

Timeliness of acute stroke care and predictors of delays in three referral hospitals in Douala, Cameroon: a multicenter cross-sectional study

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Abstract

Background

Timely access to evidence-based acute stroke care is essential for reducing disability and mortality, yet substantial delays persist in many low- and middle-income countries. Data on the timing of acute stroke care in Cameroon remain scarce. This study assessed the timeliness of acute stroke care and identified factors associated with delays in the care pathway in three referral hospitals in Cameroon.

Methods

We conducted a multicenter cross-sectional study from January to May 2025 in three referral hospitals in Douala. Adults with imaging-confirmed acute stroke were consecutively and exhaustively recruited. Sociodemographic, clinical, vascular risk factor, care pathway, and treatment data were collected. Three process-of-care intervals were assessed: onset-to-door (OTD), door-to-neurologist (DTNe), and door-to-imaging (DTI) times. Delays were defined as OTD > 4.5h, DTNe > 1h, DTI > 25 min. Univariable and multivariable logistic regression analyses were performed. Associations were reported as adjusted odds ratios (aORs) with 95% confidence intervals (CIs).

Results

A total of 126 patients were included. The mean age was 62.3 ± 13.3 years, and 51.6% were men. Hypertension was the most frequent vascular risk factor (54.0%). Ischemic stroke accounted for 60.3% cases. The median OTD time was 16.7h (45.4), with 75.4% of patients arriving > 4.5h after symptom onset or last known well, while 88.9% of patients experience a DTNe > 1h, and 71.4% exceeding the 25 minutes DTI target. In multivariable analysis, not considering stroke symptoms alarming (aOR = 7.02, 95% CI: 2.13–23.22, $p = 0.001$) and initially targeting a non-specialized healthcare facility (aOR = 2.97, 95% CI: 1.16–7.59, $p = 0.023$) were independently associated with delayed OTP. Ischemic stroke was associated with delayed DTI (aOR = 2.66, 95% CI: 1.14–6.17, $p = 0.023$), while MRI rather than CT scan was associated with delayed DTNe (aOR = 10.33, 95% CI: 2.38–44.71, $p = 0.002$).

Conclusion

Acute stroke care in these three referral hospitals in Douala was characterized by substantial delays in prehospital arrival, neurological assessment, and brain imaging. Perception of stroke symptoms and the initial point of healthcare contact were determinants of delayed hospital arrival.

Background

Stroke is a major neurological emergency and a leading cause of morbidity and mortality worldwide [1–3]. In 2019, an estimated 101.5 million people were living with stroke worldwide, with approximately 6.6 million deaths that year [4]. The prevalence of stroke is approximately 2.6% in the United States, while annual incidence in Europe ranges from 95 to 290 per 100,000 population [5, 6]. In Asia, Japan has reported particularly high incidence rates from 212 to 422 per 100,000 person-years in women and men, respectively [7]. In Africa, annual stroke incidence may reach 316 per 100,000 population, with a growing burden across sub-Saharan Africa [9]. In Cameroon, stroke accounts for approximately one in ten hospitalizations in neurology urban setting [10]. This burden is also associated with substantial economic consequences. The average annual direct medical cost of ischemic stroke in Cameroon is estimated at 932,700 XAF (approximately USD 1,600), nearly twice the annual minimum wage [11]. Moreover, in-hospital mortality following stroke remains high, reaching 27% in Cameroon [12].

To reduce stroke-related mortality and disability-adjusted life-years (DALYs), organized stroke care and acute reperfusion therapies have been developed [13–15]. A stroke unit is a geographically defined area or ward within a hospital where patients with stroke receive coordinated care from a multidisciplinary team comprising medical, nursing, and rehabilitation professionals [16]. Evidence has consistently demonstrated that stroke units and organized stroke services improve clinical outcomes and survival [17–19]. Key components of acute stroke care include reperfusion therapies, particularly intravenous thrombolysis and mechanical thrombectomy [20]. Because these interventions are highly time-dependent, their effectiveness is critically influenced by the interval between symptom onset and treatment [21]. The principle that “time is brain” reflects the rapid and irreversible loss of neuronal tissue following cerebral ischemia, estimated at approximately 2 million neurons and 15 billion synapses per minute in untreated large-vessel ischemic stroke [22, 23].

Despite advances in acute strokes systems of care, timely access to reperfusion therapy remains challenging, particularly in low- and middle-income countries (LMICs) [24, 25]. Process-of-care time measures (PCTMs) quantify the intervals between key events along the stroke care pathway, including onset-to-door, door-to-neurologist, door-to-imaging, door-to-needle, and door-to-puncture times [26, 27]. These intervals vary substantially across settings. The median onset-to-door time is approximately 2 hours in the United States, compared with 5 hours in India [28, 29]. In the Democratic Republic of Congo, nearly 90% of patients present after the 4.5-hour window for intravenous thrombolysis [30]. In China, median door-to-neurologist and door-to-imaging times have been reported at 61 and 38 minutes, respectively, whereas the median door-to-imaging time in South Africa has been reported to be as long as 8 hours [32]. Delays in PCTMs in LMICs are multifactorial and may reflect limited awareness of stroke symptoms, sociodemographic and cultural factors, prehospital barriers, and deficiencies in healthcare infrastructure and organization [33].

Several strategies have been implemented in high-income countries to reduce delays, including community education on stroke recognition, training of healthcare workers, implementation of rapid neuroimaging pathways, and standardization of acute stroke management protocols [27]. However, stroke units and comprehensive stroke centers remain scarce in Africa [9]. Although efforts are

underway to improve the availability and quality of stroke care, major gaps persist in human resources, diagnostic capacity, and access to acute stroke therapies, particularly in sub-Saharan Africa [9, 34]. In Cameroon, despite the establishment of two stroke units in major hospitals in Douala, approximately 75% of patients reportedly arrive at hospital more than 4.5 hours after symptom onset, thereby limiting their eligibility for reperfusion therapy when otherwise indicated [35].

Understanding the specific time intervals within the acute stroke pathway and identifying the factors responsible for delays are essential for improving access to time-sensitive interventions. Therefore, this study aimed to assess the different components of acute stroke care time among patients presenting with stroke and to identify the factors associated with delays in their management.

Methods

Study design and setting

We conducted a multicenter, cross-sectional analytical study from January to May 2025 in three referral hospitals in Douala, Cameroon: Douala General Hospital (DGH), Douala Gynaeco-Obstetric and Pediatric Hospital (DGOPH), and Douala Laquintinie Hospital (DLH). The study assessed the timeliness of acute stroke care and investigated factors associated with delays at key stages of the acute stroke care pathway.

DGH and DGOPH are first-category university hospitals, whereas DLH is a second-category university hospital within the Cameroonian health system. All three hospitals provide inpatient and outpatient neurological care and have facilities for acute stroke assessment. DGH has five neurologists and a stroke unit, while DGOPH and DLH have two and five neurologists, respectively. DGH and DLH have a 24-hour access to both computed tomography (CT) and magnetic resonance imaging (MRI), whereas DGOPH has 24-hour CT access. All three hospitals have a continuously operating laboratory services and access to cardiovascular investigations relevant to stroke evaluation, including electrocardiography (ECG), cardiac and vascular ultrasonography. These hospitals were selected because they are major referral facilities providing neurological and acute stroke care in Douala. DGOPH is the youngest facility, with a neurology unit with less than one year at the time of the study.

Study population and eligibility criteria

The study population comprise adults aged ≥ 18 years presenting to one of the participating hospitals with acute stroke. Stroke was defined according to American Heart Association/American Stroke Association (AHA/ASA) definition as acute neurological dysfunction attributable to a vascular cause. Stroke diagnosis and subtype were established based on clinical assessment and brain imaging.

Patients were eligible if they were aged ≥ 18 years, had a confirmed diagnosis of acute stroke, presented through the emergency department or neurology service of a participating hospital, and provided

informed consent either personally or through an authorized representative when they were unable to provide consent because of their clinical condition. Patients were excluded if they declined participation or could not provide the required consent, or if they had cerebral venous thrombosis or subarachnoid hemorrhage.

Sampling and data collection

A consecutive, exhaustive sampling approach was used. All eligible patients presenting to the participating hospitals during the study period were considered for inclusion; therefore, no formal sample-size calculation was performed.

Data were collected using a structured questionnaire developed for this study by the research team. The questionnaire was pretested before a study initiation and reviewed by the study supervisors and biostatistician. After informed consent, patients were interviewed when their clinical condition permitted. For patients unable to provide reliable information because of neurological impairment, information was obtained from accompanying caregivers and medical records.

Variables collected included sociodemographic characteristics, vascular risk factors and comorbidities, clinical presentation, stroke subtype and severity, investigations, acute management, process-of-care times intervals, and in-hospital outcomes. Sociodemographic variables included age, sex, marital status, occupation, religion, and place of residence. Vascular risk factors and comorbidities included hypertension, diabetes mellitus, dyslipidemia, alcohol consumption, smoking, kidney disease, cardiac disease, previous stroke, cancer, HIV infection, hepatitis C virus, and sickle cell disease.

Clinical data included symptom onset or last known well (LKW) time, hospital arrival time, presenting symptoms, blood pressure, pulse rate, respiratory rate, oxygen saturation, capillary blood glucose, body temperature, and neurological severity assessed using Glasgow coma scale (GCS) and the National Institutes of Health Stroke Scale (NIHSS), where applicable [36, 37]. Investigations included brain CT and/or MRI.

Process-of-care time measures

The primary outcome was the timeliness of acute stroke care. Three process-of-care time measures were assessed: onset-to-door (OTD), door-to-neurologist (DTNe), and door-to-imaging (DTI) times.

OTD time was defined as the interval between the time the patient was last known to be well and arrival at the hospital. For patients with wake-up stroke or uncertain symptom onset the LKW time was used as the reference point.

DTNe time was defined as the interval between hospital arrival and the first assessment by a neurologist. Although international acute stroke care recommendations emphasize rapid specialist

assessment, the ≤ 15 -minute target was not routinely achievable in the participating hospitals. Consequently, for the primary regression analysis, delayed DTN was defined as > 60 minutes, reflecting the observed distribution and the locally relevant performance threshold.

DTI time was defined as the interval between hospital arrival and completion of the initial brain imaging examination used for stroke diagnosis. Delayed DTI was defined as > 25 minutes, consistent with the guideline-based target for rapid brain imaging in suspected acute stroke.

For regression analyses, delayed OTD was defined as > 4.5 hours, delayed DTN as > 1 hour, and delayed DTI as > 25 minutes. These outcomes were analyzed separately.

Data management and statistical analyses

Data were reviewed for completeness and consistency, coded, anonymized, and entered into a password-protected database. Continuous variables were assessed for normality using the Shapiro-Wilk test and visual inspection histograms. Categorical variables were summarized as frequencies and percentages, while continuous variables were presented as means with standard deviations (SD) or medians with interquartile ranges (IQR), as appropriate.

Missing data were evaluated before statistical modelling. Overall missingness was $< 5\%$, and missing observations were handled using complete-case analysis for multivariable models. Missing quantitative values were explicitly coded as missing during data cleaning and were not replaced by arbitrary values.

For bivariate analyses, categorical variables were compared using Pearson's Chi-square test or Fisher's exact test, as appropriate. Continuous variables were compared using Student's t-test for normally distributed data or the Mann-Whitney U test for non-normally distributed data.

Three separate logistic regression models were constructed to identify factors associated with delayed OTD, DTN, and DTI. Univariable logistic regression was initially performed for each candidate predictor. Variables associated with the outcome at $p < 0.20$ in bivariate analysis, together with clinically relevant covariates defined a priori, were considered for multivariable modelling.

Because of the relatively small sample size and the presence of sparse cells and quasi-complete separation for some predictors, multivariable analyses were performed using Firth's penalized logistic regression. This approach reduces small-sample bias and provides finite parameter estimates in the presence of separation. Results were reported as odds ratios (ORs) with 95% confidence intervals (CIs); adjusted odds ratios (aORs) were reported for multivariable models.

All tests were two-sided, and $p < 0.05$ was considered statistically significant. Analyses were performed using IBM SPSS Statistics version 26 and Python version 3.10 using the `scipy` and `statsmodels` packages.

Ethical considerations

The study was approved by the Institutional Review Board of University of Douala (N°4746/IEC-UDo/06/2025/T), and administrative authorization was obtained from the participating hospitals. The study was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from participants or, when appropriate, their authorized representatives. Confidentiality was maintained throughout the study, and no direct personal identifiers were collected in the study database.

Results

A total of 126 patients with stroke were included : DLH (57.9%), DGH (39.7%), and DGOPH (2.4%). The mean age was 62.3 ± 13.3 years (median 62.5 years; IQR 53.0–72.0), with 46.0% age ≥ 65 years and 51.6% male. Most patients were residents of Douala (85.7%). The most frequent vascular risk factors were hypertension (54.0%), alcohol consumption (38.9%, and diabetes mellitus (21.4%). Previous stroke was reported in 18.3% of cases (Table 1).

Table 1
Demographic characteristics, comorbidities and vascular risk factors of the study population

Variable	Category / Metric	Count (n)	Percentage (%)
Age (years)	Mean $\pm$ SD	62.3 $\pm$ 13.3	—
	Median [IQR]	62.5 [53.0–72.0]	—
	Min–Max range	32–96	—
	< 45 years	12	9.5
	45–64 years	56	44.4
	$\geq$ 65 years	58	46.0
Sex	Male	65	51.6
	Female	61	48.4
Marital status	Married	68	54.0
	Widowed	33	26.2
	Single	21	16.7
	Divorced	4	3.2
Occupation	Unemployed / Housewife	66	52.4
	Retired	25	19.8
	Informal sector / Self-employed	17	13.5
	Public sector / Civil servant	11	8.7
	Private sector employee	7	5.6
Religion	Not collected in dataset	—	—
Place of residence	Douala (Urban)	108	85.7
	Outside Douala (Rural / Semi-urban)	18	14.3
Comorbidity / Risk factor	Hypertension	68	54.0
	Alcohol consumption	49	38.9
	Diabetes mellitus	27	21.4
	Previous history of stroke	23	18.3
	Cardiac disease	10	7.9

Variable	Category / Metric	Count (n)	Percentage (%)
	– Cardiomyopathy	8	6.3
	– Other cardiac disease	2	1.6
	Smoking	7	5.6
	Cancer / malignancy	3	2.4
	– Prostate cancer / tumor	2	1.6
	– Acute myeloid leukemia (AML4)	1	0.8
	Dyslipidemia (documented history)	1	0.8
	Kidney disease (documented history)	1	0.8
	HIV infection	1	0.8
	Sickle cell disease	1	0.8

At presentation, 10.3% of patients had a GCS ≤ 8 , and 23.8% had a severe stroke with a NIHSS ≥ 15 . Motor deficit was the most common presenting feature (76.2%), followed by language disorder (53.2%) and altered consciousness (15.1%). Systolic blood pressure was ≥ 180 mmHg in 32.5% of patients (Table 2).

Table 2
Clinical parameters and presentation of stroke patients

Variables	Category	Count (n)	Percentage (%)
Clinical parameters	Normal (GCS = 15)	73	57.9
	Obtundation (GCS = 9–14)	40	31.7
	Coma (GCS $\leq$ 8)	13	10.3
	Minor stroke (NIHSS 1–4)	16	12.7
	Moderate stroke (NIHSS 5–14)	80	63.5
	Severe stroke (NIHSS $\geq$ 15)	30	23.8
	SBP < 140 mmHg	28	22.2
	SBP 140–179 mmHg	57	45.2
	SBP $\geq$ 180 mmHg	41	32.5
	SpO ₂ $\geq$ 95%	78	91.8
	SpO ₂ <95%	7	8.2
	CBG < 1.40 g/L	52	65.8
	CBG 1.40–1.99 g/L	18	22.8
	CBG $\geq$ 2.00 g/L	9	11.4
	Temperature $\leq$ 37.5°C	44	81.5
	Temperature > 37.5°C	10	18.5
Clinical presentation	Motor deficit	96	76.19
	Language disorder	67	53.17
	Altered consciousness	19	15.08
	Dizziness	8	6.35
	Epileptic seizure	7	5.56
	Headaches	2	1.59
	Psychomotor agitation	2	1.59
	Visual disorder	2	1.59
	Sensory disorder	1	0.79
CBG: capillary blood glucose ; GCS: Glasgow coma scale; NIHSS: National Institute of Health Stroke Scale; SBP: systolic blood pressure; SpO ₂ : oxygen saturation.			

Variables	Category	Count (n)	Percentage (%)
	Gait disorder	0	0.00
CBG: capillary blood glucose ; GCS: Glasgow coma scale; NIHSS: National Institute of Health Stroke Scale; SBP: systolic blood pressure; SpO ₂ : oxygen saturation.			

Most patients (92.9%) had heard about stroke before the event, however, only 61.1% considered their symptoms alarming and 60.3% sought immediate hospital evaluation. Only 44.4% targeted a facility with a neurology department. CT was the predominant imaging modality (90.5%), compared with MRI (9.5%).

The median OTD time was 16.67h (IQR 45.40), while median DTN and DTI times were 9.8h (IQR 17.0) and 1.8h (IQR 8.15), respectively. Using guideline-based targets, only 3.2% of patients met the ≤ 1 -h OTD target, 3.2% met the ≤ 15 -min DTN target, and 28.6% met the ≤ 25 -min DTI target. Using locally adapted thresholds, 24.6 arrived within 4.5 h and 11.1% were assessed by a neurologist within 1 h (Table 3).

Table 3
Performance against recommended acute stroke care time targets.

Basis	Time metric	Target	Within target, n (%)	Delayed, n (%)
Guidelines-based	Onset-to-door	≤ 1 h	4 (3.17)	122 (96.83)
	Door-to-neurologist	≤ 15 min	4 (3.17)	122 (96.83)
	Door-to-neuroimaging	≤ 25 min	36 (28.57)	90 (71.43)
Locally based	Onset-to-door	≤ 4.5 h	31 (24.60)	95 (75.40)
	Door-to-neurologist	≤ 1 h	14 (11.11)	112 (88.89)
	Door-to-neuroimaging	≤ 25 min	36 (28.57)	90 (71.43)

In univariable analyses, failure to perceive stroke symptoms as alarming (OR = 7.65, 95% CI: 2.32–25.28, $p < 0.001$), and initial presentation to a non-specialized health facility (OR = 2.91, 95% CI: 1.26–6.72, $p = 0.01$) were significantly associated to delayed OTD time (> 4.5 h). Delayed DTN time (> 60 min) was significantly associated with MRI rather than CT as the initial imaging modality (OR = 8.07, 95% CI: 2.14–30.36, $p < 0.001$). Ischemic stroke compared with hemorrhagic stroke (OR = 2.89, 95%CI: 1.31–6.39, $p = 0.009$), (Table 4).

Table 4

Univariable logistic regression analyses of factors associated with delays in acute stroke care

Variable / Modality	OTD > 4.5 h, OR (95% CI); p	DTN > 60 min, OR (95% CI); p	DTI > 25 min, OR (95% CI); p
Age category			
< 45 years	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
45–64 years	0.70 (0.15–3.31); p = 0.65	1.01 (0.14–7.15); p = 0.99	2.06 (0.59–7.35); p = 0.36
≥ 65 years	0.67 (0.14–3.15); p = 0.61	0.90 (0.13–6.18); p = 0.91	3.72 (1.02–13.58); p = 0.047
Gender			
Female	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Male	1.00 (0.45–2.24); p = 1.00	0.79 (0.27–2.37); p = 0.67	1.48 (0.68–3.21); p = 0.31
Health insurance			
None / Out-of-pocket	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Partial insurance	0.16 (0.01–3.43); p = 0.24	1.91 (0.04–98.00); p = 0.74	0.45 (0.02–9.54); p = 0.61
Full insurance	—	—	—
Hypertension			
No	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Yes	1.13 (0.51–2.54); p = 0.76	1.19 (0.40–3.54); p = 0.74	0.79 (0.36–1.71); p = 0.54
Diabetes mellitus			
No	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Yes	1.98 (0.65–6.06); p = 0.23	0.43 (0.13–1.37); p = 0.15	0.74 (0.30–1.84); p = 0.51
Smoking history			
No	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Yes	0.72 (0.14–3.74); p = 0.69	0.55 (0.08–3.98); p = 0.55	0.50 (0.11–2.34); p = 0.37
Alcohol consumption			
CT : computed tomography ; DTI: door-to-imaging; DTN: door-to-neurologist; GCS: Glasgow coma scale; MRI : Magnetic resonance imaging; NIHSS: National Institute of Health Stroke Scale; OTD: onset-to-door; OR: odds ratio; SBP: systolic blood pressure; SpO2: oxygen saturation.			

Variable / Modality	OTD > 4.5 h, OR (95% CI); p	DTN > 60 min, OR (95% CI); p	DTI > 25 min, OR (95% CI); p
No	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Yes	1.00 (0.44–2.29); p = 1.00	0.82 (0.27–2.46); p = 0.72	1.37 (0.61–3.08); p = 0.44
Prior stroke history			
No	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Yes	0.87 (0.31–2.43); p = 0.79	0.73 (0.20–2.70); p = 0.63	1.46 (0.51–4.22); p = 0.48
Heart disease			
No	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Yes	0.12 (0.03–0.50); p < 0.001	0.41 (0.08–2.00); p = 0.26	2.76 (0.43–17.53); p = 0.28
Stroke subtype			
Hemorrhagic	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Ischemic	1.35 (0.60–3.05); p = 0.47	0.86 (0.28–2.65); p = 0.79	2.89 (1.31–6.39); p = 0.009
Admission NIHSS			
Minor (0–4)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Moderate (5–14)	2.21 (0.67–7.37); p = 0.19	1.58 (0.33–7.57); p = 0.56	0.61 (0.16–2.26); p = 0.45
Severe (≥ 15)	0.89 (0.24–3.25); p = 0.85	1.09 (0.19–6.12); p = 0.92	0.74 (0.17–3.20); p = 0.68
Level of consciousness (GCS)			
Normal (GCS = 15)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Obtundation (GCS = 9–14)	0.68 (0.28–1.67); p = 0.40	0.70 (0.22–2.21); p = 0.54	0.60 (0.25–1.42); p = 0.24
Coma (GCS ≤ 8)	0.71 (0.17–2.87); p = 0.62	3.01 (0.14–62.67); p = 0.47	0.56 (0.15–2.08); p = 0.38
Brain imaging modality			
CT scan	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
CT : computed tomography ; DTI: door-to-imaging; DTN: door-to-neurologist; GCS: Glasgow coma scale; MRI : Magnetic resonance imaging; NIHSS: National Institute of Health Stroke Scale; OTD: onset-to-door; OR: odds ratio; SBP: systolic blood pressure; SpO2: oxygen saturation.			

Variable / Modality	OTD > 4.5 h, OR (95% CI); p	DTN > 60 min, OR (95% CI); p	DTI > 25 min, OR (95% CI); p
MRI	0.36 (0.06–2.20); p = 0.26	8.07 (2.14–30.36); p < 0.001	1.33 (0.38–4.67); p = 0.65
Prior stroke knowledge			
Has prior knowledge	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Lacks prior knowledge	6.92 (0.34–142.57); p = 0.21	0.73 (0.11–4.97); p = 0.75	0.46 (0.12–1.84); p = 0.27
Perception of symptoms			
Considered alarming	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Did not consider alarming	7.65 (2.32–25.18); p < 0.001	0.82 (0.27–2.46); p = 0.72	1.17 (0.53–2.59); p = 0.70
Care-seeking behavior			
Sought care immediately	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Delayed care seeking	> 99.9 (Quasi-complete separation)	—	—
First hospital target			
Targeted neurology unit	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Targeted non-specialized clinic	2.91 (1.26–6.72); p = 0.01	1.28 (0.43–3.80); p = 0.65	0.74 (0.34–1.61); p = 0.44
CT : computed tomography ; DTI: door-to-imaging; DTN: door-to-neurologist; GCS: Glasgow coma scale; MRI : Magnetic resonance imaging; NIHSS: National Institute of Health Stroke Scale; OTD: onset-to-door; OR: odds ratio; SBP: systolic blood pressure; SpO2: oxygen saturation.			

In multivariable analysis, not considering symptoms alarming (aOR = 7.02, 95% CI:2.13–23.22, p = 0.001) and initially attending a non-specialized center (aOR = 72.97, 95% CI:1.16–7.59, p = 0.023) were associated with OTD delay > 4.5h. MRI use was associated with DTN delay > 1h, while ischemic stroke was associated with DTI delay > 25 min (aOR = 2.66, 95% CI:1.14–6.17, p = 0.023), (Tables 5).

Table 5

Multivariable logistic regression analyses of factors associated with delays in acute stroke care

Variable / Modality	OTD > 4.5 h, aOR (95% CI); p	DTN > 60 min, aOR (95% CI); p	DTI > 25 min, aOR (95% CI); p
MRI	0.36 (0.06–2.20); p = 0.26	8.07 (2.14–30.36); p < 0.001	1.33 (0.38–4.67); p = 0.65
Prior stroke knowledge			
Has prior knowledge	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Lacks prior knowledge	6.92 (0.34–142.57); p = 0.21	0.73 (0.11–4.97); p = 0.75	0.46 (0.12–1.84); p = 0.27
Perception of symptoms			
Considered alarming	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Did not consider alarming	7.65 (2.32–25.18); p < 0.001	0.82 (0.27–2.46); p = 0.72	1.17 (0.53–2.59); p = 0.70
First hospital target			
Targeted neurology unit	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Targeted non-specialized clinic	2.91 (1.26–6.72); p = 0.01	1.28 (0.43–3.80); p = 0.65	0.74 (0.34–1.61); p = 0.44
DTI: door-to-imaging; DTN: door-to-neurologist; MRI : Magnetic resonance imaging; OTD: onset-to-door; aOR: adjusted odds ratio.			

Discussion

Sociodemographic and clinical characteristics

In this multicenter study conducted across three referral hospitals in Douala, Cameroon, the study had a mean age around 60 years, a near-balanced sex ratio, and hypertension, alcohol consumption and diabetes mellitus were the leading vascular risk factors. Ischemic stroke accounted for more than 60% of cases, and motor deficits and language disorders were the predominant presenting clinical manifestations.

The age distribution is consistent with the established increase in stroke incidence with age [38]. However, 9.5% of patients were younger than 45 years, keeping with reports of earlier stroke onset in populations of African ancestry compared with African American and European American populations [39]. Hypertension, alcohol consumption and diabetes mellitus were the leading modifiable risk factors, consistent with previous data Cameroon and other African settings [40, 41] and with the disproportionately high prevalence of hypertension described in populations of African ancestry [42–45].

The predominance of ischemic stroke is consistent with earlier Cameroonian data [46]. The proportion of hemorrhagic stroke nonetheless remained higher than the 15–20% typically reported in high-income countries, a pattern generally attributed to the elevated prevalence and suboptimal control of hypertension in the region.

Delays in the acute stroke care pathway

Delays were observed at every stage of the pathway assessed. More than three-quarters of patients arrived at hospital beyond the 4.5-hour thrombolysis window, consistent with previous reports from Cameroon and the Democratic Republic of Congo, where a similar proportion of patients arrived after this window, and with a Nigerian study which only 7% of patients reached hospital within 6 hours [35, 47, 48].

The mean OTD time was 42.9 hours (median 16.7 hours), comparable to the 47.4 hours previously reported in Democratic Republic of Congo [30]. This prolonged prehospital interval is compatible with limited recognition of stroke symptoms, transportation constraints, long distance to appropriate, and referral through intermediate healthcare facilities; it may also be overestimated for patients with wake-up stroke, for whom sleep onset was used as the presumed reference time. Systematic recording of last-known-well time, time of symptom recognition, and mode of transport would improve the precision of future prehospital delay estimates.

After hospital arrival, close to 90% of patients were assessed by a neurologist more than 60 minutes after arrival, exceeding the 15-minute target recommended. Because few patients met this target, a pragmatic 60-minute threshold was used for the regression analysis. This delay is comparable to the median DTN time of 61 minutes reported in China, indicating that timely specialist assessment remains a challenge common to resource-constrained stroke systems [31].

Neuroimaging was a further bottleneck, with more than 70% of patients underwent imaging more than 25 minutes after arrival, against the recommended ≤ 25 -minute target, with a median DTI time of 1.8 hours. Comparable or greater delays have been reported elsewhere in the region including South Africa, where 96.1% of patient underwent CT more than one hour after arrival, and Ghana, where no patient underwent CT within 30 minutes of arrival [32, 49, 50]. CT was the predominant imaging modality in this study, appropriately reflecting its wide availability and rapid ability to exclude intracranial hemorrhage. The principal gap identified was therefore the delay in obtaining imaging after arrival rather than the choice of modality.

Factors associated with delayed care

Two factors were independently associated with delayed OTD time: not considering the initial symptoms alarming and initially attending a non-specialized center rather than a neurology-equipped facility. Both findings point to stroke recognition at the community level and the organization of referral pathways as priority targets for intervention. Poor recognition of stroke symptoms has similarly been associated with delayed hospital arrival in the Democratic Republic of Congo [30]. When initial manifestations are not

perceived as an emergency, patients or caregivers may delay seeking care or consult facilities not equipped for acute stroke management.

MRI as the initial imaging modality was strongly associated with delayed door-to-neurologist assessment. Given that only 12 patients underwent MRI, this estimate should be interpreted with caution. It likely reflects the additional logistical requirements of MRI acquisition rather than an intrinsic property of the modality and supports prioritizing rapid CT-based assessment. Ischemic stroke was independently associated with delayed neuroimaging relative to hemorrhagic stroke. The cross-sectional design does not permit causal interpretation of this association. However, in patients with suspected intracerebral hemorrhage, the combination of severe neurological presentation, markedly elevated blood pressure, reduced level of consciousness, or other clinically suggestive features may prompt an urgent CT examination.

Strengths and limitations

This study has two principal strengths: a multicenter design across three referral hospitals, and assessment of sequential components of the acute stroke pathway (onset-to-door, door-to-neurologist, and door-to-imaging), allowing delays occurring before and after hospital arrival to be distinguished.

Several limitations should be considered. Onset-to-door time relied partly on patient or caregiver recall and was therefore susceptible to recall bias, particularly for unwitnessed and wake-up strokes. The relatively small sample size limited the precision of some estimates, reflected in wide confidence intervals for several associations, and constrained the assessment of interactions between predictors. The cross-sectional, hospital-based design limits causal inference, and because recruitment was restricted to three referral hospitals in Douala, findings may not be generalized to rural or less-resourced areas of Cameroon.

Conclusion

This study demonstrates substantial delays throughout the acute stroke care pathway in Douala, with the most prominent gaps occurring in hospital arrival, neurological assessment, and neuroimaging. Lack of recognition of stroke symptoms and initial presentation to non-specialized facilities were independently associated with delayed hospital arrival, while MRI-based assessment was associated with delayed neurological evaluation and ischemic stroke with delayed imaging. These findings support the development of locally adapted stroke pathways emphasizing early recognition, direct referral, rapid specialist assessment, and timely neuroimaging.

Abbreviations

aOR: Adjusted odds ratio; AHA/ASA: American Heart Association/American Stroke Association; ARES: Académie de Recherche et d'Enseignement Supérieur; CI : confidence interval; CT: computed tomography; DALY: Disability-adjusted life-year; DGH: Douala General Hospital; DGOPH: Douala Gynaeco-

Obstetric and Pediatric Hospital; DLH: Douala Laquintinie Hospital; DTI: door-to-Imaging; DTN: door-to-neurologist; GCS: Glasgow coma scale; HIV: Human immunodeficiency virus; IQR: interquartile range; IRB: Institutional Review Board; LKW: last known well; LMIC: low- and middle-income country; MRI: magnetic resonance imaging; NIHSS: National Institutes of Health Stroke Scale; OR: odd ratio; OTD: onset-to-door; PCTM: process-of-care time measures; SD : standard deviation; WFN: World Federation of Neurology.

Declarations

Ethics approval and consent to participate

This study was approved by the Institutional Review Board of the University of Douala (N°4746/IEC-UDo/06/2025/T), and administrative authorization was obtained from the Douala General Hospital, Douala Gynaeco-Obstetric and Pediatric Hospital, and Douala Laquintinie Hospital. The study was conducted in accordance with the Declaration of Helsinki. Written informed consent to participate was obtained from all participants or, when a participant was unable to consent because of their clinical condition, from their legally authorized representative.

Consent for publication

Not applicable. This manuscript does not contain any individual person's identifiable data, images, or videos.

Availability of data and materials

The datasets generated and analyzed during the current study are available from the corresponding author, on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

DGM and NYM conceived and designed the study. DGM, LP, MD, LR, LL, JAE and NYM secured funding and managed the project. SNGJ, EGBL, DJN, HET, DPC, NJ, MT, MDz and KC contributed to data acquisition. DGM, SNGJ, AMM and KTC contributed to data curation and statistical analysis. DGM drafted the manuscript. LP, MD, AMM, KTC, JAE, LR and NYM critically revised the manuscript for important intellectual content. All authors read, critically reviewed, and approved the final manuscript.

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