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Estimating the impact of stroke unit care in a whole population:

An epidemiological study using routine data

Peter Langhorne¹, James D Lewsey², Pardeep S Jhund¹, Michelle Gillies², Jim W T Chalmers³, Adam Redpath³, Andrew Briggs², Matthew Walters¹, Simon Capewell⁴, John J V McMurray¹, Kate MacIntyre².

1. *Cardiovascular and Medical Sciences Division, University of Glasgow, Glasgow, UK*
2. *Section of Public Health and Health Policy, University of Glasgow, Glasgow UK*
3. *Information Services Division, Edinburgh, UK*
4. *Department of Public Health, University of Liverpool, Liverpool UK*

Corresponding author:

*Peter Langhorne
Professor of Stroke Care
Academic Section of Geriatric Medicine
Level 3 University Block
Royal Infirmary
Glasgow. G31 2ER
Tel: 0141 211 4976
Fax: 0141 211 4033
Email: P.Langhorne@clinmed.gla.ac.uk*

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ABSTRACT

Background and Purpose: Randomised trials indicate that organised inpatient (stroke unit) care has an important impact on patient outcomes with an absolute risk difference (ARD) of 3% for survival and 5% for returning home. However, it is unclear what impact this complex intervention actually has in routine practice. We used a comprehensive National dataset to study the impact of stroke unit implementation.

Methods: We used the Scottish linked discharge database to identify all patients admitted to hospital with an incident stroke. Analyses compared case fatality and discharge home (adjusted for age, sex, deprivation and co-morbidity) for hospitals with or without a stroke unit during four consecutive study periods (1986-90, 1991-95, 1996-2000, 2001-05).

Results: During the study period the percentage of admissions to hospitals that had a stroke unit rose from 0% to 87%, the six-month case fatality dropped from 45% to 29% and discharges home rose from 46% to 59%. Adjusted odds ratios (95% CI) for case fatality (stroke unit versus no unit) in each study period were; not calculable (no units before 1991), 0.83 (0.78-0.89), 0.90 (0.86-0.94), 0.87 (0.82-0.91). These equate to an ARD of 3.0% over the whole study period. Equivalent data for discharge home indicated an increased odds of discharge home; not calculable, 1.23 (1.15-1.31), 1.15 (1.10-1.21), 1.17 (1.11-1.23) with an overall ARD of 5%.

Conclusions: These results indicate a positive impact of a policy of stroke unit care on case fatality and discharge home. The estimated impact, after adjusting for case mix, appears very similar to that calculated using clinical trial data.

INTRODUCTION

Organised inpatient (stroke unit) care has been shown to be effective in randomised trials. Patients who are managed within a stroke unit are more likely to survive, return home and regain independence.[1] However, organised stroke unit care is a complex intervention with many facets that are difficult to define and replicate.[2] This raises challenges and uncertainties when implementing into routine services. Also, randomised trials are often carried out under unusual controlled conditions and may not be easily reproduced in routine practice. Some of these potential concerns about implementing stroke unit care were addressed by a systematic review of observational studies which suggested that stroke units may have a similar effect on case fatality when applied in more routine care settings.[3] However this review identified a number of study limitations including incomplete casemix adjustment, limited definition of service characteristics, possible selective admission to stroke units and short study periods.

Therefore important uncertainties remain about several issues. Firstly, does the benefit of stroke unit care extend across a broad range of stroke patients, in particular those with poorer prognosis who make the biggest contribution to stroke-related death and disability? Secondly, there might be the selective admission of patients to stroke units that produces a biased (favourable) estimate of benefit. Casemix adjustment may not completely compensate for this bias. Finally, most studies have used a rather informal, self-defined description of stroke unit care, which has not been externally validated.

This current study arose from the unique opportunities within Scotland to use comprehensive, linked hospital discharge data (collected over a 20-year period), to study the association between well characterised hospital services outcome (case fatality and discharge home) of stroke patients. The study allowed us to explore changes in outcome during the period in which stroke units moved from being non-existent (prior to 1990) to being recommended in clinical practice guidelines (in 1995),[4] and finally being established within the government health strategy (in 2002).[5]

METHODS

Scotland has a population of 5.1 million and an estimated annual number of strokes in excess of 10,000 per annum of whom the majority are admitted to hospital [5].

The Information Services Division (ISD) of the National Health Service (NHS) in Scotland collects data on all discharges in NHS hospitals using the Scottish Morbidity Record (SMR) Scheme. Data from patient case records are used to code up to six diagnoses at the time of discharge according to the World Health Organisation Classification of Diseases (ICD 9 prior to 1996, ICD 10, after 1996). The term “discharge” includes both live discharges and deaths. These data routinely link to information held by the General Register Office for Scotland that records information relating to all deaths in Scotland, including those that occur in individuals not previously hospitalised.

We identified all hospitalisations in Scotland for the period 1981-2005 where stroke was coded as the principal (first position) diagnosis at discharge. The following ICD9 and ICD10 codes were used to identify stroke (ICD10 codes are underlined): 430 (subarachnoid haemorrhage), 431 (intracerebral haemorrhage), 433 (occlusion and stenosis of precerebral arteries), 434 (occlusion of cerebral arteries), 436 (acute, but ill-defined cerebrovascular disease), I60 (subarachnoid haemorrhage), I61 (intracerebral haemorrhage), I63 cerebral infarction), I64 (stroke, not specified as haemorrhage or infarction). Further detail on how incident stroke was defined is described elsewhere.[6] SMR identifies stroke with an accuracy of 95% when the stroke code is recorded in the principle diagnostic position (ISD Data Quality

Assurance). A number of comorbidities were identified and recorded as in previous publications.[6] These included principal and secondary diagnoses for any previous hospitalisations in the last 5 years and secondary diagnoses recorded in the incident stroke hospitalisation: diabetes, cancer, respiratory disease, heart failure, peripheral arterial disease, atrial fibrillation essential hypertension, renal failure, coronary artery disease, valvular heart disease, venous thromboembolism, obstructive sleep apnoea, depression, Parkinsonism, dementia, falls and fractures, and alcohol misuse.

A standard definition of stroke unit was used; an area within a hospital where stroke patients are managed by a co-ordinated multidisciplinary team specialising in stroke management.[1-2] The multi-disciplinary team would meet at least once per week to plan patient care. Our broad definition of stroke unit did not discriminate between those providing acute care only, rehabilitation care only or a combination of the two (comprehensive unit). However the majority of units studied (17/19) were comprehensive or rehabilitation units. We identified the development of stroke unit care at two levels; a) the time when a hospital had any form of stroke unit service and b) the time when a hospital had a stroke unit service that had the capacity to manage at least 50% of its stroke patient admissions. The existence and capacity of stroke units was identified through a range of approaches including:

- 1) Audits of stroke services carried out at intervals over the last 15 years,[7]
- 2) Informal surveys carried out over the last 15 years to inform healthcare policy,[5]
- 3) A national survey and quality assurance inspection of Stroke Services,[8]
- 4) The National Scottish Stroke Care Audit; operating during the last 9 years,[9]

- 5) Personal contact through a national network of stroke clinicians (Scottish Stroke Collaboration).

A number of approaches were taken in the analysis of outcomes. Firstly we analysed the basic descriptive statistics of the number of stroke patients admitted to hospital over a 20-year period, the number of hospitals which had a stroke unit service and hence the number of stroke patients admitted to a hospital that could provide such a service. Secondly, we analysed 6 month case fatality and discharge destination outcomes, comparing hospitals with and without a stroke unit, and stratifying the analysis by the period of time (1986-90, 1991-95, 1996-2000, 2001-05). We compared outcomes in (a) a hospital without a stroke unit compared to one with a stroke unit, and (b) a hospital with a 'functional' stroke unit that could manage at least 50% of its stroke patient population versus one which could not manage 50% of its stroke patients. These analyses looked at crude outcomes plus the odds ratio for outcomes in a hospital with a stroke unit service. The odd ratios were calculated both for crude data and those adjusted for age, sex, socioeconomic deprivation (defined using the Carstairs-Morris index of deprivation) and comorbidity. In addition, the absolute risk reduction (ARR) was calculated using odds ratios (ORs) and case fatality (CF) without stroke unit care as follows:[10]

$$\frac{(1-CF \times CF \times (1-OR))}{1 - (CF \times (1 - OR))}.$$

The same approach was used for discharge outcome where the CF variable was the proportion discharged home from hospitals without stroke unit care.

RESULTS

Study Population

From 1st January 1986 to 31st December 2005 there were 157,639 incident strokes recorded in Scotland and 55% were in women. The median age was 74 years (IQR 65 – 82). It can be seen from *Table 1* that the distribution of age and sex were invariant over time and the socioeconomic gradient was less pronounced towards the end of the study period. The prevalence of most comorbidities increased over time.

Figure 1 shows the 6-month case fatality over the 20-year period. Also shown is the proportion of hospitals with a stroke unit service of any kind or a ‘functional’ service able to provide for at least 50% of stroke patient admissions. There was a steady fall in case fatality over the study period. From the mid-1990s, there was a rapid rise in the proportion of hospitals with stroke unit services.

Table 2 shows the demographics of stroke patients treated in a hospital where there was a stroke unit compared to stroke patients treated in a hospital with no stroke unit. Patients treated in a hospital with a stroke unit were younger on average, had a higher percentage of people from the most deprived socioeconomic deprivation fifth, and had higher prevalence of comorbidities especially atrial fibrillation, essential hypertension, coronary heart disease and alcohol misuse.

Table 3a shows the 6-month case fatality in hospitals with and without a stroke unit and when comparing a hospital with a stroke service able to provide for 50% of patients versus hospitals without such a service. Crude case fatality rates in hospitals with a stroke unit were consistently lower than in hospitals without a stroke unit.

Table 3b shows the same analysis for discharge home which was consistently higher in hospitals with a stroke unit.

Table 4a shows the adjusted and unadjusted odds ratios for 6-month case fatality in hospitals, with and without a stroke unit, stratified by study period. Also shown is the comparison of hospitals able to provide stroke unit care for at least 50% of their stroke patients versus those that could not. The apparent odds reduction for death in patients admitted to a hospital with a stroke unit was consistently 17-23% compared with hospitals without a stroke unit. The apparent odds reduction for death (22%-38%) was more marked when using this stricter definition of a 'functional' stroke unit service that could take at least 50% of stroke patients. In both examples, the odds reductions for death were attenuated but not abolished after casemix adjustment.

Table 4b shows the same analysis for the outcome discharge home. There was an increase in the odds of discharge home associated with stroke unit hospitals. This increase was 17-23% after casemix adjustment.

Table 5a compares estimated the impact of a stroke unit policy on 6-month case fatality using three different approaches; a) the crude data observed in this analysis (estimated 2440 additional survivors), b) an estimate calculated using the adjusted

odds ratios (*Table 4*) from this analysis (estimated 1420 additional survivors) and, c) an estimate calculated from the 3% ARR seen in randomised trials, (estimated 1425 additional survivors). The increasing access to stroke units in Scotland was associated with a substantial increase in survivors. During the period of stroke unit development (1991-2005) 6-month case fatality fell from 41% to 29% (i.e. ARR of 12%). The estimate that is stratified by time period and adjusted for casemix suggests that an ARR of 2-4% may be attributed to the impact of stroke unit care. In the final study period (2001-05) when stroke units were most prevalent stroke unit care appeared to account for almost 200 extra survivors per year.

Table 5b shows the same analysis but using discharge home as the variable in place of case fatality. During the period of stroke unit development (1991-2005) the proportion discharge home rose from 43% to 61% (i.e. an absolute increase of 18%) of which 4-6% might be attributed to the impact of stroke unit care. In the final study period (2001-2005) an extra 470 discharges per year could be attributed to stroke unit care.

DISCUSSION

Stroke case fatality recorded using routine data has fallen substantially during this 20-year national study. It is apparent from this analysis that the development of stroke units could partly explain the fall in case fatality in hospitalised stroke patients. The remaining component may be explained by artefact (more stroke patients admitted to hospital with milder symptoms),[11-12] changes in the natural history of stroke (e.g. less severe stroke events)[11-12] and improvements in general medical care.[12]

We believe this is the first long-term study to have shown such an association in a whole population. The potential impact when based on unadjusted data, is even larger than would have been estimated from randomised trials of stroke unit care. However unadjusted estimates may be confounded by variations in casemix such as patient age and stroke severity. The estimate based on analyses adjusted for casemix (1420 extra survivors and 2351 extra discharges home) was very similar to that obtained using the absolute risk reductions from meta-analysis of clinical trials. Although no single method of estimating impact is ideal it is reassuring to obtain similar estimates from different approaches.

The main strengths of our study are that we have studied a whole population of 5.1 million people over a 20-year period with complete follow-up to one-year post stroke. Secondly, we used a definition of stroke unit status that has a standard definition and was externally validated.[5,7,8,9]. The basic definition (2) was of multidisciplinary stroke unit care and the majority were comprehensive (acute and rehabilitation) or rehabilitation stroke units (5). Finally, our focus on whole hospital services minimises the risk of bias in patient selection for admission to a stroke unit since most hospitals served all patients within a geographical area. Alternative explanations of our observations (e.g. hospitals with better case fatality results were more likely to establish stroke units) do not seem plausible.

The mechanisms by which stroke units improve survival has been subject to some study. In randomised trials, the survival benefit occurs largely at 1-4 weeks post stroke,[13] is more marked in severe stroke patients,[13] and is linked to a reduction

in complications, particularly those caused by immobility.[14] The scale of benefit observed in our study is compatible with these observations. Furthermore, the size of association is also similar to that seen in a recent population-based observational study from Sweden [adjusted HR (stroke unit vs. no stroke unit) for death equal to 0.79 in men and 0.83 in women].[15] Our results cannot be explained by hyperacute interventions such as thrombolysis which were not in routine use during the period of study, would not be expected to reduce case fatality,[16] and would have a modest impact at a population level.[17]

There are some limitations to our study. Firstly, we used hospital discharge data and we therefore cannot always be certain of the precision of the diagnoses. However, audit carried out by Information Services Division suggest that SMR identified stroke with an accuracy of 95% when a stroke code is recorded in the first diagnostic position.[18] Secondly, although we included the key variables of age, sex, deprivation and co-morbidity, our risk adjustments will not be complete because of lack of clinical detail on items such as stroke severity. Finally, we were not able to directly study non-fatal outcomes such as disability. However, data from randomised trials [1] indicate that the benefits in survival are mirrored by improvements in functional recovery and that discharge home is a reasonable proxy for functional recovery.

CONCLUSIONS

Stroke case fatality in Scotland has fallen steadily and substantially over two decades and has been mirrored by a rise in discharges home. Part of this improvement in

prognosis can be explained by the policy of implementing a basic model of multidisciplinary stroke unit care.

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[.pdf](#) . 2007.

Table 1 Demographics of incident strokes 1986 – 1990

Demographic	1986– 1990 n = 38,622	1991– 1995 n = 41,769	1996– 2000 n = 40,146	2001– 2005 n = 37,102	Overall n = 157,639
Age (years) – median (IQR)	74 (65-81)	74 (65-82)	74 (64-82)	74 (64-82)	74 (65–82)
Sex -% women	56.6	55.7	54.1	54.1	55.1
Socioeconomic deprivation -%					
1 (least dep.)	16.7	16.4	17.6	18.2	17.2
2	19.8	19.8	20.0	20.3	20.0
3	18.1	19.1	19.5	19.6	19.1
4	21.2	21.3	20.9	20.3	20.9
5 (most dep.)	24.2	23.4	22.0	21.6	22.8
Comorbidities -%					
Diabetes	6.4	7.9	10.0	12.0	9.0
Cancer	4.6	5.8	7.6	8.1	6.5
Respiratory disease	4.5	5.9	7.8	9.3	6.9
Heart failure	6.7	8.0	8.2	7.8	7.7
Peripheral arterial disease	5.7	6.4	6.6	6.2	6.2
Atrial fibrillation	6.1	9.0	13.3	17.1	11.3
Essential hypertension	9.0	12.7	20.9	34.7	19.1
Renal failure	1.3	1.9	2.9	4.3	2.6
Coronary heart disease	13.3	16.5	19.1	21.5	17.6
Rheumatic/valvular heart disease	1.5	2.0	2.7	3.6	2.4
Pulmonary embolism & DVT	1.7	1.9	2.5	2.5	2.1
Depression	1.0	1.6	2.0	2.6	1.8
Parkinsonism	1.4	1.3	1.1	1.1	1.2
Dementia	3.0	3.5	4.3	4.9	3.9
Falls & Fracture	7.7	8.5	9.2	9.9	8.8
Alcohol misuse	1.8	2.8	4.0	5.2	3.5

Table 2 Demographics of incident strokes by whether there was a stroke unit in hospital or not

Demographic	No stroke unit in hospital n = 110,207	Stroke unit n = 47,432
Age (years) – median (IQR)	75 (66-82)	73 (63-81)
Sex -% women	55.6	54.0
Socioeconomic deprivation -%		
1 (least dep.)	16.2	19.5
2	21.9	15.7
3	19.8	17.4
4	21.2	20.2
5 (most dep.)	20.9	27.2
Comorbidities -%		
Diabetes	8.3	10.8
Cancer	6.0	7.7
Respiratory disease	6.1	8.6
Heart failure	7.7	7.7
Peripheral arterial disease	6.2	6.3
Atrial fibrillation	9.5	15.4
Essential hypertension	14.5	29.8
Renal failure	2.2	3.5
Coronary heart disease	16.2	20.6
Rheumatic/valvular heart disease	2.1	3.2
Pulmonary embolism & DVT	2.1	2.3
Depression	1.6	2.2
Parkinsonism	1.3	0.9
Dementia	3.7	4.3
Falls & Fracture	8.7	9.0
Alcohol misuse	2.8	4.9

**Table 3 Crude outcomes (with 95%CI) by stroke unit status and study period;
a) 6 month case fatality, b) proportion (%) discharged home**

a) Case fatality

Study period	No stroke unit in hospital	Stroke unit
1986 – 1990	42.8 (42.3, 43.3)	
1991 – 1995	39.8 (39.3, 40.3)	34.1 (32.7, 35.4)
1996 – 2000	35.9 (35.3, 36.5)	31.7 (31.0, 32.4)
2001 – 2005	34.6 (33.7, 35.6)	29.0 (28.4, 29.5)
Study period	Stroke unit care available for ≤50%	Stroke unit care available for >50%
1986 – 1990	47.7 (47.2, 48.2)	
1991 – 1995	44.6 (44.1, 45.1)	33.1 (31.4, 34.9)
1996 – 2000	40.1 (39.6, 40.7)	32.5 (31.5, 33.5)
2001 – 2005	37.4 (36.8, 38.1)	31.8 (31.1, 32.5)

b) Discharge home

Study period	No stroke unit in hospital	Stroke unit
1986 – 1990	46.4 (45.9, 46.9)	
1991 – 1995	50.6 (50.0, 51.1)	57.0 (55.6, 58.5)
1996 – 2000	53.6 (53.0, 54.3)	59.9 (59.1, 60.6)
2001 – 2005	56.0 (55.0, 57.0)	63.2 (62.6, 63.8)
Study period	Stroke unit care available for ≤50%	Stroke unit care available for >50%
1986 – 1990	46.4 (45.9, 46.9)	
1991 – 1995	50.5 (50.0, 51.0)	62.5 (60.6, 64.3)
1996 – 2000	54.3 (53.8, 54.9)	62.8 (61.8, 63.9)
2001 – 2005	58.4 (57.7, 59.1)	64.6 (63.9, 65.3)

Table 4 Crude and adjusted odds ratios (stroke unit in hospital vs. no stroke unit in hospital); a) 6-month case fatality b) proportion (%) discharged home

a) Case fatality

Stroke unit in hospital		
Period	Crude OR	Adjusted OR*
1991 – 1995	0.78 (0.73, 0.83)	0.83 (0.78, 0.89)
1996 – 2000	0.83 (0.79, 0.86)	0.90 (0.86, 0.94)
2001 – 2005	0.77 (0.73, 0.81)	0.87 (0.82, 0.91)
Stroke unit care available for >50% of admissions		
Period	Crude OR	Adjusted OR*
1991 – 1995	0.62 (0.57, 0.67)	0.73 (0.67, 0.80)
1996 – 2000	0.73 (0.69, 0.77)	0.85 (0.80, 0.90)
2001 – 2005	0.78 (0.75, 0.82)	0.85 (0.81, 0.89)

b) Discharge home

Stroke unit in hospital		
Period	Crude OR	Adjusted OR*
1991 – 1995	1.30 (1.22, 1.38)	1.23 (1.15, 1.31)
1996 – 2000	1.29 (1.24, 1.34)	1.15 (1.10, 1.21)
2001 – 2005	1.35 (1.29, 1.41)	1.17 (1.11, 1.23)
Stroke unit care available for >50% of admissions		
Period	Crude OR	Adjusted OR*
1991 – 1995	1.63 (1.51, 1.77)	1.35 (1.23, 1.47)
1996 – 2000	1.42 (1.35, 1.49)	1.20 (1.13, 1.26)
2001 – 2005	1.30 (1.24, 1.35)	1.15 (1.10, 1.20)

* adjusted for age, sex, socioeconomic deprivation and comorbidity

Table 5 Calculated impact of stroke unit care in Scotland, 1986 – 2005

a) Case fatality							
Period	Access to stroke unit care (patients admitted to hospitals with/without a stroke unit)	Crude observed impact (based on Table 3)		Estimated impact (based on adjusted odds ratios in Table 4) *		Calculated impact (based on data from clinical trials¹) **	
		Difference in case fatality	Difference in number of deaths	Absolute difference in case fatality	Difference in number of deaths	Absolute difference in case fatality	Difference in number of deaths
1986-1990	0/38622 (0%)	---	0	---	0	---	0
1991-1995	4655/41769 (11%)	- 5.7%	-265	- 4.4%	-205	-3% (-1, -5)	-140 (-50, -235)
1996-2000	15769/40146 (39%)	- 4.2%	-660	- 2.4%	-380	-3% (-1, -5)	-475 (-160, -790)
2001-2005	27008/37102 (73%)	- 5.6%	-1515	- 3.1%	-835	-3% (-1, -5)	-810 (-270, -1530)
1986-2005	47432/157639 (30%)	- 5.1%	-2440	- 3.0%	-1420	-3% (-1, -5)	-1425 (-480, -2380)
b) Discharge home							
Period	Access to stroke unit care	Difference in % discharges home	Difference in number discharged home	Absolute difference in discharges home	Difference in number of discharges home	Absolute difference in discharges home ***	Difference in number of discharges home
1986-1990	0/38622 (0%)	---	0	---	0	---	0
1991-1995	4655/41769 (11%)	+6.4%	298	+6.5%	+303	+5% (+1, +8)	+233 (47-372)
1996-2000	15769/40146 (39%)	+6.3%	993	+4.1%	+640	+5% (+1, +8)	+788 (158-1262)
2001-2005	27008/37102 (73%)	+7.2%	1945	+4.6%	+1250	+5% (+1, +8)	+1350 (270-2161)
1986-2005	47432/157639 (30%)	+6.7%	3236	+5.0%	+2351	+5% (+1, +8)	+2372 (474-3795)

* The absolute risk reduction (10) was calculated from odds ratios (ORs) as;

$(1 - CF \times CF \times (1 - OR))$

$1 - [CF \times (1 - OR)]$

where CF is; a) case fatality without stroke unit care, or b) proportion discharged home without stroke unit care

** Calculated using the absolute risk difference (95% confidence interval) for case fatality from clinical trials of stroke unit care. *** Based on absolute risk difference (95% confidence interval) for the proportion living at home in clinical trials

Figure 1: 6-month case fatality, percentage of hospitals with any stroke unit, percentage of hospitals with stroke unit able to provide for at least 50% of stroke patients, plotted against study year

Legend

Solid line, triangle marker – 6-month case fatality.

Dashed line, triangle marker – % of hospitals with stroke unit providing for 50%.

Dashed line, circle marker – % of hospitals with stroke unit.

