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Resource Use and Costs Associated With Neurological and Neurosurgical Conditions in a Neonatal Intensive Care Unit at the National Referral Hospital in Angola

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Abstract

Neurological and neurosurgical disorders are a major reason for neonatal intensive care in sub-Saharan Africa, but their composition and the hospital resources they consume are rarely quantified together. Angola is one of three high-burden countries in the WHO African Region not yet validated for maternal and neonatal tetanus elimination and has no legislation for folic acid fortification of staple flours. We conducted a retrospective study of all episodes recorded in the neonatal intensive care unit (NICU) register of Hospital Pediátrico David Bernardino, Luanda, from January 2020 to June 2026. Episodes were assigned to seven mutually exclusive diagnostic groups using predefined hierarchical rules. We estimated proportions with Wilson 95% confidence intervals (CI), length of stay (LOS) and bed-days by group, and direct provider costs using a WHO-CHOICE tertiary-hospital bed-day cost for Angola inflated to 2024 US dollars (US$72.23 per bed-day), with Monte Carlo uncertainty intervals (UI).

Of 1,728 NICU episodes, 536 (31.0%; 95% CI 28.9–33.2) were neurological or neurosurgical. Central nervous system infection/neonatal tetanus (39.6%) and hypoxic–ischaemic encephalopathy (21.6%) predominated; clinical tetanus alone accounted for 166 episodes, 9.6% (95% CI 8.3–11.1) of all NICU admissions. Males were over-represented (57.6% of 523 with recorded sex; binomial p = 0.004). The 478 episodes with recorded LOS used 7,309 bed-days (median LOS 10 days, IQR 4–21). Congenital conditions (neural tube defects, hydrocephalus, encephalocele) made up 28.5% of neurological admissions but an estimated 59.7% of bed-days (95% UI 53.4–62.3). Neural tube defects alone made up 14.9% of admissions and 33.0% of bed-days. Modelled direct bed-day costs totalled US$528 thousand (95% UI 229–1,215 thousand). Mean cost per episode was US$2,452 for neural tube defects versus US$567 for infection/tetanus, a 4.3-fold difference that rose to 5.1-fold when one neurosurgical procedure (US$419) was added. In-hospital mortality was not captured by the register.

Nearly one in three NICU admissions at Angola's referral paediatric hospital is neurological. The burden is dominated by two largely preventable conditions: high-volume neonatal tetanus and low-volume but resource-intensive neural tube defects. Alongside investment in neonatal neurosurgical capacity, these data support completing maternal and neonatal tetanus elimination with case-based surveillance and evaluation, and legislating mandatory folic acid fortification of wheat and maize flour.

Introduction

Neurological disorders are among the most frequent and consequential reasons for neonatal intensive care. They range from acute acquired brain injury—bacterial meningitis, neonatal tetanus, hypoxic–ischaemic encephalopathy (HIE) and seizures—to congenital malformations that require neurosurgery, such as myelomeningocele, hydrocephalus and encephalocele [1–4]. In high-income settings, neonatal neurocritical care models that integrate neonatology, neurology, imaging and neurosurgery have improved the recognition of brain injury and the standardisation of care [5–7]. In sub-Saharan Africa the burden is heavier and differently composed, yet it is seldom described in a way that informs service planning or prevention policy.

Two features make Angola an important setting. First, as of May 2026 Angola was one of only three of the 37 high-burden countries in the WHO African Region not yet validated for elimination of maternal and neonatal tetanus (MNT) [8, 9]. Neonatal tetanus is almost entirely preventable through tetanus-toxoid immunisation of women and clean delivery and cord care, but once established it carries case-fatality rates of around 50% even in tertiary units [2, 10]. At our hospital, tetanus was the leading cause of neonatal death in 2022–2023, with a proportionate mortality of 33% [11]. Second, Angola has no legislation for fortification of wheat flour, maize flour or rice, and none of its industrially milled flour is fortified [12]. Mandatory fortification of staple foods with folic acid is a safe and cost-effective population intervention against spina bifida and anencephaly. It outperforms reliance on periconceptional supplementation, whose uptake is low and inequitable where many pregnancies are unplanned and antenatal booking is late [13–16]. In 2023 the World Health Assembly adopted resolution WHA76.19 urging member states to accelerate such fortification [17]. Neural tube defects (NTD) and neonatal infections in turn drive much of the infant hydrocephalus and neurosurgical workload in Africa [18, 19].

Earlier work at Hospital Pediátrico David Bernardino (HPDB) characterised neonatal mortality [11] and bacterial meningitis in young infants [20, 21], but the neurological case-mix of the neonatal intensive care unit (NICU) and the resources it consumes have not been described. Such data are needed to quantify how much of the neonatal neurological burden is preventable at population level, to plan beds and neurosurgical capacity, and to provide a baseline against which prevention programmes can be evaluated. We therefore aimed to describe, for all NICU episodes at HPDB from 2020 to 2026, (i) the proportion and case-mix of neurological and neurosurgical conditions, (ii) length of stay (LOS) and bed-day use by diagnostic group, and (iii) modelled direct hospital costs, contrasting high-volume acute conditions with lower-volume congenital conditions.

Materials and methods

Study design and reporting

This was a retrospective study of routinely collected hospital register data, reported following the STROBE statement and its RECORD extension [22, 23] (S1 Checklist).

Setting

HPDB is Angola's tertiary teaching hospital and national referral centre for paediatrics. It has about 554 inpatient beds with an occupancy of about 97%, and no maternity unit, so all neonates are born elsewhere and referred from public and private maternities, health centres or home [11]. The neonatology service comprises a 21-bed main ward, a room for preterm infants, a dedicated unit for infants with tetanus and a post-operative care area [11]. Intensive care is provided in an emergency and intensive-care complex opened in June 2020. The complex has 135 beds, 47 of them intensive-care beds

including 19 neonatal beds, and six incubators; at opening, each emergency and intensive-care bed was equipped with a ventilator, a monitor and infusion pumps [24]. On-site diagnostics comprise portable radiography, computed tomography, and haematology, biochemistry and microbiology laboratories [24]. In 2021 the hospital employed 623 health professionals, including 101 doctors, 308 nurses and 65 diagnostic technicians [25]; staffing ratios per shift are not published.

Neurological and neurosurgical care

Neonatologists manage all NICU admissions. Neonates with tetanus are managed in the dedicated tetanus unit with sedation, muscle relaxation, antimicrobial therapy, antitoxin, cord care and ventilatory support as available, in line with standard recommendations [2]. Therapeutic hypothermia was not used for HIE, consistent with trial evidence that cooling does not reduce death or disability in low- and middle-income settings [26]. Neurosurgical assessment and surgery for neonates are provided on a consultation basis by a small number of neurosurgeons; press reports describe most paediatric hydrocephalus in Luanda's public sector being managed by two neurosurgeons at HPDB [27]. Two of the authors (SN, MCR) are neurosurgeons based at other Luanda hospitals. HPDB has collaborated with a charitable hydrocephalus centre (Centro Neurocirúrgico de Tratamento da Hidrocefalia, CNCTH) by providing volunteer surgeons, and that centre runs social-worker-led post-operative follow-up [28]. The Ministry of Health has supplied shunt valves free of charge [28]. Consultation times, joint rounds and post-discharge follow-up were not recorded in the NICU register and could not be analysed.

Participants and data source

All episodes recorded in the NICU admission register between 1 January 2020 and 30 June 2026 were eligible. The register contains admission and discharge dates, sex, postnatal age and weight at admission, and free-text diagnoses with structured markers for tetanus, meningitis, perinatal hypoxia, birth trauma and anticonvulsant use. It does not record discharge outcome. Records probably representing the same episode of care were identified by probabilistic matching with manual consistency review and consolidated conservatively (S1 Appendix). One record dated 2012 was considered a probable date-entry error, and four records lacked an admission date; these five records were retained in all analyses except the annual distribution.

Classification of neurological conditions

Episodes were classified as neurological or neurosurgical when the principal or a secondary diagnosis involved the central nervous system (CNS). Each was assigned to one primary group by a predefined hierarchical rule, taking the first applicable group (S1 Appendix): (1) CNS infection/neonatal tetanus; (2) HIE/perinatal asphyxia; (3) NTD/spinal dysraphism; (4) hydrocephalus and other cerebrospinal fluid (CSF) disorders; (5) neonatal seizures/spasms without a cause in groups 1–4; (6) birth trauma/intracranial haemorrhage/cephalohaematoma; and (7) encephalocele and other cranial

malformations. Groups 3, 4 and 7 were considered congenital and groups 1, 2, 5 and 6 acute acquired. Classification was performed by the study team; inter-rater agreement was not assessed.

Outcomes

The outcomes were the proportion of NICU episodes that were neurological; the distribution of diagnostic groups; LOS (discharge minus admission date, in days); bed-days; and modelled direct hospital costs. In-hospital mortality, neurosurgical procedures and complications were not available in the register.

Bed-days and costs

Because the register summary provided LOS as median and interquartile range (IQR) by group, mean LOS per group was estimated with the method of Wan et al. [29]. Group bed-days were estimated as mean LOS multiplied by the number of episodes with recorded LOS, then rescaled so that the groups summed to the observed total of 7,309 bed-days. The number of episodes with recorded LOS in each group was allocated in proportion to group size (478 of 536 overall), assuming non-differential missingness.

Costs were estimated from the provider perspective. The unit cost was the WHO-CHOICE estimate of the cost per inpatient bed-day in an Angolan tertiary hospital, excluding drugs: US$50.21 in 2010 US dollars; in 2010 international dollars, I$82.26 (95% UI 34.43–181.57) [30]. This was inflated to 2024 using the United States consumer price index (factor 1.4386) [31], giving US$72.23 per bed-day (95% UI 30.23–159.43), equivalent to about AOA 62,830 at the 2024 average official exchange rate of AOA 869.85 per US$ [31]. Costs are reported in US dollars because domestic inflation was high (annual average 20.2% in 2025) and the kwanza has been volatile [32]. For neurosurgery we used the fee charged to families by the CNCTH: AOA 200,000 per operation in 2020 [27]. Converted at the 2020 exchange rate (AOA 578.26 per US$) and inflated to 2024, this gives US$419, similar to the cost of a ventriculoperitoneal shunt operation reported in Nigeria [31, 33]. Because procedure counts were not recorded, procedures were analysed only as a scenario (S1 Appendix).

Statistical analysis

Proportions are reported with Wilson 95% confidence intervals (CI) [34]. The proportion of males was compared with an expected 51.2% at birth using an exact binomial test. Uncertainty in group bed-days and costs was propagated by Monte Carlo simulation with 10,000 draws (seed 2026). In each draw, individual LOS values in each group were drawn from a lognormal distribution fitted to the group median and IQR, group totals were rescaled to 7,309 bed-days, and the unit cost was drawn from a lognormal distribution fitted to the WHO-CHOICE uncertainty interval. The 2.5th and 97.5th percentiles define 95% uncertainty intervals (UI). The bed-day ratio (share of bed-days divided by share of admissions) indicates disproportionate resource use when greater than 1. Because individual-level LOS data were not available

for this analysis, groups were compared descriptively rather than with hypothesis tests. Sensitivity analyses examined the following: an alternative inflation route (2010 US dollars converted to kwanza, inflated with the Angolan consumer price index, and reconverted at the 2024 rate) [31]; costs varied by ± 50%; extrapolation to the 58 episodes without recorded LOS; and an upper-bound scenario in which every congenital case underwent one neurosurgical procedure. No annual NICU denominators were available, so temporal trends were not tested. Analyses used Python 3.12 (NumPy 2.5, SciPy 1.18, statsmodels 0.15); code is provided in S1 Code.

Ethics statement

The study was approved by the Ethics Committee of Hospital Pediátrico David Bernardino (ref. HPDB-DP 103/2026, 10 May 2026). The committee waived the requirement for informed consent because the study used anonymised routine records, in accordance with Angolan Law No. 7/25 on Biomedical and Clinical Research, Law No. 22/11 on Data Protection and the Declaration of Helsinki.

Results

Study population

Of 1,774 register rows, 46 probable duplicates (44 groups) were consolidated, leaving 1,728 NICU episodes. Of these, 536 (31.0%; 95% CI 28.9–33.2) had a neurological or neurosurgical primary group (Fig. 1). Acute acquired conditions accounted for 383 episodes (71.5%; 95% CI 67.5–75.1) and congenital conditions for 153 (28.5%; 95% CI 24.9–32.5).

Of the 523 neonates with recorded sex, 301 (57.6%; 95% CI 53.3–61.7) were male, more than expected from the sex ratio at birth ($p = 0.004$). Median age at admission was 7 days (IQR 4–11; n = 404), consistent with referral after birth elsewhere, and median weight was 2,800 g (IQR 2,300–3,290; n = 395) (Table 1). Clinical tetanus was recorded in 166 episodes: 31.0% (95% CI 27.2–35.0) of neurological episodes and 9.6% (95% CI 8.3–11.1) of all NICU episodes. Meningitis was recorded in 47 (8.8%) and anticonvulsant use in 78 (14.6%).

Table 1
Characteristics of neonates with neurological and neurosurgical conditions (n = 536).

Characteristic	n with data	Value
Proportion of all NICU episodes, n (%; 95% CI)	1,728	536 (31.0; 28.9–33.2)
Male sex, n (%; 95% CI)	523	301 (57.6; 53.3–61.7)*
Age at admission, days, median [IQR]	404	7 [4–11]
Weight at admission, g, median [IQR]	395	2,800 [2,300–3,290]
Length of stay, days, median [IQR]; range	478	10 [4–21]; 0–105
Total bed-days	478	7,309
Clinical tetanus, n (%; 95% CI)	536	166 (31.0; 27.2–35.0)
Meningitis, n (%; 95% CI)	536	47 (8.8; 6.7–11.5)
Perinatal hypoxia marker, n (%; 95% CI)	536	98 (18.3; 15.2–21.8)
Anticonvulsant use, n (%; 95% CI)	536	78 (14.6; 11.8–17.8)

*Exact binomial test against an expected 51.2% male at birth, p = 0.004. Missing data: sex 13 (2.4%), age 132 (24.6%), weight 141 (26.3%), length of stay 58 (10.8%). CI, Wilson confidence interval; IQR, interquartile range; NICU, neonatal intensive care unit.

Case-mix and length of stay

CNS infection/neonatal tetanus (212; 39.6%) and HIE/perinatal asphyxia (116; 21.6%) together accounted for 61.2% of neurological episodes (Table 2). Among congenital conditions, NTD were most frequent (80; 14.9%), followed by hydrocephalus (52; 9.7%) and encephalocele/other cranial malformations (21; 3.9%). Median LOS was longest for NTD (27.5 days), hydrocephalus (25 days) and encephalocele (22 days), and shortest for CNS infection/tetanus (5 days), seizures (6 days) and HIE (7 days).

Table 2
Distribution of diagnostic groups and length of stay (LOS).

Diagnostic group	n	% (95% CI)	LOS, days, median [IQR]	Estimated mean LOS, days*
CNS infection / neonatal tetanus	212	39.6 (35.5–43.8)	5 [3–12]	6.7
HIE / perinatal asphyxia	116	21.6 (18.4–25.3)	7 [4–14]	8.3
Neural tube defects / spinal dysraphism	80	14.9 (12.2–18.2)	27.5 [18.3–40.8]	28.8
Hydrocephalus / CSF disorders	52	9.7 (7.5–12.5)	25 [17–37]	26.3
Neonatal seizures / spasms	33	6.2 (4.4–8.5)	6 [4–9]	6.3
Birth trauma / haemorrhage	22	4.1 (2.7–6.1)	8 [5.5–15.5]	9.7
Encephalocele / other cranial malformations	21	3.9 (2.6–5.9)	22 [11–37.8]	23.6
Acute acquired (groups 1, 2, 5, 6)	383	71.5 (67.5–75.1)	—	—
Congenital (groups 3, 4, 7)	153	28.5 (24.9–32.5)	—	—
All neurological	536	100	10 [4–21]	15.3†

*Estimated from median and IQR (Wan et al.). †Observed mean (7,309 bed-days / 478 episodes). LOS recorded for 478 of 536 episodes. CI, Wilson confidence interval; CNS, central nervous system; CSF, cerebrospinal fluid; HIE, hypoxic–ischaemic encephalopathy; IQR, interquartile range.

Bed-day use and costs

The three congenital groups, 28.5% of neurological admissions, used an estimated 59.7% of neurological bed-days (95% UI 53.4–62.3), a bed-day ratio of 2.1. The four acute groups, 71.5% of admissions, used 40.3% (95% UI 37.7–46.6), a ratio of 0.56 (Fig. 2, Table 3). NTD alone made up 14.9% of admissions but 33.0% of bed-days (ratio 2.2). CNS infection/tetanus made up 39.6% of admissions but 20.4% of bed-days (ratio 0.5).

At US$72.23 per bed-day, modelled direct bed-day costs for the 478 episodes with recorded LOS totalled US$527,935 (95% UI 228,566–1,215,468), of which US$315,182 (59.7%) was attributable to congenital conditions. Mean cost per episode was US$2,452 (95% UI 987–5,392) for NTD, US$2,239 for hydrocephalus and US$2,005 for encephalocele, compared with US$567 (95% UI 256–1,385) for CNS infection/tetanus and US$709 for HIE. A congenital episode cost on average 3.7 times as much as an

acute episode (US$2,318 vs US$622). Adding one neurosurgical procedure per congenital episode raised this to 4.4 times, and the NTD-to-tetanus/infection ratio from 4.3 to 5.1.

Table 3
Modelled bed-days and direct hospital costs by diagnostic group (2024 US$).

Diagnostic group	n with LOS	Share, %	Bed-days (95% UI)	% of bed-days (95% UI)	Bed-day ratio	Total cost, US$ (95% UI)	Cost per episode, US$ (95% UI)
CNS infection / tetanus	190	39.6	1,491 (1,324–1,864)	20.4 (18.1–25.5)	0.52	107,709 (48,691–263,147)	567 (256–1,385)
HIE / perinatal asphyxia	103	21.6	1,010 (877–1,339)	13.8 (12.0–18.3)	0.64	72,987 (32,787–184,454)	709 (318–1,791)
Neural tube defects	71	14.9	2,410 (1,997–2,586)	33.0 (27.3–35.4)	2.21	174,077 (70,108–382,841)	2,452 (987–5,392)
Hydrocephalus / CSF	46	9.7	1,426 (1,110–1,571)	19.5 (15.2–21.5)	2.01	103,003 (40,858–224,822)	2,239 (888–4,887)
Seizures / spasms	29	6.2	216 (158–259)	3.0 (2.2–3.5)	0.48	15,618 (6,181–34,887)	539 (213–1,203)
Birth trauma / haemorrhage	20	4.1	228 (142–307)	3.1 (1.9–4.2)	0.76	16,440 (5,891–37,154)	822 (295–1,858)
Encephalocele / cranial	19	3.9	528 (383–960)	7.2 (5.2–13.1)	1.84	38,102 (16,947–111,386)	2,005 (892–5,862)
Congenital groups	136	28.5	4,364	59.7 (53.4–62.3)	2.09	315,182 (131,758–703,076)	2,318
Acute groups	342	71.5	2,945	40.3 (37.7–46.6)	0.56	212,753 (96,303–513,499)	622
All neurological	478	100	7,309 (observed)	100	1.00	527,935 (228,566–1,215,468)	1,104

Unit cost US$72.23 per bed-day (95% UI 30.23–159.43): WHO-CHOICE Angola tertiary hospital, excluding drugs, inflated from 2010 to 2024 with the US consumer price index. UI from 10,000 Monte Carlo draws. Group LOS denominators allocated in proportion to group size. Costs exclude drugs, consumables, imaging, surgery and family costs and are therefore a lower bound. Bed-day ratio = share of bed-days /

share of admissions. CNS, central nervous system; CSF, cerebrospinal fluid; HIE, hypoxic–ischaemic encephalopathy; LOS, length of stay; UI, uncertainty interval.

Sensitivity and scenario analyses

With the alternative inflation route (Angolan consumer price index and the 2024 exchange rate), the bed-day cost was US$54.76 and the total US$400,268. Varying the unit cost by ± 50% gave totals of US$263,967–791,902. Extrapolating to all 536 episodes, assuming the 58 without recorded LOS stayed as long as others, gave 8,196 bed-days and US$591,994. In the upper-bound scenario, if each of the 153 congenital cases underwent one procedure at US$419, procedure costs would add US$64,138 (US$32,069–96,207 with ± 50%), raising the total to US$592,073; congenital conditions would then account for 64.1% of costs. The bed-day share of congenital conditions does not depend on the unit cost, so the main conclusion was unchanged in every scenario.

Annual distribution

Annual neurological episodes were 34 (2020), 171 (2021), 62 (2022), 21 (2023), 133 (2024), 88 (2025) and 22 (January–June 2026), totalling 531 dated episodes (Fig. 3). Because annual NICU denominators were unavailable, these fluctuations cannot be distinguished from changes in total admissions or register completeness and are not interpreted as changes in incidence.

Discussion

At Angola's national paediatric referral hospital, almost one in three NICU admissions over six and a half years was for a neurological or neurosurgical condition. The burden had two distinct components. The first was high-volume and short-stay, dominated by neonatal tetanus and other CNS infections. The second was low-volume and long-stay: NTD, hydrocephalus and encephalocele, which used about 60% of neurological bed-days and all neurosurgical resources. The largest contributor to each component—neonatal tetanus and NTD—is preventable with established, low-cost population interventions that Angola has not yet fully implemented.

Neonatal tetanus: a sentinel of incomplete elimination

Clinical tetanus accounted for one in ten NICU admissions. Its short median stay should not be read as low severity: hospital data from the same neonatology service identified tetanus as the leading cause of neonatal death, with a proportionate mortality of 33% among 527 deaths in 3,653 admissions in 2022–2023 [11], and case-fatality of about 50% is reported from tertiary units elsewhere in West Africa [10]. Short stays in this group therefore probably include early deaths. WHO estimates that fewer than 5% of neonatal tetanus cases are reported [8], so hospital series such as ours underestimate the community burden. Each case represents a failure of maternal immunisation, clean delivery or cord care [2, 9]. Our findings support (i) intensified tetanus-toxoid-containing vaccination of women of reproductive age, with supplementary campaigns in high-risk municipalities; (ii) promotion of facility delivery and clean cord care; (iii) case-based surveillance in which every hospital tetanus case triggers investigation of the

mother's vaccination status and place of birth; and (iv) use of referral-hospital tetanus admissions as a monitoring and evaluation indicator of the national elimination programme, reported periodically against validation targets [9].

Neural tube defects and hydrocephalus: the case for mandatory fortification

NTD were the third most frequent group but the largest consumer of bed-days, with a mean bed-day cost per episode 4.3 times that of an infection/tetanus admission before any surgery. Their long stays reflect closure of the defect, management of infection and hydrocephalus, and waiting for theatre and shunt hardware, as described in other sub-Saharan centres where pre-operative infection is common [35, 36]. Improving neurosurgical access will reduce morbidity, but the greater gain lies upstream. Angola's estimated NTD prevalence of about 20 per 10,000 births could fall to about 6 per 10,000 with folic acid interventions in place [12]. Periconceptional supplementation requires planned pregnancy and early contact with services. Mandatory fortification of staples reaches women before they know they are pregnant and has consistently reduced NTD prevalence at population scale [14, 15]. Globally, only about a quarter of folic-acid-preventable spina bifida and anencephaly was prevented in 2022, largely because most countries, including Angola, lack mandatory fortification [16]. In line with WHA76.19 [17], we recommend that Angola legislate mandatory folic acid fortification of wheat and maize flour with regulatory monitoring, and use referral-hospital NTD admissions as a sentinel indicator of impact. Our cost estimates are a conservative lower bound but provide a local economic argument. Each NTD admission consumed about US$2,452 of bed-day costs alone, or about US$2,871 with one operation, in a country where current health expenditure was about US$76 per person in 2023 and out-of-pocket payments made up 32.5% of current health expenditure [37, 38].

Infections, HIE and the acute burden

Beyond tetanus, meningitis and HIE reflect the quality of antenatal, intrapartum and early postnatal care. Bacterial meningitis in young infants in Luanda is caused predominantly by Gram-negative organisms with substantial resistance to third-generation cephalosporins and carries high mortality [20, 21]. Infection is also the leading cause of infant hydrocephalus in Africa [18, 19], so infection prevention in maternities, prompt referral and access to lumbar puncture and appropriate antibiotics are also neurosurgical prevention. HIE accounted for one in five neurological admissions. Because HPDB has no maternity unit, these infants arrive after transfer, and therapeutic hypothermia is neither available nor supported by trial evidence in comparable settings [26]. Strengthening intrapartum care and neonatal resuscitation at referring maternities is likely to yield more than tertiary-level interventions. Male predominance is common in neonatal admission series and may reflect greater male vulnerability to perinatal brain injury and infection, though referral or care-seeking bias cannot be excluded.

Implications for service organisation

The dual configuration of the burden has practical consequences. Acute conditions require rapid stabilisation capacity: ventilated beds, a tetanus isolation unit, and protocols for meningitis, seizures and

HIE. Congenital conditions require predictable neurosurgical access: a defined time to neurosurgical review, protected neonatal theatre time, reliable shunt supply and a post-discharge pathway [36]. At HPDB, neurosurgical care depends on a few surgeons working by consultation, alongside a charitable centre that charges families about US$419 per operation [27, 28]. Bed planning based on admission counts alone would underestimate the needs of congenital conditions by roughly half. We recommend that the NICU register add discharge outcome, date of neurosurgical consultation, procedure and date, and complications. These are the minimum variables needed to evaluate a formal multidisciplinary pathway.

Strengths and limitations

This study includes all NICU register episodes over six and a half years at the national referral centre and links case-mix to resource use with explicit, reproducible uncertainty. It has important limitations. First, the register did not record discharge outcome, neurosurgical procedures or complications, so in-hospital mortality and surgical outcomes could not be reported. Mortality data cited from the same hospital come from a separate study of the whole neonatology service [11]. Second, the register appears to cover only part of the neonatology service. Avelino et al. recorded 3,653 neonatology admissions in 14 months [11], whereas our register contains 1,728 episodes over 78 months, and tetanus deaths implied by their proportionate mortality exceed the tetanus episodes in our register. Many tetanus and post-operative cases may therefore be managed in the dedicated tetanus unit or post-operative area outside the NICU register, and our counts underestimate the hospital's total neurological burden. Third, diagnoses relied on free-text clinical records classified by the study team without assessment of inter-rater agreement. Tetanus and HIE were clinically defined, and imaging and microbiology were not universally available. Fourth, bed-days by group were modelled from group medians and IQRs rather than summed from individual records, and LOS denominators were allocated proportionally. Fifth, the unit cost is a general tertiary-hospital estimate that excludes drugs and is not NICU-specific; costs are therefore a lower bound and omit family and long-term costs. Finally, as a single tertiary centre without a maternity unit, the cohort over-represents referred infants who survived transfer and cannot estimate population incidence; outcomes after discharge were not assessed.

Conclusions

Neurological and neurosurgical conditions account for nearly a third of NICU admissions at Angola's referral paediatric hospital. High-volume neonatal tetanus and low-volume but resource-intensive NTD dominate this burden, and both are largely preventable. Hospital investment in neonatal neurocritical and neurosurgical care should proceed alongside, not instead of, national action. That action means completing maternal and neonatal tetanus elimination with case-based surveillance and evaluation, and legislating mandatory folic acid fortification of staple flours. Adding outcome and procedure fields to the NICU register would allow the impact of these measures to be measured.

Declarations

Author Contribution

Author Contributions (CRediT Statement)Sérgio Neto: Conceptualization; Methodology; Data curation; Formal analysis; Investigation; Visualization; Writing – original draft; Writing – review & editing; Supervision.Moisés Cinco Reis: Investigation; Data curation; Validation; Writing – review & editing.Paula Quaresma: Investigation; Data curation; Validation; Resources; Writing – review & editing.All authors reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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Data Availability

The data derive from organised institutional clinical records. Access is subject to institutional authorisation and appropriate anonymisation.

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Figures

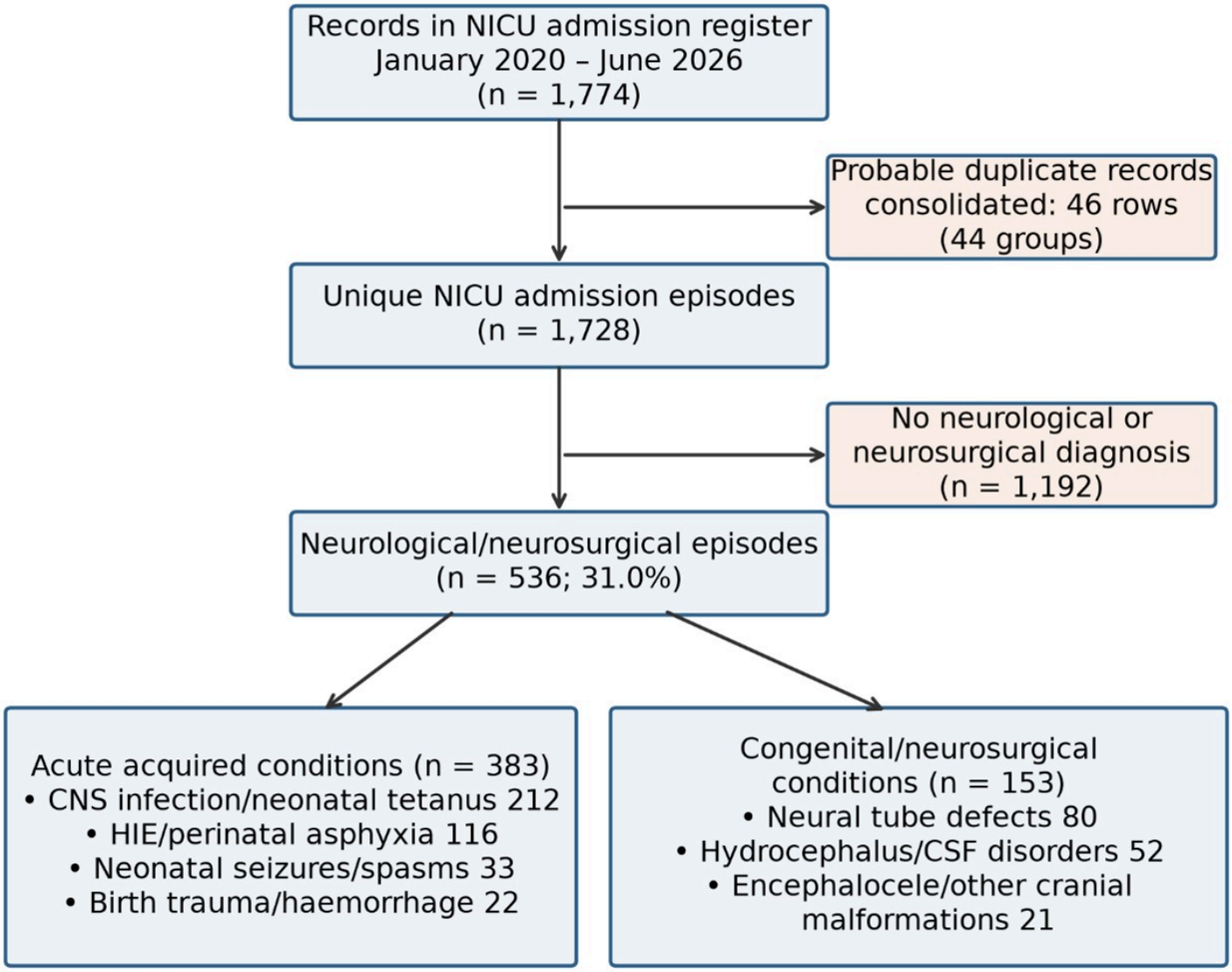


Figure 1

Flow of NICU episodes and classification of neurological and neurosurgical conditions, HPDB, January 2020 to June 2026. CNS, central nervous system; CSF, cerebrospinal fluid; HIE, hypoxic–ischaemic encephalopathy; NICU, neonatal intensive care unit.

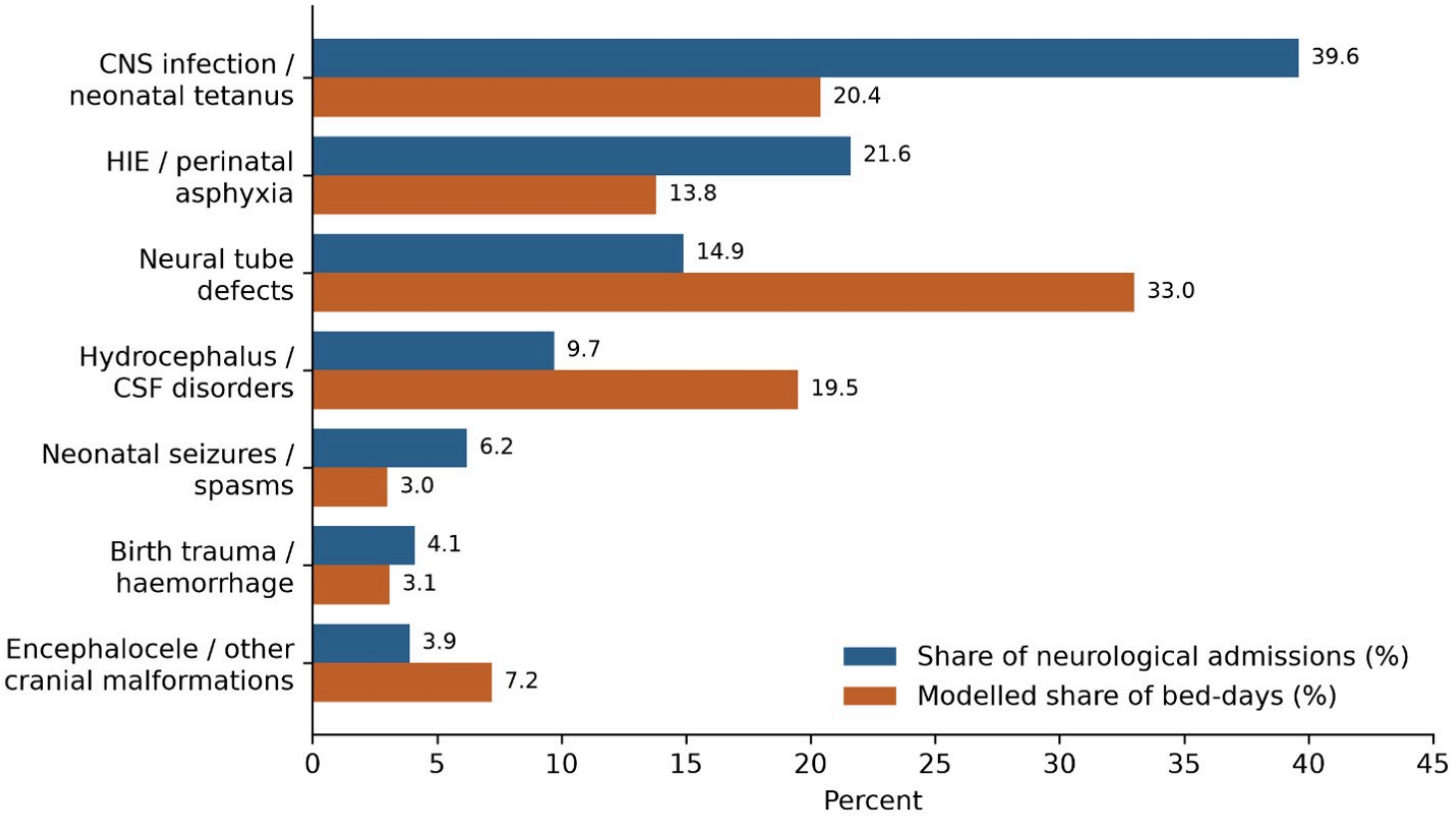


Figure 2

Share of neurological admissions versus modelled share of neurological bed-days, by diagnostic group. Bed-days were estimated from group median and interquartile range of length of stay (Wan et al.) and rescaled to the observed total of 7,309 bed-days. Uncertainty intervals are given in Table 3.

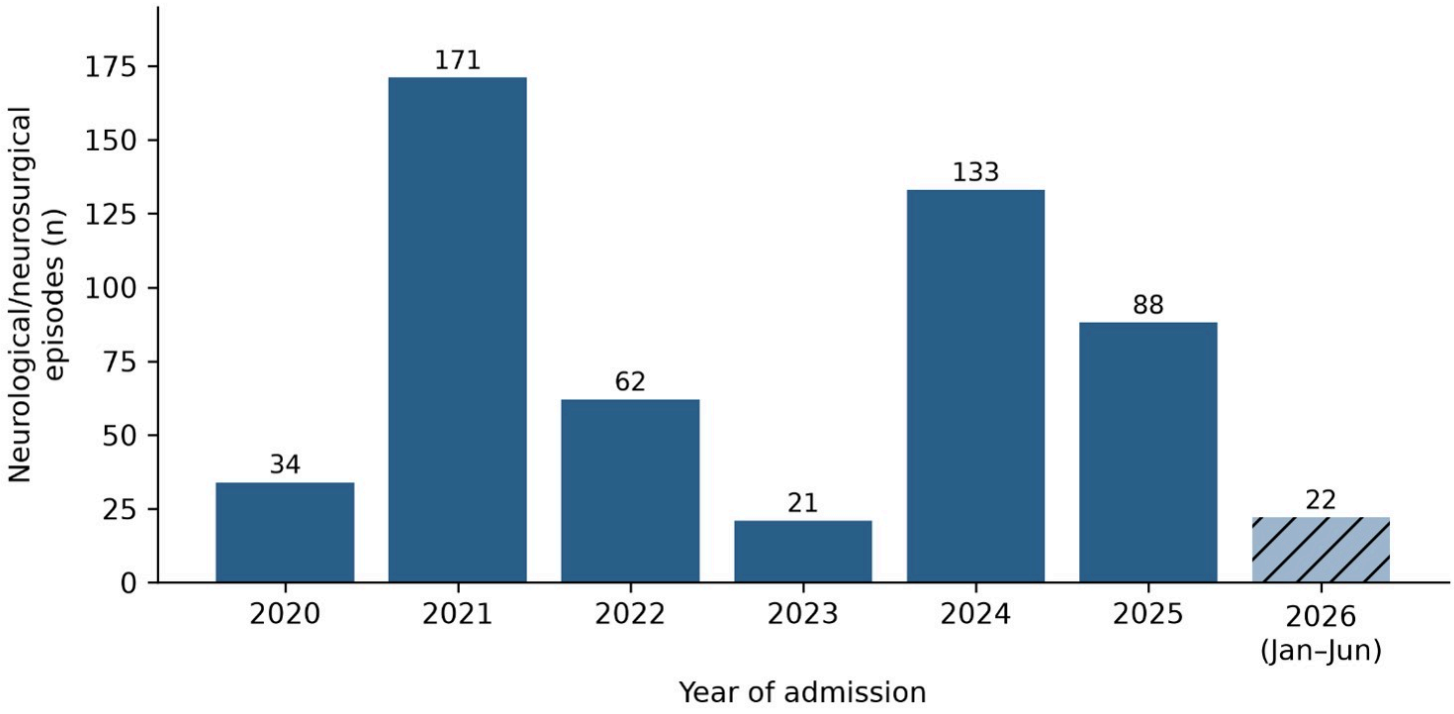


Figure 3

Neurological and neurosurgical NICU episodes by year of admission. 2026 includes January to June only. Five records with a missing or implausible admission date are excluded from this figure only.

Supplementary Files

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- S1Appendix.docx