Stroke incidence, mortality, subtypes in rural and urban populations in five geographic areas of India (2018–2019): results from the National Stroke Registry Programme

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The Lancet Regional Health - Southeast Asia 2024;23: 100308

Published Online xxx
https://doi.org/10.1016/j.lansea.2023.100308

Summary

Background Increasing stroke burden in India demands a long-term stroke surveillance framework. Earlier studies in India were urban-based, short term and provided limited data on stroke incidence and its outcomes. This gap is addressed by the establishment of five population-based stroke registries (PBSRs) of the National Stroke Registry Programme, India. This paper describes stroke incidence, mortality and age, sex, and subtypes distribution in the five PBSRs with urban and rural populations.

Methods First-ever incident stroke patients in age group ≥18 years, resident for at least one year in the defined geographic area, identified from health facilities were registered. Death records with stroke as the cause of death from the Civil Registration System (CRS) were included. Transient ischemic attack (TIA) was excluded. Three PBSRs (Cuttack, Tirunelveli, Cachar) included urban and rural populations. PBSRs in Kota and Varanasi were urban areas. The crude and age-standardized incidence rate (ASR) by age, sex, and residence (urban and rural), rate ratios of ASR, case fatality proportions and rates at day 28 after onset of stroke were calculated for years 2018–2019.

Findings A total of 13,820 registered first-ever stroke cases that included 985 death certificate-only cases (DCOs) were analysed. The pooled crude incidence rate was 138.1 per 100,000 population with an age-standardized incidence rate (ASR) of 103.4 (both sexes), 125.7 (males) and 80.8 (females). The risk of stroke among rural residents was one in seven (Cuttack), one in nine (Tirunelveli), and one in 15 (Cachar). Ischemic stroke was the most common type in all PBSRs. Age-standardized case fatality rates (ASCFR) per 100,000 population for pooled PBSRs was 30.0 (males) and 18.8 (females), and the rate ratio (M/F) ranged from 1.2 (Cuttack) to 2.0 (Cachar).

Interpretation Population-based registries have provided a comprehensive stroke surveillance platform to measure stroke burden and outcomes by age, sex, residence and subtype across India. The rural–urban pattern of stroke incidence and mortality shall guide health policy and programme planning to strengthen stroke prevention and treatment measures in India.

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Funding The National Stroke Registry Programme is funded through the intramural funding of the Indian Council of Medical Research, Department of Health Research, Ministry of Health and Family Welfare, India.

Keywords: Stroke incidence; Subtypes; Mortality; Population-based stroke registry; Rural; Urban; India

Research in context

Evidence before this study

Reliable population level data on stroke incidence & mortality is necessary for stroke surveillance and health programme planning. The evidence available till date from population-based stroke registries and community based surveys was from urban cities with little data from few rural populations in India. A most recent systematic review on incidence, prevalence, and case fatality of stroke in India concluded that further high-quality evidence was required that used WHO STEP wise approach to stroke surveillance with longitudinal data collection from populations across India. There is need for robust estimates on burden of stroke and its subtypes by age, sex and residence, to guide policy makers and strengthen stroke care services in India.

Added value of this study

The five population-based stroke registries established in five regions of India under ICMR-NCDIR's National Stroke Registry Programme, provides reliable estimates on the incidence and mortality of first-ever stroke in defined populations. The registry model integrates the STEPS approach to stroke surveillance through case-finding in hospitals and imaging centres with follow-up data on casefatality on 28 days after onset of stroke through multiple methods. This is a first of its kind study to include data on fatal events (recorded in Civil Registration System) and non-fatal non-hospitalized events of stroke. The study has produced robust estimates on incidence of first-ever stroke and mortality in rural and urban populations.

Implications of all the available evidence

The findings from this study provides comparable data on incidence & mortality of stroke in different regions of the country. It describes the burden in these areas and provides baseline evidence for planning of stroke prevention activities and its control strategies. The evaluation of urban/rural difference in burden of stroke and availability of imaging facilities for diagnosis of stroke shall envisage proper resource allocation and healthcare planning. The National Stroke Registry Programme shall establish the stroke surveillance system and support the 'National Programme for prevention and control of noncommunicable diseases (NP-NCD)' in prevention and control of stroke in India. The evidence from India shall support global efforts in burden estimations and in monitoring of the NCD targets towards attaining SDG of health and well-being.

Introduction

Stroke is one of the leading non-communicable diseases (NCDs) causing significant death and disability in India.[1] Population based studies on incidence and mortality of stroke conducted over the last three decades (1990–2020) in India were of short duration and predominantly in urban populations.[2] The global burden of diseases study (GBD) showed state level variation in stroke incidence and DALYs rate of stroke linked to the demographic and epidemiological transition in states in India.[1] Globally, higher stroke incidence and poor outcomes have been found in rural residents as compared to urban residents. This is linked to higher prevalence of stroke risk factors in rural areas.[3] Literature on stroke incidence, its subtypes, mortality and access to stroke services in rural India is limited.[2] Thus longitudinal studies in urban and rural populations are necessary to generate evidence on stroke burden in different regions of India so as to aid planning for preventive and curative stroke services.[2] In this context, the National Stroke Registry Programme, India had initiated five population-based registries (PBSR) (rural and urban) to establish stroke surveillance system in India. The main objective of PBSR was to generate reliable measurements of stroke incidence and mortality.[4] Disease registries collect data on a continuous basis on first-ever stroke, its subtypes and outcomes at day 28 after onset of stroke. This paper presents the measurements of stroke incidence and mortality and its age, sex, and subtypes distribution in five population-based stroke registries, with urban -rural differences for the period 2018–2019.

Methods

PBSRs were established in five geographical areas across different regions of India covering a population of 1 million and above. These include A. Registries with urban and rural areas—PBSR-Cuttack (east), PBSR-Cachar (north-east), PBSR-Tirunelveli (south) and B. Registries with urban areas only—PBSR-Kota (west), PBSR-Varanasi (north) (Fig. 1). The census definitions

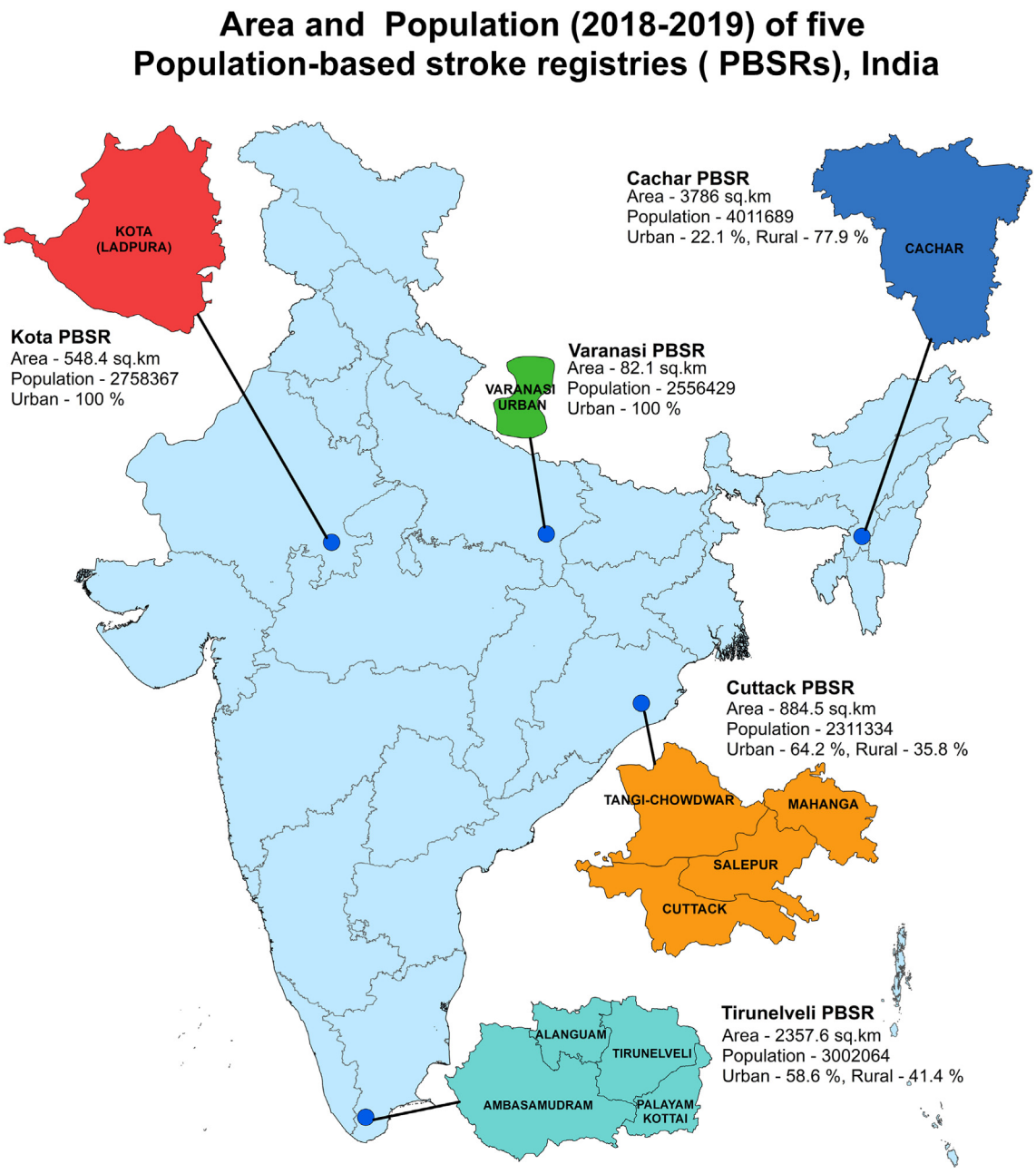

Fig. 1: **Area and population (2018–2019) of five population based stroke registries (PBSRs), India.**

of rural and urban composition and its population were used to characterize each PBSR area. The PBSR centres are major hospitals for stroke management in these geographic areas. Registry study design ensured that data was continuously collated from facilities (called as Sources of registration -SoR) that refer, diagnose, or treat stroke patients. These included hospitals, nursing homes, clinics, general physicians, imaging centres, physiotherapy and rehabilitation centres, and the civil registration system (CRS). The PBSR team of field investigators collected data on first-ever incident stroke cases in age ≥18 years who were residents for at least one year before the diagnosis of stroke, in the defined geographic area. The residential address was obtained from the patient registration slips, medical records or by interview of care givers and categorised based on the urban ward/area/town or the rural village of the registered case. Transient ischemic attacks (TIAs), traumatic

intracranial haemorrhage, symptoms due to trauma, coma of systemic vascular origin, vascular dementia, poisoning were excluded in the registry. The PBSR team reviewed hospital admission & discharge data, medical records from all departments (emergency, medicine, neurology, radio diagnosis, physiotherapy, outpatient and referral registers) of the PBSR hospital and other private and public hospitals. In addition, all Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) imaging reports, death register, death certificates were scrutinized for identification of stroke patients. Details regarding date of onset of stroke, clinical findings at onset, imaging (CT/MRI) findings, risk factors, and diagnosis of type of stroke were collected on hospital admission or attendance of stroke patients at the SoRs by data abstraction on a core form. Data on vital status was collected at day 28 after onset of stroke. In-hospital death details were noted from medical record and medical certificates of cause of death. If details were collected through telephone call or though house visits, vital status was noted, and cause of death was recorded from death certificate or medical records shared by the family during the follow-up.

Death certificates from the offices of the civil registration system in the respective areas were verified for cause of death mentioned as 'stroke' or synonyms such as 'cerebrovascular accident (CVA), brain hemorrhage, brain attack, cerebral infarction' etc. These were matched with registered incident cases to avoid duplication. The matched records were reviewed and confirmed by the field team. Through a follow-back process of unmatched death records, any new incident stroke cases identified in hospitals that had not been registered earlier, were included in the stroke registry. The remaining death certificates with stroke as underlying cause of death that were not reported by any hospital or SoR in the PBSR area were counted as 'Death certificate only (DCO)'cases.

Detailed inclusion and exclusion criteria, data collection tools, abstraction, verification, transmission processes have been earlier described in the methodology paper of the National Stroke Registry Programme, India.[3] Data collected for years 2018–2019 had been transmitted to ICMR-NCDIR through an online software portal (https://stroke.ncdirindia.org/).[5] The data sets were processed for quality checks like missing fields, date range, and consistency errors of one or many variables. The comprehensive verification of data and indicators of quality of data have been described in the report of the PBSRs.[6] These included verification of residence, completeness of data, consistency between subtypes, imaging, diagnosis, ICD 10 codes, and information on vital status on day 28 after onset of stroke. Duplicate records were identified using a 'de duplication' software application that listed probable duplicates using predefined criteria of similar names, age, sex, address, date of onset of stroke, date of diagnosis of stroke and stroke subtype. Following verification by the respective registry team, the duplicate records were deleted and tagged to the record that was retained for analysis. Duplicates occurred due to multiple registration of same patient from different sources or health facilities or recurrent stroke in same patient.

The data of 2018 and 2019 of the five PBSRs were finalized following multiple iterative process of verification of data quality and analysed to measure the following: crude and age standardized rate by age, sex, and residence (urban and rural), rate ratios of age standardized incidence (ASR), case fatality proportions, and rates. ASRs were calculated using the direct method by obtaining the age specific rates and applying these rates to the standard population of that age group.[7] The world standard population was used to normalise the differences across populations with different age structure to calculate the age standardised rate (ASR) and expressed per million population. Standard error and 95% confidence limits of ASRs were calculated using the Poisson approximation. Standardised Rate Ratio of ASR by sex group with 95% confidence limits was determined. ASR for urban and rural populations with standardised rate ratio, and ASRs by subtypes of stroke were calculated. Case fatality rate per 100,000 population (crude and age standardized) by age and sex group were calculated for all PBSRs. Cumulative risk and Rate ratio were calculated.[8] Cumulative risk explains the probability/likelihood that an adult of age ≥18 years in a population will develop stroke irrespective of other competing causes of death.

Role of the funding source

Indian Council of Medical Research has funded the establishment and implementation of the five population-based stroke registries and the coordinating unit at ICMR-NCDIR. The sponsor of the study had no role in writing the manuscript, and in the decision to submit the paper for publication.

IEC approval

The Population-based stroke registries have been approved by the respective Institutional Ethics Committee of the institute implementing the PBSR; and the overall project of establishing the PBSRs is approved by the IEC of ICMR-NCDIR.

Results

A total of 13,820 first-ever stroke cases were registered in the five PBSRs during 2018–2019. These included 985 death certificate only cases (DCOs) from the CRS. The characteristics of the registered cases of first-ever stroke by age, sex, residence, risk factors, imaging, and subtype of stroke is described in Table 1. In three PBSRs with rural and urban populations, the proportion of rural registered cases was higher than urban residents.

	Cuttack (n = 3226) mean [SD]/n (%)	Cachar (n = 2493) mean [SD]/n (%)	Tirunelveli (n = 3730) mean [SD]/n (%)	Kota (n = 2347) mean [SD]/n (%)	Varanasi (n = 2024) mean [SD]/n (%)
Age in years **Mean (SD)**	64.0 [13.7]	59.5 [13.1]	62.3 [12.8]	60.5 [15.5]	62.1 [14.0]
Age group-Male	**Male**	**Male**	**Male**	**Male**	**Male**
18–29	21 (1.1)	19 (1.2)	23 (1.0)	55 (3.8)	22 (1.8)
30–44	142 (7.5)	147 (9.1)	202 (9.1)	175 (12.0)	100 (8.0)
45–59	450 (23.6)	591 (36.8)	702 (31.7)	436 (29.8)	322 (25.6)
60–74	814 (42.8)	659 (41.0)	938 (42.3)	546 (37.3)	562 (44.7)
75+	477 (25.1)	192 (11.9)	350 (15.8)	251 (17.2)	251 (20.0)
Age group-Female	**Female**	**Female**	**Female**	**Female**	**Female**
18–29	21 (1.6)	16 (1.8)	13 (0.9)	25 (2.8)	19 (2.5)
30–44	88 (6.7)	95 (10.7)	99 (6.5)	95 (10.7)	64 (8.3)
45–59	338 (25.6)	305 (34.5)	353 (23.3)	201 (22.7)	204 (26.6)
60–74	569 (43.0)	327 (36.9)	738 (48.7)	357 (40.4)	319 (41.6)
75+	306 (23.1)	142 (16.0)	312 (20.6)	206 (23.3)	161 (21.0)
Gender					
Male	1904 (59.0)	1608 (64.5)	2215 (59.4)	1463 (62.3)	1257 (62.1)
Female	1322 (41.0)	885 (35.5)	1515 (40.6)	884 (37.7)	767 (37.9)
Place of residence					
Urban	1381 (42.8)	369 (14.8)	1419 (38.0)	2347 (100.0)	2024 (100.0)
Rural	1845 (57.2)	2124 (85.2)	2311 (62.0)	NA	NA
Risk factors					
Diabetes	844 (26.2)	289 (15.9)	985 (26.4)	559 (23.8)	707 (35.1)
Hypertension	2420 (75.0)	1239 (67.9)	1504 (40.3)	1377 (58.7)	1297 (64.1)
Current tobacco use	2009 (62.4)	970 (53.8)	861 (23.1)	756 (32.2)	385 (19.3)
Imaging studies[a]					
CT	2642 (81.9)	1810 (72.6)	2303 (61.7)	1326 (56.5)	1710 (84.5)
MRI	45 (1.4)	2 (0.1)	823 (22.1)	851 (36.3)	123 (6.1)
Both CT and MRI	39 (1.2)	1 (0.0)	112 (3.0)	160 (6.8)	14 (0.7)
Type of stroke[b]					
Ischemic	2435 (75.5)	1160 (46.5)	3163 (84.8)	1962 (83.6)	1222 (60.4)
Haemorrhagic	665 (20.6)	667 (26.8)	430 (11.5)	377 (16.1)	710 (35.1)
Undetermined	126 (3.9)	666 (26.7)	137 (3.7)	8 (0.3)	92 (4.5)
Deaths					
Deaths within 28 days of onset	540 (16.7)	1028 (41.2)	664 (17.8)	286 (12.2)	767 (37.9)

NA: Data not available. CT, Computed Tomography; MRI, Magnetic Resonance Imaging. [a]Cases registered from 'Death certificates only' are excluded. [b]Cases registered from 'Death certificates only' are included as 'undetermined stroke'.

Table 1: **Characteristics of registered cases of first-ever stroke in five Population-based Stroke Registries (PBSRs), India, 2018–19.**

Imaging of brain was done in most stroke cases (72.7% in Cachar in north-east India to 99.6% in Kota in west India). Venous strokes were included in the subtype of ischemic stroke (Table 1) as a small proportion (0.1% in Cuttack and Varanasi, 0.5% Tirunelveli, and 3% in Kota) (numbers not shown separately).

The incidence rates in the five PBSRs and pooled incidence rate by age and sex group, age standardised rate (ASR), rate ratio of ASR by sex group have been described in Table 2. The age specific incidence rate was highest in 75+ years group. The ASR in females ranged from 59.5 (Cachar) to 109.4 (Cuttack), and in males ranged from 102.8 (Cachar) to 144.6 (Cuttack). The pooled crude rate was 138.1 per 100,000 population with ASR of 103.4 (both sexes), 125.7 (males), and 80.8 (females). The cumulative risk of occurrence of first ever stroke was one in 12 (both sexes), one in ten (males), and one in 15 (females) (Fig. 2) from the pooled data of PBSRs.

Incidence rates by age group in rural and urban residents are described in Table 3. The incidence rates (crude and ASR for adults ≥18 years) was two times higher in rural Cuttack (ASR 191.7), Tirunelveli (ASR 163.3) and Cachar (ASR 93.9) as compared to the urban residents of these three PBSRs. The risk of stroke among rural residents was one in seven (Cuttack), one in nine (Tirunelveli), and one in 15 in Cachar (Fig. 3). Table 4 described incidence rates by stroke subtypes, age standardized incidence rates in males and females for all stroke subtypes, and rate ratio of ASR in each of the PBSRs. The ASR (≥18 years) for ischemic stroke ranged from 39.6 in Cachar to 96.6 per 100,000 in

Age group	Cuttack		Cachar		Tirunelveli		Kota		Varanasi		Pooled PBSRs		Both sexes
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	
	Incidence rate and 95% CI												
18–29	8.1 (4.6–11.5)	7.9 (4.5–11.3)	4.1 (2.3–6.0)	3.4 (1.7–5.1)	7.5 (4.4–10.6)	4.3 (2.0–6.7)	14.6 (10.7–18.4)	7.4 (4.5–10.4)	6.8 (4.0–9.7)	6.9 (3.8–10.0)	8.1 (6.8–9.4)	5.7 (4.5–6.9)	6.9 (6.0–7.8)
30–44	50.8 (42.4–59.1)	32 (25.3–38.7)	34.7 (29.1–40.3)	22.7 (18.1–27.2)	58 (50.0–66.0)	27.6 (22.2–33.0)	58.9 (50.2–67.6)	34 (27.1–40.8)	38.5 (30.9–46.0)	25.5 (19.2–31.7)	47.6 (44.2–51.0)	27.9 (25.3–30.5)	37.8 (35.7–39.9)
45–59	224.9 (204.1–245.6)	189.1 (169.0–209.3)	217.2 (199.7–234.7)	123.8 (109.9–137.7)	281.2 (260.4–302.0)	135.8 (121.7–150.0)	230.8 (209.1–252.5)	116.8 (100.7–132.9)	200.7 (178.8–222.6)	135.9 (117.2–154.5)	233.5 (224.3–242.7)	139.1 (131.8–146.4)	187.7 (181.8–193.6)
60–74	802.4 (747.2–857.5)	604.1 (554.5–653.7)	545.8 (504.1–587.4)	289.6 (258.2–321.0)	679.6 (636.1–723.1)	460.9 (427.6–494.1)	636.2 (582.8–689.5)	418.8 (375.4–462.3)	597.2 (547.8–646.5)	376.6 (335.3–417.9)	651.5 (630.0–673.0)	430 (412.5–447.5)	541.1 (527.2–555.0)
75+	1396.9 (1271.5–1522.3)	966.9 (858.6–1075.3)	699.2 (600.3–798.1)	506.2 (423.0–589.5)	1044.9 (935.5–1154.4)	714.4 (635.2–793.7)	1254.4 (1099.2–1409.6)	885.2 (764.3–1006.1)	1037.7 (909.3–1166.1)	696.7 (589.1–804.4)	1091.9 (1037.0–1146.8)	752.6 (708.7–796.5)	916.1 (881.2–951.0)
≥18	217.4 (207.6–227.1)	156.6 (148.2–165.1)	123 (117.3–129.4)	69.4 (64.8–73.9)	205.9 (197.3–214.5)	134.9 (128.1–141.7)	150.8 (143.1–158.6)	98.6 (92.1–105.1)	145.9 (137.9–154.0)	97.8 (90.9–104.7)	166.1 (162.6–169.6)	109.1 (106.2–112.0)	138.1 (135.8–140.4)
ASR	144.6 (134.4–154.9)	109.4 (100.1–118.7)	103 (94.8–110.7)	59.5 (53.3–65.7)	136.2 (127.3–145.0)	82 (75.5–88.4)	130.5 (119.9–141.1)	80.5 (72.1–88.9)	112.9 (103.1–122.7)	74.2 (65.9–82.4)	125.7 (121.5–129.9)	80.8 (77.4–84.2)	103.4 (100.7–106.1)
Rate Ratio of ASR (M/F)	1.32 (1.18–1.48)		1.73 (1.52–1.96)		1.66 (1.50–1.84)		1.62 (1.42–1.85)		1.52 (1.32–1.75)		1.56 (1.48–1.64)		–

Abbreviations: ASR, Age Standardised Rate; M, Male/F, Female.

Table 2: **Incidence rate of first-ever stroke (per 100,000 population) by age group & sex in PBSRs, India, 2018–19.**

Cuttack. Undetermined stroke was highest in Cachar (20.6 per 100,000 population).

Multiple methods were used to follow up to ascertain vital status on day 28 after onset of stroke. The most common method of follow up was telephone call (74.3%). Follow up was missing or unknown in 1.6% of registered cases (Supplementary Figure S1). In 38.6% registered cases, vital status was ascertained between 28 and 30 days of onset of stroke and median duration to complete follow up was 36 days.

Age standardized case fatality rates (ASCFR) per 100,000 population for pooled PBSRs was 30.0 (males) and 18.8 (females). The ASCFR ranged from 14.9 (Kota) to 43.4 (Cachar) in males and 11.1 (Kota) to 28.8 (Varanasi) in females. The rate ratio of ASCFR (males/females) ranged from 1.2 in Cuttack to 2.0 in Cachar (Table 5). Age specific case fatality rates were maximum in age group of ≥75 years for all types of stroke in all PBSRs (Tables 5 and 6). Proportion of case fatality was maximum within first week after onset of stroke (53.5%) and 17% died on same day of onset of stroke in all PBSRs (Supplementary Figure S2). Majority were ischemic (56.7%) and haemorrhagic (39.4%) (Supplementary Figure S2). In Cachar, the type of stroke was in order of haemorrhagic (57%), ischemic (38%), and undetermined stroke (5%) (Supplementary Figure S3). The ASCFR for ischemic stroke ranged from 5.2 per 100,000 population (Cachar) to 17.8 (Varanasi). The ASCFR for haemorrhagic stroke ranged from 4.7 (Tirunelveli) to 13.5 (Varanasi) (Table 6).

Discussion

This study covered five geographical populations of one to two million in India to provide measurements on incidence and mortality of stroke by age, sex, and residence (urban and rural). The crude incidence rate of first-ever stroke ranged from 96.6 to 187.6 per 100,000 population and crude case fatality rate ranged from 15.3 to 46.6 per 100,000 population. Rate ratio of age adjusted incidence of stroke was two times higher in rural as compared to the urban population in Cuttack, Cachar, and Tirunelveli. The cumulative risk of developing stroke ranged from 1 in 7 in rural Cuttack to 1 in 15 in rural Cachar. Higher incidence rates in males was observed as compared to females in age 30 and above (rate ratio ranged from 1.32 to 1.73). This translated to a cumulative risk of developing stroke of 1 in 10 among males and 1 in 15 among females age ≥18 years in the pooled population. The risk of stroke was higher in males as compared to females in all registries (Table 2 and Fig. 1). The crude incidence rates of ischemic stroke ranged from 45 (Cachar) to 143.9 per 100,000 (Tirunelveli) in age ≥18 years in both sexes. Subarachnoid haemorrhage (SAH) accounted for 1–2% of all haemorrhages,[6] and therefore incidence rates of intracerebral haemorrhage (ICH) and SAH have been presented as single group as 'haemorrhagic stroke'. The

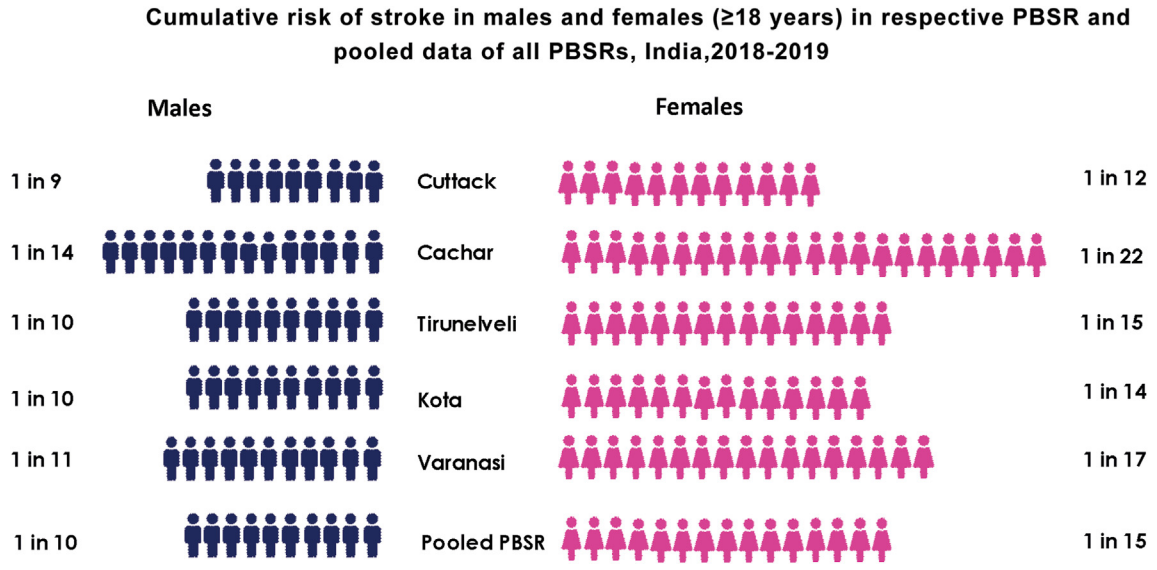

Fig. 2: Cumulative risk of stroke in males and females (≥18 years) in respective PBSR and pooled data of all PBSRs, India, 2018–2019.

Age group	Cuttack		Cachar		Tirunelveli	
	Urban	Rural	Urban	Rural	Urban	Rural
	Incidence rate and 95% CI					
18–29	4.9 (2.6–7.1)	13.0 (7.8–18.2)	0.0 (0.0–0.0)	4.7 (3.2–6.3)	3.8 (1.7–5.9)	8.8 (5.2–12.4)
30–44	21.3 (16.6–25.9)	74.9 (62.9–86.9)	10.8 (6.4–15.2)	33.9 (29.4–38.4)	24.6 (19.9–29.3)	67.9 (58.4–77.4)
45–59	139.3 (124.8–153.9)	312.4 (283.0–341.8)	76.0 (62.0–90.1)	204.1 (189.8–218.4)	120.4 (108.2–132.6)	332.1 (307.1–357.1)
60–74	546.4 (502.4–590.5)	1052.5 (979.2–1125.9)	224 (188.3–259.7)	485.4 (452.4–518.3)	349.6 (322–377.2)	849.7 (798.6–900.8)
75+	973.1 (869.1–1077.2)	1701.6 (1543.9–1859.4)	494.7 (388.3–601.1)	625.7 (548.3–703.1)	644.2 (572.4–716.0)	1150.7 (1030.7–1270.7)
≥18	120.5 (114.1–126.8)	295.9 (282.4–309.4)	56.6 (50.8–62.3)	107.3 (102.7–111.9)	108.8 (103.1–114.5)	253.8 (243.5–264.1)
ASR	94.3 (86.5–102.2)	191.7 (177.9–205.5)	43.4 (36.4–50.4)	93.9 (87.5–100.2)	67.6 (62.1–73.1)	163.3 (152.9–173.7)
Rate Ratio of ASR(R/U)	2.0 (1.81–2.28)		2.2 (1.87–2.50)		2.4 (2.17–2.69)	

Abbreviations: ASR, Age Standardised Rate; R, Rural; U, Urban.

Table 3: Incidence rate of first-ever stroke (per 100,000 population) by age group & sex in rural and urban population in three PBSRs, India, 2018–19.

incidence rate of all haemorrhagic stroke was highest in Varanasi (43.1). The pattern of incidence of ischemic > haemorrhagic > undetermined stroke was similar in all registries, in rural and urban areas,[6] and with exclusion of the DCO cases (data not presented). Stroke incidence (ASR) was higher in males as compared to females for both ischemic and haemorrhagic stroke (Table 4).

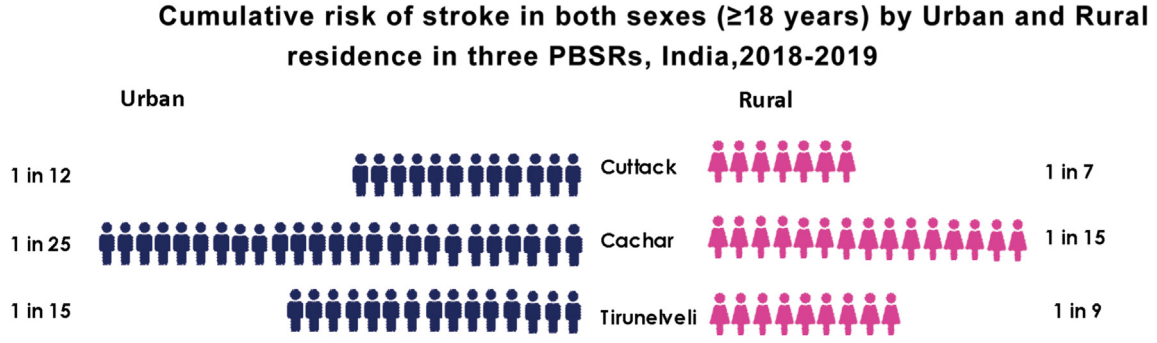

Fig. 3: Cumulative risk of stroke in both sexes (≥18 years) by Urban and Rural residence in three PBSRs, India, 2018–2019.

Age group	Cuttack			Cachar			Tirunelveli			Kota			Varanasi		
	I	H	U	I	H	U	I	H	U	I	H	U	I	H	U
	Incidence rate and 95% CI														
18–29	6.7 (4.5–8.9)	1.0 (0.2–1.8)	0.4 (0.0–0.9)	1.0 (0.4–1.6)	0.6 (0.1–1.1)	2.2 (1.3–3.1)	4.8 (3.1–6.5)	1.0 (0.2–1.8)	0.2 (0.0–0.5)	9.1 (6.9–11.3)	2.1 (1.0–3.2)	0.0 (0.0–0.0)	4.3 (2.6–6.0)	2.2 (1.0–3.4)	0.3 (0.0–0.8)
30–44	29.6 (25.1–34.1)	9.7 (7.1–12.3)	2.2 (1.0–3.4)	8.2 (6.3–10.1)	9.1 (7.1–11.1)	11.4 (9.1–13.7)	35.2 (30.8–39.6)	7.2 (5.2–9.2)	0.1 (0.0–0.4)	39.0 (33.9–44.1)	7.5 (5.3–9.7)	0.3 (0.0–0.8)	19.8 (15.9–23.7)	11.2 (8.3–14.1)	1.2 (0.3–2.1)
45–59	151.3 (138.9–163.7)	51.2 (44.0–58.4)	5.5 (3.1–7.9)	65.8 (58.8–72.8)	47.8 (41.8–53.8)	59.2 (52.6–65.8)	169.6 (158.3–180.9)	32.2 (27.3–37.1)	5.3 (3.3–7.3)	144.0 (131.6–156.4)	31.9 (26.1–37.7)	0.6 (0.0–1.4)	94.3 (83.5–105.1)	69.9 (60.6–79.2)	5.2 (2.7–7.7)
60–74	546.4 (513.6–579.2)	132.9 (116.7–149.1)	27.6 (20.2–35.0)	236.7 (217.0–256.4)	110.4 (96.9–123.9)	74.9 (63.8–86.0)	491.7 (466.5–516.9)	50.3 (42.2–58.4)	20.1 (15.0–25.2)	444.3 (412.7–475.9)	81.8 (68.2–95.4)	1.8 (0.0–3.8)	298.1 (272.8–323.4)	169.4 (150.3–188.5)	25.2 (17.8–32.6)
75+	902.8 (830.2–975.4)	231.0 (194.3–267.7)	56.2 (38.1–74.3)	338.7 (290.3–387.1)	140.5 (109.3–171.7)	122.5 (93.4–151.6)	719.2 (659.4–779.0)	76.5 (57.0–96.0)	62.2 (44.6–79.8)	905.7 (816.0–995.4)	147.9 (111.7–184.1)	2.3 (0.0–6.8)	568.8 (500.8–636.8)	253.7 (208.3–299.1)	48.6 (28.7–68.5)
≥18	141.6 (136.0–147.2)	38.7 (35.8–41.6)	7.3 (6.0–8.6)	45.0 (42.4–47.6)	25.9 (23.9–27.9)	25.8 (23.8–27.8)	143.9 (138.9–148.9)	19.6 (17.8–21.4)	6.2 (5.2–7.2)	105.1 (100.4–109.8)	20.2 (18.2–22.2)	0.4 (0.1–0.7)	74.3 (70.1–78.5)	43.1 (39.9–46.3)	5.6 (4.5–6.7)
ASR	96.6 (90.5–102.6)	26.2 (23.1–29.4)	4.9 (3.5–6.3)	39.6 (36.0–43.2)	21.7 (19.1–24.3)	20.6 (18.1–23.0)	91.4 (86.4–96.3)	12.4 (10.5–14.2)	3.9 (2.9–4.9)	88.5 (82.4–94.7)	16.9 (14.2–19.6)	0.3 (0.0–0.7)	56.8 (51.8–61.8)	33.2 (29.4–37.1)	4.3 (2.9–5.7)
Males-ASR	110.6 (101.6–119.6)	29.2 (24.6–33.8)	4.9 (3.0–6.7)	47.7 (42.2–53.2)	28.4 (24.2–32.6)	26.7 (22.8–30.7)	115.3 (107.2–123.5)	16.3 (13.2–19.3)	4.6 (2.9–6.2)	110.4 (100.6–120.2)	19.7 (15.6–23.8)	6.1 (3.8–8.5)	65.8 (58.4–73.3)	42.1 (36.1–48.1)	5.0 (2.9–7.0)
Females-ASR	81.4 (73.4–89.5)	26.2 (23.1–29.4)	4.9 (3.0–6.9)	31.0 (26.4–35.6)	14.6 (11.5–17.6)	14.0 (11.0–16.9)	69.9 (63.9–75.8)	8.8 (6.7–10.9)	3.3 (2.0–4.6)	66.2 (58.7–73.8)	14.0 (10.5–17.5)	5.6 (3.4–7.8)	47.0 (40.4–53.5)	23.6 (19.0–28.3)	3.6 (1.7–5.4)

Abbreviations: ASR, Age Standardised Rate; I, Ischemic stroke; H, Haemorrhagic stroke (includes Intracerebral and Subarachnoid Haemorrhage); U, Undetermined stroke [includes registered stroke cases from Death Certificates with stroke as cause of death].

Table 4: **Incidence rate of first-ever stroke subtype (per 100,000 population) by age group in PBSRs, India, 2018–19.**

The incidence rates were similar to rates reported in earlier population based studies in urban (140)[9] and rural Ludhiana (162.8 per 100,000),[10] 116.4 in urban and 119.4 per 100,000 in rural Trivandrum,[11] urban Kolkata (123.15),[12] and urban Mumbai (145 per 100,000).[13] The ASR in the five PBSRs ranged from 81.9 to 127.7 annually which was lower compared to Asian countries like Singapore (164.5),[14] China (246.8)[15] or European countries like Sweden (165)[16]; and higher as compared to countries like Japan (69.8)[17] and Malaysia.[18] Very few studies have reported age standardized incidence of stroke in rural residents, which has increased from 123.5 (rural Bengal),[19] 138 (rural Trivandrum)[11] in the early 2000s to 197.6 (rural Ludhiana)[10] in 2018. The latter rates were similar to incidence rates among rural residents in Tirunelveli (163.3) and Cuttack (191.7). Incidence rates were higher in rural areas as compared to urban areas at each age group in the three registries (Table 3). Stroke incidence, mortality and risk factors for stroke were higher in rural areas than urban areas in other studies in India,[20,21] and in countries like China,[15] and the USA.[3] Increase in incidence with age was observed in both sexes similar to the increasing age specific incidence estimated by the GBD study in India.[1] The GBD study also showed increase in stroke incidence and DALYs rates (1990–2019) and variation of DALYs rates of 5.5 times between the states.[1] Stroke incidence rates in the younger age group of 18–29 was almost similar in males and females in Cuttack, Cachar and Varanasi, a pattern that should be monitored in the future. Earlier studies have shown incidence rates higher in males than females[9,11] except for few exceptions in Kolkata,[12] and rural Ludhiana.[10] The sex differentials of incidence rates (men > women) in all age groups may also have a gendered dimension of access to care. A nationwide study (National Sample Survey organisation (NSSO) 2017 & 2018, India) of services availed for stroke revealed that women sought care in public hospitals as compared to men who accessed private hospitals. Men stayed longer in hospitals and overall expenditure (medical and rehabilitation) for stroke management was higher among men as compared to women.[22]There is a need for continuous robust data on stroke burden based on residence, state, and region wise, to plan for stroke care services that are grossly deficient in India.[23]

In this study, hypertension was the most common risk factor reported across all registries ranging from 40.3% to 75% among stroke patients which was lesser when compared to studies in south and north India (83–89%).[11,20] Similar observations were seen for diabetes and tobacco use. There may be some under-reporting of risk factors of stroke in our registries as it was based on data abstraction from patient medical records. The National NCD risk factor monitoring survey in India (2017–2018), revealed the national population prevalence of raised blood pressure (28.5%) and glucose

(9.3%) among adults aged 18–69 years, with higher prevalence in urban areas as compared to rural respondents.[24] The survey also captured the gaps in risk factor awareness, its management, and control cascade. Nearly 50% of those who were aware of their raised blood pressure status, were on treatment and less than 50% had their BP under control.[25] Similarly, less than half (45.8%) who were aware of their raised blood glucose levels, were on treatment and only one third had their blood glucose under control.[26] In India, poor awareness and management of risk factors are significant contributing factors for increasing incidence of cardiovascular diseases like stroke.

Diagnosis of type of stroke in a registry was based on increasing levels of confirmation using clinical, imaging records, and death certificates. Availability of imaging (CT or MRI) were high in all PBSRs (72%–99.6%), and was comparable to earlier studies that reported 38%–95% of imaging available for stroke.[2] Cerebral venous sinus thrombosis (CVST) (≤3%) reported in the registries was comparable to urban Ludhiana.[9] Nonspecific clinical presentation and poor sensitivity of the initial non contrast CT to detect CVST may have resulted in lower reporting of CVST, as imaging such as CT or MR Venography is required for its diagnosis.[27]

The most common subtype of stroke reported in earlier studies was ischemic stroke (65–84%) followed by intracerebral haemorrhage (ICH 11–35%).[2] Cachar reported the highest proportion of undetermined stroke (26.7%) due to cases registered from death certificates with 'stroke' as a cause of death. Cachar is the largest PBSR by area with predominantly rural population, and lesser number of imaging centres as compared to other PBSRs. High proportion of undetermined stroke was reported in an analysis of the nationwide insurance (Ayushman Bharat scheme) claims data, which was attributed to non-availability of standard recording of variables in stroke management in many states.[28]

Stroke mortality is a key indicator of quality of care of stroke. A total of 2296 cases died within 28 days of onset of stroke across all registries, and among them 70.6% died within first week. Similar findings were reported in Trivandrum registry with 72.1% cases dying within 10 days of stroke onset.[11] Case fatality ranged from 12.2% to 41.2%,[6] comparable to case fatality reported at 28–30 days in earlier studies between 2003 and 2013 (19–41%),[9–13,29] signifying that stroke mortality has been stagnant if not increasing over the last two decades in India. However, case fatality was higher as compared to Singapore (7.9%),[14] England (14%),[30] and Sweden (11.2%).[31] The case fatality rate seen in Kota may represent a lower rate as cause of death data is not properly recorded in the Civil Registration system. The case fatality rates were lower as compared to the stroke mortality rates estimated in the GBD 2021 (50.2),[1] the million death study (71.5),[32] and a rural community based study in central India (121.6),[21] where latter two

Age group	Cuttack		Cachar		Tirunelveli		Kota		Varanasi		Pooled PBSRS	
	M	F	M	F	M	F	M	F	M	F	M	F
	Case fatality rate and 95% CI											
18–29	0.8 (0.0–1.9)	0.8 (0.0–1.8)	3.0 (1.4–4.6)	1.5 (0.4–2.6)	0.0 (0.0–0.0)	0.3 (0.0–1.0)	1.1 (0.1–2.1)	0.6 (0.0–1.4)	3.4 (1.4–5.4)	3.3 (1.2–5.4)	1.8 (1.2–2.4)	1.3 (0.8–1.8)
30–44	4.3 (1.9–6.7)	5.5 (2.7–8.3)	16.8 (12.9–20.7)	9.8 (6.8–12.8)	6.9 (4.1–9.7)	3.3 (1.4–5.2)	6.1 (3.3–8.9)	2.9 (0.9–4.9)	12.3 (8.0–16.6)	9.6 (5.8–13.4)	9.8 (8.3–11.3)	6.3 (5.1–7.5)
45–59	26.5 (19.4–33.6)	26.9 (19.3–34.5)	102.5 (90.5–114.5)	54.8 (45.6–64.0)	44.1 (35.9–52.3)	16.2 (11.3–21.1)	23.3 (16.4–30.2)	9.9 (5.2–14.6)	61.7 (49.5–73.9)	56.6 (44.6–68.6)	54.6 (50.2–59.0)	32.5 (29.0–36.0)
60–74	128.1 (106.1–150.1)	100.9 (80.6–121.2)	201.3 (176.0–226.6)	89.4 (72.0–106.8)	105.8 (88.6–123.0)	81.2 (67.2–95.2)	46.6 (32.2–61.0)	52.8 (37.4–68.2)	229.5 (198.9–260.1)	129.9 (105.6–154.2)	143.5 (133.4–153.6)	89.5 (81.5–97.5)
75+	319.2 (259.3–379.1)	233.8 (180.5–287.1)	313.2 (247.0–379.4)	181.8 (131.9–231.7)	328.4 (267.0–389.8)	203.8 (161.5–246.1)	294.9 (219.7–370.1)	210.6 (151.6–269.6)	450.6 (366.0–535.2)	311.6 (239.6–383.6)	339.6 (309.0–370.2)	223.7 (199.7–247.7)
≥18	35.0 (31.0–38.8)	27.8 (24.1–31.3)	53.2 (49.2–57.2)	26.2 (23.5–29.1)	36.3 (32.7–39.9)	24.3 (21.5–27.3)	17.0 (14.4–19.6)	13.5 (11.1–15.9)	54.3 (49.3–59.1)	38.2 (34.0–42.6)	39.7 (38.0–41.4)	25.7 (24.3–27.1)
ASCFR	22.8 (18.8–26.9)	18.8 (15.1–22.8)	43.3 (38.3–48.5)	22.0 (18.2–25.7)	23.9 (20.2–27.7)	14.5 (11.8–17.2)	14.8 (11.3–18.5)	11.1 (8.0–14.2)	41.8 (35.9–47.8)	28.8 (23.7–33.9)	30.0 (28.0–32.1)	18.8 (17.2–20.4)
Rate Ratio of ASCFR (M/F)	1.2 (1.13–1.28)		2.0 (1.76–2.21)		1.6 (1.44–1.89)		1.3 (1.17–1.54)		1.5 (1.33–1.58)		1.6 (1.51–1.68)	

Abbreviations: ASCFR, Age Standardised Case Fatality Rate; M, Male; F, Female.

Table 5: Case fatality rate of first-ever stroke at day 28 after onset of stroke (per 100,000 population) by age group & sex in PBSRs, India, 2018–19.

Age group	Cuttack			Cachar			Tirunelveli			Kota			Varanasi		
	I	H	U	I	H	U	I	H	U	I	H	U	I	H	U
	Case fatality rate and 95% CI														
18–29	0.4 (0.1–0.9)	0.0 (0.0–0.0)	0.4 (0.0–0.9)	0.0 (0.0–0.0)	0.1 (0.0–0.3)	2.2 (1.3–3.1)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.2 (0.0–0.5)	0.3 (0.0–0.7)	0.6 (0.1–1.1)	0.0 (0.0–0.0)	2.5 (1.2–3.8)	0.5 (0.0–1.1)	0.3 (0.0–0.8)
30–44	2.0 (0.8–3.2)	1.3 (0.4–2.2)	1.6 (0.5–2.7)	0.2 (0.0–0.5)	1.9 (1.0–2.8)	11.2 (8.9–13.5)	2.0 (1.0–3.0)	3.0 (1.7–4.3)	0.1 (0.0–0.4)	2.1 (0.9–3.3)	2.4 (1.1–3.7)	0.0 (0.0–0.0)	6.3 (4.1–8.5)	3.5 (1.9–5.1)	1.2 (0.3–2.1)
45–59	12.9 (9.3–16.5)	9.8 (6.7–12.9)	4.0 (2.0–6.0)	6.2 (4.1–8.3)	14.5 (11.2–17.8)	59.2 (52.6–65.8)	13.1 (10.0–16.2)	12.0 (9.0–15)	5.5 (3.5–7.5)	9.4 (6.2–12.6)	7.5 (4.7–10.3)	0.0 (0.0–0.0)	30.6 (24.4–36.8)	23.8 (18.4–29.2)	4.8 (2.4–7.2)
60–74	64.4 (53.2–75.6)	29.6 (22.0–37.2)	21.5 (15.0–28.0)	30.8 (23.7–37.9)	42.4 (34.1–50.7)	74.0 (63.0–85.0)	53.7 (45.4–62.0)	17.8 (13.0–22.6)	19.5 (14.5–24.5)	29.8 (21.6–38.0)	19.9 (13.2–26.6)	0.0 (0.0–0.0)	87.2 (73.5–100.9)	69.9 (57.6–82.2)	25.2 (17.8–32.6)
75+	155.0 (124.9–185.1)	77.5 (56.2–98.8)	44.1 (28.1–60.1)	73.9 (51.3–96.5)	50.4 (31.7–69.1)	122.5 (93.4–151.6)	156.8 (128.9–184.7)	40.2 (26.1–54.3)	62.2 (44.6–79.8)	184.8 (144.3–225.3)	64.7 (40.7–88.7)	0.0 (0.0–0.0)	188.2 (149.1–227.3)	145.9 (111.5–180.3)	48.6 (28.7–68.5)
≥18	16.9 (15.0–18.8)	8.9 (7.5–10.3)	5.6 (4.5–6.7)	5.7 (4.8–6.6)	8.5 (7.4–9.6)	25.7 (23.7–27.7)	16.5 (14.8–18.2)	7.6 (6.5–8.7)	6.2 (5.2–7.2)	9.6 (8.2–11.0)	5.7 (4.6–6.8)	0.0 (0.0–0.0)	23.5 (21.2–25.8)	17.6 (15.6–19.6)	5.5 (4.4–6.6)
ASCFR	11.3 (9.2–13.3)	5.9 (4.5–7.4)	3.8 (2.6–5.0)	5.2 (3.9–6.5)	7.4 (5.8–8.9)	20.4 (18.0–22.9)	10.3 (8.6–12.0)	4.7 (3.6–5.9)	3.9 (2.9–4.9)	8.2 (6.3–10.1)	4.8 (3.3–6.2)	0.0 (0.0–0.0)	17.8 15.0–20.6)	13.5 (11.1–16.0)	4.2 (2.9–5.6)
Males-ASCFR	13.0 (10.0–16.1)	6.2 (4.1–8.3)	3.6 (2.0–5.2)	6.2 (4.2–8.2)	10.5 (8.0–13.1)	26.6 (22.7–30.6)	13.0 (10.3–15.8)	6.3 (4.4–8.2)	4.6 (2.9–6.2)	9.7 (6.8–12.7)	5.1 (3.1–7.2)	0.0 (0.0–0.0)	20.8 (16.6–25.0)	16.2 (12.4–19.9)	4.6 (2.6–6.5)
Females-ASCFR	9.3 (6.7–12.0)	5.6 (3.5–7.8)	3.9 (2.2–5.7)	4.2 (2.5–5.9)	4.0 (2.4–5.6)	13.8 (10.9–16.7)	7.9 (5.9–9.9)	3.3 (2.0–4.6)	3.3 (2.0–4.5)	6.8 (4.4–9.2)	4.3 (2.3–6.2)	0.0 (0.0–0.0)	14.6 (10.9–18.2)	10.6 (7.5–13.8)	3.6 (1.7–5.4)

Abbreviations: ASCFR, Age Standardised Case Fatality Rate; I, Ischemic stroke; H, Haemorrhagic stroke (includes Intracerebral and Subarachnoid Haemorrhage); U, Undetermined stroke [includes registered stroke cases from Death Certificates with stroke as cause of death].

Table 6: **28-days case fatality rate of first-ever stroke (per 100,000 population) by subtypes of stroke in PBSRs, India,2018–19.**

studies had used verbal autopsy to ascertain cause of death. The major limitation in calculating cause specific mortality rates is the poor cause of death data in the medical records and low coverage (22.5%) of Medical Certification of Cause of death (MCCD) in India.[33]

The registry design included cases admitted in hospitals and outpatient cases (fatal and non-fatal) and data from the CRS (Table 7). Major sources include public (medical college hospitals, district and sub-district hospitals, primary health centres) [37–80% cases], and private hospitals (tertiary care hospitals, nursing homes, clinics) [20–47% cases]. Data was collected from imaging centres, physiotherapy centres, alternative healing centres, and local death registration offices. A small proportion of non-fatal non-hospitalized events (as described in the STEPS 3 of the WHO Stepwise approach) could have been missed out, as the registry focused on cases that had some form of medical attendance (imaging/medical doctor). In addition, patients who had taken treatment in hospitals that were outside the PBSR area may also have been missed. Details on all risk factors of stroke (dyslipidemia, obesity, atrial fibrillation, hormonal use etc.) may not be available in all health facilities that provide data and thus population-based attribution of risk factors to stroke is not attempted in this study. Notwithstanding, the methodology with standard definitions, process of data abstraction and quality has adhered to the standard criteria of a registry for stroke surveillance that is comparable.[34] This has helped to provide reliable estimates on incidence and mortality of stroke by demography, residence, and subtypes in five geographical areas in India that are comparable and can be monitored over the years.

The evidence on stroke burden and mortality will be useful to develop and monitor interventions in the five populations. It will guide the hospitals treating stroke patients to strengthen the diagnostic, curative and follow-up services for stroke management, reduction of disability, rehabilitation, and prevention of recurrent stroke. Initiatives of the National Programme for prevention and control of non-communicable diseases (NP-NCD) like the population-based risk factor screening and management of hypertension and diabetes through a comprehensive primary health care system and monitored through IT platform called National NCD portal shall address risk factor management and control. The health and wellness centres, and Prime Minister's health insurance scheme under the Ayushman Bharat scheme have the potential to address the availability of health services for all NCDs. Recent studies have demonstrated the feasibility of training frontline health workers in rural areas for detection and reporting of stroke,[10] and in secondary prevention of risk factors of stroke.[35]

Conclusion: The study has provided clear lessons to strengthen primary prevention of risk factors and

	Cuttack				Cachar				Tirunelveli				Kota				Varanasi			
	Sources		Registered cases		Sources		Registered cases		Sources		Registered cases		Sources		Registered cases		Sources		Registered cases	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Public Hospitals	6	9.4	2097	65.0	13	65.0	1885	75.6	28	20.7	1511	40.5	2	8.3	882	37.6	2	4.3	749	37.0
Private Hospitals	39	60.9	987	30.6	5	25.0	590	23.7	79	58.5	1761	47.2	8	33.3	1099	46.8	33	70.2	946	46.7
Imaging Centre	8	12.5	66	2.0	2	10.0	18	0.7	10	7.4	263	7.1	13	54.2	345	14.7	10	21.3	261	12.9
Others (Civil Registration System, Rehabilitation and physiotherapy centres, Alternate healing centres)	11	17.2	76	2.4	0	0.0	0	0.0	18	13.3	195	5.2	1	4.2	21	0.9	2	4.3	68	3.4
	64	100.0	3226	100.0	20	100.0	2493	100.0	135	100.0	3730	100.0	24	100.0	2347	100.0	47	100.0	2024	100.0

Table 7: **Sources of registration in all PBSRs and number of registered cases (proportions) (%).**

strengthen stroke care services in these five populations. Registries provide a comprehensive framework of stroke surveillance to assess the burden and risk factors, monitor availability and accessibility of stroke care services, measure outcomes by age, sex, residence, and subtype in different parts of India. The rural vs urban risk of stroke shall guide health policy and programme to strengthen efforts for stroke prevention and control in India. Strengthening the National Stroke registry programme shall be a useful investment to inform and monitor stroke prevention and care.

Contributors

SR, DH, VK and PM contributed to the concept and design of the paper. SR & PM developed the data analysis plan and SR, DH, VK, VU, RRK, NS were involved in data acquisition, management, and statistical analysis. SR & DH conducted the literature search and prepared the manuscript. SR, DH, VK, VU, RRK, NS and PM were involved in manuscript review, editing and approved the final version of the manuscript. SR, DH, VK, VU, RRK, NS and PM were part of the central coordinating unit of the population-based stroke registry.

SS, PKM, MR, CRP, EB, KS were involved in data acquisition, manuscript review and editing.

AKM, SDN, SKS, MB, were involved in data acquisition, manuscript review and editing.

BKN, AS, AKK, BD were involved in data acquisition, manuscript review and editing.

VS, DM, BB, DEM were involved in data acquisition, manuscript review and editing.

RNC and LPM were involved in data acquisition, manuscript review and editing.

All authors have read and approved the final manuscript.

Data sharing statement

Aggregate data and summary tables of the individual registries is available for access at the following url: https://ncdirindia.org/All_Reports/pbsrbook/default.aspx. The corresponding author to be contacted for any further requirements.

Declaration of interests

The authors have no conflicts of interest to declare.

Acknowledgements

The authors acknowledge the contribution of all the sources of stroke cases of the five population-based stroke registries which contributed data and the registry staff.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lansea.2023.100308.

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