

University of East Anglia

# **Economic Evaluation of East of England Stroke Telemedicine Service**

Technical Report for Eastern Academic Health Science  
Network

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## Abstract

**Background:** Stroke is the fourth single leading cause of death in the UK and there are more than 100,000 strokes each year (Stroke Association, 2018). Timely access to urgent care and treatments, such as thrombolysis, is crucial for survival and recovery but there are national variations in care access and thus quality. The use of telemedicine may address some of the underlying challenges.

**Objective:** To explore the cost-effectiveness of an integrated Telemedicine Service - secure videoconferencing system ('Visionable') - for rapid access to stroke consultant support in the East of England acute stroke care pathway compared to usual care during out-of-hours (OOH) periods.

**Methods:** The SSNAP<sup>1</sup> Health Economics Thrombolysis tool, with relevant adaptations, enabled us to compare the Telemedicine Service to the usual acute stroke care pathway during OOH periods. The tool was used to estimate costs and cost per quality-adjusted life year (QALY) gain associated with improved thrombolysis rates at 1-yr and 5-yrs from the NHS and Social Care perspective.

**Data sources:** The East of England Telestroke Service was rolled out across seven regional hospitals, covering an area of 7,500 square miles and a population of 5.6 million to enable OOH access to thrombolysis. A cross-sectional study of this conducted by East of England Stroke Telemedicine Service provided summary inputs for the patient level data on service use and subsequent costs of using the Telemedicine Service. Between January 2014 and September 2019, 2,588 telemedicine patients were assessed by the stroke telemedicine OOH service. Based on SNAPP data, 11,163 stroke patients were admitted OOH in the participating hospitals over the equivalent period. Additionally, published sources were used to identify comparable data for the usual acute stroke care pathway.

**Telemedicine service patients:** Of the 2,588 patients accessed via the telemedicine service, 1,111 of them were thrombolysed. This is equal to an overall thrombolysis rate of 42.9% for the telemedicine service. The general characteristics and distribution of patients across the centres is summarised in Table 13: Hospital Level Summary. The average age was 70.1 years with an even distribution (49.3%) of both male and females.

**Results:** Based on SSNAP data, a total average of 1,861 stroke patients were admitted OOH in the 7 participating centres annually. The average thrombolysis rate was 9.7% when using Telemedicine Service across the participating centres relative to the total stroke patients that presented OOH. The use of the telemedicine service was an overall cost saving strategy with an incremental gain in QALYs<sup>2</sup> as well as lower costs from both NHS and Social care perspectives. Total NHS cost savings compared to usual care were estimated at £482k and £471k at the end of 1-year and 5-years respectively. The incremental cost-effectiveness ratio (ICER)<sup>3</sup> ranged between -£49.8k/QALY and -£56.3k/QALY at one year i.e. alongside cost savings, there were also QALY gains. ICERs were lower for the time-horizon of up to 5 years, ranging between -£14.9k/QALY and -£16.9k/QALY

**Conclusion:** Integrating Telemedicine services improves thrombolysis rates in OOH<sup>4</sup> acute stroke care. It is also associated with NHS and social care savings and QALY gains. Telemedicine is therefore a cost-effective approach to delivering stroke care to remote communities with limited access to stroke specialists.

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<sup>1</sup> SSNAP Sentinel Stroke National Audit Programme

<sup>2</sup> QALY Quality Adjusted Life Years

<sup>3</sup> ICER Incremental Cost Effectiveness Ratio

<sup>4</sup> OOH Out-of-Hours

## Introduction

Stroke is the fourth single leading cause of death in the UK and there are more than 100,000 strokes each year (Stroke Association, 2018). In England, the aggregate NHS and social care costs of stroke is estimated to be £8.6 billion per year (Patel *et al.*, 2020). There are two main types of stroke - ischemic and haemorrhagic, caused by a blocked vessel and bleeding in the brain respectively and incidence of ischemic stroke is far greater than that of haemorrhagic stroke.

Timely access to urgent care is central to survival and recovery. Key treatments for ischemic stroke include thrombolysis and thrombectomy. Thrombolysis treatment uses drugs to break down and disperse clots for ischemic stroke patients and it is licensed to be used up to four and half hours from onset of stroke symptoms (National Institute for Health and Care Excellence, 2012). When thrombolysed within three hours, 1 in 10 more eligible patients will be alive and living independently (Sandercock *et al.*, 2012).

The proportion of patients treated with thrombolysis has increased over the past 10 years and is now up to 11%-12% in the UK (Sentinel Stroke National Audit Programme (SSNAP), 2019). There is however, national and regional variation in the uptake of this treatment, with some units achieving thrombolysis rates of 20% (Sentinel Stroke National Audit Programme (SSNAP), 2019) and evidence of lower rates for stroke admissions during OOH. For example, using national data from SSNAP, Bray (2016) demonstrated a range of temporal variations in care quality indicators including thrombolysis rates, door-to-needle times, brain scan, admission to stroke units, assessments etc. Rapid access to acute stroke care services is limited in some regions of England. The East of England is a large, predominantly rural region covering 7,500 square miles with a population of 5.6 million people and approximately 6,000 stroke patients, annually (Agarwal *et al.*, 2014). A 2008 regional review of stroke services revealed limited access to stroke services due to prolonged ambulance transfer times of 45-60 minutes to the nearest hospital and a shortage of stroke consultants. Based on 2009-2010 regional estimates for thrombolysis, the average thrombolysis rate across the region was 6.36% (Agarwal *et al.*, 2014).

## East of England Telemedicine Service

Telestroke is becoming a widespread and fast-growing practice model for increasing access to thrombolysis. The European Stroke Organisation and the American Heart Association/American Stroke Association have both issued guidelines encouraging the formation of telestroke networks and development of teleconsultation services. East of England stroke telemedicine service conducted a cross-sectional study including stroke patients across seven regional hospitals namely: Ipswich Hospital, James Paget University Hospital, Lister Hospital, Peterborough Hospital, Queen Elizabeth Hospital, Watford General Hospital, and West Suffolk Hospital. The service was rolled out in 2010 and the main objective was to provide real-time, OOH access to thrombolysis i.e. evenings (17:00 to 08:00), weekends and bank holidays. A regional rota of 12 stroke consultants from across the sites was created to deliver this service. All participating specialists attended regional thrombolysis training days, had access to case discussions in peer-review format via regional videoconferencing meetings and were registered users for the European Safe Implementation of Treatments in Stroke (SITS) database. Thrombolysis was administered as per standard clinical guidelines and the time window for thrombolysis was 0 to 4.5 hours.

Following the success of the East of England stroke telemedicine service, an expansion utilizing telemedicine earlier in the stroke pathway to assess potential stroke mimic patients prior to emergency department admission has also been launched. This project termed Paramedic Stroke Telemedicine Digital Pioneer Project (PSTDPP) aims to explore the telemedicine support of registered

paramedics from the East of England Ambulance Service NHS Trust (EEAST) in assessing suspected stroke patients. As at the time of our analysis, the patient level data for this service was not sufficient for a full evaluation. However, we expanded the health economics tool from this report to incorporate a scenario related to the PSTDPP and estimated potential cost savings (see Page 27)

This report explores the cost-effectiveness of the integrated OOH telemedicine services in the East of England, as compared with usual OOH care.

## Methods

### Overall Approach

The Sentinel Stroke National Audit Programme (SSNAP) is a national register of stroke care across England, Wales and Northern Ireland. Its aim is to improve the quality of stroke care by auditing stroke services against evidence-based standards set out by the National Clinical Guideline for Stroke. SSNAP collects data that measures the quality of care that stroke patients admitted to all acute care hospitals receive throughout the whole care pathway up to 6 months post admission in these regions. The SSNAP database provided summary measures on the quality and organisation of stroke care in the NHS at the national, regional and local level.

There is also an associated SSNAP health economics tool (SSNAP, 2016), developed to estimate the cost-effectiveness of improved access to thrombolysis and early supportive discharge. Our analysis adapted this SSNAP health economics tool to estimate the NHS and social care costs savings, as well as QALY gains, associated with telemedicine at one year and five years for the participating hospitals. This was then expanded to estimate the cost-effectiveness of implementing OOH telemedicine service at regional (the rest of East of England) and national level.

### Data Sources:

The East of England telemedicine service provided patient-level data for OOH patients who used this service between 2014 – 2019. Key data included patients characteristics (age, sex), length of telemedicine consultation, hourly rate of telemedicine consultation based on weekend, weekday and bank holidays, outcome (thrombolysis). As a comparator to the telemedicine OOH service (i.e. usual stroke care OOH), our analysis collected data from SSNAP (Sentinel Stroke National Audit Programme (SSNAP), 2019) for the participating hospital for a similar time period. Key data collected from SSNAP included, total number of stroke patients, total number of patients arriving OOH, number of patients thrombolysed OOH, percentage of infarction. Published sources were also used to derive estimates such as thrombolysis rate of stroke care delivery OOH.

### Inputs:

We used published sources and SSNAP to represent the costs of a usual care pathway without a telemedicine service. To estimate costs associated with the Telemedicine Service, we obtained relevant cost information from the service via the project lead. The annual cost of using capital such as telemedicine carts and laptops was calculated using an annualization factor table (Drummond *et al.*, 1997), following the approach described by Walker, 2002 (Walker and Kumaranayake, 2002):

1. Estimate current value of purchasing capital item.
2. Estimate product life span (years of useful life the item can realistically be expected to have)
3. Discount rate assumed at 3.5%, derive annualization factor from standard tables.
4. Annualised cost calculated by dividing the current value if item by annualization factor.

All inputs used for the economic evaluation are as shown in Table 1 below:

Table 1: Inputs table

Description	Inflated to 2018/19 £, using CPI health	Reference
<b>Cost of stroke</b>		
1yr NHS cost	£20,564	(Sentinel Stroke National Audit Programme (SSNAP), 2016 <sup>a</sup> ) *NHS and Social care cost savings were calculated in a similar method as followed in the SSNAP health economic report. Described in further detail below.
5yr NHS cost	£27,476	
1yr Social care cost stroke	£13,536	
5yr Social care cost stroke	£42,081	
1yr NHS cost savings	£4,900*	
5yr NHS cost savings	£4,800*	
1yr Social care cost savings	£6,200*	
5yr Social care cost savings	£15,500*	
cost of ICH	£23,004	
<b>Incremental QALY</b>		
1 yr QALY gain	0.08	
5 yr QALY gain	0.26	
<b>Calculations for OOH Thrombolysis (usual care)</b>		
Avg. % eligibility for thrombolysis	12.20%	SSNAP 2014-2019 database
Total number of patients eligible for thrombolysis (OOH)	12,460	Table 5. Eligibility and achievement of each quality indicator (Bray <i>et al.</i> , 2016)
Total number of stroke patients (OOH)	102,131	Calculated from above Total eligible/% eligible
Total number of patients thrombolysed (OOH)	3,815	Table 5. Eligibility and achievement of each quality indicator (Bray <i>et al.</i> , 2016)
Thrombolysis rate (OOH)	3.74%	Calculated from above; Total thrombolysed/total no. stroke patients
<b>Telemedicine Service cost</b>		
<b>Capital costs</b>		
<b>Telemedicine Cart</b>		
Unit cost	£4,422	Stroke Telemedicine project lead. Annualization factor from 1997 for rate 3.5% (avg. 3%-4%), Table A7.2.2 (Drummond <i>et al.</i> , 1997) Annuity factor (Present value of annuity of \$1 in arrears) 10yr = 8.32055
Total no. units	14	
Avg. lifespan per cart	10	
Annual cost of Telemed cart	£7,440	
<b>Laptop</b>		
Unit cost	£1,728	Stroke Telemedicine project lead. Annualization factor from 1997 for discount rate 3.5% (avg. 3%-4%), Table A7.2.2 (Drummond <i>et al.</i> , 1997) Annuity factor (Present value of annuity of \$1 in arrears) 2yr = 1.8998
Total no. units	12	
Avg. lifespan per laptop	2	
Annual cost of laptop	£10,915	

<b>Maintenance costs (annual)</b>		
<b>Telemed Software license</b>	£12,375	Stroke Telemedicine project lead.
<b>Stroke telemedicine website hosting (SharePoint)</b>	£1,065	
<b>Licences for SharePoint access</b>	£520	
<b>eReceptionist (call-forwarding service)</b>	£1,000	
<b>Sectra - Image Exchange Portal</b>	£6,000	
<b>Training (annual cost)</b>	£2,200	
<b>Total program cost</b>	£41,515	Capital costs + Maintenance costs + Training
<b>Avg. Program cost (per person)</b>	£22.31	Total program cost/ no. of patients
<b>Avg. cost of teleconsultation</b>	£12.84	From analysed stroke telemedicine data
<b>Avg. cost Telemedicine (per person)</b>	£35.15	Avg. program cost + Avg. cost teleconsultation

### Economic analysis:

#### 1. Estimating average costs and QALYs by proportion of stroke patients thrombolysed

The SSNAP health economic report provided cost and QALY estimates associated with various thrombolysis rates, as summarised in Table 2 below. We inflated costs to current 2018-19 values and then estimated more granular estimates of cost savings and QALY gains for each extra person thrombolysed. To do this, we plotted the values in Table 2 to illustrate the relationship between the percentage of stroke thrombolysed and the mean NHS and social care cost as well as QALYs. All plots are represented in Figure 1, Figure 2, Figure , Figure , Figure 6 and Figure in the appendices. Resulting estimates were used as input values, as reported in Table 1.

Table 2: Costs and QALYs for % Thrombolysed for Ischemic stroke at 1yr and 5yr

% ICH stroke thrombolysed	1 – Year (inflated to 2018/19 values)			5 – Year (inflated to 2018/19 values)		
	Mean 1-year NHS cost	Mean 1-year Social care cost	Mean QALYs	Mean 5-year NHS cost	Mean 5-year Social care cost	Mean QALYs
<b>1%</b>	£21,037	£13,774	0.496	£28,012	£42,971	1.667
<b>3%</b>	£20,925	£13,778	0.487	£27,966	£42,210	1.634
<b>4%</b>	£20,886	£13,843	0.490	£27,981	£43,744	1.649
<b>6%</b>	£20,793	£13,546	0.494	£27,849	£42,124	1.657
<b>7%</b>	£20,748	£13,697	0.494	£27,683	£42,703	1.660
<b>9%</b>	£20,712	£13,283	0.494	£27,709	£41,246	1.658
<b>10%</b>	£20,586	£13,115	0.492	£27,440	£40,416	1.650
<b>11%</b>	£20,564	£13,536	0.495	£27,476	£42,081	1.659
<b>13%</b>	£20,412	£13,370	0.499	£27,319	£41,745	1.677

Source: <https://www.strokeaudit.org/HealthEconomics> {Cost of Stroke Portfolio (Health Economics)}

#### 2. Estimating total costs by proportion of patients thrombolysed.

Using the above estimates, we calculated 1-yr and 5-yr NHS Social care costs and QALYs for different proportions of patients thrombolysed. For example, if 3% all stroke patients were thrombolysed, the 1-yr NHS cost will be:

$$[(3\% * 1yr \text{ NHS cost savings from thrombolysis}) + (1yr \text{ NHS cost of stroke})].$$

This can be viewed in the appendix (Table 14).

### 3. Health economic tool

The SSNAP Health economics tool provided an overall framework for the analyses, as described below (*Sentinel Stroke National Audit Programme (SSNAP)- Health economics Tool for Thrombolysis*).

The tool incorporates the afore-mentioned costs associated with ischemic stroke, as well as costs associated with haemorrhagic stroke:

$$\begin{aligned}
 \text{Total cost} &= \text{Cost of ischemic stroke} + \text{cost of haemorrhagic stroke} \\
 \text{where, Cost of ischemic stroke} &= \text{Costs for patients by \% thrombolysed} * \% \text{ Ischemic stroke} \\
 &* \text{Total stroke patients.} \\
 \text{and, Cost of haemorrhagic stroke} &= \text{Cost of haemorrhagic stroke} * (1 - \% \text{ Ischemic Stroke}) \\
 &* \text{Total stroke patients.}
 \end{aligned}$$

We developed three scenarios for the economic evaluation, as follows.

Scenario 1: Average cost savings per person for selected centre(s) with telemedicine vs national avg. cost savings from SSNAP

Scenario 2: Average cost savings per person for selected centre(s) with telemedicine vs usual care (if telemedicine was not adopted in those selected centres)

Scenario 3: Total cost savings for selected centre(s) with telemedicine vs usual care (if telemedicine was not adopted in those selected centres)

### 4. Sensitivity analyses

We performed a sensitivity analysis to check the impact of using alternative cost estimates for the Telemedicine Service. We increased the capital (equipment costs) and maintenance costs by up to 30% (Table 3) and assessed the impact of this on the scenarios described above.

Table 3

Sensitivity analysis	Base case	10%	20%	30%
Telemedicine cart	£7,440	£8,184	£8,928	£9,672
Laptop	£10,915	£12,006	£13,098	£14,189
Telemed Software license	£12,375	£13,613	£14,850	£16,088
Stroke telemedicine website hosting (SharePoint)	£1,065	£1,172	£1,278	£1,385
Licences for SharePoint access	£520	£572	£624	£676
eReceptionist (call-forwarding service)	£1,000	£1,100	£1,200	£1,300
Sectra - Image Exchange Portal	£6,000	£6,600	£7,200	£7,800
Training (annual cost)	£2,200	£2,420	£2,640	£2,860
Total cost of Telemedicine Service	£41,515	£45,667	£49,818	£53,970
Avg. Cost	£22.31	£24.54	£26.78	£29.01
Cost per person (including cost of teleconsultation)	£35.15	£37.38	£39.62	£41.85

## Results

### Summary data for East of England Telestroke service.

Table 4 below provides an overview of thrombolysis rates when using the Telemedicine service for OOH between 2014 - 2019. These estimates were based on a combination of data collected from the East of England Telestroke project and the SSNAP clinical audit result (Sentinel Stroke National Audit Programme (SSNAP), 2019) database. Detailed hospital level summary measures can be viewed in the Appendix (Table 13).

Table 4: Overview of Thrombolysis rates in East of England Telestroke project

Year	No. of Telestroke patient consultations			Patients thrombolysed		Total Stroke patients (SSNAP)	Stroke patients OOH (SSNAP)		% Thrombolysed OOH using Telemed Service
	N	Female	% Females	n	%		%	N	
2014	380	182	47.3%	152	41.2%	3404	47.6%	1634	8.9%
2015	404	186	47.9%	177	45.3%	3643	48.9%	1782	9.3%
2016	481	236	48.8%	189	41.0%	3833	48.0%	1848	10.3%
2017	484	256	51.7%	199	42.5%	4023	47.6%	1924	10.0%
2018	474	228	48.3%	221	47.5%	4243	48.5%	2067	10.7%
2019	365	188	49.2%	173	49.4%	4118	46.2%	1908	9.0%

The data used for the economic evaluation are summarised in Table 5 below. Based on SSNAP data, an average of 46%-50% of stroke patients were admitted during OOH in the respective centres. Approximately 83%-92% had ischemic stroke. The average thrombolysis rates were estimated using East of England Telestroke Service data with average rates between 7.5% - 12.6%.

Table 5: Summary data inputs for the economic evaluation

SSNAP data	Total Stroke patients	% OOH	No. Stroke Patients OOH	Avg. % Thrombolysed Telemed	% infarctions
Ipswich	540	48.3%	261	12.6%	83.2%
James Paget	448	46.0%	207	8.5%	87.6%
Lister	677	50.1%	340	10.1%	91.4%
Peterborough	606	46.6%	282	10.5%	92.0%
Queen Elizabeth	541	48.4%	261	8.4%	88.9%
Watford	617	48.7%	301	10.3%	88.7%
West Suffolk	449	46.5%	209	7.5%	86.9%
<b>Total</b>	<b>3877</b>	<b>47.8%</b>	<b>1861</b>	<b>9.7%</b>	<b>88.4%</b>
<b>East of England</b>	<b>8486</b>	<b>48.6%</b>	<b>4127</b>	<b>9.7%</b>	<b>89.1%</b>
<b>England</b>	<b>83773</b>	<b>48.9%</b>	<b>40940</b>	<b>9.7%</b>	<b>87.3%</b>

## Economic evaluation results

Table 6 below represents NHS costs, social care costs and QALY gains for the respective centres. Total NHS costs across the seven centres using the Telemedicine service were £38m and £49.4m at one year and five years respectively. Social care costs were estimated to be £19.5m and £68.3m at one year and five year respectively.

Table 6: Total costs and QALYs for centres using Telemedicine service

TELEMEDICINE PATHWAY	Cases Thrombolysed	1 year			5 year		
		NHS Cost (£m)	Social care Cost (£m)	QALY gain	NHS Cost (£m)	Social care Cost (£m)	QALY gain
Ipswich	33	£5.33	£2.43	2.6	£6.83	£8.99	8.6
James Paget	17	£4.23	£2.18	1.4	£5.49	£7.53	4.6
Lister	34	£6.91	£3.68	2.7	£9.06	£12.91	8.9
Peterborough	30	£5.73	£3.06	2.4	£7.52	£10.79	7.7
Queen Elizabeth	22	£5.34	£2.80	1.8	£6.95	£9.66	5.7
Watford	31	£6.13	£3.13	2.5	£7.97	£11.07	8.0
West Suffolk	16	£4.29	£2.21	1.3	£5.54	£7.55	4.1
<b>Total</b>	<b>181</b>	<b>£37.97</b>	<b>£19.45</b>	<b>14.5</b>	<b>£49.35</b>	<b>£68.32</b>	<b>47.0</b>
<b>East of England*</b>	<b>399</b>	<b>£84.17</b>	<b>£43.63</b>	<b>31.8</b>	<b>£109.63</b>	<b>£152.87</b>	<b>103.3</b>
<b>England*</b>	<b>3959</b>	<b>£836.61</b>	<b>£422.21</b>	<b>317.3</b>	<b>£1,083.97</b>	<b>£1,484.61</b>	<b>£1,031.2</b>

\*These were estimated using SSNAP data and reflects costs if OOH Telemedicine service were to be used at Regional (East on England) and National (England) levels.

### 2.1 Scenario 1: Centre-level: East of England Telestroke Service vs national averages based on SSNAP data

Table 7 below summarises average incremental costs, incremental QALYs and ICERs by centre at 1 year and 5 years. The scenario compares the respective telemedicine centre against national averages estimated from SSNAP data. Average NHS cost savings range between £142 to £410 at one year and £77 to £576 at 5 years. Social care cost savings ranged between £404 to £1,936 at one year and £93 to £2,164 at 5 years.

### 2.2 Scenario 2: Centre-level: East of England Telestroke Service vs usual care

Table 8 below compares average incremental costs, incremental QALYs and ICERs by centre. The telemedicine service is compared against a scenario in which the telemedicine service was not adopted (usual care/standard pathway). Average NHS cost savings ranged between £152 to £401 at one year and £148 to £392 at 5 years, with highest savings in Ipswich hospital. Social care cost savings ranged between £593 to £1,379 and £184 to £427 at one year and 5 year respectively.

### 2.3 Scenario 3: Total: East of England Telestroke Service vs usual care

Table 9 below compares the total incremental costs, incremental QALYs and ICERs for the telemedicine centres against a scenario in which the telemedicine service was not adopted (usual care/ standard pathway).

Table 7: Scenario 1

Description	1 yr					5 yr				
	ANHS costs	ASocial care	ΔQALY	NHS cost per QALY gain (ICER)	NHS & Social care cost per QALY gain (ICER)	ANHS costs	ASocial care	ΔQALY	NHS cost per QALY gain (ICER)	NHS & social care cost per QALY gain (ICER)
Ipswich	-£300	-£1,936	0.007	TM Dominates	TM Dominates	-£576	-£2,164	0.023	TM Dominates	TM Dominates
James Paget	-£205	-£692	0.004	TM Dominates	TM Dominates	-£178	-£93	0.012	TM Dominates	TM Dominates
Lister	-£374	-£418	0.005	TM Dominates	TM Dominates	-£83	£1,435	0.016	TM Dominates	82,562
Peterborough	-£410	-£404	0.005	TM Dominates	TM Dominates	-£77	£1,667	0.018	TM Dominates	90,811
Queen Elizabeth	-£233	-£514	0.004	TM Dominates	TM Dominates	-£120	£436	0.012	TM Dominates	25,929
Watford	-£319	-£826	0.005	TM Dominates	TM Dominates	-£217	£267	0.017	TM Dominates	2,978
West Suffolk	-£142	-£642	0.003	TM Dominates	TM Dominates	-£165	-£343	0.010	TM Dominates	TM Dominates
Total	-£284	-£778	0.005	TM Dominates	TM Dominates	-£203	£172	0.016	TM Dominates	TM Dominates
East of England*	-£297	-£661	0.005	TM Dominates	TM Dominates	-£165	£491	0.015	TM Dominates	21,388
England*	-£256	-£920	0.005	TM Dominates	TM Dominates	-£250	-£285	0.015	TM Dominates	TM Dominates

\*These were estimated using SSNAP data and reflects costs if OOH Telemedicine service were to be used at Regional (East on England) and National (England) levels.

\*TM (telemedicine) dominates implies that telemedicine service is both more effective and less expensive.

The ICER figures are positive for some centres, indicating that there is an additional cost associated with the outcome gains. This was accounted for by the higher percentage of infarctions (consequently increasing the number of patients eligible for thrombolysis and resulting in higher social care costs) seen in the centres in comparison to national avg. for % infarctions as reported in SSNAP.

Table 8: Scenario 2

Description	1 yr					5 yr				
	ANHS costs	ASocial care	ΔQALY	NHS cost per QALY gain (ICER)	NHS & Social care cost per QALY gain (ICER)	ANHS costs	ASocial care	ΔQALY	NHS cost per QALY gain (ICER)	NHS & social care cost per QALY gain (ICER)
Ipswich Hospital	-£401	-£1,379	0.007	TM Dominates	TM Dominates	-£392	-£427	0.023	TM Dominates	TM Dominates
James Paget	-£197	-£733	0.004	TM Dominates	TM Dominates	-£192	-£227	0.012	TM Dominates	TM Dominates
Lister	-£274	-£978	0.005	TM Dominates	TM Dominates	-£268	-£303	0.016	TM Dominates	TM Dominates
Peterborough	-£294	-£1,041	0.005	TM Dominates	TM Dominates	-£287	-£322	0.017	TM Dominates	TM Dominates
Queen Elizabeth	-£196	-£730	0.004	TM Dominates	TM Dominates	-£191	-£226	0.012	TM Dominates	TM Dominates
Watford	-£286	-£1,017	0.005	TM Dominates	TM Dominates	-£280	-£315	0.017	TM Dominates	TM Dominates
West Suffolk	-£152	-£593	0.003	TM Dominates	TM Dominates	-£148	-£184	0.010	TM Dominates	TM Dominates
Total	-£259	-£931	0.005	TM Dominates	TM Dominates	-£253	-£288	0.016	TM Dominates	TM Dominates
East of England*	-£253	-£912	0.005	TM Dominates	TM Dominates	-£247	-£282	0.015	TM Dominates	TM Dominates
England*	-£256	-£920	0.005	TM Dominates	TM Dominates	-£250	-£285	0.015	TM Dominates	TM Dominates

\*These were estimated using SSNAP data and reflects costs if OOH Telemedicine service were to be used at Regional (East on England) and National (England) levels.

Table 9: Scenario 3

Description	1 yr			5 yr		
	ΔNHS costs	ΔSocial care	ΔQALY	ΔNHS costs	ΔSocial care	ΔQALY
Ipswich	-£104,729	-£360,339	1.860	-£102,404	-£111,589	56.044
James Paget	-£40,631	-£151,500	0.782	-£39,653	-£46,916	2.541
Lister	-£93,123	-£332,376	1.715	-£90,979	-£102,929	5.575
Peterborough	-£83,001	-£293,948	1.517	-£81,105	-£91,029	4.931
Queen Elizabeth	-£51,082	-£190,626	0.984	-£49,853	-£59,033	3.198
Watford	-£86,090	-£305,757	1.578	-£84,118	-£94,686	5.129
West Suffolk	-£31,735	-£123,569	0.638	-£30,938	-£38,267	2.073
<b>Total</b>	<b>-£482,438</b>	<b>-£1,732,954</b>	<b>8.944</b>	<b>-£471,257</b>	<b>-£536,657</b>	<b>29.069</b>
East of England*	-£1,044,424	-£3,762,698	19.420	-£1,020,148	-£1,165,222	63.116
England*	-£10,466,971	-£37,661,859	194.384	-£10,223,991	-£11,663,027	631.747

### Sensitivity analysis

Tables 10-12 summarize the estimated impacts of increasing the overall costs of the Telemedicine Service (+10% to +30%) and incorporating these increased costs into the acute stroke care pathway. We looked at three scenarios: first, at programme level in the east of England, second, extending the service regionally to elsewhere in the East of England and, finally, extending the service to national level. Figures in each table represent costs, incremental costs and ICERs for the East of England Stroke Telemedicine Service; cost comparisons are against an OOH usual care pathway without Telemedicine

Table 10 Scenario summary for East of England Telemedicine service

Scenario Summary	Cost of East of England Telemedicine service			
	Base case	Service cost +10%	Service cost + 20%	Service cost + 30%
<b>Telemedicine cost/pp</b>	£35.15	£37.38	£39.62	£41.85
<b>Result Cells:</b>				
<b>1YR NHS Cost of all</b>	£37,976,92	£37,981,073	£37,985,240	£37,989,389
<b>5YR NHS Cost of all</b>	£49,358,24	£49,362,395	£49,366,563	£49,370,712
<b>Cost per person</b>				
<b>1 yr ΔNHS costs</b>	-£255	-£253	-£250	-£248
<b>5 yr ΔNHS costs</b>	-£249	-£247	-£245	-£242
<b>Total costs</b>				
<b>1 yr NHS costs</b>	-£474,381	-£470,232	-£466,064	-£461,915
<b>5 yr NHS costs</b>	-£463,365	-£459,216	-£455,049	-£450,899
<b>NHS Perspective</b>				
<b>£/QALY 1yr</b>	-£53,829	-£53,359	-£52,886	-£52,415
<b>£/QALY 5yr</b>	-£16,179	-£16,034	-£15,888	-£15,743
<b>NHS and social care</b>				
<b>£/QALY 1yr</b>	-£247,579	-£247,109	-£246,636	-£246,165
<b>£/QALY 5yr</b>	-£34,640	-£34,495	-£34,350	-£34,205

Table 11 Scenario summary of East of England region

Scenario Summary	Cost of East of England Telemedicine service			
	Base case	Service cost	Service cost + 20%	Service cost + 30%
Telemedicine cost/pp	£35.15	£37.38	£39.62	£41.85
<b>Result Cells:</b>				
1YR NHS Cost of all	£84,169,619	£84,178,823	£84,188,068	£84,197,272
5YR NHS Cost of all	£109,629,927	£109,639,131	£109,648,376	£109,657,580
<i>Cost per person</i>				
1 yr ΔNHS costs	-£253	-£251	-£249	-£246
5 yr ΔNHS costs	-£247	-£245	-£243	-£240
<i>Total costs</i>				
1 yr NHS costs	-£1,044,424	-£1,035,220	-£1,025,975	-£1,016,771
5 yr NHS costs	-£1,020,148	-£1,010,944	-£1,001,699	-£992,496
<b>NHS Perspective</b>				
£/QALY 1yr	-£53,780	-£53,306	-£52,830	-£52,356
£/QALY 5yr	-£16,164	-£16,018	-£15,871	-£15,725
<b>NHS and social care</b>				
£/QALY 1yr	-£247,530	-£247,056	-£246,580	-£246,106
£/QALY 5yr	-£34,625	-£34,479	-£34,333	-£34,187

Table 12 Scenario summary for England

Scenario Summary	Cost of Telemedicine service - England			
	Base case	Service cost +10%	Service cost + 20%	Service cost + 30%
Telemedicine cost/pp	£35.15	£37.38	£39.62	£41.85
<b>Result Cells:</b>				
1YR NHS Cost of all Stroke	£836,611,607	£836,702,903	£836,794,608	£836,885,904
5YR NHS Cost of all Stroke	£1,083,966,170	£1,084,057,466	£1,084,149,172	£1,084,240,467
<i>Cost per person</i>				
1 yr ΔNHS costs	-£256	-£253	-£251	-£249
5 yr ΔNHS costs	-£250	-£248	-£245	-£243
<i>Total costs</i>				
1 yr NHS costs	-£10,466,971	-£10,375,675	-£10,283,970	-£10,192,674
5 yr NHS costs	-£10,223,991	-£10,132,695	-£10,040,990	-£9,949,694
<b>NHS Perspective</b>				
£/QALY 1yr	-£53,847	-£53,378	-£52,906	-£52,436
£/QALY 5yr	-£16,184	-£16,040	-£15,894	-£15,750
<b>NHS and social care</b>				
£/QALY 1yr	-£247,597	-£247,128	-£246,656	-£246,186
£/QALY 5yr	-£34,646	-£34,501	-£34,356	-£34,212

## Discussion

In 2012, the recommended symptom onset to thrombolysis time window was extended to 4.5 hours. Since then, the proportion of patients treated with thrombolysis has increased over the past 10 years and is now up to 11%-12% (Sentinel Stroke National Audit Programme (SSNAP), 2019). There is however, national and regional variation in the uptake of this treatment, with some units achieving thrombolysis rates of 20% (Sentinel Stroke National Audit Programme (SSNAP), 2019) demonstrating that other units have scope to improve their thrombolysis rates.

The use of Telemedicine in stroke care is becoming a widespread and fast-growing practice model for increasing access to thrombolysis. The East of England Telestroke project used a hubless model, as opposed to the most widely used hub and spoke model, in which local stroke physicians participated in the regional service and care delivery was not dependent on regional centres. Apart from local specialists retaining competencies in treating sufficient thrombolysis cases, other advantages for the model included effective sharing of burden of overnight call for low frequency and high impact events, as well as improved logistics for follow up care. Keeping services local has particular advantages in relatively large rural landscapes by minimizing dependence on regional transport services and developing rehabilitation and follow-up care for patients closer to where they live.

The use of East of England Telestroke project has significantly improved thrombolysis rates during OOH periods. The average thrombolysis rate across the region was 9.7%, as opposed to the national average of 3.7% as estimated by Bray *et al.* Here, we have further investigated the costs and cost-effectiveness of the Telemedicine Service. We estimated total NHS care costs of £37.97m and £49.35m at the end of 1-year and 5-year respectively. Social care costs were estimated at £19.45m and £68.32m at 1-year and 5-years respectively. Total NHS cost savings associated with a care pathway incorporating the Telemedicine Service were estimated at £482.4k and £471.3k at the end of 1-year and 5-years, as compared with a usual care pathway without the service.

We also estimated that QALYs would increase alongside increased thrombolysis rates. Therefore, a care pathway with telemedicine is both cheaper and provides better outcomes, providing a cost-effective method for delivering stroke care in East Anglia and other remote communities with limited access to on-site stroke specialists. Increasing the proportion of patients receiving thrombolysis will not only improve patient outcomes but also help control the financial burden following stroke.

### Study limitations

While this study presents novel and important results on the use of telemedicine service, there are several limitations. We assumed the thrombolysis rate to be constant when comparing across all centres as well as at regional and national level. This rate was estimated using the results reported in the Bray 2016 study, in the absence of centre specific thrombolysis rates prior to the use of telemedicine.

Since both SSNAP and the data collected from East of England Telestroke project included only those cases with a diagnosis of stroke, the cases that were mimics were not included. In a usual care setting, stroke mimics are transferred to a tertiary care centre due to uncertainty of diagnosis. In these cases, telemedicine consultation could allow stroke specialists to assist providers in diagnosis, treatment and transfer decision by potentially avoiding unnecessary transfers and associated costs. Based on a literature review, 25% of suspected stroke cases were stroke mimics (Jones, O'Connell and David, 2020). These could potentially add to the cost savings from using Telemedicine in acute stroke care pathway. Further economic modelling beyond the scope of this report is required to estimate these savings.

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## Appendices

Table 13: Hospital Level Summary

Hospital	Ipswich	James Paget	Lister	Peterborough	Princess Alexandra	Queen Elizabeth	Watford	West Suffolk	Total
<b>N</b>	494	182	495	439	51	271	423	233	2588
<b>Female (%)</b>	243 (49.2%)	88 (48.4%)	254 (51.3%)	227 (51.7%)	32 (62.7%)	115 (42.4%)	205 (48.5%)	112 (48.1%)	1276 (49.3%)
<b>Males (%)</b>	240 (48.6%)	94 (51.2%)	235 (47.5%)	207 (47.2%)	17 (33.3%)	214 (50.1%)	214 (50.1%)	118 (50.6%)	1277 (49.3%)
<b>Age</b>									
<b>Female</b>	71.3	70.0	69.6	69.0	67.7	73.6	75.5	74.4	
<b>Male</b>	70.1	71.0	67.7	66.5	66.8	67.7	69.6	70.1	
<b>Thrombolysed</b>									
<b>Female (%)</b>	93 (18.8%)	49 (27%)	95 (19.2%)	88 (20%)	12 (23.5%)	59 (21.8%)	75 (17.7%)	37 (15.9%)	508 (19.6%)
<b>Male (%)</b>	103 (20.9%)	57 (31.3%)	107 (21.6%)	92 (21%)	3 (5.9%)	73 (26.9%)	107 (25.3%)	57 (24.5%)	599 (23.1%)
<b>Not Thrombolysed</b>									
<b>Female (%)</b>	149 (30.2%)	39 (21.4%)	158 (31.9%)	140 (31.9%)	20 (39.2%)	56 (20.7%)	130 (30.7%)	75 (32.2%)	767 (29.6%)
<b>Male (%)</b>	138 (27.9%)	36 (19.8)	129 (26.1%)	115 (26.2%)	14 (27.5%)	79 (29.2%)	107 (25.3%)	61 (26.2%)	679 (26.2%)
<b>Median Time (hrs:mins)</b>									
<b>Onset to needle</b>	02:41	02:46	02:54	02:51	02:35	02:50	02:49	02:41	
<b>Door to needle</b>	01:13	01:26	01:22	01:17	01:51	01:13	01:16	01:16	

Note: In 2015, East and North Hertfordshire CCG announced that patients with a suspected stroke would no longer be taken to Princess Alexandra Hospital but will be taken via the ambulance service straight to the nearest specialist stroke centre instead, which was likely to be the Lister Hospital. This explains why our analysis includes data from Princess Alexandra hospital up until 2015.

Source: East of England telemedicine service data

## NHS costs by proportion of patients thrombolysed.

Figure 1

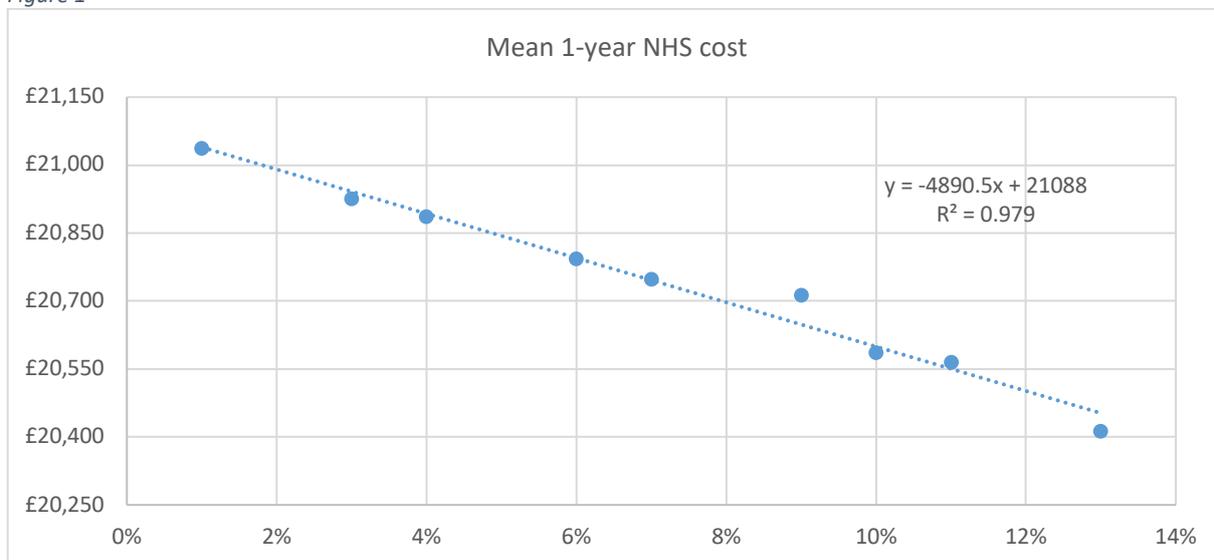
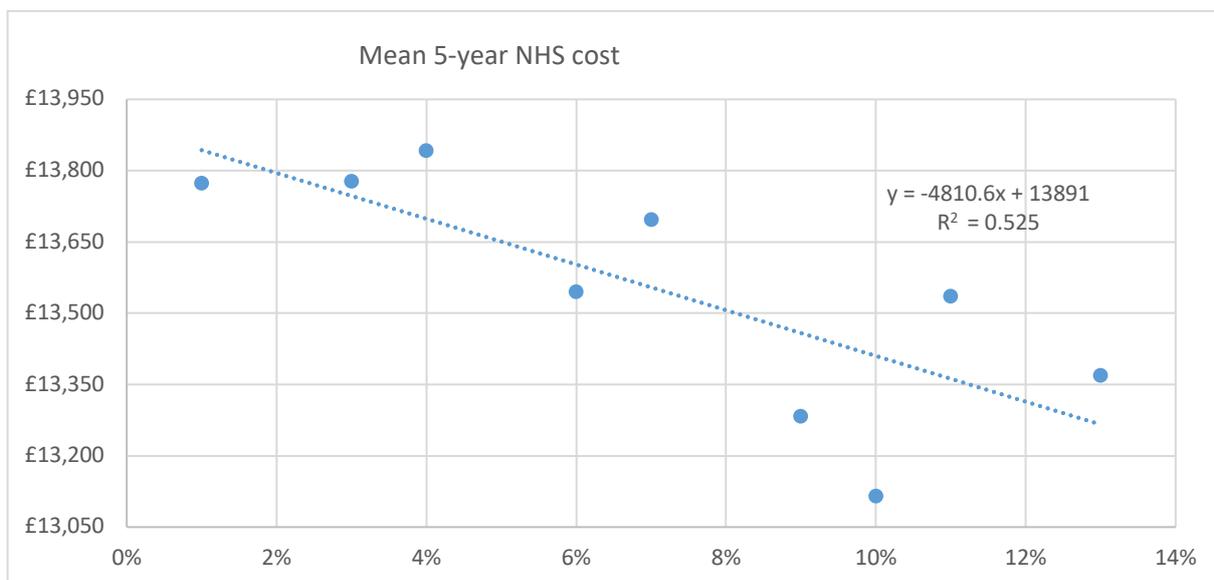


Figure 2



## Social care costs by proportion of patients thrombolysed.

Figure 3

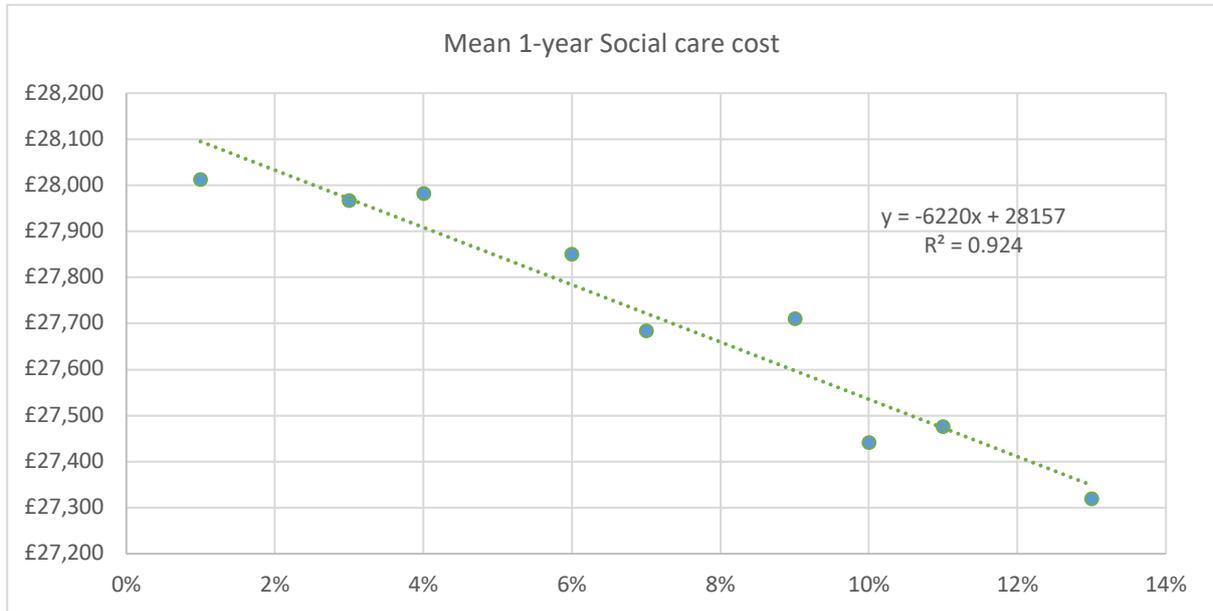
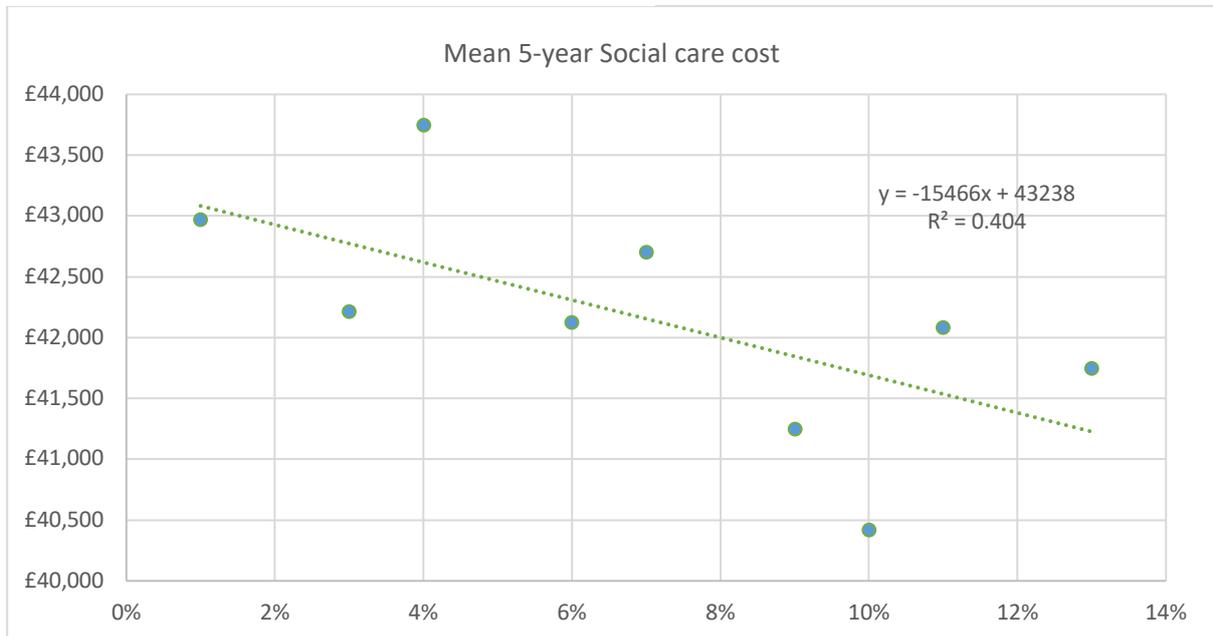


Figure 4



# QALYs by proportion of patients thrombolysed.

Figure 5

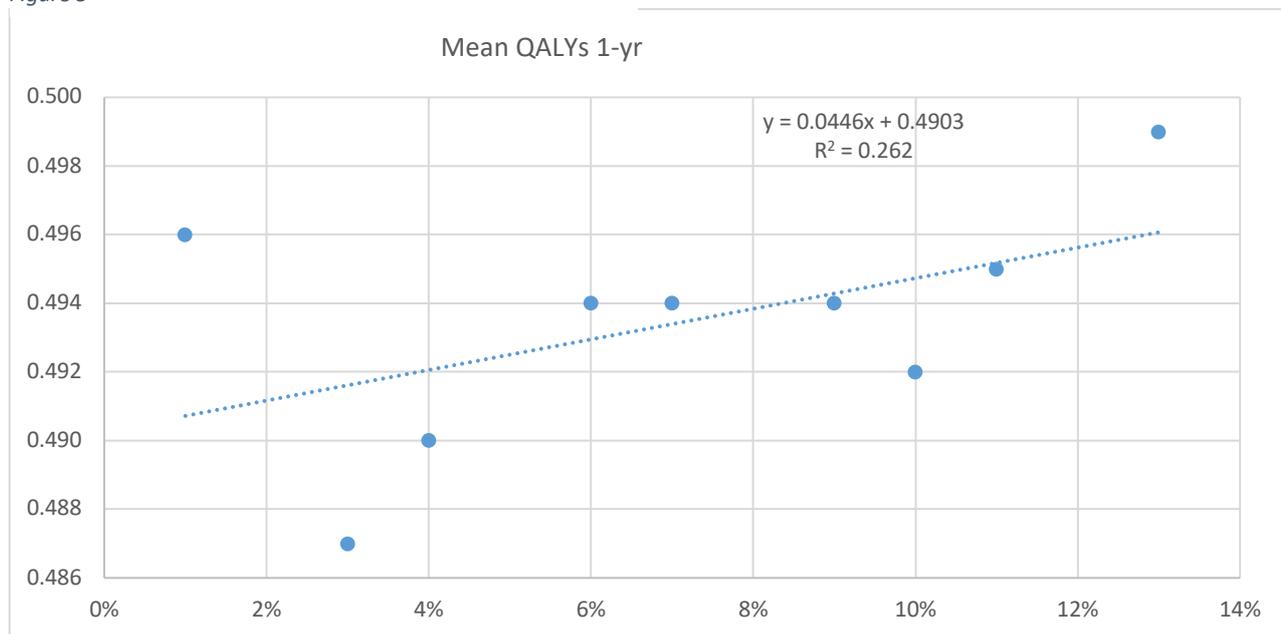
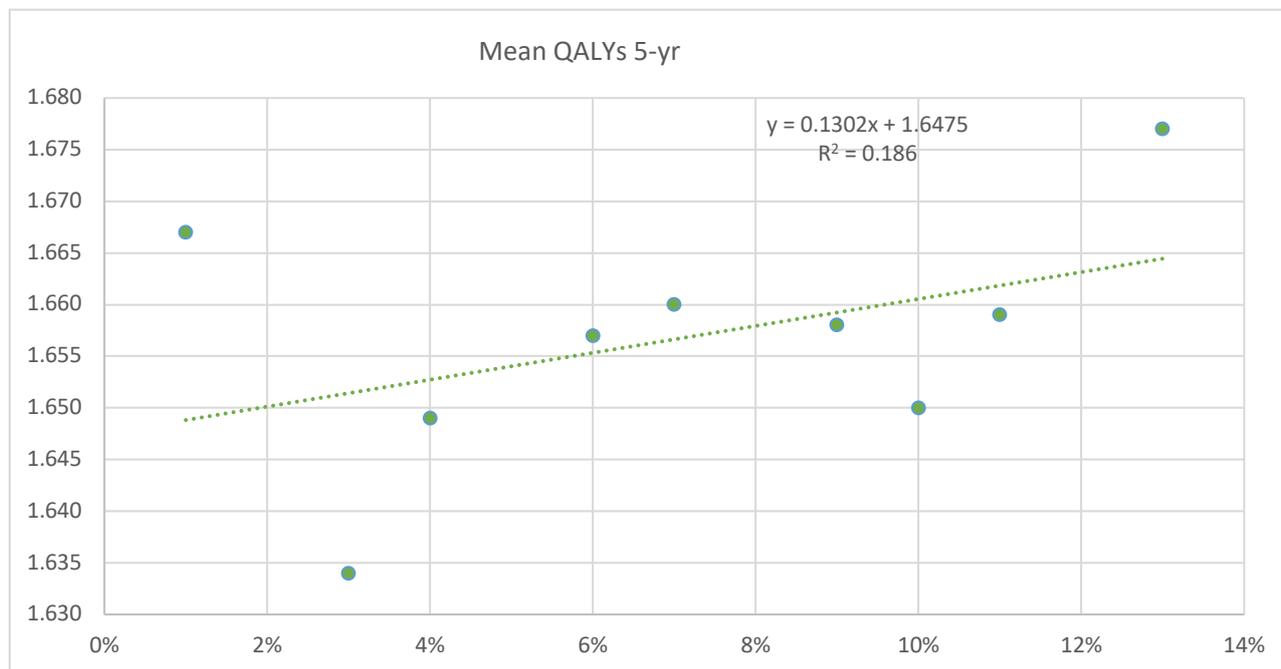


Figure 6



Costs and QALYs by proportion of Ischemic stroke thrombolysed.

Table 14

<b>% ICH stroke thrombolysed</b>	<b>1 yr NHS</b>	<b>5 yr NHS</b>	<b>1yr Social Care</b>	<b>5 Yr Social care</b>	<b>1 yr QALY gain</b>	<b>5 yr QALY gain</b>
<b>0.0%</b>	20564.44	27475.78	13536.44	42080.89	0.000	0.000
<b>0.1%</b>	20559.54	27470.98	13520.94	42076.09	0.000	0.000
<b>0.2%</b>	20554.64	27466.18	13505.44	42071.29	0.000	0.001
<b>0.3%</b>	20549.74	27461.38	13489.94	42066.49	0.000	0.001
<b>0.4%</b>	20544.84	27456.58	13474.44	42061.69	0.000	0.001
<b>0.5%</b>	20539.94	27451.78	13458.94	42056.89	0.000	0.001
<b>0.6%</b>	20535.04	27446.98	13443.44	42052.09	0.000	0.002
<b>0.7%</b>	20530.14	27442.18	13427.94	42047.29	0.001	0.002
<b>0.8%</b>	20525.24	27437.38	13412.44	42042.49	0.001	0.002
<b>0.9%</b>	20520.34	27432.58	13396.94	42037.69	0.001	0.002
<b>1.0%</b>	20515.44	27427.78	13381.44	42032.89	0.001	0.003
<b>1.1%</b>	20510.54	27422.98	13365.94	42028.09	0.001	0.003
<b>1.2%</b>	20505.64	27418.18	13350.44	42023.29	0.001	0.003
<b>1.3%</b>	20500.74	27413.38	13334.94	42018.49	0.001	0.003
<b>1.4%</b>	20495.84	27408.58	13319.44	42013.69	0.001	0.004
<b>1.5%</b>	20490.94	27403.78	13303.94	42008.89	0.001	0.004
<b>1.6%</b>	20486.04	27398.98	13288.44	42004.09	0.001	0.004
<b>1.7%</b>	20481.14	27394.18	13272.94	41999.29	0.001	0.004
<b>1.8%</b>	20476.24	27389.38	13257.44	41994.49	0.001	0.005
<b>1.9%</b>	20471.34	27384.58	13241.94	41989.69	0.002	0.005
<b>2.0%</b>	20466.44	27379.78	13226.44	41984.89	0.002	0.005
<b>2.1%</b>	20461.54	27374.98	13210.94	41980.09	0.002	0.005
<b>2.2%</b>	20456.64	27370.18	13195.44	41975.29	0.002	0.006
<b>2.3%</b>	20451.74	27365.38	13179.94	41970.49	0.002	0.006
<b>2.4%</b>	20446.84	27360.58	13164.44	41965.69	0.002	0.006
<b>2.5%</b>	20441.94	27355.78	13148.94	41960.89	0.002	0.007
<b>2.6%</b>	20437.04	27350.98	13133.44	41956.09	0.002	0.007
<b>2.7%</b>	20432.14	27346.18	13117.94	41951.29	0.002	0.007
<b>2.8%</b>	20427.24	27341.38	13102.44	41946.49	0.002	0.007
<b>2.9%</b>	20422.34	27336.58	13086.94	41941.69	0.002	0.008
<b>3.0%</b>	20417.44	27331.78	13071.44	41936.89	0.002	0.008
<b>3.1%</b>	20412.54	27326.98	13055.94	41932.09	0.002	0.008
<b>3.2%</b>	20407.64	27322.18	13040.44	41927.29	0.003	0.008
<b>3.3%</b>	20402.74	27317.38	13024.94	41922.49	0.003	0.009
<b>3.4%</b>	20397.84	27312.58	13009.44	41917.69	0.003	0.009
<b>3.5%</b>	20392.94	27307.78	12993.94	41912.89	0.003	0.009
<b>3.6%</b>	20388.04	27302.98	12978.44	41908.09	0.003	0.009
<b>3.7%</b>	20383.14	27298.18	12962.94	41903.29	0.003	0.010
<b>3.8%</b>	20378.24	27293.38	12947.44	41898.49	0.003	0.010
<b>3.9%</b>	20373.34	27288.58	12931.94	41893.69	0.003	0.010
<b>4.0%</b>	20368.44	27283.78	12916.44	41888.89	0.003	0.010
<b>4.1%</b>	20363.54	27278.98	12900.94	41884.09	0.003	0.011
<b>4.2%</b>	20358.64	27274.18	12885.44	41879.29	0.003	0.011
<b>4.3%</b>	20353.74	27269.38	12869.94	41874.49	0.003	0.011
<b>4.4%</b>	20348.84	27264.58	12854.44	41869.69	0.004	0.011
<b>4.5%</b>	20343.94	27259.78	12838.94	41864.89	0.004	0.012

<b>% ICH stroke thrombolysed</b>	<b>1 yr NHS</b>	<b>5 yr NHS</b>	<b>1yr Social Care</b>	<b>5 Yr Social care</b>	<b>1 yr QALY gain</b>	<b>5 yr QALY gain</b>
4.6%	20339.04	27254.98	12823.44	41860.09	0.004	0.012
4.7%	20334.14	27250.18	12807.94	41855.29	0.004	0.012
4.8%	20329.24	27245.38	12792.44	41850.49	0.004	0.012
4.9%	20324.34	27240.58	12776.94	41845.69	0.004	0.013
5.0%	20319.44	27235.78	12761.44	41840.89	0.004	0.013
5.1%	20314.54	27230.98	12745.94	41836.09	0.004	0.013
5.2%	20309.64	27226.18	12730.44	41831.29	0.004	0.014
5.3%	20304.74	27221.38	12714.94	41826.49	0.004	0.014
5.4%	20299.84	27216.58	12699.44	41821.69	0.004	0.014
5.5%	20294.94	27211.78	12683.94	41816.89	0.004	0.014
5.6%	20290.04	27206.98	12668.44	41812.09	0.004	0.015
5.7%	20285.14	27202.18	12652.94	41807.29	0.005	0.015
5.8%	20280.24	27197.38	12637.44	41802.49	0.005	0.015
5.9%	20275.34	27192.58	12621.94	41797.69	0.005	0.015
6.0%	20270.44	27187.78	12606.44	41792.89	0.005	0.016
6.1%	20265.54	27182.98	12590.94	41788.09	0.005	0.016
6.2%	20260.64	27178.18	12575.44	41783.29	0.005	0.016
6.3%	20255.74	27173.38	12559.94	41778.49	0.005	0.016
6.4%	20250.84	27168.58	12544.44	41773.69	0.005	0.017
6.5%	20245.94	27163.78	12528.94	41768.89	0.005	0.017
6.6%	20241.04	27158.98	12513.44	41764.09	0.005	0.017
6.7%	20236.14	27154.18	12497.94	41759.29	0.005	0.017
6.8%	20231.24	27149.38	12482.44	41754.49	0.005	0.018
6.9%	20226.34	27144.58	12466.94	41749.69	0.006	0.018
7.0%	20221.44	27139.78	12451.44	41744.89	0.006	0.018
7.1%	20216.54	27134.98	12435.94	41740.09	0.006	0.018
7.2%	20211.64	27130.18	12420.44	41735.29	0.006	0.019
7.3%	20206.74	27125.38	12404.94	41730.49	0.006	0.019
7.4%	20201.84	27120.58	12389.44	41725.69	0.006	0.019
7.5%	20196.94	27115.78	12373.94	41720.89	0.006	0.020
7.6%	20192.04	27110.98	12358.44	41716.09	0.006	0.020
7.7%	20187.14	27106.18	12342.94	41711.29	0.006	0.020
7.8%	20182.24	27101.38	12327.44	41706.49	0.006	0.020
7.9%	20177.34	27096.58	12311.94	41701.69	0.006	0.021
8.0%	20172.44	27091.78	12296.44	41696.89	0.006	0.021
8.1%	20167.54	27086.98	12280.94	41692.09	0.006	0.021
8.2%	20162.64	27082.18	12265.44	41687.29	0.007	0.021
8.3%	20157.74	27077.38	12249.94	41682.49	0.007	0.022
8.4%	20152.84	27072.58	12234.44	41677.69	0.007	0.022
8.5%	20147.94	27067.78	12218.94	41672.89	0.007	0.022
8.6%	20143.04	27062.98	12203.44	41668.09	0.007	0.022
8.7%	20138.14	27058.18	12187.94	41663.29	0.007	0.023
8.8%	20133.24	27053.38	12172.44	41658.49	0.007	0.023
8.9%	20128.34	27048.58	12156.94	41653.69	0.007	0.023
9.0%	20123.44	27043.78	12141.44	41648.89	0.007	0.023
9.1%	20118.54	27038.98	12125.94	41644.09	0.007	0.024
9.2%	20113.64	27034.18	12110.44	41639.29	0.007	0.024
9.3%	20108.74	27029.38	12094.94	41634.49	0.007	0.024

<b>% ICH stroke thrombolysed</b>	<b>1 yr NHS</b>	<b>5 yr NHS</b>	<b>1yr Social Care</b>	<b>5 Yr Social care</b>	<b>1 yr QALY gain</b>	<b>5 yr QALY gain</b>
<b>9.4%</b>	20103.84	27024.58	12079.44	41629.69	0.008	0.024
<b>9.5%</b>	20098.94	27019.78	12063.94	41624.89	0.008	0.025
<b>9.6%</b>	20094.04	27014.98	12048.44	41620.09	0.008	0.025
<b>9.7%</b>	20089.14	27010.18	12032.94	41615.29	0.008	0.025
<b>9.8%</b>	20084.24	27005.38	12017.44	41610.49	0.008	0.025
<b>9.9%</b>	20079.34	27000.58	12001.94	41605.69	0.008	0.026
<b>10.0%</b>	20074.44	26995.78	11986.44	41600.89	0.008	0.026
<b>10.1%</b>	20069.54	26990.98	11970.94	41596.09	0.008	0.026
<b>10.2%</b>	20064.64	26986.18	11955.44	41591.29	0.008	0.027
<b>10.3%</b>	20059.74	26981.38	11939.94	41586.49	0.008	0.027
<b>10.4%</b>	20054.84	26976.58	11924.44	41581.69	0.008	0.027
<b>10.5%</b>	20049.94	26971.78	11908.94	41576.89	0.008	0.027
<b>10.6%</b>	20045.04	26966.98	11893.44	41572.09	0.008	0.028
<b>10.7%</b>	20040.14	26962.18	11877.94	41567.29	0.009	0.028
<b>10.8%</b>	20035.24	26957.38	11862.44	41562.49	0.009	0.028
<b>10.9%</b>	20030.34	26952.58	11846.94	41557.69	0.009	0.028
<b>11.0%</b>	20025.44	26947.78	11831.44	41552.89	0.009	0.029
<b>11.1%</b>	20020.54	26942.98	11815.94	41548.09	0.009	0.029
<b>11.2%</b>	20015.64	26938.18	11800.44	41543.29	0.009	0.029
<b>11.3%</b>	20010.74	26933.38	11784.94	41538.49	0.009	0.029
<b>11.4%</b>	20005.84	26928.58	11769.44	41533.69	0.009	0.030
<b>11.5%</b>	20000.94	26923.78	11753.94	41528.89	0.009	0.030
<b>11.6%</b>	19996.04	26918.98	11738.44	41524.09	0.009	0.030
<b>11.7%</b>	19991.14	26914.18	11722.94	41519.29	0.009	0.030
<b>11.8%</b>	19986.24	26909.38	11707.44	41514.49	0.009	0.031
<b>11.9%</b>	19981.34	26904.58	11691.94	41509.69	0.010	0.031
<b>12.0%</b>	19976.44	26899.78	11676.44	41504.89	0.010	0.031
<b>12.1%</b>	19971.54	26894.98	11660.94	41500.09	0.010	0.031
<b>12.2%</b>	19966.64	26890.18	11645.44	41495.29	0.010	0.032
<b>12.3%</b>	19961.74	26885.38	11629.94	41490.49	0.010	0.032
<b>12.4%</b>	19956.84	26880.58	11614.44	41485.69	0.010	0.032
<b>12.5%</b>	19951.94	26875.78	11598.94	41480.89	0.010	0.033
<b>12.6%</b>	19947.04	26870.98	11583.44	41476.09	0.010	0.033
<b>12.7%</b>	19942.14	26866.18	11567.94	41471.29	0.010	0.033
<b>12.8%</b>	19937.24	26861.38	11552.44	41466.49	0.010	0.033
<b>12.9%</b>	19932.34	26856.58	11536.94	41461.69	0.010	0.034
<b>13.0%</b>	19927.44	26851.78	11521.44	41456.89	0.010	0.034
<b>13.1%</b>	19922.54	26846.98	11505.94	41452.09	0.010	0.034
<b>13.2%</b>	19917.64	26842.18	11490.44	41447.29	0.011	0.034
<b>13.3%</b>	19912.74	26837.38	11474.94	41442.49	0.011	0.035
<b>13.4%</b>	19907.84	26832.58	11459.44	41437.69	0.011	0.035
<b>13.5%</b>	19902.94	26827.78	11443.94	41432.89	0.011	0.035
<b>13.6%</b>	19898.04	26822.98	11428.44	41428.09	0.011	0.035
<b>13.7%</b>	19893.14	26818.18	11412.94	41423.29	0.011	0.036
<b>13.8%</b>	19888.24	26813.38	11397.44	41418.49	0.011	0.036
<b>13.9%</b>	19883.34	26808.58	11381.94	41413.69	0.011	0.036
<b>14.0%</b>	19878.44	26803.78	11366.44	41408.89	0.011	0.036
<b>14.1%</b>	19873.54	26798.98	11350.94	41404.09	0.011	0.037

<b>% ICH stroke thrombolysed</b>	<b>1 yr NHS</b>	<b>5 yr NHS</b>	<b>1yr Social Care</b>	<b>5 Yr Social care</b>	<b>1 yr QALY gain</b>	<b>5 yr QALY gain</b>
<b>14.2%</b>	19868.64	26794.18	11335.44	41399.29	0.011	0.037
<b>14.3%</b>	19863.74	26789.38	11319.94	41394.49	0.011	0.037
<b>14.4%</b>	19858.84	26784.58	11304.44	41389.69	0.012	0.037
<b>14.5%</b>	19853.94	26779.78	11288.94	41384.89	0.012	0.038
<b>14.6%</b>	19849.04	26774.98	11273.44	41380.09	0.012	0.038
<b>14.7%</b>	19844.14	26770.18	11257.94	41375.29	0.012	0.038
<b>14.8%</b>	19839.24	26765.38	11242.44	41370.49	0.012	0.038
<b>14.9%</b>	19834.34	26760.58	11226.94	41365.69	0.012	0.039
<b>15.0%</b>	19829.44	26755.78	11211.44	41360.89	0.012	0.039
<b>15.1%</b>	19824.54	26750.98	11195.94	41356.09	0.012	0.039
<b>15.2%</b>	19819.64	26746.18	11180.44	41351.29	0.012	0.040
<b>15.3%</b>	19814.74	26741.38	11164.94	41346.49	0.012	0.040
<b>15.4%</b>	19809.84	26736.58	11149.44	41341.69	0.012	0.040
<b>15.5%</b>	19804.94	26731.78	11133.94	41336.89	0.012	0.040
<b>15.6%</b>	19800.04	26726.98	11118.44	41332.09	0.012	0.041
<b>15.7%</b>	19795.14	26722.18	11102.94	41327.29	0.013	0.041
<b>15.8%</b>	19790.24	26717.38	11087.44	41322.49	0.013	0.041
<b>15.9%</b>	19785.34	26712.58	11071.94	41317.69	0.013	0.041
<b>16.0%</b>	19780.44	26707.78	11056.44	41312.89	0.013	0.042
<b>16.1%</b>	19775.54	26702.98	11040.94	41308.09	0.013	0.042
<b>16.2%</b>	19770.64	26698.18	11025.44	41303.29	0.013	0.042
<b>16.3%</b>	19765.74	26693.38	11009.94	41298.49	0.013	0.042
<b>16.4%</b>	19760.84	26688.58	10994.44	41293.69	0.013	0.043
<b>16.5%</b>	19755.94	26683.78	10978.94	41288.89	0.013	0.043
<b>16.6%</b>	19751.04	26678.98	10963.44	41284.09	0.013	0.043
<b>16.7%</b>	19746.14	26674.18	10947.94	41279.29	0.013	0.043
<b>16.8%</b>	19741.24	26669.38	10932.44	41274.49	0.013	0.044
<b>16.9%</b>	19736.34	26664.58	10916.94	41269.69	0.014	0.044
<b>17.0%</b>	19731.44	26659.78	10901.44	41264.89	0.014	0.044
<b>17.1%</b>	19726.54	26654.98	10885.94	41260.09	0.014	0.044
<b>17.2%</b>	19721.64	26650.18	10870.44	41255.29	0.014	0.045
<b>17.3%</b>	19716.74	26645.38	10854.94	41250.49	0.014	0.045
<b>17.4%</b>	19711.84	26640.58	10839.44	41245.69	0.014	0.045
<b>17.5%</b>	19706.94	26635.78	10823.94	41240.89	0.014	0.046
<b>17.6%</b>	19702.04	26630.98	10808.44	41236.09	0.014	0.046
<b>17.7%</b>	19697.14	26626.18	10792.94	41231.29	0.014	0.046
<b>17.8%</b>	19692.24	26621.38	10777.44	41226.49	0.014	0.046
<b>17.9%</b>	19687.34	26616.58	10761.94	41221.69	0.014	0.047
<b>18.0%</b>	19682.44	26611.78	10746.44	41216.89	0.014	0.047
<b>18.1%</b>	19677.54	26606.98	10730.94	41212.09	0.014	0.047
<b>18.2%</b>	19672.64	26602.18	10715.44	41207.29	0.015	0.047
<b>18.3%</b>	19667.74	26597.38	10699.94	41202.49	0.015	0.048
<b>18.4%</b>	19662.84	26592.58	10684.44	41197.69	0.015	0.048
<b>18.5%</b>	19657.94	26587.78	10668.94	41192.89	0.015	0.048
<b>18.6%</b>	19653.04	26582.98	10653.44	41188.09	0.015	0.048
<b>18.7%</b>	19648.14	26578.18	10637.94	41183.29	0.015	0.049
<b>18.8%</b>	19643.24	26573.38	10622.44	41178.49	0.015	0.049
<b>18.9%</b>	19638.34	26568.58	10606.94	41173.69	0.015	0.049

<b>% ICH stroke thrombolysed</b>	<b>1 yr NHS</b>	<b>5 yr NHS</b>	<b>1yr Social Care</b>	<b>5 Yr Social care</b>	<b>1 yr QALY gain</b>	<b>5 yr QALY gain</b>
<b>19.0%</b>	19633.44	26563.78	10591.44	41168.89	0.015	0.049
<b>19.1%</b>	19628.54	26558.98	10575.94	41164.09	0.015	0.050
<b>19.2%</b>	19623.64	26554.18	10560.44	41159.29	0.015	0.050
<b>19.3%</b>	19618.74	26549.38	10544.94	41154.49	0.015	0.050
<b>19.4%</b>	19613.84	26544.58	10529.44	41149.69	0.016	0.050
<b>19.5%</b>	19608.94	26539.78	10513.94	41144.89	0.016	0.051
<b>19.6%</b>	19604.04	26534.98	10498.44	41140.09	0.016	0.051
<b>19.7%</b>	19599.14	26530.18	10482.94	41135.29	0.016	0.051
<b>19.8%</b>	19594.24	26525.38	10467.44	41130.49	0.016	0.051
<b>19.9%</b>	19589.34	26520.58	10451.94	41125.69	0.016	0.052
<b>20.0%</b>	19584.44	26515.78	10436.44	41120.89	0.016	0.052
<b>20.1%</b>	19579.54	26510.98	10420.94	41116.09	0.016	0.052
<b>20.2%</b>	19574.64	26506.18	10405.44	41111.29	0.016	0.053
<b>20.3%</b>	19569.74	26501.38	10389.94	41106.49	0.016	0.053
<b>20.4%</b>	19564.84	26496.58	10374.44	41101.69	0.016	0.053
<b>20.5%</b>	19559.94	26491.78	10358.94	41096.89	0.016	0.053
<b>20.6%</b>	19555.04	26486.98	10343.44	41092.09	0.016	0.054
<b>20.7%</b>	19550.14	26482.18	10327.94	41087.29	0.017	0.054
<b>20.8%</b>	19545.24	26477.38	10312.44	41082.49	0.017	0.054
<b>20.9%</b>	19540.34	26472.58	10296.94	41077.69	0.017	0.054
<b>21.0%</b>	19535.44	26467.78	10281.44	41072.89	0.017	0.055
<b>21.1%</b>	19530.54	26462.98	10265.94	41068.09	0.017	0.055
<b>21.2%</b>	19525.64	26458.18	10250.44	41063.29	0.017	0.055
<b>21.3%</b>	19520.74	26453.38	10234.94	41058.49	0.017	0.055
<b>21.4%</b>	19515.84	26448.58	10219.44	41053.69	0.017	0.056
<b>21.5%</b>	19510.94	26443.78	10203.94	41048.89	0.017	0.056
<b>21.6%</b>	19506.04	26438.98	10188.44	41044.09	0.017	0.056
<b>21.7%</b>	19501.14	26434.18	10172.94	41039.29	0.017	0.056
<b>21.8%</b>	19496.24	26429.38	10157.44	41034.49	0.017	0.057
<b>21.9%</b>	19491.34	26424.58	10141.94	41029.69	0.018	0.057
<b>22.0%</b>	19486.44	26419.78	10126.44	41024.89	0.018	0.057
<b>22.1%</b>	19481.54	26414.98	10110.94	41020.09	0.018	0.057
<b>22.2%</b>	19476.64	26410.18	10095.44	41015.29	0.018	0.058
<b>22.3%</b>	19471.74	26405.38	10079.94	41010.49	0.018	0.058
<b>22.4%</b>	19466.84	26400.58	10064.44	41005.69	0.018	0.058
<b>22.5%</b>	19461.94	26395.78	10048.94	41000.89	0.018	0.059
<b>22.6%</b>	19457.04	26390.98	10033.44	40996.09	0.018	0.059
<b>22.7%</b>	19452.14	26386.18	10017.94	40991.29	0.018	0.059
<b>22.8%</b>	19447.24	26381.38	10002.44	40986.49	0.018	0.059
<b>22.9%</b>	19442.34	26376.58	9986.94	40981.69	0.018	0.060
<b>23.0%</b>	19437.44	26371.78	9971.44	40976.89	0.018	0.060
<b>23.1%</b>	19432.54	26366.98	9955.94	40972.09	0.018	0.060
<b>23.2%</b>	19427.64	26362.18	9940.44	40967.29	0.019	0.060
<b>23.3%</b>	19422.74	26357.38	9924.94	40962.49	0.019	0.061
<b>23.4%</b>	19417.84	26352.58	9909.44	40957.69	0.019	0.061
<b>23.5%</b>	19412.94	26347.78	9893.94	40952.89	0.019	0.061
<b>23.6%</b>	19408.04	26342.98	9878.44	40948.09	0.019	0.061
<b>23.7%</b>	19403.14	26338.18	9862.94	40943.29	0.019	0.062

<b>% ICH stroke thrombolysed</b>	<b>1 yr NHS</b>	<b>5 yr NHS</b>	<b>1yr Social Care</b>	<b>5 Yr Social care</b>	<b>1 yr QALY gain</b>	<b>5 yr QALY gain</b>
<b>23.8%</b>	19398.24	26333.38	9847.44	40938.49	0.019	0.062
<b>23.9%</b>	19393.34	26328.58	9831.94	40933.69	0.019	0.062
<b>24.0%</b>	19388.44	26323.78	9816.44	40928.89	0.019	0.062
<b>24.1%</b>	19383.54	26318.98	9800.94	40924.09	0.019	0.063
<b>24.2%</b>	19378.64	26314.18	9785.44	40919.29	0.019	0.063
<b>24.3%</b>	19373.74	26309.38	9769.94	40914.49	0.019	0.063
<b>24.4%</b>	19368.84	26304.58	9754.44	40909.69	0.020	0.063
<b>24.5%</b>	19363.94	26299.78	9738.94	40904.89	0.020	0.064
<b>24.6%</b>	19359.04	26294.98	9723.44	40900.09	0.020	0.064
<b>24.7%</b>	19354.14	26290.18	9707.94	40895.29	0.020	0.064
<b>24.8%</b>	19349.24	26285.38	9692.44	40890.49	0.020	0.064
<b>24.9%</b>	19344.34	26280.58	9676.94	40885.69	0.020	0.065
<b>25.0%</b>	19339.44	26275.78	9661.44	40880.89	0.020	0.065
<b>25.1%</b>	19334.54	26270.98	9645.94	40876.09	0.020	0.065
<b>25.2%</b>	19329.64	26266.18	9630.44	40871.29	0.020	0.066
<b>25.3%</b>	19324.74	26261.38	9614.94	40866.49	0.020	0.066
<b>25.4%</b>	19319.84	26256.58	9599.44	40861.69	0.020	0.066
<b>25.5%</b>	19314.94	26251.78	9583.94	40856.89	0.020	0.066
<b>25.6%</b>	19310.04	26246.98	9568.44	40852.09	0.020	0.067
<b>25.7%</b>	19305.14	26242.18	9552.94	40847.29	0.021	0.067
<b>25.8%</b>	19300.24	26237.38	9537.44	40842.49	0.021	0.067
<b>25.9%</b>	19295.34	26232.58	9521.94	40837.69	0.021	0.067
<b>26.0%</b>	19290.44	26227.78	9506.44	40832.89	0.021	0.068
<b>26.1%</b>	19285.54	26222.98	9490.94	40828.09	0.021	0.068
<b>26.2%</b>	19280.64	26218.18	9475.44	40823.29	0.021	0.068
<b>26.3%</b>	19275.74	26213.38	9459.94	40818.49	0.021	0.068
<b>26.4%</b>	19270.84	26208.58	9444.44	40813.69	0.021	0.069
<b>26.5%</b>	19265.94	26203.78	9428.94	40808.89	0.021	0.069
<b>26.6%</b>	19261.04	26198.98	9413.44	40804.09	0.021	0.069
<b>26.7%</b>	19256.14	26194.18	9397.94	40799.29	0.021	0.069
<b>26.8%</b>	19251.24	26189.38	9382.44	40794.49	0.021	0.070
<b>26.9%</b>	19246.34	26184.58	9366.94	40789.69	0.022	0.070
<b>27.0%</b>	19241.44	26179.78	9351.44	40784.89	0.022	0.070
<b>27.1%</b>	19236.54	26174.98	9335.94	40780.09	0.022	0.070
<b>27.2%</b>	19231.64	26170.18	9320.44	40775.29	0.022	0.071
<b>27.3%</b>	19226.74	26165.38	9304.94	40770.49	0.022	0.071
<b>27.4%</b>	19221.84	26160.58	9289.44	40765.69	0.022	0.071
<b>27.5%</b>	19216.94	26155.78	9273.94	40760.89	0.022	0.072
<b>27.6%</b>	19212.04	26150.98	9258.44	40756.09	0.022	0.072
<b>27.7%</b>	19207.14	26146.18	9242.94	40751.29	0.022	0.072
<b>27.8%</b>	19202.24	26141.38	9227.44	40746.49	0.022	0.072
<b>27.9%</b>	19197.34	26136.58	9211.94	40741.69	0.022	0.073
<b>28.0%</b>	19192.44	26131.78	9196.44	40736.89	0.022	0.073
<b>28.1%</b>	19187.54	26126.98	9180.94	40732.09	0.022	0.073
<b>28.2%</b>	19182.64	26122.18	9165.44	40727.29	0.023	0.073
<b>28.3%</b>	19177.74	26117.38	9149.94	40722.49	0.023	0.074
<b>28.4%</b>	19172.84	26112.58	9134.44	40717.69	0.023	0.074
<b>28.5%</b>	19167.94	26107.78	9118.94	40712.89	0.023	0.074

<b>% ICH stroke thrombolysed</b>	<b>1 yr NHS</b>	<b>5 yr NHS</b>	<b>1yr Social Care</b>	<b>5 Yr Social care</b>	<b>1 yr QALY gain</b>	<b>5 yr QALY gain</b>
<b>28.6%</b>	19163.04	26102.98	9103.44	40708.09	0.023	0.074
<b>28.7%</b>	19158.14	26098.18	9087.94	40703.29	0.023	0.075
<b>28.8%</b>	19153.24	26093.38	9072.44	40698.49	0.023	0.075
<b>28.9%</b>	19148.34	26088.58	9056.94	40693.69	0.023	0.075
<b>29.0%</b>	19143.44	26083.78	9041.44	40688.89	0.023	0.075
<b>29.1%</b>	19138.54	26078.98	9025.94	40684.09	0.023	0.076
<b>29.2%</b>	19133.64	26074.18	9010.44	40679.29	0.023	0.076
<b>29.3%</b>	19128.74	26069.38	8994.94	40674.49	0.023	0.076
<b>29.4%</b>	19123.84	26064.58	8979.44	40669.69	0.024	0.076
<b>29.5%</b>	19118.94	26059.78	8963.94	40664.89	0.024	0.077
<b>29.6%</b>	19114.04	26054.98	8948.44	40660.09	0.024	0.077
<b>29.7%</b>	19109.14	26050.18	8932.94	40655.29	0.024	0.077
<b>29.8%</b>	19104.24	26045.38	8917.44	40650.49	0.024	0.077
<b>29.9%</b>	19099.34	26040.58	8901.94	40645.69	0.024	0.078

## Paramedic Stroke Telemedicine Digital Pioneer Project (PSTDPP)

The main aim of the PSTDPP is to explore the telemedicine support of registered paramedics from the East of England Ambulance Service NHS Trust (EEAST) in assessing of suspected stroke patients. We further expanded the health economics tool to incorporate a scenario related to the PSTDPP and to estimate associated costs. We focused on the impact of PSTDPP on treatment outcomes and reduction of stroke mimic rates (currently estimated regionally at 40% - 50%).

The data inputs for the paramedic service are summarised in Table 14 below:

*Table 15 Data inputs for the Paramedic Stroke Telemedicine Digital Pioneer Project.*

<b>Paramedic service cost</b>		
<b>avg. cost of Telemed consultation</b>	£12.84	from East of England Telestroke Health economic tool
<b>avg. cost of telemedicine service</b>	£10.71	Service costs lower as telemedicine offered for OOH + office hours.
<b>avg. annual cost Telemedicine (per person)</b>	£23.55	
<b>Training cost of paramedics</b>	9480	Service Impact Review 2018-19
<b>Duration of paramedic assessment (min)</b>	30	**assumption
<b>Cost of paramedic assessment</b>	£8.32	duration*hourly rate
<b>avg. annual cost of service</b>	£36.57	
<b>Median Hourly rate-paramedic (band 6)</b>	16.64	<a href="https://www.nhsemployers.org/pay-pensions-and-reward/agenda-for-change/pay-scales/hourly">https://www.nhsemployers.org/pay-pensions-and-reward/agenda-for-change/pay-scales/hourly</a>
<b>Paramedic Service Resource use</b>		
<b>MRI use</b>	0.58	Stroke mimic diagnoses presenting to a hyper acute stroke unit
<b>MRI Scan cost</b>	131	
<b>Median LOS (days)</b>	1	
<b>Stroke day case cost</b>	£244.95	NHS Ref costs 2017-18, Regular day or night admissions (AA35B-F)

The implementation scenario we examined involved the paramedics accessing the telemedicine software via an app on a mobile, wireless-enabled iPad or iPhone over a secure connection. Telemedicine training is provided as part of the Hyper Acute Study Day during office hours (Monday-Friday, 09:00 – 16:00hrs). When the paramedic subsequently attends a potential stroke mimic patient, they will undertake their usual assessment and record a ROSIER score and, if further advice required, can rapidly link to one of the two hospitals' stroke consultants at Ipswich Hospital, who will be available on a rota basis. The consultants can access the telemedicine system via their personal work PCs or their existing two stroke telemedicine carts within the hospital.

We assumed that the telemedicine service used during OOH would be expanded to the acute care pathway during office-hours, thereby lower the average per person cost of telemedicine service use. The teleconsultation costs were considered the same as those during out-of-office hours. The cost per hour for paramedic was derived from national data sources. Training and additional costs of the paramedic service were obtained from the Stroke telemedicine project lead (Impact Review 2018/19).

In addition to NHS and social care costs, we included the costs of mimics avoided, comprising avoided MRI scans and average Stroke day care cost (NHS ref costs).

For the centres enrolled in the East of England Telestroke project, we estimated that the total annual cost of using the Paramedic service was £73.7k. By avoiding MRI scan costs of £35k and hospital admission costs of £112.9k, associated costs savings were £74.1k.