Stroke pathway – Evidence Base Commissioning

An Evidence Review

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Editors:

Professor Charles D A Wolfe OBE FFPH FRCP
Professor of Public Health, King's College London

Professor Anthony G Rudd CBE FRCP
Emeritus Professor of Stroke Medicine, King's College London

Professor Helen Rodgers FRCP
Emeritus Professor of Stroke Care, Newcastle University

Professor Chris McKevitt PhD
Professor of Social Sciences & Health, King's College London

Chapter 1 Authors:

Dr Yanzhong Wang BSc, MBA, PhD
Reader in Medical Statistics, King's College London

Mr Hatem Wafa
Research Assistant, King's College London

Chapter 2 Author:

Dr Iain Marshall MBChB, MRCGP, PhD
MRC Fellow in Health Informatics, King's College London

Chapter 3 Author:

Dr Lesli Skolarus MD, MS
Associate Professor of Neurology, University of Michigan

Chapter Authors continued:

Chapter 4 Authors:

Dr Ajay Bhalla MD, MSc, MBBS, FRCP
Consultant physician in stroke care, Guy's and St Thomas' Hospital

Dr Walter Muruet-Gutierrez
Research Fellow in stroke epidemiology, King's College London

Dr Eva Emmett
Research Fellow, King's College London

Chapter 5 Authors:

Dr Ajay Bhalla MD, MSc, MBBS, FRCP
Consultant physician in stroke care, Guy's and St Thomas' Hospital

Dr Peter Sommerville MA, MBBS
Consultant physician in stroke care, Guy's and St Thomas' Hospital

Dr Jonathan Birns BSc, MBBS, PhD
Consultant physician in in stroke care, Guy's and St Thomas' Hospital

Chapter 6 Authors:

Professor Catherine Sackley BSc, MSc, PhD
Professor of Rehabilitation, King's College London

Miss Stephanie Clarke
Senior Research Physiotherapist, Guy's and St Thomas' Hospital

Chapter 7 Authors:

Professor Catherine Sackley BSc, MSc, PhD
Professor of Rehabilitation, King's College London

Miss Stephanie Clarke
Senior Research Physiotherapist, Guy's and St Thomas' Hospital

Chapter Authors continued:

Chapter 8 Author:

Miss Fara Hamidi
Research Assistant, King's College London

Chapter 9 Author:

Professor Anthony G Rudd CBE FRCP
Emeritus Professor of Stroke Medicine, King's College London
Professor Charles Wolfe OBE FFPH FRCP
Professor of Public Health, King's College London

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- SAFE EU Burden of Stroke report- https://strokeeurope.eu/
- National Audit Programme (SSNAP). National Clinical audit August-November 2016 Public Report. Available from: https://www.strokeaudit.org/Documents/National/Clinical/AugNov2016/AugNov2016-PublicReport.aspx. [cited 2019 June 11].
- NICE Quality Standards - https://www.nice.org.uk/guidance/qs2

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Commonly used abbreviations:

AF – atrial fibrillation

AHPs – allied health professionals (including occupational therapy (OT), physiotherapy (PT), speech and language therapy (SALT), clinical and neuro psychology)

AS –Ambulance Service (to include 999 services and paramedics)

BM – blood sugar

BP – blood pressure

CSC – comprehensive stroke centres (IAT ready)

CTA – CT angiogram

CTH – CT head

CVD – cardiovascular disease

EMS-Emergency Medical Services

ESD – early supported discharge

GCS – Glasgow Coma Scale

HASU – Hyperacute Stroke Unit

HTN – hypertension

IAT –intra arterial (mechanical) thrombectomy

ICSWP-Inter Collegiate Stroke Working Party

IVT – intravenous thrombolysis

MI- Myocardial infarction

NNT – number needed to treat

O_2 SATs – oxygen saturations

OT – occupational therapy

PT – physiotherapy

QALYs – Quality Adjusted Life Years

SALT – speech and language therapy

Foreword

Stroke remains a major cause of death and disability in the UK and internationally. It is only in recent decades that it has been a disease considered treatable at all. But high quality research has now shown that interventions such as thrombolysis (dissolving a blood clot with intravenous medication) and thrombectomy (removal of the blood clot by an interventional neuroradiologist), treating people in specialist stroke units and provision of early supported discharge services 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 and there are many unanswered questions that need further research, particularly in areas such as rehabilitation and improved longer 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 providers (commissioners, primary and secondary care teams, networks) and national policymakers of what needs to be achieved to deliver world class services equitably across England. The scope of literature was very wide indeed, and any more intensive method would have been prohibitive. Our aim has been to scope the broad landscape of the stroke literature using high quality synthesised sources of research as a starting point. This would not preclude more formal evidence synthesis/guidelines in future, and our review can help identify areas for this.The review has been undertaken by academics and stroke clinicians who all have expertise in stroke and reviewing the literature. The review across the whole pathway from prevention to long term care should guide commissioning. The editors recognise that there may be areas that have not been addressed, so feedback is welcomed.

Charles Wolfe

Tony Rudd

Helen Rodgers

Chris McKevitt

Introduction

Stroke is a major cause of adult mortality. In the UK it is estimated that around 82,000 people a year have a new stroke. Estimates of prevalence, the number of people living after a stroke, are around 1.2 million. While the incidence of stroke is declining, increasing life expectancy means that the number of people having a stroke may increase by 2035 by as much as 44%. Stroke is typically thought of as affecting older people with a mean age at onset of 72 years for men and 78 years for women but stroke can happen to people of all ages including children. Among people of African origin, the median age at onset is much lower, at around 62 years. There is also evidence of increased risk of stroke among people from lower socio-economic groups with people in the lowest decile of socio-economic status having a stroke on average seven years earlier than those in the top decile.

The impact of stroke is considerable. Two thirds of stroke survivors live with mild to moderate deficits in function including mobility and self-care. Self-reporting from stroke survivors indicates that around one half of stroke survivors have a range of unmet medical, rehabilitation and social needs for at least five years after stroke.

Stroke Care

Stroke care has seen numerous improvements over the past decades, with concerted efforts from clinicians, NHS organisations, researchers, patient organisations and government agencies to increase and enhance primary prevention, public and professional awareness and quality of care. There is evidence that specific methods of organising stroke care improves outcomes, including the development of stroke units, early supported discharge services and centralisation of acute stroke services.

Interventions such as intravenous thrombolysis and mechanical thrombectomy have been shown to reduce disability, although these interventions are only appropriate for a proportion of patients with acute stroke (up to 20% thrombolysis and 10% thrombectomy) .

The Sentinel Stroke National Audit Programme (SSNAP), which measures the quality of care provided to over 90% of stroke patients treated in NHS hospitals across England, Wales and Northern Ireland, demonstrates unexplained and unacceptable variations in the provision of evidence based care both in hospital and after discharge in the community. In many areas of stroke care evidence of effective interventions is scarce. This is particularly in relation to social and psychological as well as self management interventions to meet the longer term needs of stroke survivors, and their family caregivers.

Prevention of stroke

There have been major developments in prevention, both from the perspective of the development of more effective drugs and in implementing better population based prevention. The direct oral anticoagulants have made management of patients with atrial fibrillation much easier and better access to statins has enabled improved management of hyperlipidaemia. Smoking rates in the population have fallen over the last few decades and introduction of initiatives such as NHS Healthchecks have contributed to better population based cardiovascular risk management, such as hypertension and lipid control.

NHS Long Term Plan

Cardiovascular disease and specifically stroke has been identified as a major priority in the NHS Long Term Plan. Prevention of vascular disease, and where not successful, provision of high quality acute care through stroke units, delivery of thrombolysis and thrombectomy, establishment of integrated stroke delivery networks are all specified. Rehabilitation pilots will test the best ways of delivering high quality rehabilitation across England and there is a recognition of the importance of providing effective longer term care and support to patients surviving with disability.

Chapter 1 - Epidemiology of Stroke

Key points

- Around 80 to 90,000 people have a first in a lifetime stroke each year in England.
- Around 60,000 people have a transient ischaemic attack every year, of whom 17% will progress to stroke within three months.
- Inequalities exist between different population groups: men, older people, ethnic groups, and those of lower socioeconomic status have 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.
- About 1 million people live with the consequences of a stroke in England.
- Around 16% of those who have had a stroke are expected to have a recurrent stroke within 5 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).
- In England, more than 30,000 people (36%) die every year after their stroke.
- 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, 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.

Introduction

This chapter cites Engand data wherever possible, otherwise UK or global data are referenced.
Every two seconds, someone in the world will have a stroke, and a life will consequently be lost every six seconds[1]. Stroke occurs every five minutes in the UK, resulting in around 80 to 90,000 stroke patients each year. Every year, stroke accounts for a loss of more than 30,000 lives in England and 660,000 disability-adjusted life years (DALY) — a DALY is an equivalent to one year of healthy life lost because of premature death or living in a suboptimal-condition due to disability[2].

Stroke in England

In 2015, approximately 55 million people were living in England representing more than 84% of the UK's population[3]. Contempory studies estimating the epidemiology of stroke in England are very limited (Oxfordshire and south London), however, rates for England can be crudely calculated based on subpopulation rates, assuming representativeness to the whole of England. For instance, a South London Stroke Register study estimated stroke incidence rate at 149.5 per 100,000 per year[4]. Applying this rate to England's 2015 population results in more than 82,000 stroke cases. Similarly, data from the Global Burden of Disease study reported 84,000 stroke events in England in 2015[5]. Furthermore, according to national data from the Sentinel Stroke National Audit Programme, around 85,000 people a year are admitted to hospital with a stroke[6]. This equates to around one stroke every five minutes.
Studies in Oxfordshire and south London have recorded declines in the age adjusted incidence rates over time[7,8]. A decline of 19% was reported between 1990 and 2010[9]. Nethertheless, the absolute numbers are expected to increase as the population continues to grow and live to an older age. Projection is discussed later on in this Chapter.

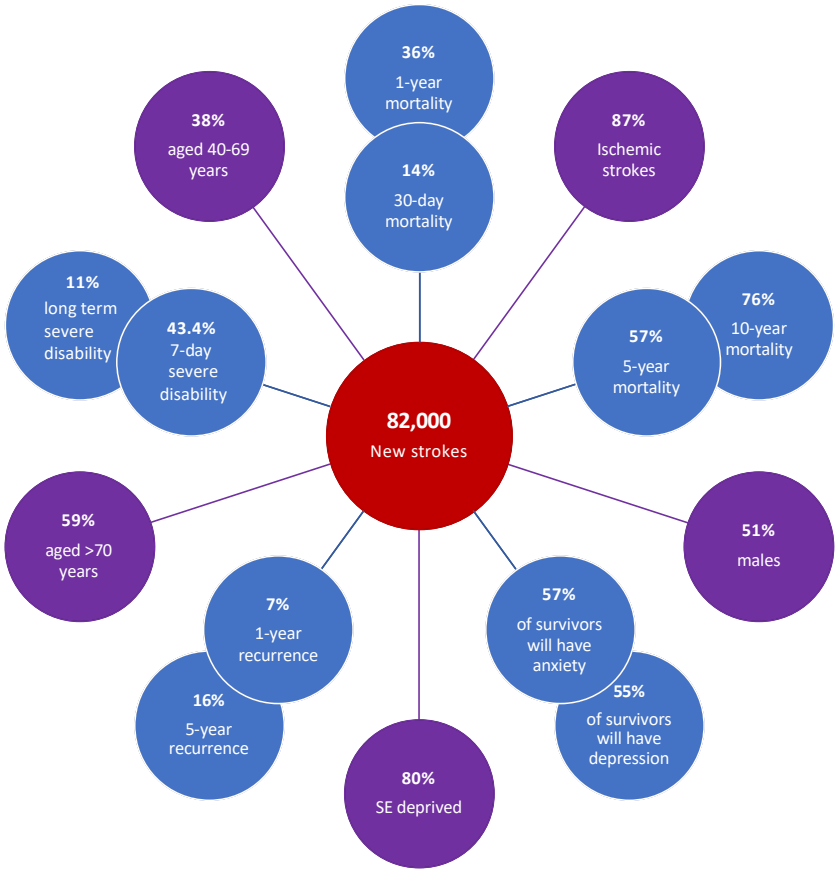

Figure 1: Diagram of key statistics in England

- The majority of stroke cases are due to ischemia (87%), whereas haemorrhagic events comprise 13% of total strokes in England[10].
- 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[11].
- Strokes are occurring at an earlier age in non biased population studes; age at onset has fallen from 70.5 to 68.2 in males and 74.5 to 73 in females between 2007 and 2016.
- Stroke is more common in males (51%) [11,12].
- The African and African Caribbean groups have a higher incidence rate (SLSR data (267.5 strokes per 100,000 population compared to 137/100,000 in the white ethnic group))[4]. 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.

- Stroke incidence is lowest in the least deprived quintile of the population. Increasing deprivation is associated with increasing incidence and death rates. Stroke risk is twice as high in the most deprived groups compared to the least deprived and the subsequent death is 26% more likely[10]. Around 80% of stroke patients came from lower socio-economic groups[13].
- Nearly 14% of stroke cases die within the first 30 days of stroke onset[4,10].
- Cumulative mortalities are 36.3%, 57.2%, and 76% at 1, 5, and 10 years respectively[14].
- 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[11].
- 7.1% and 16.2% of stroke patients will have another stroke within one and five years of stroke onset respectively[15].
- The highest proportion of severely disabled stroke survivors is observed seven days after stroke (43.4%)[16], while the proportion remained at around 15 % after three months[14]. Additionally 34% have mild disability 14% moderate disability.
- 22% of stroke survivors will be cognitively impaired[17].
- 57% of stroke survivors experience symptoms of anxiety at some point in the 10 years after their stroke[18].
- 55% of stroke survivors experience episodes of depression within 15 years after their stroke[19].
- Almost 1 million people live with a stroke in England, around 1.7% of England's population[20]

The term Transient Ischaemic Attack (TIA) refers to a symptoms resembling stroke but lasting for less than 24 hours. The latest English data from the Oxford Vascular Study suggests around 108 definite or probable TIA per 100,000 population[7]. Based on these data, there were approximately 60,000 new TIAs in England in 2015. Generally, the estimates of risk of tia in the community internationally are outdated and use differing methodologies.

- 1 in 12 people could have a stroke within a week of having a TIA.
- Around 17% of those who have had a TIA will have a stroke within three months[21].

Stroke-like events (included in review as affect the stroke pathway pre hospital and in the hyper acute phase)

Patients may present in the emergency departments and pre-hospital settings with a "stroke-like" clinical picture caused by a disease other than stroke. These are referred to as stroke mimics, attributed most commonly to seizures, migraines and psychiatric disorders[22,23].

- One quarter of suspected stroke cases will turn out to be a mimic[22-26].
- At least 1.6% of suspected stroke admissions are due to medically unexplained symptoms. That is 2400 admissions per year in the UK[27]. The corresponding number in England is calculated at around 2000 admissions per year.

Currently in the UK, the Face Arm Speech Test (FAST) is commonly used in the pre-hospital settings, which can correctly identify up to 82% of cases (sensitivity) and rule out 83% of non-cases (specificity)[28]. A more detailed assessment tool, Recognition of Stroke in the Emergency Room (ROSIER), has been developed and validated for use in the A&E departments, which has a better accuracy (93% sensitivity and 83% specificity). Other tools include the Los Angeles Prehospital Stroke Screen (LAPSS), Cincinnati Prehospital Stroke Scale (CPSS) and Melbourne Ambulance Stroke Screen (MASS)[29]. Meta-analysis suggests that CPSS has the best overall sensitivity and specificity but the difference from the FAST is fairly small and probably not sufficient to justify a change in England. All of the scales will miss a significant number of stroke patients, but any scale that attempted to identify all patients would be impracticable to use because of time, complexity and the large proportion of false positive cases[30]. (See chapter 3 for further details).

Intra Venous Thrombolysis (IVT) and Intra Arterial Thrombectomy (IAT) rates in England (included here as related to the expected numbers based on the epidemiology/need identified in this Chapter)
An overview of the current evidence, practice, and areas of uncertainty is discussed in detail in Chapter 5.

Intra Venous Thrombolysis (IVT)

Deciding whether IVT should be given to a stroke patient depends on nature of stroke, and other factors that may contraindicate treatment, and time since stroke onset. Since the prevalence of these factors will fluctuate across time, eligibility levels are expected to vary. For instance, better organisation of health services and improved public awareness would allow faster recognition and admission to A&E departments, which would in turn increase the proportion of stroke patients who would meet the criteria for IVT treatment. On the other hand, population ageing could yield older cohorts of stroke patients with multiple comorbidities in whom IVT complications might outweigh the anticipated benefits. Currently, up

to 20% of all stroke patients would be appropriate for the treatment. In 2018, 11-12% of all ischaemic stroke cases in England were thrombolysed[12,20,31,32].

- It appears that over time , more patients who are eligible for IVT (as defined using data available in the SSNAP data) have received IVT, increasing from 74.3% in 2013 to 87.7% in 2018.
- The proportion of patients who received IVT within 1 hour of stroke onset has increased from 53.2% in 2013 to 63.7% in 2018.
- The median time between onset of symptoms and arrival at hospital is 3 hours 6 minutes.(see Chapter 4 for details of time to IVT on outcome)
- The average door to needle (DTN) times for patients receiving IVT has improved from 59 minutes in 2013 to 51 minutes in 2018 but this is still significantly longer than achieved in some units and countries.
- There is evidence that shortening DTN times to 20 minutes is feasible[67].

Intra Arterial Thrombectomy (IAT)

IAT is becoming increasingly accepted[33-38], and NICE guidance says it is safe and effective when provided in line with the standards used in the randomised controlled trials[39]. Currently however, few centres can provide the service and the number of trained professionals who can perform the procedure is insufficient for IAT to be rolled out geographically across England or temporally across the week[12,20].

- Approximately 10% of stroke admissions are eligible for IAT each year[32,40], up to 8,000 patients in England.
- The number of patients receiving IAT has increased from 503 in 2016 to 708 in 2018[31].
- Average puncture-to-end of procedure time has reduced from 56 minutes in 2016 to 48 minutes in 2018.
- IAT was carried in 2018 out by 24 teams across England, with the median number of procedures per team being 23 (IQR 13-31).

NHS England is funding and supporting measures to increase the workforce needed to deliver the procedure. However, ensuring there are sufficient numbers of trained professionals to offer the treatment across the country day and night is a logistical challenge that requires careful planning and with current numbers of interventional neuroradiologists unachievable.

Costs and outcomes of IVT and IAT treatments

- The cost of IVT treatment in England was estimated at £1,214 per patient (including cost of medication and staff time for administration); and that of IAT, £8,365 per patient (including the cost of the stent, the material and the procedure)[41].
- Despite the additional cost of treatment with IVT compared to the standard care without, IVT accrues lower NHS costs and better outcomes in the long run[42].
- For each extra patient receiving IVT, an NHS savings of around £4100 (**Figure 2**), and health gains of 0.26 QALYs (**Figure 3**), are expected during the first 5 years since stroke onset[42].
- Adjunctive IAT is estimated to cost £39 244 over 20 years, versus £31 812 for IVT alone. The incremental cost of £7431 per patient was estimated to yield an additional 1.05 QALYs over 20-years period (about 3.8 QALYs for IVT alone versus 4.8 QALYs for adjunctive IAT)[41].
- From health economics perspective, both treatments, stand alone or in combination, are deemed cost-effective.

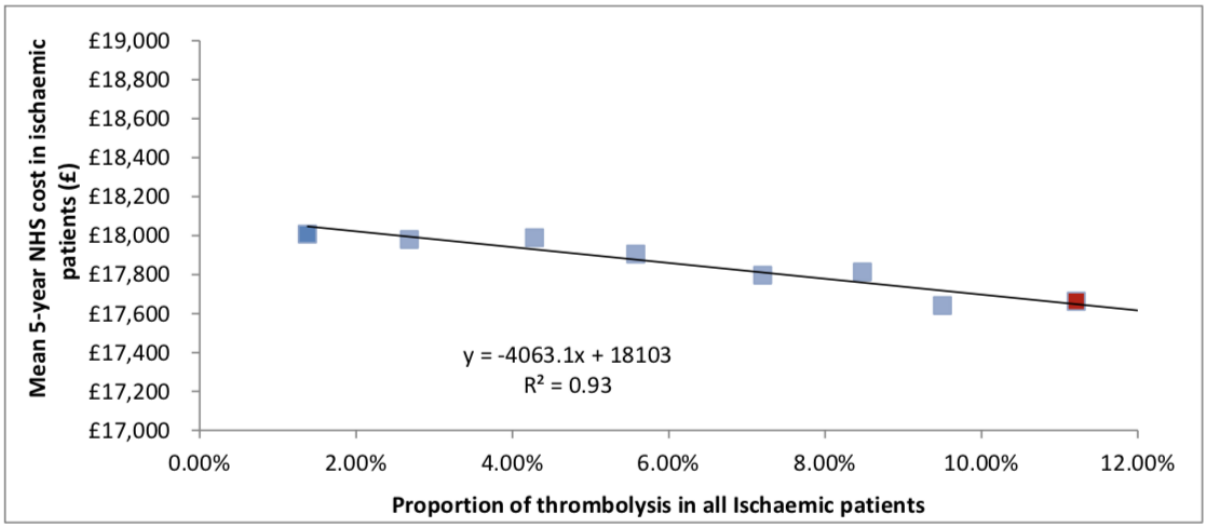

Figure 2: Five-years mean NHS cost at different proportions of thrombolysis in all ischaemic patients.

Source: Sentinel Stroke National Audit (SSNAP)[42].

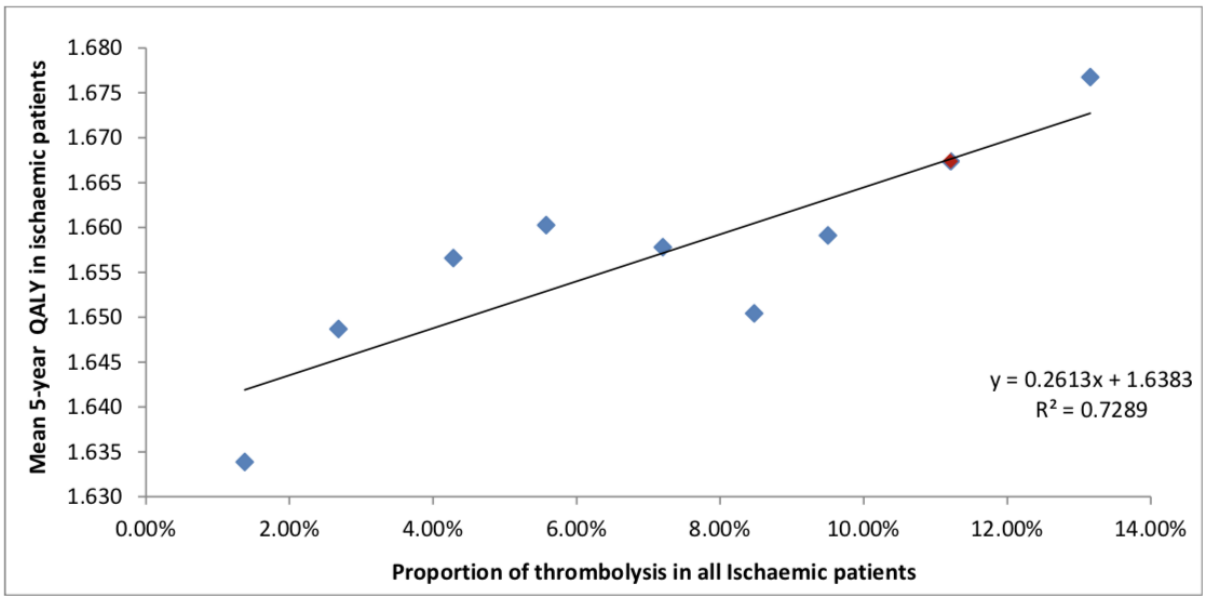

Figure 3: Mean QALY of ischaemic patients with different thrombolysis proportions five years after the first stroke. Source: Sentinel Stroke National Audit (SSNAP)[42].

Inequalities

The geographic variation in stroke within England is well estimated, with greater stroke incidence in the north than the south[43,44]. Furthermore, it has long been recognised that some aspects of care provision and accessibility to health services may not be equitably distributed across different population groups[45-48]. Table 1 summarises some of the key differences among ethnic and socioeconomic groups in the UK.

	All	Ethnicity		SES	
		White (W)	Black (B)	Higher (H)	Lower (L)
Incidence (per 100,000)[4]	149.5	137.1	267.5	≈ twice the risk (L vs H)	
Age of onset (mean)[10,49]	71.7	73.9	62.6	79	72
Survival years (median)[50]		2.6	3.3		
Case-fatality (30d)[10,16]	14%	23%	11.7%	14%	13%
Morbidity (BI <15, 7d)[16]	43.4%	44.4%	42.3%		
Recurrence[15]					
Within 1y	7.1%	7.4%	6.1%	6.5%	7.7%
Within 5y	16.2%	16.1%	16.7%	14.7%	17.5%
Hospital admission[51]	85.1%	OR: 1.59 (B vs W)		OR: 1.52 (H vs L)	

Rehabilitation (0-90 days)[51,52]			
PT/OT	70.7%	OR: 1.90 (B vs W)	OR: 0.53 (H vs L)
SALT	59.8%	OR: 1.35 (B vs W)	OR: 0.43 (H vs L)

Table 1: Ethnic and socioeconomic disparities in stroke incidence, outcomes, and care provision.

BI, Barthel index; NA, not available; OR, odds ratio; OT, occupational therapy; PT, physiotherapy; SALT, speech and language therapies; and SES, socioeconomic status.

In England people of African and Asian origin have around twice the incidence of stroke compared to their white counterparts, which are normally of greater severity [4,53,54]. In addition, they tend to experience strokes approximately 11 years earlier in their lives compared to white people. Nevertheless, several UK-based studies suggest that these patients are more likely to survive their strokes than caucasian patients[4,16,50]. A 2011 London study demonstrated that around 12% of black patients die within 30 days of stroke onset compared to 23% in the white group. Despite these differences in the natural history of stroke, patients of black origin have 26% higher hospitalisation rates and are 90% more likely to have had received physiotherapy or occupational therapy regardless of the initial stroke severity and age at onset (Table 1)[51,52].

Lower socioeconomic status (SES) is associated with up to a doubling of the risk of stroke. A UK study showed that about half of the excess risk is attributed to higher prevalence of conventional risk factors (e.g. hypertension, diabetes, smoking, drinking, poor diet, and physical inactivity)[55]. There is evidence suggesting that lower SES is also associated with more severe stroke and higher levels of disability and handicap[56,57]. Despite the higher risk and greater severity of stroke in the socioeconomically disadvantaged groups, evidence from Canada and Finland showed that these individuals are less likely to receive high-quality care[58,59]. However, studies from the UK have not detected such association. In fact, a recent study in England reported no difference in the quality of in-patient care among socioeconomic groups[10]. No evidence of disparities was found in DTN times for IVT, swallow screening, specialist physician and stroke nurse, or physiotherapy and speech therapies assessments in the acute phase. Nevertheless, it has been reported that patients from the most deprived areas were 11% less likely to receive IVT treatment, occupational therapy assessment, or be admitted to a specialised stroke unit. Moreover, lower SES is associated with 9% lower rates of brain imaging within 1 h of arrival at hospital.

Self-managements programmes are highlighted as a priority in the UK and have been shown to deliver positive impacts on quality of life and allow more appropriate use of health resources[60-62]. However,

concerns have been raised that such programmes might be less accessible for those considered "hard to reach"[63,64], like minority ethnic groups and those with lower SES. Data on dissemination and utilisation of self-management packages by different ethnic and socioeconomic groups are lacking in the UK. More affirmative evidence is required to identify gaps in health outcomes and care provision following strokes between ethnic and socioeconomic groups.

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. Producing reliable estimates are largely dependent on a set of "plausible" assumptions about the future, particularly those related to population size and structure and the prevalence of key risk factors associated with the disease (e.g. hypertension and smoking). Few studies have attempted to forecast the burden of stroke and almost none provided predictions of resources use. A couple of these are summarised in Table 2 along with corresponding calculations of the expected numbers of acute ischaemic stroke patients accessing IVT and IAT treatments in England, assuming complete coverage of all eligible patients at 20% and 10% of all strokes respectively.

Study	Period	% increase	Expected numbers*	Resource use†	
				IVT	IAT
SAFE[65]	2015-2035	44%	118,000	23,600	11,800
Truelsen et al[66]	2000-2025	36.4%	61,788	12,358	6,179

Table 2: Studies projecting number of incident strokes in the future

IVT indicates intravenous thrombolysis; and IAT, intra-arterial thrombectomy. *expected numbers of stroke at the end of projection period.†assuming complete coverage of all eligible patients (20% IVT, and 10% IAT).

Based on Truelsen et al projections that are now old and based on rather simple assumptions, there will be around 62,000 new strokes in 2025 in England. The more up to date SAFE study estimates an increase of 44% between 2015-2035, which would result in more than 118,000 new stroke cases in 2035. On the other hand, some other global data provide more optimistic figures. For instance, Global burden of Disease data indicates a modest increase in stroke numbers between 2007 and 2017 (9% increase) in the UK. If such a trend persists, it means an even smaller numbers of stroke events in the next decades. There are multiple

methodological and data quality issues that need to be considered in interpreting these trends and they do come with these caveats.

In terms of treatments, around 23,600 and 11,800 patients will have received IVT and IAT respectively in 2035, given a predicted 118,000 acute strokes according to SAFE estimates and assuming complete coverage of all eligible patients. However, there is evidence suggesting that cutting in-hospital delay to 20 minutes in stroke thrombolysis is possible[67], and one might expect 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. On the other hand, if the treatments were to be restricted to younger age groups in the future, and given the projected increase in the proportion of older patients, eligibility rates might actually decline[68]. Systematic research is 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 work[20]. It was estimated that in 2015 the average societal cost of stroke per person was £45,409 in the first year after stroke[69]. An additional £24,778 per patient has been estimated for subsequent years (cost of prevalent stroke). There are no robust estimates of overall stroke cost in England. However, it can be assumed to be around 84% of the total cost in the UK, since 84% of stroke cases occur in England.

- Stroke costs the UK society around £25.6 billion each year.
- Around 57% of this sum is incurred by informal carers (relatives and friends).
- 29% 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 (**Error! Reference source not found.**)

- Stroke will cost the UK £43 billion in 2025, and £75 billion in 2035.

This will indeed present real societal challenge in future which will require additional funding and policy support.

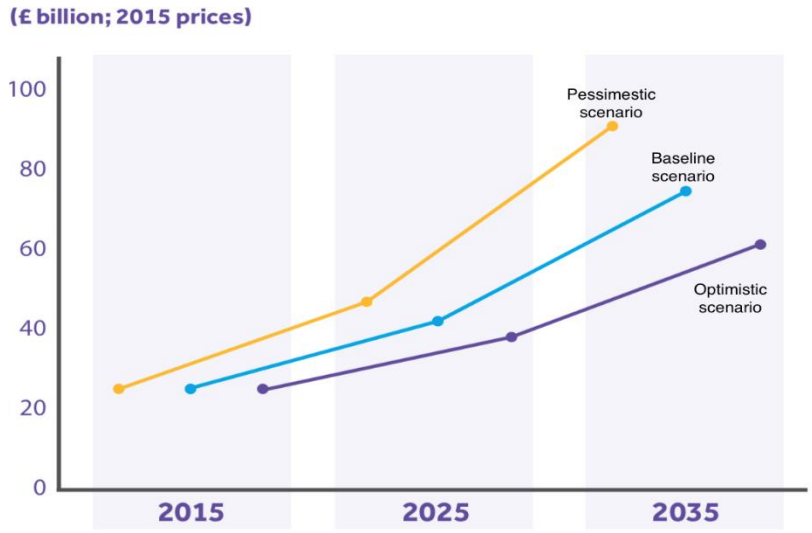

Figure 4: Expected changes in aggregate cost of stroke over time in the UK.

Source: Stroke Association[69]

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Chapter 2 - Stroke prevention in primary care

Key Points

- As much as 90% of stroke is 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, although currently stretched
- 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 no evidence has found clinically meaningful reductions in other risk factors, for example hypertension, in participants

Introduction

We included data from the National Institute for Health and Care Excellence (NICE) guidelines relevant to the primary prevention of stroke, including NICE guideline on Hypertension from 2011[1], Cardiovascular disease: risk assessment and reduction, including lipid modification 2014[2], and atrial fibrillation[3]. We also used data from the 2016 Intercollegiate Stroke Working Party (ICSWP) National clinical guideline for stroke[4] around secondary prevention of stroke. We additionally extracted information from the General Practice GMS contract 2019/20 regarding the latest performance targets from the Quality and Outcomes Framework (QOF)[5]. 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 factors[6].

Risk factors comprise those which are non-modifiable (age, ethnicity, sex, and genetics), and modifiable (poor diet, being overweight, smoking, inactivity, dyslipidaemia, and hypertension)[6]. Diabetes independently increases the risk of all CVDs[7]. Atrial fibrillation is additionally a key risk factor for stroke[8]. Social factors (including socio-economic status and low educational attainment) have been additionally recognised as risk factors for stroke and other CVDs[9]; this relationship is partly explained by increased levels

of conventional risk factors among deprived populations, and also through inadequate access to health care[9].

INTERSTROKE was a case-control study conducted across 22 countries, and published in 2010, which examined the population attributable risk[1] of major stroke risk factors; the key results are summarised in Table 1. Overall, this study estimated that 90% of stroke was attributable to modifiable risk factors.

Risk factor	**Population Attributable Risk (95% CI)**
hypertension	35% (30–39%)
smoking	19% (15–23%)
overweight	27% (19–36%)
poor diet	18% (11–30%)
diabetes (types I or II)	5% (3–10%)
inactivity	29% (15–49%)
teetotaller	not assessed
excessive alcohol	4% (1–15%)
psychosocial stress	5% (2–10%)
depression	3% (3–10%)
cardiac causes	7% (5–9%)
dyslipidaemia	25% (16–37%)
Total	**90% (85–94%)**

Table 1: Population attributable risks for stroke from INTERSTROKE

[1] Defined as an estimate of the absolute reduction in disease incidence expected if the risk factor were absent in the population.

Stroke prevention may be considered as *primary prevention* (i.e. preventing stroke in the general 'healthy' population), and secondary prevention (i.e. preventing a further stroke [and other non-stroke cardiovascular events] in people who have had a stroke previously). Though acute stroke is increasingly a specialty of large hospitals, stroke prevention is achieved primarily in the community: both targeting the high risk general population (primary prevention), and those discharged home following a stroke (secondary prevention). However, the principles of primary and secondary prevention of stroke are similar, and aim to reduce the same key risk factors. We consider each risk factor in turn below, and describe any differences in approach between primary and secondary prevention.

Targeting prevention

An individual's risk of future stroke may be estimated using statistical models. The seminal example was the Framingham score; in the UK, NICE recommends the use of QRISK2[2],[11]. 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 risk[12]. NICE recommend that general practices systematically calculate approximate CVD risk scores for their registered patients up to age 84 using already-held data in the electronic care record[11]. 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 stratification[4].

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 population[11]. The programme targets men and women aged 40–74 years old who have not experienced CVD before (i.e. the primary prevention population). The check is run by local authority public health departments as a mandated service, and in practice is delivered in various venues (many general practices, and sometimes workplaces, libraries, sports venues and supermarkets). 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[14].

[2] An updated version QRISK3 has been released subsequent to the most recent NICE guideline

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 the risk of death, and likely have little or no effect on cardiovascular mortality[15].

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 thousand[16]. The overarching aim is that individual local practices would still be able to deliver personalised care to their patients while taking advantage of their networks ability to have wider population impact, but with the increased 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[17]. A network pilot in Tower Hamlets including 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, and 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. The study describes that the pilot area appeared to have greater improvements in CVD outcomes compared with the national average during the study period, but notes that these could represent secular trends rather than the effect of the pilot itself.

Quality and Outcomes Framework

The Quality and Outcomes Framework (QOF) remains a key component of general practice income, and a large part continues to be contingent on practice-level performance on a series of clinical indicators, of which CVD prevention forms a major part[5]. Currently, the QOF measures performance on targets listed in Table 2 which are relevant to stroke prevention. Of note, a major change in the 2019/2020 QOF targets has aligned all of the risk factor target levels with those in the relevant NICE guidelines. We describe these targets in more detail in the next sections.

Condition	Indicator
Atrial fibrillation (AF)	Percentage who have had a stroke risk assessment (e.g. CHA_2DS_2-VASc) in the past 12 months Percentage of those with CHA_2DS_2-VASc ≥ 2 who are prescribed anticoagulant therapy
Hypertension	Percentage with blood pressure of 140/90mmHg or less (for those aged under 80) Percentage with blood pressure of 150/90mmHg of less (for those aged 80 or over) Percentage of those aged ≥30 and <75 with a new hypertension diagnosis (who also have no previous CVD or diabetes) who have had a CVD risk assessment (e.g. QRISK2) Percentage of those with QRISK2 score ≥20% who are prescribed statins Percentage of *all* patients aged ≥45 who have a recorded blood pressure in the past 5 years
Stroke and TIA	Percentage prescribed an antiplatelet or anticoagulant Percentage who have received influenza vaccination Percentage with blood pressure of 140/90 or less* (aged under 80) Percentage with blood pressure of 150/90 or less* (aged 80 or over)
Smoking	Percentage of people with existing CVD, or other high risk conditions for CVD (including hypertension, diabetes, COPD, and serious mental illness) where smoking status is

	recorded Percentage of current smokers who have been offered support and treatment (bi-annual in general population; annual in those with existing CVD or high risk comorbidities)

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[18].

The 2011 guidelines recommend the following key points:

- That hypertension should be diagnosed based on ambulatory blood pressure monitoring (ABPM) where possible (i.e. using a large number of readings recorded of a 24 hour period; not based on one-off blood pressure measurements);
- The guideline uses the definition of stage 1 (or mild) hypertension as clinic blood pressure measurements exceeding 140/90mmHg (or home measurements exceeding 135/85mmHg)
- Stage 2 hypertension is defined as clinic blood pressure measurements exceeding 160/100mmHg (or home measurements exceeding 155/95mmHg);;
- Those with grade I hypertension should be offered an assessment of global CVD risk (i.e. a QRISK assessment), and consider treatment where their risk exceeds 20%, or where there is evidence that hypertension has led to end-organ damage;
- 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 analysis found ABPM was cost saving compared with clinic measurements, primarily since ABPM has higher specificity (i.e. a lower false-positive rate)[18]. 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. The evidence review included nine high quality observational studies, and additionally concluded that ABPM was more

strongly predictive of clinical outcomes (cardiovascular events and mortality) than clinic blood pressure measurements.

Subsequent to the guideline; key new evidence has been published. 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)[19]. The trial found that intensive treatment reduced the composite endpoint of MI, acute coronary syndromes, stroke, heart failure, and cardiovascular death (1.65% per year with intensive treatment *v* 2.19% per year with standard treatment; hazard ratio [HR] 0.75; 95% CI 0.64 to 0.89). This trial suggests there may be benefit in blood pressure lowering to a stricter target than recommended in NICE guideline.

Evidence supporting the tight control of blood pressure following stroke comes from the PROGRESS trial[20]. 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 intervention reduced stroke recurrence by 42% and major coronary events by 35%. This benefit was seen even in those with blood pressure measured as low as 115/75mmHg.

County-level QOF data[3] from 2018-19 found that 80% of patients with a diagnosis of hypertension had their blood pressure recorded as being below 150/90mmHg, although data from previous years has shown a much smaller proportion had their blood pressure controlled to the NICE recommended target of 140/90mmHg[21].

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 (56,934 participants)[22]. The review found that for primary prevention, statins reduced all cause mortality (OR 0.86, 95% CI 0.79 to 0.94), combined fatal and non-fatal CVD RR 0.75 (95% CI 0.70 to 0.81), combined fatal and non-fatal CHD events RR 0.73 (95% CI 0.67 to 0.80) and combined fatal and non-fatal stroke (RR 0.78, 95% CI 0.68 to 0.89).

Similar benefits have been found for statin use as secondary prevention. The SPARCL trial compared atorvastatin 80 mg daily versus placebo in patients with TIA or stroke in the prior 6 months[23]. The trial found that atorvastatin significantly reduced stroke (relative risk reduction [RRR] 15%) and major coronary events (35% RRR). The trial did find that atorvastatin increased intracerebral haemorrhage by 67% (95% CI 9 to 156); the risk was highest for those whose initial stroke was of haemorrhagic aetiology.

[3] https://qof.digital.nhs.uk/

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 (the decision based on a discussion about the person's own preferences, with use of personalised estimates of their risk). NICE recommends that atorvastatin 20mg should be the first choice of treatment.

The 2016 ICSWP National Clinical Guideline for Stroke recommends for secondary prevention should be offered atorvastatin 20-80mg daily, with the aim of reducing non-HDL cholesterol by 40%[4].

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 factor Xa inhibitors (known as 'NOACs' or 'DOACs' for novel/direct oral anticoagulants). A 2009 Cochrane review found five RCTs (2,313 participants) comparing warfarin versus placebo for preventing stroke and TIA in people with atrial fibrillation[24]. The review found that warfarin significantly reduced stroke and all-cause mortality compared with placebo (relative risk reductions for warfarin *v* placebo; stroke: 59%, 95% CI 39 to 63%, mortality: 39%, 95% CI 5 to 48%).

A 2014 systematic review and network meta-analysis compared RCTs of warfarin, novel anticoagulants, aspirin, and placebo for stroke prevention in AF, identifying 16 RCTs with 82,396 participants[25]. Dabigatran and apixaban were associated with reduced risk of stroke compared with warfarin (ORs with 95% CIs: 0.66 [0.53 to 0.82] and 0.78 [0.65 to 0.94] respectively). There was no significant difference in stroke between either edoxaban or rivaroxaban and warfarin (ORs with 95% CIs: 0.87 [0.74 to 1.02] and 0.88 [0.74 to 1.04] respectively). Edoxaban, apixaban, edoxaban, and dabigatran were all associated with significantly lower rates of major bleeding, but the differences were small in absolute terms.

The 2014 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[3]. For most people this will result in a recommendation to take an anticoagulant (either warfarin or a DOAC)[3]. 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[4]. They note that the European Atrial Fibrillation Trial found anticoagulation led to a substantial benefit post-stroke, with the annual risk of subsequent stroke being reduced from 12% to 4% (HR 0.34; 95% CI 0.20-0.57)[26].

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 likely to be recorded as such by their GPs[27].

Innovative approaches to diagnosing AF — a national pilot

- Two key problems around reducing AF-related stroke are: 1. a large proportion of people with AF are unaware of it; and 2. a large proportion of those who are aware do not receive optimal treatment with anticoagulation.
- To address these issues, NHS England commissioned the Academic Health Science Networks (AHSNs) to procure 6000 mobile ECG devices across England.
- In south London alone, 400 AF detection devices were distributed across the 12 boroughs from January 2018 to March 2019.
- These devices were portable electronic devices which performed a single lead ECG from the user, who gripped it with both thumbs. The results are automatically received and analysed by a smartphone app.
- Groups at increased risk of AF were targeted, and sites included general practice, community podiatry, mental health teams, community nurses, prison, urgent care centre, hospital-based clinics, community therapy teams and a range of third sector organisations. Across south London, approximately 15,000 pulse rhythm checks were performed using the mobile ECG device, detecting approximately 600 people with possible AF[42].

Antiplatelets

Although there is strong evidence for use of antiplatelets for the secondary prevention of stroke; antiplatelets are no longer recommended as primary prevention. This is due to systematic reviews of large RCTs which found aspirin led to no evidence of important reduction in CVD risk, but does lead to a small risk of haemorrhage, which may be severe[28.29].

The 2016 ICSWP National Clinical Guideline for Stroke recommends that people with ischaemic stroke or TIA without AF should receive clopidogrel 75mg daily in most cases; but if this is not possible (e.g. if side effects were not tolerated), then combination treatment with aspirin 75 mg daily and modified-release dipyridamole 200 mg twice daily could be considered.

The evidence for use of antiplatelets comes from a meta-analysis by the Antithrombotic Trialists' Collaboration (2002), which found antiplatelets reduced vascular events by 22% in those with a previous stroke or TIA[30]. A NICE 2010 technology appraisal found that clopidogrel was more cost-effective than

other antiplatelet options for the secondary prevention of stroke[31]. 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[41].

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[8]. 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[32-35]. Cahill et al conducted a network meta-analysis evaluating a total of 26 drug treatments, using data from 267 RCTs identified from 12 Cochrane systematic reviews[36]. Nicotine replacement therapy (NRT), bupropion, varenicline and cytisine were all found to significantly increase the odds of abstinence compared to placebo (ORs with 95% Confidence Intervals; NRT 1.84 [1.71 to 1.99], bupropion 1.82 [1.60 to 2.06], varenicline 2.88, [2.40 to 3.47], and cytisine 3.98, [2.01 to 7.87]). The trials did not evaluate the effects of smoking cessation interventions on later CVD.

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 (BMI)[37]. 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[37].

Although advocating a 'healthy' diet is customary, there is little trial evidence to support any particular diet for stroke prevention. A Cochrane systematic review of RCTs (search date 2012) found only one RCT which examined CVD rates directly as an outcome[38]. This large RCT (48,835 women) assessed an intensive programme to educate and monitor dietary intake, with the aim of increasing fruits, vegetables, and grains. The intervention was successful in changing diet: there were high levels of adherence, significant reductions in fat consumption (a mean reduction in quantity of >8%), and increases in the intake of grains (0.5 mean additional portions per day), and fruit and vegetables (1.1 additional portions per day). Nonetheless the trial found no significant difference in CVD (hazard ratio (HR) for CVD events: 0.98, 95% CI 0.92 to 1.05, mean follow up time 8.1 years)[39].

Multimorbidity

In 2016 NICE published the first version of their guidelines on multimorbidity[40]. 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 are 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.

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Chapter 3 - Pre-hospital management of stroke

Key points

- Acute stroke treatments are time sensitive. Increasing stroke awareness , activating 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 preparedness could decrease post-stroke disability.
- Given the lack of a 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.

Introduction

Acute stroke care begins in the community at the onset of stroke symptoms. Thus, stroke witnesses, emergency medical services (EMS) dispatch, and ambulance crews are key to initiating acute stroke care.

Community Awareness:

Most people (95%) have their onset of stroke outside of hospital[1]. Thus, given the time sensitivity of acute stroke care, stroke awareness 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 stroke treatment and timely treatment of haemorrhage patients[1]. How best to get the population 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[2], but overall the direct link between stroke awareness and a decrease in pre-hospital delay is weak, particularly among populations at greatest stroke risk[3-6].

Overall, educational campaigns are recommended to increase stroke awareness, particularly among populations most at risk[1,7].

Gaps in knowledge: Additional research to determine the optimal approach to increase and sustain stroke preparedness is needed. Novel approaches to reaching those at greatest risk – ethnic minorities, older patients and those with lower educational levels—are needed as well as in younger people.

EMS dispatch and Ambulance Evidence Based Recommendations:

Calls received by ambulance services, including call handlers, should be triaged as a medical emergency[1]. Calls to 111 for suspected stroke should be routed to 999. EMS evaluation of a suspected stroke patient should include the Face Arm Speech Test (FAST) to assess the most common signs of stroke[1,8]. If positive, pre-hospital notification and rapid transfer to closest 'stroke ready' hospital should occur[7]. Those people with persisting neurological symptoms who screen positive using a validated stroke assessment tool, in whom hypoglycaemia has been excluded, and who have a possible diagnosis of stroke, should be transferred to a specialist acute stroke unit ideally within a maximum of 4 hours for maximal effect[9]. Some factors that reduce pre-hospital delay include that all EMS implement a 'code stroke' protocol, including highest priority dispatch, pre-hospital notification and rapid transfer to the closest 'stroke-ready' centre. (strong; moderate quality of evidence)[7].

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[7]. Trials are ongoing to assess the value of giving antihypertensives in the ambulance[10], although a recent trial did not show a benefit in functional outcomes[11].

Gaps in knowledge:

Recognition of stroke by emergency dispatchers and ambulance personnel is challenging[12]. Ideally there would be a biomarker to identify stroke and, even a step further, to identify large vessel occlusion in order to facilitate transfer to an IAT capable centre. The closest 'biomarker' approximation are clinical scales, of which the FAST, which was developed in England, is most commonly used[13]. Other stroke assessment tools are available and more are under development[12,14]. The use of clinical scales to identify large vessel occlusion and subsequent triage of the patient to IAT capable hospital requires decisions about the trade-offs of sensitivity and specificity of clinical scales. For example, one such scale the Rapid Arterial occlusion Evaluation (RACE) scale ≥ 5 has a sensitivity of 0.85, specificity of 0.68 which would result in patients being transferred to an IAT capable centre who do not have a large vessel occlusion (see figure)[15]. Currently, the European Academy of Neurology and European Stroke Organization conclude that there is insufficient

evidence to recommend a pre-hospital stroke scale to predict large vessel occlusion[7]. Upon optimisation of pre-hospital large vessel occlusion tools, apps to facilitate triage to appropriate level of care may be helpful.

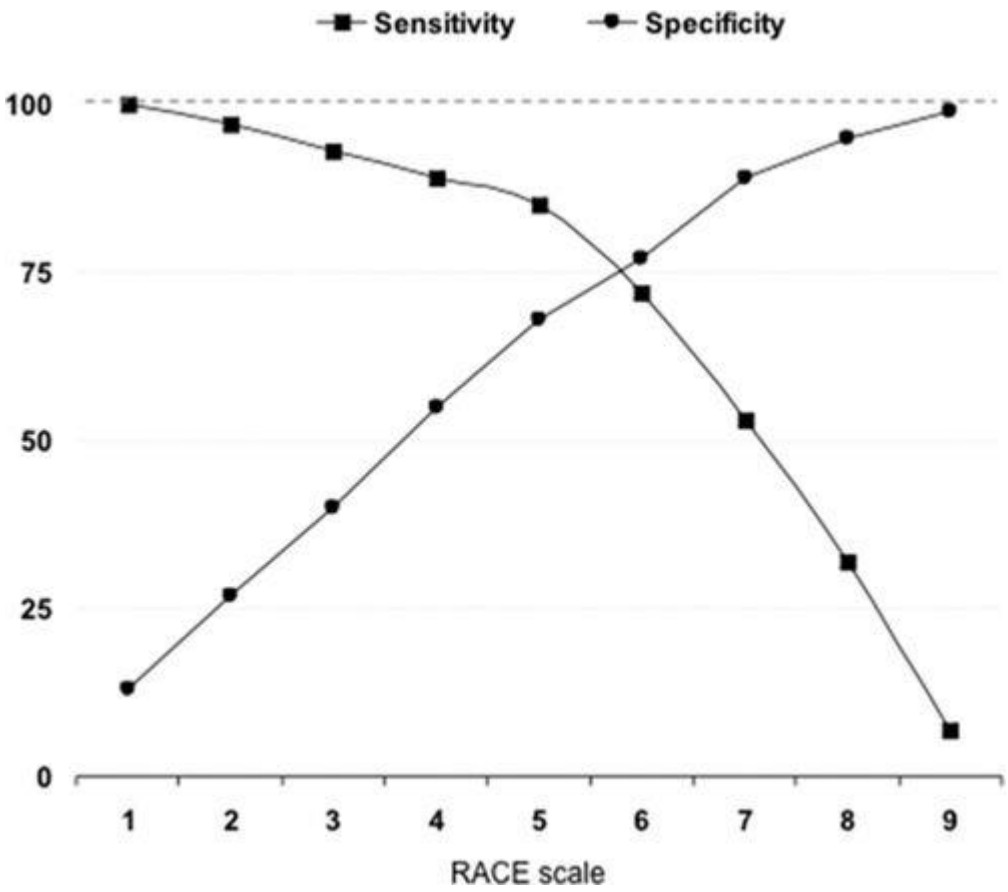

Figure 1. Sensitivity (squares) and specificity (circles) of different cut off values of the Rapid Arterial occlusion Evaluation (RACE) scale for the detection of large vessel occlusion.[15]

Similarly work, such as modelling and stakeholder engagement[16], is needed to determine the provision of Hyperacute stroke unit (HASU)/Comprehensive stroke centre (CSC) distribution which may require a hub-and-spoke model of care, telemedicine or other forms of cross-site collaboration.

Mobile stroke units are seen as practical and may reduce onset-to-treatment time[17], but clinical effectiveness and cost-effectiveness has not been established. As an example of local innovation, there is a mobile stroke unit in Southend UK[18] but again evidence for its clinical or cost effectiveness are lacking. Given the lack of effectiveness data, no recommendation of the additional value of prehospital telemedicine, which may facilitate stroke diagnosis and appropriate triage, can be made[7].

Emergency Department - Key points

- With the emergence of IAT, including patients selected based on perfusion imaging, the Emergency Department has an important role in the diagnosis and determination of eligibility of acute stroke treatment options.
- The best approaches to delivering evidenced based thrombectomy care, including pre-hospital triage and allocation of CT/MR angiography and CT/MR perfusion technology, will need to be determined.

Over the past decade, acute stroke care has evolved with the addition of IAT and treatment of hypertension among patients with intracerebral haemorrhage (ICH). IAT is a highly efficacious treatment for stroke patients with large artery occlusion. The Emergency Department and stroke units are the key gatekeeper to acute stroke care. From there all acute ischemic stroke management decisions including IVT, IAT or transfer to an IAT capable centre are made.

Patients with persisting neurological symptoms who paramedics or referring providers believe had a stroke or who screen positive using a validated tool should be transferred to a hyperacute stroke unit (HASU) as soon as possible[1]. Patients with suspected acute stroke should be assessed for emergency stroke treatments by a specialist physician without delay[1]. Selection of patients eligible for acute stroke treatments relies on a detailed history and examination as well as imaging techniques to determine the type of stroke. All HASUs need immediate, round the clock access to brain imaging including CT angiography[1]. 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[1]. Currently the American Heart Association's guidelines recommend imaging within less than 20 minutes of hospital arrival for over half of the suspected stroke patients. While the 2016 National Clinical Guideline for Stroke is less directive with regards to CT perfusion, recent trials of IVT and IAT within an extended time window, including wake up stroke, require a favourable perfusion pattern prior to treatment, suggesting the need for CT perfusion for this patient population[21-23]. Plain CT and CT perfusion with artificial intelligence software, such as RAPID or Brainomix, are currently being used in practice to improve and speed up the reporting of the scans[22,23]. When a positive confirmation of a ischaemic stroke is needed, MRI is the imaging modality of choice[1].

Most ICH patients who present within 6 hours of symptom onset with a systolic blood pressure above 150mmHg should be treated urgently using a locally agreed protocol for blood pressure lowering to a systolic blood pressure of 140 mmHg for at least 7 days[19]. Patients with ICH can deteriorate quickly and should be admitted directly to a HASU for urgent specialist assessment and monitoring[1]. Patients with anticoagulation associated haemorrhage should be urgently reversed with the appropriate agent[19].

Gaps in Knowledge and Service Provision

- The precise role of artificial intelligence for interpreting brain imaging, particularly newer advanced imaging modalities, needs to be defined[24].
- The proportion of patients for whom extended hours thrombectomy will be appropriate needs to ascertained.
- Whether the role of telemedicine could be expanded to improve stroke care acute stroke care, particularly in areas with significant practical or geographical obstacles is another unknown. Currently, 93 sites use telemedicine about half of which use it solely for thrombolysis decision making[19].
- In the last quarter of 2018, 312 thrombectomies were performed accounting for 1.4% of all stroke patients suggesting that IAT services and transfer systems, including image transfer and referral process are currently under-developed[25]. Increasing the rate of thrombectomies is one of the greatest challenges facing acute stroke care.

Areas of uncertainty

The number of units capable of providing thrombectomy and the number of non thrombectomy centres delivering the rest of acute stroke care needs to be determined. Data on transfers to Comprehensive Stroke Centres including average delay and sources of delay are needed as well as access to interventional radiology expertise. Ultimately moving forward, the best approaches to delivering evidenced based thrombectomy care will need to be determined.

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Chapter 4 - Acute management of stroke

Key points

- Stroke care has undergone significant changes with the establishment of dedicated stroke units across England. Re-organisation into a smaller number of highly specialised hyper-acute stroke units occurred in the densely populated metropolitan areas of London and Greater Manchester. These reorganisations have proved cost-effective and have led to improvements in patients' outcomes.
- The acute organisational audit conducted by the Sentinel Stroke National Audit Programme (SSNAP) demonstrates a shortage in the workforce, e.g. stroke consultants and qualified clinical psychologists. Re-organisation of services in urban areas might improve the efficient use of scarce resources. However, in rural areas re-organising services into fewer highly specialised units might be limited by an increase in travelling times.
- 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.
- Transient Ischaemic Attacks (TIAs) are a common neurological emergency. The risk of stroke after a TIA is approximately 10% during the first months. Furthermore, despite complete symptom resolution, 17% of patients with TIA will be dependent at 6 months and 5% will die due to a subsequent stroke.
- 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 treatments for ischaemic stroke. There is not only evidence that IVT improves long-term outcomes, but it is also a cost-effective intervention.
- The benefits of IVT are highly time dependent. Although the current treatment window is 4.5 hours, the maximum benefit of IVT is obtained if the administration occurs within the first three hours from symptom onset. Conversely, the risk of complications increases with longer symptom onset to intravenous thrombolysis time.
- There is overwhelming evidence for the effectiveness of mechanical thrombectomy in improving functional outcomes in patients presenting within 6 hours after onset with 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.
- Evidence strongly suggests that the use of mechanical thrombectomy in addition to IVT improves outcomes and cost-effectiveness compared to IVT alone for some patients.

Overall organisation of acute stroke services

Stroke Unit Care

High-quality acute care for stroke patients depends on an organisation that allows appropriate assessments and treatments to occur at a level of high quality and within a relatively narrow time frame. There is strong evidence that admission to a specialised stroke unit is associated with higher quality care[1] and lower rates of mortality, disability and institutionalisation, without leading to longer hospital stays[2]. 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[3-5].

National[3] and international[5] 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 (National Institute for Health and Care Excellence (NICE) quality standard, Statement 1[6], and SSNAP key indicator[7]) to facilitate timely assessments by a specialised team.

Despite this consensus, between 12%[8] and 22%[9] of stroke patients are never admitted to a hospital, patients being managed in care homes, TIA/minor stroke clinics. A lack of awareness of the symptoms of stroke and/or the appropriate response to stroke in the general public[10, 11] could lead to a delay in medical attention seeking and could explain some non-admissions. Further efforts are therefore important to increase stroke awareness in the general population and those involved in emergency services (see Chapter 3).

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 arrival[7]. This indicates significant room for improvement with regards to the admission pathway for stroke patients in many hospitals. Delayed stroke unit admissions are more frequent in winter, reflecting the additional burden of winter-related illness on emergency services and how general pressure on the health system affects stroke patients[12].

Delivery of networked stroke services

As stroke care is developing and becoming increasingly complex and highly skilled, not every hospital will be able to provide the specialist staff and equipment required for optimal care. To address this problem and improve coordination between service providers, the 2007 National Stroke Strategy[13] and the NHS Long Term Plan[14] propose the establishment of stroke networks serving a population of 0.5 to 2 million. These networks

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.

Hospitals that do not offer hyperacute services should have arrangements in place with neighbouring hospitals equipped for hyperacute care. These arrangements include service level agreements of care provision with the hyperacute hospital, clear protocols with the ambulance trust/s to take all acute patients directly to the trust providing hyperacute care and protocols to arrange immediate transfer from the emergency department of the non-acute site to the hyperacute site of patients who self-present or are not recognised by the paramedics as having a stroke as well as agreements concerning patient repatriation.

Such “hub and spoke” models of care have been introduced in some regions of the country, mainly densely populated, urban areas such as Greater Manchester and London. Other examples of hospitals 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 Hospital[15].

Across England, acute stroke services now vary significantly by location consisting of either:

- a hyperacute stroke unit (HASU) admitting patients during the first 72 h after stroke. From there, patients move to another unit within the same hospital or to the patient’s local hospital for post 72-hour acute care;
- a stroke unit providing both hyperacute and acute care; or
- a comprehensive stroke unit providing interventional neuroradiology services alongside hyperacute and acute care[3].

London and Greater Manchester (GM) have undergone extensive re-organisation of acute stroke services since 2010[16]. 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 reorganised 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 reorganisations, 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, including brain imaging, receive the appropriate acute treatment, and are admitted to a HASU for the initial 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 reorganisation

Evaluating the reorganisations of these services has provided evidence that centralisation can improve care and outcomes while being cost-effective.

Performance

In London, 93% of patients received treatment in a HASU following the service reorganisation (2015/16 data)[17]. Patients were significantly more likely to receive evidence-based interventions, such as a brain scan within 3 hours and arrival at a stroke unit within 4 hours, compared to before the reorganisation 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 reorganisation with the 4-hour admission cut-off, rising to 86% in 2015/16). No benefit was seen overall for patients in GM, but after the further centralisation in 2015, improvements of over 10% occurred for brain scan within 60 minutes, admission to a stroke unit within 4 hours, and assessments within 72 hours. Adherence to the local stroke pathway was much higher in London, with 98% of suspected stroke patients taken appropriately to a hyperacute unit, compared to only 66% of suspected stroke patients presenting within 4 hours in GM after the first attempt at reorganisation. This difference in outcomes demonstrates the value of a simpler, more uniform stroke emergency pathway.

Since the service reorganisation, length of hospital stay in London declined by 1.4 days (7% reduction) and in GM by 2.0 days (9% reduction) over and above the reduction seen in the RoE, representing 12,766 and 8,842 fewer hospital bed days per year respectively[16].

A study of the impact of service reorganisation in Northumberland including urban and rural areas similarly showed a reduction in length of inpatient stay, and shortened door-to-imaging and door-to needle times[15].

Outcomes

Following centralisation 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. The lower mortality rate was sustained as confirmed with 2016 figures[16]. The population in London covered by the service reorganisation includes 8.17 million people, with approximately 8,000 annual hospital admissions following stroke[16]. Therefore, the decline in mortality as calculated in the evaluation led to an additional 11.8 lives saved per million people and year, which would equate to 651 lives saved across the English population of 55.6 million people. These numbers

represent, obviously, a rough estimation as there is currently no direct evidence that the London reorganisation would produce exactly similar benefits in different areas.

In GM, there was a significant decline in mortality among those treated at a HASU (-1.8% or 69 fewer deaths per year). Evidence for a reduction in mortality across all hospital-admitted stroke patients in GM between 2008 and 2016 was only borderline, with the percentage of patients treated in hyperacute units rising from 39% in 2010/12 to 86% in 2015/16.

Based on a model incorporating patient outcomes over 10-years following stroke, reorganisations in London and GM resulted in additional quality-adjusted life years (QALYs) compared to the RoE (London: 58 additional QALYs/1000 patients, GM after 2010 reorganisation: 18 QALYs/1000 patients)[16, 17].

There are not enough data to adequately assess the impact of these reorganisations on outcomes such as quality of life, disability or improved level of activity[16]. While the metric QALY incorporates some information on the state of health derived from standard valuations, it does not reflect a broader set of outcomes. Further research is needed to include these measures. However, there is evidence of the positive long-term impact of intravenous thrombolysis and better-organised stroke unit care on these outcome measures[18]. It is therefore reasonable to expect some improvements in short- and long-term disability and quality of life due to service reorganisation that increases those aspects of acute care.

Clinician skills

An appropriately skilled multi-disciplinary stroke unit team is the cornerstone of a holistic approach to stroke care[3]. 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. The national stroke guideline defines a specialist as a healthcare professional with the necessary specific knowledge, practical experience and skills in managing people with stroke or its mimics, usually by having the relevant further qualification and keeping up to date through continuing professional development.

An HASU should provide immediate access to specialist medical staff trained in the hyperacute management of stroke, including diagnostic and administrative procedures needed for the delivery of emergency treatments. It should also offer immediate, on-site access to tertiary services for endovascular therapy, such as thrombectomy, for neurosurgery, vascular surgery, and cardiology services[3].

Clinical staff assessing stroke admissions should be trained in the interpretation of brain imaging and thrombolysis. Stroke physicians will have had training during their specialist training, and both stroke physicians and non-medical specialist practitioners should have attended specialist thrombolysis training. Acute stroke services should have an in-house education programme for all staff providing acute care,

including ambulance and appropriate emergency department staff. External training should be available. Specific training should be provided in accordance with the Stroke-Specific Education Framework (www.stroke-education.org.uk) which was developed in 2007 as part of the National Stroke Strategy in order to establish a nationally recognised, quality-assured training programme. Additionally, stroke services should participate in national and local audits, multi-centre research, and quality improvement programmes, including regular review of care processes and outcomes[3, 19].

While these recommendations are part of the national guidelines, there are no national data to demonstrate the extent of adherence to these recommendations or the effectiveness of particular training programmes in clinical care, including interventional radiology training in newer imaging modalities.

Cost of delivering a seven-day hyperacute service and cost-effectiveness of re-organisation

As detailed in the national guideline[3], 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 advocated for thrombolysis and its benefits for stroke outcomes have been demonstrated[20]. An hyperacute unit should therefore have constant access to a consultant with expertise in stroke medicine, requiring a minimum of six appropriately thrombolysis trained physicians on rota 24/7, and a minimum of 2.9 WTE nurses per bed. A HASU should provide a consultant stroke specialist led ward round seven days per week[3].

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 2 and 3[21], a stroke unit bed-day cost an estimated £238[22] in 2013/4. Conversely, factors such as length of hospital stay are essential when considering the cost per stroke admission and the number of beds required per population. Economic analysis of the re-organisation in London investigated costs up to 90 days post-stroke and found average costs per patient reduced by £811 (from £14,117 in 2007/8 to £13,306 in 2010/1), predominantly due to shorter length of stay[23].

As survival after stroke improves, it becomes increasingly relevant to consider the cost of acute hospital care alongside the effects on long-term health- and social care costs. Furthermore, it is necessary to compare these costs with the long-term health benefits gained.

Data from 2008 to 2012 is highly suggestive that the reorganisation in both London and GM was cost-effective. Using a 10-year time horizon, and comparing both cities with the RoE, it was estimated that in London 58 additional QALYs per 1000 patients were gained at an extra cost of £1,014,363. There was an incremental cost-effectiveness ratio of £17,452, well below the commonly reported willingness to pay of between £20,000 and £30,000 for the NHS. In GM, 18 QALYs per 1000 patients were gained over 10-years

with less cost (-£470,848) compared to the RoE. Comparing the further centralisation in GM in 2015 with the RoE, the model suggests an 88% probability of it being cost-effective at 90 days, but only a 31% probability at 10- years at a willingness to pay for a QALY gained of £20,000[16].

This indicates that in London, re-organisation led to significant clinical improvements compared to the RoE and a high probability that these benefits were cost-effective. In GM, re-organisation was cost-saving due to shorter length of stay but resulted in fewer clinical improvements[16, 23].

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

Outside the two metropolitan areas of London and GM, many hospitals have not set up separate wards as purely HASUs but use dedicated areas or beds within a stroke unit for hyperacute patients. According to the latest available data from the 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 exclusive for first 72 hours of care and 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[24].

Based on the evaluation of service reorganisation in London and GM, a nation-wide reorganisation of stroke services might be desirable. There is scanty 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 appears to correspond with an adequate level of institutional experience and competence in providing hyperacute treatments[25] and a volume of between 600 and 1,500 patients admitted per year has been recommended[19,26] 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 reorganisation guidelines for stroke services suggest that travel times should be ideally up to 30 minutes but no more than 60 minutes[27]. A study examining the feasibility of a hyperacute stroke unit model of care across England[28] 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 min and up to 98% of patients within 60 min of travel time respectively.

Currently, there are 113 routinely admitting teams in England providing hyperacute care so there would need to be a reduction of about a quarter to meet the recommendations in the paper.

As acute treatment for stroke is evolving, requiring more specialised knowledge and skills, re-organisation of stroke services might become a pre-requisite for high-quality acute care. A country-wide re-organisation of stroke services could provide advantages to most of the population. While re-organising stroke services could result in a large proportion of the population gaining access to centres with significant levels of expertise in delivering high-quality stroke care, a small minority of patients might be adversely affected due to prolonged

travelling time[28]. Encouragingly, a study evaluating the impact of centralisation in Northumberland, which includes urban and rural areas, did not show an increase in time from stroke onset to hospital admission[15].

Workforce required and current workforce gaps for physicians, nurses, and AHP

Although trial-based evidence for appropriate staffing levels is lacking, minimum staffing levels for stroke units have been defined in hyperacute stroke service reorganisations such as London. Detailed recommendations of weekday staffing levels for nursing, medical, and rehabilitation staff (including physiotherapists, occupational therapists, speech and language therapists, psychologists, and dieticians) are part of the national guideline[3] for acute and hyperacute services respectively. While these recommendations are based on weekday working, observational evidence is accumulating from national registries about the substantial benefits of appropriate staffing levels outside office hours and during weekends[29-31].

In the 2019 SSNAP Acute Organisational Audit Report[24], several key indicators gave an insight into gaps in the current workforce. Only 58% of sites were achieving adequate levels of senior nurses on stroke units, defined as 2.4 band 6 and 7 nurses per 10 stroke unit beds, despite senior nurses being essential for management, maintaining standards of care, and training junior staff, in addition to frequently undertaking initial assessments and management of stroke patients in A&E. Patients and carers report high levels of neuropsychological impairments following a stroke, but only 7% of sites had access to at least one qualified clinical psychologist per 30 stroke unit beds.

With regards to seven-day service, only 30% of sites with hyperacute services had adequate numbers of nurses on duty on weekends, despite an association shown between stroke mortality and weekend staffing by registered nurses[29]. Similarly, only 47% of sites offered at least two types of therapy (including occupational therapy, physiotherapy, and speech and language therapy) seven days a week[24].

The percentage of sites with hyperacute beds providing a consultant-led ward round every day of the week as recommended in the national guidelines has improved from 84% in 2016 to 90% in 2019. The reported gap in the stroke consultant workforce continues to rise: SSNAP data showed that the percentage of sites with vacant posts has increased from 26% in 2014 to 40% in 2016 and 48% in 2019[24]. The need for more stroke consultants reflects the demands of an increasingly complex and highly specialised service requiring timely and frequent consultant input.

A 2019 report by the British Association of Stroke Physicians (BASP)[26] estimates that, while 676 stroke consultants currently work in the NHS in the UK, to provide a comprehensive dedicated stroke service, including the new seven-day working standards set out by NHS England, an additional 226 full-time stroke consultants are required. However, the number of sites providing accredited training programmes in stroke medicine has fallen significantly from 56 sites in 2016 to 44 sites in 2019[24].

In the BASP report[26], the number of consultant sessions ("direct clinical care programmed activities", DCC PA) required to run a HASU admitting 600 stroke patients per year is calculated as 41, compared to 68 for a HASU admitting 1200 patients. Further reorganisation of stroke services across the country might therefore help to make services more efficient by using the limited time of highly skilled stroke specialists more effectively.

The Royal College of Physicians is introducing a new physician training structure which will involve all doctors training in neurology as well as selected trainees from acute and geriatric medicine to undergo specialist training in stroke. Similarly, the NHS Long Term Plan proposes to develop a programme for hospital consultants from a variety of relevant disciplines for the accreditation of particular competencies, such as thrombectomy[14]. These programmes could be benchmarked against other countries' programmes for training.

Management of transient ischaemic attack

The term Transient Ischaemic Attack (TIA) refers to a temporary disruption in the blood supply to a region of the brain. The lack of oxygen caused by this momentary interruption of cerebral circulation leads to sudden neurological symptoms that recede spontaneously, usually within one hour. The primary characteristic of a TIA is that there is no permanent cerebral injury (infarction) after the event[32].

Two definitions of TIA exist. The first one is time-based and refers to a focal neurological sign or symptom lasting less than 24 hours. Meanwhile, the second one is tissue-based referring to focal neurological signs or symptoms without evidence of infarction on brain imaging[33]. Although the tissue-based definition has gained popularity in recent years, the time-based definition seems to convey more prognostic information regarding the risk of imminent subsequent stroke[34].

A TIA is a neurologic emergency[35] In predominantly white populations, the incidence of TIAs has been variously reported (Chapter 1 for latest England study) at rates between 28 and 150 per 100,000 people[36-38], although a more recent study from a population-based study in Italy describes the incidence, standardised to the 2011 European population, as 28.6 per 100,000 people[39]. Patients presenting with a TIA have an early risk of subsequent stroke as high as 8 to 10% within the first week after the event[40] and around 17% within the immediate 3 months[40,41]. Furthermore, TIAs are usually indicative of underlying cardiac or atherosclerotic disease. Even if the complete resolution of symptoms occurs, 17% of patients with TIA will be dependent at six months after the event, and 5% will die[42]. The primary cause being a subsequent stroke. A large, international, prospective study found that the rate of any cause mortality at five years after a TIA was 10.6%. The rate of death from cardiovascular causes was 2.7%, and that of intracranial haemorrhage and major

bleeding was 1.1% and 1.5%, respectively[43]. Nonetheless, early initiation of secondary prevention after a TIA is associated with an 80% relative risk reduction in the risk of early recurrent stroke[40].

Transient ischaemic attack mimics

Despite similar pathophysiology and presentation to stroke, the differential diagnosis of TIA differs greatly due to the transience of symptoms. Furthermore, the rate of mimics is higher and more varied for TIAs than for strokes. Observational studies of patients referred to neurovascular clinics with an initial diagnosis of TIA has shown that only between 39% and 80%[44-48] of patients receive a final diagnosis of TIA, and up to 60% will have a non-ischaemic cause of transient neurologic attack[45], although this depends on the referring clinician. Common TIA mimics seen in the clinic include migraine aura[48,49], seizures[48], syncope and functional neurological symptoms[47]. A careful consideration of the different diagnostic possibilities is necessary to avoid unnecessary treatments, with their associated side effects, and to avoid delaying the diagnosis of non-ischaemic causes.

Assessment and management of transient ischaemic attack

The recommendations from the National Institute for Health and Care Excellence (NICE) for the management of patients with suspected TIA include early aspirin and referral. The recommendation for the management of a suspected TIA is to prescribe 300 mg daily of aspirin immediately unless contraindicated. Referral to a specialist should be within 24 hours of symptoms onset[41]. 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. Current guidelines discourage the use of scoring systems that attempt to quantify the risk of subsequent stroke , such as ABCD2, to inform the urgency of referral. These systems have been shown to be unreliable to discriminate between low and high risk patients and do not help to streamline clinic workload[41]. Unfortunately, 53% of referring stroke teams in England still apply these systems[50]. Currently, NICE recommends the use of these scoring systems only when it is required to ration emergency services[41].

NICE guidelines recommend that magnetic resonance imaging (MRI) including diffusion-weighted and blood-sensitive sequences, should be considered after specialist assessment to determine the territory of ischaemia and to rule out haemorrhage or alternative pathologies. If there is an indication for an MRI, this should take place on the same day as the assessment. The indication for carotid imaging is in patients with suspected atherosclerotic stroke who are potential candidates for carotid endarterectomy[41].

The choice of secondary prevention depends on the findings of the clinical assessment. For patients with TIAs of atherosclerotic or small-vessel origin, the recommendation is to start antiplatelets (e.g. aspirin or clopidogrel, or aspirin/dipyridamole)[51] and statins (eg. atorvastatin, rosuvastatin, simvastatin, pravastatin)[52]. In all patients with above-normal blood pressure values, the recommendation is to control blood pressure. Lifestyle modifications are the first-line intervention. For patients with blood pressure above 130/80 mmHg, it is advisable to consider the use of antihypertensive medication. There is no evidence favouring a specific antihypertensive agent[4]. In patients with TIA of cardiac origin (cardioembolic) anticoagulation is a better alternative to antiplatelets. This treatment recommendation is regardless of any history of ischaemic heart disease. The start of anticoagulation therapy should be within the first two weeks after the event. Warfarin, dabigatran, rivaroxaban, apixaban and edoxaban are reasonable therapeutic options for anticoagulation. There is evidence suggesting that rivaroxaban and edoxaban have a lower risk of haemorrhage when compared to warfarin[53, 54].

Carotid endarterectomy

Urgent carotid endarterectomy should be considered for patients with stable neurological symptoms who have carotid stenosis as a cause of their symptoms. The North American Symptomatic Carotid Endarterectomy Trial (NASCET) criteria define carotid stenosis of 50 to 99% as amenable to treatment by endarterectomy[41, 55]. Patients with symptomatic carotid stenosis of less than 50% according to NASCET criteria, or less than 70% according to the European Carotid Surgery Trial (ECST) criteria should not receive surgery[41].

Reperfusion therapy for acute ischaemic stroke

Reperfusion therapy refers to the timely restoration of blood flow to the regions of the brain that are ischaemic but not yet infarcted. Reperfusion therapy aims to reduce disability and mortality in ischaemic stroke patients. There are two modalities of reperfusion therapy available: mechanical thrombectomy and intravenous thrombolysis.

Intravenous Thrombolysis (IVT)

Intravenous thrombolysis (IVT) thrombolytic agents, also known as clot-busting medications, are used to restore blood flow to occluded vessels. Alteplase and tenecteplase are effective options for reperfusion therapy. However, in the UK only alteplase is currently recommended for use in ischaemic stroke[41,56]. Tenecteplase, although available, is only licensed for the treatment of acute myocardial infarction[57].

Although recent years have seen the rise of IVT as an effective intervention for salvaging ischaemic brain tissue, IVT with recombinant tissue plasminogen activators remains the mainstay treatment for patients with ischaemic stroke and is often the only curative treatment available for most patients. 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 thrombolyse at least 20% of all stroke patients, and 85% of eligible patients[58]. Unfortunately, despite of these recommendations the rate of patients receiving IVT remains low, and only around 12% of all ischaemic stroke patients receive IVT in England, Northern Ireland and Wales according to data from the Sentinel Stroke National Audit Programme (SSNAP) Annual Clinical Audit report for the period April 2017 and March 2018[59].

Indications

The National Institute of Health and Care Excellence (NICE) as well as the American Stroke Association recommends the use of alteplase for treatment of acute ischaemic stroke within its marketing authorisation, if the treatment is started as soon as possible within 4.5 hours of symptom onset, provided intracranial haemorrhage has been appropriately excluded both clinically and radiologically[56, 58, 60]. If the time of symptom onset is not known, then the last time the patient was known to be normal is used as reference. There has been some discussion regarding the usefulness of advanced neuroimaging methods to identify eligible patients when time of symptom onset is unknown with observational studies suggesting comparable outcomes in well selected patients. Results from the WAKE-UP trial suggest that using mismatch in diffusion weighted imaging and FLAIR sequences on MRI are useful in identify patients for IVT. Patients selected in this way were more likely to have a modified rankin Score of ≤1 at three months, compared with patients not receiving IVT (adjusted OddsRatios 1.61 [1.09, 2.36]).

Benefits of IVT

IVT with alteplase is effective at reducing disability and improving the chances of good functional outcome and independence (defined as a modified ranking scale score ≤ 2) at three and six months after stroke (adjusted OR 1·53 [1·26,1·86])[4, 61]. Additionally, there is evidence from a randomised control trial[62], propensity score matched prospective studies[18, 63], and observational studies[64 65] that thrombolysis improves long term survival and functional status. Furthermore, IVT is a cost-effective intervention at the level of £20,000 to £30,000 Incremental Cost-Effective Ratio per QALY gained[56].

Benefit by time of symptom onset to treatment time

The benefits of IVT are highly time-dependent. Initially, the recommended time window for IVT was 3 hours based on the results from the first randomised clinical trials demonstrating significant benefits for patients treated up to this time[66-68]. However, currently is accepted that a time window of up to 4.5 hours from symptom onset is effective based on the positive results from the ECASS III trial[68].Thrombolysis between 4.5 and 6 hours is not currently recommended by guidelines and further research is required, although findings from the International Stroke Trial 3 (IST-3) demonstrated a benefit in a group of patients treated up to this time[69]. However, the efficacy of IVT decreases with longer onset-to-needle times[61, 70] as shown by the number needed to treat (NNT) for one additional excellent outcome (modified Rankin scale 0-1) increasing drastically within the first 4.5 hours, from a NNT of 10 at 3 hours to 50 when alteplase is administered beyond 4.5 hours[71]. The number needed to harm (NNH) for fatal intracranial haemorrhage within 7 days of treatment is 40 for those thrombolysed within 3 hours, 50 for those treated between 3 and 4.5 hours and 40 when the administration occurs between 4.5 hours and 6 hours. The overall NNH for all-cause mortality within 90 days is 71[71].

Because time from symptom onset to treatment is so critical to ensure a good outcome SSNAP has set a benchmark for achieving rapid treatment with IVT of ≤ 60 minutes. As part of the national stroke quality improvement programme, at least 50% of patients receiving thrombolysis should be treated within 1 hour. Currently, according to figures from the SSNAP Annual Report 2018-2019, 64% of patients receiving IVT are being treated within 1 hour of hospital arrival in England, Northern Ireland and Wales.

Complications

Use of alteplase for intravenous thrombolysis is associated with complications such as intracerebral and systemic bleeding, and angioedema. Intracerebral bleeding, also known as intracerebral haemorrhage (ICH), is classified into symptomatic and asymptomatic. Symptomatic ICH (sICH) is by far the most severe and dangerous thrombolysis-related complication. It is estimated that the risk of early sICH in patients treated with alteplase is in the range of 2% to 7%[72], and that severe sICH carries a mortality rate close to 50%[66].

Services performing IVT

Because of the potential risks, alteplase should only be administered within a well organised stroke service with properly trained staff in thrombolysis delivery and post-thrombolysis monitoring. There should be nursing staff trained to provide level 1 and level 2 care, and immediate access to neurological imaging with staff trained to interpret the results must be available[73]. Although the British National Formulary recommends that alteplase should only be administered under a specialist neurology physician, NICE guidelines extends this recommendation to allow appropriately trained staff in emergency departments

administer alteplase to eligible stroke patients, provided that there is support from an acute stroke service with neuroradiological and stroke physician support[73]. Additionally, a recent meta-analysis showed that telemedicine could be used to support administration of IV alteplase within 3 hours, although it is still unclear if these findings can be generalised to the 3 to 4.5 hour period as well[74].

Areas of uncertainty

Further evidence is still required for the following questions:

- What is the usefulness of advanced neuroimaging techniques to select patients with unclear time of symptom onset likely to benefit from IVT?
- Could alternative thrombolytic (clot busting) agents, such as tenecteplase or reteplase, be used in standard clinical practice as substitutes for alteplase?
- Is bridging therapy with IVT necessary, and how are patients selected, before mechanical thrombectomy?
- Is IVT safe and efficacious in children and adolescents in transitional services?

Mechanical Thrombectomy (IAT)

IAT represents the newest modality of reperfusion therapy. In contrast with IVT where clot busting medications are administered into the venous system, mechanical thrombectomy refers to the retrieval of the ischaemia causing clot by means of an interventional procedure (Figure 1)

Figure 2: Clot retrieval device with thrombus

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. This benefit is evident if delivered within six hours of onset following ischaemic stroke[78]. The number needed to treat to afford functional independence (Modified Rankin Score 0-2) is between 3.2 to 7.4 patients and the number need to treat to afford an improvement in functional outcome is 2.6.

For trials focussing specifically within 6 hours, the rate of functional independence was between 35% to 42% with IAT using modern devices (MR CLEAN [79], EXTEND IA[80], SWIFT PRIME[81], THRACE[82], PISTE[83] and EASI[84]). 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%[80, 81, 85] with IAT. Not only are rates of improved functional outcome consistent with IAT compared with IVT but so too are rates of recanalization with similar rates of symptomatic intracranial haemorrhage and a trend towards lower mortality[86].

In terms of devices used, comparing stent retrievers or aspiration devices, there are no advantages between either in terms of affording improvements in functional outcome. 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.

As a result of this, the Intercollegiate Stroke Working Party 2016 Stroke Guidelines[3] and NICE 2019 Stroke Guidelines[41] have endorsed the use of IAT as soon as possible within 6 hours of symptom onset in patients with a measurable neurological deficit in combination with IVT (if not contraindicated) in confirmed occlusion of the proximal anterior circulation demonstrated by CT angiography or MR angiography. In addition to this, mechanical thrombectomy can be used within the same time frame (within 6 hours of symptom onset) when thrombolysis is also contraindicated.

For patients with delayed presentation, including patients with wake up stroke up to 24 hours, there is now increasing evidence for mechanical thrombectomy in patients presenting between 6-24 hours: DAWN trial[87] and 6-16 hours: DEFUSE 3 trial[88] with the use of perfusion based imaging techniques including CT and MRI. Absolute benefits (good functional outcome) for patients in the DAWN trial compared with standard medical care equated to 36% as compared with DEFUSE 3 being 28%. The use of this criteria has been supported by NICE 2019 Stroke Guidelines up to 24 hours if there is potential to salvage brain tissue as shown by either CT perfusion or diffusion weighted MRI sequences delineating limited core volumes. However in reality, a low proportion of patients will satisfy these criteria and it is envisaged that a conservative estimate of around only 6% of patients with large vessel occlusion would be represented in the UK.

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 5 years equating to 8,000 patients per year. Current estimates suggest that 12% (10,000 to 11,500 stroke admissions) of the UK population are 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. The current estimates suggest that with an eligible population of 12% of ischaemic stroke population, 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. [89]

Reorganisation of services

There is still some uncertainty as to which is the preferred 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 (Comprehensive Stroke Centres: CSC) or just intravenous thrombolysis (Primary Stroke Centres: PSC). The choice of model will depend on local and regional service organisation, patient characteristics, volume of admissions, as well as the directive of the Integrated Stroke Delivery Networks (ISDN). For example, a 'Mothership' model whereby all stroke patients or those with suspected large artery occlusion are taken to CSCs may be the preferred model in metropolitan areas whereas a 'Drip and Ship' model may be preferable where addition transportation times to a CSG may result in delayed thrombolysis. Centralised configurations for stroke admissions per annum have been estimated up to a maximum of 2,000 patients. 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 and as such 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[90]. 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.

Appropriate imaging modalities such as CT angiography are also required at centres to identify patients with LAO who may benefit from recanalization, Further advanced imaging techniques such as CT perfusion with artificial intelligence software may help to select patients presenting beyond 6 hours, with stroke of unknown time of onset and large core volumes[91].

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 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 two 24/7 thrombectomy centres operating in the UK. It is estimated that probably 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[92].

IVT and IAT

IAT plus IVT is superior to IVT treatment alone according to two meta-analysis of randomised clinical trials[75, 76]. Current NICE recommendations are that eligible patients should receive IVT regardless of whether IAT is being considered. This recommendation is supported by a meta-analysis of 13 observational studies[77]. There is currently little evidence to suggest that IAT alone is superior to IAT with IVT.

Costs

Studies have consistently demonstrated that IAT in addition with IVT compared with intravenous thrombolysis alone is likely to be cost effective and cost saving with estimates calculated at £7,061 per QALY gained[93]. The cost of implementing mechanical thrombectomy including devices, staff salaries, set up costs such as training and equipment across the UK over 5 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 5 years[83]. IAT is currently under the aegis of specialist commissioning and the current tariff per case of £13,400 and therefore accurate calculations are required in future business models to ensure regional services delivering this model are both sustainable and cost effective.

Areas of uncertainty

Further evidence is still required for the following questions:

- What are the benefits of IAT in patients presenting with basilar artery occlusion?
- How do we accurately establish the degree of collateral blood supply with advanced imaging?
- Are there any additional advantages to using alternative thrombolysis agents to alteplase in combination with mechanical thrombectomy?
- Can interventional radiologists or other specialists who have obtained a credential in interventional neuroradiology (stroke) provide similar outcomes including safety profiles in comparison to Interventional Neuro-radiologists in operating mechanical thrombectomy?
- What is the optimal anaesthetic strategy for mechanical thrombectomy and advanced interventional radiology procedures: local versus general anaesthetic?
- What proportion of patients would benefit from treatment with thrombectomy beyond 6 hours after onset of stroke?
- How should thrombectomy services be configured in England to enable the best access to services with available resources?

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Chapter 5 - Acute care in the stroke unit

Key points

- 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.

Introduction

Hyperacute stroke units (HASUs) admit patients who have had a recent stroke in order to deliver specialist and co-ordinated multidisciplinary stroke care. An HASU serves to concentrate expertise and resources in order to meet the acute care needs of people who have suffered a recent stroke. HASUs may be geographically separate from a stroke unit (SU), as in the London stroke model, or co-located in a service that delivers both; a 'comprehensive stroke service' – see chapter 5. 'Acute stroke care' This chapter describes the care delivered in both HASUs and SUs. Rehabilitation refers to the restoration of physical, mental and social function after a stroke, usually as a result of multidisciplinary team working.

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

- The need for hyper-acute evidence-based interventions such as thrombolysis and thrombectomy for ischaemic stroke and treatments to limit haematoma expansion for intracerebral haemorrhage. See Chapter 5 for further discussion of the role these treatment modalities play.
- The need to restore and maintain physiological homeostasis in the face of pre-existing co-morbidities, the stroke itself and its complications.
- The need for prevention, early detection and timely management of the complications of stroke (and its treatments) when they occur.

- The acute need for early rehabilitation from the multidisciplinary stroke team and specifically allied health professionals (AHPs) to maximise functioning, in particular physiotherapists (PT), occupational therapists (OT) and speech and language therapists (SALT).
- The need to promptly identify patients expected future care requirements via a multidisciplinary approach including the assessment of the need to transfer to SUs where applicable.
- The need for patients, their families and their carers to be in receipt of explanations, information and psychological support in the aftermath of stroke.

75% 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[1] .The conditions which may predispose to stroke (e.g. heart attack, 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 for these conditions.

Close involvement of AHPs ensures not only the optimisation of rehabilitation and prevention of early complications but also allows for timely decision making regarding discharge or transfer to SU. Both physiological stability and a co-ordinated multidisciplinary assessment allow for transfer out of the HASU which is essential for flow.

Evidence based acute stroke care

There is strong evidence that specialised stroke unit care initiated as soon as possible after the onset of stroke provides effective treatments that reduce long-term brain damage, disability and healthcare costs. These reductions are multifactorial and are in part due to enhanced MDT working, the presence of dedicated management pathways as well as the concentration of expertise and specialist educational opportunities.

The national clinical guideline for stroke (2016), which is consistent with the NICE guideline [2019] for stroke[2,3], sets out recommendations relevant to the organisation of care in an acute stroke service:

- Acute stroke services should provide specialist multi-disciplinary care for diagnosis, hyper acute and acute treatments, normalisation of homeostasis, early rehabilitation, prevention of complications and secondary prevention.
- Acute stroke services should have 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.

- Acute stroke services should have immediate access to brain imaging including CT angiography and should be capable of undertaking brain imaging as soon as needed.
- Acute stroke services should have protocols for monitoring, referral and transfer of patients to regional neurosurgical centres for decompressive hemicraniectomy, surgical management of intracranial haemorrhage and the management of symptomatic hydrocephalus including external ventricular drain insertion.

The sections below discuss the evidence base, where it exsits, for these recommendations which are reflected in national guidance[2,3]. Where possible data are presented regarding the national uptake of different interventions.

Cost

The reorganisation of stroke care brought about by the London Stroke Model caused a reduction in the cost of individual strokes from £15,002 to £12,889[4].

Rationale for physiological monitoring

Clinical benefits in HASUs were believed to be derive from monitoring and control in the acute phase of hypertension, hyperglycaemia, hypoxia, pyrexia and hydration[5]. Middleton et al (2011) showed that training stroke unit staff in the use of standardized protocols to manage physiological status can significantly also improve outcomes[6].

The frequent monitoring of physiological parameters including blood pressure, heart rate, oxygen saturations and temperature are required for the following reasons.

Detection of sepsis

During the first week 5% of people with acute stroke develop urinary sepsis and 9% require antibiotics for pneumonia [1]. Patients with post stroke pneumonia have worse functional outcomes and mortality and infections require rapid treatment to avoid significant mortality and morbidity[7]. Detection of sepsis relies in part on the frequent monitoring of temperature, pulse rate and blood pressure, with reduced oxygen saturations being an early marker of chest infection.

Management of hypertension

Approximately 30% of patients with acute stroke are hypertensive[8] 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 lowing post haemorrhage[9-13] than ischaemic stroke[14-17] for which there is still uncertainty as to optimal management. Further research is required here to determine best blood pressure control targets and treatments. National guidance[2,3] has incorporated trial evidence with consensus opinion to advocate intensive blood pressure management to keep blood pressure within specified values depending on the stroke subtype and whether systemic thrombolysis has been used.

Management of dehydration and malnutrition

Dehydrated patients on admission have worse survival[18], and adequate fluids, nutrition and aspirin are associated with a 0.55 odds ratio of death[19]. A Cochrane review of the signs and symptoms of impending and current water-loss dehydration in older people[20] concluded that there is little evidence that any one symptom, sign or test, including many that clinicians customarily rely on, have any diagnostic utility for dehydration – therefore multimodal assessment of hydration relying on objective physiological and biochemical parameters and clinical examination is recommended.

No national data exist for the provision of physiological monitoring by acute stroke services.

Rationale for early specialist swallowing assessment

Dysphagia, or difficulty swallowing is present in up to 35-78% of people who have a stroke and is a reliably identified risk factor for poor nutrition and aspiration pneumonia[21]. There is good evidence from a systematic review[22] that the investigation of dysphagia with instrumental assessments helps predict outcomes and improve treatment outcomes. Meanwhile Bray et al. demonstrated the rates of stroke associated pneumonia rise with delays to SLT assessment, with a 3% incidence with patients immediately assessed rising to a 5% incidence by 48 hours[23]. The 2016-2017 SSNAP annual report[24] found that currently 87% of patients with stroke receive a formal swallow assessment, usually by a speech and language therapist, within 3 days of arriving at hospital and 74% receive a swallow screen usually by a nurse trained in swallow screening.

Rationale for neurological monitoring

The National Institutes of Health Stroke Scale (NIHSS) and Glasgow Coma Scale (GCS) are validated and reliable methods of objectively assessing neurological impairment and level of wakefulness which can be

performed quickly by appropriately trained staff. They are especially relevant in hyperacute, but also in acute, stroke care where rising NIHSS or falling GCS are 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[25,26]

Rationale for routine monitoring 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 seen at 24, 48 and 72 hour periods of monitoring. Appropriate anticoagulation when AF is detected reduces risk of recurrent stroke by around two thirds. This, and the risk of co-incident acute, life threatening and treatable cardiac conditions such as myocardial infarction justify the routine monitoring of cardiac rhythm [27].

No national data exist for assessing the provision of neurological or cardiac monitoring in acute stroke services.

Rationale for the provision of intermittent pneumatic compression (IPC) stockings

Prospective studies have identified the risk of venous thromboembolism (VTE) in hospitalized 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[28]. Accordingly IPC stockings are recommended in national guidelines for all stroke patients with reduced mobility. Currently only 21% of patients with stroke have IPCs applied whilst in hospital.

Rationale for the early and close involvement of AHPs

AHPs offer acute assessment of stroke related impairments and advise on need for ongoing rehabilitation, often necessitating transfer to a different stroke unit. If timely therapy assessments do not occur patients may be transferred unnecessarily in situations where their post stroke function has not been adequately assessed leading to a poor patient experience and unnecessary system demand[29].

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 discomfort, and maximize functional and maintain soft tissue length. Good positioning may also help to reduce respiratory complications and avoid compromising hydration and nutrition[2]. 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 4 hours of arrival in hospital and that trained stroke unit staff undertake appropriate positioning at all points in patients' stays.

Post stroke therapy results in greater functional improvements post stroke, and studies on the intensity have led to guidelines supporting a 'dose' of 45 mins/day. These benefits are expected to accrue from 24 hours onwards[30].

The AVERT trial examined the functional benefits of very early mobilization after stroke (i.e. within 24 hours). Although the trial was not positive and reported adverse consequences, there were positive subgroups, which may be identified by physiotherapists[31]. Consequently it is recommended that very early mobilisation after stroke should be conducted after specialist assessment of mobility with a tailored plan according to individual abilities.

Currently 95% of patients with stroke receive physiotherapy assessment within 3 days of arriving at hospital, where required. Subsequently 80% will receive at least 45 minutes of physiotherapy on 5 days in the week, while 84% will receive the same quantity of occupational therapy[24].

Chapter 6 deals in more detail with rehabilitation in hospital, in particular rehabilitation past the first days after stroke.

Cost

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 5 beds. See chapter 5 for further discussion on recommended staffing levels for HASUs.

The estimated cost for this level of staffing is £384 082 per annum for Monday to Friday working on a 20 bedded HASU, costed at top of the band 6 pay scale since a range of staff at different banding levels are required.

The corresponding figure for weekend working with the above assumptions and staffing levels is £222 768 taking into account 1.3x pay on Saturday and 1.6x on Sunday[32].

There are 1,495 new stroke per million in the UK[33] of whom 12-22% never come to hospital[34]. In 2018 84% of patients in SSNAP audit population spent 90% of their time on a stroke unit[24]. The average length of stay on a HASU is estimated as 2.5 days as some are discharged, transferred or die before 72 hours. These patients would require 3,737 HASU bed days if they all went to a HASU. If 80% of these are on a HASU for

2.5 days, 2,990 bed days are required per million per annum. A 20 bedded HASU could provide 7,300 bed days, but at 90% occupancy 6,570 bed days. The annual cost of AHP staffing as above per million would therefore approximate to £276 000 for weekdays and weekends.

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Chapter 6 -Rehabilitation in Hospital

Key points

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

- 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.

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[1].

"Rehabilitation consists of assessment, treatment and management of the consequences of stroke to enable an individual (and their family/carers) to achieve their maximum potential for physical, cognitive, social and psychological function, participation in society and quality of living"[86].

The multidisciplinary team provides interventions aimed to address stroke related impairments, day to day activity loss and reduced participation in society as defined by the International Classification of Functioning, Disability and Health[2]. The focus of effective rehabilitation is to maximise independence in self-care and reduce immobility related complications[2].

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[3 - 6]. Despite initial costs, these acute costs are offset by longer term savings in the cost of community care[7]. The health and societal cost consequences are improved because more effective stroke care will reduce long-term rehabilitation and care cost[1].

Meta analysis of stroke unit trials[3] has demonstrated a clear and clinically significant improvement in mortality and morbidity and reduced institutionalisation rate. The contributing 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 2016 Intercollegiate Stroke Working Party (ICSWP) National Clinical Guidelines for stroke[1] recommend that stroke unit care and early supported discharge services are provided by a coordinated multidisciplinary team. Whilst recent national audit data[8] has shown improvements in this area, particularly in seven day working, it continues to highlight improvements that can be made.

The rehabilitation team is multidisciplinary and provision varies depending on the stage of recovery and clinical need. The multidisciplinary rehabilitation team would typically be made up of physiotherapists, occupational therapists, speech and language therapists, orthoptists, clinical psychologists, nurses, generic rehabilitation workers and dieticians. In stroke rehabilitation or neurological rehabilitation units and community services it may also include orthotists[1]. Competencies are described in the Stroke Specific Education Framework[5]. Nurses and stroke physicians contribute to the rehabilitation team but have wider responsibilities.

There is evidence for a dose response to rehabilitation[82]. Current guidelines recommend 45 minutes of each relevant therapy for at least five days a week[1] as a pragmatic choice. Whilst challenging, this is achievable by the NHS. 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 (Chapter 7)[1]. Recent SSNAP data shows that there are still significant proportions of patients who do not receive the amount of rehabilitation that are recommended[8]. 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[10]. Whether this is appropriate or not needs to be determined.

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'[11,12]. A Cochrane review[13] 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. There is a need to consider how to develop the knowledge and skills of rehabilitation staff to support self-management[1] and identify key features of effective self-management programmes and assess their cost effectiveness[13].

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[13]. It is recommended that should difficulties be identified then appropriate management should be started as soon as possible[13] and that therapists should not base their provision on treatment approaches but on the selection and prescription of the most suitable specific intervention for the individual patients' needs.

Current rehabilitation standards set out by the British Association of Stroke Physicians in 2014[15,16], describe expectations for acute care and rehabilitation. These require swallow assessments within 24 hours; access to a stroke specialist multidisciplinary team; a nutritional screening assessment; early mobilisation; and the promotion of bladder and bowel continence.

As previously mentioned, a multidisciplinary approach is promoted. These recommendations[16] also give expectations for staffing levels for in-patient stroke rehabilitation and the costs associated with these. Provision of staff varies dependent on clinical speciality. For example, one full time physiotherapist is recommended per five beds, based on a seven day service, whereas for Speech and Language Therapists one full time equivalent is expected per ten beds, based on the same seven day service. These provisions are reinforced in the 2016 ICSWP guidelines[1], suggesting that the number of available therapists should be increased, and rehabilitation services should reorganise to increase the proportion of time each therapist

spends in face-to-face contact[1]. It has been argued that in order to meet these standards nationally, finances must be available to services to transition and successfully deliver gold standard care[16].

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. The AVERT programme assessed very early mobilisation, delivered within 24 hours of stroke onset, against usual care[17]. They defined early mobilisation as the commencement of sitting, standing and walking using a clinical protocol tailored to the severity of the stroke. It suggested that very early mobilisation may in fact be harmful, despite its recommendation by multiple guidelines. It is advised that people with acute stroke should be encouraged to take part in an active programme of rehabilitation when their clinical condition permits, currently largely guided by consultants in relation to medical presentation[18]. A non-randomised study exploring the implementation of evidence based in-hospital rehabilitation[19] showed that appropriately delivered, high intensity, specialist rehabilitation early post stroke leads to better functional outcomes for stroke patients.

It is also worth noting that vocational rehabilitation should begin in the initial stages of recovery (in hospital), however, the practicalities of this, are not straight-forward as there are time and staff constraints[20]. Therapists should also be urged to find way to maximise patients' opportunities to practice functional tasks (both supervised; semi-supervised and unsupervised) such as independent practice/ peer support, working visitors; various activity 'clubs' (eg breakfast club; art classes etc), exercise classes to promote balance, mobility, prevent falls and upper limb function etc.[1, 21].

Movement and mobility

Post stroke, difficulties with movement and physical function are both common, and can have a profound effect on a patient's quality of life and levels of independence. A Cochrane review of 96 trials[21] examined physical rehabilitation approaches for the recovery of function and mobility following stroke. More than half of the studies (50/96) were carried out in China and so there may be limited generalisability to NHS care. Many of the interventions were heterogeneous and the studies were poorly reported.

Physical rehabilitation had a significantly beneficial effect, compared with no treatment, on functional recovery after stroke indicated by improvement independence in activities of daily living scales, and this effect persisted beyond the length of the intervention period[21].

Pooled data from 12 studies found physical rehabilitation to be more effective than usual care in improving motor function. Physical rehabilitation was also more effective in improving balance. The authors

concluded that, physical rehabilitation, comprising a selection of components from different approaches, is effective for recovery of function and mobility after stroke.

The most recent evidence suggests that thirty to sixty minutes daily, seven days a week is better than the previously suggested five days a week[1]. This is supported by the NHSE Long Term Plan[22], whereby all services should be aspiring to achieve seven day working and therapy input, to ensure best patients' outcomes. Physical rehabilitation was significantly more effective than usual care or attention control in improving motor function, however, no one physical rehabilitation approach was more or less effective than any other approach in improving independence in promoting recovery of function and mobility and thus activities of daily living[21]. Therefore, clinical selection of the most appropriate physical treatments for individual stroke survivors should be undertaken using evidenced-based interventions and critical clinical decision making. The evidence for specific interventions to improve mobility, balance, physical fitness and participation after stroke is summarised in the ICSWP National Clinical Guidelines for Stroke[1]. Evidence is robust showing that people with impaired balance and walking ability benefit from balance training and strengthening exercises[23,24] . Task specific walking training at an intensity to improve cardiorespiratory fitness and muscle strength has been shown to be beneficial[21]. Treadmill training for patients able to walk[25] and for some patients who need partial body weight support during exercise can also be beneficial[26]. Where patients have poor mobility there is still good evidence to support the use of exercise to improve fitness and strength[27].

Vision

Current guidelines[1] state that orthoptists should be part of the acute stroke multidisciplinary team. The incidence of acute stroke-related visual impairment is 60%[72]. Visual impairment constitutes a considerable comorbidity of stroke. Visual impairment, on its own or in addition to other stroke-related disabilities, can cause significant impact to quality of life[73]. 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[74,75,76]. Interventions for stroke-related visual impairment are well established but require referral to appropriate eye care services, which is facilitated through orthoptic service routes[76]. Where visual impairment is identified, this facilitates optimisation of other therapy and early access to vision rehabilitation. 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[77,78,79]. Evidence relating to the management of patients (from the general population) with age-related visual problems and eye movement disorders are available from other Cochrane reviews and are likely to be the best evidence available for making treatment decisions about

individual patients. There is limited evidence which supports the use of compensatory scanning training for patients with visual field defects (and possibly 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[28]. 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, suggesting that these may be effective interventions; moderate-quality evidence also indicated that unilateral arm training may be more effective than bilateral arm training[28]. Information was insufficient to reveal the relative effectiveness of different interventions. The GRASP (Graded Repetitive Arm Supplementary Programme) intervention, is shown to be effective in some individuals in improving upper limb function[29]. Electromechanical and robot arm assisted training may also be beneficial to improve arm function[30] and there is some evidence that intensive arm rehabilitation even late after stroke can have some benefits in improving activities of daily living[31]. Current research acts to guide clinical application dependant on specific details of an individual patient or setting, or both, and clinical decisions will require expert clinical reasoning and judgement if available evidence is to be interpreted and applied effectively[28]. Further research is needed to define dose of interventions, larger randomised controlled trials to reinforce benefits of current treatment and provide up to date reviews and exploration of further adjuncts with limited current evidence (such as biofeedback, electrical stimulation and repetitive task training)[28].

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[32]; art therapy, facilitated by an art psychotherapist[33;] and the introduction of different exercise methods such as yoga for post stroke depression and anxiety[34]. 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[35].

There is an ever-growing body of evidence[36,37] highlighting the importance of psychology provision. We know that physical and mental strength and wellbeing are heavily linked[38.] The role of clinical psychology in the management of stroke patients is strongly recommended. The NICE Quality standard for Stroke in 2016[18] suggests that all adults who have had a stroke have access to a clinical psychologist with expertise in stroke rehabilitation. Current evidence shows that only five percent of patients in hospital are deemed to be applicable for review by a psychologist, likely to be a direct result of limited service provision[8] , and so this overwhelming lack of psychological services for stroke survivors needs urgently addressing[8].

There has however, encouragingly been some significant improvement in the percentage of people who are being assessed for mood and cognition within six weeks of admission. A study looking at mood disorders post stroke[39] suggests that clinician uncertainty about which tool to use is one practical barrier and thus review a range of available tools and concluded that uncertainty surrounding screening tool choice remains. A randomised controlled trial[40] looking at interventions that may improve long term stroke outcome, highlighted a protocol for identifying stroke patients and their carer's in need of psychological support (among other needs) and suggested that "… successfully addressing the needs of a heterogeneous post-stroke population remains problematic. Future work could explore stratifying patients and targeting services towards patients (and carers) with specific needs, leading to a more specialised bespoke service".

Cognitive rehabilitation

Overall, this area of stroke management is poorly evidenced, and guidelines are largely based on best practice. The 2016 National Clinical Guideline for Stroke[1] states that cognitive impairment is associated with poor outcomes after stroke, such as increased length of hospital stays and reduced independence. It is considered important 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[41], and is worthy of further investigation. Multiple sources advocate the use of appropriate cognitive screening tools and outcome measures to ensure effective rehabilitation. Examples of standardised screening tools used in UK stroke services include the Montreal Cognitive Assessment (MOCA)[42] and the Oxford Cognitive Screen (OCS)[43].

A Cochrane review[44] of 19 studies assessing the improvement of cognition on executive function found limited evidence that different interventions resulted in statistically significant improvements.
A review of the current evidence and how it related to the published guidelines completed in 2019 by a team of stroke experts, does not make specific recommendations on executive function. It does state that where a cognitive deficit is identified, a detailed assessment using valid, reliable and responsive tools should be carried out before designing a treatment programme[45]and new research should have an enhanced focus on function.

Communication

Communication difficulties that occur after stroke include aphasia, dysarthria and apraxia of speech[31].
Evidence of the effectiveness of SLT for dysarthria is limited (five small RCTs) and apraxia but expert group recommendations support SLT intervention (ICSWP)[83,84]. 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[32,85].
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. 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[33]. Preceding this trial, a systematic review of data trials found no evidence of a differences between SLT-directed computer facilitated SLT and face-to-face therapy with the therapists [32].
Software support for the provision of SLT to people with aphasia offers an important self-management option for people with aphasia. Future studies should target generalisation of new vocabulary in the conversation for patients with chronic aphasia post-stroke[33].
Guidelines from the ICSWP[1] suggest that the 45 minutes of daily therapy should be applied to SALT input also based on expert clinical guideline recommendations. Some evidence exists to support this specific level of intensity or the timing of when this intervention should start following aphasia but not in the context of dysarthria or apraxia.
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 2 hours rehabilitative therapy time weekly[51]. Overall language benefits were greatest in the context of 20-50 hours of therapy in total.

Timing

Evidence for the optimal timing of SLT for aphasia has seen trials of early intervention presenting conflicting evidence alongside evidence for continued potential benefits of SALT several years after a stroke[30]. A trial of very early intensive aphasia rehabilitation (VERSE) compared early SLT to usual ward care but found that there was no benefit to very early intervention when compared to conventional input [34]. More recently, a large network 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 6 months after aphasia onset.

Trials of the timing of complex SLT interventions evaluate the delivery of a specific therapy intervention (frequency, intensity, duration and dosage) which may not be optimal for language recovery in that context. The Cochrane review found that higher intensity SLT interventions offered benefit to participants that remained in the study compared to lower intensity groups. However significantly more people ceased to participate in the high intensity groups compared to the lower intensity interventions suggesting that tolerance to intensive approaches may be an issue. Additionally, the participants that withdrew from the intensive interventions were all within three months of stroke while the studies that recruited several years after onset did not report any participants that declined to continue. Importantly, the benefits of the higher intensity approaches were only observed amongst the participants within three months after stroke.

Orthotics

It is well understood that stroke has a defined impact on movement and physical function, and as a result of this many stroke survivors benefit from orthotic devices, which through aiding mobility and prevention of secondary complications, can in turn promote independence[50]. The most common orthotic intervention post stroke is the Ankle Foot Orthosis (AFO) and should be considered an adjunct to therapy to aid recovery. For many, orthotics is a critical aspect to the success of a rehabilitation programme and in turn are both beneficial and cost effective[51]. Current best practice details the value of orthotist intervention within the wider stroke rehabilitation team[1, 52]. 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[45]. Further evidence is needed to identify optimum methods of orthotic intervention and to increase nationwide access to orthotists and their specialist skills as key members of the stroke MDT.

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. Incontinence of urine greatly increases the risk of skin breakdown and pressure ulceration and often causes the patients and carers great distress. Incontinence of faeces is associated with more severe stroke and is even more difficult to manage[66]. Incontinence is an area of stroke that has received little research interest, despite it substantial negative impact.

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[1]. Where possible, the stroke survivor should be involved with any decisions and offered behavioural interventions such as timed toileting. Current recommendations are largely based on NICE guidance and ICWSP consensus[14,18]. A recent Cochrane review[66] found that behavioural interventions may reduce the mean number of incontinence episodes in 24 hours but makes little or no difference to quality of life.

Complementary therapies such as acupuncture may increase the number of participants continent after treatment[67]. Physical therapies, such as transcutaneous electrical nerve stimulation, may reduce the average number of incontinent episodes in 24 hours and therefore improve quality of life and involvement in activities of daily living[68]. However, the quality of the evidence was limited due to poor reporting of study details and the small number of study participants in most comparisons[66]. It is an area of stroke rehabilitation that warrants further research and intervention development.

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Chapter 7 - Rehabilitation in the community

Patients are being discharged from hospital more quickly than ever before, with the length of stay reducing considerably since 2001[4]. Most stroke survivors have ongoing medical, rehabilitation and psychosocial needs[1]. A third of these patients are discharged to an ESD or community rehabilitation team. The stroke survivors discharged via these routes are usually cared for by stroke or neurology specialist teams[74].
The Stroke Association in their document 'State of the Nation – Stroke Statistics'[54] state that out of over one million stroke survivors in England, Wales and Northern Ireland, 84% of patients 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 reports feeling 'abandoned' after leaving hospital[45]. It is well evidenced that stroke survivor's symptoms can continue to improve long after 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[41].

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'[1].
In order to make the transition between hospital and the community (whichever setting that may be) smooth, successful, and as easy as possible for the survivor and their family/friends, a handover between teams and professionals is vital. Continuity of care, with comprehensive pathways within the community is a key area for development [59].

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. Alongside this one in five commissioning areas do not offer access to speech and language in the community[54].
The transfer from hospital to home is a critical time for the stroke survivor and their carers and national guidelines advise that the stroke survivors' home should be made both safe and enabling prior to leaving hospital.[78.79] The Sign Guidelines recommendations[105] include a list of information to be transferred to the

community . There is evidence that discharge planning increases patient satisfaction[82] and that patient-held records may enhance the patient's understanding and involvement in their care[83].
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 ADL and participation.[109]In a stroke population there is evidence of the feasibility of a trial[80] and a full trial is on-going.[81]
There is no agreed protocol for discharge to a care home and there is little empirical evidence of best practice. There has been some consensus work indictating that there needs to be clear ownership of the process and precise information on medication and nutritional needs. Few stroke survivors have a pre-discharge visit to the care home and there is little evidence of how to enhance discharge planning for those entering institutionalised care[87].

Early supported Discharge

Early Supported Discharge (ESD) is a stroke specialist service, which enables stroke patients to continue their rehabilitation at home at the same intensity as in hospital. This enables patients to return home faster than would be possible otherwise. ESD is a multidisciplinary team intervention, delivered by a coordinated specialist team of occupational therapists, speech and language therapists, physiotherapists, nurses, psychologist and physician[99]. The success of ESD in providing stroke specialist rehabilitation at home (rather than in the stroke unit), for a stroke survivor deemed medically fit for discharge is well documented[48].
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[48].[8,3]
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[4]. 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[54]. The opportunities to access care in the community for those with more severe strokes is an area in need of research.

An international ESD consensus defined the core components of an ESD service; a stroke specialist multidisciplinary team with appropriate staff/ patient ratios and coordinated MDT working[99]. Adoption of core components was associated with a more responsive and intensive ESD service[101]. Consensus has also

been reached on the core components of evidence based community stroke services and how these would complement delivery of ESD[97].

Qualitative findings highlighted the importance of communication between acute and community stroke services, particularly with regard to referral decision making processes as well as challenges associated with securing social care input and follow on services. This resonated with the fact that patients valued the speed at which rehabilitation commenced but felt that the six-week cut off from Early Supported Discharge was 'abrupt' and that the transition on to other services was not always well managed[98].

Community based therapy and longer term stroke care

There are many heteregenous studies combined in systematic reviews that have investigated the effectiveness of therapy based interventions in the community. A high quality Cochrane review of domiciliary occupational therapy shows benefit in improving and maintaining ADL[88], but the evidence has been downgraded since the first review in 2006 because of methodological changes in the review interpretation. A recent systematic review including 49 occupational therapy and physiotherapy studies[89] reported moderate improvements in ADL and noted a positive effect of carer training. A less rigorous review of interventions to improve community participation after stroke[99] concludes that there is potential to improve participation (extended ADL, such as leisure) and HRQoL. However Lee et al point out that few studies have looked at civic and societal activities beyond leisure[90]. A systematic review[55] 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. The control groups were to include routine or usual care received by patients, including any therapy provided in outpatient departments or day hospitals. The review identified five trials for synthesis of data for 487 participants. Two of the included studies were also included in the review by Pollock et al[35]. Three of the studies were set in the UK but the latest was published in 2006. Two of the studies focussed on physiotherapy, one on occupational therapy and two used a multi-disciplinary rehabilitation intervention where a combination of physiotherapy and occupational therapy in an outpatient setting was used. As in the Pollock et al. review[35], subsets of studies were analysed depending on the comparison and availability of data. There was no significant difference in this outcome between the groups (SMD -0.06, 95% CI -0.32 to 0.20).

Research has been conducted to investigate and facilitate implementation of ESD in real world settings. An international ESD consensus defined the core components of an ESD service (stroke specialist multidisciplinary team with appropriate staff/ patient ratios, coordinated MDT working)[99].

The recent publication of the EXTRAS (Evaluation of an Extended Stroke Rehabilitation Service) randomised controlled trial and economic analysis[77], evaluated a new longer-term community stroke rehabilitation service which commenced when routine ESD ended. The results highlighted that such an intervention could be both cost effective and improve health-related quality of life and satisfaction with service provision.

Spasticity Services

There are specialist spasticity services that include adult stroke across the UK. Eligibility is locally determined as is the staffing pattern but can include rehabilitation medicine consultants, neurologists, physiotherapists and nurse specialists. There is strong evidence supporting the use of botulinum toxin type A in reducing spasticity and improving passive function summarised in the European consensus table on the use of botulinum toxin type A in adult spasticity[66]. They included 12 RCTs for upper limb spasticity, 7 RCTs for lower limb, 2 mixed RCTs (upper and lower limb) and 2 meta-analyses.
A more recent systematic review[104] included 29 RCTs (n=940) and found Neuromuscular electrical stimulation (NMES) significantly reduced spasticity and increased range of motion compared to control. A systematic review and meta-analysis of randomised controlled trials of NMES included 29 RCTs (n=940) and found NMES significantly reduced spasticity and increased range of motion compared to control.

Exercise

Physical activity and exercise for community dwelling stroke survivors is a complex area. There have been at least 40 systematic reviews in the last 5 years. These have addressed stroke impairments such as strength and balance, functional activities, walking, cognition, mood, and cardiovascular risk. Exercise has been delivered by therapists, gym based trainers and remotely by a variety of platforms including social media, both as individual programmes and groups. Essentially, any exercise is beneficial but the most difficult part is accessing and sustaining it and further research is required.

Non NHS services

The Stroke Association provide a range of services, which in some areas offers “Moving Forward After a Stroke”[106], a 12 week exercise and education group. Some alternative providers exist such as the National

Centre for Conductive Education in Birmingham. Local authority funding is available but fluctuates, a feasibility trial has been completed[92].

Care Homes

Rehabilitation standards[58] highlight that no patient with stroke should be discharged to permanent institutional care without a comprehensive assessment of their potential for rehabilitation. At discharge from rehabilitation to a care home stroke survivors tend to be more disabled with more complications such as incontinence, dysphagia and pneumonia[92]. Unfortunately, complications develop further in care homes with contractures, pain and depression[93]. Models of care found to be successful in domiciliary settings[94,95] have not demonstrated benefit in care home populations.[96]

Carer Interventions

Multiple systematic reviews have been undertaken in recent years investigating non-pharmacological interventions[102] and psychosocial interventions for carers of stroke survivors[103]. These reviews have flagged up several limitations with the existing evidence to date. Legg and colleagues found that there was a lack of a description of the key characteristics that define the informal carer population[102]. Brereton[110] concluded that many studies did not identify a conceptual basis for the intervention but there were some benefits for multiple interventions: caregiver training; education and counselling; social problem solving partnerships, delivered by telephone; nurse led support and education programme and a support programme either delivered to groups or one to one. However, Brereton commented that the trials included in the review were generally of low quality preventing firm conclusions to be drawn.

The most recent systematic review and meta-analysis of psychosocial interventions [103] for stroke survivors, carers and survivor-carer dyads found that psychosocial interventions reduced depressive symptoms in carers. However there was limited evidence that such interventions reduced anxiety symptoms, or improved quality of life and coping and no evidence that they improved self-efficacy, carer strain or carer satisfaction.

A high quality trial of a structured training programme for caregivers of inpatients after stroke found no benefit[84]. A process evaluation of the trial concluded that contextual factors, such as other workload pressures and staff perceptions negatively impacted on the trial[85].

Alternative models have been developed in the UK (OSCARS, BISC)[10,11] and the results were presented at the UK Stroke Forum in 2019 and provided useful insights for how we should best support carers in the

context of current health and social care systems including the NHS and charitable services[10,11]. A key message from both trials is that there should be more focus on understanding how interventions can be integrated into existing stroke services and a need to develop clear implementation plans.

Moving Forwards

Implementation and further development of higher intensity care models for stroke rehabilitation are expected to show savings that can be reinvested in improved patient care. [36] Further development of SSNAP, particularly in relation to community based care, will provide a comprehensive dataset that meets the needs of clinicians, commissioners and patients by reporting the processes of care provided for stroke patients during their rehabilitation pathway and ongoing life after stroke care.

Community interventions have historically operated a five-day week service, however, with the recommendations put forward in the NHS Long Term plan[36] it is important that this is adapted to be able to follow updates to guidelines. The financial implications, in practice, for community stroke services are unknown, however, have been evaluated in other areas, such as major trauma. The costs have been well researched in the acute setting and further economic evaluation is required for community based services.

Further improvements in the transition and delivery of rehabilitation in the community could reduce ongoing care needs, promote the stroke survivors return to an improved quality of life and help reduce the risk of further vascular events, improve stroke survivors' and carers' psychological status and improve social participation and well-being. There is robust clinical trial evidence for ESD reducing length of hospital stay, morbidity and costs, preventing institutionalisation and reducing levels of disability. We also know that adoption of evidence based core components in practice, is related to ESD services providing more responsive and intensive rehabilitation (Fisher et al 2011; 2020)[99,101]. Whilst it is recommended that ESD is only appropriate for a subset of patients, (approximately forty percent of stroke survivors with mild to moderate symptoms)[48] , provision of appropriately resourced community stroke rehabilitation (with ESD) ensures a wider population of stroke survivors can be cared for (Fisher et al 2013, EXTRAS)[100].

Summary

There is no single optimal rehabilitation pathway for stroke survivors, given the wide range of symptoms, levels of disability and individual circumstances that are experienced. This is particularly relevant to care for those survivors with a severe stroke, which is a much needed area of research. However, current evidence

suggests funding is required for specialist rehabilitation services capable of meeting the specific health, social and vocational needs of people with stroke of all ages; services capable of delivering specialist rehabilitation in community settings in liaison with in-patient services. The National Stroke Programme supports the implementation of Integrated ESD and community stroke /neuro rehabilitation services to provide appropriate therapies for as long as required to meet rehabilitation goals. This will be achieved, through integrated working between the NHS, social care and the voluntary sector (Fisher et al 2013).Resource is also required to provide much needed psychological support and vocational rehabilitation. Social prescribing, as well as a 'rehabilitation prescription' and patient passport can also be used to facilitate integrated service provision. Commissioners should be putting plans in place to ensure local delivery of the ambitions set out in the Long Term Plan guided by national evidence based service specifications as part of their immediate and longer term planning, They should ensure that they are engaging their local communities around the opportunity to improve patient outcomes[36,53].

Integrated Stroke Delivery Networks , working with NHS organisations and Local Authority partners will set out how they intend to translate the plan's contents into local action. Services should be commissioned which meet those recommended in the National Pathway Specification and published clinical guidelines.

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Chapter 8 - Follow-up and long-term support after stroke

Key points

- Follow-up care and long-term support for stroke survivors and their families is 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 (Chapter 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.
- Models of social care integration focus on generic health conditions. There is currently no stroke-specific model of health and social care integration.
- Supported self-care and management of stroke survivors is outlined in national guidelines,

however there is limited evidence of effectiveness of programmes.

- The completion of 6 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 6-month review is required on a national level.
- Stroke 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 drop in the number of sites seeking patient and carer views on stroke services.

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[1]. A survey of stroke survivors 1 to 5 years following stroke found long-term clinical and social needs to be unmet. More than half of respondents (54%) found stroke information to be inadequate, including information about diet, benefits applications and home adaptations. Respondents reported a negative impact on work (52%) and leisure activities (67%)[2]. Home help/personal care and therapy are also common unmet needs[3]. Because there were few significant differences between

the national and population register samples, results from the national sample are reported with frequencies using weighted data[2].

Table 1 Proportion of Respondents Reporting Stroke-Related Health Problems and the Extent to Which Needs are Met

	No. Reporting A Problem (Weighted %)	Proportion Reporting Need Unmet (Weighted %)	Proportion Reporting Need Met to Some Extent (Weighted %)	Proportion Reporting Need Met (Weighted %)
Mobility problems	321 (58.4)	25	3	32
Falls	265 (43.9)	21	47	32
Incontinence problems	217 (37.2)	21	40	39
Pain	249 (39.5)	15	34	51
Fatigue problems	301 (51.7)	43	36	21
Emotional problems	244 (38.4)	39	34	27
Concentration problems	260 (44.7)	43	41	16
Memory problems	260 (42.8)	59	25	16
Speaking difficulties	194 (34.3)	28	39	33
Reading difficulties	148 (23.2)	34	43	23
Sight problems	212 (37.2)	26	35	39

McKevitt et al, 2011[2]

The 2016-17 annual report by the Sentinel Stroke National Audit Programme (SSNAP) reveals year-on-year improvements in accessibility of post-stroke services, with the percentage of patients discharged from hospital with stroke/neurology specific Early Supported Discharge at 34.6% in 2016/17, compared to 24.7% in 2013/14. Similarly, six-month assessments after stroke were at 32.1% in 2016/17, compared with 16.5% in 2013/14[4].

Despite these improvements, stroke survivors and caregivers feel abandoned and marginalised by healthcare services. Limitations in access to services, a lack of adequate information about stroke, recovery and healthcare services, ineffective communication between survivors and healthcare services and a lack of continuity of care all contribute to stroke survivors' dissatisfaction with post-stroke care[5].

Best practice guidelines for (and evidence this improves outcome): Primary care (see Chapter 2)

GPs play a key role in the ongoing medical care of stroke patients and in reinforcing education, support, lifestyle alterations and secondary prevention. They are 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. This includes detailed information on continuing medication as well as prescribing changes made in hospital and the reason for such changes. 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. Pain should be identified, assessed and treated. Where pain is unresponsive to standard treatment, patients should be assessed for central post-stroke pain[6].

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 4-year period from 2004-2008. This research makes an important contribution to several topical policy initiatives, including the merits of prevention and early intervention, and shifting care from secondary settings to primary care[7].

The strategy for the implementation of high quality, evidence-based treatment is the development and distribution of clinical guidelines. However, the guidelines alone are not enough to implement a certain practice. Despite being a serious condition, stroke gets limited attention in the first year of follow-up in general practice[8]. Evidence for improved patient outcomes as a result of post-stroke primary care is limited and further research is required.

Secondary prevention

Stroke survivors have an elevated risk of a further stroke, which is usually more severe and disabling than the primary event. [9] The risk of recurrent stroke in survivors is 3.1% (95% CI, 1.7–4.4) at 30 days, 11.1% (95% CI,

9.0–13.3) at 1 year, 26.4% (95% CI, 20.1–32.8) at 5 years, and 39.2% (95% CI, 27.2–51.2) at 10 years after initial stroke[10].(Chapter 1) Optimum secondary prevention of recurrent stroke requires rapid diagnosis and treatment and timely recognition of the underlying vascular cause. Effective treatments include assessment and management in an acute specialist unit, immediate antiplatelet therapy and early carotid revascularisation. 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[9].

Secondary stroke prevention is part of the role of the clinical nurse specialist (CNS). The Royal College of Nursing identified how CNS's are in a good position to improve self-management, reduce complications, manage symptom control and maintain adherence to treatment. However, nurse-led clinics are not included in local or national guidelines and protocols and its effect on patients is not known[11]. 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[12].

Follow-up in the stroke clinic can aid secondary prevention, identify and address post-stroke complications, enhance patient education and enable access to rehabilitation services. Research in the US has shown that a first scheduled stroke clinic follow-up after hospital discharge is best achieved in patients admitted to the neurology service. Standardised discharge instructions with provided time and date of outpatient appointment was associated with successful follow-up[13].

Stringent guidelines for the secondary prevention of stroke survivors have been introduced in the UK and North America. The Stroke PROTECT (Preventing Recurrence Of Thromboembolic Events through Coordinated Treatment) programme in the US systematically implements, at the time of acute transient ischemic attack (TIA) or ischemic stroke admission, 8 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[14]. 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[15].

The Canadian Stroke Best Practice Recommendations for the Secondary Prevention of Stroke is a collection of current evidence-based recommendations intended for use by clinicians across a wide range of settings. The goal is to provide guidance for the prevention of ischemic stroke recurrence through the identification and management of modifiable vascular risk factors. Recommendations include those related to diagnostic testing, diet and lifestyle, smoking, hypertension, hyperlipidaemia, diabetes, antiplatelet and anticoagulant therapies, carotid artery disease, atrial fibrillation, and other cardiac conditions. They include a range of supporting materials such as implementation resources to facilitate the adoption of evidence to practice, and related performance measures to enable monitoring of uptake and effectiveness of the recommendations. The guidelines underscore the need for a systems approach to stroke care, involving an interprofessional team, with access to specialists regardless of patient location, and the need to overcome geographic barriers to ensure equity in access within a universal health care system[16].

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[17].

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 5 years[18].

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. Effective lifestyle interventions require changes in behaviour such as smoking, exercise, diet and

alcohol consumption. Global modification of lifestyle has been shown to be more beneficial than the treatment of single risk factors. Patients fulfilling all 5 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[20]. Healthcare practitioners have a responsibility to give accurate information, advice and support to help people to make and maintain lifestyle changes[17].

On-going rehabilitation

Many patients wish to continue rehabilitation and therapy in the longer term, either continuously or on an intermittent basis. As well as facilitating recovery, exercise or rehabilitation delivered later after stroke may prevent regression of physical or cognitive gains achieved in the earlier stages of recovery[17].

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[20]. 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[21]. A small two-week increase in intensive aphasia treatment contributes substantially to recovery from post-stroke aphasia[22]. 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)[6].

The evidence suggests a need for continuing rehabilitation post-stroke, however the Burden of Stroke in Europe report found inadequate ongoing rehabilitation and long-term support for stroke survivors across Europe. It identified the need for development of national systems to ensure that survivors' needs are followed up, and for countries to set targets for secondary prevention[23].

The Intercollegiate Stroke Working Party (ICSWP) recognises that the course of recovery after stroke in any individual may fall outside expected time frames. Some patients start or continue to improve many months after the event and these people may benefit from further rehabilitation at a late stage. Whilst the evidence is limited, there is evidence to suggest that for some patients improvements in communication, walking and ADL can be achieved with interventions more than 6 months after stroke. In order to try and capture this

group and to monitor and address other significant unmet needs, the consensus of the Working Party is that comprehensive reassessment should be undertaken at six months[17].

The National Institute for Health and Care Excellence (NICE) recommends regularly reviewing the goals of stroke survivors in order to identify which kind of rehabilitation would be suitable for them. Goals should be set within 5 days of arrival at A&E. Reviewing goals should take place at intervals suitable to the ability of the individual and nature of the goal, such as at 6 weeks, 3 months, 6 months and annually[24]. Patients with stroke should be offered further therapy if goals for specific functions and activities can be identified and agreed and the potential for change is likely. Stroke survivors should also be provided with the contact details of a named healthcare professional (e.g. a stroke co-ordinator) who can provide further information and advice[17].

Greater adherence to post-acute stroke rehabilitation guidelines has been associated with improved patient outcomes[25]. There is, however, a significant and often unmet demand for community rehabilitation following discharge from hospital. Post stroke future initiatives should include the development of policies which support more effective, equitable multidisciplinary rehabilitation for stroke patients in the community[26]. To address this, a trial comparing 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 with usual practice delivered by Stroke Care Coordinators (SCC) was designed. The system of care incorporated structured assessment focused on patient- and carer-centred problems and associated evidenced-based treatment algorithms. This well conducted trial demonstrated no benefit for clinical effectiveness or cost-effectiveness outcomes for the system of care compared with usual SCC practice[27].

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[28].

A successful model of integrated, cost effective care was also conceived 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. A key policy of the NHS and other health systems is to learn from this model. The NHS needs to break down the barriers between primary, secondary, and tertiary care and embrace the kind of integrated clinical governance that has allowed Kaiser to achieve its cost effective, integrated services and evaluate whether this can be achieved in the stroke population in England[29].

NICE recommends that health and social care professionals should work collaboratively to ensure a social care assessment is carried out promptly, before the patient is discharged to the community. The assessment should identify and document any ongoing needs (benefits, care needs, housing, return to work, transport) and offer training in care to family members (moving and handling, help with dressing)[24].

The models outlined offer promising results in improved delivery of services and outcomes for both patients and carers. Their focus, however, is on generic conditions and chronic diseases. To date, there is no evidence-based system of health and social care integration that is stroke-specific. The complex needs of stroke patients and the ongoing physical, cognitive, emotional and psychological impact of the disease makes the development of effective and efficient collaborative care pathways for stroke an important and topical consideration for policy makers.

Supported self-care/management

The National Clinical Guideline for Stroke recommends that people with stroke should be offered self-management support based on self-efficacy, aimed at the knowledge and skills needed to manage life after stroke, with special attention given to this at reviews and transfers of care. Patients with stroke whose motivation and engagement in rehabilitation appears reduced should be assessed for changes in self-esteem, self-efficacy or identity and mood and cognitive impairment. Patients with significant changes in self-esteem, self-efficacy or identity after stroke should be offered information, support and advice and considered for one or more of the following psychological interventions: increased social interaction; increased exercise; other psychosocial interventions, such as psychosocial education groups[17].

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. The evidence concerning the determinants influencing self-efficacy and the self-efficacy interventions makes clear how nurses can develop and tailor self-efficacy interventions for the clinical practice of people with stroke[30]. Guideline recommendations serve to emphasise the important interaction between newly recognised psychosocial concepts of self-efficacy and self-management, and functional outcomes and social participation after recovery from stroke. 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[17].

Self-management in the context of therapy rehabilitation delivered soon after the stroke event has been found to lead to short-term improvements in basic and extended activities of daily living, and a reduction in poor outcomes (dependence/death). Use of personalised stroke management tool kits have successfully been shown to aid patients through ongoing education after discharge and improve patient experience and empowerment[31]. Furthermore, 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. Individual studies reported benefits for health-related behaviours such as reduced use of health services, smoking and alcohol intake, as well as improved diet and attitude. However, there was no superior effect for such programmes in the domains of locus of control, activities of daily living, medication adherence, participation or mood.[32].

Future research should focus on managing the emotional, medical and social tasks of long-term survivorship.[33] A multicentre randomised control trial addressed this shortcoming by evaluating an extended stroke rehabilitation service which commences when routine organised stroke care, including ESD ends. The intervention group received an extended stroke rehabilitation service provided for 18 months following completion of ESD. This involved regular contact with a senior ESD team member who leads and coordinates further rehabilitation. The results from this trial are expected to inform future stroke service planning and configuration[34].

Carers

Research has historically focused on the recovery and rehabilitation of the stroke survivor with little attention paid to the needs of those caring for them beyond hospital discharge. Families of stroke survivors can

suddenly find themselves in a caring role for which they have received little warning and are ill prepared to undertake.

Lutz and colleagues interviewed 40 stroke family carers for 33 stroke survivors and found that preparation for this role would have been enhanced by; conducting a risk assessment of the patient and the caregiver; identifying gaps between the patient's needs and the carers abilities; the caregivers commitment and capacity to deliver such care and the co-development of a plan for improving their readiness to undertake this role[54].

Multiple systematic reviews have been undertaken in recent years investigating non-pharmacological interventions[55], and psychosocial interventions[57] for carers of stroke survivors. These reviews have flagged up several limitations with the existing evidence to date. Legg and colleagues found that there was a lack of a description of the key characteristics that define the informal carer population. Brerton[56] concluded that many studies did not identify a conceptual basis for the intervention but there were some benefits for multiple interventions: caregiver training; education and counselling; social problem solving partnerships, delivered by telephone; nurse led support and education programme and a support programme either delivered to groups or one to one. However Brerton commented that the trials included in the review were generally of low quality preventing firm conclusions to be drawn[55].

The most recent systematic review and meta-analysis of psychosocial interventions for stroke survivors, carers and survivor-carer dyads found that psychosocial interventions reduced depressive symptoms in carers. However there was limited evidence that such interventions reduced anxiety symptoms, or improved quality of life and coping and no evidence that they improved self-efficacy, carer strain or carer satisfaction[57].

A recent feasibility trial of a biopsychosocial intervention study focusing on the carers physical health as well as their psychosocial wellbeing and adjustment demonstrated that such an intervention could be successfully delivered and that it was acceptable to those in the caring role. However, they noted that the timing of an approach to carers who may not necessarily initially identify as carers was critical and that the mode of delivery of the intervention required tailoring to the individual needs of the carer[56].

6-month reviews

Many stroke survivors have difficulty accessing the support they need, which may result in avoidable deterioration[35]. Survivors will also experience changes in their needs over time. Six-month reviews for stroke

survivors help to identify any unmet needs at this point and signpost them to appropriate, targeted support that is available to meet their needs[36]. They also help to ensure that 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[35].

Recommendations for the provision of six-month reviews for stroke survivors have been driven by national guidelines/standards, including the National Service Framework for Older People, National Stroke Strategy, Care Quality Commission review on stroke care, Royal College of Physicians (RCP) National Clinical Guidelines for Stroke, NICE, CCG Outcomes Indicator Set[36]. Evidence suggests that contrary to the recommendations proposed, the completion of reviews is inadequate. SSNAP 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[37]. The National Clinical Guideline for Stroke reports that not all patients are receiving a review, despite some services carrying out reviews without being commissioned to do so because they see the benefits. Commissioners need to ensure that everyone with stroke has access to a structured assessment six months after a stroke[17].

Secondary care services, all Trusts delivering stroke services, local providers of rehabilitation services, voluntary services, nursing and residential home providers, general practice, primary care providers, clinical networks, social care services and domiciliary care providers need to work to improve longer term outcomes and community support. Reviews of stroke survivors' health and social wellbeing should encompass medicines/general health needs, mood, memory, cognitive & psychological status, on-going therapy & rehabilitation needs, social care needs, carer's needs, benefits & finance and driving & transport[36]. The location of the six-month review should include patient choice, and travel time for patients, mobility, communication issues and costs must all be considered. Advantages of home reviews include assessing a patient's ability to undertake real life activities of daily living in their own home and observing how well patients are coping. In some instances face to face reviews should be offered as the preferred method, however telephone reviews can also be offered depending on patient choice and accessibility[38].

The London Stroke Strategic Clinical Leadership Group recommends that 100% of eligible patients with stroke should be offered a review at six months following their stroke, 100% of CCGs should commission six month reviews, GPs should be involved in the outcomes of reviews as well as ongoing care, information sharing should be transparent and flow in both directions between primary care and the review provider.[39] The six-month review needs to be embedded into the care pathway and strategies for secondary prevention

reviewed and consolidated at each stage. Reviewers should be allowed the freedom to individualise the process on a needs-led basis rather than adhering to a rigid framework dictated by policy[40].

Despite the guideline recommendations, long-term stroke management, including follow-up reviews, has been a neglected area in both clinical service development and research.[36] At present, there is not a strong evidence base regarding the benefits of stroke reviews in terms of patient outcomes[38]. Limited provision of six-month post-stroke reviews has resulted in a paucity of 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.

Work has been underway regionally to address the shortcomings in stroke follow-up review services. A benchmarking report compiled by NHS Cheshire and Merseyside Strategic Clinical Networks aimed to highlight issues around the provision of 6-month reviews and inform the development of Cheshire and Merseyside best practice frameworks. It identified a variation in the format that six-month reviews take, with some trusts running consultant-led clinics whilst others have nurse/therapist led clinics. It also revealed an unacceptable variation in the number of stroke survivors accessing reviews, with accessibility of reviews a barrier for people with frailty, those with a severe disability and/or in nursing homes. There is a lack of consistency across the region in the provision of six-month reviews. An integrated whole pathway approach involving all providers supported by clear service specifications would help to reduce duplication and inequity. All teams undertaking six-month reviews should submit data to SSNAP. This will help providers and commissioners understand what is happening regionally and nationally and will inform improvement[41].

A national audit of stroke six-month review services undertaken by the University of Nottingham also identified variation and inequality in stroke service provision. The aim of the project was to map current provision of six-month follow-up reviews in England and examine adopted processes and data collection tools. The audit exposed evidence of a post-code lottery of service provision, with coverage within each Strategic Clinical Network varying from 5% of CCGs to 80% of CCGs commissioning a six-month review service. Self-devised 'in house' review forms were commonly used; review services should aim to adopt evidence-based tools, including the Greater Manchester – Stroke Assessment Tool (GM-SAT), designed specifically for the purpose of providing a comprehensive review of post-stroke care needs. Furthermore, there are limitations on referrals for additional support post-review, including limited availability or lack of access to speech and language therapy and psychology services. Ongoing rehabilitation should be available to stroke survivors identified as having unmet needs at the time of the six-month review[42].

Annual reviews

Reviewing the health and social care needs of adults who have had a stroke enables health and social care practitioners to identify any problems or difficulties the person who had the stroke and their family or carers may be experiencing. This can help adults who have had a stroke and their family or carers to make changes according to their needs[24].

The South London Stroke Register (SLSR) is a population-based register created in 1995 which collects prospective data on all first-ever strokes in patients living in Lambeth and Southwark. There are currently over 6000 patients on the Register. Follow-up assessments are carried out with all registered stroke survivors at 3 months, 1 year, 5 years, 15 years and then annually. Data are gathered on patients' health condition, lifestyle, cognition, instrumental activities of daily living, degree of disability or dependence, social networks, mood and emotional well-being, as well as therapies they are currently in receipt of. The assessments identify stroke survivors' unmet needs in the months and years following their stroke. Analysis of the data has shown that 20-30% of stroke survivors have poor functional outcomes (such as walking ability) up to 10 years after stroke, over half of survivors have depression, and 22% have long-term cognitive impairment[43]. These findings draw attention to the importance of and need for annual follow-up reviews to ensure that stroke survivors' unmet needs are identified and addressed.

The National Clinical Guideline for Stroke recommends 'routine follow-up of patients 6 months post discharge'. The Sentinel Stroke National Audit Programme sets a standard of 6 months post-admission follow-up, capturing data on process and outcomes. There appears to be no convincing model of stroke follow-up at 6 months, and despite evidence of unmet need in almost 50% of stroke survivors 1–5 years after their stroke, little work focuses on the first 12 months of recovery[44].

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 [45].

There is uncertainty regarding the clinical utility of the data obtained from patient-reported outcome measures (PROMs) for patient care[46]. However, 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, to monitor complications after the patient has left hospital and to improve patient information[47].

The importance of obtaining outcomes information directly from patients is gaining recognition. The potential benefits of including tools such as Patient-Reported Outcomes Measurement Information (PROMIS) and Quality of Life in Neurological Disorders (NeuroQoL) as outcomes in stroke clinical trials are compelling. They include the ability to measure outcomes on a continuous scale potentially improving their power to detect change, the incorporation of patient viewpoints, and the ability to assess outcomes across multiple domains affected by stroke. 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[48]

Value-based health care aims to bring together patients and health systems to maximize the ratio of quality over cost. To enable assessment of healthcare value in stroke management, an international standard set of patient-centred stroke outcome measures was defined for use in a variety of healthcare settings. A consensus stroke measure Standard Set was developed as a simple, pragmatic method to increase the value of stroke care. Patient-reported outcomes proposed for assessment at 90 days were pain, mood, feeding, self-care, mobility, communication, cognitive functioning, social participation, ability to return to usual activities, and health-related quality of life. The set should be validated in practice when used for monitoring and comparisons across different care settings[49].

The significance of acquiring new first-hand knowledge from patients about their experiences of healthcare was highlighted in a study exploring the experiences of patients who had accessed the ambulance service for acute myocardial infarction (AMI) or stroke. It found that the factors that contribute to better patient experience are not necessarily understood in the same way by patients and clinicians. It identified the need to develop PROMs/PREMs for pre-hospital stroke and AMI care[50].

Persisting post-stroke cognitive problems are common and include issues with attention, concentration, memory and aphasia, all of which adversely impact stroke survivors' confidence, self-esteem and long-term functional recovery. Stroke survivors, caregivers and health professionals collectively agree that improving cognition is the number one research priority for life after stroke. Patient perspectives on outcomes are

collected using PROMs, however there is currently no patient-centred PROM suitable for use with cognitively impaired stroke survivors to evaluate trials of post-stroke comprehensive cognitive rehabilitation[51].

Self-management is important to the recovery and quality of life of people following stroke. Many interventions to support self-management after stroke have been developed, however no reliable and valid outcome measure exists to support their evaluation. Research on a newly developed PROM of self-management competency following stroke; the Southampton Stroke Self-Management Questionnaire (SSSMQ), has yielded promising early results. It represents a potentially reliable and valid PROM for the evaluation of post-stroke self-management[52].

The use of both objective and patient-reported trial outcomes is now common and ensures that trials better capture information regarding aspects of recovery that are important to patients[53]. Current health policy emphasises patient experience, together with effectiveness and safety, as key components of quality of care. Consequently, patient reported outcome measures (PROMs) and patient reported experience measures (PREMs) are increasingly viewed as important for assessing quality of care, evaluating outcomes of specific interventions and for clinical assessment and decision support[50].

Contrary to these observations, patient perspectives on outcome are often overlooked in stroke trials.[51] The National Clinical Guideline for Stroke recommends that the views of people with stroke and their family/carers be actively sought when evaluating service quality and safety, and when planning service developments[17]. The SSNAP Acute Organisational Audit (2019) found, however, that the proportion of national sites seeking the views of patients and carers, even as infrequently as once a year, has fallen from 61% in 2016, to 56% in 2019. At the same time fewer than half of sites have patient or carer representation on their strategic planning group[54].

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Chapter 9 - Emerging technology and innovation in stroke care delivery

Key points

- 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 out patient and community settings for assessment and management.
- 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.
- Advances in genetics and molecular biology has helped us achieve some understanding of the mechanisms underlying stroke that have the potential over time to develop more targeted therapies.
- The application of communication technology to stroke care has resulted in telemedicine networks and 'mobiles stroke units' that have the potential to scale up the coverage of high quality stroke care to remote locations.
- 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, particularly in the field of acute imaging diagnostics and prognostication.
- Although promising, further evaluation is required of these technologies to ensure their safety and cost-effectiveness over and above current approaches.
- The COVID-19 pandemic has brought telehealth to the fore and appeared to be feasible and safe yet the development and spread of this technology requires robust evaluation.

Introduction

Emerging technologies have the potential to complement and or 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[1]. 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.

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.

Due to its inherent multidisciplinary nature, and large and diverse number of applications, several taxonomies, or classification systems, have been proposed to help characterise and separate digital health interventions into somewhat discrete areas of focus. Although each taxonomy may vary in its focus, five broad areas of applications for digital healthcare interventions are common between classification systems:

- Administrative systems: Interventions in this area focus on managerial functions such as supply chain management, health financing and human resources. Additionally, interventions in this area are also concern with 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 system to improve efficiency, continuity of care, adherence to guidelines and patient satisfaction.
- 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 and improved computational methods, 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[2,3]. Additionally, new, more sophisticated techniques are being currently developed. 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 rare and common causes of stroke and vascular risk factors[4] to the impact of molecular mechanisms in stroke severity and prognosis[3].

Examples of applications of this technology to improve stroke care include improved understanding of genetic markers for stroke subtypes[5, 6] and vascular risk factors[7, 8], more accurate prediction models[6, 9, 10], use of pharmacogenetics to predict response of current treatments[11, 12], develop stroke subtype specific management strategies[13] and identification of new therapeutic targets[5, 6, 14], and use of Mendelian randomisation in research to improve our understanding of the role of vascular risk factors as a cause of stroke[6]. All these advances require the links between the established Genomic England initiative with the stroke population through UK Biobank and emerging clinical networks.

Telemedicine

Telemedicine and telehealth consist on 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, greatly expanding the potential coverage of the stroke care network and improving 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 with intravenous thrombolysis (IVT) with tissue plasminogen activator. The effectiveness and safety of IVT in hospital settings in a telemedicine network for stroke has been shown to be comparable with that achieved in dedicated stroke centres[15]. Furthermore, hospitals benefiting from telemedicine are also able to recognise earlier patients requiring advanced care, thus reducing delays in transfer times to designated IVT centres. Telemedicine networks can, in addition, being 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 on the tele-rehabilitation group. The targeting of arm

movement rehabilitation with a six week course of telerehabilitation in the USA (11 sites) produced substantial gains in arm motor function whether delivered in clinic or by telerahabilition[15].
Although telemedicine networks have an upfront implementation cost, they lead to reduced direct and indirect costs for the health care system by reducing length of hospital stay, and long-term disability.

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 potentially valuable prehospital resource for patients living in areas without rapid access to in-hospital stroke care[17]. MSU are equipped with standard ambulance equipment and leverage the use of portable CT scanners, high-speed wireless data transfer (for telemedicine) and point-of-care laboratory facilitating time-saving stroke triage decisions[18]. A randomised controlled clinical trial demonstrated that MSU could potentially reduce the time from call to therapeutic decision[19].
Furthermore, it is surmised that the use of portable neuroimaging technology would inform whether a patient should be taken to a stroke unit to receive standard care, or taken to a HASU although current guidance in England proposes that all patients go to a HASU initially and then are transferred to a SU.
Nonetheless, additional research is still required to evaluate the safety, and particularly the cost-effectiveness of these units[18] 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 technology[20]. Additionally, although some studies have shown potential benefits for MSU in urban settings, any potential usefulness, if any, in rural, less densely populated areas is still unclear[21].

Imaging modalities

Emerging imaging modalities have the potential to improve not only stroke diagnosis, but to facilitate the identification of the underlying cause of stroke, and thus guiding secondary prevention optimizing strategies. Examples of these new imaging modalities include:
Vessel wall MRI[22], 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 CT Angiography (CTA)[22] (4D-CTA) is a technique that has become available with the invention of wide detectors, and combines the functional imaging of fluoroscopy with the 3 Dimensional capabilities of CT. 4 Dimensional (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 strokes[23]. 4D-CTA has been used in

clinical practice as a method to improve diagnostic accuracy of anterior circulation intracranial occlusions and for the selection of patients which would benefit from reperfusion therapies[24] (i.e.IVT).
4D-CTA can be produced from CT perfusion sequences obtained from a new-generation multi-section CT scanner. Furthermore, 4D CTA sequences can be obtained by processing already obtained CT perfusion (CTP) images, thus avoiding the need of additional radiation and contrast exposure if CTP has been already performed[25].

Artificial intelligence (AI)

AI, and machine learning, as an example of AI,represent an intersection between traditional statistics and computer science, where computer algorithms are used to automatically identify patterns in complex inputs, such as large datasets. Although the general framework for machine learning methods was developed as early as the 1950s, their implementation and potential clinical applications have only become feasible with the availability of increased computational power. The risk currently is that the word AI is used generically and as there are many approaches within AI, the role of AI versus traditional statistical approaches requires evaluation and the optimal use of the old and new techniques clarified.
Although there has been a steadily growing interest in the applications of AI to the clinical practice, use of this technology is still not routinely used, and more research is needed before it can be deployed in standard clinical practice. Nonetheless, machine learning methods have the real potential to be applied to stroke diagnosis, management and prognostications. Recent studies have shown promising applications in fields such as:

- Stroke recognition in the emergency department, where a small cluster randomised trial[26] and a retrospective study[27] 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 thrombectomy[27] and carotid artery stenting[29].
- Neuroimaging, where deep neural networks are starting to be used for image segmentation, automated featurisation and multimodal prognostication[30], to automatically and reliably calculate the ASPECT score[31], and to identify interdependence in brain regions and reveal predictive relationships between lesion site and outcomes[32].
- In population health, by providing a reliable method of predicting and forecasting the number of stroke recurrences[33] and major cardiovascular events[29].

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 2018 cochrane review and a meta-analysis of 14 randomised controlled trials suggests that robot-assisted rehabilitation was more effective in improving motor function recovery, particularly in chronic strokes[34]. A large RCT has recently found that although robot assisted training did improve upper limb impairment this did not translate into improvement in arm function[34]. 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 (standardized mean difference 0.41 [0.19, 0.63]), however, no difference was found between traditional and robotic-assisted therapy in other scenarios[35].

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Chapter 10 - Effective system design

Introduction

Stroke is 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, is 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.

The development of an innovative, yet achievable, stroke system change that conforms to the LTP and views of stakeholders is key. The public, patients and their families and carers, commissioners, health and social care workforce and services all require input to the debate.

Specifically for stroke a well worked up consensus across Europe provides practical advice for development of the system and in previous Chapters the transformation in care in London and Manchester have been highlighted.

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 prehospital and from emergency departments and stroke specialists[1].

Figure 1 summarizes the 10 programs and Figure 2 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 locally.

Ten steps

1 Establish a Stroke Register

Data are essential to improve care and outcomes. You cannot improve what you do not measure, therefore a stroke register is essential to identify current performance, areas for improvement and the effects of quality improvement programs. Registers should ideally be population-based, encompassing pre-hospital care, in-hospital care and survival, function and quality of life. Only essential data that are easily measurable should be collected and where possible the data should be extracted from routine data sets.

Quality improvement programmes both locally and nationally require a register of patients that characterize patients (sociodemography, case mix, process of care in acute and longer term care, outcome assessment).

2. Create Public Awareness

Two major barriers to timely stroke intervention are late recognition by the public and lack of activation of emergency medical services (EMS). Both are crucial for successful early treatment, yet the latter is dependent upon the first. Increasing public awareness of stroke entails improving knowledge of its acute presentation. In a summary of 22 studies that surveyed such knowledge, only a few participants could name more than two risk factors in most the studies. Knowledge of stroke warning signs varied widely, with a substantial proportion not knowing a single sign of stroke[2]. For awareness of stroke warning signs, most studies detected a better knowledge in women compared with men. Individuals with pre-existing conditions tended to know more about risk factors and warning signs than people without such history and most the studies reported better knowledge in older participants. Lower socio-economic groups and people with less education were less knowledgeable than higher socio-economic groups and people with higher education.

Accompanying this challenge is the added need for the public to recognize stroke as a treatable medical condition and therefore immediately activate EMS. Help-seeking behavior after acute stroke is a complex and not well-understood process, requiring not only knowledge of stroke symptoms but also their correct recognition by the patient or bystander, and an understanding of how to activate the process of acute stroke care. Studies have shown that patients brought to the hospital by EMS arrive sooner after onset of their symptoms than those transported by other means and receive more rapid evaluation and treatment[3]. In countries with well-developed EMS systems, people with stroke use EMS about 60% of the time for transportation to the hospital[20]. In England about 80% of patients arrive by ambulance. Individuals showing signs of major stroke such as paresis, aphasia, or altered level of consciousness are more likely to use EMS than those with symptoms such as vision disturbance, ataxia, or vertigo[4,5]. Patients transported by EMS receive more sophisticated prehospital care and evaluation[6] and are treated more quickly at the stroke center[7]. Thus, promoting early recognition and triggering an EMS-focused response are paramount priorities for public stroke education.

3. Start Public Education

Educational efforts should be broad-based and built upon advertising success in other domains. These can include mass media campaigns, targeted programs in schools, ambassadors and social media. An important part of public education is dispelling fatalistic attitudes about stroke using success stories that highlight the potential for excellent functional outcomes, with the best likelihood for optimal recovery when identified readily and treated rapidly. Studies have shown that when aimed at potential patients and bystanders, such knowledge can incentivize learning, remembering, and implementing a stroke recognition and action plan, resulting in more rapid hospital presentation and intervention[8]. Regardless of approach, one challenge is maintaining the durability of the education initiative and this may require repeat messaging in various media formats and recurring reminders using testimonials of success. The ultimate goal is to foster an ongoing partnership between the public, EMS, the hospitals and community that results in more rapid programs to intervene in a potentially devastating but potentially reversible condition. Stroke education and campaigning should be directed both to the public and to the medical services and in-hospital personnel involved in stroke triage and treatment.

4. Improve Early Recognition by First Responders

Early recognition of potential stroke symptoms by emergency dispatchers is critical to activating emergency stroke care. Once a call to an emergency center occurs, the call-taker needs to differentiate the 1-2 % of patients with stroke from the range of other emergency conditions. As patients often do not recognize their symptoms as being due to stroke, their description of symptoms may be unclear. Emergency call centers often use a predefined guideline for prioritizing stroke as part of their computer aided dispatch system (CAD). Some strategies are insensitive, detecting between 40 % and 65 % of acute strokes with variable specificity[9-11]. There is no evidence favoring any one particular diagnostic scale or strategy by emergency call takers to identify stroke[12]. Many stroke patients and relatives contact non-acute health services, such as general practitioners or various help lines. These should also be able to identify potential stroke patients and to directly activate the emergency call center.

5. Practice rapid and timely dispatch

Accurate recognition by dispatchers is key to rapid treatment (see Chapter 3). In a Norwegian study[13], when the emergency call-taker suspected a diagnosis of stroke, ambulance services were dispatched as high priority response to 92 % of patients. But if the call-taker missed the diagnosis, the ambulance was dispatched as high priority response in only about 55 % of cases. Based on the initial dialogue, the presence of key symptoms (for instance Face-Arm-Speech-Time (FAST) questions) should lead to an immediate high priority response. Even patients with transient stroke symptoms should have an acute EMS response. Once

an initial response is sent, additional questions may clarify the diagnosis and allow dispatch of additional specialist resources, such as a mobile stroke unit. When acute stroke is suspected, call-takers should ask additional questions, e.g. contact information for caregiver, time last known well, and communicate the results to the EMS team to assist in choosing the appropriate receiving hospital.

6. Optimize Prehospital Stroke Care and Triage

There are three phases of a prehospital stroke care program: field screening and assessment, treatment in the field and in transit, and notification of the receiving hospital. During the screening phase, emergency personnel should use validated stroke identification tools[14,15]. Once stroke is suspected, other tools may be employed aiming to identify strokes due to large vessel occlusion (LVO)[16,17], although all current existing prehospital LVO detection tools have low specificity and currently should not be used to triage patients for thrombectomy. Essential vital sign assessment should include heart rate, blood pressure, blood glucose and pulse oximetry measurement[18,19]. The emergency personnel on site should provide supplemental oxygen to hypoxic patients and treat hypoglycemia if required. The pre-arrival notification phase is the critical link between prehospital and hospital care to shorten the time interval from hospital arrival to treatment initiation. In addition to notifying that a suspected stroke patient is en route, provision of key information will allow the hospital to prepare for appropriate prompt assessment and treatment[20,21]. The recently published PASTA trial[22] tested whether paramedics obtaining additional prehospital information, a structured hospital handover, practical assistance up to 15 minutes after handover, and a predeparture care checklist followed by and clinician feedback could increase the proportion of patients receiving intravenous thrombolysis. The trial was negative.Alternative solutions to improve the efficiency of prehospital care need to be developed and tested. There is an important balance between adequate assessment and treatment in the pre-hospital environment and rapid transport to definitive hospital care. The patient should be triaged to a pre-defined facility for intravenous thrombolysis and endovascular reperfusion treatment based on the local stroke system of care. It is key for effective acute stroke services to have regional planning of a stroke system of care and clear pathways to minimize delays in therapeutic decision-making and delivery of care. This requires transportation to a centre that will minimize treatment time. Optimising these transport decisions requires modelling based on factors such as population density, stroke incidence, hospital capabilities and transport times. An ideal acute stroke service is one that is reached quickly, with immediate access to stroke specialist care either on site or via telemedicine, capable of brain imaging including angiography, with a dedicated stroke unit, expertise in intravenous thrombolysis and interventional neuroradiology, and all organized to provide expert care with minimal delay[23]. For the provision of thrombectomy air transport providers should work together to identify the most efficient

transport option both pre- and inter-hospital. This should include immediate availability and back-up systems.

7. Optimize In-hospital Basic and Advanced Care

Expert guidelines for the management of stroke in the emergency department have been produced[24,25] and will not be repeated here and many of the important aspects of care are covered in other chapters of this document. There is good evidence to show that rapid treatment of both ischemic and haemorrhagic stroke[26] can improve outcomes but the need for early rehabilitation is often neglected. However, achieving this requires high levels of coordination and ongoing staff training involving EMS staff, radiology and the stroke team. Up-to-date evidence-based protocols are needed to cover the acute management of ischemic and haemorrhagic stroke, and TIA[24,27] and there needs to be regular review of performance against these protocols. It is unacceptable that some units have average door to needle times of one hour when others can achieve it 20 minutes[28,29]. While not all admitting units will have access to interventional neuroradiology, protocols are needed to ensure rapid 'door in, door out' times, and immediate transfer of medical records and imaging to the thrombectomy centres.

The exclusion of mimics (chapter 3) in the acute phase is important so that patients can be triaged appropriately to other services and reduce the chances of unnecessary and potentially harmful acute thrombolytic and other therapies. This requires awareness of mimics and improved access to scanning.

8. Use Smart Technologies

New technologies are emerging and have been successful in other areas of emergency care and may assist with recognition and early treatment of stroke. Linguists and computer scientists may be able to develop new solutions. Machine Learning and other forms of artificial intelligence should be evaluated to assist dispatchers in recognizing possible cases of stroke and are already used to aid in interpretation of neuroimaging. New Video-Assisted dispatch systems might enable dispatchers to better assess calls and be able to identify potential strokes. Smartphones are available in most communities, and provide a cost effective means for public education in awareness of stroke symptoms and the importance of timely activation of emergency services, as well as activating the emergency medical response[30]. Telemedicine is invaluable in providing expert advice in the acute setting, particularly in hospitals in rural areas where on site specialists available 24/7 is not feasible[31]. The use of telemedicine in the ambulance service is less well developed but has been shown to be practicable[32]. Mobile stroke units have been shown to shorten assessment and treatment times compared to conventional hospital care but have not yet been shown to improve outcomes or to be cost-effective[33].

9. Demonstrate Accountability

One of the hallmarks of excellent stroke care is an ongoing quality improvement programme, such as SSNAP, with transparent public reporting of data with regular monitoring of the metrics allowing the public to identify the best-performing centres while motivating hospitals at the lower end of performance to improve[34]. Transparency is essential when reporting performance of an emergency response and treatment system for acute stroke. It allows the community and stakeholders to gauge a system's progress as well as its opportunities for improvement. Those involved in developing and optimizing the system are accountable to the public, to administrators and funding bodies, and to each other. Metrics describing a system's performance may vary depending on the intended audience. Potential choices for primary performance metrics may also vary given the robustness of the available medical and emergency response systems. Reporting should be linked to incentives for performance, annual accountability to stakeholders, and making decisions related to systems of care.

10. Create a Culture of Excellence

The secret of moving a system from its current performance level to a 'Culture of Excellence' requires an environment that empowers, focuses and engages staff, and equips teams with the right mindset and skills necessary to achieve the best results. A culture of excellence has a system and staff that use a combination of best practice evidence and performance data to continually review their practices and identify opportunities to improve patient care. They must focus on creating a system that exudes excellence, breaking records and achieving extraordinary results. As has been witnessed from the work of the Global Resuscitation Alliance in Out-of-Hospital Cardiac Arrest, we need to identify the "best of breed" and seek to emulate their performance[35]. A system that sets the benchmark for excellence is not necessarily the best resourced service or the most advanced, but the one that integrates, and recognizes the importance of, the whole system in achieving the best possible outcomes for patients. To create a culture of excellence takes time and it starts with you!

To achieve a culture of excellence, every staff member must understand not only the organization's vision, but also know their own roles, responsibilities and the specific actions they need to implement to achieve this vision. In a culture of excellence, staff feel that their contribution is meaningful, significant, and purposeful. Staff need to be inspired by the common purpose which becomes the driving force behind everything that they do. Organizations focused on achieving a Culture of Excellence must set an expectation of high performance. Every staff member must be supported and encouraged to become a

master in their role and area of expertise. Leadership of system change has been cited as a key ingredient to successful buy in from stakeholders and implementation

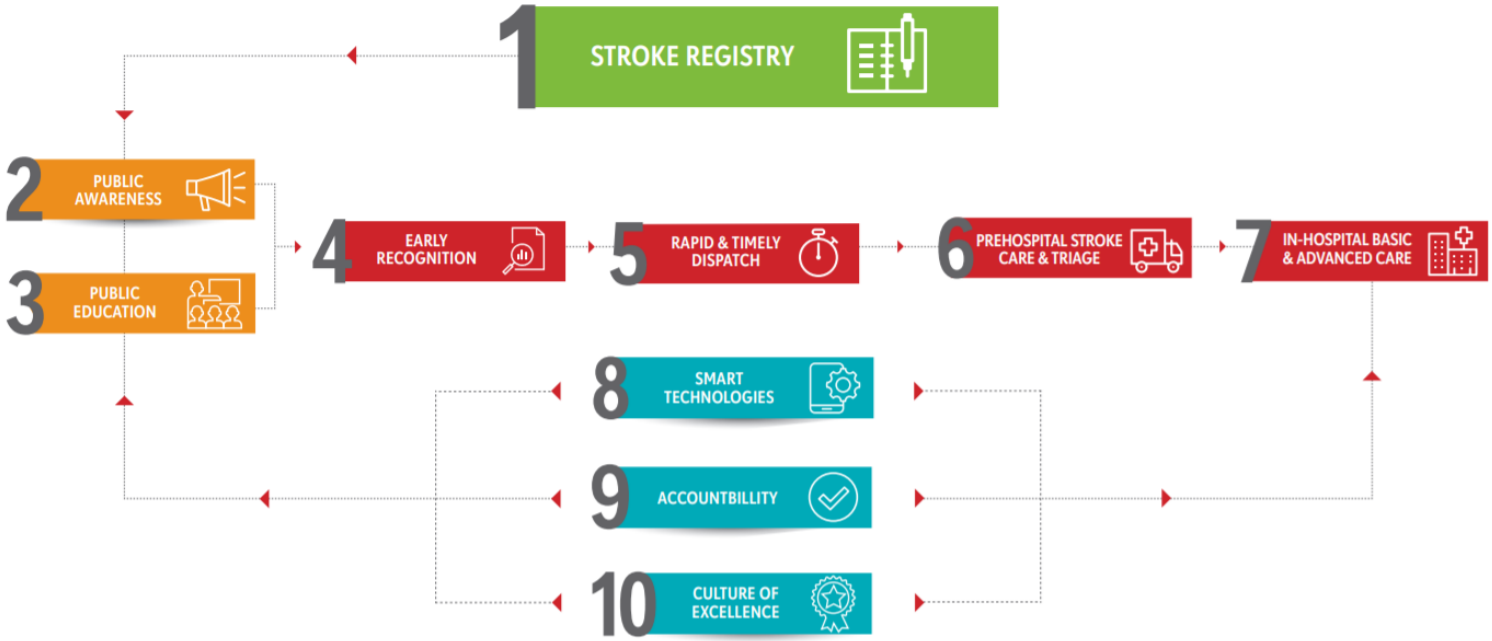


Figure 1. The 10 components needed for high quality emergency stroke care

Figure 2: 'Chain of Survival' for Emergency Stroke Care

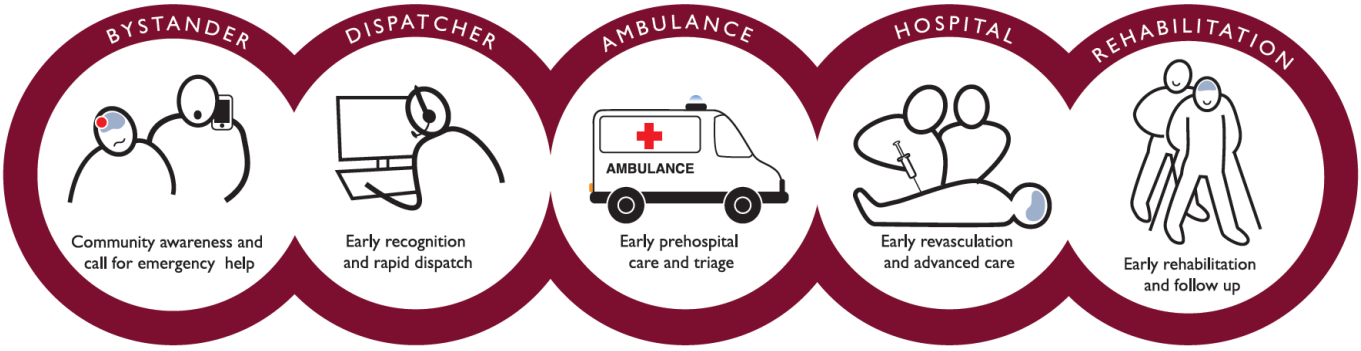
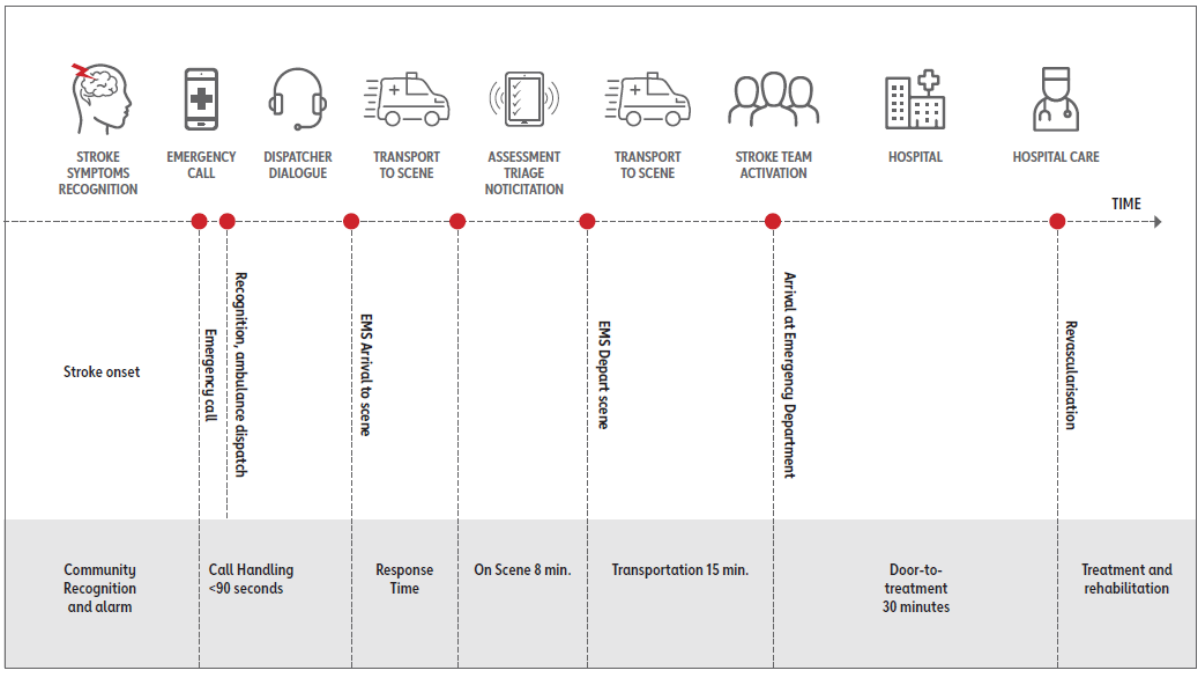


Figure 3: Stroke Patient Journey with consensus recommedations for timings



Integrated stroke care in hospital

The evidence for stroke unit care is very strong. The Cochrane review from the Stroke Unit triallists' Collaboration included 28 trials, involving 5855 participants, comparing stroke unit care with an alternative service[35]. 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, 95% confidence interval (CI) 0.69 to 0.94; P = 0.005), the odds of death or institutionalised care (OR 0.78, 95% CI 0.68 to 0.89; P = 0.0003) and the odds of death or dependency (OR 0.79, 95% CI 0.68 to 0.90; P = 0.0007. 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 stroke[36]. 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-d mortality risk of 15.2% (aHR 1.18, 95% CI 1.07-1.29) compared to 11.2% for patients admitted to a unit with 3.0 nurses/ten beds (aHR 0.85, 95% CI 0.77-0.93), 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 patients in-patient stay should be on a specialist unit, not just during the first few days. This is not the typical model of care in the US where patients are often managed in stroke units for the first few days of their illness but then transferred to generic rehabilitation units for on-going care. There is no trial evidence to support this model of care.

Case study 1. Reorganising stroke care in London(see Chapters 4 and 5 for reorganisation in London and Manchester in more detail)

More than 8,000 people having a stroke are admitted to London hospitals each year and around one in six people die. The evidence base is strong showing that well organised stroke care on stroke units reduces mortality and disability. Thrombolysis suitable for about 20% of stroke admissions significantly increases the likelihood of recovery with reduced or no disability. Before the

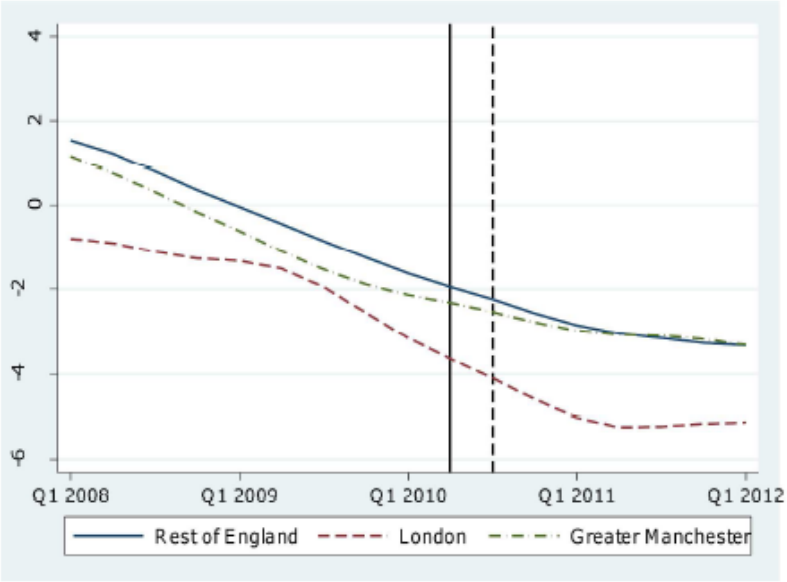
reorganisation of care huge inequalities existed in the quality of care a patient might receive depending upon where in London they lived with a total of 32 units providing some sort of acute stroke care. The prevalence of stroke is highest in outer London where there was the most limited access to specialist stroke services. Prior to the reorganisation of stroke services fewer than 40% of patients were directly admitted to a stroke unit and only 3.8% of patients received thrombolysis. Commissioners and clinicians had tried to improve stroke services over many years but this had resulted at best in small, incremental improvements. The scale of the problem required collaboration to address the issue together with a whole system approach. Commissioners across London came together as the Joint Committee of Primary Care Trusts (PCTs) to develop proposals to develop world class stroke services in London. A clinical expert panel with clinicians and lay members from both in and outside of London included consultants, nursing and therapy representatives, as well as other professionals, such as the London Ambulance Service, guided the development of these proposals. The clinical advisory group on the basis of their review of evidence agreed a new model of care with a smaller number of specialised Hyper Acute Stroke Units (HASUs) providing 24/7 immediate response, specialist assessment on arrival, brain imaging and thrombolysis (if appropriate) within 30 minutes, high dependency care and stabilisation. The HASUs would be supported in a network by a larger number of local Stroke Units providing high quality inpatient rehabilitation in local hospitals, multi-therapy rehabilitation and on-going medical supervision, co-located with TIA assessment services. A number of factors were taken into account when working out the best number and location of HASUs and stroke units:

- *Capacity of hospitals*: extensive bed modelling was undertaken to establish the right number of specialist beds in the right locations.
- *Access:* the location of units needed to ensure all Londoners received the right care within 30 minutes by blue light ambulance;
- *Critical Mass*: Evidence showed that teams providing complex care to lots of people have the best outcomes for patients - therefore fewer, larger units are likely to provide better care for stroke patients.

A number of models were considered and debated by the clinical advisory group. London benefits from its dense population as larger, high volume specialist units were possible whilst still achieving timely access. It was concluded that 8 HASUs and 24 Stroke units with co-located TIA assessment services were required in London to provide a clinically optimal solution which was practicably deliverable. The Joint Committee of PCTs invested £23m per annum to support the development of the stroke model of care. The increased investment applied as an uplifted tariff paid only if

extremely rigorous standards of care were delivered. Implementation of the improved standards both in the HASUs and the Stroke Units required dramatic changes to many of the previously poorly performing hospitals. This was achieved with the assistance of the stroke and cardiac network and the London Stroke Clinical Director. Each unit underwent regualr visits and inspections form a team including the clinical director and commissioneers.

The reorganisation has resulted in improvements in the processes of care and improvements clinical and financial outcomes. The thrombolysis rate has risen to 19% of all stroke admissions, average length of stay has fallen by about 30% with 40% of patients being discharged within 3 days of admission and over 90% of patients are admitted directly to a specialist stroke unit. Mortality has fallen with a significant decline in risk-adjusted mortality at 3, 30 and 90 days after admission. At 90 days the absolute reduction was -1.1% (95% CI, -2.1 to -0.1; relative reduction 5%), indicating 168 fewer deaths (95% CI, 19 to 316) during the 21 month post-reorganisation period in London[5]. A cost effectiveness analysis show that this achieved with significant cost savings. Money is saved through lower rates of admissions to intenisve care units, fewer admissions to long term nursing home care and reduced requirements for social support in the community[6]. Patient satisfaction with the services are high.



(c) Mortality at 90 days
237x174mm (300 x 300 DPI)

The lessons from London are now being implemented in several other areas of England. The key messages from this work have been:

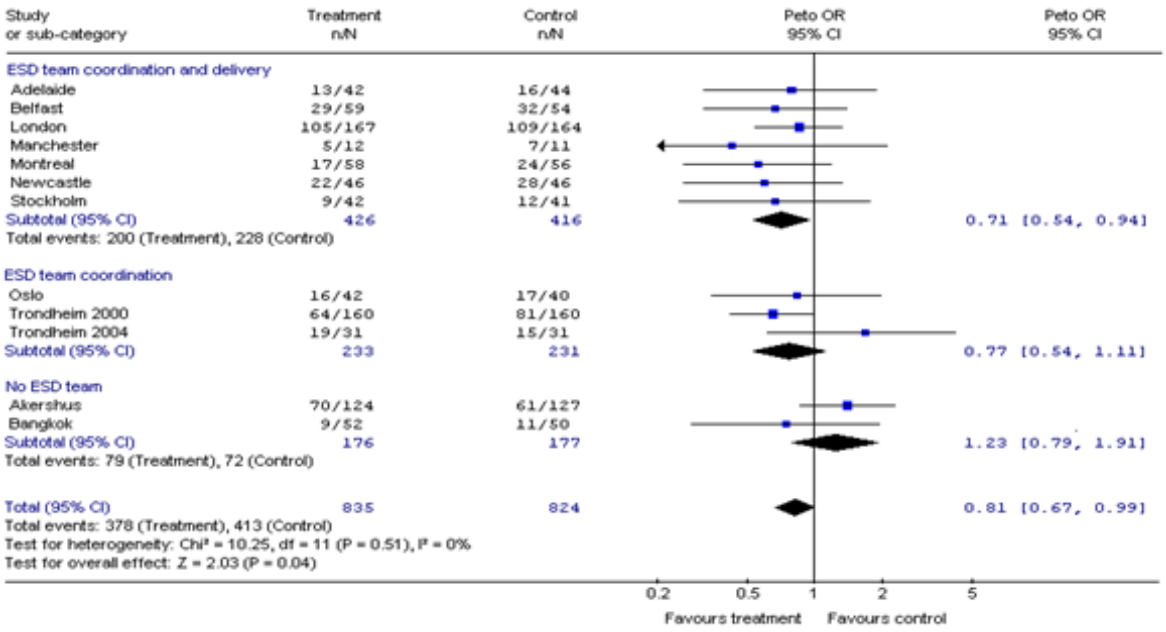
1. Value of collaborative work between commissioners, managers from provider units, network staff and clinicians both in setting up the services and maintaining the quality of the services through regular visits, support and inspections.
2. Setting very high quality standards that are common across London 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

The traditional model for stroke care over the years has been admission to hospital and then remaining as an inpatient either in the acute hospital or in a bed based rehabilitation unit until they are considered fit for discharge. On leaving hospital some patients may receive further rehabilitation but often not from stroke or neurology specialists and usually of low intensity. Rehabilitation in a hospital environment offers the advantage that the therapist does not spend time travelling and there is usually space and equipment available to deliver the treatment. The disadvantages include the facts that the rehabilitation is not being done in the environment that the patient is going to be living in and therefore may not be directly relevant to the patents' needs and having nursing staff available at all times may encourage dependence and institutionalisation. One of the most frequent complaints seen in surveys of stroke patients is that they feel abandoned when they leave hospital. They have received plenty of attention and help and then suddenly they are left to their own devices, often ill equipped to manage the physical and psychological demands of life after stroke.

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. The patient usually needs to be able to independently transfer on and off a toilet safely or to do that with the help of a willing and available carer and not be medically unstable or have very unpredictable needs. The patient leaves hospital and would expect to be seen by the therapy team in their own home within 24 hours and receive daily physiotherapy, occupational therapy and speech therapy according to their needs for a period of up to six weeks.

Eleven randomised controlled trials have been performed and the meta-analysis of these has shown that outcomes are better in terms of combined mortality and disability and mortality and institutionalisation and patient satisfaction[37]. Carer stress is predictably slightly increased. Mean length of stay is reduced by 8 days. These improved outcomes are achieved at slightly lower cost. The incremental cost-effectiveness ratio of SU 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. The failure of hospital teams to fully trust the competence of community teams and vice versa has also led to inefficiencies in the systems resulting in excessive lengths of stay in hospital. ESD works best where the teams work collaboratively with good information sharing and preferably rotation of staff between the hospital and community teams.

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[38]. 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 3-6 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[39]. The high levels of anxiety and depression are perhaps more difficult to manage with little evidence that pharmacological treatments are beneficial and few studies having examined the role for cognitive behaviour therapy.

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[40] and the vascular components of the NHS Long term plan are 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. International guidelines have been produced e.g. European Union Stroke Initiative, but most experts consider it important that each health system examines the evidence themselves and constructs their recommendations relevant to their own health systems. 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 commissioners with the intention of encouraging integrated whole pathway management. The recommendations in this document designed for those people commissioning stroke care are one attempt to define what an integrated model of care should look like:

Overall organisation of acute services

Effective stroke care will only occur if the organisational structure allows and facilitates the delivery of the best treatments at the correct time to the correct patients. we make recommendations that are primarily derived through logic and not directly from evidence; for example, thrombolytic treatment (a recommended treatment) can only be given within 4.5 hours if patients arrive in the appropriate setting within that time. These recommendations apply to all stroke care.

Recommendations

A *All community medical services and ambulance services (including call handlers) should be trained so that they treat patients with symptoms suggestive of an acute stroke as an emergency requiring urgent transfer to a centre with specialised hyperacute stroke services.*

B *All patients seen with an acute neurological syndrome suspected to be a stroke should ideally be transferred directly to a specialised hyperacute stroke unit that will assess for thrombolysis and other urgent interventions and deliver them if clinically indicated.*

C *All hospitals receiving acute medical admissions that include patients with potential stroke should have arrangements to admit them directly to a specialist acute stroke unit (onsite or*

at a neighbouring hospital) to monitor and regulate basic physiological functions such as blood glucose, oxygenation, and blood pressure.

D *All hospitals admitting stroke patients should have a specialist stroke rehabilitation ward, or should have immediate access to one.*

E *All 'health economies' (geographic areas or populations covered by an integrated group of health commissioners and providers) should have a specialist neurovascular (TIA) service able to assess and initiate management of patients within 24 hours of transient cerebrovascular symptoms.*

F *There should be public and professional education programmes to increase awareness of stroke and the need for urgent diagnosis and treatment'.*

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. Get with the Guidelines in the US measures the quality of care for about 50% of hospitals and has been a powerful tool for change. 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. Data are collected on detailed processes of care from the point of stroke to 6 months after the stroke following the patients path through acute hospitals, rehabilitation in hospital or the community to 6 months where data are collected on outcomes. Individual providers are provided with quarterly reports on performance compared with the national data and with the full dataset available to commissioners, politicians and the public. Separate reports are sent on key indicators to the clinical commissioning groups and the data are used by the Care Quality Commission. Special lay versions of the reports are prepared to make the data comprehensible and useful to the public. 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. In Australia, the National Stroke Foundation (NSF) also runs a biennial audit consisting of an organisational survey of stroke structure and processes, and a clinical audit of 40 consecutive stroke patients. The NSF then provides participating hospitals with their data benchmarked against national data. In addition the NSF runs the StrokeLink program in one Australian state, Queensland, working with clinicians to initiate practice change to improve their audit results[41].

The RIKS stroke register in Sweden has been operating even longer than the stroke audit in England although with less comprehensive data. In addition, the Australian Stroke Clinical Registry (AuSCR) was established in 2009 providing a national stroke and TIA register from both public and private settings and, unlike many other stroke registries, collects patient outcome data three to six months following stroke.

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 American Heart Association recommends use of clinical registries as important ways to monitor quality of care, effectiveness of new healthcare initiatives with the aim of improving patient outcomes[42].

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.

In a bid to drive routine data collection in stroke to improve care and patient outcomes, both the UK and Australia have developed national clinical care standards for stroke consisting of quality statements which describe the care a person should receive, and corresponding stroke quality indicators. The indicators can be used by service providers to monitor stroke care in their organisation[43].

The 'Learning Healthcare System' (LHS)[44] 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.

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Chapter 11 – Gaps in evidence base

National Priorities to be blended with Gap Analysis for Stroke care pathway

1. Longitudinal research into rehabilitation/life after stroke with tailored outcome measures for patients, including the impact on the health and social care system and local economies

2. Developing and testing new patient pathways, including: haemorrhagic stroke, hyper-acute care in rural geographies, and personalised secondary prevention

3. Diagnosis – AI solutions at a diagnostic level for patients to be put on to the right pathway; innovative triage tools and behavioural insights into referral (pre-hospital); technologies for the early and accurate diagnosis/detection of stroke and how that can reduce inequalities of outcomes and access to services

4. Long-term supported and monitored active self-management of stroke for the prevention of tertiary reoccurrence, regression, and the maintenance of mental and physical wellbeing

5. Multi-morbidity across the life course – how to understand the impact of multi-morbidity on treatment/acute stay and appropriate decision making.

Gaps in evidence base identified on evidence review of stroke or NHSE Long Term Plan

1. **Epidemiological and health care data**

    a. Develop and evaluate methods to improve estimates of trends in risk and outcome of stroke.
    b. Estimate long term outcomes after stroke (and non-stroke population comparisons) using validated outcome measures and PROM/PREMs.
    c. Develop an interactive dashboard of all relevant data on stroke nationally to inform policy, service and clinical decision making.

    Assess the feasibility and development of an interactive data repository with improved data linkage between national stroke 'process' (e.g. thrombectomy services) and 'assessment' data, to help inform policy service and clinical decision making. This linked dataset would help identify the best configuration of the number and siting of stroke services in England and establish the long term outcomes after stroke (using validated outcome measures and PROM/PREMs). Output: Comprehensive dashboard for different stakeholders (service users/providers)

2. **Prevention in Primary Care**

    a. Evaluate innovative interventions for the management of stroke risk factors in context of multiple morbidity.

b. Evaluate the effectiveness of Integrated Stroke Delivery Networks (ISDNs) for improving management of risk factors.
c. Evaluate the effectiveness of alternative approaches to 'Health Checks' for prevention as these have not been shown to be universally effective.
d. Assess the optimal approach to increase and sustain stroke awareness, along with novel approaches to reaching those at greatest risk e.g. ethnic minorities, older patients and those with lower educational levels are needed.

Effective behavioural interventions for prevention, including approaches to increase awareness, education and adherence in high risk groups.

3. **Pre-hospital management**

a. Evaluate biomarkers and clinical scales to identify stroke, differentiate between haemorrhage and infarct subtypes for better management strategies.
b. Evaluate the clinical and cost effectiveness of mobile stroke units.
c. Evaluate more specific areas of application of artificial intelligence methodologies in brain image interpretation.
d. Evaluate the role of telemedicine in pre-hospital acute stroke care, particularly in areas with significant practical or geographical barriers to access to care.
e. Model the number of units capable of providing thrombectomy along with the number of centres required to deliver the acute stroke care pathway.

Evaluate the role and outcome of telemedicine in pre-hospital acute stroke care and TIA. Further research required to develop reliable diagnostic stroke tools/ clinical scales (long-term goal).

4. Acute Care

a. Evaluate the benefits of mechanical thrombectomy in patients presenting with basilar artery occlusion.
b. Investigate the degree of collateral blood supply with advanced imaging?
c. Evaluate the advantages of alternative thrombolysis agents to alteplase in combination with mechanical thrombectomy.
d. Assess whether 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. Estimate the proportion of patients that would benefit from treatment with thrombectomy beyond 6 hours after onset of stroke.
f. Evaluate the utility/practicality/clinical and cost effectiveness of using perfusion scanning to identify patients for treatment with intravenous thrombolysis and thrombectomy outside usually time frames.
g. Evaluate how thrombectomy services should be configured to enable the best access to services with available resources.

Evaluate the evidence base and outcomes for interventional radiologists/other specialists (with stroke interventional neuroradiology credential) delivering mechanical thrombectomy and the use of alternative thrombolytic.

5. Stroke pathway care

a. Investigate how to optimise blood pressure management after ischaemic stroke.
b. Evaluate the optimal medical, nursing and therapy staffing ratios for stroke units.
c. Evaluation of the 'dose-response' relationships of early mobilisation.
d. Evaluate the effectiveness of psychological interventions and when they should start after stroke as well as their intensity and duration.

Evaluate the correlation between workforce, staff capability and intervention in the delivery of effective stroke care. Assess the evidence base for physical, cognitive, psychological needs and interventions.

6/7 Rehabilitation

a. Establish the association between intensity of therapy and outcomes.
b. Evaluate the clinical and cost effectiveness of seven day rehabilitation services on stroke units.
c. Evaluate the effective balance between qualified therapists and therapy assistants in hospital and after discharge in community therapy teams.
d. Evaluate how equipment and technology (e.g. robotics, telemedicine) best facilitate/replace traditional rehabilitation, to increase intensity of rehabilitation.
e. Evaluate how best to deliver multidisciplinary team working on stroke units.
f. Evaluation of the effective delivery and promotion of self-management in areas such as information provision, shared decision making, carer involvement, home visits, mood and fatigue.
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. Evaluate a range of areas identified in clinical practice: acute occupational therapy intervention regarding for example 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.

Evaluate how best to facilitate the maintenance and or improvement of a patients rehabilitation/recovery trajectory for their life after stroke, incorporating a 6 month review.

8. Follow up

a. Evaluate the gaps in evidence for follow up and benefits for patients: structured and systematic follow-up assessments of stroke survivors with primary care health

professionals following discharge from hospital; lifestyle interventions in secondary prevention.

b. Evaluate longer term rehabilitation-when, setting, intensity, modalities.

c. Evaluate patient outcomes associated with best practice standards and guidelines for post-stroke rehabilitation.

d. Evaluate the effectiveness of a stroke-centric model of health and social care.

e. Evaluate the effectiveness and outcomes of supported self-care and management programmes designed for stroke survivors.

f. Evaluate new approaches for the systematic provision, means of delivery and benefits derived from six-month follow-up reviews.

g. Develop and test PROMs and gain insights into the lived experiences of stroke survivors in order to elicit patient outcomes after post-stroke rehabilitation, primary care and secondary prevention interventions.

h. Evaluate the effectiveness of systems (what are the components, how should they be delivered) for improved self-management.

Determine the cost-effectiveness and evidence-base for follow-up assessments. Assess the effectiveness and outcomes of self-management programmes within systems.

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 is required to understand the challenges involved in the deployment and adoption of these technologies within healthcare organisations.

NOTE: *Technology included in other priority areas*

10. Effective system design

a. Evaluate new approaches to increase public awareness of stroke and the need for urgent management.

b. Develop approaches to improve recognition of stroke symptoms by emergency medical service call handlers and first responders.

c. Explore which treatments could be given by paramedics to improve outcome.

d. Investigate the best configuration of the number and siting of stroke services in England: do 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 are required.

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

f. Evaluate whether follow up of patients after stroke should be undertaken by specialist services or primary care.

g. Evaluate the best system for identifying longer term deterioration after a stroke and facilitating re-entry into medical and rehabilitation services.

Appendix 1 - SSNAP data in England for all chapters (2013-2019)

Thrombectomy in England

Between April 2018 and March 2019, it was reported that thrombectomy was started in 1,075 patients out of 79,953 stroke patients in England. The device was deployed in 989 of these interventions. Thrombectomy was carried out by 26 teams; the median number of thrombectomies per team was 34 (IQR 25-61.5). Two of these teams are neuroscience centres which only submit data on thrombectomy patients to SSNAP, as all other stroke care is delivered at other hospitals.

	Thrombectomy*	Thrombectomy (all stroke types)	**2016_17**	**2017-18**	**2018-19**
		N	**515**	**718**	**1,075**
		D	**78,227**	**79,250**	**79,953**
		%	**0.8**	**1.0**	**1.5**

Median and IQR for scanning

Between 2013-2019 the percentage of patients scanned at any time has increased from 98.5 – 99.6% of all patients

Between 2013-2019 the median time from arrival at hospital (clock start) to scan has decreased from 1 hour 20 minutes (IQR 00:31HH:MM-03:33HH:MM) to 51 minutes (IQR 00:21HH:MM-02:16HH:MM).

The % scanned within one hour of arrival has increased from 42.6 to 54.7%. The audit set a target of 50% to be scanned within an hour but with the 2016 guideline recommends that all patients should be scanned within an hour. This is not improving very rapidly.

Item	*Data type*	***England***	***England***	***England***	***England***	***England***	***England***

Time period:		***Apr 2013-Mar 2014***	***Apr 2014-Mar 2015***	***Apr 2015-Mar 2016***	***Apr 2016-Mar 2017***	***Apr 2017-Mar 2018***	***Apr 2018-Mar 2019***
Patient went to a stroke unit (SU) at any point at the first admitting hospital	*n*	***68,747***	***72,956***	***74,962***	***74,956***	***76,087***	***76,887***
	d	***71,567***	***76,567***	***78,048***	***78,227***	***79,250***	***79,953***
	%	***96.1***	***95.3***	***96***	***95.8***	***96***	***96.2***
Time from arrival to stroke unit (hours:mins)	*Median*	***3:31***	***3:35***	***3:33***	***3:37***	***3:36***	***3:33***
	Lower IQR	***2:06***	***2:07***	***2:04***	***2:05***	***2:01***	***1:57***
	Upper IQR	***6:19***	***6:44***	***6:27***	***6:50***	***6:56***	***6:38***
First ward of admission:	*d*	***71,567***	***76,567***	***78,048***	***78,227***	***79,250***	***79,953***
MAU/AAU/CDU	*n*	***13,906***	***14,326***	***12,735***	***11,868***	***11,567***	***11,004***
	%	***19.4***	***18.7***	***16.3***	***15.2***	***14.6***	***13.8***
Stroke Unit	*n*	***53,420***	***57,413***	***60,267***	***61,166***	***62,279***	***63,525***
	%	***74.6***	***75***	***77.2***	***78.2***	***78.6***	***79.5***
ITU/CCU/HDU	*n*	***1,281***	***1,422***	***1,570***	***1,526***	***1,602***	***1,710***
	%	***1.8***	***1.9***	***2***	***2***	***2***	***2.1***
Other	*n*	***2,960***	***3,406***	***3,476***	***3,667***	***3,802***	***3,714***
	%	***4.1***	***4.4***	***4.5***	***4.7***	***4.8***	***4.6***

Item	*Data type*	***England***	***England***	***England***	***England***	***England***	***England***
		Apr 2013-Mar 2014	***Apr 2014-Mar 2015***	***Apr 2015-Mar 2016***	***Apr 2016-Mar 2017***	***Apr 2017-Mar 2018***	***Apr 2018-Mar 2019***
First Ward SU, within 4 hours (Out of Hours)	n	**20,410**	**21,698**	**22,798**	**22,104**	**22,788**	**23,348**
	d	**34,268**	**36,605**	**37,706**	**37,447**	**38,736**	**38,294**
	%	**59.6**	**59.3**	**60.5**	**59**	**58.8**	**61**

Thrombolysis

Disappointingly the rate of thrombolysis (all strokes) has not been increasing. As you see below:

Thrombolysis	Thrombolysis:	d	***71,567***	***76,567***	***78,048***	***78,227***	***79,250***	***79,953***
	Yes	n	**8,322**	**8,924**	**8,717**	**9,032**	**9,024**	**9,310**
		%	**11.6**	**11.7**	**11.2**	**11.5**	**11.4**	**11.6**
	No	n	**2,178**	**1,122**	**803**	**953**	**709**	**713**
		%	**3**	**1.5**	**1**	**1.2**	**0.9**	**0.9**
	No but = justifiable reason	n	**61,067**	**66,521**	**68,528**	**68,242**	**69,517**	**69,930**
		%	**85.3**	**86.9**	**87.8**	**87.2**	**87.7**	**87.5**

We are seeing a small increase in thrombolysis within an hour, but we are seeing a similar increase in onset to arrival times which will offset the benefit of this.

Speed of therapy assessments after arrival at hospital. Therapists are assessing patients more rapidly after admission.

Category	*Item Reference*	*Item*	*Data type*	***E***	***England***	***England***	***England***	***England***	***England***
	H11.16	*Time (hh:mm) from arrival to physiotherapy assessment (of those assessed within 72 hours of clock start)*	*Median*	***22:16***	***22:01***	***21:18***	***21:04***	***20:42***	***20:35***
	H11.17		*Lower IQR*	***16:44***	***16:31***	***15:45***	***15:20***	***15:02***	***14:56***
	H11.18		*Upper IQR*	***32:40***	***30:02***	***27:47***	***27:17***	***26:35***	***26:10***
	H12.16	*Time (hh:mm) arrival to speech and language therapy assessment (of those assessed within 72*	*Median*	***25:15***	***24:40***	***23:49***	***23:17***	***22:59***	***22:50***

		hours of clock start)							
	H12.17		*Lower IQR*	***18:33***	***18:17***	***17:29***	***16:53***	***16:34***	***16:33***
	H12.18		*Upper IQR*	***45:18***	***44:00***	***42:45***	***41:08***	***40:18***	***40:22***
	H10.16	*Time (hh:mm) from arrival to occupational therapy assessment (of those assessed within 72 hours of clock start)*	*Median*	***23:40***	***23:12***	***22:07***	***21:45***	***21:16***	***21:04***
	H10.17		*Lower IQR*	***18:01***	***17:37***	***16:30***	***15:55***	***15:31***	***15:24***
	H10.18		*Upper IQR*	***41:05***	***39:20***	***34:20***	***30:32***	***28:42***	***27:45***

Discharge to ESD and institutionalisation

The in hospital mortality rate has not changed 14.8%-14.6%

The rate of new institutionalization (not previously a care home resident) highlighted below has shown a slow rate of decrease.

The transfer to an ESD team has shown an increase year on year (highlighted below)

			England	England	England	England	England	England
			Apr 2013-Mar 2014	***Apr 2014-Mar 2015***	***Apr 2015-Mar 2016***	***Apr 2016-Mar 2017***	***Apr 2017-Mar 2018***	***Apr 2018-Mar 2019***
Discharge destination	Discharge destination:	d	69,580	76,187	77,814	77,396	77,915	78,219
	Died in hospital	n	10,328	11,499	11,418	11,594	11,467	11,382
		%	14.8	15.1	14.7	15	14.7	14.6
	Discharged to a care home	n	7,157	7,496	7,739	7,387	7,030	6,775
		%	10.3	9.8	9.9	9.5	9	8.7
	Discharged home	n	30,842	31,107	29,191	27,695	27,400	25,315
		%	44.3	40.8	37.5	35.8	35.2	32.4
	Discharged somewhere else	n	4,878	2,348	1,748	1,689	1,580	1,175
		%	7	3.1	2.2	2.2	2	1.5

	Transferred to an ESD/community team	n	15,962	20,080	23,325	24,381	25,549	28,768
		%	22.9	26.4	30	31.5	32.8	36.8
	Transferred to a non-participating inpatient team	n	0	2,618	2,798	2,580	2,754	2,807
		%	0	3.4	3.6	3.3	3.5	3.6
	Transferred to a non-participating ESD/community team	n	0	731	1,146	1,458	1,523	1,495
		%	0	1	1.5	1.9	2	1.9
	Death by discharge:	d	69,580	76,187	77,814	77,396	77,915	78,219
	Discharged alive from inpatient care	n	59,252	64,688	66,396	65,802	66,448	66,837
		%	85.2	84.9	85.3	85	85.3	85.4
	Died on a stroke unit	n	8,845	9,708	9,740	9,950	9,901	9,711
		%	12.7	12.7	12.5	12.9	12.7	12.4

	Died not on a stroke unit	n	1,483	1,791	1,678	1,644	1,566	1,671
		%	2.1	2.4	2.2	2.1	2	2.1
	If discharged home:	d	30,842	31,107	29,191	27,695	27,400	25,315
	Living alone	n	7,803	7,731	7,218	6,846	6,800	6,158
		%	25.3	24.9	24.7	24.7	24.8	24.3
	Not living alone	n	21,240	21,669	20,226	19,343	19,280	18,039
		%	68.9	69.7	69.3	69.8	70.4	71.3
	Not known	n	1,445	1,071	1,019	1,068	869	774
		%	4.7	3.4	3.5	3.9	3.2	3.1
	If discharged to a care home:	d	7,157	7,496	7,739	7,387	7,030	6,775
	Previously a resident	n	2,527	2,688	2,702	2,654	2,628	2,425
		%	35.3	35.9	34.9	35.9	37.4	35.8
	Not previously a resident	n	4,595	4,792	4,997	4,721	4,391	4,313
		%	64.2	63.9	64.6	63.9	62.5	63.7

	If discharged alive, newly institutionalised (discharged to a care home where not previously a resident)	n	4,595	4,792	4,997	4,721	4,391	4,313
		d	59,252	64,688	66,396	65,802	66,448	66,837
		%	7.8	7.4	7.5	7.2	6.6	6.5
	If newly institutionalised:	d	4,595	4,792	4,997	4,721	4,391	4,313
	Temporary	n	776	817	917	839	906	900
		%	16.9	17	18.4	17.8	20.6	20.9
	Permanent	n	3,811	3,971	4,084	3,883	3,484	3,412
		%	82.9	82.9	81.7	82.2	79.3	79.1
ESD	If discharged alive, discharged with early supported discharge (ESD) team:	d	59,252	64,688	66,396	65,802	66,448	66,837

	Yes, stroke/neurology specific	n	14,635	18,242	21,778	22,767	23,589	26,066
		%	24.7	28.2	32.8	34.6	35.5	39
	Yes, non-specialist	n	830	970	664	526	465	468
		%	1.4	1.5	1	0.8	0.7	0.7
	No	n	43,787	45,448	43,921	42,474	42,359	40,264
		%	73.9	70.3	66.2	64.5	63.7	60.2
CRT	If discharged alive, discharged with multidisciplinary community rehabilitation team (CRT):	d	59,252	64,688	66,396	65,802	66,448	66,837
	Yes, stroke/neurology specific	n	13,509	13,584	14,541	14,147	15,217	14,437
		%	22.8	21	21.9	21.5	22.9	21.6
	Yes, non-specialist	n	3,792	4,916	4,183	3,619	3,389	3,275
		%	6.4	7.6	6.3	5.5	5.1	4.9
	No	n	41,951	46,188	47,672	48,036	47,842	49,125

		%	70.8	71.4	71.8	73	72	73.5
ESD/CRT	If discharged alive, discharged with a stroke/neurology specific service (ESD and/or CRT)	d	59,252	64,688	66,396	65,802	66,448	66,837
		n	24,116	27,686	31,936	32,704	33,822	35,557
		%	40.7	42.8	48.1	49.7	50.9	53.2