Background and Purpose—Stroke unit care is one of the most powerful interventions available to help stroke patients. There are limited data available to assess the impact of stroke units in routine clinical practice outside randomized clinical trials. This article uses data from the 2001 to 2002 National Stroke Audit to assess the effectiveness of stroke unit care in England, Wales, and Northern Ireland in delivering effective processes of care and in reducing case fatality and disability.

Methods—An observational study of the organization, structure, process of care, and outcomes for stroke in 2001. Case fatality after stroke in England was compared using data from the audit and routinely collected data from the Department of Health. 240 hospitals (196 Trusts) from England, Wales, and Northern Ireland took part in the 2001 to 2002 National Stroke Audit, a response rate of >95%. These sites assessed a total of 8200 patients using the Royal College of Physicians Intercollegiate Working Party Stroke Audit Tool.

Results—The availability of stroke unit care varies hugely across the country. Case fatality after stroke was higher in Trusts with least availability of stroke unit care. These differences persisted after control for case mix. The process of care was better for patients managed on stroke units compared with other settings. Overall, the risk of death for patients who received stroke unit care was estimated to be ≈75% that of the risk for those having no stroke unit care (95% CI, 60 to 90).

Conclusions—Stroke unit care as provided in routine clinical practice in England, Wales, and Northern Ireland reduces case fatality by ≈25%, which is in line with the figures obtained from systematic analysis of stroke unit trial data. (Stroke. 2005;36:103-106.)

Key Words: outcome ■ stroke units

Several studies have reported that organized stroke care of a high standard results in better outcomes for patients. The Stroke Unit Trialists’ Collaboration (SUTC) demonstrated that within clinical trials, there were fewer deaths and less morbidity for patients admitted to stroke units. Two studies from Sweden appear to confirm these results in routine care, indicating lower rates of case fatality and morbidity among patients managed in stroke units. The National Service Framework for Older People in England recognized this and set a national target that every hospital admitting stroke patients should have a stroke unit by April 2004. However, there are few data that confirm that the results of the formal trials can be replicated in routine stroke unit care across a whole country. The 2001 to 2002 National Sentinel Stroke Audit collected observations of the routine care of stroke in >95% of hospitals in England, Wales, and Northern Ireland and provided an opportunity to compare care within stroke units to that in general medical and generic rehabilitation wards.

Materials and Methods
Organization of hospital care in England and Wales is coordinated by local Trusts that will be responsible for one or more general hospitals delivering care for stroke patients. All Trusts within England, Wales, and Northern Ireland were invited to take part in the third round of the National Sentinel Audit of Stroke, 2001 to 2002. The audit tool comprised organizational and clinical proformas, and details of audit forms and methodology can be found at www.rcplondon.ac.uk. Data were collected from up to 40 consecutive stroke cases at each site between April and June 2001. The organizational audit proforma was completed in January 2002.

Analyses at Trust Level
From routine hospital statistics, the Department of Health in England calculates the number of deaths within 30 days of emergency
admission to hospital after a stroke, per 100,000 patients per year. Numbers are age- and gender-standardized, and include deaths in hospital and after discharge. An indicator score is derived for each acute Hospital Trust. This indicator was used to divide English Trusts into quartile groups for presentation of results from the National Stroke Audit.

In addition to case fatality outcomes, the National Stroke Audit recorded morbidity indices that included Barthel disability score at discharge and institutionalization (or not) on discharge for those living independently before admission. Access to stroke unit care was measured as the percentage of patients admitted to a stroke unit and as the percentage spending more than half their stay in a stroke unit. Multiple linear regression methods (SPSS v11.5) were used to investigate the association between English National Health Service indicator case fatality and audit of stroke care. Indicator case fatality was not restricted to Trusts in England, and National Stroke Audit hospital data have been amalgamated when there was >1 hospital per Trust. The $R^2$ statistic was used to quantify the proportion of variation in case fatality between Trusts explained by stroke care exposure, by all 15 case-mix variables, and by stroke care after adjusting for case mix.

Trusts from England, Wales, and Northern Ireland were also grouped for presentation into quartiles according to the proportion of their patients that went to a stroke unit. Multiple linear regression methods (SPSS v11.5) assessed the association of stroke unit care with audit case fatality, morbidity, and domains of the process of care, after adjusting for case mix, at Trust level.

The process of inpatient care was measured for each Trust by the percentage compliance on each of 33 process standards, within seven domains—initial patient assessment, clinical diagnosis, multidisciplinary assessment, screening and functional assessment, management/care planning, communication with patients and carers, and primary secondary interface. Each domain score was the simple average of the compliance of the standards within the domain. Also, a subset of 10 standards, selected as representative of the clinical patterns of care, was amalgamated into a single indicator. This aggregated measure has since been adopted by the Healthcare Commission, which is the organization responsible for monitoring the quality of health care delivery in England, as one of its indicators of hospital performance. The subset comprised screening for swallowing disorders <24 hours, brain scan <24 hours, aspirin <48 hours, physiotherapy assessment <72 hours, occupational therapy assessment <72 days, weighed during admission, mood assessed during admission, antithrombotic therapy by discharge, rehabilitation goals agreed by multidisciplinary team, and home visit before discharge.

Fifteen continuous case-mix variables were selected before analysis: percentage males, median age, percentage aged 85 years and older, percentage with infarction, percentage living in a residential or nursing home before stroke, percentage with previous stroke/transient ischemic attack, percentage with diabetes, percentage with hyperlipidemia, percentage with hypertension, percentage with myocardial infarction/angina, mean prestroke Barthel score, percentage with prestroke Barthel score <10, percentage with prestroke bladder incontinence (Barthel), percentage unconscious, and percentage able to walk independently. Four of these variables (hyperlipidemia, mean prestroke Barthel, prestroke Barthel <10, prestroke bladder incontinence) were transformed to reduce skewness.

Analysis of Individual Patient Data: Impact of Stroke Unit on Outcomes

Patient entry to a stroke unit can occur at any time during admission and some patients could have died before this was possible. We analyzed 30-day survival from the day of admission for the 89% of patients admitted within 2 days of their stroke, and 30-day survival from time of stroke for the 4% who had their stroke in hospital. Survival time was taken as days to death if within 30 days, or as 30 days if the patient was alive at 30 days of the stroke, or as days to discharge (<30 days) if status at 30 days was missing. Case-mix variables were the patient equivalent of those previously described for Trust level analyses.

Stata 8 software was used to perform Cox regression survival analyses with stroke unit entry as a discrete time-varying covariate, to estimate the risk of death from stroke unit care relative to the risk from having no stroke unit care. Adjustment was made for case-mix variables and for hospital clustering. The effects of within-hospital clustering were accounted for by using robust standard errors for the estimated hazard ratios. We also examined hospital clustering using a frailty model that allowed the hazard function to vary at random among hospitals, analogous to regression models with random effects.

Results

Analysis of Trust Performance

Organization of care data were reported by 199 hospital Trusts (240 sites) and clinical care data were returned on 8200 patients in 196 hospital (235 sites). There was a stroke unit in 73% (175/240) of hospitals, although only 36% (2859/7975) of patients spent any time in a stroke unit.

The 30-day case fatality in our study for the 152 English Acute Trusts was of similar order to that reported by the Department of Health (Table 1). Across the quartiles there is a clear pattern showing that lower case fatality per Trust is associated with greater use of stroke units ($R^2$=0.057) and of percentages spending most of their stay there ($R^2$=0.062). Multiple regression analyses with all 15 case-mix measures gave a $R^2$ statistic of 0.219. The extra $R^2$ associated with percentage admitted to a stroke unit was +0.020 ($P=0.06$), whereas for the percentage having the majority of their stay in a stroke unit the extra $R^2$ was +0.027 ($P=0.03$). Table 2 contains results from all 196 Trusts in England, Wales, and Northern Ireland grouped according to the proportions of patients admitted to stroke units. Similar patterns of case fatality apply whether measured as 7-day, 30-day, or in-hospital. There was again an additional association between higher case fatality per Trust and a lower proportion being treated in a stroke unit, beyond that explained by the case-mix variables.

Although more patients were discharged alive from the Trusts with most stroke unit care, they had no greater disability (Barthel function scores) or institutionalization if previously in independent living. There were clear trends involving process standards in that the higher the proportion of these standards that were met, the greater the proportion of patients that went to a stroke unit (Table 3).

Analysis of Individual Patient Data

At the patient level, 7622 cases were patients admitted to hospital within 2 days of stroke or who had their stroke in hospital. Stroke entry status/details were incomplete for 270. Of the remaining 7352, 34% (2487) were admitted to a stroke unit within 30 days and 69% (1726) of these were admitted within 7 days. The median (interquartile range) time from admission to entry to a stroke unit was 3 (0 to 9) days and the median (interquartile range) stay in a stroke unit was 21 (9 to 49) days. The overall life-table estimate of 30-day case fatality was 25%. Prestroke Barthel disability scores were unavailable for 23% (1658), but in separate analyses the effects of variables derived from the Barthel score (ie, score=20, score <10, bladder incontinence) had virtually no effect on survival after adjusting for other case-mix variables. Without the Barthel data, there were 7204 cases for analyses involving all other case-mix variables.
In summary, the risk of death from stroke unit care was estimated to be \( \frac{75}{100} \) that of the risk from having no stroke unit care (95% CI, 60% to 90%). More specifically, the Cox regression model with stroke unit entry as a discrete time covariate and with adjustment for hospital clustering and case-mix factors estimated the hazard ratio as 0.736 (95% CI, 0.613 to 0.883). The use of frailty models to account for the effects of clustering by allowing the hazard function to vary at random between clusters gave an estimate of 0.756 (95% CI, 0.656 to 0.870).

### Discussion

Cerebrovascular disease accounts for 22,907 deaths in English hospitals in 2001 to 2002, with >10% of all deaths occurring in hospital. These data suggest that patients managed in hospitals admitting a large proportion of their patients to stroke units have better process of care and survival than those admitted to hospitals with low stroke unit provisions. The stroke audit is an observational study of routine care across almost the whole country and was of consecutive patients. The data are collected by the clinical teams and have been shown to be highly reproducible. The association of better processes of care, more provision of care within stroke units, and less case fatality makes logical sense. The completeness of the coverage across the country and the fact that this was observing routine care of patients make it probable that the findings are generalizable.

### Table 1. Stroke Units, Case Mix, and Outcome for 152 English Trusts According to the DoH NHS Performance Indicator for 30-Day Case Fatality

<table>
<thead>
<tr>
<th>Characteristics of Quartile</th>
<th>Quartile 1</th>
<th>Quartile 2</th>
<th>Quartile 3</th>
<th>Quartile 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>% NHS performance indicator [% deaths/100 000 admissions/year], median (range)</td>
<td>23 (12.2–24.4)</td>
<td>26 (24.4–27.4)</td>
<td>29 (27.4–30.0)</td>
<td>32 (30.0–43.1)</td>
</tr>
<tr>
<td>No. of Trusts (patients)</td>
<td>38 (1616)</td>
<td>38 (1756)</td>
<td>38 (1636)</td>
<td>38 (1516)</td>
</tr>
<tr>
<td>No. of patients studied per Trust, median (range)</td>
<td>40 (38–40)</td>
<td>40 (39–40)</td>
<td>40 (36–40)</td>
<td>40 (36–40)</td>
</tr>
</tbody>
</table>

This study: case fatality

- % 30 days: 18 (12–27) 25 (19–33) 28 (22–32) 29 (24–35) 0.28†
- % Died in hospital: 23 (17–30) 32 (25–38) 32 (27–38) 36 (28–41) 0.035†

Use of stroke unit care

- % Admitted to stroke unit: 41 (15–71) 35 (15–49) 30 (19–48) 28 (9–44) –0.24†
- % Spent >50% of stay in stroke unit: 31 (9–58) 25 (10–42) 20 (9–40) 15 (0–31) –0.25†

Quartile groups were created from the indicator for presentation: death within 30 days of admission to hospital per 100,000 patients (age- and sex-standardized, includes deaths in hospitals and after discharge).

### Table 2. Audit Case Fatality and Morbidity for 196 Trusts From England, Wales, and Northern Ireland Grouped into Quartiles According to the Percentage of Patients Admitted to a Stroke Unit

<table>
<thead>
<tr>
<th>Characteristics of Quartile</th>
<th>Quartile 1</th>
<th>Quartile 2</th>
<th>Quartile 3</th>
<th>Quartile 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Admitted to stroke unit, median (range)</td>
<td>0 (0–12)</td>
<td>26 (13–32)</td>
<td>44 (33–54)</td>
<td>73 (55–100)</td>
</tr>
<tr>
<td>% Spent &gt;50% of stay in stroke unit (Range)</td>
<td>0 (0–2)</td>
<td>16 (12–24)</td>
<td>33 (28–40)</td>
<td>58 (48–74)</td>
</tr>
<tr>
<td>No. of Trusts (patients)</td>
<td>49 (1921)</td>
<td>49 (2277)</td>
<td>49 (2066)</td>
<td>49 (1936)</td>
</tr>
<tr>
<td>No. of patients per Trust</td>
<td>40 (30–40)</td>
<td>40 (33–51)</td>
<td>40 (39–40)</td>
<td>40 (37–40)</td>
</tr>
</tbody>
</table>

Audit outcomes

- % 7-day case fatality rate: 11 (8–15) 15 (10–18) 12 (7–18) 8 (3–13) 0.450 0.029 0.002
- % 30-day case fatality rate: 25 (16–32) 30 (23–34) 24 (17–32) 18 (11–23) 0.496 0.043 <0.001
- % Died in hospital: 30 (23–40) 33 (25–38) 28 (22–38) 23 (14–30) 0.507 0.038 <0.001
- % Discharge to nursing/residential home if previously independent/warden-controlled: 14 (9–23) 12 (9–20) 16 (10–24) 13 (5–17) 0.227 0.006 0.228

Audit outcomes: Mean Barthel score at discharge: 14.9 (13.6–15.7) 14.8 (13.4–16.1) 14.1 (13.1–15.6) 14.9 (13.1–15.9) 0.236 0.008 0.177

Body of Table gives Trust medians (interquartile ranges) unless stated otherwise.
A potential weakness comes from sampling only 40 cases per Trust, but the similarity to the Department of Health of England performance indicators figure offers validity. The differences between hospitals are not explained by the case-mix control factors, nor are they explained by stroke units selecting only those patients with less severe disease, because the analysis was of all admissions to the hospital. We included most of the variables suggested by Counsell et al\(^7\) as case-mix adjusters after stroke. An exception was socio-economic group, but for that to be relevant would imply that the analysis was of all admissions to the hospital. We included most of the variables suggested by Counsell et al\(^7\) as case-mix adjusters after stroke. An exception was socio-economic group, but for that to be relevant would imply that either stroke unit provision was more likely or stroke was less severe in better-off areas. Importantly, the increased survival does not appear to be associated with an increased disability.

The magnitude of the effect of stroke unit care compared with that provided in other settings from this study in real life is comparable with that found in the Stroke Unit Trialists’ Collaboration\(^1\) (OR, 0.86; 95% CI, 0.71 to 0.94). Using routine hospital data, Jarman et al\(^8\) showed that hospitals with an acute stroke unit were associated with 11% lower odds of death.

These data reinforce the view that if stroke unit care were offered to all patients with stroke in the country, it would have a major impact on stroke survival. In 2002, nearly two-thirds of patients were not managed in a stroke unit.\(^9\) In England and Wales, there are \(\approx 120 000\) first strokes per annum, with a 30% 1-year mortality rate. Thus, 80 000 are being managed on non-specialist wards with 14% to 25% higher mortality rates (Stroke Unit Trialists’ Collaboration\(^1\) and data from this article) than is found in stroke units. This would translate into the potential for between 3500 and 6000 lives to be saved annually by reorganization of care provision in England and Wales.

The precise relationship between the processes of stroke care and outcome require more research, but these data support the government’s stated policy that each hospital should have specialist stroke care. A further round of the Sentinel Stroke audit is being conducted in 2004, and it is anticipated that there will have been significant progress over the past 3 years. However, as a society we should not be satisfied until high-quality stroke unit care is available to all.

Acknowledgments

Thanks to the many organizations and individuals who have participated in the National Sentinel Audit of Stroke 2002. This includes the consortium of funders, comprising The Stroke Association, Boehringer Ingelheim, Merck, Sharp and Dohme, Sanofi-Synthelabo, and Bristol-Myers Squibb, who generously sponsored the Stroke Programme for 2000 to 2002 and made the third round of the National Sentinel Stroke Audit possible.

References


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**TABLE 3. The 7 Process of Care Domains, and Aggregated Summary Indicator of Care Quality for 196 Trusts From England, Wales and Northern Ireland Grouped Into Quartiles According to the Percentage of Patients Admitted to a Stroke Unit.**

<table>
<thead>
<tr>
<th>Characteristics of Quartile</th>
<th>Quartile 1</th>
<th>Quartile 2</th>
<th>Quartile 3</th>
<th>Quartile 4</th>
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<td>26 (13–32)</td>
<td>44 (33–54)</td>
<td>73 (55–100)</td>
</tr>
</tbody>
</table>

**Audit process of care: domain score means**

<table>
<thead>
<tr>
<th>Audit process of care</th>
<th>Quartile 1</th>
<th>Quartile 2</th>
<th>Quartile 3</th>
<th>Quartile 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial patient assessment</td>
<td>64 (52–79)</td>
<td>71 (61–80)</td>
<td>72 (63–85)</td>
<td>79 (69–90)</td>
</tr>
<tr>
<td>Clinical diagnosis</td>
<td>53 (43–63)</td>
<td>56 (42–69)</td>
<td>57 (47–67)</td>
<td>66 (55–80)</td>
</tr>
<tr>
<td>Multidisciplinary assessment</td>
<td>47 (37–67)</td>
<td>50 (35–60)</td>
<td>51 (46–67)</td>
<td>64 (49–77)</td>
</tr>
<tr>
<td>Screening and functional assessment</td>
<td>57 (45–72)</td>
<td>57 (48–66)</td>
<td>62 (50–75)</td>
<td>69 (54–83)</td>
</tr>
<tr>
<td>Management/care planning</td>
<td>48 (32–68)</td>
<td>55 (34–67)</td>
<td>58 (41–65)</td>
<td>63 (52–79)</td>
</tr>
<tr>
<td>Communication with patients and carers</td>
<td>64 (43–75)</td>
<td>61 (54–74)</td>
<td>63 (56–72)</td>
<td>71 (52–86)</td>
</tr>
<tr>
<td>Primary secondary interface</td>
<td>59 (50–78)</td>
<td>57 (44–74)</td>
<td>66 (55–77)</td>
<td>69 (59–87)</td>
</tr>
<tr>
<td>Mean of 10 process standards*</td>
<td>58 (51–62)</td>
<td>58 (52–67)</td>
<td>64 (54–72)</td>
<td>71 (63–78)</td>
</tr>
</tbody>
</table>

*See Materials and Methods section for description of these 10 standards. Body of Table gives site medians and interquartile ranges (IQR) unless stated otherwise. For characteristics of Trust quartiles, see Table 2.
Stroke Unit Care and Outcome: Results from the 2001 National Sentinel Audit of Stroke (England, Wales, and Northern Ireland)
A.G. Rudd, A. Hoffman, P. Irwin, D. Lowe and M.G. Pearson

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