

# Using Best-Worst Scaling to Understand the Preferences of Stroke Survivors, their Relatives/Carers and the Public on Providing Stroke Thrombectomy Services in England

Darren Flynn (✉ [d.flynn@ncl.ac.uk](mailto:d.flynn@ncl.ac.uk))

Teesside University <https://orcid.org/0000-0001-7390-632X>

Hannah Lumley

Newcastle University

Diarmuid Coughlan

Newcastle University

David Burgess

North East and North Cumbria Stroke Patient and Carer Panel

Tomos Robinson

Newcastle University

Gary A Ford

Oxford University Hospitals NHS Foundation Trust and Oxford Academic Health Science Network

Peter McMeekin

Northumbria University

Phil White

Newcastle University

---

## Research article

**Keywords:** Best-worst scaling, stroke, patient and public preferences, effectiveness, costs, equity

**DOI:** <https://doi.org/10.21203/rs.3.rs-26642/v1>

**License:** © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

---

## Abstract

**Background** Outcomes for acute ischaemic stroke patients with large artery occlusion are significantly improved with endovascular thrombectomy (EVT). We aimed to identify preferences of stroke survivors, their relatives/carers and the public in England on: (i) EVT service organisation (localised versus centralised expert-delivered EVT services) and (ii) modelled outcomes for EVT effectiveness, equity of access and costs of EVT provision (based on increasing the number of comprehensive stroke centres across England that provide EVT from 24 to 30).

**Methods** Stroke survivors, their relatives/carers and the public were engaged in an iterative co-design process to develop an accessible survey incorporating two Best-Worst Scaling (BWS) tasks: EVT service organisation (4 attributes each with 2 levels) and modelled outcomes (3 attributes each with 2 levels). On-line pilot testing was undertaken with 10 stroke survivors/carers. BWS data were transformed into standardised scores with corresponding 95% confidence intervals (CIs).

**Results** 105 respondents completed the survey (stroke survivors [18%]; relative/carer of stroke survivor [32%]; member of public [50%]). Centralised (local) EVT provision by experienced and specialised medical teams was associated with the strongest positive preference (0.76, 95% CIs = 0.69, 0.82), followed by secondary inter-hospital transfer for EVT; associated with positive preferences whether required (0.15, 95% CIs = 0.07, 0.22) or not (0.30, 95% CIs = 0.22, 0.38). Travel times by emergency ambulance > 45 min (-0.29, 95% CIs=-0.37, -0.22) were associated with stronger negative preferences than length of stay < 48 hours [-0.16, 95% CIs=- 0.22, - 0.10]. Maximal effectiveness of EVT (52% recovering with none/mild disability) was associated with stronger positive preferences (0.40, 95% CIs = 0.27, 0.53) than equity of access (71% or 72% of eligible patients) to EVT within 7 hours since onset of stroke symptoms, which was associated with marginal positive preferences. Costs of EVT provision were associated with negative preferences; maximal cost had the strongest negative preference (-0.29, 95% CIs=-0.40, -0.18).

**Conclusions** Centralised stroke centres with experienced specialised teams and secondary transfers with travel times ≤ 45 minutes are likely to be acceptable to patients/carers and the public. Equity of access to EVT may be less of a priority than effectiveness, although both were considered more important than costs of EVT provision.

## Background

Acute stroke is a medical emergency [1], the fourth leading cause of premature death in the United Kingdom [2–4], and second globally [5], with two thirds of survivors left with long-term disability [6–7]. The standard emergency care pathway for acute stroke in the UK is shown in Fig. 1.

Pre-hospital assessment of patients with suspected stroke involves administration of a standard clinical checklist upon arrival at the scene by paramedics - the Face Arm Speech Test (FAST) which records facial weakness, arm weakness and/or speech disturbance [8]. FAST positive patients are conveyed by emergency medical services (EMS) ambulance to the nearest hyper-acute stroke unit (HASU), which ideally is pre-alerted. Brain (CT) imaging and stroke specialist review is undertaken to confirm stroke and sub-type (ischaemic or haemorrhagic). In the case of confirmed ischaemic stroke (accounting for approximately 85% of stroke [9]), intravenous thrombolysis (IVT) is usually indicated when time from symptom onset is less than 4.5 hours [10]. In addition, patients with large artery occlusion (LAO) within 6 hours of symptom onset are eligible for secondary transfer via EMS ambulance (referred to as drip and ship) to a specialist comprehensive stroke centre (CSC) for further treatment with endovascular thrombectomy (EVT) [11].

EVT in the treatment of acute ischaemic stroke caused by LAO significantly decreases functional disability, with no increase in mortality or symptomatic intracranial haemorrhage [12]. Between 10,140 and 11,530 stroke patients in the UK are eligible for EVT annually, equating to 11–12% of UK stroke hospital admissions [13, 14]. In 2016, there were 24 CSCs in England that provided EVT, most did not provide it 24/7, with variable use of imaging scoring systems and criteria influencing patient selection for EVT [15]. With reference to an individual patient data meta-analysis of EVT [16], it is estimated that an additional 2,420 stroke patients per year could achieve functional independence with comprehensive implementation of EVT in the United Kingdom (UK), with annual savings of ~£73 million over the lifetime of patients [13].

There are multiple options for increasing provision of EVT across England. For example, a mothership model involving bypassing the nearest HASU with direct transfer of stroke patients with large artery occlusion to CSC for EVT. However, due to a range of issues such as the lack of robust stratification tools for use in the pre-hospital phase by paramedics [17], a drip and ship model (treatment with IVT at the nearest HASU before transfer to a CSC for EVT) was found to be the most preferred service configuration amongst professionals [18]. In a previous modelling study [19] using genetic algorithms, one optimal solution to expedite EVT within the drip and ship paradigm would be to increase the number of CSCs providing EVT in England. A modest geographically targeted increase, for instance from 24 to 30 centres, has been indicated as maximising the population gains [19, 20]. Modelled outcomes for 24 versus 30 CSCs across England using a discrete event simulation indicated this service reconfiguration would deliver health gains within current thresholds of cost-effectiveness with a very high probability of being cost-effective [20].

It is important to capture and integrate patient and public preferences with other research evidence in health economic modelling to inform commissioning decision-making. Understanding patient and public preferences on planned or potential service re-organisation and the impact on outcomes can help to optimise the acceptability of decision making by commissioners and service providers, including the subsequent uptake and efficiency of healthcare provision [21].

Attributes associated with a drip and ship model of EVT provision such as: safety of treating a patient with IVT at an acute stroke unit, and then immediately conveying the patient via emergency ambulance to a CSC for EVT (referred to as a secondary hospital transfer); the impact on equity of access to EVT for eligible patients within 7 hours across England; treatment efficacy and costs are all likely to be sensitive to patient and public preferences.

Patients and public should be involved in the co-design of methods used to capture their preferences and values. This is imperative for optimising accessibility by people with different health literacy levels [22], and in the case of stroke survivors, post-stroke communication difficulties (aphasia) can inhibit their capability to respond meaningfully.

We aimed to identify preferences related to localised versus more centralised EVT services from the perspective of stroke survivors, their relatives/carers and the public with specific reference to (i) service organisation for EVT in England; and (ii) outcomes derived from health economic modelling.

## Methods

Best-Worst Scaling (BWS) is a technique that belongs to the conjoint analysis family of methods that aim to identify peoples' preferences and trade-offs that contribute to their choices about products or services. BWS surveys are arguably less cognitively demanding than other conjoint analysis methods such as discrete choice experiments (DCEs). BWS offer a better way of identifying the relative trade-offs between levels of attributes (compared with making judgements on groups of attributes within scenarios as in DCEs or simple comparisons using Likert scales) [23, 24]. DCEs typically present a series of alternative scenarios that convey information on multiple attributes with a range of variable levels, whereby respondents choose their preferred scenario [25]. Conjoint analyses make explicit the trade-off between the benefits of increasing one attribute at a cost of decreasing another. After careful consideration and expert advice, BWS was selected in this study as the preferred technique to elicit patient, relative/carer and public preferences.

In a BWS task, respondents are asked to select both the "best" (i.e. most preferred) and "worst" (i.e. least preferred) items in different subsets. The participant chooses "the pair that exhibits the largest perceptual difference on an underlying continuum of interest" [24, 26]. BWS has been used in a variety of health and health care settings. For instance, recently published studies have used BWS to understand patient, carer and public preferences on multiple aspects of healthcare, particularly on medical treatments [27–30]. In this study, we used the BWS profile/attribute case method (also referred to in the literature as 'Case 2'), in which the importance of each contributing attribute of a decision is evaluated relative to all other attributes.

Two separate BWS tasks were designed. One focused on critical attributes of service organisation for EVT, and the second explored preferences on modelled outcomes for increasing the number of CSCs across England.

## Selection of attributes and levels for the service organisation BWS task

Attributes and their levels for service organisation were derived from a survey (N = 147 responses) of stroke survivor (n = 27/18%); relatives/carer of stroke survivors (n = 51/35%) and other members of the public (n = 69/47%) views on service organisation for EVT in England (Appendix 1a & b). This resulted in four attributes with  $2 \times 2 \times 2 \times 2 = 16$  possible combinations of attribute levels for the service organisation BWS task (Table 1).

Table 1  
Attributes and levels in the service organisation BWS task

Attribute	Levels
Secondary hospital transfer	Needed May be needed
Clinical team expertise in EVT	Less experience/less specialised but a local service More experienced/specialised rather than a local service
Length of stay in CSC	< 48 hours > 48 hours
Travel time by emergency ambulance	< 45 minutes 45 minutes or longer

## Selection of attributes and levels for the modelled outcomes BWS task

Previous modelling studies indicated that increasing the number of CSCs from 24 (current number in England) to 30 would deliver both greatly enhanced population access to EVT plus health gains with a very high probability of being cost-effective [19, 20]. Therefore, three outcomes with levels informed by 24 and 30 CSCs were included as attributes in the modelled BWS task: (1) clinical effectiveness of EVT; (2) cost of setting up,

maintaining and running CSCs; and (3) equity of access to EVT for eligible patients. Each modelled outcome attribute had two levels, although to reduce the cognitive burden on respondents the attribute level descriptors did not refer to numbers of CSCs.

Levels for the modelled clinical effectiveness of EVT attribute were described as modified Rankin Scale (mRS) outcomes derived from those published by the academic Highly Effective Reperfusion evaluated in Multiple Endovascular Stroke trials (HERMES) collaboration [11]. The mRS outcomes were defined as the proportion of patients that would likely be independent (mRS 0 to 2 – mild or no disability), dependent (mRS 3 to 5 – moderate or severe disability) or dead (mRS 6) after treatment with EVT within 4 hours (30 CSCs) or 4 to 6 hours (24 CSCs) at 90 days follow-up. The levels for effectiveness (41% and 52% recover with no/mild disability) reflected proportions of patients that would reach a CSC within the treatment window, and receive treatment with EVT, due to increasing the number of CSCs from 24 to 30 across England. These outcomes were taken from Saver et al [11] Fig. 1B, where the reduced effectiveness of EVT over time is estimated.

As opposed to use of currency values, the cost of EVT provision was represented using a metaphor to ensure that costs were evaluated against another hi-tech and potentially highly valued health service provision. After considerable consideration, the metaphor chosen was the equivalent cost of setting up, maintaining and running MRI scanners for 2 years. Like angiography suites for EVT, additional MRI machines involves the provision of hi-tech expensive imaging infrastructure with multiple different staff groups required to run them, yet is an item which would be at least somewhat familiar to many, even most, respondents. Costs were estimated via in-house costing work (HL) based on published data [11, 19, 31–38] and expert opinion. Equity was operationalised as proportions of patients with and without access to thrombectomy within 7 hours since onset of stroke symptoms. This resulted in three attributes with  $2 \times 2 \times 2 = 8$  attribute level combinations for inclusion in the modelled outcomes BWS task (Table 2).

Table 2  
Attributes and levels in the modelled outcomes BWS task

Attribute	Levels	# CSCs
Clinical effectiveness	41% recover with no/mild disability; 49% recover with moderate/severe disability; 10% will die	24
	52% recover with no/mild disability; 41% recover with moderate/severe disability; 7% will die	30
Cost	Cost of setting up, maintaining and running 70 MRI scanners for 2 years	24
	Cost of setting up, maintaining and running 88 MRI scanners for 2 years	30
Equity of Access	71% will have access to thrombectomy within 7 hours of symptom onset; 29% will not	24
	72% will have access to thrombectomy within 7 hours of symptom onset; 28% will not	30

## BWS Survey Design

The research programme PPI representative (DB) facilitated recruitment of 7 stroke survivors and their relatives/carers from the NE CRN (Stroke) PPI Panel in an iterative co-design process to develop the form and content of the BWS survey informed by best evidence on presentation of probabilities (numerical and graphical [39]) and guidelines on the design of information for people with aphasia [40]. Online pilot testing was conducted with 10 stroke survivors/carers and two researchers with expertise in choice experiments (TR, DC).

By their very design and construction, BWS tasks are repetitive; therefore, attempts were made to present the fewest possible number of questions to maximise both participation in and completion rates of the survey. However, to have enough degrees of freedom to provide individual parameter estimates across key subgroups, a minimum of 8 responses per participant for each BWS task is required [41].

A randomised block design was used to generate two blocks of 8 questions for the service organisation BWS task (with each participant only completing 1 of 2 blocks) and one block of 8 questions (completed by all participants) for the modelled outcomes BWS task. Attribute levels within each block was controlled by ensuring even numbers of levels for each attribute were included between blocks. Maximum difference scaling was used, whereby respondents stated their most and least (best or worst) preferred options for four attributes (with 2 levels each) in the service organisation BWS task (Fig. 2) and three attributes (with 2 levels each) in modelled outcomes BWS tasks (Fig. 3). In total, individual respondents were required to answer  $2 \times 8$  (16) BWS questions

Figure 2. Attributes and levels for the service organisation BWS task

The final survey (Appendix 2) was delivered via on-line QualtricsXM platform using the ‘maximum difference scaling’ question type. A URL to the anonymous survey was generously hosted on the Stroke Association website and a link to the survey, along with information about the study was

distributed to all Healthwatch services in England and for national Clinical Research Networks to distribute to patient groups. The survey also appeared in June 2019 edition of the NHS In Touch Newsletter. The introduction of the survey provided an overview of thrombectomy and aims of the study, including a link to a short film about thrombectomy produced by the BBC [42]. In order to help completion of the BWS questions, a short information film was embedded at the start explaining the repetitive nature of BWS surveys and the rationale for using this methodology in appropriate language and style for the intended PPI respondents [43].

Anonymised demographic data were collected at the end of the survey on age, gender, region of England, and respondent type (stroke survivor, relative/carer of a stroke survivor or member of the public).

## Statistical Analysis

Standardised scores were calculated for each attribute level that ranged from - 1 to + 1, which represented the strength of preferences (best [positive scores] or worst [negative scores]) for the attribute level across the sample. These were calculated by establishing the difference between the frequency of an attribute level being chosen as best versus worst divided by the 'availability' of each attribute (the number of times it appeared across the design). Each attribute level was shown four times to each of the 105 respondents who fully completed the survey, giving a total attribute availability of 420. For example, if one level of an attribute was chosen as best ( $n = 320$ ) and worst ( $n = 2$ ), the difference (B-W) is 318, and the standardised score =  $318/420 = 0.76$  (positive preference). Corresponding 95% confidence intervals for standardised scores were generated by iteratively resampling with replacement each of 105 respondent's data 1,000 times (referred to as bootstrapping). All analyses were conducted in Stata version 15 [44] and Microsoft Excel [45]. In other BWS studies, standardised scores have been shown to provide similar information to regression coefficients from a conditional logistic regression model, but with a greater ease of both interpretation and calculation [46, 47].

## Results

154 respondents accessed the survey, and 105 (68%) fully completed all the items (mean age = 37 [range 18 to 86] years; 70% female; 47% from the North East, 53% from other regions in England; 18% urban, 56% suburban, 26% rural; 18% stroke survivors [10% with aphasia]; 32% relative/carer of a stroke survivor; and 50% member of the public).

## Service Organisation BWS Task

Standardised scores for the service organisation attribute levels (Fig. 4) showed that an experienced/specialist medical team had the strongest positive (best) preferences (0.76, 95% CIs = 0.69, 0.82), with a local service staffed by less experienced medical teams the strongest negative (worst) preferences (-0.62, 95% CIs = -0.72, -0.52). Stronger positive preferences were reported for secondary transfers for EVT not being required [0.3, 95% CIs = 0.22, 0.38] than transfers being required 0.14, 95% CIs = 0.06, 0.22). No strong preferences were reported for travel times by emergency ambulance < 45 min (-0.04, 95% CIs = -0.13, 0.05). Travel times of > 45 minutes by emergency ambulance were associated with stronger negative preferences [-0.29, 95% CIs = -0.37, -0.22] than length of stay in hospital for < 48 hours (-0.16, 95% CIs = -0.22, -0.10).

## Modelled Outcomes BWS Task

As expected, standardised scores for modelled outcomes (Fig. 5) demonstrated that maximal clinical effectiveness (highest proportion of independent patients, 52% recover with no/mild disability) was associated with the strongest positive preferences (0.40, 95% CIs = 0.27, 0.53), with no strong preferences associated with lower clinical effectiveness, 41% recover with no/mild disability (0.06, 95% CIs = -0.08, 0.21). Both levels of costs were associated with strong negative preferences (-0.27 [95% CIs = -0.38, -0.16] and -0.29 [95% CIs = -0.40, -0.18]). Both levels for equity were associated with marginally positive preferences (slightly larger for 72% of eligible patients having access to EVT within 7 hours from onset of stroke symptoms [0.06, 95% CIs = -0.07, 0.19] versus 71% [0.05, 95% CIs = -0.09, 0.18]).

There were no statistically significant differences between standardised scores stratified in terms of stroke survivor/relative status versus the public for service organisation or modelled outcomes (Results not shown).

## Discussion

This is the first study to use BWS to investigate stroke survivor, relative/carer and public preferences for service organisation and outcomes in the context of stroke services. Our data indicate that expertise of centralised teams is of paramount importance for patients and the public. Combined with a positive preference for secondary transfer (to EVT capable hospital), our study suggests that patient and public preferences are broadly aligned with those of professionals for the drip and ship paradigm of EVT provision [18]. Travel times of up to 45 minutes are likewise identified as acceptable to patients and the public, which concur reasonably well with transport time to nearest EVT centres derived from modelling studies (30 to 54 minutes in urban/suburban settings; 49 to 141 minutes in rural setting) [48]. Mitigation of longer transport times for those residing in sparsely populated remoter rural settings could be achieved to a considerable extent with secondary transfer via helicopters instead of ground-based ambulance [49].

As expected, protracted length of stay in hospital was associated with negative preferences; although this could be offset to some extent by communicating to patients and public that EVT as well as improving clinical outcomes, reduces length of stay compared with medical therapy alone [50]. Furthermore, 76% of respondents in the thrombectomy service organisation survey, which informed the corresponding BWS task would be willing to stay in EVT hospital for > 48 hours.

With regards to modelled outcomes, based on an increase in number of CSCs from 24 to 30 in England, improved clinical efficacy and higher costs were the most and least preferred outcomes respectively. The strong preference for improved efficacy is consistent with studies reporting that even relatively mild deficits from stroke result in negative patient preferences for health states due to stroke [51].

Our findings suggest that, whilst increasing the number of centres may be acceptable to patients and public in terms of increased effectiveness, this may be offset by negative perceptions of the higher costs involved. Health care in England is publicly funded, and costs in the BWS task may have represented concerns that other highly valued services (such as MRI scanners used as a metaphor for costs in our study) would not be funded.

Respondents in our sample preferred effectiveness over equity, which were both valued more than costs. The levels for the equity attribute had an absolute difference of only 1%, which was informed by robust statistically modelling, but may have obfuscated the impact of this attribute in the BWS task. However, it may equally be the case that increasing equity of access for a minority of stroke patients was not considered to be sufficiently important by patients and the public. Findings for both BWS tasks were consistent across respondent type, which indicated that experience with acute stroke may not be a factor involved in forming preferences about service organisation and outcomes in the context of EVT and thus allows these findings to be considered more generalisable.

The advantages of our approach were engaging stroke survivors and carers in a meaningful, iterative co-design process, which enabled the development of an inclusive and accessible survey, which enhanced comprehensibility of the information and thus meaningfulness of responses. A potential disadvantage that could be inferred from our approach is the modest sample size achieved despite wide dissemination, and a preponderance of respondents from the north east of England. The inherent repetitive nature of BWS may have reduced the completion rate. Furthermore, the attribute levels in the service organisation BWS tasks were explicit, whereas those in the modelled outcomes BWS tasks were implicit (i.e. it was not stated that the levels of attributes corresponded with 24 and 30 CSCs). This was done to decrease cognitive burden, but this restricts the extent that findings can be used to justify public and patient support for increasing the number of CSCs across England.

Future work might explore patient and public preferences on helicopter emergency medical service transfers for EVT, including the method of preference elicitation using BWS and other commonly used conjoint analysis methods such as DCEs. We chose BWS on the basis that it is less demanding; however, people use a range of decision-making strategies [52]. Consequently, preference-elicitation tasks may be susceptible to patient and public preferences and be variably acceptable to respondents when they are presented as BWS or a DCE format. Studies support the concept that responses to both survey methods may arise from identical underlying preferences [e.g. 53]. Indeed, studies have demonstrated the validity of assessing preferences of caregivers of people with Alzheimer's Disease for 17 attributes using a DCE and a BWS task, with two overlapping attributes in both preference-elicitation formats [54]. A further study found similar patterns of preference weights from DCE and BWS for social care outcomes [55].

## Conclusions

Our data indicate that preferences of stroke survivors, their relatives and the public for critical aspects of service organisation of EVT services are broadly consistent with preferences of stroke professionals and modelling studies. Secondary transfer to a CSC with travel time via emergency ambulance for EVT of up to 45 mins was acceptable to our sample of respondents. Clinical effectiveness was prioritised over equity of access with costs of EVT evaluated negatively. Commissioning decision-making should consider patient and public preferences on trade-offs between maximising health gains from EVT and preferences for costs.

## Declarations

## Ethics approval and consent to participate

All respondents were furnished with detailed information about the rationale for the study, including that participation is completely anonymous, data would be securely stored, and the voluntary nature of participation (see supplemental file). Participants indicated their consent by completing the anonymous survey. This survey was completed voluntarily and anonymously by respondents, did not include any sensitive topics, and did not involve recruitment from the NHS. Based on the NHS Health Research Authority decision tool (<http://www.hra-decisiontools.org.uk/ethics/>), approval by a Local Research Ethics Committee was not required [<https://www.hra.nhs.uk/approvals-amendments/what-approvals-do-i-need/research-ethics-committee-review/non-nhs-research-projects/>].

## Consent to publish

Not applicable

## Availability of data and materials

Final versions of the surveys are included as supplemental files. The datasets analysed during the current study are available from the corresponding author on reasonable request.

## Competing Interests

DF, PM, PW and GAF are co-applicants on the PEARS Programme Grant. PW is co-PI for 2 randomised trials (PISTE & STABILISE) investigating different aspects of thrombectomy in acute stroke. Start-up phase of PISTE was mainly funded by Stroke Association but was also part funded by unrestricted institutional educational grants from Covidien & Codman who both manufacture devices used for stroke thrombectomy. STABILISE is part funded by Microvention. PW has also undertaken educational consultancy work within last 3 years for Codman & Microvention who both manufacture devices used for stroke thrombectomy

## Funding

This article presents independent research funded by the National Institute for Health Research (NIHR) under its Programme Grant for Applied Research Programme (RP-PG-1211-20012) – Promoting Rapid and Effective Stroke Care (PEARS). The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health. The NIHR had no role in study design, data collection, data analysis, data interpretation, or writing of the manuscript.

## Authors' contributions

DF, HL, DB, DC, PM, GAF and PW contributed to the development of the survey. HL developed the electronic version of the survey. DB, DF and HL refined and piloted the survey. TR and DC conducted the data analyses and produced the graphs. All authors contributed to the drafting of the manuscript and approved the final manuscript.

## Acknowledgements

Members of the NE CRN (Stroke) PPI Panel and National Lay Member Stroke Research Network for the valued assistance to the development and design of the survey. Amy Crowder (LCRN Administrator, Division 2 – Circulatory Systems, NIHR Clinical Research Network North East and North Cumbria); Healthwatch England; and Dominic Brand (Executive Director of Marketing and External Affairs, The Stroke Association for their assistance with distributing the surveys. Terry N Flynn (Director, TF Choices LTD) for advice on the design of the BWS survey; and Healthwatch England for distributing the BWS survey. Clare Bowes (Newcastle University) for her excellent administrative support.

## References

1. Saver JL. Time Is Brain-Quantified. *Stroke*. 2006;37:263–6.
2. Office for National Statistics. Statistical Bulletin: Deaths Registered in England and Wales. 2016. <https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletins/deathsregistrationsummarytables/2016>. Accessed February 2018.
3. National Records of Scotland. Table P4: Deaths, by Cause, Scotland 2013 to 2016. [Internet]. National Records of Scotland Web. 2013. <https://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/vital-events/general-publications/births-deaths-and-other-vital-events-preliminary-annual-figures/2016>. Accessed February 2018.
4. Northern Ireland Statistics and Research Agency. Table 6.4: Deaths by Sex, Age and Cause [Internet]. 2016. <https://www.nisra.gov.uk/publications/registrar-general-annual-report-2016-cause-of-death>. Accessed February 2018.
5. World Health Organisation. The Top 10 Causes of Death. World Health Organisation. 2017. <http://www.who.int/mediacentre/factsheets/fs310/en/>. Accessed February 2018.
6. Adamson J, Beswick A, Ebrahim S. Is stroke the most common cause of disability? *J Stroke Cerebrovasc Dis*. 2004;13:171–7.
7. Feigin V, Forouzanfar M, Krishnamurthi R, Mensah G, Connor M, Bennett D, et al. Global and regional burden of stroke during 1990–2010: findings from the global burden of disease study 2010. *Lancet*. 2014;383:245–55.
8. Harbison J, Hossain O, Jenkinson D, Davis J, Louw S, Ford G. Diagnostic accuracy of stroke referrals from primary care, emergency room physicians, and ambulance staff using the face arm speech test. *Stroke*. 2003;34:71–6.
9. Intercollegiate Stroke Working Party. National Clinical Guideline for Stroke. London: Royal College of Physicians; 2016.
10. Wardlaw J, Murray V, Berge E, del Zoppo G. Thrombolysis for acute ischaemic stroke. *Cochrane Database Syst Rev*. 2014(7): CD000213.

11. Saver J, Goyal M, Van der Lugt A, Menon B, Majoie C, Dippel D, et al. Time to treatment with endovascular thrombectomy and outcomes from ischemic stroke: a meta-analysis. *JAMA*. 2016;316:1279–88.
12. Flynn D, Francis R, Halvorsrud K, Gonzalo-Almorox E, Craig D, Robalino S, et al. Intra-arterial mechanical thrombectomy in the treatment of acute ischaemic stroke: a systematic review and meta-analysis. *Eur Stroke J*. 2017;2:308–18.
13. McMeekin P, White P, James, Flynn D, Price CI, Ford GA. Estimating the numbers of stroke patients in the UK that are eligible for treatment with mechanical thrombectomy. *Eur Stroke J*. 2017;2:319–26.
14. 10.1177%2F1747493018801108  
McMeekin P, White P, James MA, Price CI, Flynn D, Ford GA. Incorporating evidence from recent trials in to estimates of stroke patients eligible for thrombectomy. *Eur Stroke J*. 2018. <https://doi.org/10.1177%2F1747493018801108>. Accessed April 2020.
15. Flynn D, Ford GA, McMeekin PJ, White P. Characteristics of intra-arterial thrombectomy service provision in England. *Int J Stroke*. 2016;11(8):NP83–5.
16. Campbell BCV, Hill MD, Rubiera M, Menon BK, Demchuk A, Donnan GA, et al. Safety and efficacy of solitaire stent thrombectomy individual patient data meta-analysis of randomized trials. *Stroke*. 2016;47:798–806.
17. Lumley H, Flynn D, McClelland G, Ford GA, White P, Price C. A review of technology to assist with patient stratification during the emergency assessment of suspected stroke. *BMC Emerg Med*. 2020;20(1):30. doi:10.1186/s12873-020-00323-0.
18. Halvorsrud K, Flynn D, Ford GA, McMeekin P, Bhalla A, Balami J, et al. Future delivery of thrombectomy services in England: A Delphi study and ranking exercise with clinicians. *BMC Health Serv Res*. 2018;18:135.
19. Allen M, Pearn K, James J, Ford GA, White P, Rudd AG, McMeekin P, Stein K. Maximising access to thrombectomy services for stroke in England: a modelling study. *Eur Stroke J*. 2018;4:39–49.
20. McMeekin P, Flynn D, Allen M, Coughlan D, Ford GA, Lumley H, et al. Estimating the effectiveness and cost-effectiveness of establishing additional endovascular Thrombectomy stroke centres in England: a discrete event simulation. *BMC Health Serv Res*. 2019;19(1):821.
21. Dirksen CD, Utens CM, Joore MA, van Barneveld TA, Boer B, Dreesens DH, et al. Integrating evidence on patient preferences in healthcare policy decisions: protocol of the patient-VIP study. *Implement Sci*. 2013;8:64.
22. Brett J, Staniszewska S, Mockford C, Herron-Marx S, Hughes J, Tysall C, et al. Mapping the impact of patient and public involvement on health and social care research: a systematic review. *Health Expect*. 17(5).
23. Flynn TN, Louviere J, Peters TJ, Coast J. Best-worst scaling: what it can do for health care research and how to do it. *J Health Econ*. 2007;26:171–89.
24. Flynn A, Louviere JJ. Determining the appropriate response to evidence of public concern: the case of food safety. *J Public Policy Mark*. 1992;11:12–25.
25. Discrete Choice Experiment (DCE) [online]. (2016). York; York Health Economics Consortium. 2016. <https://yhec.co.uk/glossary/discrete-choice-experiment-dce/>. Accessed March 2020.
26. Mühlbacher AC, Kaczynski A, Zweifel P, Johnson FR. Experimental measurement of preferences in health and healthcare using best-worst scaling: an overview. *Health Econ Rev*. 2016;6(1):2.
27. Paquin RS, Fischer R, Mansfield C, Mange B, Beaverson K, Ganot A, et al. Priorities when deciding on participation in early-phase gene therapy trials for Duchenne muscular dystrophy: a best–worst scaling experiment in caregivers and adult patients. *Orphanet J Rare Dis*. 2019;14(1):102.
28. Kremer IE, Evers SM, Jongen PJ, Hiligsmann M. Comparison of preferences of healthcare professionals and MS patients for attributes of disease-modifying drugs: a best-worst scaling. *Health Expect*. 2018;21:171–80.
29. Kok MM, Weernink MG, von Birgelen C, Fens A, van der Heijden LC, van Til JA. Patient preference for radial versus femoral vascular access for elective coronary procedures: The PREVAS study. *Catheter Cardiovasc Interv*. 2018;91:17–24.
30. Hollin IL, Peay H, Fischer R, Janssen EM, Bridges JF. Engaging patients and caregivers in prioritizing symptoms impacting quality of life for Duchenne and Becker muscular dystrophy. *Qual Life Res*. 2018;27:2261–73.
31. Balami JS, Coughlan D, White PM, McMeekin P, Flynn D, Roffe C, Natarajan I, Chembala J, Nayak S, Wiggam I, Flynn P, Simister R, Sammaraiie Y, Sims D, Nader K, Dixit A, Lumley H, Rice S, Burgess D, Craig D, James M, Buchan AM, Ford GA, Gray A. The cost of providing mechanical thrombectomy in the UK National Health Service: a micro-costing study. *Clinical Medicine* 2020 (accepted)
32. Health Information and Quality Authority. Health Technology Assessment of a National Emergency Endovascular Service for Mechanical Thrombectomy in the Management of Acute Ischaemic Stroke. 2017.
33. Lumley H, Flynn D, Coughlan D, McMeekin P, Ford GA, Craig D, Rice S, Burgess D, Balami JS, Mawson A, White PM. Secondary transfers by helicopter emergency services for thrombectomy in rural England: a feasibility study. *UK Stroke Forum* 2018.
34. White PM, Bhalla A, Dinsmore J, James M, McConachie N, Roffe C, Young G. Standards for providing safe acute ischaemic stroke thrombectomy services (September 2015). *Clin Radiol*. 2017;72(2):175-e1.
35. NHS England. Service specification: Neurointerventional Services for Acute Ischaemic & Haemorrhagic Stroke. 2018.

36. Kinnas C. CT Scanner Service Cost Price Info. Info.blockimaging.com. Available at: <<https://info.blockimaging.com/bid/95421/ct-scanner-service-cost-price-info>> Accessed 21 April 2020.
37. urgent. 2020. Contact. [online] Available at: <<https://eurgent.co.uk/contact/>> Accessed 21 April 2020.
38. Proimaging services. How much does it cost to operate an MRI?. 2020.
39. Flynn D, Ford GA, Stobart L, Rodgers H, Murtagh MJ, Thomson RG. A review of decision support, risk communication and patient information tools for thrombolytic treatment in acute stroke: lessons for tool developers. *BMC Health Serv Res.* 2013;13(1):225.
40. Pearl G, Cruice M. Facilitating the involvement of people with aphasia in stroke research by developing communicatively accessible research resources. *Top Lang Disord.* 2017;37:67–84.
41. Louviere JJ, Flynn TN, Marley A. Best–worst scaling: theory, methods and applications. Cambridge: Cambridge University Press; 2015.
42. British Broadcasting Corporation. Dr Patankar Treats a Patient for Stroke. Keeping Britain Alive: The NHS in a Day. 2013. <https://www.bbc.co.uk/programmes/p016v0hb>. Accessed 12 Mar 2019.
43. PEARS 2 Best-Worst Scaling Introduction. <https://youtu.be/FXmteG8Zn6E> Accessed 12 Mar 2019.
44. StataCorp. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC; 2017.
45. Microsoft, Corporation. 2018. Microsoft Excel. <https://office.microsoft.com/excel>.
46. Flynn TN. Valuing citizen and patient preferences in health: recent developments in three types of best-worst scaling. *Expert Rev Pharmacoecon Outcomes Res.* 2010;10(3):259–67.
47. Wittenberg E, Bharel M, Bridges JF, Ward Z, Weinreb L. Using best-worst scaling to understand patient priorities: a case example of papanicolaou tests for homeless women. *Ann Fam Med.* 2016;14:359–64.
48. Schlemm L, Endres M, Nolte CH. Bypassing the closest stroke center for thrombectomy candidates. what additional delay to thrombolysis is acceptable? *Stroke.* 2020;51:867–75.
49. Coughlan D, McMeekin P, Flynn D, Ford GA, Craig D, Rice S, et al. Secondary transfer of stroke patients for thrombectomy by air ambulance in England: a cost-effectiveness analysis. *Emerg Med J (under review)*.
50. Tate WJ, Polding LC, Kemp S, Mlynash M, Heit JJ, Marks MP, et al. Thrombectomy results in reduced hospital stay, more home-time, and more favorable living situations in DEFUSE 3. *Stroke.* 2019;50:2578–81.
51. Solomon NA, Glick HA, Russo CJ, Lee J, Schulman KA. Patient preferences for stroke outcomes. *Stroke.* 1994;25:1721–5.
52. Flynn D, van Schaik P, van Wersch A, Douglass A, Cann P. Non-medical influences upon medical decision-making and referral behaviour. MT: USA: Praeger Publishers; 2003.
53. Hess S, Rose JM. Can scale and coefficient heterogeneity be separated in random coefficients models? *Transp.* 2012;39:1225–39.
54. Zhang J, Reed Johnson F, Mohamed AF, Hauber AB. Too many attributes: a test of the validity of combining discrete choice and Best-Worst scaling data. *J Choice Model.* 2015;15:1–13.
55. Potoglou D, Burge P, Flynn T, Netten A, Malley J, Forder J, et al. Best-worst scaling vs. discrete choice experiments: an empirical comparison using social care data. *Soc Sci Med.* 2011;72:1717–27.

## Abbreviations

BWS - Best-worst scaling

CIs – Confidence intervals

CSC - Comprehensive stroke centre

DCEs - Discrete choice experiments

EMS - Emergency medical services

EVT - Endovascular thrombectomy

FAST - Face Arm Speech Test

HASU - Hyper-acute stroke unit

IVT - Intravenous thrombolysis

LAO – Large artery occlusion

mRS - modified Rankin Scale

## Figures

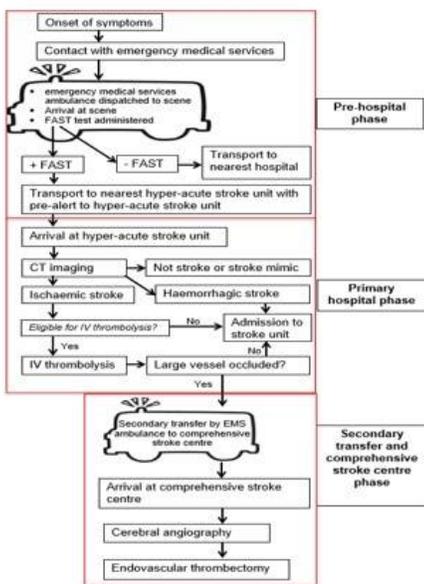


Figure 1

Chart

The screenshot shows a Best Worst Scale (BWS) item for service organisation. It features a scale from 'Most Preferred' (thumbs up) to 'Least Preferred' (thumbs down). The item text is: 'A transfer from the first hospital you visit to a clot removal centre is not needed to get clot removal treatment.' To the right is a graphic of a red 'X' over a hospital building. Below the text are four statements, each with a radio button and a graphic:

- Statement 1: 'Treatment is provided by medical teams less experienced with clot removal in a less specialised facility so that you can have a local service.' Graphic: 'Local Stroke Unit' with a person at a desk.
- Statement 2: 'The length of stay at a clot removal centre is less than 48 hours.' Graphic: '48h' with a clock.
- Statement 3: 'To get access to clot removal treatment, you will have to travel in an ambulance for 45 minutes or longer.' Graphic: Ambulance.

At the bottom, it says '7 questions left for part 1'.

Figure 2

Note: This is example of 1 of 8 BWS items for service organisation. The text and associated graphics were co-designed with stroke survivors to maximise their accessibility and aphasia-friendliness

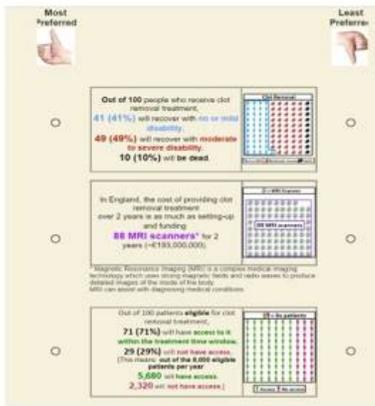


Figure 3

Note: This is example of 1 of 8 BWS items for modelled outcomes. The text and associated graphics were co-designed with stroke survivors to maximise their accessibility and aphasia-friendliness

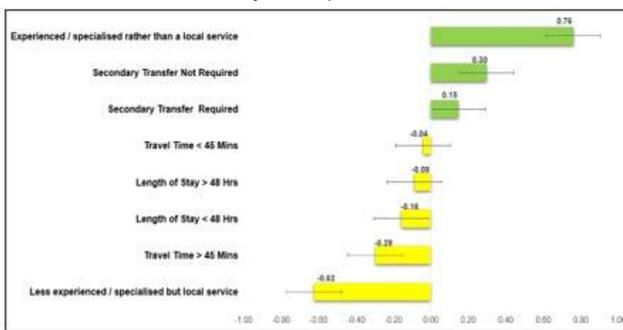


Figure 4

Note: confidence interval bars overlapping 0 (- to +) for a standardised score indicates a lack of strong preferences (positive or negative)

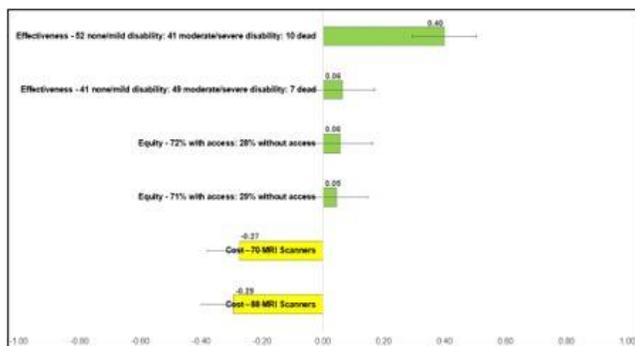


Figure 5

Note: confidence interval bars overlapping 0 (- to +) for a standardised score indicates a lack of strong preferences (positive or negative)

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [BWSversion1Appendices.docx](#)