Cohort profile: The South London Stroke Register — a population-based register measuring the incidence and outcomes of stroke

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Purpose: The South London Stroke Register (SLSR) is a population-based cohort study, which was established in 1995 to study the causes, incidence, and outcomes of stroke. The SLSR aims to estimate incidence, and acute and long term needs in a multi-ethnic inner-city population, with follow-up durations for some participants exceeding 20 years. *Participants:* The SLSR aims to recruit residents of a defined area within Lambeth and Southwark who experience a first stroke. More than 7700 people have been registered since inception, and >2750 people continue to be followed up. At the 2011 census, the source population was 357,308. *Findings to date:* The SLSR was instrumental in highlighting the inequalities in risk and outcomes in the UK, and demonstrating the dramatic improvements in care quality and outcomes in recent decades. Data from the SLSR informed the UK National Audit Office in its 2005 report criticising the poor state of stroke care in England. For people living in the SLSR area the likelihood of being treated in a stroke unit increased from 19% in 1995−7 to 75% in 2007−9. The SLSR has investigated health inequalities in stroke incidence and outcome. SLSR analyses have demonstrated that lower socioeconomic status was associated with poorer outcome, and that Black people and younger people have not experienced the same improvements in stroke incidence as other groups. *Future plans:* As part of an NIHR Programme Grant for Applied Research, from April 2022 the SLSR has expanded to recruit ICD-11 defined stroke (including those with <24 h symptoms where there are neuroimaging findings), and have expanded the follow up interviews to collect more detailed information on quality of life, cognition, and care needs. Additional data items will be added over the Programme based on feedback from patients and other stakeholders.

Registration The SLSR is registered at ClinicalTrials.gov (NCT05298436)

- The SLSR is a population-based register, where trained fieldworkers use multiple notification sources to track down and recruit residents of the study area who experience a first stroke; this method allows more reliable estimates of incidence and outcomes.
- All stroke diagnoses are independently confirmed and subtypes classified by a senior stroke physician with reference to the medical records and imaging and other test results.
- The SLSR collects rich long-term outcome data on participants, with follow-ups conducted up to 15 years

and beyond in many cases. This detailed long-term follow-up is an important strength of the study as there are few large studies following up stroke patients beyond 1 year.

- As with other similar long-running studies, maintaining contact with participants is challenging. Multiple methods are used for tracing and to contact patients who moved out of the area, but up to 20% of participants remain uncontactable at each follow-up point.

Introduction

The South London Stroke Register (SLSR) is a cohort study, running continuously since 1995, which aims to recruit all patients with a first stroke in a defined geographical area of south London, within Lambeth and North Southwark boroughs.The SLSR aims to estimate acute and long term needs in a multi-ethnic inner-city population, with follow-up durations for some participants exceeding 20 years. The cohort is used by interdisciplinary groups to address relevant questions to the local population and stroke survivors, that in addition have national relevance. From inception to April 2022, the SLSR has utilised the WHO ICD-10 clinical definition of stroke: rapid onset focal neurological deficit lasting more than 24 h or leading to death, where no cause other than a vascular origin is evident.[1] From April 2022, the SLSR has expanded its scope to include the recent ICD 11 definition, which focuses on the findings from neuroimaging.[2]

Since January 2022, the SLSR has been funded by a UK NIHR Programme Grant for Applied Research. The programme has a broader aim of improving the lives of stroke survivors, through better utilization of data. The SLSR is core to this work, and the key objectives in the coming period are to:

Understand the incidence and outcomes of the of stroke, defined by the new ICD-11 criteria

Define the outcomes and needs of long-term stroke survivors

Support stroke survivors and stakeholders with detailed data and analyses

Describe the use of formal, informal, and social care services up to 15 years after stroke

Assess the influence of formal, informal, and social care use on stroke recovery and generate patient-level total costs up to 15 years after stroke

Cohort description

The SLSR is a population-based register, which aims to recruit all residents of a geographically defined area within Lambeth and Southwark boroughs who have experienced a first stroke (see map of study area, Fig. 1). At the time of the 2011 UK census, the source population contained 357,308; this estimate will update in 2022 on publication of data from the 2021 UK census. From this
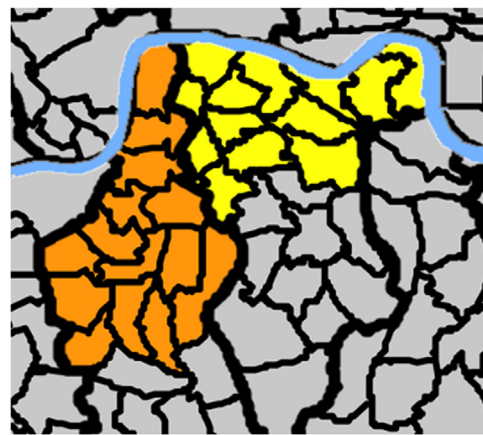

Fig. 1. *Map of the electoral wards comprising the study area in South London, covering parts of Lambeth (orange) and Southwark (yellow) boroughs.*

population, we aim to recruit all residents who experience a first stroke. As of June 2022, 7,784 of participants have been registered.

Participants are identified by 'hot pursuit', where a team of clinical fieldworkers regularly scrutinise records from overlapping sources of notification including hospital stroke units, radiology departments, and relevant outpatient clinics, including GP and A+E referrals to stroke/ TIA clinics. Additional notifications come from GP practices, community therapists, and death certificates. A capture-recapture study estimated that the SLSR identified 88% of cases of stroke.[3]

From 1995 to 2022, stroke diagnosis was defined using the criteria set out by the World Health Organization (WHO) in ICD-10,[4] and confirmed by a study clinician. ICD-10 defines stroke as a rapid onset focal neurological deficit lasting more than 24 h or leading to death, where no cause other than a vascular origin was evident. This definition includes strokes of ischaemic aetiology, intracerebral haemorrhage (ICH), and subarachnoid haemorrhage.

From April 2022 onwards, the SLSR uses the recently expanded ICD-11 definition of stroke; which removes the requirement for symptoms to last more than 24 h.[2] Instead, a diagnosis is predominantly made with confirmation by neuroimaging, no matter the duration of symptoms. This change reflects increased availability of Magnetic Resonance Imaging (MRI) scans (near universal in our population), and acute treatments such as thrombectomy and thrombolysis which may rapidly reverse symptoms. The full inclusion and exclusion criteria for the different stages of the study are shown in Table 1.

The introduction of the ICD-11 definition will lead to an increase in the numbers of people defined as having stroke; with the inclusion of patients with detectable, but milder cerebrovascular disease.

There have been some changes in follow-up time points to reflect the needs of projects and available funding at various points during the study. Until 2014,

Table 1. *Eligibility criteria for the South London Stroke Register.*

1995-2022 protocol	2022- protocol
Inclusion criteria	
Confirmed stroke (WHO ICD-10 clinical definition)	Confirmed stroke (WHO ICD-11 clinical definition)
Cerebral ischaemic stroke, primary intracerebral haemorrhage, subarachnoid haemorrhage and stroke not known if ischaemic or haemorrhagic.	Cerebral ischaemic stroke, primary intracerebral haemorrhage, subarachnoid haemorrhage and stroke not known if ischaemic or haemorrhagic.
	Formerly defined TIA with scan evidence of cerebrovascular disease are classified as ischaemic stroke under this definition.
Living in the study area at the time of the first stroke.	Living in the study area at the time of the first stroke
First stroke since 1st January 1995	First stroke since 1st April 2022
Exclusion criteria	
First ever stroke is before 1st January 1995 or after 1st April 2022	First ever stroke is before 1st April 2022
Patients' main residence at the time of first stroke is outside the study area.	Patients' main residence at the time of first stroke is outside the study area.
Focal neurological signs resolved within 24 h (pre ICD-11 TIA)	Focal neurological signs resolved within 24 h and no CT/MRI scan reports evidence of cerebrovascular disease (ICD-11 TIA)
CT/MRI scans positive for cerebrovascular disease but absence of related focal neurological deficits (asymptomatic cerebrovascular disease)	CT/MRI scans positive for cerebrovascular disease but absence of related focal neurological deficits (asymptomatic cerebrovascular disease)
Brain lesion other than stroke causes the acute symptoms such as cerebral tumour or metastases	Brain lesion other than stroke causes the acute symptoms such as cerebral tumour or metastases

ICD = International Classification of Diseases; TIA = Transient Ischaemic Attack, CT = Computer Tomography, MRI = Magnetic Resonance Imaging.

participants underwent an in-depth initial assessment and follow-up interviews at 3 months, 1 year, then annually on symptoms, treatment and functional outcomes. Since 2014 participants have been followed up at 3 months, 1 year, 5 years, 15 years then annually. From 2022 onwards, as part of an NIHR Programme Grant for Applied Research we will include an additional 10-year time point for previously enroled participants. Newly recruited participants will return to the annual follow-up schedule to characterise the health trajectories following ICD-11 stroke.

Numbers of follow up interviews completed varies across participants, depending mainly on time of enrolment, survival over time, changes to follow-up schedule over the study lifetime and other reasons for attrition like withdrawals and moving out of study area.

Follow up rate calculations are complex for this cohort, reflecting changes over the course of the study in follow up schedules, and geographical area (from November 2004 to December 2007 the recruitment area was temporarily expanded as part of a clinical trial). We present a flow diagram of follow up rates for the whole cohort (*n* = 7784) registered between Jan 1995 and May 2022 in Fig. 2. We calculate loss to follow-up rates independently at each time-point; therefore, for example, a participant lost at the 3 month follow up may be interviewed successfully at 1 year (and thus lost to follow up rates are not cumulative).

The average loss of follow-up rate is 11% with a range between 4.7% and 27% for individual interviews. Loss rates per timepoint were as follow: 3mo (27%); 1y (19%); 2y (20%); 3y (18%); 4y (17%); 5y (17%); 6y (16%); 7y (15%); 8y (13%); 9y (12%); 10y (9%); 11y (10%); 12y (10%); 13y (9%); 14y (8%); and 15y (7%).

Records of stroke recurrence, and death are less dependent on questionnaire follow up rates. Stroke recurrences are captured by the core study methodology described above; and participant deaths are notified by the Office for National Statistics/NHS Digital mortality data.

Data are collected at each follow-up point by trained study fieldworkers, by completing a standardised questionnaire. Data is collected primarily by patient interview. At time of initial stroke, interviews are conducted primarily face-to-face (typically in the hospital Hyper-Acute Stroke Unit), with data on care processes and test results collected from the Electronic Health Record (EHR). Follow-up interviews are either conducted face-to-face, by telephone, or in some cases by postal return of a completed questionnaire. Historically, the majority of follow-up interviews took place face-to-face. This switched to primarily telephone delivery during the United Kingdom Covid-19 lockdowns from 2020 to 22. This is likely to be the primary format for future interviews. All stroke diagnoses and aetiological subtypes are determined independently by an experienced study stroke physician with reference to the presenting history, brain imaging, and
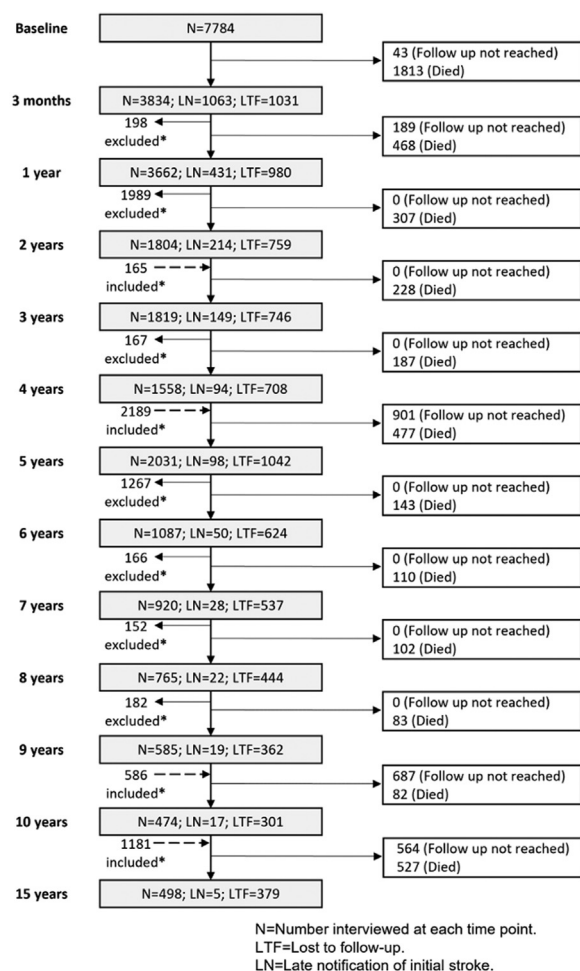
Fig. 2. *Follow up rates at each questionnaire timepoint. Loss to follow up rates are not cumulative, but indicate people 'lost' at each timepoint. *included/excluded refers to participants not included in the demoninator as not eligible to complete a follow up (for reasons including changes to survey frequency and eligible geographical area over the course of the study)*

other test results. The variables collected at each time point are described in Table 2. This data collection is being further expanded as part of the current programme through collaborative work with various stakeholders.

Recurrent strokes are identified using the same method and notification sources as first strokes. In addition, patients are asked about recurrent stroke at each follow-up. To assess survival times, date of death is confirmed either from hospital records or from NHS Digital.

Findings to date

Data from the SLSR was used by the UK National Audit Office in its 2005 report criticising the poor state of stroke care in England. This report prompted the UK National Strategy for Stroke, setting out how to improve the coordination and provision of care for people with stroke, which in turn caused stroke to become a national health priority, leading to improving treatment and services for stroke patients.[5] For people living in the SLSR area, the likelihood of being admitted to hospital for stroke increased from 82% in 1995−7, to 95% in 2007−9; the likelihood of being treated in a stroke unit increased from 19% to 75% in the same period.[6]

SLSR data underpinned the highly successful 2010 centralization of stroke services in London. This introduced a new system of directing patients in the first 72 h after stroke to eight high quality Hyper-Acute Stroke Units, rather than to one of 30 hospitals in the capital.[7] SLSR data was used to estimate of the number of people who can be expected to have a stroke and to model the most cost-effective way of delivering stroke treatment services, i.e. the number and allocation of Hyper-Acute and Acute Stroke Unit beds in London. These improvements to stroke services led to 96 fewer people dying from stroke

Table 2. . *Data collected.*

Time point	Measurement
Baseline 1995-Present	Socio-demographic characteristics
	Risk factors and medications prior to stroke
	Characteristics of stroke event
	Stroke severity measures
	Interventions and resource use during admission
	Newly diagnosed risk factors and medications on discharge
Follow-up assessments 3 months, 1 year and annually	Living conditions
	Therapies received
	Other resource use (including visits to doctors and help from social services)
	Newly diagnosed risk factors and current medications
	Level of disability (Barthel index)
	Activity level (Frenchay Activities index)
	Level of anxiety and depression (Hospital anxiety and depression scale)
	Cognition (2022 onwards: MoCA cognitive score; previously Abbreviated Mental Test (AMT), Mini-Mental State Exam (MMSE)
	Health related quality of life (SF12, 2022 onwards: EQ5D-5L)
Recurrent strokes	Same data as at initial event

every year in London, and have been emulated across the UK and internationally.[8]

Epidemiologically, the study has characterised the health of survivors over very long-term follow-up. Data from SLSR has shown that, as of 2016, 1 in 5 patients survive at least 15 years after first stroke and substantial proportions (30-60% of these patients experience disability, cognitive impairment or depression (see Fig. 3). More recently, data from the SLSR has found reducing incidence of ischaemic stroke,[9] and improving likelihood of long-term survival (see Fig. 3).[10] These changes in stroke presentation have coincided with reduction over time in the likelihood of lower limb motor deficit, dysphagia, and incontinence.[11] We have found that women are more likely to survive stroke than men; but that female survivors are likely to have a lower quality of life, mood, and daily functioning than men.[12]

Over its history, the SLSR has investigated health inequalities in stroke incidence and outcome. Key findings included that lower socioeconomic status was associated with worse outcomes from stroke,[13,14] and that Black people and younger people did not experience the same improvements in stroke incidence as other groups.[15] The SLSR has found that around one third of survivors experience functional disability, reduced social participation and depression/anxiety, and observed that longer term assessment and management of stroke have been neglected.[15−18]

Patient and public involvement

The SLSR hosts the King's College London Stroke Research Patient and Family group, which all participants are eligible to join. The group meets regularly, and have input at all stages of the project, including in setting study aims, and informing funding applications and ethical aspects of the research. As part of our current research programme, we are investigating novel methods for engaging patients with research. In addition to active patient participation in our stakeholder group, and patient membership of the Steering Committee overseeing the project, we are inviting patient membership of 'Policy

Fig. 3. *Improvements in the likelihood of survival from stroke between 2000 and 2015 [reproduced from Wafa et al, Ref.[10]]*

Labs' (a novel method for bringing a variety of stakeholders together to translate the findings of research into policy and practice), and investigating the use of patient portals which allow patients to access their own research data.

Strengths and limitations

The SLSR is a population-based register, aiming to determine the incidence and outcomes of all strokes occurring in a geographic area. This contrasts with routinely collected data on stroke, which are likely lead to biased estimates of stroke incidence (missing e.g. those who were not admitted to hospital), severity (e.g. potentially missing people with very severe stroke who died before arriving in hospital), and care (e.g. being less likely to identify people cared for on hospital wards other than stroke units).

The SLSR uses multiple sources of notification aiming to reduce bias in estimates of incidence and outcome. Researchers make daily visits to local hospitals, where ward records of stroke units and neurosurgical units, electronic patient records, brain imaging requests, TIA outpatient clinics, and accident and emergency records are scrutinised. All stroke diagnoses are independently confirmed and subtypes classified by a senior stroke physician with reference to the medical records and imaging and other test results.

The SLSR collects rich long-term outcome data on participants, with follow-ups conducted up to 15 years and beyond in many cases. This detailed long-term follow-up is an important strength of the study as there are few large studies following up stroke patients beyond 1 year. This design has allowed great insight into the health of stroke survivors as they move beyond the recovery from the initial event to become a cohort of patients with complex impairments and (vascular) co-morbidities.

The study is enhanced by a rich programme of participant and public engagement and qualitative work as well as input from stakeholders in stroke care and health policy.[19,20] This ensures the study is aligned to the needs of patients and the health service.

A potential weakness of the SLSR is that it collects data on a specific geographical area only, albeit an area which is highly diverse in terms of age, socioeconomic status, and ethnicity. An aim of our current research programme is to use models to produce high quality national estimates of stroke incidence and outcomes, by leveraging the low bias and detailed outcome assessments from the SLSR, and the large-scale data collection from the Sentinel Stroke National Audit Programme (SSNAP).[21]

SLSR collects in depth data on stroke phenotype and health and function scales across a range of domains collectable by questionnaire. To date, it has not included blood sampling, clinical measurements or brain imaging data. Biological studies using blood sampling and
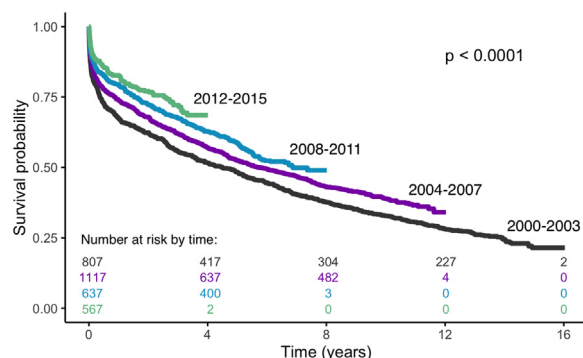
imaging studies based on routinely collected scans are areas for future funding applications and primary care records can be accessed for a subset of the sample via linkage to Lambeth Datanet.[22]

As with other similar long-running studies, maintaining contact with participants is challenging, and a further weakness is loss to follow up. Multiple methods are used for tracing and to contact patients who moved out of the area. We mitigate for potential follow up bias for death by receiving notifications from NHS Digital; and we capture stroke recurrence information via our core surveillance methodology.

Collaboration, and data sharing

The SLSR team collaborates with a number of established stroke registries and welcomes further collaboration from investigators interested in the broad areas of stroke incidence, care and outcomes and the health of vascular patients. Requests for data access for academic use should be made to the South London Stroke Register (SLSR) team, where data will be made available subject to academic review and acceptance of a data-sharing agreement. Data may be shared as limited sets of requested variables. The majority of data collected may be shared, but there are restrictions on sharing exact dates and 'fine grained' categorizations of patient characteristics, eg exact age, ethnicity, for reasons of identifiability. These may be shared as broader categorizations. Information can be requested by contacting IJM and MO'C by email (iain.marshall@kcl.ac.uk, and matthew. o'connell@kcl.ac.ukmailto:).

Ethics approval

The SLSR has ethical approval from the NHS Health Research Authority (Wales REC 1 Research Ethics Committee, reference number: 22/WA/0027), and previously from the ethics committees of Guy's and St Thomas' Hospital Trust, King's College Hospital, Queens Square, and Westminster Hospital (London). Consent is obtained from all living patients before participating in the register, except where patients lack capacity to decide, in which case advice from a consultee is sought in line with the Mental Capacity Act.

Funding statement

Contributorship statement

IJM, MO'C, and CW conceived and wrote the first draft of the paper. IJM, MO'C, AB, AD, YW, and CW designed the new protocol and obtained funding. EE led data acquisition. HW conducted the analysis of loss to follow with the supervision of YW. IJM, HW, and YW created the figures. YW and AD are the statistical leads. All authors reviewed and contributed to several drafts, and all authors approved the final version.

Declaration of Competing Interest

The authors declare they have no competing interests.

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