USE OF MODELLING TO INFORM REGIONAL RECONFIGURATION OF HYPERACUTE STROKE SERVICES

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Background

In an urban setting, reconfiguring hyperacute care (first 72 hours) into fewer, larger hyperacute stroke units (HASUs) requires minimal compromise in ambulance transport times. In a more dispersed, mixed urban and rural environment, reconfiguration poses a greater challenge since trade-off points are more apparent and stakeholders have different priorities. We discuss the modelling approaches taken to explore and communicate trade-offs & priorities.

Methods

We modelled the clinical impact of reconfiguration of HASUs in South West England (population 4.5million, 201 people/km^2) currently served by 14 acute hospitals receiving over 7,500 acute stroke admissions/year. The model identified solutions with between 2-13 HASUs based on a number of criteria:

- ***minimise** average and maximum ambulance transport time*
- ***maximise** proportion of patients within 30 min ambulance transport time*
- ***maximise** anticipated net clinical benefit of thrombolysis*
- ***maximise** proportion of patients who live and are treated within region*
- ***maximise** proportion of patients attending a HASU with 600-1500 admissions/year*

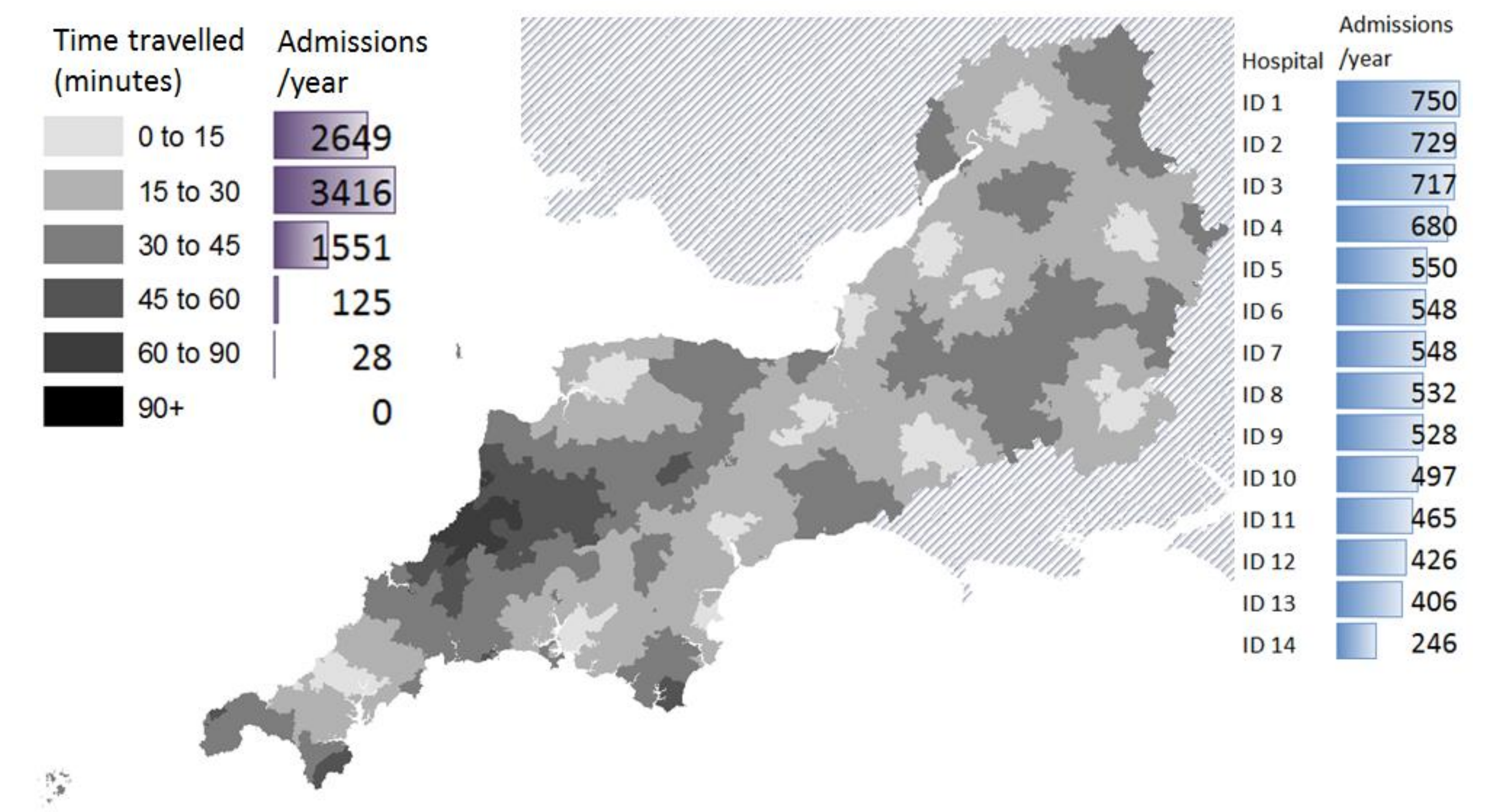
Onset-to-treatment (OTT) times were predicted for scenarios, by altering:

1) number and locations of HASUs
2) arrival-to-treatment (ATT) times for HASUs

OTT time was converted to clinical benefit based on the meta-analysis published by Emberson *et al*. (2014).

Results

Multiple scenarios (as defined above) were performed and reported, Fig. 1.



Average travel time (mins)	Maximum travel time (mins)	Patients within 30 min travel (%)	Clinical benefit*	Patients to HASU with >600 ad/year (%)	Patients treated at regional HASU (%)
21	65	78	10.9	38	98

Fig. 1. A typical scenario output is shown. For all 14 current regional HASUs open, the map shows numbers of patients in 15 min ambulance transport time zones, and by location. HASU admissions/year are shown. The bottom table show the forecast performance of the decision criteria

For a specified number of HASUs, the model identifies the mathematically optimal solution by selecting the combination, from the large number of possible combinations, that provides a reasonable trade-off between the often conflicting criteria. The choice of HASU combination, and the associated impact on the criteria, was explored. Zone graphs (Fig. 2) were pivotal to understand trade-offs that exist within the system. They showed the range of values that could be obtained if the balance of priorities changed.

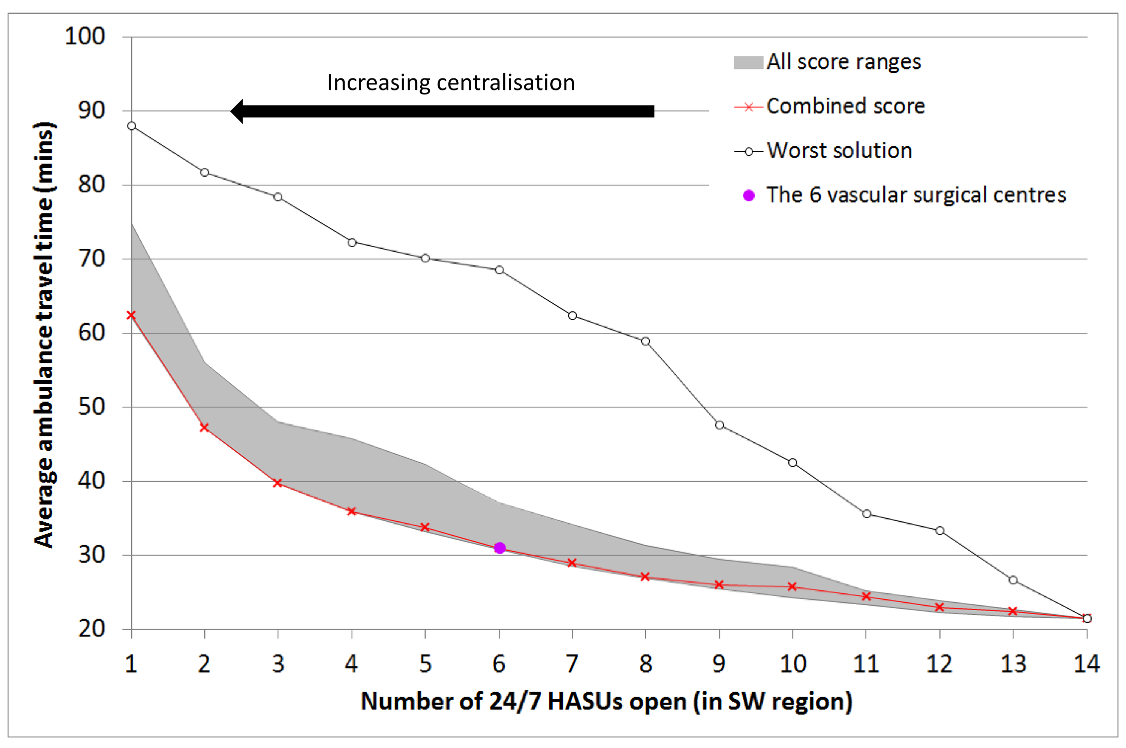


*Fig. 2. The relationship between the number of HASUs and the criterion: average ambulance travel time. **Red line:** mathematically optimal solution. **Grey zone:** range if relative importance between the criteria change. **Open circle line:** combination of HASUs that gives the worst possible value. **Purple point:** real life example, the 6 regional vascular surgical centres*

The model also identifies the 'near-equivalent' solutions that have a score similar to the mathematically optimal solution. Each solution has different strengths and weaknesses. For example, the similarly scoring solutions for 6 HASUs highlight the trade-off between maximum travel time and the proportion of patients attending a HASU with >600 admissions/year (Table 1). This also allows stakeholders to consider additional 'soft' factors and to prefer an option from this group.

Ranking		Score Components					Output not part of score	Hospital ID					
Rank (score)	Score (%max)	Average Travel Time (mins)	Maximum Travel (mins)	Patients Within 30 Mins Travel (%)	Clinical Benefit*	Patients Attending Hospital With >600 Admissions (%)	Patients Treated Within Region (%)						
1	82.3	31	65	47	10.4	94	80	1	2	3	4	5	6
2	82.1	31	65	46	10.4	93	80	1	3	4	5	7	6
3	82.0	31	65	46	10.4	94	81	1	2	3	4	5	6
4	82.0	32	65	46	10.4	94	90	1	3	8	4	5	6
5	81.9	31	70	49	10.4	93	88	1	2	3	8	4	6
6	81.9	31	65	45	10.4	93	81	1	3	4	5	7	6
7	81.9	31	92	50	10.4	100	90	1	2	8	4	5	6
8	81.7	31	65	46	10.4	92	80	1	9	2	3	4	6
9	81.6	31	65	46	10.4	93	80	1	9	2	3	4	6
10	81.6	32	65	46	10.4	94	89	1	3	8	4	5	6
11	81.5	31	92	49	10.4	100	90	1	2	8	4	5	6
12	81.5	31	92	48	10.4	100	84	1	2	4	10	5	6
13	81.4	31	71	48	10.4	93	88	1	2	3	8	4	6
14	81.4	31	95	50	10.4	100	90	1	8	4	5	7	6
15	81.4	31	65	45	10.4	93	84	1	3	4	10	5	6
16	81.4	31	70	47	10.4	92	83	1	2	3	4	10	6
17	81.3	32	93	50	10.4	100	89	1	9	2	8	4	6
18	81.1	32	93	50	10.4	100	89	1	9	2	8	4	6
19	81.1	32	93	50	10.4	100	90	1	2	8	4	10	6
20	81.1	34	74	46	10.3	100	87	1	3	8	4	10	6
21	81.1	31	92	48	10.4	100	84	1	2	4	10	5	6
22	81.0	31	65	45	10.4	93	85	11	1	2	3	4	6

*Clinical Benefit = additional MRS0-1 patients per 100 patients clinically suitable for thrombolysis

Table 1: Similarly scoring solutions for the placement of 6 HASUs

Modelling highlighted that ATT times were as important as the choice of number of HASUs. A network with 4 HASUs operating with 45 minute ATT times could produce the same net clinical benefit as the current network of 14 stroke units performing with their current ATT times (Fig. 3, red line)

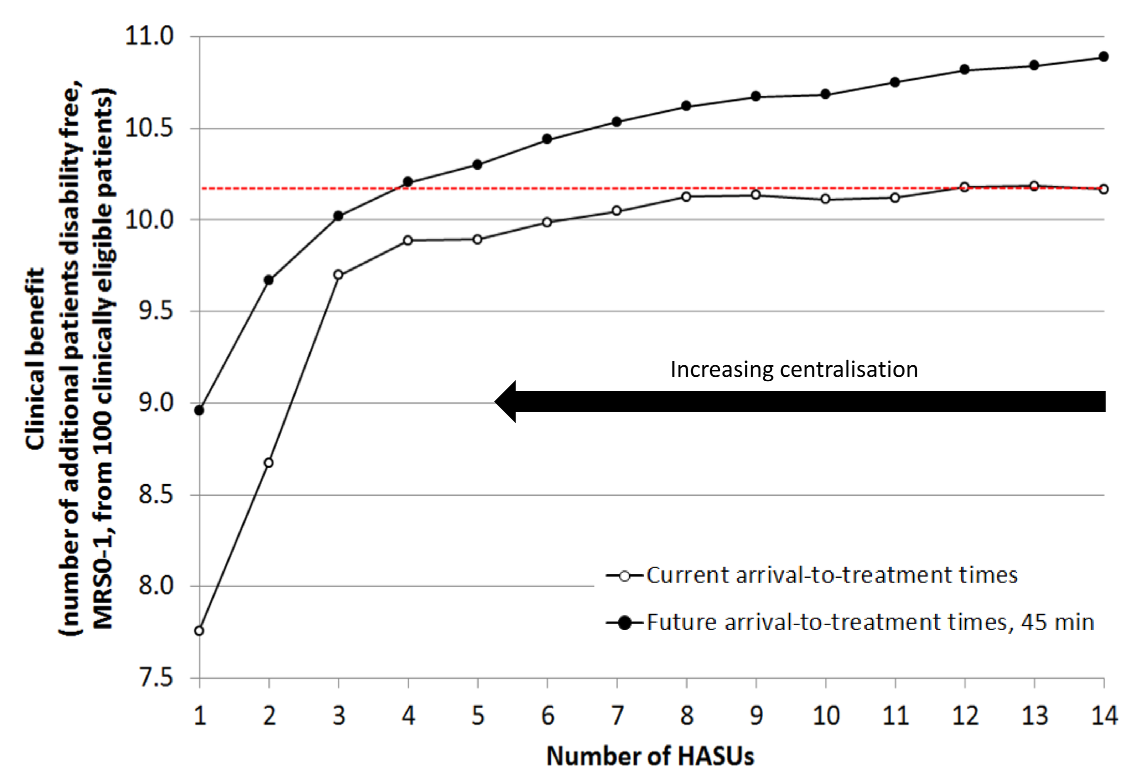


Fig 3. Predicted clinical benefit from thrombolysis with varying numbers of HASUs. All HASUs use either their current ATT times (range 33-89 minutes) (O), or 45 min ATT time (●)

Discussion

Our model took into account multiple criteria to identify the best configuration for centralising HASU services in South West England. Reconfiguration of stroke services is a challenging and emotive subject with unavoidable trade-offs required. While increased centralisation helps to bring 'critical mass' to a service allowing for better 24/7 resourcing and developing substantial clinical experience, it moves location of care further away for some patients and families. Additionally, removal of acute stroke services from hospitals may be perceived as a threat to other services in that hospital.

The model does not 'solve' trade-off problems, but better informs stakeholders of the nature of the trade-offs and identifies the best solutions at any given trade-off point.

We found that the modelling exercise provided the most value, and was better received, when the range of stakeholder views was explored and a choice of solutions given for each balance of priorities, rather than presenting a single 'best compromise' solution. This allowed a range of stakeholder views to be explored, and aided discussions regarding the trade-offs in their system.

Conclusions

Our experience was that modelling contributed significantly to the planning of services, but must never be performed in isolation from the knowledge of other factors that may influence the selection from a range of 'near-equivalent' configurations. Modellers must be careful to avoid presenting a single solution, or presenting solutions that cater for only one prioritisation of competing criteria.

References

1 Emberson J, Lees KR, Lyden P, et al. Effect of treatment delay, age, and stroke severity on the effects of intravenous thrombolysis with alteplase for acute ischaemic stroke: a meta-analysis of individual patient data from randomised trials. Lancet 2014;384(9958):1929-35.

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