Non-CTIMP Study Protocol

**Rates, Risks and Routes to Reduce Vascular Dementia (R4VaD)**

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LIST OF ABBREVIATIONS

|  |  |
| --- | --- |
| 4AT | 4 A’s test |
| ACCORD | Academic and Clinical Central Office for Research & Development |
| AD | Alzheimer’s disease |
| ADAS\_Cog | Alzheimer’s disease assessment scale cog |
| ADL | Activities of daily living |
| AE | Adverse Event |
| APPLE | Assessing post-stroke psychology a longitudinal evaluation |
| AVM | Arteriovenous malformation |
| BFI | Brief fatigue inventory |
| BI | Bathel index |
| BMET | Brief memory and executive test |
| BP | Blood Pressure |
| CI | Chief Investigator |
| CRF | Case Report Form |
| CROMIS-2 | Clinical relevance of microbleeds in stroke 2 |
| CT | Computed Tomography |
| DPUK | Dementia Platform UK |
| DTI | Diffusion tensor imaging |
| ECG | electrocardiogram |
| eCRF | Electronic Case Report Form |
| ESO | European Stroke Organisation |
| FLAIR | Fluid Attenuated Inversion Recovery |
| FOCUS | Fluoxetine or Control under Supervision |
| GAD | Generalised anxiety disorder |
| GCP | Good Clinical Practice |
| GWAS | Genome Wide Association Studies |
| ICA | Internal Carotid Artery |
| ICF | Informed Consent Form |
| ICH | Intracerebral haemorrhage |
| IL-β | Interleukin 1 beta |
| IPD | Individual patient data |
| IQCODE | Informant questionnaire on cognitive decline in the elderly |
| ISF | Investigator Site File |
| JPND | Joint programme neurodegenerative disease research |
| LACI-2 | Lacunar intervention trial 2 |
| MCI | Mild cognitive impairment |
| MI | Myocardial Infarction |
| MMSE | Mini mental state examination |
| MOCA | Montreal Cognitive Assessment |
| MRI | Magnetic Resonance Imaging |
| mRS | Modified Rankin Scale |
| MSS2 | Mild stroke study 2 |
| NHS | National health service |
| NIHSS | National Institute for Health Stroke Scale |
| NPI-Q | Neuropsychiatric inventory questionnaire |
| O2 | Oxygen |
| OA-Cog | Optimising analysis of trials of cognition |
| PHQ | Patient health questionnaire |
| PI | Principal Investigator |
| PIS | Participant Information Sheet |
| PROHIBIT-ICH | Prevention of hypertensive injury to the brain – intracerebral haemorrhage |
| PSCI | Post-stroke cognitive impairment |
| PVS | Perivascular Spaces |
| QoL | Quality of life |
| RCTs | Randomised clinical trials |
| REC | Research Ethics Committee |
| SAE | Serious Adverse Event |
| SCANS | St George’s cognition and neuroimaging in stroke |
| SIGNAL | A trial in patients with microbleeds and haemorrhage |
| SIS | Stroke impact scale |
| SPS3 | Secondary Prevention of Subcortical Strokes Trial |
| SSCAS | Scottish Stroke Care Audit System |
| SSNAP | Sentinel Stroke National Audit Programme |
| STRATEGIC | A study about cognitive decline in vascular disease |
| SVD | Small Vessel Disease |
| TARDIS | Triple antiplatelets for reducing dependency after ischaemic stroke |
| TIA | Transient Ischaemic Attack |
| TICS | Telephone Interview for Cognitive Status |
| TNF-α | Tumor necrosis factor alpha |
| UK | United Kingdom |
| VAD | Vascular dementia |
| VCI | Vascular Cognitive Impairment |
| VCI-ICH | Vascular Cognitive Impairment-International Conference on Harmonisation |
| VISTA-COG | Virtual international stroke trials archive-cognition |
| WMH | White Matter Hyperintensities |

SUMMARY

Stroke commonly affects cognition and, by definition, vascular dementia is driven by stroke disease in some way. However, fundamental knowledge about risk factors is widely acknowledged to be missing, restricting mechanistic understanding, prevention, treatment, and design of patient services.

We aim to recruit a wide range of patients with stroke, presenting to geographically diverse UK hospitals, into a longitudinal study to determine rates of, and risk factors for, cognitive and related impairments after stroke, to assess mechanisms and improve prediction models.

We will recruit about 2000 patients within six weeks of stroke, collect patient, stroke, socioeconomic, lifestyle, cognitive (plus fatigue, mood) and informant data using streamlined methods appropriate to the stroke stage. We will obtain more detailed assessments at 6+/-2weeks post baseline assessment and follow-up by phone and post yearly to at least 2 years. We will assess diagnostic neuroimaging in all, and high-sensitivity inflammatory blood markers and genetic analysis in the majority; separate protocols will address neuroimaging and vascular function mechanism substudies.

Outputs will include reliable data on cognition long-term after stroke, stratified by prior cognition, stroke and patient-related variables, improved risk prediction and understanding the influence of neuroimaging, vascular, inflammatory and genetic markers. Participants will be in follow-up and consented for re-contact, facilitating future clinical trials.

**Lay Summary**

Background: People affected by stroke report that memory and thinking problems are amongst their greatest concerns. Stroke and vascular dementia are closely related but traditionally have been studied as separate processes and this has delayed advances in knowledge and treatment. A more ‘joined up’ study would help. Stroke patients are good at joining studies, and some blood vessel related treatments might help protect thinking and memory in future.

Aims: Our collaboration of experts in stroke and vascular dementia have worked with people affected by both diseases to create a program of work that answers fundamental questions: who will develop memory and thinking problems after stroke, why does this happen, how can we treat it?

Methods: We will invite many patients (about 2000) who attend hospital with a stroke of any type, or ministroke, to join the study. We will collect information about the person, their health, the stroke, assess their thinking and memory, and talk to their relatives. We will use short or longer assessments at different stages after the stroke to avoid tiring the patient. We will find out about recovery, changing symptoms and thinking skills at about 6+/- 2weeks after baseline assessment and by post/telephone annually to 2 years and beyond. We will assess routinely collected brain scans and other routine tests, and in where possible, do more blood tests or genetic analysis to work out what affects memory and thinking.

Outcomes: We will provide much better information on how many patients’ thinking and memory are affected, how to identify them, their outlook for recovery. This will help to understand vessel mechanisms better, advise patients, and plan health services. Patients in the study will be offered opportunities to join clinical trials as new treatments become ready for testing, to help avoid dementia in future.

# INTRODUCTION

## BACKGROUND

Stroke and dementia share many risk factors (1,2) and each is a risk factor for the other (3,4). Patients with stroke or TIA are at increased risk of post-stroke cognitive impairment (PSCI) and vascular dementia (VaD)(3), but risk-prediction for the individual is difficult. Improved understanding of clinical, demographic, laboratory, neuroimaging and social predictors would improve risk stratification, identification of mechanisms and intervention targets(5). VaD, including vascular cognitive impairment (VCI) that falls short of dementia, can arise from apparently ‘silent’ vascular brain damage on scanning (multiple infarcts, small vessel disease (SVD), amyloid angiopathy, haemodynamic ischaemia), rare genetic variants, as well as after ischaemic or haemorrhagic stroke (PSCI)(6). Patients with VCI or VaD can present to GPs, stroke, memory, or mobility services, as acute emergencies with an unrelated comorbidity, or go unrecognised until late stage in the community.

We focus on cognition in patients with stroke for several reasons. Patients with stroke are at high risk of cognitive decline(3) presenting an ‘enriched’ sample with substantial progression to cognitive outcomes, similar to mild cognitive impairment (MCI) and Alzheimer’s disease (AD). PSCI is a common, under- researched problem for patients, carers and health services (7). It reaches medical attention at a time-point defined by the stroke, capturing cognitive decline that was unmasked by the stroke, or that followed the stroke. The distinction between PSCI and VaD without stroke seems increasingly arbitrary(8) many strokes are ‘silent’ so that patients may not notice or may ignore(9) subtle vascular neurological or cognitive symptoms(10,11); vascular lesion patterns on imaging often overlap;(6) and the triad of stroke, cognitive impairment and gait problems are often present.

The strength of a PSCI cohort study is our established access to stroke patients providing prompt and substantial recruitment of very well phenotyped patients (including both cortical and subcortical VaD/VCI), in follow-up and consented for re-contact for future trials. This is particularly important given the recent difficulties recruiting patients with VCI into trials (http://www.isrctn.com/ISRCTN31208535). Our proposal combines the UK’s considerable stroke research strengths, which have helped transform stroke care into co-ordinated prevention, treatment and recovery in the last 25 years, with the dementia research expertise of the Dementia Platform UK (DPUK)(12).

Fundamental gaps in knowledge on stroke, cognition and dementia have been highlighted by recent expert groups(5,12). Dementia varies from 7% (population studies, 1st stroke, no pre-stroke dementia) to 41% (hospital studies with recurrent stroke and pre-stroke dementia) at one year(3,13), but with confidence intervals spanning 2-3 fold differences in dementia that are largely unexplained. Prevalence of MCI (29-68%) and dementia (8-22%) after transient ischaemic attack (TIA) are similarly variable and based on few patients(14). The aetiology, risk factors and prognosis of PSCI(5) are poorly understood. They lack information on stroke subtype, e.g. lacunar stroke(13) or intracerebral haemorrhage (ICH)(15), progression of VCI to dementia(5), or PSCI rates beyond the first year after stroke (3,13). Few studies consider pre-morbid intelligence(16) or failing cognition pre-stroke(13), yet lower IQ in youth(16) and failing cognition(4,17) increase stroke risk. There are few data on the complex interplay between individual risk factors and PSCI or dementia, how risk factors affect dementia pathophysiology, or brain health and resilience(12), making it difficult to advise individuals, plan randomised clinical trials (RCTs) or develop clinical services(18). Generalisability of data is restricted by selection bias(19,20), suboptimal testing(21) and attrition(6,22).

Cognitive testing is recommended in UK stroke guidelines (23), but many tests are impractical for stroke or insensitive to VCI.(6,5). Lack of proven clinical utility may explain why many GPs do not do cognitive screens routinely. Use of different cognitive tests inflates variance in VCI/dementia rates, hampers between-study comparisons(24) and efforts to understand mechanisms, e.g: meta-analyses were uncertain if systemic/carotid arterial stiffness affected cognitive decline(25) as individual studies lacked vascular risk factor adjustment; similarly, systematic reviews(3) and routine health data(2) disagree on the importance of common risk factors. Cognitive testing alone does not capture the psychological sequelae of stroke: fatigue, apathy, mood (26) affect cognition; in turn, 3-month cognition scores correlate highly with dependency, mood, and quality of life (QoL)(27).

## RATIONALE FOR STUDY

The proposed study is needed now, as other current work will not fill the gaps. The applicants are engaged in several relevant pooling initiatives of individual patient (IPD) or tabular data from RCTs or cohorts. These include:

*Optimising Analysis of Trials of Cognition* [OA-Cog, Bath; RCTs of vascular prevention, VaD, AD; 49 studies, n=115,312, but young mean age (67±9.5 yrs), 36% female, only MMSE/ADAS-Cog];

*Virtual International Stroke Trials Archive-Cognition* [VISTA-COG, Quinn; IPD of stroke RCTs and observational cohorts, >5,000 patients, with cognition/mood; but also young, male, memory focused];

*DPUK* [31 studies, median n=2700, range 80-1,300,000, of dementias, excludes stroke, VCI/VaD and lacks vascular risk factor data];

*JPND METACOHORTS* [Wardlaw(28) >90 studies, n=667,064, mean age 72 (15-106) yrs, on vascular disease, but gaps in prediction data];

*Sentinel Stroke National Audit Programme* [SSNAP, Rudd; logs cognitive testing activity not results(29); 31% of 79,720 eligible patients (2013-14) were not assessed];

*studies collecting PSCI data*: RCTs [TARDIS, Bath; PRESERVE, Markus; LACI-2, Wardlaw; PROHIBIT-ICH, Werring] and observational studies [APPLE, Quinn; OxVasc-Cognition; SCANS, Markus; MSS2, Wardlaw; CROMIS-2, SIGNAL, Werring; STRATEGIC, O’Sullivan], either focus on restricted stroke subtypes, have short follow-up, or research intense settings.

In summary, as noted at recent expert workshops(12), despite large amounts of data, prior studies, frustratingly, will not improve risk prediction modelling in the individual, inform service design, or clarify risk factor interactions on PSCI pathophysiology. They will not provide detailed patient-level stratification by risk of PSCI or mechanisms, tell us little about the optimal approach to, or clinical utility of, early cognitive screening, and thus are hampering advances in clinical practice.

# STUDY OBJECTIVES

## OBJECTIVES

### Primary Objective

Determine rates of cognitive impairment and dementia up to at least two years after stroke;

### Secondary Objectives

I. Identify key risk predictors and develop better risk prediction models for individual patients;

II. Perform studies to improve cognitive testing and mechanistic understanding of PSCI;

III. Establish a well phenotyped population, in follow-up, with consent for re-contact for future trials;

IV. Provide data to plan future RCTs and services for patients with PSCI.

## ENDPOINTS

### Primary Endpoint

Cognitive decline or dementia up to at least two years post stroke assessed with an ordinal scale that includes death.

### Secondary Endpoints

1. Death
2. Disability (mRS)
3. Function in activities of daily living (Barthel; SIS)
4. Recurrent stroke or other vascular disease
5. Other neuropsychological consequences of stroke: Mood, Frailty, Apathy, Fatigue
6. Quality of life assessment
7. Vascular measures: Blood pressure from serial readings, carotid stenosis, vascular stiffness, cardiac dysfunction
8. Imaging findings (lesion location, size, background pre-stroke changes)
9. Inflammation (blood markers)
10. Genetic markers

# STUDY DESIGN

We propose a large, multicentre, longitudinal, inclusive study in patients presenting with stroke to UK Stroke Centres, using standardised proportionate ascertainment methods to assess cognition to at least two years after stroke. The strength of a post stroke cohort is our access to these patients through the CRN-Stroke infrastructure allowing prompt and substantial recruitment. We aim to capture the ‘messy reality’ of PSCI, determine its rates and progression by clinically-relevant strata(5,8): pre-morbid and pre-stroke cognition, medical, lifestyle and socioeconomic factors (Figure 1). A broad stroke cohort will capture all potential VaD phenotypes (SVD, multi-infarct, strategic infarct, mixed pathologies)(6), adding considerably and uniquely to knowledge on VaD. We propose to collect cognitive information across a continuum of stroke severities because data are limited and it is inappropriate to assume that cognition is not relevant after either severe or very mild stroke which have previously been under studied. Prospects for recovery, even after severe stroke, are changing radically with thrombolysis, thrombectomy, improved discharge support and community rehabilitation, but their impact on cognition is largely unknown: therapists say that potentially limiting cognitive deficits may be more apparent in patients who make a good physical recovery from initially severe stroke (Roffe, personal commun); equally, deficits in mild stroke may be missed(30). We acknowledge the mortality and attrition associated with including the spectrum of stroke severities(31), so propose multimodal patient focussed follow-up to minimise losses and analysis methods to account for competing risk biases associated with early mortality. The proposed study will embed important substudies at scale: imaging, vascular function, inflammation, genetics, and store blood samples for discovery work in ‘omics. It will provide ‘trial ready’ patients, stratified, consented and in follow-up, aid trial design, create synergies and efficiencies between researchers from differing fields towards a common goal(12), and accelerate discovery of new interventions, like the ‘trial-ready’ cohorts and accessible data sources available for AD. The proposed study will inform service design (18) and assist those at risk of PSCI to plan their future(7).

Design: Prospective observational, longitudinal inception cohort with central follow-up and nested substudies in major UK stroke centres representing geographic and socioeconomic diversity. An electronic case record form (eCRF), as for RCTs (Bath), will streamline baseline and follow-up data collection and verification. Central follow-up by validated telephone and post methods will reduce local research burden, data loss and facilitate analyses. Data collected for SSNAP (Rudd, Tyrrell) will reduce duplication, patient and researcher burden, and determine the study’s representativeness of UK hospital-assessed stroke patients (29), We will use safe havens to link our data to other health datasets providing an anonymised, ethics- and governance-approved secure database.

Recruitment: Patients with stroke presenting to participating Stroke Centres will be recruited. NIHR CRN- Stroke (lead Robinson) and DeNDRoN (lead O’Brien) research practitioners will aid recruitment and data collection (Figure 1, Flow Diagram).

Participants: All patients with ischaemic or haemorrhagic stroke or TIA who are expected to survive to at least 12 weeks after stroke. Due to the varying and evolving concepts and definitions of VaD, rather than restrict the cohort, we will include all and collect necessary investigations, cognitive, functional data to allow varying diagnostic criteria and stratification to be explored.

**Figure 1 – flow chart of recruitment and study protocol**

**Follow up visit 6+/-2 weeks post baseline assessment in person (if possible)**

Cognitive testing (as suitable and tolerated by patient)

Assessment for delirium, mood, apathy, fatigue, frailty, QOL

Incident vascular events

Blood sampling (in a subset of patients)

**Annual follow up (to minimum 2 yrs) by phone/post**

Cognitive assessment

Modified Rankin scale

recurrent vascular events

mood, apathy, fatigue, QOL, IQCODE

**Baseline visit 24h-6 weeks post stroke**

Informed consent from patient and/or informant (where possible)

Collect routine demographic and clinical data, hospital test results

Brief cognitive screening including delirium, apathy, depression, frailty

Pre morbid function (IQCODE) and education level

BP measurements

**Patient attends stroke services.**

Screened for eligibility by clinical team and PIS issued to patient/proxy.

If patient agrees, proceeds to….

**Data linkage for outcomes** (up to 20 years after stroke)

# STUDY POPULATION

## NUMBER OF PARTICIPANTS

## At least 2000 from UK Stroke Centres.

## INCLUSION CRITERIA

To avoid the selection biases of previous studies, and recognising changes in recovery with new treatments, we propose inclusive recruitment:

* patients aged ≥18,
* no upper age
* no severity limit,
* ischaemic, or spontaneous haemorrhagic (non-traumatic, non-subarachnoid haemorrhage, non-AVM) stroke and transient ischaemic attack (TIA; where feasible),
* expected to survive at least to 12 weeks.

## EXCLUSION CRITERIA

Inclusion criteria are not met, in particular, at onset, the patient is not expected to survive more than 12 weeks.

Aneurysmal, traumatic or AVM-associated haemorrhage or subarachnoid haemorrhage.

Stroke mimics such as brain tumours.

Prior diagnosis of cognitive impairment or dementia is NOT an exclusion criterion.

## CO-ENROLMENT

R4VaD is intended to facilitate recruitment to other observational and interventional studies.

Thus, co-enrolment in other observational studies in stroke is encouraged. Where the data collected in R4VaD are consistent in type and time with the co-enrolled study, use of already collected data will be encouraged in R4VaD, and vice versa, to reduce the burden of data collection on patients.

Co-enrolment is also permissible in RCTs of interventions, including CTIMPs, as long as the other study and R4VaD would not confound each other’s results or make attribution of adverse reactions difficult in the CTIMP.

Local researchers should avoid overburdening patients.

# PARTICIPANT SELECTION AND ENROLMENT

## IDENTIFYING PARTICIPANTS

Participants will be recruited from the stroke clinical service in the participating centres. At the initial hospital visit, potentially eligible patients will be approached by the usual clinical team including CRN research practitioners who are members of the clinical team, and then given a PIS. If patient/informant is agreeable then they will have the baseline assessment (as inpatient or outpatient, whichever is easier for the patient). At the baseline visit, the member of the study team will inform the patient of all aspects pertaining to participation in the study and go through the PIS again with the patient. It will be explained to the potential participant that entry into the study is entirely voluntary and that their treatment and care will not be affected by their decision. It will also be explained that they can withdraw at any time. In the event of their withdrawal, it will be explained that their data collected so far should not be erased and we will seek consent to use the data in the final analyses where appropriate. The discussion of the study and preferred method of contact will be recorded in the patients’ notes. Patients will be given/have had as much time as they require (but at least 24 hours) to consider the study information before deciding whether to join the study or not.

**5.2 CONSENTING PARTICIPANTS**

Consent: will be modular and sensitive to different stages after stroke. It will include collection of:

* baseline core clinical and imaging data,
* information from carers/informants,
* follow-up to at least two years,
* taking/storing/analysing blood,
* permission for data linkage to primary care, SSNAP and other central hospital and deaths registry datasets for longer term outcomes (e.g. death, admission to care-home) for up to 20 years after the index stroke.

Participants (and informants where available)) will give informed written consent upon entry to the trial (baseline assessment), prior to any trial related procedures taking place. The decision to participate in clinical research is voluntary and should only be based on a clear understanding of what is involved. The lack of availability of an informant will not preclude participation in the study.

Consent will be sought for permission to approach the patient about possible participation in other relevant studies.

Consent will be sought for sharing of data with collaborators to analyse the study data and for future data linkage.

Consent will also be sought for further analyses of data in future studies and sharing of anonymised data, including stored blood derived samples or imaging data, for analyses in other relevant secondary analyses.

Consent will be sought for linkage of study data to individual participant’s SSNAP data, Scottish Stroke Audit data, NHS Digital central hospital records including the Information Statistics Division in Scotland, GP data, and General Registry Office deaths data.

Consent will be obtained by Good Clinical Practice (GCP) trained staff who are members of the clinical research team after full discussion of the study procedures and requirements with the patient. The Investigator is responsible for ensuring that the ICF is completed, signed and dated by all parties prior to any protocol specific procedures being carried out. Participants must receive adequate oral and written information – appropriate PIS and ICF will be provided. The oral explanation to the participant should be performed by the Investigator or designated person, and must cover all elements specified in the PIS/ICF. The participant must be given every opportunity to clarify any points that they do not understand and, if necessary, ask for more information. It should be emphasised that the participant may withdraw their consent to participate at any time without loss of benefits to which he/she would be entitled.

The participant should be informed and agree to their medical records being inspected by regulatory authorities and representatives of the sponsor. The date that the patient is given the PIS should be documented in the patient’s medical records.

The Investigator or delegated member of the study team and the participant should sign and date the ICF(s) to confirm that consent has been obtained. The participant should receive a copy of this document, and the original filed in the investigator site file (ISF). The patient should retain their copy of the PIS, and a copy of the completed ICF.

Consent, assent or opinion will be obtained from the appropriate person for each jurisdiction (Scotland, Northern Ireland, England, Wales) where a potential participant is unable to consent for themselves at the start of the study. Assessing tests that a patient is unable to complete is valuable, so we will record non-testability and inability to consent. It will also allow us to track patients’ recovery when initially unable to provide consent within the first few weeks post-stroke. This person may also act as the informant.

If the capacity of the participant previously unable to consent improves sufficiently during the course of the study, they will receive information about the study via a participant information sheet and be approached to give consent. Should a participant indicate in any way that they do not wish to be involved in the study, they will be withdrawn from the study.

We will continue to collect data from patients who lose capacity during the course of the study, and will seek consent for this. Should this happen, we will consult the appropriate consultee, relative, friend, welfare attorney, as defined by local guidelines, to inform them of their continuation in the study.

## SCREENING FOR ELIGIBILITY

The treating physician and study team combined will screen for eligibility before taking informed consent.

## INELIGIBLE AND NON-RECRUITED PARTICIPANTS

Participants who have been approached for the study and subsequently found to be ineligible will be informed of the reasons why and receive routine medical care.

Screening logs will not be used as part of the data collection for this study. Case mix and assessment of representativeness of the recruited population will be assessed using data from the Sentinel Stroke National Audit Programme (SSNAP) which publishes anonymised site-specific data on all stroke admissions in England and Wales quarterly, and using data from the Scottish Stroke Central Audit System (SSCAS) which provides similar data on all stroke admissions in Scotland.

### Withdrawal of Study Participants

Participants may withdraw consent at any point. We will retain the data collected up to the point of withdrawal for analysis. If the participant is willing, we will record the reason for withdrawal in the case record form.

# STUDY ASSESSMENTS

## STUDY ASSESSMENTS

Our approach to assessment recognises that different stages after stroke need specific approaches(5). We will assess:

1. pre-morbid cognitive ability,
2. pre-stroke cognitive decline and
3. post stroke cognitive status at specific points after stroke to map cognitive trajectories (Figure 1, flow chart).

Our choice of tests uses the following principles: a) avoid overburdening participants and carers, b) avoid duplication, c) each test is essential, d) consistent across stages, e) valid, with wide stroke usage (32,33,24) for external comparison (e.g. we already have data on TICS (cognition) & Zung (mood) for >7500 pts (27,34), and f) minimise known biases(22,20).

Our choice of tests is also guided by Cochrane Dementia and NIHR Complex Reviews Support Group, focus groups with study nurses and many service users. The latter commented particularly on timing and duration of cognitive assessments, care of patients with cognitive difficulties, importance of including all stroke severities, carer involvement and careful wording of study information to convey the work’s importance but not exacerbate worry in those recently overwhelmed by acute stroke.

Our test paradigm, based on stakeholder feedback, majors on efficiency (minimising test time & duplication)(5), validity (systematic reviews of test properties(24,35); relevance to VCI (32) and feasibility (postal or telephone versions available (36), Table 1. Neuropsychological batteries may become overly burdensome(37), so we propose a stepped approach with core brief assessments for all participants, supplemented by more detailed tests as feasible(5). Where previous studies focussed on cognition, the neuropsychological effects of vascular disease include delirium, fatigue, apathy and mood disorder (26) which we will assess. Recognising substantial attrition in previous studies,(22) our follow-up will be flexible and include face-to-face (although this is ideal, it is unfeasible in all, or in a study of this size), telephone or postal follow-up. Combining phone and postal questionnaires allows a greater range of cognitive assessment than either alone (e.g. postal allows visuospatial tests) and improves rates of completion.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Activity / assessment** | **Baseline assessment** | **Study visit 1** | **Annual follow up** | **End of study** |
| Eligibility Criteria | X |  |  |  |
| Informed Consent | X |  |  |  |
| Demographics | X |  |  |  |
| Medical/Surgical History | X |  |  |  |
| Vital Signs | X |  |  |  |
| Premorbid function | X |  |  |  |
| Collect routine tests\* | X |  |  |  |
| Vascular events |  | X | X |  |
| Function | X | X | X |  |
| Cognitive/mood testing | X | X | X |  |
| Blood sampling |  | X |  |  |
| Genetic sampling | XA |  |  |  |
| Data linkage |  |  |  | X |
|  |  |  |  |  |
| End of study |  |  |  | X |

\*blood results, carotid or cardiac imaging results, routine diagnostic brain imaging results

A Genetic sampling may also be performed at study visit 1

Assessing tests that a patient is unable to complete is valuable, so we will record non-testability, employing “intention to diagnose” approaches to deal with partial or total test non-completion (20). Finally, informants know the patient well, can recognise change (35), and are invaluable if communication problems preclude even brief direct-to-patient assessments, so we have identified relevant validated informant versions. Engagement with relatives and partners will be sought to increase retention and data completeness, plus we will collect data on care-giver strain.

Baseline assessment will occur as soon as possible, but we allow between 24h to 6 weeks after stroke to enable patients to be included who were very ill in the first week but start to recover. We will record demographic, clinical, family history, education (for premorbid IQ16), socioeconomic, lifestyle, pre-stroke functioning (mRS) (including non-testability in patients without capacity (38) and lab data (including BP, carotid Doppler, ECG; echocardiography where performed). Initial, direct-to- patient cognitive assessment (Table 1) will use brief cognitive screening tools(32,33), including for delirium(39), fatigue(40), mood(41), apathy (42) and frailty(43), prioritised and done as feasible, noting incomplete items (details Appendix 1)(20). Informants will be asked about pre-stroke cognition (IQCODE, (35)). BP will be assessed using standard protocols (44). Routine brain imaging (CT in many, MRI in some; see below) will be collected to classify the index stroke and pre-stroke findings with standard tools(45,46). Bloods will be taken for analysis of genetics.

Early follow-up will be at 6+/-2weeks post baseline assessment (i.e. 4-14 weeks after stroke depending on the timing of the baseline assessment) when participants are more likely to be able to complete multidomain cognitive tests(32), or shorter tests(30). We will also assess fatigue (BFI (40)), mood(33), apathy (21) and health-related quality of life (Table 1). BP will be assessed in all using standard protocols and validated, calibrated monitors to obtain three measures with at least one minute between them. Bloods will be taken for analysis of inflammatory markers (and genetics where not taken at the baseline assessment) and stored for future analysis. The assessment will coincide with local clinic review, those remaining in hospital being assessed in hospital. We will also record if the patient has died or their place of residence.

Contact by post or phone will also be offered.

Annual follow-up (to 2 years, minimum, maximum 4 years) will be by post and phone using validated functional (mRS)(38), recurrent vascular events, cognition(36), mood, apathy, fatigue and quality of life assessments as above, from both participant and informant (IQCODE), death or place of residence. We considered online/email follow-up but only 53% of 1-adult and 85% of 2-adult households aged>65 have internet (Office of National Statistics 2016). Most patients in FOCUS (fluoxetine for recovery after stroke) are not online and strongly preferred paper/post or phone (Dennis, personal commun); of Biobank’s healthy subjects (C Sudlow, personal commun) only 40% use online follow-up and most preferred paper/post. Therefore online methods are for future consideration.

Consensus cognition diagnosis. Data from a subsample of those reaching 1 & 2 year follow-up will be assessed by an expert, multidisciplinary panel to assign a definitive cognition diagnosis (Quinn, O’Brien, Doubal).

Data linkage: We will use data linkage to ascertain recurrent stroke, dementia, death, place of residence and vital status and limit losses. We will use GP records (McManus) and registry data to ascertain long term outcomes (recurrent stroke, dementia, myocardial infarct, death, place of residence) to supplement follow-up information to two years and thereafter.

Workpackages benefit from the well-phenotyped inclusive sample stratified by patient, stroke, vascular risk and neuroimaging variables. Where a subset is required, a sample representative of known key predictive variables will be invited based, where possible, on random selection. The following are core to the study.

a) ***Cognition assessment validation***: Purpose: The study provides a major opportunity to validate the proposed staged approach to cognition and related assessments, both for research and clinical use.

Method: The achievement of recruitment targets and completeness of baseline and follow-up data, including of informant data, will give practical evidence of the acceptability, feasibility and practicality of the assessments. Active feedback from participants will identify areas for improvement. We will compare phone/post data with clinical diagnosis of dementia and, in a random sample, compare remote with in-person assessments and central adjudication of dementia diagnoses.

b) ***Neuroimaging***: Purpose: To stratify patients by acute and pre-stroke features(45,46) determine sensitivity/specificity of acute and pre-stroke lesion patterns for VaD subtypes,(6) test independent effects of pre-stroke ‘brain frailty’ markers (45) on VCI/dementia risk and test the predictive value of imaging markers for cognitive decline (47) and dementia.

Method: All diagnostic scans (MR and CT) from all patients will be collected centrally and analysed by validated methods (acute lesion(45), SVD features(46) including brain and lesion volumes). MRI standard sequences (T1, T2, T2\*, FLAIR, DTI)(46) are used in many UK centres particularly in milder strokes; in severe stroke, CT is more feasible and the acute lesion is usually visible(45). MRI would not be feasible in all. Both CT and MR were used concurrently, with standard assessments, in large stroke trials(45,34).

c) ***Vascular***: Purpose: to determine if carotid stenosis and pulsatility (stiffness) predict current and future cognition since existing data, mostly from non-stroke studies, disagree(25); to assess if blood pressure at admission predicts cognitive decline(44); and to assess the role of routinely measured cardiac dysfunction on predicting PSCI(3).

Method: Internal carotid artery (ICA) stenosis will be obtained from routine carotid imaging and carotid artery velocities from carotid Doppler ultrasound (routine in many patients) to estimate carotid stiffness (pulsatility index for input; resistivity index for downstream resistance(25)). Systolic, mean, diastolic BP will be recorded on admission to calculate pulse pressure and BP variability (48)). Cardiac function (rhythm, echo parameters) collected routinely will be analysed against cognitive outcomes.

d) ***Inflammation***: Purpose: Identification of blood-derived risk predictors for future cognitive decline is a fast-moving field, therefore blood-derived samples will be stored for current analysis and future discovery analyses. In R4VaD, we will assess the role of inflammation in PSCI. Inflammatory cytokines (e.g. IL-1β and TNF-α) are involved in learning, memory and cognitive decline (50) including PSCI(51). Increased serum TNF-α is associated with rapid cognitive decline in AD and sustained inflammatory response post-stroke may lead to vascular dementia(52). We will assess these markers vs. pre- and post-stroke cognitive status and trajectories.

Methods: Blood will be taken in as many patients as possible at 6+/-2 weeks after baseline assessment, for high sensitivity IL-1β and TNF-α analysis using single molecule counting technology (Singulex) to detect extremely low cytokine levels (details Appendix 2). Samples will be transferred to Manchester University for analysis.

Blood will be also stored for discovery ‘omics, the use of such valuable samples being funded separately.

e) ***Genetics***: Purpose: To determine genetic factors in PSCI. Genetic susceptibility is recognised as important in AD and stroke but under-studied in VaD: in worldwide collaborations, we identified ~20 new gene variants for stroke using Genome Wide Association Studies (GWAS)(53). Genetic factors are likely to be important in VaD and may also identify novel pathways.

Method: blood will be taken for DNA (from all possible participants) for GWAS, with standard QC, imputation and statistical analysis methods to compare genetic profiles with and without PSCI (sample collection details Appendix 3). To estimate heritability of genetic risk for PSCI, we will use statistical techniques such as Genome-wide Complex Trait Analysis to identify the proportion of phenotypic variance explained by genome-wide Single Nucleotide Polymorphisms (SNPs) from zero (none) to one (complete). Studies with this technique gave estimates of heritability in ischaemic stroke of between 20-40%, similar to AD. A sample size of 1000 will have sufficient power to obtain useful information. We will also use GWAS to identify SNPs significantly associated with dementia at the genome wide significance level of 5 x 10-8. By combining with the International Stroke Genetics and other Consortia, we will have ~5,000 patients, the 1,000 patients from this proposal making a crucial contribution to the global cohort.

# DATA COLLECTION

Please see section 6.1 above for measurements and timepoints.

The medical history, vital signs, NIHSS, mRS, physical examination and cognitive and other assessments, will be obtained from the patient in person and one or more informants and from medical notes to minimise burden on patient, by the study team and supporting research team. These researchers will also obtain blood samples. Samples will only be identified by their study ID number.

All baseline medical, cognitive and laboratory data will be entered into a secure password protected electronic case record form (eCRF) hosted at the University of Nottingham by the recruiting researcher, which will also record the collection of study samples. The eCRF will include range and other validity checks, track missing/incomplete data and flag follow-up timepoints to aid the flow of data collection, study recruitment tracking and study management. All data derived from analysis of primary study data will also be retained in data files as created from these analyses linked to the main study database, with each subject identified only by their study ID, and matched with the eCRF data for statistical analysis.

The electronic study record will replace the usual role of the paper CRF as the source documents for efficiency and to streamline monitoring. Each electronic form will be signed electronically by the researcher with any changes or updates also signed by the individual making these changes.

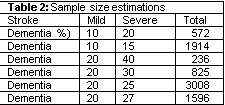
Paper versions of the CRF will be available to assist with data collection when interviewing patients at baseline and during follow-up visits. Paper CRFs will be filed in the patient’s paper-based folder and held in a secure locked filing cabinet at site.

Patients who fail to attend for planned follow-ups will be telephoned to see if they require assistance, e.g. with transport or if there is some other reason. All paper forms will be filed in the patient’s paper-based folder in a secure locked facility after data have been entered onto the eCRF.

# STATISTICS AND DATA ANALYSIS

## SAMPLE SIZE CALCULATION

Sample size: We used meta-analyses and trial data to determine sample size and provide scenarios to address uncertainty (Table 2).



A key purpose of this work is to provide robust data on incidence and natural history of PSCI. SSNAP provides data on numbers of patients admitted to hospital in England & Wales:~7000 stroke patients are admitted to the applicants’ hospitals/yr with ~5700 alive at discharge(29); about ~1000 (minor stroke) are seen as outpatients; numbers of TIAs are not available for all sites. Thus, recruitment of 1000+ patients (20%; 125/centre) is feasible in 1yr, ~2000 in 2yrs (250/centre), i.e. 1600-1700 ischaemic and ~400 ICH strokes, with streamlined, light touch approaches. This sample would, e.g. almost double ICH data(15), but represents ~20% of patients admitted per applicant centre, a conservative recruitment estimate for an observational study with very broad entry criteria. We also have considerable interest in the study from CRN-Stroke (Robinson), so expect to include up to 15 other NIHR LCRNs able to recruit ~1000 patients/yr, thus potentially recruiting more than 2000, or completing recruitment of 2000 participants faster.

Statistical Power: At power 0.90, alpha=0.05, we could detect the following differences in dementia in mild vs. severe stroke respectively (Table 2): 20 vs. 27%, n=1596; 10 vs. 15%, n=1914; 10 vs. 20%, n=572. Thus 2000 patients, with a wide range of stroke severities, will allow us to detect small (5% absolute), clinically meaningful differences in dementia between mild vs. severe stroke, although the difference in dementia between mild and severe is likely to be larger (10+% difference)(27). A sample of ~2000 will be able to detect differences in degrees of VCI and dementia and by subgroups such as age, pre-morbid cognitive ability, stroke subtype, or vascular risk factors, in multivariable models.

## PROPOSED ANALYSES

We will assess prevalence of VCI and dementia and incidence by time after stroke using an ordinal outcome scale which assesses presence and severity of cognitive impairment (and dementia) and will include death. We will operationalise this scale using data obtained as above to classify outcome by pre- specified strata (age, sex, educational attainment, SES, vascular risk factors and disease burden, neuroimaging findings, and stroke severity) accounting for major acute treatments. We will tabulate cognitive scores by strata and use repeated measures to predict PSCI by baseline variables, adjusted for patient-, stroke- and life-course-related risk factors. We will use competing risks analyses to model losses due to severe stroke or death and global (rather than dichotomous) cognitive analysis to increase power. We will compare our sample to SSNAP, England/Wales, to determine the representativeness of the study patients in a) the participating hospitals and b) the UK(29).

# ADVERSE EVENTS

AEs and SAEs will not be reported in this observational study in which there is no intervention or change to usual care. There are no pharmacovigilance issues specific to this work. Key events such as recurrent stroke or TIA, cardiac disorders, cognitive problems and other serious medical conditions will be recorded as outcome events at each follow-up visit as part of the study assessments. Pre-existing medical conditions (i.e. existed prior to informed consent) will be recorded as part of the medical history.

# PREGNANCY

Pregnancy is not an exclusion criterion.

# OVERSIGHT ARRANGEMENTS

## STUDY MANAGEMENT

The study team will form a *Steering Committee* with an independent chair, funders, an external expert, and user representatives who will be consulted throughout. The work will be organised in Work-packages (Study Management including eCRF, Cognition, Imaging, Vascular function, Inflammation, Genetics, Statistical analysis) to share responsibilities, with Service User input

## INSPECTION OF RECORDS

Investigators and institutions involved in the study will permit study related monitoring and audits on behalf of the sponsor, REC review, and regulatory inspection(s). In the event of audit or monitoring, the Investigator agrees to allow the representatives of the sponsor direct access to all study records and source documentation. In the event of regulatory inspection, the Investigator agrees to allow inspectors direct access to all study records and source documentation.

## STUDY MONITORING AND AUDIT

## The ACCORD Sponsor Representative will assess the study to determine if an independent risk assessment is required.  If required, the independent risk assessment will be carried out by the ACCORD Quality Assurance Group to determine if an audit should be performed before/during/after the study and, if so, at what frequency.

Risk assessment, if required, will determine if audit by the ACCORD QA group is required. Should audit be required, details will be captured in an audit plan. Audit of Investigator sites, study management activities and study collaborative units, facilities and 3rd parties may be performed.

# GOOD CLINICAL PRACTICE

## ETHICAL CONDUCT

The study will be conducted in accordance with the principles of the International Conference on Harmonisation Tripartite Guideline for Good Clinical Practice (ICH GCP).

A favorable ethical opinion will be obtained from the appropriate REC and local R&D approval will be obtained prior to commencement of the study.

## INVESTIGATOR RESPONSIBILITIES

The Investigator is responsible for the overall conduct of the study at the site and compliance with the protocol and any protocol amendments. In accordance with the principles of ICH GCP, the following areas listed in this section are also the responsibility of the Investigator. Responsibilities may be delegated to an appropriate member of study site staff and recorded in a delegation log.

### Informed Consent

The Investigator is responsible for ensuring informed consent is obtained before any protocol specific procedures are carried out. The decision of a participant to participate in clinical research is voluntary and should be based on a clear understanding of what is involved.

Participants must receive adequate oral and written information – appropriate PIS and ICFs will be provided. The oral explanation to the participant will be performed by the Investigator or qualified delegated person, and must cover all the elements specified in the PIS and ICF.

The participant must be given every opportunity to clarify any points they do not understand and, if necessary, ask for more information. The participant must be given sufficient time to consider the information provided. It should be emphasised that the participant may withdraw their consent to participate at any time without loss of benefits to which they otherwise would be entitled.

The participant will be informed and agree to their medical records being inspected by regulatory authorities and representatives of the sponsor(s) but understand that their name will not be disclosed outside the hospital.

The Investigator or delegated member of the trial team and the participant will sign and date the ICF to confirm that consent has been obtained. The participant will receive a copy of this document and a copy filed in the ISF and participant’s medical notes.

Consent or assent will be obtained from the appropriate person for each jurisdiction (Scotland, Northern Ireland, England, Wales) will be sought where a potential participant is unable to consent for themselves. An information leaflet and appropriate consent form have been developed for this purpose. The research team will always approach the patient first about participating in the study. Verbal information will be tailored to each individual's ability. Should a participant indicate in any way that they do not wish to be involved in the study, they will be withdrawn from the study even if prior consent from a relative or guardian has been obtained.

If the capacity of the participant previously unable to consent improves sufficiently during the course of the study, they will receive information about the study via a participant information sheet and be approached to give consent. Should a participant indicate in any way that they do not wish to be involved in the study, they will be withdrawn from the study.

### Study Site Staff

The Investigator must be familiar with the protocol and the study requirements. It is the Investigator’s responsibility to ensure that all staff assisting with the study are adequately informed about the protocol and their trial related duties.

### Data Recording

The Principle Investigator is responsible for the quality of the data recorded in the CRF at each Investigator Site. The source data plan identifies which source data correspond to CRF data and states which data are recorded directly into the CRF.

### GCP Training

All study staff must hold evidence of appropriate GCP training.

### Confidentiality

All laboratory specimens, evaluation forms, reports, and other records must be identified in a manner designed to maintain participant confidentiality. All records must be kept in a secure storage area with limited access. Clinical information will not be released without the written permission of the participant. The Investigator and study site staff involved with this study may not disclose or use for any purpose other than performance of the study, any data, record, or other unpublished, confidential information disclosed to those individuals for the purpose of the study. Prior written agreement from the sponsor or its designee must be obtained for the disclosure of any said confidential information to other parties.

### Data Protection

All Investigators and study site staff involved with this study must comply with the requirements of the Data Protection Act 1998 and General Data Protection Regulation 2018 with regard to the collection, storage, processing and disclosure of personal information and will uphold the Act’s core principles. Access to collated participant data will be restricted to those clinicians treating the participants, representatives of the sponsor(s) and representatives of regulatory authorities.

Computers used to collate the data will have limited access measures via user names and passwords.

Published results will not contain any personal data that could allow identification of individual participants.

# STUDY CONDUCT RESPONSIBILITIES

## PROTOCOL AMENDMENTS

Any changes in research activity, except those necessary to remove an apparent, immediate hazard to the participant in the case of an urgent safety measure, must be reviewed and approved by the CI.

Amendments to the protocol must be submitted in writing to the appropriate REC and local R&D for approval prior to participants being enrolled into an amended protocol.

## PROTOCOL VIOLATIONS AND DEVIATIONS

Prospective protocol deviations, i.e. protocol waivers, will not be approved by the sponsors and therefore will not be implemented, except where necessary to eliminate an immediate hazard to study participants. If this necessitates a subsequent protocol amendment, this should be submitted to the REC and local R&D for review and approval if appropriate.

Protocol deviations will be recorded in a protocol deviation log and logs will be submitted to the sponsors every 3 months. Each protocol violation will be reported to the sponsor within 3 days of becoming aware of the violation.

## STUDY RECORD RETENTION

All study documentation will be kept for a minimum of 5 years from the protocol defined end of study point. When the minimum retention period has elapsed, study documentation will not be destroyed without permission from the sponsor.

## END OF STUDY

The end of study is defined as the completion of study visits and data analysis.

The Investigators and/or the study steering committee and/or the co-sponsor(s) have the right at any time to terminate the study for clinical or administrative reasons.

The end of the study will be reported to the REC within 90 days, or 15 days if the study is terminated prematurely. The Investigators will inform participants of the premature study closure and ensure that the appropriate follow up is arranged for all participants involved.

A summary report of the study will be provided to the REC within 1 year of the end of the study.

## INSURANCE AND INDEMNITY

The co-sponsors are responsible for ensuring proper provision has been made for insurance or indemnity to cover their liability and the liability of the CI and staff.

The following arrangements are in place to fulfil the co-sponsors' responsibilities:

* The Protocol has been designed by the CI and researchers employed by the University and collaborators. The University has insurance in place (which includes no-fault compensation) for negligent harm caused by poor protocol design by the Chief Investigator and researchers employed by the University.
* Sites participating in the study will be liable for clinical negligence and other negligent harm to individuals taking part in the study and covered by the duty of care owed to them by the sites concerned. The co-sponsors require individual sites participating in the study to arrange for their own insurance or indemnity in respect of these liabilities.
* Sites which are part of the United Kingdom's Nation Health Service will have the benefit of NHS Indemnity.

# REPORTING, PUBLICATIONS AND NOTIFICATION OF RESULTS

## AUTHORSHIP POLICY

Ownership of the data arising from this study resides with the whole study team. On completion of the study, the study data will be analysed and tabulated. A clinical study report will be prepared in accordance with the funder’s requirements.

## PUBLICATION

Publication will be planned in advance and a publication strategy to deal with primary and key secondary outputs will be put in place via the Study Steering Committee. Publications will be in the name of the investigator group; all investigators will have to approve publications. Individual investigators will wish to publish the results of substudies or other outputs from the study; such proposals should be made to the SSC to avoid duplication and help maintain information on outputs for reporting to the funder and in ResearchFISH as appropriate.

A committee will be established to assess proposals for analyses from external groups.

The anonymized study data will be made available for use by external investigators in appropriate analyses upon request via a publicly accessible portal (eg University of Edinburgh datashare). The mechanisms and processes for managing external access will be determined during the course of the study.

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**Appendix 1: Neuropsychological Testing**

**Appendix 2: Blood sampling instruction for inflammation analysis and long term storage**

**Appendix 3: Genetic samples**