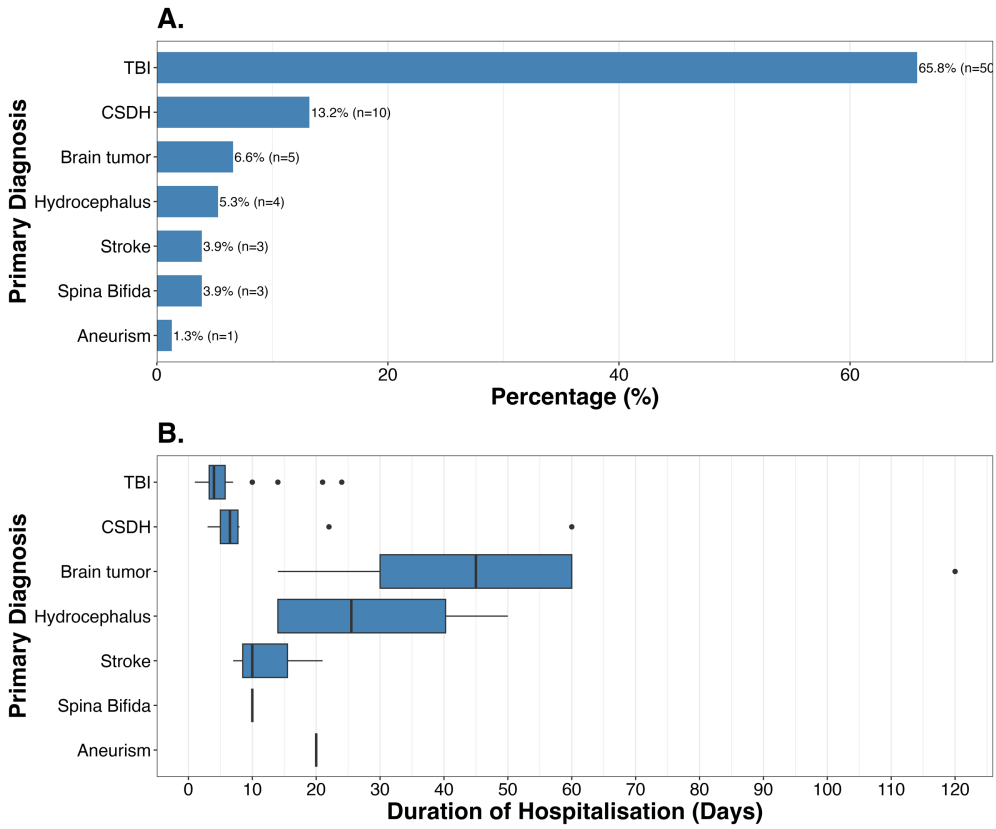

FIGURE 3
Distribution of primary diagnoses **(A)** and hospital stay duration by diagnosis **(B)**. CSDH, Chronic Subdural Hematoma; TBI, Traumatic Brain Injury.

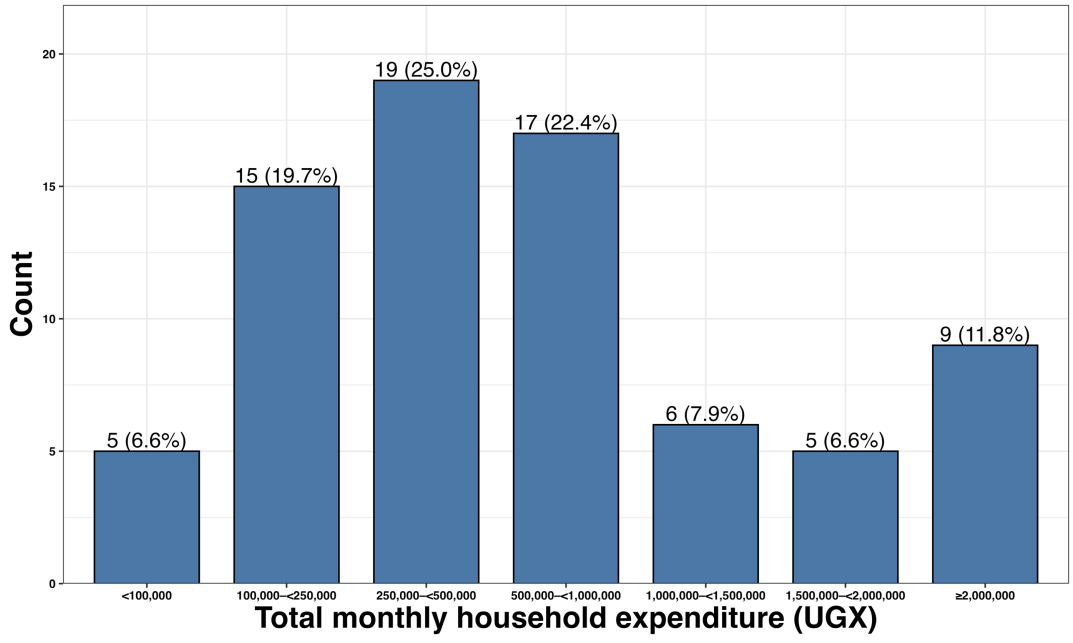

FIGURE 4
Distribution of total monthly household expenditure (UGX) among participants, showing counts and percentages across expenditure categories.

Median OOP health payments of UGX1.23 million (918 international dollars, 2021 purchasing power parity) represent about a quarter (26.3%) of Uganda's GDP per capita in PPP terms ($3,488) (9). When contextualized against the median monthly household income of only UGX436,000 ($125) in urban areas and UGX667,000 (~$190) in Kampala (12), the necessity of paying $394 demonstrates an overwhelming financial exposure that existing mechanisms are failing to mitigate, leading to a high likelihood of CHE. In

TABLE 3 Distribution of household costs by category and hospital.

Metric	Overall	MNRH	MRRH
Direct medical cost	880,000 [251 USD] (650000–1,527,500)	910,000 [260 USD] (745,000–1,682,500)	720,000 [206 USD] (560,000–1,417,500)
Direct non-medical cost	359,000 [103 USD] (229500–573,250)	345,000 [99 USD] (227,500–592,250)	372,500 [106 USD] (242,250–466,500)
OOP health payments (direct medical + direct non-medical)	1,227,000 [351 USD] (913,500–2,111,250)	1,355,000 [387 USD] (1,020,000–2,153,750)	1,219,250 [348 USD] (875,000–1,919,500)
Indirect cost	125,000 [36 USD] (69167–380,000)	245,000 [70 USD] (95,000–426,250)	91,667 [26 USD] (49,417–201,250)
Total economic burden	1,378,167 [394 USD] (1055333–2,497,500)	1,471,667 [420 USD] (1,199,250–2,610,000)	1,294,500 [370 USD] (897,917–2,010,083)

Median (Q1, Q3); 1 $ = 3,500 UGX.

Vietnam, the combined medical and surgical costs for head injury treatment amounted to ~$287, highlighting the substantial financial strain on families in LMICs, although this represented approximately 10% of Vietnam's per capita GDP in market terms in 2017, the year of that study (~$2,956), indicating somewhat greater capacity to absorb such costs (13). Even within Uganda, a previous government hospital study reported median direct medical costs of $118 and non-medical expenses of $84 for general surgical patients, though only 3% were neurosurgical and their specific costs were not defined, indicating that neurosurgical care is likely substantially higher (14).

In our study, median direct medical costs were the highest, predominantly driven by ICU admission, prosthetics/devices, and MRI scans. Evidence from other settings has shown that neuroimaging alone can account for over 99% of patients' costs, and that ICU stay significantly increases overall direct costs (15, 16). ICU services are resource-intensive, requiring continuous monitoring by trained staff, ventilatory support, costly drugs and consumables, making ICU days one of the most expensive components of hospital care, often requiring OOP payments when public resources are inadequate (17). Neurosurgical prosthetics and implants are frequently imported and purchased privately, as they are not included in Uganda's essential health benefits packages (18).

When examining transportation, only 38.2% of patients in our study traveled to the hospital by ambulance, highlighting a heavy reliance on private vehicles and motorcycles. Similar patterns have been reported regionally, like in Tanzania, where over half of trauma patients used motorized two- or three-wheelers, while formal ambulances were rarely used even in serious cases (19). In rural Uganda, only 7.2% of trauma patients accessed ambulance services to reach care (20). Patients experience delays in reaching neurosurgical care, which can exacerbate injuries, particularly for those with traumatic brain injury, increase the likelihood of ICU admission, prolong hospital stays, and drive up overall treatment costs. This causes indirect costs to also rise, as families incur repeated travel expenses (21, 22).

These delays are particularly concerning given that a substantial proportion of patients in our cohort spent between 2–4 h traveling to the hospital, with evidence from a rural hospital in Eastern Uganda showing trauma patients often required up to 7.5 h to reach care – only 18.9% arrived within one hour and 45.8% within six hours (20). This far exceeds the recommended "golden hour" of 60 min, which is associated with improved survival and reduced morbidity for traumatic injuries (23). In our cohort, 65% of patients had TBI, the largest diagnostic category, and while these patients had shorter hospital stays, delays to care could still increase secondary brain injury and complicate recovery (24). Longer travel times and low ambulance use contribute to higher direct non-medical costs and delayed care.

Three quarters of households (76.0%) met the CHE-10% threshold and 41.2% met the CHE-40% threshold. Half of households were below the international poverty line before seeking care, one in eight of the remainder was pushed below it by OOP health payments, and among those already poor the poverty gap deepened substantially, which underscores the financial vulnerability of this population. More recent global estimates suggest that 81.3 million people incur CHEs related to surgical healthcare each year, with the greatest burden borne by LMICs (25). Of these, 32.8 million people represent the costs of surgery alone, and up to 48.5 million from associated non-medical costs (26). Incorporating subsidies for high-cost procedures, ICU admissions, medications, prosthetics, and MRI scans, can further reduce OOP expenses. Investing in ambulance services and prehospital care is essential to reduce delays in accessing neurosurgical care, thereby improving outcomes and reducing associated costs. Encouraging the adoption of health insurance schemes that cover neurosurgical procedures can also reduce the financial risk for households.

Comparative evidence shows that neurosurgical patients in Uganda face substantially higher financial burden than other surgical populations, both within the country and globally. In Ethiopia, for example, 49% of households with patients treated for hydrocephalus and spina bifida experienced CHE (27). In Nigeria, neurosurgical care for children under 15 years costs an average of $896, equivalent to 40.18% of the national GDP per capita (16). These findings, although considerable, remain far below those observed in our neurosurgical cohort.

When compared with general surgical patients in Uganda, the contrast becomes even more apparent. Anderson et al. reported that among general surgical patients, 31% faced CHEs at the 10% threshold and 7–12% at the 40% threshold, while 32% of households experienced a financial catastrophe when all direct costs were considered, and 67% were pushed below the poverty line (14). Another study from MNRH found that 93% of surgical patients experienced financial catastrophe, and 12% were impoverished by healthcare spending, with over 59% of patients already below the poverty line before seeking care (28). Our own pre-payment headcount of 50.7% is consistent with this, and it is why the impoverishing effect of neurosurgical payments must be measured as the increase in the poverty headcount rather than its level after payment. Similarly, research among rural surgical inpatients found that 29% incurred CHEs and 31% became impoverished despite nominally free healthcare services, largely due to OOP payment for procedures and supplies (29). These observations suggest that neurosurgical patients likely face a higher financial burden than

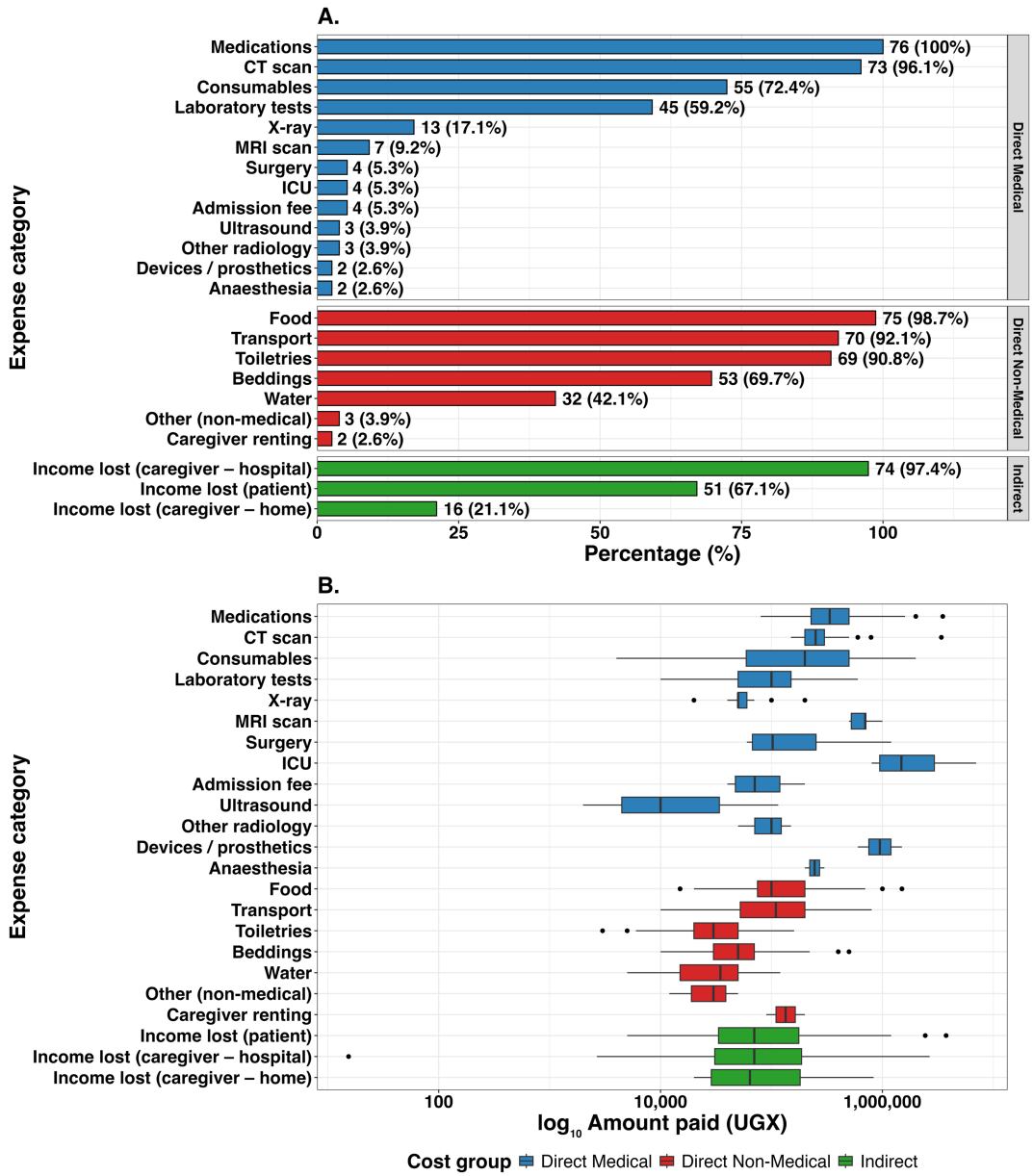

FIGURE 5
Bar chart **(A)** shows the proportion of respondents with OOP payments; Boxplot **(B)** displays the distribution of OOP amounts on a $\log_{10}$ scale, both grouped by cost category.

general surgical patients in Uganda because neurosurgical care is more specialized, resource-dependent, and often requires costly equipment and medication. In our study, the median total cost of neurosurgical care exceeded the average reported household expenditure, further highlighting the unsustainable financial burden faced by affected families.

Over 80% of participants in our study used savings to finance neurosurgical care, and nearly two-thirds used borrowed money, often at high interest rates. In addition, almost one-quarter were forced to sell property, further depleting household assets. Although few studies have specifically examined these coping mechanisms among neurosurgical patients, evidence from broader surgical contexts reveals similar financial distress. A similar pattern was reported in previous research on OOP payments for surgery in Uganda, where 53% borrowed money, and 21% sold possessions to pay for care (14). Across 15 African countries, borrowing and selling assets to meet healthcare costs ranged from 23% of households in Zambia to 68% in Burkina Faso, with a strong association with higher inpatient expenditures (30). Likewise, in Ethiopia, 24.6% of patients borrowed funds to pay for abdominal surgery; in rural Rwanda, 64.4% borrowed funds and 18.4% sold possessions to afford cesarean delivery; and in rural Haiti, 69.8% of patients relied on loans or donations to cover surgical costs (31–33). Patients continue to bear this debt burden for months or even years after treatment (34–36). While these studies primarily focus on general, obstetric, or emergency surgery rather than neurosurgery, they provide relevant insights into the costs of surgical care and highlight our findings in the context of neurosurgical care, which often involves greater costs, longer hospital stays, and a high risk of postoperative disability. The consistent pattern of borrowing and asset liquidation across surgical fields underscores the likelihood that

TABLE 4 Household strategies for financing care.

Characteristic	Overall $N = 76^1$	MNRH $N = 44^1$	MRRH $N = 32^1$
Used savings to pay for care (among adult respondents, $n = 72$)			
Yes	60 (83.3%)	37 (84.1%)	23 (82.1%)
No	12 (16.7%)	7 (15.9%)	5 (17.9%)
Borrowed money to pay for care			
Yes	50 (65.8%)	27 (61.4%)	23 (71.9%)
No	26 (34.2%)	17 (38.6%)	9 (28.1%)
Amount borrowed (among borrowers, $n = 50$)	750,000 [USD214] (525,000, 1,500,000)	1,000,000 [$286] (600,000, 2,000,000)	700,000 [$200] (500,000, 1,300,000)
Interest incurred (among borrowers, $n = 50$)			
Yes	32 (64.0%)	20 (74.1%)	12 (52.2%)
No	18 (36.0%)	7 (25.9%)	11 (47.8%)
Interest amount (among those who paid interest, $n = 32$)	120,000 [$34] (72,500, 200,000)	120,000 [$34] (90,000, 200,000)	100,000 [$29] (40,000, 200,000)
Sold property to pay for care (all households, $n = 76$)			
Yes	18 (23.7%)	6 (13.6%)	12 (37.5%)
No	58 (76.3%)	38 (86.4%)	20 (62.5%)
Estimated value of property sold (among sellers, $n = 18$)	755,000 [$216] (500,000, 1,375,000)	1,500,000 [$429] (750,000, 1,500,000)	660,000 [$189] (350,000, 906,250)
Price obtained (among sellers, $n = 18$)	700,000 [$200] (325,000, 1,500,000)	750,000 [$214] (300,000, 1,500,000)	590,000 [$169] (260,000, 1,750,000)

[1]n (%); Median (Q1, Q3).

neurosurgical patients face similar or greater severe economic hardships. Our findings highlight the fragility of household finances in the face of unexpected illness, particularly in settings that offer limited financial risk protection. Even with health insurance coverage, households can still experience prolonged debt after surgery, emphasizing the need for formal prepaid schemes and further social protections.

These financing patterns suggest that direct household OOP expenditures capture only a portion of the true economic burden of neurosurgical illness. Future iterations of this work should incorporate additional cost categories, including governmental inputs, organizational subsidies, and external financial or philanthropic support, to better reflect the full spectrum of expenditure required to deliver neurosurgical care. Disaggregating cost contributions across actors – such as government, households, NGOs, and facility support – would allow a more complete understanding of health financing gaps and inform targeted policy responses.

On this note, while our study focuses on household OOP expenditures, this represents only a portion of the total economic costs of neurosurgical care delivery. Prior micro-costing work in LMICs has shown that a substantial part of neurosurgical expenses are subsidized by the public sector in the form of personnel salaries, infrastructure, OR resources, and overheads, beyond the high proportion of direct and indirect costs that patients themselves also face. A recent economic analysis at Mulago National Referral Hospital estimated the provider-side cost of neurosurgical procedures to inform resource allocation and planning, showing that the mean total cost of a neurosurgical operation was USD 542 (USD 291–1,220 depending on procedure type). Overhead expenditures represented the largest single cost category (29–41% of total cost), with diagnostic imaging and ward personnel also contributing substantially to total expenditure. It was reported that capital and infrastructure inputs, including OR time, staffing, and diagnostic equipment, were heavily subsidized by the hospital and government rather than borne by patients, which indicates that household OOP payments are only a portion of the total economic cost of neurosurgical care in this setting (37). These findings emphasize that neurosurgical care delivery in Uganda is dependent on public sector financing and cost absorption at the facility level as well, which to some extent shields households from the true procedural cost, but still exposes them to catastrophic expenditures at the point of care.

This misalignment between who pays and who benefits highlights the need for greater risk pooling and pre-paid financing within Uganda's emerging Universal Health Coverage (UHC) model, given that point-of-care OOP payments are economically inefficient and inequitable for high-cost, high impact care such as neurosurgery. It is essential to expand financial protection through UHC schemes, by subsidizing high-cost procedures.

Policy implications

Beyond quantifying financial risk, these findings highlight an important but often overlooked dimension of neurosurgical care, its cost-effectiveness. Many neurosurgical interventions, including trauma surgery, shunt placement for hydrocephalus, and decompression for mass lesions, are associated with substantial reductions in disability and premature mortality, generating large health gains at relatively low cost when evaluated through DALYs averted compared to other widely funded health interventions (38, 39). Demonstrating that neurosurgery is both life-saving and economically efficient strengthens the argument for integrating essential neurosurgical procedures within national UHC financing and benefit packages, rather than relying on impoverishing OOP payments.

On that note, the integration of neurosurgical services within Uganda's evolving UHC framework requires deliberate health financing and policy reforms. Expansion of risk pooling and prepayment mechanisms through strengthened national health insurance schemes and community-based financing models would reduce reliance on OOP expenses and ensure more equitable access to essential neurosurgical care. In parallel, the introduction of targeted subsidies for high-cost procedures, such as trauma surgery, cerebrospinal fluid shunt placement, craniotomies, neuroimaging, surgical implants, and ICU care, could provide immediate financial protection for households at greatest risk of CHE and impoverishment (40). Such subsidies would address the disproportionate economic burden of neurosurgical emergencies and align with broader equity goals of UHC.

Furthermore, multisectoral injury-prevention strategies remain central to reducing demand for emergency neurosurgical interventions. Stricter enforcement of road safety regulations, sustained helmet use campaigns, and investments in prehospital emergency care systems are critical to lowering the incidence of traumatic brain injury and other preventable neurosurgical conditions (41). Together, these

interventions would strengthen Uganda's neurosurgical system, reduce poverty driven by health spending, and accelerate progress toward sustainable development and UHC.

These results align with previous literature that has documented high rates of CHE and impoverishment following surgical procedures, particularly in Sub-Saharan Africa (42, 43). Our study expands on this evidence by looking at both direct and indirect expenditures, bringing attention to neurosurgical care, which is an area that has been understudied and neglected despite its importance in the global surgery agenda – particularly in issues such as TBI, epilepsy, and neural tube defects (44). Our findings also support the recommendations of the Lancet Commission of Global Surgery, which emphasize the importance of evaluating financial risk protection as a key metric for surgical systems performance (45).

Limitations

This study is subject to several limitations that should be considered when interpreting the findings. The small sample size and cross-sectional design may limit causal interpretation and generalizability. Enrolling at discharge necessarily excluded patients who died in hospital, were transferred or referred onward, or left against medical advice, and it could not reach households deterred from seeking neurosurgical care by its cost. Because these groups are likely to include the most financially affected households, the estimates reported here probably understate the true burden. Cost data were based on self-reported expenditures and income, which may be affected by recall bias and reporting inaccuracies despite efforts to minimize these through interviews conducted at discharge or within two weeks post-discharge. Verification of expenditures against receipts was encouraged but was not documented, so the proportion of amounts corroborated is unknown. Caregivers reported on behalf of the patient in 56.6% of cases, which may introduce error in reported income and expenditure. Indirect costs were valued from self-reported monthly income, an unreliable basis in an economy where most earners are informally employed, and the lost time of non-earners was valued at zero, so the indirect burden on households without wage income is understated. An asset inventory was not collected, so wealth quintiles were based on consumption expenditure, which also forms the denominator of the burden share. Two thirds of the sample had TBI, so the pooled cost estimates are weighted toward a diagnosis with short admissions, and settings with a larger share of tumor or hydrocephalus patients would be expected to show higher household costs. Because payments at referring facilities before arrival and all costs after discharge fall outside the cost boundary, and both omissions act in the same direction, the totals reported here are a lower bound on the household cost of a neurosurgical care episode. Findings may also not be generalizable beyond Uganda's two principal public neurosurgical centers.

Furthermore, temporal and policy-related factors during the study period could have influenced service availability and pricing. While direct and indirect costs were quantified, broader economic dimensions such as pre-existing household debt and productivity losses were not captured. Also, longer-term costs after discharge were not captured, which may underestimate the true economic burden. Future research should aim to quantify the longer-term economic impacts, including post-discharge debt servicing, asset recovery rates, and the true burden of productivity losses associated with long-term disability, as the current figures likely underestimate the total financial shock sustained by these families.

The financial vulnerability reflected in this study reflects not only the cost burden of neurosurgical care but the broader inequities in access to essential surgical services across LMICs. Longer-term follow-up would more accurately capture the full financial impact of neurosurgical illness and is critical for estimating societal costs and guiding policy reforms aimed at financial protection and health system strengthening. Collectively, these findings emphasize that without deliberate policy interventions to expand financial protection and strengthen health system financing, neurosurgical illness will continue to drive families into cycles of debt, poverty, and inappropriate health care.

Conclusion

Neurosurgical care in Uganda imposes a substantial financial burden on patients and their households, resulting in catastrophic expenditure for three quarters of households and pushing a further one in eight below the poverty line. The financial crisis is driven by extremely high direct medical costs – particularly for intensive care, specialized surgical devices, and neuroimaging – and is compounded by substantial indirect expenses amplified by prehospital system failures. These findings highlight the urgent necessity for specific, targeted policy interventions to ensure that access to essential, life-saving neurosurgical care does not guarantee economic ruin. These include integrating specialized neurosurgical care within Uganda's evolving UHC framework through targeted subsidies, expanded financial risk-pooling mechanisms, and inclusion of essential neurosurgical procedures in national health benefit packages. Strengthening prehospital systems and social protection programs will also be critical to reducing both the economic and health consequences of neurosurgical illness, like TBI, linking improved patient outcomes directly to poverty alleviation. Ultimately, ensuring comprehensive financial protection for neurosurgical patients is paramount not only to achieving health equity but also to meeting the critical performance metrics necessary for sustainable surgical system development in resource-limited settings.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by the Uganda National Council for Science and Technology (HS5875ES), Mbarara University of Science and Technology Institutional Review Board (MUST-2025-270), Mulago National Hospital Research Ethics Committee (MHREC 2923), and Duke University Health System

Institutional Review Board (Pro00117682). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

AB: Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. CP: Conceptualization, Data curation, Formal analysis, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. TK: Data curation, Formal analysis, Investigation, Validation, Writing – original draft, Writing – review & editing. PA: Data curation, Formal analysis, Investigation, Validation, Writing – original draft, Writing – review & editing. EO: Data curation, Formal analysis, Investigation, Validation, Writing – original draft, Writing – review & editing. JS: Data curation, Formal analysis, Investigation, Validation, Writing – original draft, Writing – review & editing. IM: Data curation, Formal analysis, Investigation, Validation, Writing – original draft, Writing – review & editing. BK: Data curation, Formal analysis, Investigation, Validation, Writing – original draft, Writing – review & editing. AS: Data curation, Formal analysis, Validation, Writing – original draft, Writing – review & editing. AK: Data curation, Formal analysis, Investigation, Validation, Writing – original draft, Writing – review & editing. NF: Data curation, Formal analysis, Validation, Writing – original draft, Writing – review & editing. DS: Data curation, Formal analysis, Investigation, Validation, Writing – original draft, Writing – review & editing. BM: Conceptualization, Methodology, Writing – review & editing. CM: Methodology, Project administration, Resources, Validation, Writing – review & editing. JNaj: Methodology, Validation, Writing – review & editing. BT: Methodology, Validation, Writing – review & editing. JNal: Methodology, Project administration, Resources, Validation, Writing – review & editing. OO: Methodology, Writing – review & editing. JK: Methodology, Supervision, Validation, Writing – review & editing. DK: Methodology, Supervision, Validation, Writing – review & editing. MH: Funding acquisition, Methodology, Supervision, Writing – review & editing. A-EU: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that Generative AI was not used in the creation of this manuscript.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fneur.2026.1897555/full#supplementary-material

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