REVIEW

Stroke pathway — An evidence base for commissioning — An evidence review for NHS England and NHS Improvement [version 1; peer review: awaiting peer review]

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Abstract

Background: Stroke is a leading cause of death and disability in the UK with around 90,000 new stroke patients each year. The NHS England (NHSE) Long Term Plan is committed to saving 150,000 lives from cardiovascular disease over the next 10 years and improving the quality of care available for patients who have a stroke.

Methods: This overview was commissioned by NHSE to summarise what we currently know and don’t know across the breadth of the care pathway. We conducted a series of evidence reviews to inform NHSE and its providers (commissioners, primary and secondary care teams, networks) of what needs to be achieved to deliver world class services equitably across England. Here, we present a concise summary of this work.

Results: Our report summarised the findings of 539 research articles, which we organised into ten sections relating to different stages of the stroke care pathway, from prevention in the community, to acute pre-hospital and hospital care, and on to rehabilitation and longer-term care in the community. Priorities include better prevention (with 90% of stroke attributable to modifiable risk factors), and improving awareness to maximise the chances that people experiencing an ischaemic stroke will reach hospital in time to be eligible for acute treatments. We describe the effects of reorganising hospital care into a smaller number of ‘hyperacute’ centres, and early supported
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Plain english summary
Stoke is a major cause of death and disability in the UK, with around 90,000 new stroke patients each year. It is only in recent decades that it has been a considered a treatable disease. But high-quality research has now shown that treatments such as: thrombolysis (dissolving a blood clot with an injected medication); thrombectomy (removal of the blood clot by a specialist radiologist); treating people in specialist stroke units; and supporting people to leave hospital early by providing specialist stroke therapy at home can save lives and prevent disability.

This report is a summary of the latest research evidence about how to prevent and treat stroke, and how stroke care services should be organised. It was written by a group of stroke clinicians and researchers, and commissioned by NHS England, who selected the topics.

Introduction
Stoke remains a major cause of death and disability in the UK with between 80 and 90,000 new cases per year. It is only in recent decades that it has been a considered a treatable disease. But high-quality research has now shown that interventions such as: thrombolysis (dissolving a blood clot with intravenous medication); thrombectomy (removal of the blood clot by an interventional neuroradiologist); treating people in specialist stroke units; and provision of early supported discharge services to support people to leave hospital early by providing specialist stroke therapy at home can save lives and prevent disability. Stroke mortality has reduced by about 60% over the last 30 years through better primary and secondary prevention and stroke treatments. However, there remains much to be done to ensure evidence-based treatments are provided to all patients who may benefit and there are many unanswered questions that need further research, particularly in areas such as rehabilitation and long-term physical and mental health.

The NHS Long Term Plan is committed to saving 150,000 lives from cardiovascular disease over the next 10 years and to improving the quality of care available for patients who do have a stroke. This evidence overview has been commissioned to summarise what we currently know and what we don’t know across the breadth of the care pathway, so as to inform NHSE and its providers (commissioners, primary and secondary care teams, networks) of what needs to be achieved to deliver world class services equitably across England. The scope of literature review was very wide indeed. Our aim has been to scope the broad landscape of the stroke literature using high quality synthesised sources of research as a starting point. While we have attempted to be comprehensive any more intensive method would have been prohibitive. This is a concise version of our report. We make a full version (with further detail about the included studies and results) available on our website. The editors recognise that there may be areas that have not been addressed, so feedback is welcomed.

This article summarises the available evidence relating to ten areas of stroke epidemiology, care and health systems which have been selected as priorities by NHS England. It concludes with an overview of gaps in the evidence base for each area, set out as a list of research questions to be prioritised and addressed.

Methods
This review seeks to understand the research landscape in stroke care, to aid commissioning. We seek to review the literature around interventions and design of health systems, such that better outcomes are achieved as outlined in the NHS Long Term Plan for stroke. Our review aims to not only look at gaps in evidence or whether a particular evidence is effective or not, but also to include: the need for the interventions (Section 1), and the evidence underpinning the proposed Long Term Plan for stroke. This document is therefore not a single review of a particular question but aims to make sense of the many hundreds of potential interventions that are processes in a care pathway, from prevention to long-term care, and including system redesign.

We aim to take a broad approach and synthesise evidence relevant to all parts of stroke care, from prevention in the community, through to acute pre-hospital and hospital care, and on to rehabilitation and longer-term care in the community. Through this, we aim to understand the research designs used in the field, summarise the key concepts needed for commissioning, and identify key gaps for future research.

To address our objectives, we conducted a series of evidence reviews for different stages of stroke care. Our aim was to provide broad description of the literature base in the field of stroke, aiming to understand the designs, approaches, and focus of research. To achieve this, we relied on high-quality secondary sources of research as a source of references. This approach allowed us to provide a wide-ranging description of the hundreds of interventions and processes which make up contemporary stroke care. Our approach contrasts with that taken by systematic reviews, which typically address a precisely defined question often with an empirical quantitative answer (for example, by how much do statins reduce the risk of secondary stroke?).

Our areas of focus (with lead authors for each), selected as priorities by NHS England are:
1. Epidemiology of stroke (Yanzhong Wang and Hatem Wafa)
2. Stroke prevention in primary care (Iain Marshall)
3. Pre-hospital admission management of stroke (Lesli Skolarus)
4. Acute management of stroke (Ajay Bhalla, Walter Muruet-Gutierrez, and Eva Emmett)
5. Acute care in the stroke unit (Ajay Bhalla, Peter Sommerville, and Jonathan Birns)
6. Rehabilitation in hospital (Catherine Sackley and Stephanie Clarke)
7. Rehabilitation in the community (Catherine Sackley and Stephanie Clarke)
8. Follow up and long-term support after stroke (Fara Hamidi)

9. Emerging technology and innovation in stroke care delivery (Anthony G Rudd and Charles Wolfe)

10. Effective system design (Charles Wolfe and Anthony G Rudd)

All authors contributed to the final review, which was overseen and edited by Iain J Marshall, Anthony G Rudd, Helen Rodgers, Christopher McKevitt, and Charles D A Wolfe.

Sources of evidence
We use systematically developed secondary resources as the source of studies included in this review. Across all sections, we use the European Union Burden of Stroke report (Stroke Alliance for Europe [SAFE]), the UK National Clinical Guideline for Stroke, the UK National Institute for Health and Care Excellence (NICE) Quality Standards in Stroke, and the associated NICE clinical guidelines in diagnosis and management and rehabilition.

Eligibility criteria
We take a broad approach to eligibility, reflecting the aims of the evidence review. To be included in the review, papers needed to measure or focus on an aspect of stroke care or epidemiology relating to the particular section. The overarching criteria is whether the literature contributes to the understanding of the research field for the purposes of healthcare commissioning. We include both peer-reviewed journal articles of primary research and summarise guideline recommendations which relate to commissioning. We included quantitative, qualitative and mixed-method studies. Papers were excluded where they did not focus on stroke prevention or care, or were otherwise deemed irrelevant for commissioning. We report preferentially from systematic reviews and systematically produced clinical guidelines where available; and report primary studies where these do not exist.

Data selection and extraction
Section lead authors manually reviewed reference lists of each of the evidence sources for eligibility, and selected references relevant to the section topic for further review. The review editors reviewed reference lists independently and selected additional studies for inclusion where appropriate. Any disagreements were resolved by consensus.

We did not conduct a formal quality assessment of the included studies but report key quality limitations as described in the literature sources where relevant to the interpretation of the outcomes. We synthesised the included studies narratively.

Evidence review management
This review was commissioned by NHS England, for the Long Term Plan for Stroke; the scope and early drafts were reviewed by the commissioners. This review underwent a process of peer review by members of the Intercollegiate Stroke Working Party (ICSWP). The ICSWP is made up of is made up of senior representatives from all the professional bodies involved in stroke care, as well as the voluntary sector and patient representation. The current membership of this group is listed at https://ssnap.zendesk.com/hc/en-us/articles/115004862974-SSNAP-Steering-Group. This report represents a ‘concise’ version of our evidence review for NHS England. We make our full version available here.

The views expressed are those of the authors and not necessarily those of the NIHR or the Department of Health and Social Care, the ICSWP, or NHS England.

1 - Epidemiology of stroke

Introduction
In England, around 80 to 90,000 people have a first in a lifetime stroke each year. More than 30,000 people (36%) die every year after their stroke, and almost one million people are living with the consequences of a stroke. Around 60,000 people have a transient ischaemic attack every year, of whom 17% will have a stroke within three months. Around 16% of those who have had a stroke are expected to have a recurrent stroke within five years. Of all people admitted to hospital with a suspected stroke, around 25% will turn out not to be a stroke (i.e. stroke mimic) (Figure 1).

Inequalities exist between different population groups: men, older people, ethnic groups, and those of lower socioeconomic status have a higher risk of stroke. Higher risk and poorer outcomes are observed in the north compared to the south of England in association with higher levels of cardiovascular diseases in the north.

In 2018, 14–15% of ischaemic stroke patients received intravenous thrombolysis (IVT), which is lower than the estimated 20% of all stroke patients eligible for the treatment (but higher than most other countries). Only 708 (around 1.2% of all stroke patients) received intra-arterial thrombectomy (IAT) in 2018, and an estimated 10% of total strokes were actually eligible for the procedure. In 2035, the number of first in a lifetime strokes in England is expected to reach 118,000. Consequently, patients eligible for IVT and IAT could rise to 23,600 and 11,800 respectively.

In the UK, stroke aggregate cost was estimated at £25.6 billion in 2015, which is expected to rise to £43 billion in 2025, and £75 billion in 2035.

Key statistics (England)
- The majority of stroke cases are due to ischemia (87%), whereas haemorrhagic events comprise 13% of total strokes in England.
- Stroke incidence increases with age; 3% of the total strokes occurred in people aged under 40, 38% in people aged 40 to 69, and 59% in people aged over 70.
- Strokes are occurring at an earlier age; age at onset has fallen from 70.5 to 68.2 years in males and 74.5 to 73 years in females between 2007 and 2016.
The African and African Caribbean groups have about double the incidence rate compared to the white population. Applying these rates to the population of England will result in around 5,000 and 66,000 cases of African and African Caribbean and white ethnic groups respectively.

Increased deprivation is associated with increased incidence and death rates. Stroke risk is twice as high in the most deprived groups compared to the least deprived and subsequent death is 26% more likely. Around 80% of stroke patients come from lower socio-economic groups.

Nearly 14% of stroke cases die within the first 30 days of stroke onset.

Cumulative death rates are 36%, 57%, and 76% at one, five, and ten years respectively.

There are around 32,000 stroke-related deaths in England each year. Deaths related to stroke have declined by 49% in the past 15 years due to a combination of better prevention, earlier treatment and improved quality of care.

7% and 16% of stroke patients will have another stroke within one and five years of stroke onset respectively.

The highest proportion of severely disabled stroke survivors is observed seven days after stroke (43%), while 15% remain severely disabled after three months. Additionally 34% have mild disability and 14% moderate disability at this time.

22% of stroke survivors are cognitively impaired.

57% of stroke survivors experience symptoms of anxiety at some point in the 10 years after their stroke.

**Figure 1. Diagram of key statistics in England.**
• 55% of stroke survivors experience episodes of depression within 15 years after their stroke11.

• Almost one million people in England have had a stroke, around 1.7% of England’s population12.

• Unless effectively managed 8% of people will have a stroke within a week of having a transient ischaemic attack (TIA)13, and 17% of those who have had a TIA will have a stroke within three months14.

• 25% of suspected stroke cases will turn out to have a diagnosis other than a stroke – a stroke mimic15–19.

Projections of stroke numbers and the economic cost

Modelling future health scenarios is important for medium- and long-term planning and organisation of stroke services and prevention activities. Few studies have attempted to forecast the burden of stroke and almost none have provided predictions of resources use. The most up to date SAFE20 study estimates an increase in strokes of 44% between 2015–2035 would result in more than 118,000 annual stroke cases by 2035. However, the Global Burden of Disease data indicates a more modest increase in stroke numbers between 2007 and 2017 (9% increase) in the UK21. There are multiple methodological and data quality issues that need to be considered in interpreting these trends. In terms of treatments, around 23,600 and 11,800 patients will receive IVT and IAT respectively in 2035, given a predicted 118,000 acute strokes assuming complete coverage of all eligible patients. However, there is evidence suggesting that cutting in-hospital delay to 20 minutes in stroke thrombolysis is possible21, and one might expect an increased number of patients arriving to the hospital within the treatment time window, because of improved accessibility and public awareness of stroke symptoms. These could therefore result in increased eligibility rates and the subsequent numbers receiving the acute treatments. Systematic research in this area is warranted to produce reliable estimates of future trajectories.

The economic burden of stroke falls on different sectors of society. Every new case of stroke represents a significant cost to the NHS, social care services, the patient and their family. There are also indirect costs due to loss of productivity when stroke survivors and their carers can no longer work22. It was estimated that in 2015 the average societal cost of stroke per person was £45,409 in the first year after stroke23. An additional £24,778 per patient has been estimated for subsequent years (cost of prevalent stroke). Stroke costs the UK society around £25.6 billion each year. Around 57% of this sum is incurred by informal carers (relatives and friends). Twenty-nine per cent of cost is borne by the NHS, 11% social care, and 3% productivity loss.

Due to predicted rises in the number of older people in the population and the expected improvements in care provision, the number of stroke cases and survivors will increase. As a result, the corresponding overall cost of care will almost triple in 2035 with stroke costing the UK £43 billion in 2025, and £75 billion in 2035.

2 - Stroke prevention in primary care

Introduction

Stroke prevention is usually considered alongside the prevention of other cardiovascular diseases (CVDs) (coronary heart disease, peripheral vascular and aortic disease) since they share a common aetiology of atherosclerosis, and common risk factors23.

Risk factors comprise those which are non-modifiable (age, ethnicity, sex, and genetics), and modifiable (poor diet, being overweight, smoking, excess alcohol consumption, inactivity, dyslipidaemia, and hypertension)23. Diabetes independently increases the risk of all CVDs23. Atrial fibrillation is additionally a key risk factor for stroke24. Social factors (including socio-economic status and low educational attainment) have been additionally recognised as risk factors for stroke and other CVDs26; this relationship is partly explained by increased levels of conventional risk factors among deprived populations, and also through inadequate access to health care26.

Results

Targeting prevention

INTERSTROKE was a case-control study conducted across 22 countries, and published in 2010, which examined the population attributable risk27 of major stroke risk factors. Overall, this study estimated that 90% of stroke was attributable to modifiable risk factors.

An individual’s risk of future stroke may be estimated using statistical models. NICE recommends the use of QRISK228 although an updated version, QRISK3, has been released subsequent to the NICE guideline. These models are embedded in the primary care clinical record and taking values recorded for key modifiable risk factors produce an estimate of the ‘global’ risk of CVD, typically as a percentage risk of CVD occurring over the following 10 years.

These models are particularly useful for targeting primary prevention; people at higher risk would be expected to obtain more benefit from risk factor modification than those at lower risk29. NICE recommend that general practices systematically calculate approximate CVD risk scores for their registered patients up to age 84 years using already-held data in the electronic care record29. Those with an estimated score of ≥10% would then be invited to attend for a more detailed formal risk assessment, including assessment of lipids.

By contrast, those who have had a previous stroke are all considered to be at high risk of recurrence and thus are eligible for all preventative treatments without further risk stratification29.

The NHS Health Check programme

The NHS Health Check programme was launched in the UK in 2009, with the primary aim of reducing CVD risk factors in the population30. The programme targets men and women aged 40–74 years old who have not experienced CVD before. The check is run by local authority public health departments as a mandated service. A 2019 analysis of 127,891 NHS Health Check participants compared with matched controls with data
obtained via Clinical Practice Research Datalink and found that rates of smoking reduced by a clinically important amount following the check with approximately 10% reduction in odds of smoking among men and women. However, other risk factors reduced by either small amounts (blood pressure and weight), or showed no change at all (total cholesterol). The authors commented that these small changes in risk factors for individuals might still lead to important reduction in cardiovascular disease across the population. A 2019 Cochrane review included 17 RCTs, with 251,891 participants, examining similar health checks internationally, and concluded with high certainty that health checks have little or no effect on cardiovascular mortality.

**New ways of working: integrated care and primary care networks**

NHS England has prioritised plans to encourage all GP practices to group together as ‘primary care networks’, which typically comprise a geographically adjacent group of practices with a total list size of around 30–50,000. The overarching aim is that individual local practices would still deliver personalised care to their patients while taking advantage of their network’s ability to have wider population impact, but with administrative, economic, and innovation efficiencies and improvements that become possible in a larger organisation. There is evidence from a 2009 pilot that such systems could improve cardiovascular disease prevention. A network pilot in Tower Hamlets, London, which included 34 GP practices, ran a scheme where the network organised and administered a CVD risk reduction scheme. The scheme included administrative and managerial support from the network, alongside clinical education and financial incentives for the participating practices to achieve CVD targets. The pilot reported the key success was a substantial increase in statin prescribing with an 18% increase in the pilot versus 6% national average over the same time period. This needs confirmation with a definitive evaluation.

**Hypertension**

Hypertension management for primary prevention is covered by the most recent NICE hypertension from 2011; but is due to be updated after new evidence has been published.

The 2011 guidelines recommend the following key points:

- That hypertension should be diagnosed based on ambulatory blood pressure monitoring (ABPM) where possible and not based on one-off blood pressure measurements;

- Treatment should be based on the ‘ACD’ guideline, with an ACE inhibitor or angiotensin II antagonist being first line, then calcium channel blockers, and thiazide diuretics. In those over 50, or black ethnic groups, a calcium channel blocker is preferred.

The recommendation that hypertension should be diagnosed by ABPM was based on an economic analysis conducted for the NICE guideline. This showed cost saving compared with clinic measurements, primarily since ABPM has higher specificity (i.e. a lower false-positive rate). Fewer people who had normal blood pressure were erroneously treated with antihypertensives; the cost savings from avoiding unnecessary treatment exceeded the expense of more sophisticated monitoring.

Key new evidence has been published subsequent to the guideline. The SPRINT trial randomized 9,361 people aged 50 or over to intensive (aiming for a systolic pressure of <120mmHg) or standard treatment (<140mmHg systolic). The trial found that intensive treatment reduced the composite endpoint of myocardial infarction, acute coronary syndromes, stroke, heart failure, and cardiovascular death suggesting there may be benefit in blood pressure lowering to a stricter target than recommended in the current NICE guideline.

Evidence supporting the tight control of blood pressure following stroke comes from the PROGRESS trial. This trial randomly assigned participants following a stroke or TIA (52% with normal blood pressure) to receive two additional blood pressure-lowering drugs to people after stroke or TIA. The trial found that the relative risk reduction of the intervention was 42% for stroke recurrence and 35% for major coronary events. This benefit was seen even in those with blood pressure within the normal range.

**Lipid modification**

High quality evidence from systematic reviews has found that statin treatment reduces the risk of cardiovascular disease, both as primary and secondary prevention. A 2013 Cochrane systematic review included 18 RCTs with 56,934 participants. The review found that both for primary and secondary prevention, statins reduced all cause mortality, combined fatal and non-fatal CVD, combined fatal and non-fatal CHD and combined fatal and non-fatal stroke. The SPARCL trial compared atorvastatin 80 mg daily versus placebo in patients with TIA or stroke in the prior six months. The trial found that atorvastatin significantly reduced stroke and major coronary events. The trial did find that atorvastatin increased intracerebral haemorrhage by 67%; the risk was highest for those whose initial stroke was of haemorrhagic aetiology.

As a result of these data, NICE recommends for primary prevention, that people with an estimated CVD risk of ≥10% should be eligible to be offered a statin and that atorvastatin 20 mg should be the first choice of treatment.

**Atrial fibrillation**

Atrial fibrillation is a key risk factor for stroke and there is high quality evidence that treating AF with anticoagulation is effective at preventing stroke both as primary and secondary prevention, and for most people the expected benefits substantially exceed the small risk of haemorrhage. Effective treatments include warfarin, and direct oral anticoagulants (DOACs). A 2009 Cochrane review found five RCTs comparing warfarin versus placebo for preventing stroke and TIA in people with atrial fibrillation. It found that warfarin significantly reduced stroke and all-cause mortality compared with placebo.
A 2014 systematic review and network meta-analysis of 16 RCTs compared trials of warfarin, DOACs, aspirin, and placebo for stroke prevention in AF. Dabigatran and apixaban were associated with reduced risk of stroke compared with warfarin. There was no significant difference in stroke risk between either edoxaban or rivaroxaban and warfarin. Edoxaban, apixaban, edoxaban, and dabigatran were all associated with small but significantly lower rates of major bleeding compared to warfarin treatment. Aspirin was shown to not be effective in reducing the risk of stroke in these patients.

The 2021 NICE guideline for AF recommends for primary prevention that people with AF should be assessed for their stroke risk, taking into account their risk of bleeding. For most people this will result in a recommendation to take an anticoagulant (either warfarin or a DOAC). For secondary prevention, the 2016 ICSWP National Clinical Guideline for Stroke recommends that people with cardioembolic stroke are treated with anticoagulation in nearly all cases based in part on the European Atrial Fibrillation Trial that showed the annual risk of subsequent stroke reduced from 12% to 4%.

England-level QOF data (https://qof.digital.nhs.uk/) for 2018–19 shows that 94% of those with a diagnosis of AF had undergone a stroke risk estimation (with the CHA2DS2-VASC tool). Of those estimated to have a high stroke risk, 86% were receiving treatment with an anticoagulant. However, a key issue is that AF is likely to be substantially under-diagnosed. An analysis by Public Health England estimated that the true national prevalence of AF was likely to be 2.5%, and that only 70% of those with AF were recorded by their GPs.

**Antiplatelets**

Although there is strong evidence for use of antiplatelets for the secondary prevention of stroke, antiplatelets are not recommended as primary prevention. Systematic reviews of large RCTs found that aspirin did not lead to an important reduction in CVD risk, but was associated with a small risk of haemorrhage, which may be severe.

The evidence for use of antiplatelets comes from a meta-analysis by the Antithrombotic Trialists’ Collaboration, which found antiplatelets reduced vascular events by 22% in those with a previous stroke or TIA. A NICE 2010 technology appraisal found that clopidogrel was more cost-effective than other antiplatelet options for the secondary prevention of stroke. The CHANCE and POINT trials both examined whether dual antiplatelet therapy with aspirin and clopidogrel were of benefit and concluded that the strategy might be useful in high-risk patients with minor stroke or TIA, but just for the first 21 days.

England-level QOF data from 2018–19 (https://qof.digital.nhs.uk/) shows that 92% of people who had been diagnosed with ischaemic stroke or TIA had been prescribed either an antiplatelet or anticoagulant drug.

**Smoking cessation**

In those who smoke, smoking provides the greatest contribution to CVD risk. Numerous large, high-quality cohort studies have found that CVD risk reduces quickly after smoking cessation, with ex-smokers having a similar CVD risk to never-smokers around 15 years after quitting.

**Dietary change**

Obesity, which affects around 10% of the world’s population, is a major risk factor for CVD, with observational studies finding a linear increase in risk of CVD and mortality with increasing body mass index. There is consistent evidence from observational studies that intentional weight loss leads to improvement in cardiovascular risk factors, including reduced blood pressure, reduced left ventricular mass, and reduced resting heart rate.

**Multimorbidity**

In 2016 NICE published the first version of their guidelines on multimorbidity. This guideline focuses on optimising care for people with multiple long-term conditions. In particular, one aim of the guideline is to provide a framework for reducing treatment burden, including both polypharmacy and multiple clinical appointments, particularly in those who are frail. The guideline advocates that clinicians should identify people who might benefit from a reduction in care including potentially those prescribed ≥10 regular medications, and those who exhibit signs of frailty. The guideline recommends that patients have a structured review, where their health priorities can be discussed alongside estimates of the likelihood of benefit and harm from medication.

**Summary**

Up to 90% of stroke cases are preventable, through improving key risk factor management including hypertension, poor diet, overweight, smoking, inactivity, dyslipidemia, and atrial fibrillation. Primary care is the ideal place to tackle these risk factors in the general population. Key priorities for stroke prevention include better detection and treatment of atrial fibrillation, and continuing improvements in control of vascular risk factors. Programmes such as the NHS Health Check programme have succeeded in realising reductions in smoking, and increased statin prescription, but so far there is no evidence of clinically meaningful reductions in other risk factors, for example, hypertension.

**3 - Pre-hospital admission management of stroke**

**Introduction**

Most people (95%) have their onset of stroke outside of hospital. Thus, given the time sensitivity of acute stroke care, increasing stroke awareness by enabling people affected by stroke and witnesses to recognise and respond to stroke symptoms by calling 999, would likely increase the proportion of ischemic stroke patients eligible for acute treatment and timely treatment of patients with intracerebral haemorrhage. How best to get individuals to recognise stroke symptoms and to call 999 is unknown. Research suggests that public health campaigns may increase the proportion of strokes presenting to the hospital admissions via the Emergency Department (ED) and acute stroke treatment rates, but overall the direct link between stroke awareness and a decrease in pre-hospital delay is weak, particularly among populations at greatest stroke risk.
Overall, educational campaigns are recommended to increase stroke awareness, particularly among populations most at risk\textsuperscript{65,66}.

**Results**

**Emergency medical services (EMS)**

Pre-hospital delay can be reduced by implementing an EMS ‘code stroke’ protocol, which includes highest priority dispatch, pre-hospital notification and rapid transfer to the closest ‘stroke-ready’ centre\textsuperscript{65}. EMS evaluation of a suspected stroke patient should include the Face Arm Speech Test (FAST) to assess the most common signs of stroke\textsuperscript{59,66}.

There is weak evidence for pre-hospital care to include oxygen therapy to maintain normoxia, while pre-hospital treatment of hypertension and hyperglycaemia are not currently recommended\textsuperscript{66}. It is vital that hypoglycaemia is excluded as a cause of the neurological symptoms. Trials are ongoing to assess the value of giving antihypertensives in the ambulance\textsuperscript{66}, although a recent trial did not show a benefit in functional outcomes\textsuperscript{66}.

Recognition of stroke by emergency dispatchers and ambulance personnel is challenging\textsuperscript{66}. Ideally there would be a biomarker to identify stroke and a further biomarker to identify large vessel occlusion in order to facilitate transfer to an IAT capable centre. The closest ‘biomarker’ approximation are clinical scales, of which a number of tools are available or under development\textsuperscript{66,69}; FAST is most commonly used\textsuperscript{66}. The use of clinical scales to identify large vessel occlusion and subsequent triage of the patient to an intra-arterial thrombectomy (IAT) capable hospital requires decisions about the trade-offs of sensitivity and specificity of clinical scales. One such scale the Rapid Arterial Occlusion Evaluation (RACE) scale \( \geq 5 \) has a sensitivity of 0.85 and specificity of 0.68 which would result in many patients being transferred to an IAT capable centre who do not have a large vessel occlusion\textsuperscript{66}. Currently, the European Academy of Neurology and European Stroke Organisation conclude that there is insufficient evidence to recommend a pre-hospital stroke scale to predict large vessel occlusion\textsuperscript{65}.

Mobile stroke units (which include a CT head scan) may reduce onset-to-treatment time for thrombolysis\textsuperscript{71}, but clinical and cost effectiveness has not been established. Given the lack of effectiveness data, no recommendation of the additional value of prehospital telemedicine or imaging, which may facilitate stroke diagnosis and appropriate triage, can be made\textsuperscript{65}.

**Emergency department**

Over the past decade, acute stroke care has evolved with the addition of IAT and the emergency treatment of hypertension among patients with intracerebral haemorrhage (ICH). IAT is a highly efficacious treatment for some stroke patients with large artery occlusion. The Emergency Department and stroke units are the key gatekeeper to acute stroke care.

Patients with suspected acute stroke should be assessed for emergency stroke treatments by a specialist physician without delay\textsuperscript{72}. Selection of patients eligible for acute stroke treatments relies on a rapid detailed history and examination as well as urgent imaging techniques to determine the type of stroke. All Hyper-Acute Stroke Units (HASUs) need immediate, round the clock access to brain imaging including CT angiography\textsuperscript{72}. The National Clinical Guideline for Stroke recommends brain imaging should occur urgently and at most within one hour of arrival to maximize the potential benefit from revascularization treatment and acute management of intracerebral haemorrhage\textsuperscript{72}. Recent trials of intravenous thrombolysis (IVT) and IAT within an extended time window, including wake up stroke, require a favourable perfusion pattern prior to treatment showing the need for CT perfusion for this patient population\textsuperscript{73-75}. Plain CT and CT perfusion with artificial intelligence software, such as RAPID or Brainomi\textsuperscript{76}, are currently being used in practice to improve quality and speed of the reporting of scans.

Most ICH patients who present within six hours of symptom onset with a systolic blood pressure above 150 mmHg should be treated urgently to lower blood pressure to 140 mmHg for at least seven days\textsuperscript{76}, be admitted directly to a HASU and those on an anticoagulant should have it urgently reversed\textsuperscript{76}.

**Summary**

Acute stroke treatments are time sensitive. Increasing stroke awareness, enabling people to recognise and respond to stroke symptoms by calling 999, would likely increase the proportion of ischemic stroke patients eligible for acute stroke treatment. Determining the optimal approach to increasing and sustaining stroke awareness of symptoms and appropriate response could decrease post-stroke disability.

Given the lack of gold standard clinical scale to identify large vessel occlusion, stakeholders will need to determine the balance between the current scales’ sensitivity and specificity. At this time, there is no currently available tool to differentiate between large vessel occlusion and other cause of stroke. Thus, organisation of stroke services cannot be based on prehospital assessment.

**4 - Acute management of stroke**

**Introduction**

Stroke care has undergone significant changes with the establishment of dedicated stroke units across England. There is strong evidence that admission to a specialised stroke unit is associated with higher quality care\textsuperscript{77} and lower rates of mortality, disability and institutionalisation, without leading to longer hospital stays\textsuperscript{78}. Stroke units are defined as discrete hospital areas equipped for monitoring and rehabilitating stroke patients and staffed by a specialist stroke multidisciplinary team holding multidisciplinary team meetings at least once a week for exchange of information and goal setting\textsuperscript{79-81}. In this section we summarise the evidence pertaining to the setting and organisation of HASUs, together with evidence for acute interventions in that setting. We consider post-acute hospital stroke unit care in Section 5 and consider service organisation more widely for the full stroke pathway (from prevention, early recognition, and treatment to rehabilitation) in Section 10.
Results

Overall organisation of acute stroke services

Stroke unit care (see Section 10)

National79 and international81 guidelines recommend transferring patients with suspected stroke to the nearest hospital with a stroke unit equipped to admit acute stroke patients. After an initial assessment, and unless stroke is not the predominant clinical problem, the current recommendation is to admit everyone with suspected stroke to a stroke unit ideally within four hours of hospital arrival to facilitate timely assessments by a specialised team42,83.

Between 12%84 and 22%85 of stroke patients are not admitted to hospital. These patients are cared for at home, in care homes and some access specialist care as an outpatient. Raising stroke awareness in the general population and those involved in primary care, community care homes and emergency services is important to ensure that these patients receive the care most likely to deliver recovery and prevent further strokes or for some patients with severe stroke, end of life care.

While nationally the vast majority (84%) of admitted stroke patients now spend at least 90% of their hospital stay on a stroke unit, only 56% of them are admitted within four hours of hospital arrival81. Delayed stroke unit admissions are more frequent in winter, reflecting the additional burden of winter-related illness on emergency services86.

Delivery of networked stroke services

As stroke care is becoming increasingly complex, not every hospital will be able to provide the specialist staff and equipment required for optimal care. To address this problem, it is proposed to establish stroke networks serving a population of 0.5 to 2 million77,87. These networks will consist of a reduced number of “hubs” providing highly specialised care in the first 72 hours (hyperacute care) and a larger number of “spokes” providing specialist stroke care post 72 hours.

“Hub and spoke” models of care have been introduced in some regions of the country, mainly densely populated areas such as Greater Manchester and London. Other examples of services adopting this strategy include Bedford moving care to Luton, Kettering to Northampton, Basildon to Chelmsford as well as Wansbeck, North Tyneside, and Hexham General Hospitals moving all emergency services to the new, purpose-built Northumbria Specialist Emergency Care Hospital88.

London and Greater Manchester (GM) have had extensive re-organisation of acute stroke services starting in 201089. In London, the number of hospitals admitting stroke patients within the first 72 hours of stroke decreased from 32 stroke units/wards to eight HASUs, and a further 13 stand-alone stroke units exclusively for post-72-hour care. In GM, acute stroke services were reconfigured into three hyperacute services (comprehensive and primary stroke centres) and 11 non-hyperacute services. Initially, the cut-off point for admission to hyperacute services was four hours post-stroke. This was dropped in 2015, making all acute stroke patients eligible for hyperacute services and bringing GM more in line with London.

Following these re-configurations, the London and GM stroke pathways now specify that all patients with suspected stroke are taken by ambulance to the nearest hospital offering hyperacute services. Upon arrival, suspected stroke patients receive specialist assessment, investigation and treatment and are admitted to a HASU for the first three days after stroke. Patients are then either transferred to their local hospital for further acute care and in-hospital rehabilitation or discharged to community rehabilitation services or home with various levels of rehabilitation support.

Evaluating the effects of service reconfiguration

Evaluating the reconfigurations of these services has provided evidence that centralisation can improve care and outcomes and be cost-effective.

Performance

In London, 93% of patients received treatment in a HASU following the service re-configuration (2015/16 data)91. Patients were significantly more likely to receive evidence-based interventions, such as a brain scan within three hours and arrival at a stroke unit within four hours, compared to before the re-configuration or the rest of England. GM’s hyperacute services performed similarly well as HASUs in London and significantly better than non-hyperacute units in this area but treated a smaller proportion of stroke patients (39% after the initial 2010 re-configuration with the four-hour admission cut-off, rising to 86% in 2015/16). No benefit was seen overall for patients in GM, after the first reorganisation but after further centralisation in 2015 improvements of over 10% occurred for brain scan within 60 minutes, admission to a stroke unit within four hours, and assessments within 72 hours.

Length of hospital stay in London declined by 1.4 days and in GM by 2.0 days over and above the reduction seen in the rest of England, representing 12,766 and 8,842 fewer hospital bed days per year respectively80.

A study of the impact of service reconfiguration in Northumberland including urban and rural areas showed a similar reduction in length of inpatient stay, and improved speed of investigation and treatment92.

In London, 90-day mortality rate declined by 1.1% over and above the rest of England with an estimated additional 96 lives saved per year. This would equate to 651 lives saved across the English population of 55.6 million people if all areas achieved similar reductions.

Clinician skills

An appropriately skilled multi-disciplinary stroke unit team is the cornerstone of a holistic approach to stroke care93. Any hyperacute or acute stroke service should provide specialist medical, nursing, and rehabilitation staff, including physiotherapists,
occupational therapists, speech and language therapists, clinical psychologists, and dieticians. Specific training should be provided in accordance with the Stroke-Specific Education Framework (www.stroke-education.org.uk).

Cost effectiveness of centralising acute stroke care

Running a hyperacute stroke service requires increased staffing levels compared to acute services, in particular with regards to the number of registered nurses and stroke specialist consultants. A continuous seven-day service is needed for thrombolysis and thrombectomy. A hyperacute unit therefore requires a minimum of six stroke trained physicians, and a minimum of 2.9 WTE nurses per bed. A hyperacute unit should provide a consultant stroke specialist ward round seven days per week. The increased availability of highly trained staff and specialist diagnostic and therapeutic equipment in hyperacute units raises the cost of running the service. While the cost of a bed-day on a London HASU was estimated at £665 for day one and £399 for day two and three, a stroke unit bed-day cost an estimated £238 in 2013/4. Economic analysis of the re-organisation in London up to 90 days post-stroke found average costs per patient reduced from £14,117 in 2007/8 to £13,306 in 2010/1, predominantly due to shorter length of stay. Using a 10-year time horizon and comparing both London and GM with the rest of England, it was estimated that in London 58 additional Quality Adjusted Life Years (QALYs) per 1000 patients were gained at an extra cost of £1,014,363. There was an incremental cost-effectiveness ratio of £17,452.

Number and distribution of HASUs – current and number required for optimal coverage

According to the latest available data from the national organisational audit, 121 (82%) of stroke services offer acute care for at least some stroke patients in England with a total of 728 stroke unit beds available exclusively for the first 72 hours of care and a further 1,523 for both pre-72 hours and post-72 hours care. Additionally, there are 27 (18%) sites providing care solely beyond the first 72 hours post-stroke. Based on the evaluation of service reconfiguration in London and GM, a nationwide reconfiguration of stroke services might be desirable. There is limited evidence regarding the optimal size of a HASU, with observational studies providing most of the available data. A volume of at least 500 acute admissions a year corresponds with an adequate level of institutional experience and competence in providing hyperacute treatments and a volume of between 600 and 1,500 confirmed stroke patients admitted per year has been recommended based at least in part on cost effectiveness. Centralisation, and larger numbers of admissions must be balanced against geographical access and increasing patient travelling times, particularly for more rural areas. NHS England reconfiguration guidelines for stroke services suggest that maximum travel times should be ideally up to 30 minutes but no more than 60 minutes. A study examining the feasibility of a hyperacute stroke unit model of care across England calculated that 75–85 HASUs would be required, assuming annual stroke admissions per unit are in the range of 600 to 2,000 patients and up to 82% of patients can reach the nearest HASU within 30 minutes and up to 98% of patients within 60 minutes of travel time respectively.

Management of transient ischaemic attack

The recommendation from NICE for the management of a suspected TIA is to prescribe 300 mg daily of aspirin immediately unless contraindicated, with referral to be seen by a specialist within 24 hours of symptoms onset preferably as an outpatient. In England, 142 (96%) of stroke treating sites have a neurovascular/TIA clinic. Of these sites, 115 (81%) initiate investigations and treatment for outpatient TIA patients within the next working day or sooner. NICE guidelines recommend that magnetic resonance imaging (MRI) including diffusion-weighted and blood-sensitive sequences should be considered after specialist assessment to determine the site of damage and to rule out haemorrhage. If there is an indication for an MRI, this should take place on the same day as the assessment. Carotid imaging should be performed urgently for patients potentially suitable for carotid endarterectomy. The choice of secondary prevention depends on the findings of the clinical assessment. For patients with TIAs of atherothrombotic or small-vessel origin, the recommendation is to start antiplatelet medication and a statin. All patients with raised blood pressure should have it controlled. In patients with TIA of cardiac origin, anticoagulation is a better alternative to antiplatelets. The start of anticoagulation therapy should be within the first two weeks after the event.

Carotid endarterectomy

Urgent carotid endarterectomy should be considered for patients with TIA or stable neurological symptoms who have carotid stenosis of 50 to 99% as a cause of their symptoms. NICE guidance has not been updated since 2008 when the recommendation was that surgery should be performed within a maximum of two weeks after symptom onset. Given that the highest risk of stroke after TIA is within the first few days the objective should be to operate as soon as possible.

Intravenous thrombolysis

Alteplase and tenecteplase are effective options for reperfusion therapy if given within 4.5 hours of the onset of symptoms; however, in the UK only alteplase is currently licenced for use in ischaemic stroke. IVT is effective at reducing disability and improving the chances of good functional outcome and independence (defined as a modified Rankin scale score ≤2) at three and six months after stroke (adjusted OR 1.53). Additionally, there is evidence from a randomised control trial, propensity score matched prospective studies, and observational studies that thrombolysis improves long term survival and functional status. IVT is a cost-effective intervention at the level of £20,000 to £30,000 Incremental Cost-Effective Ratio per QALY gained. Results from the WAKE-UP trial suggest that using mismatch in diffusion weighted imaging and FLAIR sequences on MRI are useful to identify and treat patients where the time of onset is not known. Because of the potential risks, alteplase should only be administered within a well organised stroke service with properly trained staff in thrombolysis delivery and monitoring.
There should be nursing staff trained to provide level one and level two care, and immediate access to neurological imaging with staff trained to interpret the results must be available.102

Due to its potential to significantly improve patients’ prognosis, administration of IVT is considered a key indicator of quality of care, with the National Stroke Programme recommending that acute stroke centres should thrombolysed at least 20% of all stroke patients, and at least 85% of eligible patients.115 Unfortunately, despite these recommendations, the proportion of patients receiving IVT remains low, at around 12% of all ischaemic stroke patients.116 As part of the national stroke quality improvement programme, the aim is to treat at least 50% of patients receiving thrombolysis within one hour. Currently, data from Sentinel Stroke National Audit Programme (SSNAP) Annual Report 2018–2019 shows that 64% of patients receive IVT within this time window: the golden hour when maximum benefit can be achieved.

Mechanical thrombectomy (IAT)

There is strong evidence for the effectiveness of mechanical thrombectomy in improving functional outcome at 90 days in patients presenting with proximal occlusion of a large vessel artery in the anterior circulation.

For trials focussing specifically on treatment within six hours of symptom onset, functional independence was achieved between 35% to 42% with IAT using modern devices.117-123 Overall good functional outcome at 90 days was 20% greater (absolute benefit) with IAT compared with IVT.

Trials involving selective advanced imaging to identify salvageable ischaemic brain tissue also demonstrated good functional outcome ranging from 29% to 40%.119,120,124 with IAT. The mantra of ‘Time is Brain’ is as important for IAT as with IVT, with greater benefits observed if delivered within 4.5 hours of onset, particularly in patients with the limited brain injury and good collateral circulation. For patients with delayed presentation, including patients with wake-up stroke up to 24 hours, there is now increasing evidence for mechanical thrombectomy.125,126 However, in reality, a low proportion, perhaps around 6% of patients will satisfy the criteria for late treatment.

The evidence base for intervening for posterior circulation stroke including proximal basilar artery occlusion is not robust but intervention with mechanical thrombectomy may be considered up to 24 hours until further trial evidence is available.

Eligibility for IAT in the UK

Currently 1% of the ischaemic stroke population undergoes IAT in the UK with a planned target of 10% in the next five years equating to 8,000 patients per year. Current estimates suggest that 12% (10,000 to 11,500 stroke admissions) of the UK population may be eligible for mechanical thrombectomy and the use of advanced imaging in particular may have an impact on decision making especially for those who present late. This could result in an additional 2,550 patients being functionally independent with an additional 4,500 patients with improved functional outcomes compared with IVT each year.127

Developing IAT services

There is uncertainty as to the best model to deliver mechanical thrombectomy services in the UK. There are currently about 127 acute stroke centres in England delivering either a combination of mechanical thrombectomy and intravenous thrombolysis (23 Comprehensive Stroke Centres: CSC) or just intravenous thrombolysis (104 Primary Stroke Centres: PSC). The choice of model will depend on local and regional service organisation, patient characteristics and volume of admissions. For example, a ‘Mothership’ model whereby all stroke patients are taken to CSCs may be the preferred model in metropolitan areas. A ‘Drip and Ship’ model where the patient is assessed for suitability for thrombectomy, intravenous thrombolysis is started where appropriate and then the patient is transferred to a comprehensive centre, may be preferable where additional transportation times to a CSC may result in delayed thrombolysis. At present there are no published models that predict outcome comparing these two service designs. However, it is likely that in the UK a pure CSC model is unlikely to be deliverable so a hybrid model involving an estimated 75–80 centres (involving both CSCs and PSCs) would potentially provide significant benefit to most patients in England (between 95% to 98% patients within 45 minutes and 60 minutes travel time respectively).128 In such a mixed model, the PSCs would not only facilitate quicker intravenous thrombolysis times but also temper admission numbers that would otherwise directly attend the CSCs leading to overburdening such centres and limiting patient flows.

Within the workforce and infrastructure, there is an urgent requirement to increase the number of Interventionalists to deliver IAT. Currently this is delivered under the aegis of the 24 Neuroscience Centres in England by Interventional Neuroradiologists (INR) of whom 86 of the 91 in the UK are in England, and about a third are operating in London. Operating a 24/7 rota would require a workforce of six operators at each centre to ensure skills are maintained and demand is met. There are currently only two 24/7 thrombectomy centres operating in the UK. It is estimated that a doubling of Interventionalists are required and that credential training for other specialties such as Interventional Radiology may be a potential option to support the delivery infrastructure in maintaining the necessary skills and expertise for mechanical thrombectomy.129

Costs

Studies have demonstrated that IAT compared with intravenous thrombolysis alone is likely to be cost effective and cost saving with estimates calculated at £7,061 per QALY gained.130 The cost of implementing mechanical thrombectomy including devices, staff salaries, set up costs such as training and equipment across the UK over five years is estimated to be up to £400 million. These costs would be potentially offset by the significant reduction in disability and long terms costs to healthcare systems amounting to £1.3 billion over five years.122

Summary

Re-organisation into a smaller number of highly specialised hyper-acute stroke units in the densely populated metropolitan areas of London and Greater Manchester have proved cost-effective and have led to improvements in patients’ outcomes.
Given that there are workforce shortages, re-organisation of services in urban areas might improve the efficient use of scarce resources, but the increase in travelling times may limit this in rural areas. The seven-day service standard for acute stroke services requires an increase in the stroke workforce. Focus on cross-speciality or cross-profession accreditation of particular competencies, as set out in the NHS Long Term Plan, might help to address this.

The risk of stroke after a TIA is approximately 10% during the first few months. Furthermore, 5% will die due to a subsequent stroke within the first six months. Assessment and treatment within 24 hours after a TIA is critical. Timely initiation of secondary prevention post-TIA can reduce the relative risk of recurrence by 80%.

Intravenous thrombolysis (IVT) is one of the few approved acute treatments for ischaemic stroke. It improves long-term outcomes and is cost-effective. The benefits of IVT are highly time dependent. Although the current treatment window is 4.5 hours, treatment is more effective the earlier it is given.

There is overwhelming evidence for the effectiveness of mechanical thrombectomy in improving functional outcomes in patients treated within six hours of the onset of a proximal large vessel occlusion in the anterior circulation. One in 2.6 patients undergoing mechanical thrombectomy experience reduced disability and one in five achieve functional independence.

Urgent management of intracerebral haemorrhage by tight blood pressure control and reversal of anticoagulation improves outcomes.

5 - Acute care in the stroke unit (after immediate interventions)

Introduction

The health needs of the population of patients on a HASU who have recently had a stroke are:

- Restoration and maintainance of physiological homeostasis in the face of pre-existing co-morbidities, the stroke and its complications.
- Prevention, early detection and timely management of the complications of stroke and its treatments.
- Early rehabilitation from the multidisciplinary stroke team and specifically allied health professionals (AHPs) to maximise function.
- Identifying patients’ expected future care requirements via a multidisciplinary approach including the assessment for transfer to alternative settings for treatment.
- Appreciation of the need for patients, their families and their carers to be in receipt of information and psychological support in the aftermath of stroke.

Seventy-five per cent of patients with acute stroke admitted to hospital in the UK have at least one co-morbidity and one in ten have at least three. The conditions which may predispose to stroke (e.g. heart attack, atrial fibrillation, severe uncontrolled blood pressure) as well as its complications (e.g. pneumonia, early neurological deterioration) may all threaten life, and it is important that hyperacute stroke services are set up with the staffing and resources to provide round the clock acute care to identify and treat these conditions.

Results

Evidence based acute stroke care

National Clinical Guidelines for Stroke, set out recommendations for the provision of acute stroke care:

- Multi-disciplinary care for diagnosis, treatment, normalisation of homeostasis, early rehabilitation, prevention of complications and secondary prevention.
- Management protocols for the admission pathway including neurological and physiological monitoring, swallowing assessment, hydration and nutrition, vascular surgical referrals, rehabilitation, end of life care, secondary prevention, the prevention and management of complications, communication with people with stroke and their family/carers and discharge planning.
- Immediate access to brain imaging including CT angiography and should be capable of undertaking brain imaging as soon as needed.
- Protocols for monitoring and where necessary transfer of patients to regional neurosurgical centres for decompressive hemicraniectomy, surgical management of intracranial haemorrhage and the management of symptomatic hydrocephalus.

Rationale for physiological monitoring

Clinical benefits derive from monitoring and control in the acute phase of hypertension, hyperglycaemia, hypoxia, pyrexia and hydration. Training stroke unit staff in the use of standardised protocols to manage physiological status can significantly improve outcomes. Regular monitoring aims to identify:

Sepsis

During the first week 5% of people with acute stroke develop urinary sepsis and 9% require antibiotics for pneumonia. Patients with post stroke pneumonia have worse functional outcomes and mortality and infections require rapid treatment to avoid significant mortality and morbidity.

Hypertension

Approximately 30% of patients with acute stroke are hypertensive and those with severe hypertension are at increased risk of secondary ischaemic and haemorrhagic stroke as well as cardiac complications. Randomised controlled trials have provided better evidential support for acute blood pressure lowering post haemorrhage than ischaemic stroke, for which there is still uncertainty as to optimal management.

Fluid management

Dehydrated patients on admission have worse survival, and adequate fluids, nutrition and aspirin are associated with a 0.55
odds ratio of death. A Cochrane review of the signs and symptoms of impending and current dehydration in older people concluded that there is little evidence that any one symptom, sign or test have any diagnostic utility for dehydration – therefore multimodal assessment of hydration relying on objective physiological and biochemical parameters and clinical examination is recommended.

**Dysphagia**

Dysphagia is present in up to 35–78% of people who have a stroke and is a risk factor for poor nutrition and pneumonia. There is good evidence from a systematic review that the investigation of dysphagia with instrumental assessments helps predict outcomes and improve treatment outcomes. Rates of stroke associated pneumonia rise with delays to SLT assessment, with a 3% incidence with patients assessed immediately rising to a 5% incidence if not assessed by 48 hours.

**Neurological deterioration**

A rising National Institutes of Health Stroke Scale (NIHSS) or falling Glasgow Comas Scale (GCS) is indicative of a number of stroke complications that may require urgent potentially life-saving management including provision of clotting products for secondary bleeding, neurosurgery and the treatment of delirium.

**Disorders of cardiac rhythm**

Almost 20% of strokes are caused by atrial fibrillation (AF), but in many cases this is undetected on initial ECG. Prolonged monitoring results in increasing detection. Routine monitoring of cardiac rhythm is therefore needed.

**Rationale for the provision of intermittent pneumatic compression (IPC) devices**

Prospective studies have identified the risk of venous thromboembolism (VTE) in hospitalised stroke patients to be as high as 20–40%. The large, randomised controlled CLOTS3 trial found an adjusted odds ratio of 0.65 for VTE in patients with IPC stockings compared to those without. Accordingly, IPC stockings are recommended in national guidelines for stroke patients with reduced mobility.

**Rationale for the early involvement of AHPs**

Following a stroke, patients may have reduced ability to change position and posture. Therapeutic positioning, usually undertaken by physiotherapists, occupational therapists or skilled nursing staff aims to reduce skin damage, limb swelling, shoulder pain or subluxation, and maximize functional recovery. Good positioning may also help to reduce respiratory complications and avoid compromising hydration and nutrition. An evidence base for the benefits of therapeutic positioning is lacking but it is recommended by the national guideline that a specialist assessment for positioning take place as soon as possible within four hours of arrival in hospital and that trained stroke unit staff then ensure appropriate positioning at all times.

The AVERT trial examined the functional benefits of very early mobilisation after stroke within 24 hours. The trial was negative and reported adverse consequences. Consequently, it is recommended that very early mobilisation after stroke should only be conducted after specialist assessment of mobility with a tailored plan according to individual needs.

**Cost and bed requirements**

The recommended staffing level of AHPs on hyperacute stroke units are 0.73 whole time equivalent (WTE) PT, 0.68 WTE OT and 0.34 WTE SALT per five beds. The approximate estimated cost for this level of staffing is £384,082 per annum for a five-day service working on a 20 bedded HASU. The corresponding figure for weekend working is £222,768.

**Summary**

People who have had a recent stroke are likely to have a number of acute care needs relating to the need to maintain physiological homeostasis in the face of their co-morbidities, the stroke itself, its treatments and its complications. Adequate medical and nursing staffing and the ability to monitor physiological and neurological parameters are required to optimise patients’ clinical conditions. Allied health professionals have an important role in early determination of levels of physical function and to enhance mobilisation, positioning and swallow care. A multidisciplinary team-based approach is required to determine the correct pathway for onward care.

**6 - Rehabilitation in hospital**

**Introduction**

Stroke rehabilitation is a multidimensional process, which is designed to facilitate restoration of, or adaption to the loss of physiological or psychological function when reversal of the underlying pathological process is incomplete.

There is a substantial body of trial-based evidence and other research to support both the effectiveness and cost effectiveness of stroke rehabilitation both in hospital and in the community. Despite initial costs, these acute costs are offset by longer term savings in the cost of community care. The health and societal cost consequences are improved because more effective stroke care will reduce long-term rehabilitation and care cost.

Meta-analysis of stroke unit trials has demonstrated a clear and clinically significant improvement in mortality and morbidity and reduced institutionalisation rate. The trials pre-date acute interventions such as thrombolysis and thrombectomy so the benefits are a result of coordinated care with higher-quality nursing care and rehabilitation.

The rehabilitation team is typically made up of physiotherapists, occupational therapists, speech and language therapists, orthoptists, clinical psychologists, nurses, generic rehabilitation workers and dieticians. Competencies are described in the Stroke Specific Education Framework. Nurses and stroke physicians contribute to the rehabilitation team but have wider responsibilities.

There is evidence for a dose response to rehabilitation. Current guidelines recommend 45 minutes of each relevant therapy for at least five days a week as a pragmatic choice. However,
it is likely that the ideal amount is higher than this and will vary in intensity and delivery from patient to patient.

Rehabilitation should continue for as long as a patient is willing and capable of participating and showing measurable benefit from the intervention both in hospital and in the community. Recent SSNAP data shows that there are still significant proportions of patients who do not receive the amount of rehabilitation that is recommended\(^{166}\). It is also evidenced that stroke survivors who are younger, those with lower pre-morbid disability, less severe stroke, those who have had an infarction, and those with few medical complications receive more intensive intervention\(^{167}\).

A patient centred approach is recommended, with goals that are agreed with the individual, and promote their engagement in their recovery. Self-management has been defined in various ways, but many programmes refer to the ‘actions and confidence of individuals to manage the medical and emotional aspects of their condition in order to maintain or create new life roles’\(^{156,160}\). A Cochrane review\(^ {170}\) of 14 trials showed that self-management programmes improved quality of life in people with strokes and improved self-efficacy when compared with usual care. Programmes mainly focus on supporting the knowledge and skills required to self-manage and range from educational approaches to interventions to support behaviour change.

**Results**

**Acute stroke rehabilitation**

An individual should be screened on arrival at hospital for problems, including but not limited to: orientation; swallowing; continence; positioning/function; and communication\(^{179}\). At present, guidelines suggest starting rehabilitation as soon as possible after stroke, however, it is evidenced that high intensity mobilisation in the first 24 hours after symptom onset should not be offered\(^{168}\). A non-randomised study exploring the implementation of evidence based in-hospital rehabilitation\(^ {171}\) showed that appropriately delivered, high intensity, specialist rehabilitation early post stroke leads to better functional outcomes for stroke patients.

**Movement and mobility**

A Cochrane review\(^ {162}\) examined physical rehabilitation approaches for the recovery of function after stroke. Many of the interventions were heterogeneous and the studies were poorly reported. Physical rehabilitation had a significantly beneficial effect, compared with no treatment, indicated by improved independence in activities of daily living scales, and this effect persisted beyond the length of the intervention period\(^ {162}\).

The most recent evidence suggests that thirty to sixty minutes daily, seven days a week is better than five days a week\(^ {159}\). This is supported by the NHSE Long Term Plan\(^ {172}\). No one physical rehabilitation approach was more or less effective than any other approach in improving independence\(^ {172}\). Therefore, clinical selection of the most appropriate physical treatments should be undertaken using evidenced-based interventions and critical clinical decision making. Evidence is robust showing that people with impaired balance and walking ability benefit from balance training and strengthening exercises\(^ {173,174}\). Task specific walking training at an intensity to improve cardiorespiratory fitness and muscle strength has been shown to be beneficial\(^ {162}\). Treadmill training for patients able to walk\(^ {175}\) and for some patients who need partial body weight support during exercise can also be beneficial\(^ {176}\). Where patients have poor mobility there is still good evidence to support the use of exercise to improve fitness and strength\(^ {177}\).

**Vision**

The incidence of acute stroke-related visual impairment is 60%\(^ {178}\) and it causes a considerable degree of disability\(^ {179}\). For many, it results in inability or altered ability to undertake many aspects of daily activities with impact on return to work, participation in hobbies and family life, and can lead to social isolation, altered mood and depression\(^ {180-182}\). Interventions for stroke-related visual impairment are well established but require referral to appropriate eye care services, facilitated through orthoptic services\(^ {182}\). Cochrane reviews for interventions for disorders of eye movements, age-related visual problems and visual field defects in patients with stroke examined vision rehabilitation approaches for the recovery of visual function\(^ {183-185}\). There is limited evidence which supports the use of compensatory scanning training for patients with visual field defects and co-existing visual neglect to improve scanning and reading outcomes.

**Upper limb recovery**

Improving upper limb function is a core element of stroke rehabilitation needed to maximise patient outcomes and reduce disability\(^ {186}\). A Cochrane review exploring the current body of moderate-quality evidence showed a beneficial effect of constraint-induced movement therapy (CIMT), mental practice, mirror therapy, interventions for sensory impairment, virtual reality and a relatively high dose of repetitive task practice. Moderate-quality evidence also indicated that unilateral arm training may be more effective than bilateral arm training\(^ {186}\). Electromechanical and robot arm assisted training may also be beneficial to improve arm function\(^ {187}\) and there is some evidence that intensive arm rehabilitation even late after stroke can have some benefits in improving activities of daily living\(^ {188}\).

**Psychological support**

Few randomised controlled trials and even fewer systematic reviews have assessed the effectiveness of psychological support for stroke patients. Those that have been undertaken include studies of psychotherapy, yoga and mindfulness. Several interventions which potentially could provide psychological support for stroke patients have, yet, only been assessed for their feasibility. For example, computerised cognitive behavioural therapy to treat depression and anxiety\(^ {189}\), art therapy, facilitated by an art psychotherapist\(^ {190}\) and the introduction of different exercise methods such as yoga for post stroke depression and anxiety\(^ {191}\). Similarly, feasibility studies of interventions to improve the psychological wellbeing of carers of individuals who have had a stroke have been reported in the literature, although these are not hospital delivered studies\(^ {192}\).
The NICE Quality Standard for stroke in 2016\textsuperscript{163} suggests that all adults who have had a stroke have access to a clinical psychologist with expertise in stroke rehabilitation. However, the overwhelming lack of psychological services for stroke survivors needs urgently addressing\textsuperscript{156}.

Cognitive rehabilitation
This area of stroke management is poorly evidenced, and guidelines are largely based on best practice. The 2016 National Clinical Guideline for Stroke\textsuperscript{159} states that cognitive impairment is associated with poor outcomes after stroke, such as increased length of hospital stays and reduced independence. It is recommended that cognitive rehabilitation begins at an early stage to aid overall recovery, as cognitive losses are probably present in the early post-stroke period for many stroke survivors, including those without limb weakness.

The DRESS trial (a feasibility randomized controlled trial of a neuropsychological approach to dressing therapy for stroke inpatients) demonstrates the potential benefits of a systematic neuropsychological approach to dressing therapy, particularly for patients with right hemisphere damage\textsuperscript{156}. A Cochrane review\textsuperscript{104} of 19 studies assessing the improvement of cognition on executive function found limited evidence that different interventions resulted in statistically significant improvements.

Communication
Communication difficulties that occur after stroke include aphasia, dysarthria and apraxia of speech. Evidence of the effectiveness of SLT for dysarthria is limited (five small RCTs) and apraxia but expert group recommendations support SLT intervention\textsuperscript{196,197}. A Cochrane review of 57 trials found that speech and language therapy input for people with aphasia resulted in clinically and statistically significant benefits to patients' functional communication, reading, writing, and expressive language. There was some evidence to suggest that SLT-directed social support had an active role in stimulating language, but significantly more patients disengaged from these social interventions than more formal therapy services\textsuperscript{198,199}.

The Big CACTUS study assessed self-managed computerised speech and language therapy (CSLT) as a means of providing more therapy than patients can access through usual care alone\textsuperscript{200}. It found that augmenting usual care with the SLT-facilitated software which the patient then self-managed at home resulted in a clinically significant improvement in personally relevant word finding but did not result in an improvement in conversation\textsuperscript{200}. Preceding this trial, a systematic review of data trials found no evidence of a difference between SLT-directed computer facilitated SLT and face-to-face therapy with the therapists\textsuperscript{198}.

The RELEASE Collaboration found that based on 1766 individual participants’ data from 45 RCTs using network meta-analysis, the highest functional communication gains following aphasia were associated with SLT 4–5 times weekly, and with up to two hours rehabilitative therapy time weekly\textsuperscript{201}. Overall language benefits were greatest in the context of 20–50 hours of therapy in total. A large meta-analysis found that the highest language gains were associated with SLT starting within 28 days of aphasia onset though significant gains were also observed amongst participants that started SLT intervention more than six months after aphasia onset.

Orthotics
Many stroke survivors benefit from orthotic devices to promote independence\textsuperscript{202}. Orthotics is a critical aspect to the success of a rehabilitation programme and in turn are both beneficial and cost effective\textsuperscript{203}. Whilst some evidence is available focusing on lower limb orthotic use following stroke, the majority of the research is not robust due to small sample sizes, methodological weaknesses and poor-quality descriptions of the intervention. Current recommendations around orthotic intervention following stroke are largely based on NICE Clinical Guidelines for stroke rehabilitation.

Continence
Loss of bladder and bowel control is common in the acute phase of stroke and may persist into the later stages of recovery and beyond. Current guidance suggests that stroke unit staff be trained in continence assessment and management protocols, with catheter use only when indicated to relieve urinary retention\textsuperscript{159}. Where possible, the stroke survivor should be engaged/involved with any decisions and offered behavioural interventions such as timed toileting. Current recommendations are largely based on NICE guidance and ICWSP consensus\textsuperscript{199,204}. A recent Cochrane review found that behavioural interventions may reduce the mean number of incontinence episodes in 24 hours but may make little or no difference to quality of life.

Summary
There is strong evidence that a coordinated multidisciplinary team approach including rehabilitation results in a reduction in death, institutionalisation, and dependency. Current UK guidelines recommends that patients should ‘accumulate at least 45 minutes of each appropriate therapy every day at a frequency that enables them to meet their rehabilitation goals’. National audit data have shown improvements towards this target particularly via seven day working. Despite the advances, stroke survivors and their families still perceive services fall short of their needs. Further work is required to identify the optimal timing, dose and content of hospital delivered rehabilitation.

7 - Rehabilitation in the community
Introduction
Patients are being discharged from hospital more quickly than ever before, with the length of stay reducing considerably since 2001\textsuperscript{205}. Most stroke survivors have ongoing medical, rehabilitation and psychosocial needs\textsuperscript{206}. A third of these patients are discharged to an early supported discharge (ESD) or community rehabilitation team. The stroke survivors discharged via these routes are usually cared for by stroke or neurology specialist teams\textsuperscript{207}.

The Stroke Association in their document ‘State of the Nation – Stroke Statistics’\textsuperscript{208} state that out of over one million stroke survivors in England, Wales and Northern Ireland, 84% were
discharged from hospital requiring help with their daily living activities, but 20% of those who needed help did not receive it. On average, stroke survivors receive less than half the amount of rehabilitation recommended by national guidelines and many report feeling ‘abandoned’ after leaving hospital\textsuperscript{206}. It is well evidenced that stroke survivors’ symptoms can continue to improve long after their hospital stay, and specialist rehabilitation should continue in the community to enable return to a higher quality of life. New evidence is suggestive that improvements can be seen up to three years after initial onset\textsuperscript{210}.

Results

Leaving hospital

The National Clinical Guideline for Stroke recommends that before the transfer of care from hospital to home or care home occurs ‘the person and their family/carers should be given information and offered contact with relevant statutory and voluntary agencies’\textsuperscript{208}. Data shows that approximately half of the stroke survivors being discharged from hospital have been assessed for all appropriate therapies and have agreed goals for their ongoing rehabilitation. At present stroke survivors requesting psychological support wait on average over three months for review, and even then, services are limited. One in five commissioning areas do not offer access to speech and language in the community\textsuperscript{209}.

There is evidence that occupational therapy (OT) led home visits for older people result in more input from OT in terms of aids and equipment but are not effective in improving activities of daily living and participation. For those entering institutionalised care, few stroke survivors have a pre-discharge visit to the care home and there is little evidence of how to enhance discharge planning\textsuperscript{211}.

Early supported discharge

Clinical trials have shown that appropriately resourced ESD services with co-ordinated multidisciplinary team input, can reduce long-term dependency and admission to institutional care as well as reducing the length of hospital stay and are clinically and cost effective\textsuperscript{206,212,213}. Sentinel Stroke National Audit data shows that the percentage of patients discharged from hospital with an ESD service has improved steadily from 25% in 2014/2015 to 39% in 2018/2019\textsuperscript{206}. Most patients are reviewed within one day after discharge and remain within the service for a median of 37 days. However, ESD is only appropriate for approximately 40 percent of the stroke population, and current figures suggest that one fifth of hospitals in England, Scotland and Wales are unable to offer this service\textsuperscript{206}.

Care homes

Rehabilitation standards\textsuperscript{214} highlight that no patient with stroke should be discharged to permanent institutional care without a comprehensive assessment of their potential for rehabilitation. Patients discharged to a care home tend to be more disabled with more complications such as incontinence, dysphagia and pneumonia\textsuperscript{215}. Complications can develop further in care homes with contractures, pain and depression\textsuperscript{216}. Models of care found to be successful in domiciliary settings\textsuperscript{217,218} have not demonstrated benefit in care home populations\textsuperscript{219}.

Carer interventions

Multiple systematic reviews have been undertaken in recent years investigating non-pharmacological interventions\textsuperscript{220} and psychological interventions for carers of stroke survivors\textsuperscript{221}. The most recent systematic review and meta-analysis of psychosocial interventions\textsuperscript{221} for stroke survivors and carers found that psychosocial interventions reduced depressive symptoms in carers, but found limited evidence for reductions in anxiety symptoms, or improved quality of life and coping, and no evidence for improvement in self-efficacy, carer strain or carer satisfaction. A trial of a structured training programme for caregivers of inpatients after stroke found no benefit\textsuperscript{221}.

Community based therapy and longer term stroke care

A 2017 systematic review including 49 occupational therapy and physiotherapy studies reported moderate improvements in ADL and noted a positive effect of carer training\textsuperscript{222}. A systematic review\textsuperscript{223} looked at the impact of rehabilitation therapy delivered by a physiotherapist or occupational therapist in randomised controlled trials of stroke patients resident in the community more than one year after stroke onset. This concluded that there was a lack of evidence of effectiveness for the heterogeneous interventions included in the review. The publication of the EXTRAS (Evaluation of an Extended Stroke Rehabilitation Service) randomised controlled trial and economic analysis, evaluated a new longer-term community stroke rehabilitation service which commenced when routine ESD ended\textsuperscript{224}. The results highlighted that, while there was no significant improvement in primary outcomes, such an intervention could be both cost effective and improve health-related quality of life and satisfaction with service provision.

Vocational rehabilitation

One in four strokes occur in people of working age, but most stroke survivors who were in employment do not return to work after their stroke\textsuperscript{225}. Non-return to work is associated with worse psychological wellbeing\textsuperscript{226}, and likely contributes to the economic burden of stroke. Despite this, we found little evidence relating to vocational rehabilitation in stroke. The ongoing RETAKE trial is a multi-centre RCT evaluating early vocational rehabilitation in stroke and will provide evidence on the effectiveness of supporting adults to return to work after stroke\textsuperscript{227}.

Spasticity services

There is strong evidence supporting the use of botulinum toxin type A in reducing spasticity and improving passive function\textsuperscript{228,229}. A systematic review found that treatment significantly reduced spasticity and increased range of motion compared to control\textsuperscript{230}.

Summary

In recent years, stroke survivors have increasingly been discharged early from hospital into the care of community services. ESD can be clinically- and cost-effective, but ESD
8 - Follow-up and long-term support after stroke

Introduction

Survivors of stroke are often left with long-term physical impairments impacting on daily life and limiting their activities. After discharge from hospital and community stroke care, many stroke survivors have ongoing medical, rehabilitation, psychological and other needs. They also have a heightened risk of recurrent strokes. Improvements in the delivery of follow up care and secondary prevention could reduce the risk of further vascular events, disability and death. It could also improve stroke survivors’ and carers’ psychological status, social participation and emotional well-being.

Long-term needs identified by stroke survivors include mobility aids, home adaptations, housing, financial support, information and transport\(^\text{231}\). A survey of stroke survivors one to five years following stroke found unmet long-term clinical and social needs. More than half of respondents (54\%) found stroke information to be inadequate. Respondents reported a negative impact on work (52\%) and leisure activities (67\%)\(^\text{32}\). Home help/personal care and therapy are also common unmet needs\(^\text{231}\).

Primary care (see Section 2)

Primary care plays a key role in the ongoing medical care of stroke patients and in reinforcing education, support, lifestyle alterations and secondary prevention. It is well placed to identify deterioration in function which may occur post discharge and arrange for referral for further therapy. For successful discharge, the GPs and community staff should receive adequate information from the hospital prior to discharge. GPs should aim to enable patients to receive appropriate rehabilitation to maintain and improve levels of functioning while monitoring the patient’s physical and emotional well-being. Secondary prevention, medication and lifestyle interventions for patients after stroke should also be monitored in primary care.

The Quality and Outcomes Framework (QOF) was introduced into UK primary care in 2004 and is one of the most ambitious endeavours to immerse preventive efforts into the health system. It offers financial incentives to general practitioners for a wide range of care processes and outcomes. Research carried out by the Health Foundation using a dataset covering 50 million patients in England found an association between GPs achieving the QOF indicators and a reduction in hospital costs and lives saved, particularly for stroke care. It estimated that a one-percentage point increase in the stroke QOF score is associated with a £16.5 million annual reduction in total patient costs. Over the period studied, the mean practice QOF stroke score increased by 10 percentage points, suggesting that improvements in primary care for stroke may have reduced secondary costs by £165 million over a four-year period from 2004–2008\(^\text{234}\).

Secondary prevention

Stroke survivors have an elevated risk of a further stroke, which is usually more severe and disabling than the primary event\(^\text{235}\). The risk of recurrent stroke in survivors is 3.1\% at 30 days, 11.1\% at one year, 26.4\% at five years, and 39.2\% at 10 years after initial stroke\(^\text{236}\). Immediate and sustained implementation of effective secondary prevention strategies in patients with first-ever stroke has the potential to reduce the burden of stroke by up to a quarter\(^\text{235}\).

The extent to which GPs comply with national guidelines recommending that stroke survivors’ needs be assessed at regular intervals after stroke is also unknown. A survey completed by 300 GPs revealed that a structured assessment of stroke survivors’ needs was not offered by 31\% of GPs, only half the GPs reported integrating the information obtained into care plans, and only a quarter of GPs had a protocol for follow-up of identified needs\(^\text{237}\).

The Stroke PROTECT (Preventing Recurrence Of Thromboembolic Events through Coordinated Treatment) programme in the US systematically implements, at the time of acute TIA or ischemic stroke admission\(^\text{238}\), medication/behavioural secondary prevention measures known to improve outcome in patients with stroke. Adherence rates in patients without specific contraindications were 100\% for antithrombotics, 99\% for statins, 92\% for angiotensin-converting enzyme inhibitors/angiotensin receptor blockers, and 80\% for thiazides. Awareness of the importance of calling 911 in response to stroke was 87\%. Adherence to diet and exercise guidelines were 78\% and 70\%, respectively. Of the 24 smokers, tobacco cessation was maintained in 20 (83\%). High rates of adherence to PROTECT therapies were maintained at 90 days after hospital discharge\(^\text{238}\). Longer term adherence to secondary prevention measures in the years following a stroke is a more accurate marker of success however, and this was not investigated in the PROTECT programme. Furthermore, a number of initiatives to improve adherence to preventative measures after stroke have failed. This includes the STOP stroke study, which trialled a definitive risk factor management intervention on stroke survivors and their general practitioners based on a framework for complex interventions proposed by the UK Medical Research Council\(^\text{239}\).

Evidence-based recommendations for the medical interventions for physiological risk factors are also presented in the National Clinical Guidelines for Stroke. These include treatment for blood pressure, and lipid lowering, antiplatelet and anticoagulation treatments. The guidelines further recommend that people
with stroke or TIA should receive a comprehensive and personalised strategy for vascular prevention including medication and lifestyle factors, which should be implemented as soon as possible and should continue long-term. People with stroke or TIA should also receive information and advice about stroke, vascular risk factors and medication for secondary prevention.\(^{240}\)

Evidence for lifestyle interventions relates mainly to the primary prevention of vascular events. The Stroke Association estimates that an atrial fibrillation screening programme could avoid 500 new strokes each year. Appropriate anticoagulant management of atrial fibrillation in all eligible patients could avert an estimated 4,551 strokes each year. A successful strategy to increase the proportion of diagnosed hypertension cases by 15% could potentially avoid 10,790 new cases and 4,138 prevalent cases of stroke over five years.\(^{241}\)

Changes in lifestyle are as important in secondary prevention as they are in primary prevention; however, there is limited evidence of lifestyle modifications translating into a reduction in stroke recurrence or mortality. Patients fulfilling all five criteria of low-risk lifestyle (no smoking, regular physical activity ≥ 30 min per day, healthy nutrition, moderate alcohol consumption, BMI < 25 kg/m\(^2\) ) have a reduced stroke risk by 80% as compared to patients fulfilling none of these criteria.\(^{242}\)

**On-going rehabilitation**

Research has identified the benefits of ongoing rehabilitation for stroke survivors.

- In a review of fifteen trials including 700 participants, therapy interventions delivered more than six months after stroke provided a small but significant 8% improvement from baseline in walking measures, together with a non-significant improvement in activities of daily living.\(^{243}\)
- In a review of 57 studies, speech and language therapy at high dose or over a longer period may be beneficial to improved language and communication in stroke survivors.\(^{244}\) A small two-week increase in intensive aphasia treatment contributes substantially to recovery from post-stroke aphasia.\(^{245}\)
- A Cochrane review of nine trials including 1,258 patients found that occupational therapy delivered to patients after stroke and targeted towards personal activities of daily living improved performance and reduced the risk of poor outcome (death, deterioration or dependency in personal activities of daily living).\(^{246}\)
- Greater adherence to post-acute stroke rehabilitation guidelines has been associated with improved patient outcomes.\(^{247}\)
- A trial compared a new evidence-based system of care aimed at meeting the longer-term needs of stroke survivors and their carers living at home in the community. Usual practice was delivered by Stroke Care Coordinators (SCC) incorporating structured assessment focused on patient- and carer-centred problems and associated evidenced-based treatment algorithms. However, it showed no benefit for clinical effectiveness or cost-effectiveness outcomes for the system of care compared with usual SCC practice.\(^{248}\)

**Integration with social care**

There is evidence to suggest that health and social care integration has a positive effect on patient outcomes.

- The NHS Torbay Model has delivered improved outcomes, with health and social care workers operating together in a single team under the leadership of a manager in charge of all health and social care services. This initiative saw the daily average number of occupied beds fall, and the lowest emergency bed day use in the population aged 65 in the region.\(^{249}\)
- A successful model of integrated, cost effective care in the US, Kaiser Permanente, integrates inpatient and outpatient care with doctors, specialists and health care workers as part of one connected team. Furthermore, the system integrates funding with provision of service, focuses on minimising hospital stays, teaches patients how to care for themselves and places emphasis on skilled nursing. This has resulted in much lower hospital admissions and shorter lengths of stay, and has provided much better value than the NHS, largely by using only a third of the acute bed days used by the NHS.\(^{250}\)

**Supported self-care/management**

Patients with high self-efficacy function better in terms of mobility, activities of daily living and quality of life than patients with low self-efficacy. A Cochrane review of 14 trials with 1863 participants found that self-management programmes may benefit people with stroke who are living in the community. The benefits of such programmes lie in improved quality of life and self-efficacy. Stroke services need to consider how to develop the knowledge and skills in rehabilitation staff to support self-management, and how to provide psychological interventions as an adjunct to more familiar physical treatments, including in community stroke services.\(^{251}\) Future research should focus on managing the emotional, medical and social tasks of long-term survivorship.\(^{252}\)

**Six-month reviews**

Many stroke survivors have difficulty accessing the support they need and may experience changes in their needs over time, which may result in avoidable deterioration.\(^{253}\) Six-month reviews for stroke survivors may help to identify any unmet needs and signpost them to appropriate, targeted support that is available to meet their needs.\(^{254}\) They also help survivors and their families continue to feel supported after stroke, and provide the chance to access any advice, support, information and rehabilitation that may be needed.\(^{255}\)

Evidence suggests that contrary to the recommendations proposed, the completion of reviews is inadequate. The Sentinel Stroke National Audit Programme’s clinical audit reported that
out of 19,671 patients considered to be applicable to receive a six-month follow-up assessment, only 31.5% received a review from April 2017–July 2017\cite{253}.

NHS England has developed the Commissioning for Quality and Innovation Scheme (CQUIN); a pay for performance scheme aimed at providers contracted under the NHS standard contract to deliver healthcare services. The CQUIN prioritises the conduct and recording of six-month post-stroke reviews, with a view to reducing the risk of subsequent vascular disease, looking back on treatment efficacy to inform future system planning and looking for further service improvement opportunities for people beyond six months post stroke\cite{251}.

Despite the guideline recommendations, long-term stroke management, including follow-up reviews, has been a neglected area in both clinical service development and research\cite{252}. At present, there is not a strong evidence base regarding the benefits of stroke reviews in terms of patient outcomes\cite{254}. Limited provision of six-month post-stroke reviews has resulted in weakened data on stroke care, pathways and outcomes locally and nationally. This has limited understanding of the scale of the stroke rehabilitation and ongoing care challenge.

**Patient reported outcome measures/experiences (PROMs/PREMs)**

Patient-reported outcome measures (PROMs) offer enormous potential to improve the quality-of-care provision of patient-centred health services. They provide validated evidence of health from the point of view of the user or patient. They may be used to assess levels of health and need in populations, and in users of services, and over time they can provide evidence of the outcomes of services for the purposes of audit, quality assurance and comparative performance evaluation. They may also improve the quality of interactions between health professionals and individual service users\cite{255}.

In the Swedish healthcare system, one-fifth of national quality registers report examples of how patient-reported data are used for local quality improvement. This includes enhancing shared decision-making in clinical encounters (most common), as a basis for care plans, clinical decision aids and treatment guidelines. Recent advances in the technical capabilities to electronically administer PROMs make this feasible. Further research is needed to evaluate PROMs tools in stroke clinical trials\cite{256}.

**Summary**

Follow-up care and long-term support for stroke survivors and their families are not meeting their needs or expectations. There is insufficient evidence of improved patient outcomes following primary care, community-based stroke rehabilitation and social care integration in accordance with best practice guidelines.

Medical interventions for the secondary prevention of stroke are addressed by national guidelines (Section 2). There is less evidence that lifestyle interventions and follow up in primary care effect sustained reductions in risk.

The need for ongoing post-stroke rehabilitation has been identified, however, patients’ needs remain unmet due to shortfalls in the provision of ongoing therapies after stroke. Supported self-care and management of stroke survivors is outlined in national guidelines, however there is limited evidence of effectiveness of programmes. Furthermore, the completion of six-month and annual reviews for stroke survivors has been found to be inadequate, despite guideline recommendations for the provision of post-stroke reviews to identify unmet care needs. Work has been undertaken regionally in England to address this shortcoming; however, the integration of a structured and standardised six-month review is required on a national level.

Models of social care integration focus on generic health conditions. There is currently no stroke specific model of health and social care integration.

Stoke patient reported outcome and experience measures are beginning to gain recognition. There is further need for the development and application of stroke specific tools to assess patient outcomes relating to care and rehabilitation. There has also been a reduction in the number of sites seeking patient and carer views on stroke services.

**9 - Emerging technology and innovation in stroke care delivery**

**Introduction**

Emerging technologies have the potential to complement and replace some current practices in stroke research, prevention, diagnosis, acute and longer-term management including rehabilitation, as well as to improve timely access to care\cite{257}. However, these technologies are mostly still in the development stage, and although their application in the future has potential to reduce stroke morbidity and mortality, the value of implementing them at the system and population level still requires evaluation.

**Results**

**Digital healthcare and interventions**

Digital healthcare refers to a combination of medical science, delivery systems and emerging information technologies for the generation, structure, storage and analysis of health data and the extraction and presentation of useful and actionable insight from it.

There are five broad areas of applications for digital healthcare interventions:

- **Administrative systems**: Interventions in this area focus on managerial functions such as supply chain management, health financing and human resources, data storage and structure.
- **Cohort-based analytics**: Interventions in this area focus on solving health care systems information challenges, allowing to improve health information access and data utilisation, as well as to inform decision regarding population health.
• Personalised medicine: Interventions in this area provide a framework to improve quality of care by integrating data from several sources (i.e. electronic health records, prescription history, investigations results, genomic data), and providing clinical decision support systems.

• Real-time healthcare: Leverages the use of new technologies such as wearables, sensors and smart devices to improve personal health tracking, improving patient self-care, engagement and empowerment.

• Scientific and business process systems for research and development: Interventions in this area provide support to research activities by providing platforms for trial management, data management, manipulation and analysis, improved documentations and replicability and logistic support.

Genomics
As a result of technological advances, the study of the molecular mechanisms underlying stroke has shifted from relying only on single candidate gene association studies, to more comprehensive analyses such as genome-wide association studies (GWAS), RNA and protein analysis, and epigenetics providing a more detailed understanding of the genetic basis of stroke.258,259. The identification of novel genetics leads for the biochemical and cellular mechanisms of stroke have wide-ranging applications of clinical interest, from a better understanding of genetic variation associated with stroke and vascular risk factors260 to the impact of molecular mechanisms in stroke severity and prognosis.260.

Examples of applications of this technology to improve stroke care include improved understanding of genetic markers for stroke subtypes261,262 and vascular risk factors263,264, more accurate prediction models262,265,266, use of pharmacogenetics to predict response of current treatments267,268, develop stroke subtype specific management strategies269 and identification of new therapeutic targets261,262,270. All these advances require the links between the established Genomics England initiative with the stroke population through UK Biobank and emerging clinical networks.

Telemedicine
Telemedicine and telehealth consist of a network of audiovisual communication and computer systems for delivery of clinical services and make use of the advances in high-speed data transfer and data security to provide remote centres with the expertise usually only available in urban centres. These greatly expand the potential coverage of the stroke care network and improve access to high-quality stroke care with optimal patient safety and data protection.

Telemedicine has applications in the acute and post-acute phases of stroke care. In the acute phase, there is evidence suggesting that telemedicine networks enable stroke-specific procedures to be performed safely by less experienced clinicians under the guidance of stroke medicine specialists. Studies have shown that telemedicine can lead to earlier initiation of stroke therapy performed safely and effectively with intravenous thrombolysis (IVT)271. Hospitals are also able to recognise earlier patients requiring advanced care, thus reducing delays in transfer times to designated IVT centres. Telemedicine networks can also be used to select and enrol patients into acute stroke trials, allowing for a more representative sample of the population as well as increased recruitment.

For post-acute stroke care, many studies evaluating the use of telemedicine for stroke physical and cognitive rehabilitation have failed to show a difference between tele-rehabilitation and face-to-face therapy or have shown greater improvement in the tele-rehabilitation group.

Mobile stroke units (MSU)
Timely access to care remains one of the most critical barriers to adequate stroke care and efficient use of our current services. MSUs provide a possible solution, particularly in rural areas. A randomised controlled clinical trial demonstrated that MSUs could potentially reduce the time from call to therapeutic decision272. Nonetheless, additional research is still required to evaluate the safety and, particularly, the cost-effectiveness of these units273 which relies on significant long-term quality-adjusted life-years mediated by access to earlier treatment to offset the substantial costs associated with start-up and maintenance of this technology274.

Imaging modalities
New imaging techniques have the potential to improve stroke prevention, diagnosis and management. Examples of these new imaging modalities include:

• Vessel wall MRI275, which provides high-resolution analysis of both extracranial and intracranial vasculature to help identify previously occult lesions or give a better overview of lesions that portend a worse prognosis.

• Four-dimensional dynamic CTA275 (4D-CTA) that combines the functional imaging of fluoroscopy with the 3D capabilities of CT. 4D-CTA provides a less invasive alternative to digital subtraction angiography and offers a useful approach to determine the extent of the clot burden and examine the degree of collateral blood flow in large atherothrombotic strokes276.

Artificial intelligence (AI)
Recent studies have shown promising applications in fields such as:

• Stroke recognition in the emergency department, where a small cluster randomised trial277 and a retrospective study278 showed that artificial neural networks (ANN) could be used to differentiate ischaemic strokes from stroke mimics.

• Patient selection and outcome prediction, where ANNs have shown potential to predict outcomes in patients undergoing invasive interventions such as mechanical thrombectomy278 and carotid artery stenting279.

• Neuroimaging to automatically and reliably calculate the ASPECT score280, and to identify interdependence
in brain regions and reveal predictive relationships between lesion site and outcomes281.

• In population health, by providing a reliable method of predicting and forecasting the number of stroke recurrences282 and major cardiovascular events279.

Robotics
The use of robot-assisted therapy, in particular for upper limb, is an emerging field of research and could help therapists to provide high-intensity, repetitive, and task-specific treatments based on neuro-plasticity theories. Evidence from a meta-analysis of 14 randomised controlled trials suggests that robot-assisted rehabilitation was more effective in improving motor function recovery, particularly in chronic strokes283. A large RCT has recently found that although robot assisted training did improve upper limb impairment this did not translate into improvement in arm function284. A more extensive meta-analysis showed that robotic training produces better outcomes than conventional treatment in a subgroup of patients with severely impaired lower limb function; however, no difference was found between traditional and robotic-assisted therapy in other scenarios285.

Summary
New technologies applicable to healthcare can be classified into five broad areas: administrative systems, cohort-based analytics, personalised medicine, real-time healthcare, and scientific and management process systems. Emerging technologies have the potential to complement or replace some current practices in stroke prevention, diagnosis, acute management and rehabilitation, longer term care, research, and audit, particularly in outpatient and community settings for assessment and management.

In terms of personalised care, advances in genetics and molecular biology have helped us achieve some understanding of the mechanisms underlying stroke that have the potential over time to develop more targeted therapies. Advances in the technology used to image the brain have the potential to improve diagnosis and target secondary prevention therapies. Artificial intelligence and robotics are emerging technologies that can assist healthcare professionals to improve stroke patients’ care.

The application of communication technology to stroke care has resulted in telemedicine networks and ‘mobile stroke units’ that have the potential to scale up the coverage of high-quality stroke care to remote locations. The COVID-19 pandemic has brought telehealth to the fore and it appears to be feasible and safe yet the development and spread of this technology requires robust evaluation.

10 - Effective system design
Introduction
Stroke is a long-term condition that requires a systems approach embracing prevention, acute care, long term care in primary and social care. In the NHS, this is currently proposed to be delivered through integrated and primary care networks, although their effectiveness has not been established and are essentially a remodelling of previous structures and processes in the NHS. The links with non-health aspects such as social care, highly pertinent to stroke, are also challenging as integration of workforce in public and other organisations (care homes, charities, other third sector) has no governance framework and pooling of budgets does not currently happen for prevention and longer-term care.

Results
Integrated pathways pre-hospital to acute
A recent meeting in Utstein, Norway developed a 10-step pathway for the development of high-quality care pre-hospital. It was developed with a group of international experts in emergency medical care both pre-hospital and from emergency departments and stroke specialists286.

Figure 2 summarizes the 10 programs and Figure 3 shows the key recommendations. The benefit of having these 10 steps is that it is then possible to pick any of these within a limited area, define responsibility and implement them locally. Figure 4 summarises the recommended standards for the stroke pathway.

Integrated stroke care in hospital
The evidence for stroke unit care is very strong. The Cochrane review from the Stroke Unit Trialists’ Collaboration included 28 trials, involving 5855 participants, comparing stroke unit care with an alternative service287. Better organised care was consistently associated with improved outcomes. Stroke unit care showed reductions in the odds of death recorded at final (median one year) follow-up (odds ratio (OR) 0.87), the odds of death or institutionalised care (OR 0.78) and the odds of death or dependency (OR 0.79). Outcomes were independent of patient age, sex, initial stroke severity or stroke type, and appeared to be better in stroke units based in a discrete ward. There was no indication that organised stroke unit care resulted in a longer hospital stay. Recent evidence also exists demonstrating the association between the ratio of registered nurses to beds on weekends and mortality after stroke288. There was a dose-response relationship between weekend nurse/bed ratios and mortality risk, with the highest risk of death observed in stroke services with the lowest nurse/bed ratios. In multivariable analysis, patients admitted on a weekend to a SU with 1.5 nurses/ten beds had an estimated adjusted 30-day mortality risk of 15.2% compared to 11.2% for patients admitted to a unit with 3.0 nurses/ten beds, equivalent to one excess death per 25 admissions. The key features of a stroke unit that should be provided throughout the in-patient care of the stroke patient are that it should be a geographically defined unit just caring for stroke patients, have a multidisciplinary team of clinicians who have stroke specific expertise and operating to agreed protocols.

Most of the trials included in the Cochrane review were trials of rehabilitation type stroke units rather than the hyperacute units described in the London case example and therefore it is important that the whole of the patient’s in-patient stay should be on a specialist unit, not just during the first few days.

Lessons from reconfiguring stroke care in London
1. Value of collaborative work between commissioners, managers from provider units, network staff and clinicians both in setting
Figure 2. The 10 components needed for high quality emergency stroke care.

Figure 3. 'Chain of survival' for emergency stroke care.

Figure 4. Stroke patient journey with consensus recommendations for timings.
up the services and maintaining the quality of the services through regular visits, support and inspections.

2. Setting very high-quality standards that are common across London and then rewarding their achievement through an enhanced tariff has been a very powerful tool for change.

3. Strategic planning for the whole population of London for a condition such as stroke, where centralisation of specialist services is the only way to enable all patients to get access 24/7 to the level of care needed, can be highly effective and should be considered for other services.

4. Patients and professionals will accept major service reorganisation if it can be shown to improve the quality of care and patient safety.

5. The stroke and cardiac networks and clinical director were instrumental in providing the bridge between the commissioners and providers, ensuring the quality is maintained and offering help and support to struggling units.

**Integrated pathways acute to community**

Early supported discharge schemes aim to transfer the management of the patient home as soon as practicable and then replicate stroke unit care in the community and to ensure that the transfer of care is achieved smoothly. Seventeen randomised controlled trials have been performed and the meta-analysis of these has shown that outcomes are better in terms of combined death and disability, combined death and requiring institutional care, death, activities of daily living, and patient satisfaction\(^\text{289}\). Carer stress is predictably slightly increased. Mean length of stay is reduced by eight days. These improved outcomes are achieved at slightly lower cost. The incremental cost-effectiveness ratio of stroke unit care followed by ESD is £10,661 compared with the general medical ward without ESD care and £17,721 compared with the SU without ESD. The service is applicable for up to 40% of stroke discharges in the UK.

**Barriers to introducing ESD**

In the UK, where ESD was first tested as a model of care, there is about 75% geographical coverage of the country but overall, only 39% of patients receive the services of an ESD team.

Pressure on in-patient beds increases year on year and schemes that can successfully transfer care to the community while maintaining or even improving the quality of care and outcomes is of value not just for the stroke patients but for the rest of the health service. The main problem in developing these services is that they require the transfer of resources and therefore income from hospital to the community. They also require close collaboration between hospital and community services to run effectively. This has proved difficult in England and is the dominant reason why not all areas have adopted an intervention that is clinically- and cost-effective.

**Integrated care: longer term rehabilitation and vocational rehabilitation**

Even with the best acute care there will still be a high proportion of patients requiring ongoing rehabilitation and support. Data from the population based South London Stroke Register showed that 20%–30% of stroke survivors had a poor outcome over ten years of follow-up\(^\text{290}\). So, for example, 110 individuals per 1,000 population were judged disabled from three months to ten years, and rates of anxiety and depression fluctuated over time but affected about a third of the population. While the rate of recovery after stroke is highest in the early weeks it is not the case, stated often by clinicians, that there is no prospect of further improvement beyond the first three to six months. Patterns of recovery vary between patients and different impairments seem to recover at different rates. There is evidence to show that late rehabilitation can have a beneficial effect on outcome, by reducing impairment, helping patients to become more independent through adaptation to their impairments and though cardio-respiratory and strength training resulting in higher levels of general fitness and therefore better performance\(^\text{291}\).

**Integrating stroke care with the management of other vascular diseases**

There are many overlaps between the needs of stroke patients and the prevention of stroke and other vascular diseases such as diabetes, renal disease and ischaemic heart disease. Patients with stroke often have other long-term conditions. Over 50% of stroke admissions have hypertension, 20% diabetes, 21% atrial fibrillation and 5% cardiac failure. One of the most frequent causes of death after stroke is ischaemic heart disease. Reducing the risk of stroke is achieved by adopting very similar strategies as are needed to prevent ischaemic heart disease, renal disease and diabetes. A frequently heard complaint is that they spend much of their lives attending medical clinics, often receiving contradictory advice or at best hearing the same messages repeatedly. Information systems are often not good enough to prevent the patient having to repeat the same stories endlessly to different clinicians none of whom have access to the thoughts and decision made by the others. While acute treatment is clearly different and each condition needs specialist input longer term support again often overlaps. Lessons learnt for one condition may not be understood by the others. So, for example, if a patient has an acute myocardial infarction they will usually be referred for cardiac rehabilitation with the aim of improving cardio-respiratory fitness. Stroke patients, even those with mild neurological impairments, are unlikely to be offered similar treatment even though there is evidence to show that it might be beneficial. In an attempt to integrate care for vascular disease the Department of Health in England published in 2013 the Cardiovascular Disease Outcomes Strategy and NHS England are encouraging innovative projects to improve efficiency and patient experience through collaborative working\(^\text{292}\). The vascular components of the NHS Long term plan are also being implemented through a cardiovascular disease programme board.

**Key elements of successful system change**

**Quality improvement**

Most high-income countries have developed stroke guidelines but relatively few (Australia, New Zealand, UK and Canada) have attempted to produce guidelines covering the whole stroke pathway, from prevention to longer term management of disability. The National (England) Clinical Guidelines for Stroke published by the Intercollegiate Stroke Working Party...
at the Royal College of Physicians London have produced recommendations aimed at not only clinicians but commission-ers with the intention of encouraging integrated whole pathway management.

While guidelines are an important component of quality improvement, without an active implementation strategy they are likely to have little or no impact. One key component of such a strategy is audit and feedback. In England, national audit of stroke has been taking place since 1998 with 100% participation since 2004. Initially this was a snapshot audit occurring every two years but since 2013 the Sentinel Stroke National Audit Programme (SSNAP) has been collecting continuous data on all stroke admissions. It involves 100% of hospitals admitting acute stroke patients with an estimated 95% case ascertainment rate. The national audit has been a very powerful tool for change over the years providing the momentum for the Department of Health to produce a National Stroke Strategy in 2007 and to provide the motivation for many local service improvements.

Simply publishing data on the quality of data is not enough to drive quality improvement. There needs to be an active implementation strategy, preferably with support from government, development of strong leaders locally, active patient and public involvement in the design and monitoring of services and support from national clinical leaders.

The value of routinely collected information to improve the integration of care across organisations and sectors

Health systems require high quality reliable information to plan care, address unmet need and inequality, and guide best practice in personalised medicine and care. The richest source of evidence to support this is from routine healthcare contacts of the population, covering a range of organisations or purpose-specific registries.

The challenges are in supporting the infrastructure needed to integrate and manage high-quality information from a variety of sources for the development of models of care and decision support. There are knowledge gaps such approaches could resolve such as better identification of those patients at risk of stroke, more accurate diagnosis and prognostication along with more appropriate management long term of the consequences of stroke and associated morbidities.

There is no shortage of data on patients with long term conditions, yet it is collected in different systems often for different purposes and no one information source provides all the requirements for the range of stakeholders (patients, health care professionals and commissioners of services) to target and personalise prevention and long-term management. For example, electronic patient records are in widespread use in primary care, with ‘alerts’ for practitioners regarding guideline treatments and prognosis, yet the data being used does not harness that detail collected across primary, secondary, community and social care and are not specifically tailored to the patient. Furthermore, stroke datasets often collect information using slightly different indicator definitions that make national and international comparisons about the quality of stroke care difficult.

The ‘Learning Healthcare System’ (LHS) describes a model of care that utilises routine healthcare recording to link and summarise local data. This data repository is analysed to produce decision support tools (patient specific guidance, prognostic and risk stratification tools) that guide professionals and patients in real time and in targeting vulnerable and hard to reach patients. The ‘Learning Healthcare System’ (LHS) is a model of care that brings together electronic health records from large numbers of individual patients to produce a better picture of a local population’s needs. By linking this information to international guidelines for best quality care, health professionals can produce individualised recommendations tailored to the circumstances and needs of specific patients. The LHS is:

- Patient-centred: outcomes data captured from patients;
- Prevention-oriented: earlier diagnosis and more effective application of research findings prevents further morbidity and limits disease progression;
- Efficient and resilient: both re-use of routine data and rapid adoption of research findings increase the cost-effectiveness of care and embedding these systems in existing health care information and communication technology makes them resilient.
- Whether a LHS actually improves the quality of care, clinical outcomes and cost effectiveness still needs to be tested.

Summary

The importance of system design has been demonstrated in, for example, the success of (hyperacute) stroke units with defining key features in improving stroke outcomes cost-effectively. Lessons learned from past re-configurations of acute services in Manchester and London are available to feed into future system re-design.

Longer term stroke care needs to be part of integrated care systems, and there are perceived benefits to integrating stroke care with management of other vascular diseases. However, there are challenges in adopting an agreed system design across a health and social care landscape which lacks common governance frameworks and budgets. Taking just one element of the stroke care pathway, ESD, barriers to implementation (resource allocation, joint working) are evident in some areas.

Underlying system change is audit and feedback, supported by patient care and outcome data. However, the best approach for optimising data use by clinicians and patients, for example, via a Learning Healthcare System, is unclear.

Summary, and evidence gaps

In this review, we have described the landscape of the literature relevant for stroke services. At the time of writing, 80–90 thousand people experience a first stroke each year in the UK, and almost one million are living the consequences of stroke.
There remain inequalities in stroke risk, and in the receipt of evidence-based assessment and care. Over the next 15 years, with an aging population, these impacts will increase.

We have described key areas for improving care. Up to 90% of strokes are attributable to modifiable risk factors. Better and more systematic efforts to improve blood pressure, lipids, nutrition, weight, and reducing smoking, together with tackling health inequalities in these areas would not only reduce stroke, but other cardiovascular diseases with similar causation.

In early hospital care, highly effective strategies exist for managing stroke, including mechanical thrombectomy, thrombolysis, and multidisciplinary stroke unit care. Timeliness of access to these services is critical. Improving awareness of the stroke in the population is likely to increase the proportion of people with ischaemic stroke who reach hospital in time to be eligible for acute treatments.

In urban areas, re-organisation of stroke unit care into a smaller number of hyperacute centres is effective and cost-effective. In rural areas, although the model holds promise, additional challenges need to be overcome: hyperacute care is likely to require an increase in workforce, and a change in how teams operate.

Early supported discharge from hospital improves outcomes, but there is variation in whether it is received, and it is not always delivered appropriately. Common problems include lack of a community stroke pathway, inadequate assessment and goal setting, and a lack of community rehabilitation and psychology services.

In the longer term, current follow up and long-term support for stroke survivors and their families are not meeting their needs or expectations. There is insufficient evidence about what works, and particularly around 6-month reviews, and self-management. These are likely to require specific models designed to meet the needs of stroke survivors, and better integrated working of health and social care services.

In future, there is the potential for new technologies to transform care, particularly with advances in genomics which could allow better targeted treatments, and advances in imaging and artificial intelligence, in addition to telehealth.

During the process of writing this review, we have come across evidence gaps — key clinical priorities where there was a paucity or lack of evidence to support decision making. We have summarised these gaps in Table 1. This list was created through

### Table 1. Gaps in evidence base by section.

<table>
<thead>
<tr>
<th>Stroke care pathway priority area</th>
<th>Gaps in evidence base</th>
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<tbody>
<tr>
<td>1. Epidemiology/need and outcome</td>
<td>a. Development of more precise methods to estimate trends in risk and outcome of stroke, particularly to identify high risk groups and health inequalities</td>
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<td></td>
<td>b. Better define long term outcomes after stroke (and non-stroke population comparisons) using validated outcome measures including patient reported outcomes and experience</td>
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<td></td>
<td>c. Developing an interactive dashboard of all relevant data on stroke nationally to inform policy service and clinical decision making.</td>
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<td>2. Prevention</td>
<td>a. Identify the best ways of managing risk factors in context of multiple morbidity</td>
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<td></td>
<td>b. Define the most effective systems within the NHS for managing stroke prevention</td>
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<td></td>
<td>c. Effectiveness of alternative approaches to ‘Health Checks’ for prevention as these have not been shown to be universally effective.</td>
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<tr>
<td>3. Pre-hospital management</td>
<td>a. Identify the optimal approach to improve stroke awareness and appropriate response in the population, particularly focussing on those at greatest risk e.g. ethnic minorities, older patients and those with lower educational levels.</td>
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<td></td>
<td>b. Find ways of improving recognition of stroke by emergency dispatchers and ambulance personnel.</td>
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<td></td>
<td>c. Identify a biomarker or clinical tool to reliably identify stroke, differentiate between haemorrhage and infarct, and to identify large vessel occlusion in order to facilitate transfer to the appropriate hospital for their needs</td>
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<td></td>
<td>d. Establish whether mobile stroke units are clinically- and cost-effective, particularly in the context of identifying patients for thrombectomy.</td>
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<td></td>
<td>e. Define the role of artificial intelligence for interpreting brain imaging and how it is best used in routine clinical practice.</td>
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<td></td>
<td>f. What treatments could be given by paramedics to improve outcome?</td>
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<tr>
<td></td>
<td>g. Evaluate the role of telemedicine in pre-hospital acute stroke care, particularly in areas with significant practical or geographical barriers to access to care.</td>
</tr>
</tbody>
</table>
### 4. Acute care

- **a.** Define value of mechanical thrombectomy in patients presenting with basilar artery occlusion?
- **b.** How do we accurately establish the degree of collateral blood supply with advanced imaging?
- **c.** Are there any advantages using alternative thrombolysis agents to alteplase in combination with mechanical thrombectomy?
- **d.** Can interventional radiologists, or other specialists who have obtained a credential in interventional neuroradiology (stroke), provide similar outcomes including safety profiles compared to interventional neuro-radiologists in delivering mechanical thrombectomy?
- **e.** What proportion of patients benefit from treatment with thrombectomy beyond six hours after onset of stroke?
- **f.** What is the utility/practicality/clinical- and cost-effectiveness of using perfusion scanning to identify patients for treatment with IV thrombolysis and thrombectomy outside usual time frames?
- **g.** How should thrombectomy services be configured to enable the best access to services with available resources?

### 5. After care in the hyperacute stroke unit

- **a.** What is the optimal blood pressure management after ischaemic stroke?
- **b.** Although early consultant review and nurse staffing ratios above three per 10 beds is associated with decreased mortality on hyperacute units, optimal medical, nursing and therapy staffing ratios are not known for stroke units.
- **c.** When should mobilisation start after stroke? Which patients benefit from early intensive rehabilitation, and which benefit more by delaying treatment?
- **d.** Whilst psychological disturbance is common after stroke there is insufficient evidence from which to draw conclusions about what psychological interventions are effective, when they should start after stroke as well as what intensity and duration of the psychological intervention.

### 6. and 7. Rehabilitation

- **a.** Establish the association between intensity of therapy and outcomes?
- **b.** What is the clinical- and cost-effectiveness of seven-day rehabilitation both in hospital and the community?
- **c.** What is the most effective balance between qualified therapists and therapy assistants in hospital and after discharge in community therapy teams?
- **d.** How can equipment and technology (e.g. robotics, telemedicine) best facilitate/replace traditional rehabilitation, to increase intensity of rehabilitation and for the provision of adaptive equipment for patients at home.
- **e.** Areas such as information provision, shared decision making, carer involvement, home visits, are all thought to have an impact on outcome but need further evaluation and evidence to understand how the interventions are best used and how to promote self-management.
- **f.** Studies are needed to understand the aetiology and best systems for managing mood and cognitive disturbance and fatigue after stroke.
- **g.** Further exploration into screening and assessment to improve access to effective treatments is indicated, particularly in relation to the psychological impact of stroke, dysphasia, depression and cognition.
- **h.** Evaluation of the development and implementation of competencies in such areas as sexual activity, vocational rehabilitation, continence, fatigue, cognition and their effectiveness.
- **i.** There are specific areas identified in clinical practice that are worthy of evaluation: acute occupational therapy intervention regarding e.g. how to optimise toileting independence and the use of adaptations; the prevention of immobility related complications post stroke; improvements in management of common stroke complications including spasticity, depression, shoulder pain, central post stroke pain and venous thrombus embolism; the development of systems to prevent and treat carer strain and mood disorders.

### 8. Follow up

- **a.** An evidence base is needed to determine the most effective way of performing systematic follow-up assessments of stroke survivors. What are the benefits, who should perform them, how and when?
- **b.** What is the role of longer-term rehabilitation: when, where, how much and for whom?
- **c.** Models of health and social care with teams operating as a single unit have demonstrated improvements in outcomes for patients; however, a stroke-centric model needs to be established and evaluated.
- **d.** The effectiveness and outcomes of supported self-care and management programmes designed for stroke survivors needs to be evaluated.
- **e.** There is a necessity for validated patient reported outcome measures specifically aimed at eliciting patient outcomes of post-stroke rehabilitation, primary care and secondary prevention interventions. Furthermore, nationally there is a need for stroke services to invest more time and effort to gain insight into the lived experiences of stroke survivors.
9. Emerging technology and innovation in stroke care

a. Further research is required to ascertain real world usefulness and cost effectiveness of most emerging technologies, in particular when considering overall population needs.

b. Implementation and organisational research are required to understand the challenges involved in the deployment and adoption of technologies within healthcare organisations.

10. Effective system design

a. How do we improve public awareness of stroke and the need for urgent management?

b. How do we improve recognition of stroke symptoms by emergency medical service call handlers and first responders?

c. What treatments could be given by paramedics to improve outcome?

d. What is the best configuration of the number and siting of stroke services in England? Does a “hub and spoke” model deliver benefits even in rural areas, how many HASUs, thrombectomy centres and acute stroke units are required as well as how many bed-based rehabilitation units?

e. How much care currently provided as an inpatient could be delivered more effectively at home?

discussion and consensus between the authors with reference to the reviews and refined after feedback from members of the Intercollegiate Stroke Working Party (ICSWP). The final table reflects the views of the authors.

Data availability

Underlying data

No data are associated with this article.

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