

BMJ Open One-year mortality after acute stroke: a prospective cohort study from a comprehensive stroke care centre, Kerala, India

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ABSTRACT

Objectives The primary objective was to report the 1-year all-cause mortality among patients with stroke. The secondary objectives were (1) to report the mortality stratified by type of stroke and sex and (2) to report predictors of 1-year mortality among patients with stroke.

Design A prospective cohort study.

Setting Institutional—stroke care unit of a tertiary care hospital

Participants Patients who were treated in the study institution during 2016–2020 for acute stroke and were followed up for a period of 1 year after stroke in the same institution.

Main outcome measures The main outcome measures were the mortality proportion of any stroke and first ever stroke cohorts at select time points, including in-hospital stay, along with 2 weeks, 2 months, 6 months and 1 year after index stroke. The secondary outcomes were (1) mortality proportions stratified by sex and type of stroke and (2) predictors of 1-year mortality for any stroke and first ever stroke.

Results We recruited a total of 1336 patients. The mean age of participants was 61.6 years (13.5 years). The mortality figures for 2 weeks, 2 months, 6 months and 12 months after discharge were 79 (5.9%), 88 (6.7%), 101 (7.6%) and 114 (8.5%), respectively, in the full cohort. The in-hospital mortality was 45 (3.4%). The adjusted analysis revealed 3 predictors for 1-year mortality after first ever stroke—age, pre-treatment National Institutes of Health Stroke Scale (NIHSS) score and Modified Rankin Scale (mRS) score at baseline. The same for the full cohort had only two predictors—age and pre-treatment NIHSS score.

Conclusion Mortality of stroke at 1-year follow-up in the study population is low in comparison to several studies published earlier. The predictors of 1-year mortality after stroke included age, NIHSS score at baseline and mRS score at baseline.

INTRODUCTION

Stroke is the leading cause of mortality, disability and economic loss across the globe. Patients with stroke require immediate care and long-term follow-up for better outcomes.¹ World stroke organisation estimated the global burden of new stroke to be

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ The strengths of this study include a large sample size and minimal lost to follow up.
- ⇒ The analytical approach can significantly reduce residual confounding.
- ⇒ The single study setting may reduce the generalizability of study findings.
- ⇒ The extraction of data was from hospital information system and this might have resulted in low accuracy of the comorbid profile.

13.7 million per year.^{2,3} One in four persons above the age of 25 years will be affected with stroke in their life time.^{2,3}

Globally, developing nations bear considerable burden of stroke (70%).⁴ Mortality and disability adjusted life years (DALY) due to stroke is huge (87%) in low-income and middle-income countries (LMICs).⁴ There are 4.85 million stroke deaths and 91.4 million DALYs annually, in LMICs compared to 1.6 million deaths and 21.5 million DALYs in high-income countries.⁴ The incidence of stroke has declined by 42% in high-income countries but doubled in LMICs during the last 4 decades.^{5–7}

The global burden of disease study puts the number of incident cases of stroke in India at 1.29 million (2019).⁸ The deaths due to stroke in India is approximately 699 000 per year.⁸

Several stroke cohorts from different studies across the globe have reported post stroke mortality at various time points including death during in-hospital treatment.^{9–20} They reported post-stroke mortality at 1 year ranging from as low as 2.1% to as high as 34.3%.^{9–20} A recently published systematic review reported that the 1 month case fatality rate for stroke in India ranged between 18% and 42%.²¹



Previous studies have identified several predictors of post-stroke mortality and poor outcome at 1 year.^{18 22} The Anglia Stroke Clinical Network Evaluation Study reported that increasing age, haemorrhagic stroke, total anterior circulation stroke type, higher pre-stroke frailty, history of hypertension and ischaemic heart disease and admission hyperglycaemia predicted 1-year mortality.¹⁸ The Prospective Cohort with Incident Stroke study reported that the independent predictors for poor outcome 1 year after first-ever ischaemic stroke were age, education, National Institutes of Health Stroke Scale (NIHSS) score, pre-stroke physical disability and diabetes mellitus.²²

Hospital-based registries covering stroke and related disorders are rare in India. This is despite the fact that a properly executed hospital based registry can in all probability improve the clinical decision-making, improve patient care, predict future needs and identify areas of concern related to stroke management. All these factors can also improve the overall outcomes of patients with stroke in terms of reducing the disability, increasing the survival probability and improving the quality of life. Such a registry will also stimulate research initiatives in this area.^{23–25}

There is a definite need for identifying the current mortality profile of acute stroke in the Indian context. Such data will identify the current lacunae in management of stroke as well as provide opportunities to improve the mortality outcome in stroke. The current paucity of data related to the predictors of mortality among patients with acute stroke in India appears to be a hindrance for appropriate interventions in this direction. The current study aims to address these two deficiencies.

The primary objective of this study was to report the overall 1-year all-cause mortality among patients with stroke. The secondary objectives were (1) to report the mortality rate of stroke in general as well as the same stratified by type of stroke and sex and (2) to report the predictors of 1-year mortality among patients with stroke.

METHODS

Selection and description of study participants

The current study is a hospital registry-based prospective cohort study. All subjects with confirmed stroke who underwent treatment from the comprehensive stroke care centre of the study institution (Amrita Institute of Medical Sciences, Kochi, Kerala, India) during the study period (January 2016–June 2020) were included in the registry. We included (1) patients with first-ever stroke and (2) patients with recurrent stroke if the index admission was due to a new stroke. We excluded (1) patients with no reliable medical record or neuroimaging studies, (2) patients with epidural or subdural haematomas, or intracerebral haemorrhage secondary to tumours or arteriovenous malformation and (3) lost to follow-up patients with stroke and patients with insufficient data related to study objectives.

We used the data from the Anglia Study to calculate the sample size for 1-year mortality after stroke.¹⁸ This study reported a 1-year mortality of 31.8% for patients after an episode of acute stroke.¹⁸ We used 3% absolute precision and 5% α error giving us a minimum sample size of 913 patients. We included a total of 1336 considering incomplete data and lost to follow-up.

Technical information

All data were captured by an electronic database. A study questionnaire was predesigned in paper and tested on 50 patients. The same was validated as per response to individual questions under each domain. The validated questionnaire was cross checked by consultants and approved after consensus. This version was converted to an electronic database (MS Access). The electronic template was tested on 30 patients for data accuracy and ease of administration. Appropriate changes were made after analysing this preliminary data.

All information related to demographics, basic patient details, diagnostic/procedural information, treatment details and follow-up status were captured from the hospital information system by a research associate who was trained in stroke-related data capture before the start of the data collection. The data were entered in electronic data base (MS Access). Images (CT and MRI) were retrieved from the med-vision system of the institution and evaluated/scored according to standard protocols by research personnel under the supervision of the principal investigator (PI). The types of stroke were assigned by the PI (senior neurology consultant) using ICD codes. The subtypes of stroke were defined using universally accepted criteria: ischaemic stroke and intracerebral haemorrhage on the basis of clinical and neuroimaging findings (CT or MRI) and subarachnoid haemorrhage on the basis of clinical, neuroimaging or cerebrospinal fluid findings. Transient ischaemic attack (TIA) was defined as a transient episode of neurological dysfunction caused by focal brain, spinal cord or retinal ischaemia, without acute infarction, with symptoms usually lasting <24 hours. The patient status at specific time points were determined from Electronic Medical Records (EMR) in those who completed the follow-up visits. In the case of patients failing to visit the hospital during the scheduled visits, telephonic contact was established with the family by the registry personnel and patient status was extracted from the patient/caretaker.

The severity of stroke was assessed by NIHSS score.²⁶ The Modified Rankin Scale (mRS) was used to measure the stroke outcome.²⁷ We classified acute ischaemic stroke using the Trial of Org 10172 in Acute Stroke Treatment (TOAST) classification.²⁸

Patient and public involvement

Patients and/or the public were not involved in the design, conduct, reporting or dissemination plans of this research.

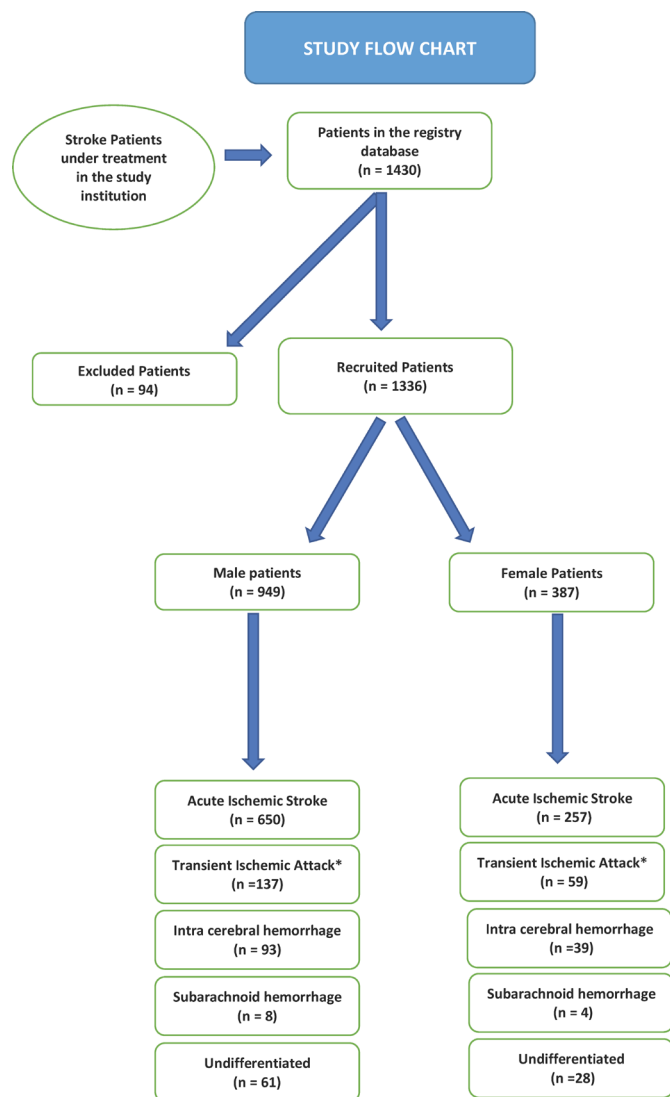


Figure 1 Study flow chart.

Statistical analysis

Statistical analysis was performed using IBM SPSS V.20.0 (Chicago, IL, USA). We summarised continuous variables using mean (SD) and categorical variables using frequency and percentage. Univariate analyses of survival were carried out by Kaplan-Meier method and the evaluations of differences were performed using log rank test. We did multivariate survival analysis using the Cox Proportional hazard model. We report the adjusted HR with 95% CIs for factors independently associated with 1-year mortality after stroke. A two-sided p value of less than 0.05 was considered as statistically significant.

RESULTS

The stroke registry provided data from 1430 patients with a documented history of stroke who underwent initial care at the study institution. We excluded 94 patients who had no follow-up data after discharge providing us with a cohort of 1336 patients. The study flow chart is presented as [figure 1](#) below. Details of excluded patients

are presented as online supplemental appendix table 1. A total of 1046 (78.3%) patients completed their 1-year follow-up by visiting the study institution and the rest were followed up telephonically by study personnel. In this cohort, 1179 (88.2%) patients were admitted for first ever stroke and the remaining 157 (11.8%) were admitted for recurrent stroke. The baseline details of the cohorts are presented as [table 1](#).

The mean age of the study patients was 61.3 years (13.5 years). Diabetes, hypertension and dyslipidaemia were present in 627 patients (46.9%), 849 patients (63.5%) and 426 patients (31.9%), respectively. A total of 157 patients (11.8% patients) were admitted with a recurrence of stroke. The baseline details stratified by the type of stroke are presented as online supplemental appendix table 2.

The profile of symptoms at presentation are presented in [table 2](#).

The symptom profile in the full cohort was dominated by dysarthria (452 patients, 33.8%), facial palsy (229 patients, 17.1%), hemiplegia (214 patients, 16.0%), aphasia (156 patients, 11.7%) and ataxia (141 patients, 10.6%). The pre-treatment NIHSS was low (<4) in 581 patients (43.5%), intermediate (4–10) in 458 patients (34.3%) and high (>10) in 297 patients (22.2%) in the full cohort.

The details of the subtypes of stroke for both cohorts are presented as [table 3](#).

Acute ischaemic stroke (AIS) was seen in 907 patients (67.9%). Stroke due to intracerebral haemorrhage (ICH) was seen in 132 patients (9.9%). Stroke presenting as TIA was reported by 196 patients (14.7%) subjects. These patients presented with TIA but were proven to have stroke on further evaluation. We were unable to classify 89 patients (6.7%) patients for the type of stroke in this cohort.

We sub-classified patients with AIS (n=907) to report the subtype of AIS using TOAST classification.²⁸ AIS due to large artery atherosclerosis was seen in 202 (22.3%), cardio-embolism in 64 (7.1%), small vessel occlusion in 268 (29.5%), other determined aetiology in 196 (21.6%) and undetermined aetiology in 177 (19.5%).

Among patients, 74 (5.5%) received thrombolytic therapy, 16 (1.2%) received endovascular therapy and 53 (4%) received neurosurgical interventions.

The mortality profile in general as well as the same stratified by type of stroke is presented as [table 4](#).

A total of 114 patients (8.5%) in the full cohort expired after hospital admission for the index stroke till the end of 1-year follow-up. A total of 45 (3.4%) patients from the full cohort died during the first admission. The mortality figures for 2 weeks, 2 months, 6 months and 12 months after discharge were 79 (5.9%), 88 (6.7%), 101 (7.6%) and 114 (8.5%), respectively, in the full cohort. Similar figures were reported for the first ever cohort ([table 4](#)).

We calculated the stroke mortality rate per 1000 follow-up years for the two cohorts. The overall mortality rate at the end of 1 year follow-up after discharge for

Table 1 Baseline characteristics of the study population—full cohort and first ever stroke cohort

Full cohort			
Variables	Total (n=1336)	Male (n=949, 71%)	Female (n=387, 29%)
Age in years	61.25±13.5	60.86±12.9	62.2±14.7
Risk factors			
Diabetes mellitus	627 (46.9)	456 (48.1)	171 (44.2)
Hypertension	849 (63.5)	611 (64.4)	238 (61.5)
Dyslipidaemia	426 (31.9)	306 (32.2)	120 (31)
CRF	59 (4.4)	50 (5.3)	9 (2.3)
OLD TIA	65 (4.5)	55 (5.4)	10 (2.5)
Stroke	157 (11.8)	116 (12.2)	41 (10.6)
Hypothyroidism	84 (6.3)	37 (3.9)	47 (12.1)
Coagulopathies	46 (3.4)	38 (4)	8 (2.1)
Family history stroke	29 (2.2)	22 (2.3)	7 (1.8)
Heart disease			
RHD	46 (3.4)	27 (2.8)	19 (4.9)
Prosthetic valve	19 (3.4)	7 (0.7)	11 (2.8)
CAD	184 (13.8)	154 (16.2)	30 (7.8)
AF	61 (4.6)	41 (4.3)	20 (5.2)
First ever stroke cohort			
Variables	Total (n=1179)	Male (n=833, 70.7%)	Female (n=346, 29.3%)
Age in years	60.77±13.6	60.38±13	61.70±15
Risk factors			
Diabetes mellitus	530 (44.9)	384 (46.1)	146 (42.2)
Hypertension	732 (62.1)	525 (63)	207 (59.8)
Dyslipidaemia	367 (31.1)	261 (31.3)	106 (30.6)
CRF	51 (4.3)	43 (5.2)	8 (2.3)
OLD TIA	51 (4.5)	41 (4.9)	10 (2.9)
Hypothyroidism	73 (6.3)	30 (3.6)	43 (12.4)
Coagulopathies	38 (3.2)	30 (3.6)	8 (2.3)
Family history stroke	27 (2.3)	20 (2.4)	7 (2)
Heart disease			
RHD	43 (3.7)	26 (3.1)	17 (4.9)
Prosthetic valve	14 (1.2)	6 (0.7)	8 (2.3)
CAD	139 (11.8)	116 (13.9)	23 (6.7)
AF	52 (4.4)	35 (4.2)	17 (4.9)

Values are mean (SD) or frequency (%).
AF, atrial fibrillation; CAD, coronary artery disease; CRF, chronic renal failure; RHD, rheumatic heart disease; TIA, transient ischaemic attack.

the full cohort was 91.8 per 1000 person years (95% CI 76.3 to 109.2). The corresponding figures for male and female patients were 84.5 (95% CI 67.0 to 104.7) and

Table 2 Symptom profile—full cohort and first ever stroke cohort

Full cohort			
Variables	Total (n=1336) (%)	Male (n=949) (%)	Female (n=387) (%)
Aphasia	156 (11.7)	105 (11.1)	51 (13.2)
Hemiplegia	214 (16)	145 (15.3)	69 (17.8)
Ataxia	141 (10.6)	108 (11.4)	33 (8.5)
Dysarthria	452 (33.8)	318 (33.5)	134 (34.6)
Loss of consciousness	66 (4.9)	39 (4.1)	27 (7.0)
Facial palsy	229 (17.1)	163 (17.2)	66 (17.1)
Loss of vision	49 (3.7)	33 (3.5)	16 (4.1)
First ever stroke cohort			
Variables	Total (n=1179) (%)	Male (n=833) (%)	Female (n=346) (%)
Aphasia	127 (10.8)	84 (10.1)	43 (12.4)
Hemiplegia	177 (15.0)	114 (13.7)	63 (18.2)
Ataxia	117 (9.9)	91 (10.9)	26 (7.5)
Dysarthria	402 (34.1)	281 (33.7)	121 (35.0)
Loss of consciousness	62 (5.3)	38 (4.6)	24 (6.9)
Facial palsy	197 (16.7)	139 (16.7)	58 (16.8)
Loss of vision	38 (3.2)	26 (3.1)	12 (3.5)

110.2 (95% CI 79.5 to 147.5), respectively (online supplemental appendix table 3). The stroke type stratified figures for mortality rate in the full cohort showed the highest mortality rate for SAH (333.3 per 1000 person years, 95% CI 74.9 to 700.7) followed by ICH (203.5, 95% CI 133.6 to 289.6) and AIS (83.5, 95% CI 65.8 to 104.2). Similar figures were reported for the first ever cohort (online supplemental appendix table 3).

The final adjusted model for mortality at 1-year follow-up after an episode of stroke is presented as table 5.

Only two predictors—age and pre-treatment NIHSS score—showed significant associations with post stroke mortality in the full cohort. Patients older than 45 years at the time of the primary event (stroke) had a much higher mortality compared with patients younger than them (HR: 3.48, 95% CI 1.28 to 9.46, p=0.015). Similarly, those patients with pre-treatment NIHSS score in the range of 4–10 (HR: 3.65, 95% CI 1.64 to 8.16, p=0.002) as well as those with score >10 (HR: 14.85, 95% CI 6.96 to 31.69, p<0.001) had higher mortality compared with those with scores <4 (reference category).

The same analysis was repeated for the first ever stroke cohort. The analysis revealed three predictors for 1 year mortality after first ever stroke—age, pre-treatment NIHSS score and MRS score at baseline. Patients older than 45 years had a much higher mortality (HR: 3.14,

Table 3 Stroke subtypes for the entire cohort and for first ever stroke cohort

Over all cohort			
	Total (n=1336)	Male (n=949)	Female (n=387)
Type of stroke	n (%)	n (%)	n (%)
Stroke–TIA	196 (14.7)	137 (14.43)	59 (15.24)
Stroke–AIS	907 (67.9)	650 (68.49)	257 (66.40)
Stroke–ICH	132 (9.9)	93 (9.7)	39 (10.07)
Stroke–SAH	12 (0.9)	8 (0.84)	4 (1.03)
UD	89 (6.7)	61 (6.4)	28 (7.2)
First ever stroke cohort			
	Total (n=1179)	Male (n=833)	Female (n=346)
Type of Stroke	n (%)	n (%)	n (%)
Stroke–TIA	172 (14.5)	120 (14.40)	52 (15.02)
Stroke–AIS	795 (67.4)	567 (68.06)	228 (65.89)
Stroke–ICH	121 (10.2)	86 (10.32)	35 (10.1)
Stroke–SAH	12 (1.01)	8 (0.96)	4 (1.15)
UD	79 (6.7)	52(6.2)	27(7.8)

AIS, acute ischaemic stroke; ICH, intracerebral haemorrhage; SAH, subarachnoid haemorrhage; TIA, transient ischaemic stroke; UD, undifferentiated.

95% CI 1.15 to 8.55, $p=0.025$) compared with younger patients similar to that seen for the full cohort. Similarly, those patients with pre-treatment NIHSS score in the range of 4–10 (HR: 2.78, 95% CI 1.20 to 6.48, $p=0.018$)

as well as those with score >10 (HR: 11.16, 95% CI 4.99 to 24.96, $p<0.001$) had higher mortality compared with those with scores <4 (reference category). In addition, those patients with MRS score more than 3 at baseline (HR: 2.51, 95% CI 1.02 to 6.19, $p=0.0145$) had higher mortality compared with those with scores <3 (reference category).

DISCUSSION

The current registry provides detailed information related to prevalence of risk factors, comorbidities, profile of symptoms at presentation, mortality rates as well as predictors of mortality related to stroke from Kerala, India. A total of 114 patients from the full cohort expired during the follow-up period providing us with a 1-year stroke mortality of 8.5%. The stroke mortality rate per 1000 person years for the full cohort was 91.8. The adjusted analysis revealed three predictors for 1-year mortality after first ever stroke—age, pre-treatment NIHSS score and MRS score at baseline. The same for the full cohort had only two predictors—age and pre-treatment NIHSS score. Risk factors like diabetes, hypertension and dyslipidaemia failed to show any significant association with 1-year mortality after stroke.

Non-communicable neurological disorders are showing a rising trend in India.⁸ The contribution of non-communicable neurological disorders to total DALYs in the country doubled from 4.0% in 1990 to 8.2% in 2019.⁸ The GBD study reported a national level incidence of 93 per 100 000 population for stroke and Kerala topped the metric at 152 per 100 000 population.⁸

Table 4 Mortality profile—entire cohort and first ever stroke

Full cohort						
	AIS (n=907)	ICH (n=132)	SAH (n=12)	TIA (n=196)	UD (n=89)	Total (n=1336)
In-hospital	27 (2.9%)	15 (11.36%)	0 (0%)	0 (0%)	3 (4.49%)	45 (3.36%)
2 weeks	45 (4.96%)	19 (14.39%)	3 (25%)	1 (0.51%)	11 (11.35%)	79 (5.91%)
2 months	54 (5.95%)	19 (14.39%)	3 (25%)	1 (0.51%)	11 (12.35%)	88 (6.66%)
6 months	62 (6.8%)	21 (15.90%)	3 (25%)	3 (1.53%)	12 (13.48%)	101 (7.63%)
12 months	71 (7.82%)	23 (17.42%)	3 (25%)	3 (1.53%)	14 (15.73%)	114 (8.53%)
First ever stroke cohort						
	AIS (n=795)	ICH (n=121)	SAH (n=12)	TIA (n=172)	UD (n=79)	Total (n=1179)
In-hospital	23 (2.89%)	15 (12.39%)	0 (0%)	0 (0%)	1 (2.53%)	39 (3.30%)
2 weeks	39 (4.90%)	18 (14.87%)	3 (25%)	1 (0.58%)	9 (10.12%)	70 (5.85%)
2 months	48 (6.03%)	18 (14.87%)	3 (25%)	1 (0.58%)	9 (11.39%)	79 (6.70%)
6 months	55 (6.91%)	19 (15.70%)	3 (25%)	3 (1.74%)	10 (12.65%)	90 (7.63%)
12 months	64 (8.05%)	21 (17.35%)	3 (25%)	3 (1.74%)	12 (15.18%)	103 (8.73%)

The time points mentioned are after discharge for the first admission.
AIS, acute ischaemic stroke; ICH, Intracerebral haemorrhage; SAH, subarachnoid haemorrhage; TIA, transient ischaemic stroke; UD, undifferentiated.

**Table 5** Prediction model for stroke mortality at 1-year follow-up from baseline variables—full cohort and first ever stroke cohort

	B	SE	Wald	Sig.	Exp(B)	95.0% CI for exp(B)	
						Lower	Upper
A. stroke mortality prediction model—full cohort							
Age <45 years	Ref.						
Age >45 years	1.246	0.511	5.950	0.015	3.48	1.28	9.46
NIHSS preTx_R (<4)	REF						
NIHSS preTx_R (4–10)	1.295	0.410	9.971	0.002	3.65	1.64	8.16
NIHSS preTx_R (>10)	2.698	0.387	48.634	<0.001	14.85	6.96	31.69
B. Stroke mortality prediction model—first ever stroke cohort							
Age <45 years	REF						
Age >45 Years	1.144	0.512	4.997	0.025	3.14	1.15	8.55
NIHSS_preTx_R (<4)	REF						
NIHSS_preTx_R (4–10)	1.024	0.431	5.632	0.018	2.78	1.20	6.48
NIHSS_preTx_R (>10)	2.412	0.411	34.508	<0.001	11.16	4.99	24.96
MRS_Admission (1–3)	REF						
MRS_Admission (>3)	0.922	0.460	4.015	0.045	2.51	1.02	6.19

The Shiga cohort from Japan suggests that our study population gets stroke at least a decade earlier than the Japanese cohort.¹³ The current study reported younger mean ages for any stroke (61.3 vs 72.9), AIS (61.6 vs 74.7), ICH (60.0 vs 71.0) and SAH (53.2 vs 64.6) in comparison to the Japanese cohort.¹³

The current study identified three predictors for 1-year mortality in first ever stroke which were age, pre-treatment NIHSS score and MRS score at baseline. The same for any stroke were age and pre-treatment NIHSS score. Patients older than 45 years appear to have thrice the risk for 1-year mortality after stroke compared with their younger counterparts. Similar findings of increased risk of post stroke mortality with increasing age were reported by several studies published earlier.^{13 18 19 29} The Anglia study demonstrated an age related increase in stroke mortality with the lowest mortality shown by 18–64 years (11.7%), followed by 65–75 years (20%), 76–81 years (27.1%) and 82–86 years (41.4%). The maximum mortality was seen in the age group of 86–100 years (54.8%). Chen *et al* reported that the HR for 1-year mortality after ischaemic stroke was 3.35 for patients older than 65 years compared with those below 45 years.²⁹ All these studies confirm that age is strongly associated with post stroke mortality.

The association of NIHSS score at admission and 1-year mortality seen in the current study appears to be very strong. Compared with those with NIHSS score <4 at baseline, those with score 4–10 (HR: 3.65, 95% CI 1.64 to 8.16) and >10 (HR: 14.85, 95% CI 6.96 to 31.69) had much higher mortality at 1 year for the any stroke cohort. This is similar to that reported by the Mashhad stroke incidence study from Iran (HR: 1.14, 95% CI 1.10 to 1.17).¹⁹

Our study demonstrated a significant association between baseline mRS and 1-year mortality in the first

ever cohort. Patients with baseline mRS score >3 had more than double the risk of mortality at 1-year follow-up compared with those with mRS ≤3 (HR: 2.51, 95% CI 1.02 to 6.19). A similar association between early mRS score (day 7) and later mortality was demonstrated by Hallevi *et al*.³⁰ The 90-day mortality in patients with ischaemic stroke increased from 2.5% (mRS 3 group) to 7.2% (mRS 4 group) and to 31% (mRS 5 group).³⁰

Our study did not find any significant association between diabetes and 1-year mortality after stroke. Similar findings were reported by the Taiwan cohort separately for cerebral haemorrhage (HR: 0.99, 95% CI 0.84 to 1.18) and cerebral infarction (HR: 1.06, 95% CI 0.97 to 1.17).²⁹ On the contrary, the Shiga cohort reported a positive association between 2-year mortality and diabetes among patients with stroke (HR: 1.40, 95% CI 1.17 to 1.68).¹³ The current study failed to demonstrate any significant association between hypertension or dyslipidaemia with 1-year mortality after stroke. Similar findings were reported for 2-year mortality after stroke by the Shiga cohort.¹³

The in-hospital death for stroke reported in the current study is 3.4% for entire cohort and 2.9% for AIS. This is comparable to the recently published data by Gatttringer *et al* and lower than that reported by Heuschmann *et al*.^{31 32} Gatttringer *et al* reported an in-hospital mortality of 2% for 77 653 patients with AIS treated in the Austrian stroke unit registry. The German stroke registers cohort reported a 4.9% in-hospital mortality from 13 440 patients admitted with a diagnosis of AIS.³² These three studies are in contrast to the very high in-hospital mortality for AIS reported from Nepal (21%) by Shah *et al* in 2017.³³

The study suggests that threefourths of the deaths due to stroke during 1-year follow-up happen during the first 2 months after discharge in the study population. The

mortality rate for AIS at 2 months follow-up in the current study (6%) is comparable to a large cohort of 7144 patients with AIS published recently by Abadi *et al.*³⁴ They reported a 1-month mortality rate of 8% for AIS from the USA.³⁴

The current study reported the lowest 1-year mortality after stroke compared with the studies mentioned earlier except Deleu *et al.*^{9–20} Deleu *et al.* reported a 1-year mortality of 2.1% for a stroke cohort (AIS and TIA) from Arabian peninsula.²⁰ This cohort was much younger than the current study population (mean age 58.9 vs 61.3 years).

The 1 year mortality for first ever stroke is significantly lower in the current study compared with the Shiga cohort for any stroke (8.7% vs 24.6%), AIS (8.1% vs 19.1%), ICH (17.4 vs 29.2%) and SAH (25% vs 40.8%).¹³ The gradient in stroke mortality across the globe is well demonstrated by the more than triple mortality seen for stroke in a recent study from Chile in comparison to the current study at 6 months (30% vs 7.6%) and 1 year (32.7% vs 8.7%) after a first ever stroke.¹⁵

The very low rates for in-hospital mortality, case fatality rate at 1 month and mortality at 1 year seen in the current study could be due to several reasons. The probable reasons could be region specific as well as those related to the study centre. One major reason could be the excellent healthcare indices for the state of Kerala. The state has the lowest infant mortality, lowest under five mortality, lowest maternal mortality and highest life expectancy in India.³⁵

Another major reason could be the steady decline in mortality following stroke seen on a global basis as suggested by a recent systematic review.⁶ A third probable reason could be the stroke care facilities available at the study centre. The current institution is a tertiary comprehensive care centre with a comprehensive stroke unit led by a stroke care specialist. The centre receives patients from all districts in the state. A multidisciplinary team, including specialists from stroke medicine, neuroradiology, stroke neurosurgery and neurophysiotherapy, is available for managing patients with stroke. A dedicated stroke unit based care can prevent complications and reduce mortality in patients with stroke as suggested by earlier studies.^{36 37}

A fourth reason could be due to the design of the current study. Hospital-based stroke registries are likely to report relatively less proportion of stroke mortality compared with community based registries. This is due to the fact that a subset of patients with severe stroke may expire before reaching a stroke treatment facility and will never be captured in such registries. Another probable reason could be the fact that the cohort has a higher proportion of less severe stroke as suggested by the low pre-treatment NIHSS score in a larger subset (<4 in 43.5%) and lower proportion of hemiplegia (16%) during index admission. The higher proportion of less severe stroke on admission seen in the current study could probably be due to early referral from peripheral

centres as well as increased awareness in the community about the need for immediate treatment in patients with acute stroke.

The current study findings confirm the fact that good mortality outcomes are possible after acute stroke even in low resource settings like India when care is delivered through a well-equipped comprehensive stroke care unit.

CONCLUSIONS

Mortality of stroke at 1-year follow-up in the study population is low in comparison to several studies from different parts of the world. The predictors of 1-year mortality included age, NIHSS score at baseline and mRS score at baseline. This study demonstrates that a comprehensive stroke centre based care for acute stroke can significantly reduce the post stroke mortality in low resource countries like India. Establishment of affordable multidisciplinary stroke care centres should be promoted to improve stroke care quality and to reduce stroke mortality in low resource countries.

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