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Determinants of Delays in Stroke Care in Mali: A Prospective Study at Sikasso Regional Hospital

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Abstract

Background: Stroke is a medical emergency requiring rapid diagnosis and treatment. In resource-limited settings, delays may occur both before and after hospital admission. This study assessed prehospital and in-hospital delays in stroke care at Sikasso Regional Hospital, Mali, and identified associated factors.

Materials and Methods: This prospective study included 135 patients with stroke confirmed by computed tomography between 2021 and 2022. Prehospital delay was defined as at least three hours from symptom onset to hospital admission, and in-hospital delay as at least one hour from admission to computed tomography. Multivariable multinomial logistic regression identified factors associated with delay categories.

Results: Overall, 78.5% of patients arrived at least six hours after symptom onset, 59.3% waited at least three hours for computed tomography, and 86.7% experienced both prehospital and in-hospital delays. Rural residence was associated with arrival after at least six hours (adjusted odds ratio 5.50; 95% confidence interval 1.15–26.31). Occupational category was also associated with prehospital delay. Abnormal blood glucose was associated with shorter imaging delays.

Conclusion: Stroke care delays were substantial and cumulative. Reducing geographical and organizational barriers may improve timely stroke care in Mali.

Keywords: Stroke; Treatment Delay; Healthcare Access; Computed Tomography; Rural Health; Mali

Abbreviations

DALY: Disability Adjusted Life Year; LMICs: Low-and Middle-Income Countries; CT: Computed Tomography.

Introduction

The global distribution of stroke disproportionately affects low- and middle-income countries (LMICs), which bear most cases and disability-adjusted life year (DALY)

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losses [1]. As a leading acute neurological illness, stroke contributes substantially to mortality and disability worldwide, and rapid treatment is closely associated with improved functional outcomes [1,2].

In resource-limited settings, particularly in sub-Saharan Africa, delays in accessing stroke care remain a major obstacle to improving prognosis and reducing mortality [3,4]. These delays are associated with multiple factors, including limited awareness of warning signs, transportation difficulties, scarcity of specialized facilities, and the cost of diagnostic investigations [5-10].

In Mali, where the population increased from approximately 22.4 million in 2021 to 23.1 million in 2022 [11], few studies have specifically investigated determinants of delays in stroke care. Available hospital-based evidence nevertheless indicates a substantial burden of stroke. At Sominé Dolo Hospital in Mopti, stroke accounted for 134 of 468 medical admissions (28.6%) in 2016, with an in-hospital case fatality rate of 17% [12]. However, evidence on prehospital and in-hospital delays remains limited, particularly outside Bamako and in southern Mali.

Sikasso Regional Hospital is a referral hospital in southern Mali. Hospital activity data from 2015 to 2021 indicate that the facility comprised 14 departments, including eight inpatient departments, with a total capacity of 163 beds and 253 staff members [13]. In 2021, the hospital recorded 5,899 admissions [13]. Despite this substantial hospital activity, evidence regarding the organization and timeliness of stroke-care pathways in Sikasso remains limited. This evidence gap is particularly relevant because geographical constraints, access to diagnostic facilities, and the organization of referral pathways may contribute to delayed stroke assessment. Available hospital-based studies have documented a substantial burden of stroke and high hospital mortality in Mali, while evidence from regional settings outside Bamako remains limited [10,12].

In this context, this study aimed to identify factors associated with prehospital and in-hospital delays in stroke care at Sikasso Regional Hospital by analyzing sociodemographic, care-pathway, biological, and organizational characteristics.

Materials and Methods

Design and Study Setting

We conducted a prospective study at Sikasso Regional Hospital, Mali, between November 2021 and October 2022. Reporting followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (checklist provided in the Supplementary Material). The hospital serves as the main referral center for stroke patients in Sikasso and its catchment area.

Study Population

All patients hospitalized with stroke confirmed by brain computed tomography (CT) were included, regardless of age or sex. Patients with diagnoses other than stroke or without imaging confirmation were excluded.

Sampling

The sample size was determined using the Schwartz formula [14,15]:

$$n = Z^2 \times p \times (1 - p) / m^2$$

where n denotes the required sample size, Z the standard normal deviate corresponding to a 95% confidence level (1.96), p the anticipated proportion of delayed care, and m the tolerated absolute error.

In the absence of precise data for this setting, p = 0.50 was used to maximize variance. With m = 8.5% and a 95% confidence level, the estimated sample size was approximately 133 participants and was rounded to 135.

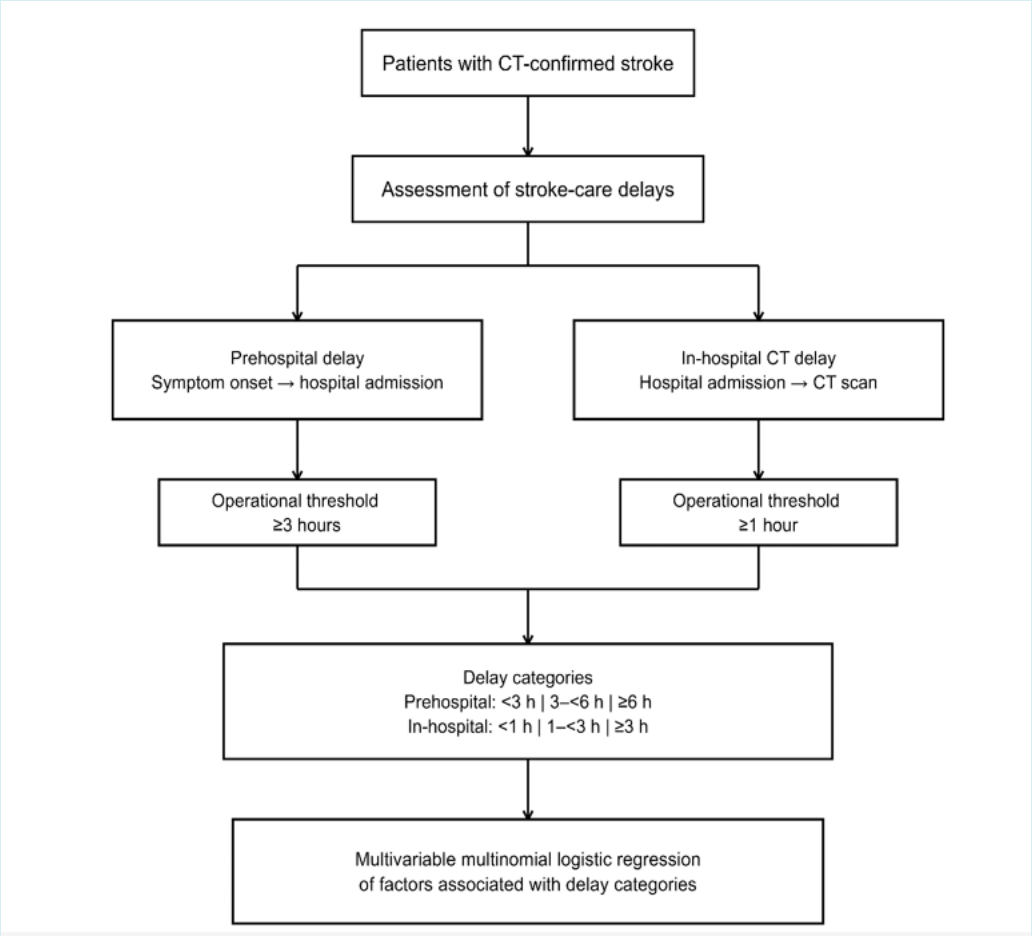
Data Collection

Sociodemographic, clinical, biological, imaging, and organizational data were collected using standardized survey forms completed by trained staff during admission. The times of symptom onset, hospital admission, and CT scanning were recorded.

Prehospital delay was defined as an interval of at least 3 hours between symptom onset and hospital admission. In-hospital delay was defined as an interval of at least 1 hour between hospital admission and CT scanning. For descriptive and multinomial analyses, prehospital delays were further categorized as <3 hours, 3–<6 hours, and ≥6 hours [1,2,16-18], while in-hospital delays were categorized as <1 hour, 1–<3 hours, and ≥3 hours [2,19-21].

Delay categories were defined a priori in relation to therapeutic windows for intravenous thrombolysis and mechanical thrombectomy [2,16,17] and operational targets for emergency brain imaging [20].

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Note: All patients admitted to Sikasso Regional Hospital during the study period with CT-confirmed stroke were assessed for prehospital delay (time from symptom onset to hospital admission) and in-hospital CT delay (time from hospital admission to CT scanning). Prehospital delay was defined as ≥3 hours and in-hospital delay as ≥1 hour. For multinomial analyses, prehospital delay was categorized as <3 hours, 3–<6 hours, and ≥6 hours, and in-hospital delay as <1 hour, 1–<3 hours, and ≥3 hours.
Figure 1: Study framework for the assessment and analysis of prehospital and in-hospital stroke-care delays.

Statistical Analysis

Analyses were performed using R version 4.4.2. Categorical variables were summarized as counts and percentages. Continuous variables were reported as mean and standard deviation or, for non-normally distributed variables, median and interquartile range. Bivariate comparisons were performed using the chi-square test or Fisher's exact test, as appropriate.

Associations between covariates and delay categories were estimated using multivariable multinomial logistic regression. Results were reported as adjusted odds ratios with 95% confidence intervals. A two-sided p-value <0.05 was considered statistically significant. Because the objective was explanatory rather than predictive, diagnostic performance metrics were not assessed.

Ethical Approval

No formally constituted research ethics committee or institutional review board was available at Sikasso Regional Hospital at the time of the study. Therefore, no formal ethics committee or institutional review board approval was obtained. Administrative authorization to conduct the study was obtained from the management of Sikasso Regional Hospital. Written informed consent was obtained from all participants or, where applicable, from their legally authorized representatives before enrollment. All data were de-identified prior to analysis and were handled confidentially, with access restricted to the research team.

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Results

Descriptive results

Sociodemographic and Clinical Profile of Participants

The cohort comprised 135 patients with CT-confirmed stroke. The mean age was 60.4 years (SD 12.6), and the median age was 62 years (range: 27–88).

Among the participants, 60 (44.4%) were aged 45–64 years and 61 (45.2%) were aged ≥65 years. The male-to-female ratio was 1.33. Most patients (75.7%) lived in rural areas, 42.2% were housewives, and 35.6% were farmers. In addition, 66.7% had no personal means of transportation.

More than half of the participants (53.3%) had at least two cardiovascular risk factors, including hypertension, diabetes, or previous cardiovascular disease, and 37.8% had documented cardiovascular disease.

Clinically, 78.5% presented with multiple neurological deficits on admission, 70.4% had hypertension, and 74.8% had ischemic stroke (Table 1).

Characteristics	n	%	95% CI
General condition (n=135)			
Good	55	40.7	32.5–49.0
Bad	80	59.3	51.0–67.5
Neurological deficits (n=135)			
One deficit	29	21.5	14.6–28.4
More than one deficit	106	78.5	71.6–85.4
Hypertension (n=135)			
Yes	95	70.4	62.7–78.1
No	40	29.6	21.9–37.3
Blood glucose (n=135)			
Normal	101	74.8	67.5–82.1
Abnormal	34	25.2	17.9–32.5
Blood creatinine (n=135)			
Normal	107	79.3	72.4–86.1
High	28	20.7	13.9–27.6
Stroke type (n=135)			
Ischemic	101	74.8	67.5–82.1
Hemorrhagic	29	21.5	14.6–28.4
Mixed	5	3.7	0.5–6.9
Clinical progression (n=135)			
Favorable	115	85.2	79.2–91.2
Unfavorable	20	14.8	8.8–20.8

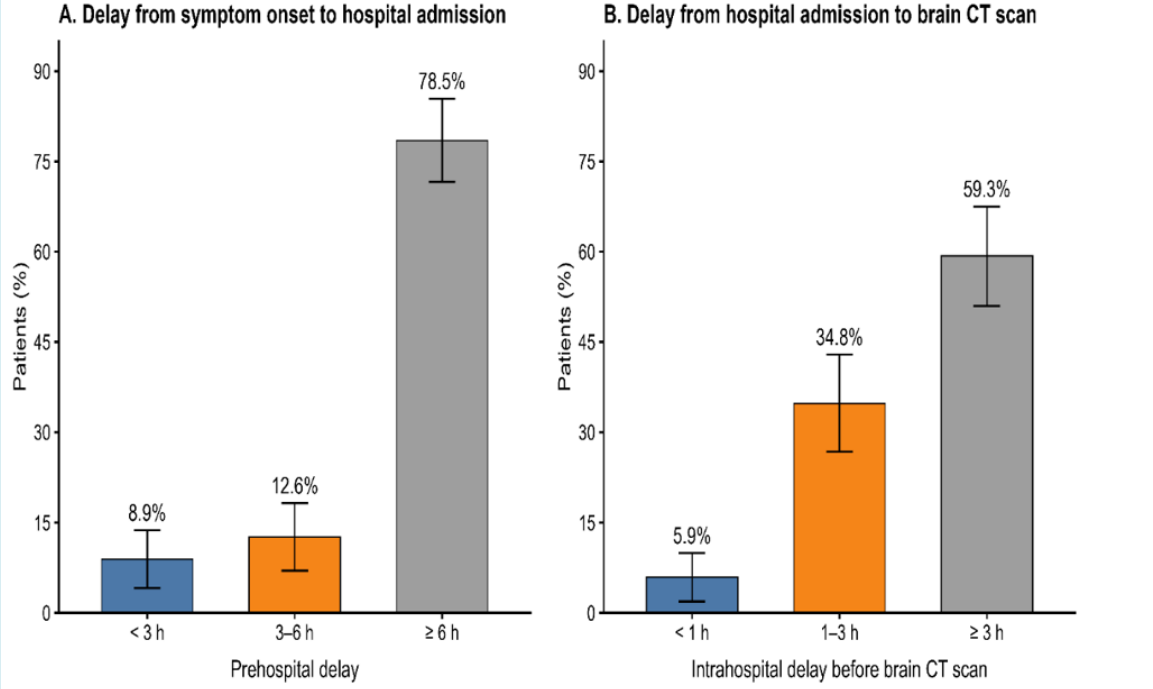
Table 1: Characteristics of the study population, Sikasso, Mali (n = 135)
Note: CI, confidence interval.

Delays in Care

The time between symptom onset and hospital admission was categorized into three groups: <3 hours, 12 patients (8.9%); 3–<6 hours, 17 patients (12.6%); and ≥6 hours, 106 patients (78.5%) (Figure 2A).

The time between hospital admission and CT scan completion was categorized into three groups: <1 hour, 8 patients (5.9%); 1–<3 hours, 47 patients (34.8%); and ≥3 h, 80 patients (59.3%) (Figure 2B).

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Note: Verticals bars represent 95% confidence intervals

Figure 2: Distribution of prehospital and intrahospital stroke care delays (n=135).

Overlap of Delays

A Venn diagram showed that 86.7% of patients experienced both a prehospital delay of ≥3 hours and an in-hospital delay of ≥1 hour. Overall, 4.4% experienced only prehospital delay, whereas 7.4% experienced only in-hospital delay. Only 1.5% of patients met both operational target time windows (hospital admission <3 hours and CT scanning <1 hour) (Figure 3).

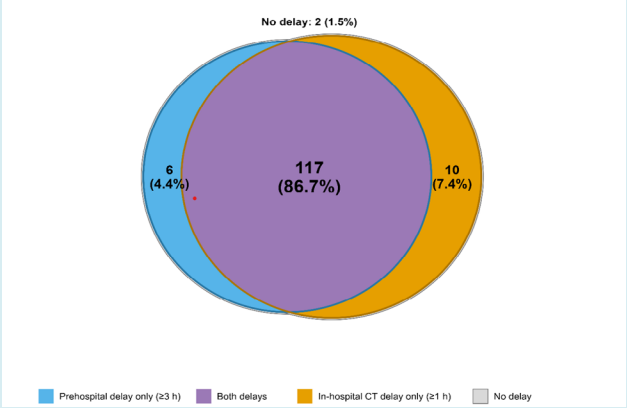


Figure 3: Overlap of prehospital delay (≥3 h) and in-hospital delay before CT scan at Sikasso Regional Hospital (n = 135).

Analytical Results

Bivariate Analysis

Prehospital Delay: Residence and occupational category were significantly associated with symptom-to-admission delay ($p = 0.001$ and $p = 0.003$, respectively). Rural residence was more frequent among patients with delays of ≥6 hours, while the "other" occupational category was more frequent among patients admitted within 3 hours.

In-Hospital Delay: Lipid profile testing, uric acid testing, and clinical progression were significantly associated with admission-to-CT delay ($p < 0.001$, $p = 0.01$, and $p = 0.02$, respectively).

Multivariable Analysis using Multinomial Logistic Regression

Multinomial logistic regression was used to identify factors associated with delay categories, using the shortest delay category as the reference (<3 hours for hospital admission and <1 hour for CT scanning). The full results of the final multinomial models are presented in Tables 2 and 3, while only statistically significant associations are described in the text.

Prehospital Delay: Rural residence was associated with a higher likelihood of admission ≥6 hours after symptom

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onset compared with urban residence (aOR = 5.50; 95% CI: 1.15–26.31; p = 0.03). Compared with housewives, patients in the "other" occupational category had a lower likelihood of admission ≥6 hours after symptom onset (aOR = 0.17; 95% CI: 0.04–0.77; p = 0.02) (Table 2).

Symptom-to-admission delay (ref.: <3 hours)	Predictors	aOR	*95%CI*	p
3–<6 hours	(Intercept)	0.26	*[0.02 – 3.64]*	0.31
	Zone [Rural]	5.89	*[0.93 – 37.26]*	0.06
	Professional activity type [Farmer]	0.91	*[0.06 – 13.23]*	0.94
	Professional activity type [Other]	0.26	*[0.04 – 1.55]*	0.14
	Mode of transport [No]	5.80	*[0.62 – 54.23]*	0.12
≥6 hours	(Intercept)	4.73	*[0.61 – 36.89]*	0.14
	Zone [Rural]	**5.50**	*[1.15 – 26.31]*	**0.03**
	Professional activity type [Farmer]	1.73	*[0.16 – 19.05]*	0.65
	Professional activity type [Other]	**0.17**	*[0.04 – 0.77]*	**0.02**
	Mode of transport [No]	1.32	*[0.24 – 7.27]*	0.74

Note: R^2 / adjusted R^2 = 0.143 / 0.132. aOR, adjusted odds ratio; CI, confidence interval. Reference categories: urban residence and housewife. Other occupational category included nurses, nursing assistants, drivers, retirees, tailors, repairers, and laborers.
Table 2: Associations with symptom-to-admission delay, Sikasso, Mali (n = 135).

In-Hospital Delay: Abnormal blood glucose was associated with a lower likelihood of both intermediate CT delay (1–<3 hours: aOR = 0.18; 95% CI: 0.04–0.91; p = 0.04) and prolonged CT delay (≥3 hours: aOR = 0.17; 95% CI: 0.04–0.84; p = 0.03), compared with CT scanning within 1 hour (Table 3).

Admission-to-CT scan delay (ref.: <1 hour)	Predictors	aOR	*95%CI*	p
1–<3 hours	(Intercept)	24.85	*[3.91 – 58.06]*	0.001
	Conjunctival coloration [Bad]	0.53	*[0.10 – 2.88]*	0.46
	Blood glucose [Abnormal]	**0.18**	*[0.04 – 0.91]*	**0.04**
	Progression [Unfavorable]	0.34	*[0.02 – 5.10]*	0.43
	Lipid profile [Test not done]	0.5	*[0.08 – 3.04]*	0.45
≥3 hours	(Intercept)	12.26	*[1.86 – 80.86]*	0.01
	Conjunctival coloration [Bad]	0.23	*[0.04 – 1.24]*	0.09
	Blood glucose [Abnormal]	**0.17**	*[0.04 – 0.84]*	**0.03**
	Progression [Unfavorable]	1.94	*[0.18 – 20.29]*	0.58
	Lipid profile [Test not done]	2.58	*[0.41 – 16.47]*	0.31

Note: R^2 / adjusted R^2 = 0.129 / 0.120. aOR, adjusted odds ratio; CI, confidence interval. Normal blood glucose and admission-to-CT delay <1 hour were the reference categories.
Table 3. Determinants of admission-to-CT delay, Sikasso, Mali (n = 135).

Discussion

This prospective single-center study identified substantial and cumulative delays in stroke care at Sikasso Regional Hospital. Nearly four in five patients (78.5%) arrived ≥6 hours after symptom onset, 59.3% underwent CT imaging ≥3 hours after admission, and 86.7% experienced both prehospital and in-hospital delays. Only 1.5% met both operational target windows. Rural residence and occupational category were independently associated with prehospital delay, while abnormal blood glucose was associated with shorter admission-to-CT delays.

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The findings should be interpreted in light of several limitations. The single-center design limits generalizability, and symptom-onset times partly relied on patient or family reports, introducing potential recall bias. Education, income, and other socioeconomic variables were unavailable. In addition, the small numbers of patients in the shortest-delay reference categories resulted in wide confidence intervals and limited precision of some multinomial estimates. Long-term outcomes and mortality were not assessed.

The magnitude of prehospital delay is particularly important because stroke treatment is highly time-dependent and rapid imaging is required to determine eligibility for reperfusion therapies [2]. Similar barriers have been reported in other sub-Saharan African settings, where long travel distances, limited transportation, weak prehospital systems, and financial constraints contribute to delayed stroke care [4,5,10]. In our study, rural residents had substantially higher odds of admission ≥6 hours after symptom onset than urban residents (aOR = 5.50; 95% CI: 1.15–26.31). This finding is consistent with the predominantly rural composition of the cohort and suggests an important geographical inequality in access to timely stroke care.

Occupational differences may also reflect socioeconomic inequalities in access to care. Compared with housewives, participants in the "other" occupational category had lower odds of admission ≥6 hours after symptom onset. Differences in financial resources, health literacy, transportation access, or ability to navigate the healthcare system may contribute to this association, although these mechanisms could not be directly evaluated because detailed socioeconomic information was unavailable.

In-hospital delays were also substantial. Patients with abnormal blood glucose had lower odds of both intermediate and prolonged CT delays than those with normal blood glucose. Glycemic abnormalities are clinically relevant in the acute management of ischemic stroke [22]. One possible explanation is that metabolic abnormalities prompted more rapid clinical assessment or imaging. However, this interpretation remains speculative, and the observed association should not be interpreted as evidence of a formal prioritization mechanism. Nevertheless, the high overall frequency of delayed CT imaging supports the need for standardized stroke triage, rapid access to brain imaging, staff training, and routine monitoring of admission-to-imaging times.

Taken together, the coexistence of prehospital and in-hospital delays indicates that interventions targeting a single stage of the care pathway may have limited impact. Community awareness of stroke warning signs, improved emergency transportation and referral systems, and strengthened regional diagnostic capacity should be combined with hospital-based stroke pathways and priority access to CT imaging. Such measures may be particularly important in rural areas and regional hospitals outside Bamako.

This study has several strengths, including its prospective design, CT-confirmed stroke diagnoses, and simultaneous assessment of prehospital and in-hospital delays. Larger multicenter studies incorporating socioeconomic and health-system factors are needed to confirm these findings and evaluate interventions aimed at reducing delays across the stroke care pathway.

Conclusion

This study highlights substantial and cumulative delays in stroke care at Sikasso Regional Hospital. Most patients arrived beyond conventional therapeutic windows and also experienced substantial in-hospital imaging delays. Rural residence and occupational category were associated with prolonged prehospital delay, highlighting potential geographical and socioeconomic barriers to timely stroke care.

Reducing these delays will require integrated strategies combining community health education, improved transportation and referral systems, and optimized in-hospital stroke pathways with rapid access to CT imaging. Addressing both prehospital and in-hospital barriers is essential to improve timely stroke care in Mali.

From a public health perspective, these findings provide evidence to support the development of integrated stroke-care strategies in Mali addressing both community-level access barriers and delays within regional hospitals.

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Conflicts of Interest

The authors declare no conflicts of interest.

Ethical Approval

No formally constituted research ethics committee or

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institutional review board was available at Sikasso Regional Hospital at the time of the study. Therefore, no formal ethics committee or institutional review board approval was obtained. Administrative authorization to conduct the study was obtained from the management of Sikasso Regional Hospital. Written informed consent was obtained from all participants or, where applicable, from their legally authorized representatives before enrollment. All data were de-identified prior to analysis and were handled confidentially, with access restricted to the research team.

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