Evaluation of a single centre stroke service reconfiguration – the impact of transition from a combined (acute and rehabilitation) stroke unit to a hyperacute model of stroke care

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ABSTRACT

We reorganised the combined (acute and rehab) stroke unit (SU) at Gloucestershire Royal Hospital into a hyperacute stroke unit (HASU) and a rehab SU where patients are moved after spending about 72 hours on HASU. Continuous monitoring of physiological variables was introduced and consultant job plans were reorganised to provide a HASU physician of the week model with enhanced 7-day senior presence along with redistribution of junior medical staff. Sentinel Stroke National Audit Programme (SSNAP) data for 14 months preceding the reorganisation (n=1,049) and 14 months after (n=974) were accessed for outcomes. More patients were admitted directly to the HASU with favourable reductions in time to computerised tomography scanning and stroke consultant assessment after the change. There were significant reductions in length of stay, pneumonia and urinary tract infections at 7 days and a favourable shift in modified Rankin scores (odds ratio 1.60, 95% confidence interval 1.36–1.89, p<0.001) on discharge from hospital.

KEYWORDS: Outcomes, stroke, stroke unit

Introduction

Organised inpatient or stroke unit (SU) care has been shown to improve outcomes for stroke patients with reductions in death, dependency and need for institutionalisation.[1] Stroke units can be broadly classified as acute, rehabilitation and combined (acute and rehab) units.[1] Acute units include hyperacute stroke units (HASUs), which are characterised by facilities for continuous physiological monitoring, high nurse staffing levels and daily senior stroke specialist ward rounds 7 days a week. Other acute units are based on less intensive models. In both instances, acute units care for patients typically for up to 72 hours and sometimes for up to 7 days. Rehabilitation stroke units accept patients when they are stable and focus on rehabilitation. Combined stroke units accept patients acutely but with less intensive levels of care and also provide rehabilitation for at least several weeks.

The HASU model has been widely adopted and has led to major service reorganisation in several UK regions, such as London and Manchester, where acute services have been centralised in a smaller number of centres.[2,3] Evaluation of these reorganisations suggests a reduction in mortality and length of stay (LOS).[2,3] There is, however, no randomised controlled trial confirmation of the benefits of the HASU model and only one randomised controlled pilot trial of HASU care versus less acute care.[4] The Cochrane review found no convincing difference between acute (semi-intensive) SU care and comprehensive SU care.[1] A need for further comparisons between different forms of SU care, particularly the HASU model, has been suggested by the Cochrane group.[1]

Results from the ongoing Sentinel Stroke National Audit Programme (SSNAP) audit at our centre have shown poor results within several key indicators. Stroke services were reorganised at our centre in July 2015 from a combined SU model to a HASU and rehab SU in an effort to improve our SSNAP results and outcomes for patients. This has presented a unique opportunity, akin to a natural experiment,[5] to compare outcomes at the level of a single hospital before and after service reconfiguration.

Methods

Setting and pre-reconfiguration state

The stroke service at Gloucestershire Royal Hospital (GRH) has a catchment area with a population of 560,000, admitting 850–900 patients annually. The stroke unit at GRH initially consisted of a large combined (acute and rehab) stroke unit with 59 beds. New patients admitted to the combined units would previously have been seen by any of four stroke physicians during their ward rounds. Patients admitted in the afternoons would usually not be reviewed by a consultant until the next day. Weekend ward rounds were conducted by one of four stroke physicians and four geriatricians. There were limited facilities for acute physiological monitoring. The

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rehabilitation team, comprising physiotherapists, occupational therapists, speech and language therapists and psychology, provided a 5-day service. There was a stroke specialist early supported discharge team (ESDT) in place, which accepted about 35% of patients on discharge. There were no community stroke specialist rehabilitation facilities and very few patients were discharged to intermediate care settings. A 24/7 thrombolysis service was already in place.

Change

After several months of planning, the reconfiguration was implemented in full on 25 July 2015, creating a 15-bed HASU and a 44-bed rehabilitation stroke unit where patients are transferred from the acute unit, typically within 72 hours of admission. The rehabilitation stroke unit is able to treat patients for several weeks. An updated patient pathway was launched to embed the policy of direct admission of all suspected strokes to HASU with computerised tomography (CT) scanning en route to HASU (if not needed more urgently). One additional stroke physician was appointed, job plans were reviewed and an acute physician of the week model was set up with enhanced senior presence on HASU (including weekend ward rounds by the HASU consultant). Continuous physiological monitoring for 15 patients was introduced and junior doctor numbers were redistributed to increase HASU cover within hours. The stroke specialist registrar was based primarily on the new HASU. There was no change in the out of hours junior doctor cover. There was, however, no provision for 24/7 consultant advice (except for remote thrombolysis) and nurse staffing levels were not increased to meet the levels recommended for HASUs by the British Association of Stroke Physicians (BASP).[6] Protocols for common complications and prophylaxis of venous thromboembolism, as recommended by BASP, were relaunched.[6] Thrombolysis continues to be provided in the emergency department and patients are transferred to the HASU after the drug is administered. Patients suitable for thrombectomy are transferred to a tertiary centre, within hours. There were no changes in the rehabilitation team or ESDT service and hence the BASP recommendations for therapy levels on acute stroke units (45 minutes of all therapies 7 days a week) were not met.[6] No additional rehabilitation beds were made available in the community.

Patient population

The 'pre-HASU' patient population studied comprised consecutive stroke patients admitted to our combined stroke unit from 6 May 2014 to 24 July 2015 and their outcomes were compared with consecutive patients admitted to the new HASU (and subsequently transferred to our rehab stroke unit) from 25 July 2015 to 1 September 2016 (the 'post-HASU' group). Stroke was defined as 'a clinically defined syndrome of rapidly developing symptoms or signs of focal loss of cerebral function with no apparent cause other than that of vascular origin with symptoms lasting more than 24 hours or leading to death'.[7] Imaging was undertaken in all patients to aid the diagnosis and confirm the type of stroke. Patients with transient ischaemic attack (TIA) and stroke mimics and other non-stroke patients were excluded.

Data collection and outcome measures

Data were extracted from the SSNAP dataset[8] for GRH. This clinical audit programme collects a minimum dataset for stroke patients in England, Wales and Northern Ireland.[8] Data are entered prospectively by stroke teams using a secure web portal with inbuilt prompts for completeness and validation.[8] All patient identifiers were removed from our dataset before analysis. The study had trust approval and was classed as a service evaluation (16/103/GHT/SE).

Baseline characteristics for comparison between the two groups included age, sex, type of stroke (infarct or haemorrhage), pre-stroke modified Rankin Scale (mRS)[9] score and initial National Institutes of Health Stroke Scale (NIHSS)[10] score. The mRS is a seven-point scale to measure degree of disability while the NIHSS is used to quantify the impairment caused by a stroke.[9,10] The proportion of patients with atrial fibrillation (AF) (either known or newly diagnosed), hypertension, diabetes, previous stroke/TIA and congestive cardiac failure (CCF) between the two groups were also compared. Age, NIHSS, the presence of AF and stroke type have been validated as a SSNAP casemix model to allow valid comparison of outcomes between different groups of patients.[11]

Outcome measures were LOS, pneumonia and urinary tract infection (UTI) by day 7, mRS score at discharge, first admitting ward (SU or other ward), deaths in hospital, discharge destination (usual place of residence or new care home) and numbers discharged with ESDT support. Proportion of patients thrombolysed, door-to-needle times (DTNT), time taken to arrive on SU, time to first stroke consultant review and time to CT were also measured.

Statistical analysis

The Chi squared test was used for proportions and Students' t test or the Wilcoxon rank sum test for numerical variables. Analysing changes in the distribution of patients over the entire range of ordinal outcome scales (shift analysis) is an increasingly recommended endpoint in stroke trials.[12] A shift analysis for mRS scores at discharge was therefore performed using ordinal regression adjusted for various prognostic covariates (age, type of stroke, baseline mRS score, NIHSS score on admission and presence of AF, hypertension, CCF, diabetes, previous stroke/TIA) and adjusted odds ratios calculated. The same prognostic covariates were used in a multiple linear regression model for LOS and logistic regression for other outcomes such as pneumonia, UTI, deaths in hospital and discharge to new care homes. Statistical control charts ($\bar{X}$ and S) were also used to evaluate temporal trends and variation in LOS.[13] Missing data were few and dealt with by list-wise deletion. Data were analysed using R.[14]

Results

We admitted 1,049 consecutive patients between 6 May 2014 and 24 July 2015 to the combined stroke unit ('pre-HASU') and 974 consecutive patients from 25 July 2015 to 1 September 2016 (the 'post HASU' group). Table 1 shows the baseline characteristics of the two groups, which were evenly matched by age, sex, NIHSS score on admission but differed significantly in terms of the median baseline mRS score and comorbidities such

Table 1. Baseline characteristics of the pre- and post-HASU groups

	Pre-HASU (n=1,049)	Post-HASU (n=974)	p-value
Median age (IQR), years	78 (68–86)	77 (68–85)	0.0942
Proportion of male patients	50.7%	52.3%	0.6093
Stroke type – proportion of infarcts	87.0%	86.8%	0.9322
Median baseline mRS (IQR)	1 (0–2)	0 (0–1)	<0.01
Median NIHSS on admission (IQR)	4 (2–10)	4 (2–9)	0.2736
Proportion with AF (known or newly diagnosed)	29.7%	24.8%	0.0171
Proportion with hypertension	55.5%	52.7%	0.2211
Proportion with history of previous stroke/TIA	27.6%	25.4%	0.2868
Proportion with diabetes	20.3%	20.3%	1
Proportion with CCF	18.7%	8.6%	<0.001

AF = atrial fibrillation; CCF = congestive cardiac failure; HASU = hyperacute stroke unit; IQR = interquartile range; mRS = modified Rankin scale score; NIHSS = National Institutes of Health Stroke Scale

as proportion with AF and proportion with CCF. mRS scores were missing in less than 2% of cases; onset to arrival time, arrival to SU and arrival to CT time were missing in about 6% of cases. Comorbidities were missing for less than 5%. Missing items were dealt with by list-wise deletion.

Table 2 shows outcomes before and after reconfiguration with significance tests not adjusted for prognostic covariates. There were significant improvements in the proportion of patients admitted directly to the SU, and the time taken to reach the SU and have the first scan. LOS and the number with UTI and pneumonia within 7 days of admission were also significantly reduced in the 'post-HASU' group. There was no change in the proportion discharged with ESDT support or discharged to care homes. A total of 199 patients were thrombolysed in the study period with no statistically significant difference in thrombolysis rates or DTNT after reorganisation. Because of the difference in the baseline characteristics of the before and after group, particularly in the proportion of patients with CCF and AF, further analyses were undertaken to adjust for these confounders. Table 3 displays odds ratios for the outcomes in the pre-HASU group and adjusted odds ratios controlling for age, admission NIHSS score, baseline mRS score, AF, CCF, hypertension, diabetes and type of stroke. For both pneumonia and UTI, only age, admission NIHSS score, mRS score and group (pre- or post-HASU) were significant factors associated with these outcomes. CCF and AF were not significant confounders in these regression models.

Fig 1 shows the statistical control charts ($\bar{X}$ and S) for mean LOS and standard deviations in subgroups (n≈70) based on discharges per month. Special cause variation is suggested by the transition from the pre-HASU phase of statistical control to absence of statistical control for both variability and subgroup means after reconfiguration. The relationship between LOS and group (pre- or post-HASU) was further explored with age, sex, pre-stroke mRS score, type of stroke, admission NIHSS score, AF, CCF, hypertension, previous stroke/TIA and diabetes as covariates in a linear regression model. Belonging to the pre-HASU group, increasing age, admission NIHSS score and premorbid mRS score were positively associated with LOS, but CCF, AF and other factors were not significant covariates. The strongest association with LOS was with membership of the pre-HASU group; regression coefficient 8.0 (95% confidence interval (CI) 5.7–10.3), p<0.0001. The overall model R^2 was 0.11.

Fig 2 shows the mRS scores at discharge, with 0 indicating no symptoms and 6 indicating death. There was a significant

Table 2. Outcomes in the two groups

	Pre-HASU (n=1,049)	Post-HASU (n=974)	p-value
SU first admitting ward	53.5%	69.8%	<0.001
Median time from hospital arrival to SU admission (IQR), hours	4.50 (3.49–31.4)	4.33 (3.38–10.4)	<0.001
Median time to assessment by stroke consultant (IQR), hours	16.50 (11.56–20.33)	11.27 (2.96–15.62)	<0.001
Median time to CT scan (IQR), hours	2.50 (0.87–13.79)	1.34 (0.18–3.53)	<0.001
Proportion thrombolysed (all strokes)	10.8%	9.7%	0.4484
Median door-to-needle time (IQR), minutes	51.5 (37.0–70.3)	57.0 (43.0–73.0)	0.2972
Median LOS (IQR), days	12.0 (5.0–32.0)	7.0 (3.0–20.0)	<0.0001
Pneumonia by 7 days	21.5%	14.4%	0.0030
UTI by 7 days	10.6%	5.1%	<0.001
Deaths in hospital	12.6%	11.1%	0.3319
Patients discharged to new care home	8.0%	7.4%	0.6635
Patients discharged with ESDT support	34.8%	35.8%	0.5781

CT = computerised tomography; ESDT = early supported discharge team; HASU = hyperacute stroke unit; IQR = interquartile range; LOS = length of stay; SU = stroke unit; UTI = urinary tract infection

Table 3. Simple and multivariable models testing the association between group (pre-HASU versus post-HASU) and outcomes

	Unadjusted OR (95% CI)	Adjusted OR (95% CI)*	p-value*
Pneumonia by 7 days in the pre-HASU group	1.63 (1.29–2.07)	1.54 (1.19–1.99)	0.007
UTI by day 7 in the pre-HASU group	2.20 (1.56–3.15)	2.10 (1.47–3.04)	<0.001
Death in hospital in the pre-HASU group	1.15 (0.88–1.51)	1.03 (0.67–1.43)	0.8147
Discharge to new care home in the pre-HASU group	1.09 (0.78–1.51)	1.02 (0.66–1.46)	0.8691

*Adjusted for age, pre-stroke modified Rankin Scale score, NIHSS score on admission, stroke type, CCF, AF, hypertension, previous stroke/TIA and diabetes in logistic regression models

AF = atrial fibrillation; CCF = congestive cardiac failure; CI = confidence interval; HASU = hyperacute stroke unit; NIHSS = National Institutes of Health Stroke Scale; OR = odds ratio; TIA = transient ischaemic attack; UTI = urinary tract infection

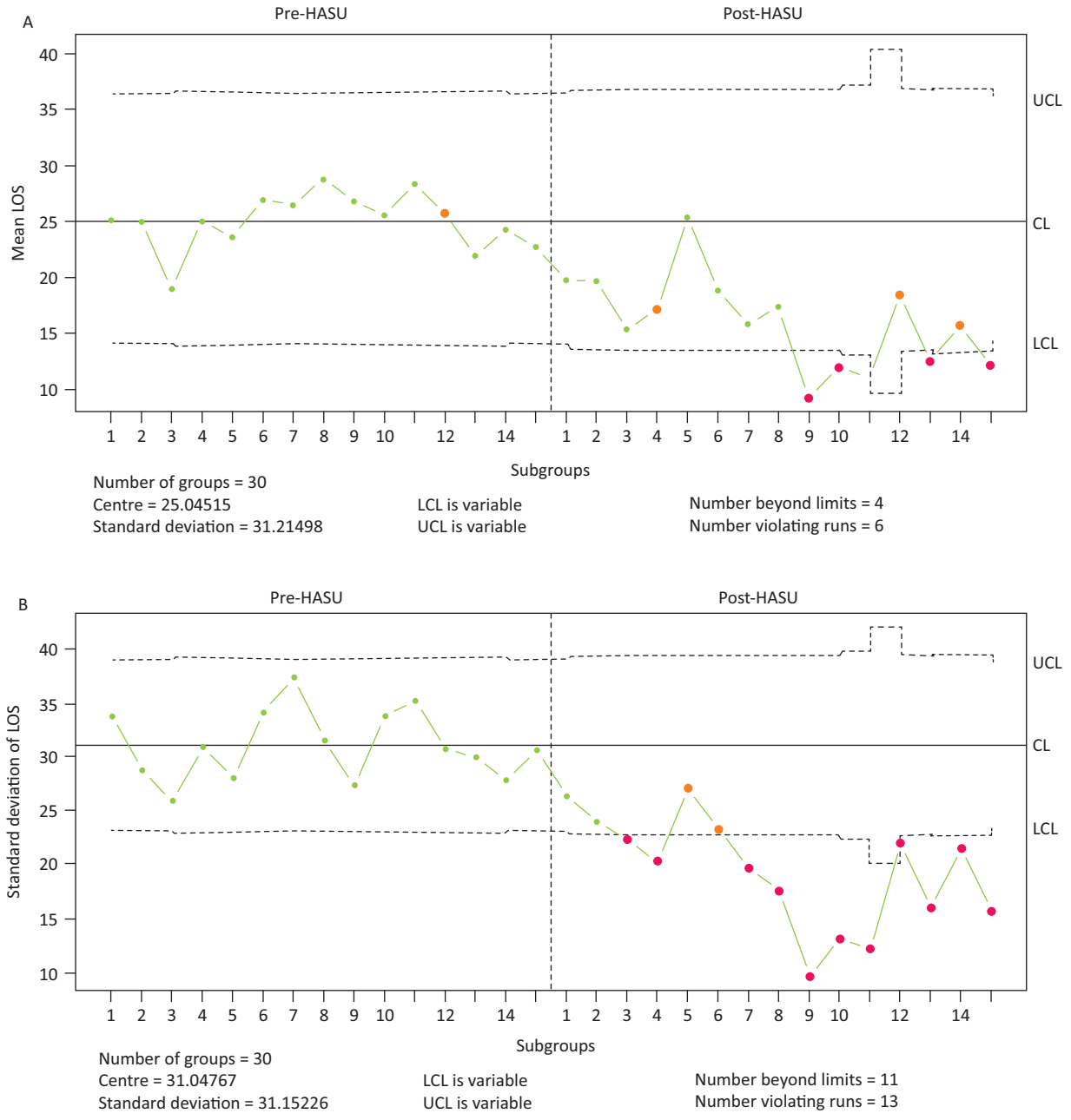

Fig 1. Length of stay (LOS) before and after reconfiguration. A – $\bar{X}$ (mean); B – S (standard deviation). LCL = lower control limit; UCL = upper control limit

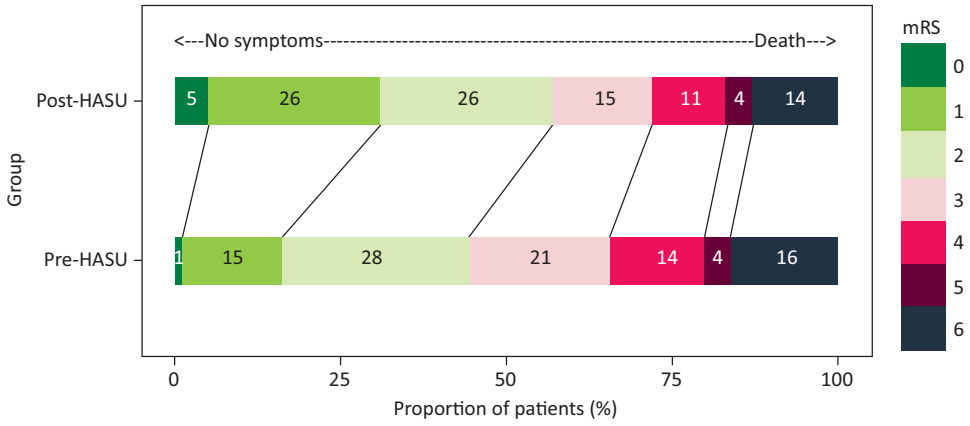

Fig 2. Distribution of modified Rankin Scale (mRS) scores on discharge in the pre- and post-HASU groups. Rounded proportions of patients for each score are shown.

favourable shift in the mRS score (particularly mRS 0–2) in the post-HASU group compared with the pre-HASU group. This was statistically significant in an ordinal logistic regression analysis with adjustment for age, pre-stroke mRS score, NIHSS score on admission, type of stroke and the proportion with AF, CCF, hypertension, diabetes and previous stroke/TIA in the two groups. Adjusted overall odds ratio for lower mRS scores in the post-HASU group compared with pre-HASU was 1.60, 95% CI 1.36–1.89 ($p<0.001$).

Discussion

Our data show that the reorganisation of a combined stroke unit into a HASU and separate rehab SU at our hospital reduced LOS and improved outcomes for patients treated after the reorganisation. LOS reduced from a median of 12 days to 7 days with no increase in patients discharged to new care homes. A larger proportion of patients were directly admitted to the SU after the reorganisation with a small reduction in the median time from hospital arrival to SU admission. Time to CT scan from arrival at hospital and time of first assessment by a stroke consultant were significantly lower in the post-HASU group. The proportion of patients with pneumonia and UTI within 7 days of admission was significantly lower in the group treated after the reorganisation. There was no difference in the proportion that died.

Previous evaluations have shown significant reduction in LOS and improved outcomes, including mortality, in regions such as London and Manchester where services have been reconfigured and concentrated in fewer hyperacute centres.[2,3] Such reorganisations have been associated with a large increase in the proportion of patients thrombolysed and improvements in acute care.[2,3] Our study is one of the first to provide data showing that reorganisation of services in a single centre can be associated with reduced LOS and improved outcomes.
One of the expected benefits of HASU care is quicker access to specialist care and the management of acute physiological variables, such as blood pressure, temperature, hydration status, glucose levels and oxygen saturations, to limit acute neurological deterioration.[15] In our evaluation, we found that patients were able to access the HASU more quickly because of a greater availability of beds created by reducing the LOS and increasing in-reach into the emergency department and other wards to pull in the strokes to the HASU. Early screening for dysphagia, venous thromboprophylaxis using intermittent pneumatic compression[6,16] and prevention of other complications are some of the other benefits of hyperacute management. Of note, the proportion of patients thrombolysed at our centre remained unchanged and DTNT worsened slightly although increased stroke consultant in-reach into the emergency department (primarily for thrombectomy assessments) was possible as a result of our reorganisation. Unlike in some centres with HASUs, thrombolysis is still delivered in our emergency department rather than on our HASU because of its proximity to the CT scanner. We surmise that increasing pressures on the emergency department have led to a slippage in DTNT. Improvement in CT scanning time was primarily because of our updated pathway ensuring CT scans are done en route to the HASU (when not required more urgently). Nurse staffing levels and therapy intensity after reorganisation did not meet full HASU specifications although improvements are planned.[6] In that sense, we have not yet implemented a complete HASU model at our centre and conceivably not achieved best possible results.

This evaluation has several limitations, in particular its uncontrolled before-after design.[17] Such studies can overestimate benefits of treatment and are prone to selection bias.[17] Trends over time may account for some of the improvement in outcomes seen in such studies. It is known that LOS and stroke mortality have reduced in the last few years. However, robust evaluation of the benefits of the HASU model would require a cluster randomised trial design, which is impractical in this context. Given these difficulties, a study of this kind is the only realistic method of evaluation and has produced useful data.

The strengths of this study were those of the SSNAP data collection methodology; SSNAP data were entered prospectively via an online system for all consecutive stroke patients. Stroke diagnosis was made by experienced stroke clinicians and not derived from coding. There were no changes in the personnel (specialist nurses, admin staff and therapists) entering SSNAP data before and after the reconfiguration. Data collectors were not aware that this evaluation was planned at the time of data entry. Very few items were missing in the dataset. There were no significant changes in referral criteria or rehabilitation teams during the period of the study. There were more patients with CCF and AF in the before group, which could be attributed to chance as well as the national drive to increase anticoagulation

for AF. There was no selection bias as no patients were excluded from the SSNAP registry. Covariates were adjusted for in the regression analyses and neither CCF nor AF were significant confounders in any of our regression models. Previous stroke prognostic studies have shown age and stroke severity to be the most important prognostic factors and in the SSNAP casemix model, AF was a significant but less important factor and CCF was not significant.[11] There were no changes in community rehabilitation settings or discharges with ESDT, thus eliminating these factors as potential confounders for LOS. The study period was just over 2 years and it is unlikely that improving national trends in outcomes would be noticeable in this time frame. Moreover, statistical control charts were used to analyse LOS, an outcome that may be subject to temporal trends, and special cause variation was demonstrated. Although our centre is unusual in the fact that all rehabilitation beds are in hospital rather than in the community, we feel that in most other respects our stroke service is comparable to similar district general hospitals in the UK. Our results can, therefore, be generalised to other combined stroke units contemplating reconfiguration to more acute models.

In summary, our evaluation suggests that, just as in larger regional service reorganisation, a single centre reconfiguration of services from a combined stroke unit model to a hyperacute and rehabilitation model reduces LOS and improves outcomes. Given the limitations of our methodology, further data from other centres would be useful. ■

Conflicts of interests

DD is the principal investigator of a Bayer sponsored randomised controlled trial and Boehringer Ingelheim sponsored AF registry. KH has accepted sponsorship for lecture fees and conference attendance from Bayer and Boehringer Ingelheim. Bayer and Boehringer Ingelheim sponsored a clinical pathways manager and Pfizer-BMS sponsored a reconfiguration meeting. The other authors report no individual conflicts of interest.

Author contributions

DD came up with the idea for the paper, wrote the study proposal and obtained trust permission. DD performed the statistical analysis and wrote the first draft. KH, MO and AD contributed to the writing of the paper and approved the final version. All the authors are guarantors of the paper.

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