Quality of Care and Patient Outcome in Stroke Units

Is Medical Specialty of Importance?

Marie Louise Svendsen, MHSc,† Lars Holger Ehlers, PhD,†‡ Morten Frydenberg, PhD,§ Annette Ingeman, PhD,* and Søren Paaske Johnsen, PhD**

Background: Specialized stroke unit care improves outcome in stroke patients. However, it is uncertain whether the units should be placed in a neurological or non-neurological (eg, internal medicine or geriatric) setting.

Objectives: To assess whether stroke unit setting (neurological/non-neurological) is associated with quality of care and outcome among patients with stroke, and whether these associations depend on the severity of comorbidity.

Methods: In a nationwide population-based follow-up study, we identified 45,521 patients admitted to stroke units in Denmark between 2003 and 2008. Outcomes were quality of care (whether patients received evidence-based processes of acute stroke care), mortality, length of stay, and readmission. Charlson comorbidity index was used to assess comorbidity, and comparisons were adjusted for patient and hospital characteristics.

Results: Patients admitted to stroke units in neurological settings had higher odds for early antiplatelet therapy (odds ratio, 1.68; 95% confidence interval, 1.10-2.56) and early computed tomographic scan or magnetic resonance imaging (odds ratio, 1.77; 95% confidence interval, 1.29-2.45) compared with patients in non-neurological settings. No other differences were found when studying quality of care and patient outcomes. However, patients with moderate comorbidity admitted to stroke units in neurological settings had higher odds for 1-year mortality, but comparisons across strata of comorbidity were not statistical significant.

Conclusions: Except for early antiplatelet therapy and early computed tomographic scan or magnetic resonance imaging, the medical setting was not associated with differences in processes of acute stroke care and patient outcome. No medical setting related differences were found according to comorbidity, although indications of a worse outcome in patients with moderate comorbidity in neurological settings warrant further investigation.

From the *Department of Clinical Epidemiology, Aarhus University Hospital; †Department of Health Technology Assessment and Health Service Research, Aarhus N; ‡Department of Business Studies, Aalborg University, Aalborg; and §Department of Biostatistics, Aarhus University, Aarhus C, Denmark.

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Reprints: Marie Louise Svendsen, MHSc, Department of Clinical Epidemiology, Aarhus University Hospital, Olof Palmes Allé 43-45, DK-8200 Aarhus N, Denmark. E-mail: mls@dce.au.dk.

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The scientific literature in general suggests better outcomes with specialist care rather than generalists care for a broad range of diseases, and much of the available evidence shows that specialist physicians are able to deliver care of higher quality within the specific area of their specialty.[1] However, the studies have methodological shortcomings such as inadequate adjustment for patient case mix and practice environment.[1] Furthermore, the amount of evidence is limited, in particular in patients with multiple chronic conditions which traditionally is the strength and domain of generalists.[1] Among patients with stroke, several observational studies which were not restricted to stroke units found that patients with stroke are subjected to increased diagnostic testing and use of secondary medical prophylaxis when cared for by neurologists compared with other specialists.[2–6] A number of studies also showed that patients have a reduced risk of death when cared for by neurologists,[2,4,5,7–9] although this was not confirmed in other studies.[3,6,10] However, some studies question whether patients with comorbid disease profit by specialized care. Studies suggest that specialty settings may have inadequate coordination of care for coexisting diseases and that patients with comorbid disease may profit less by specialized treatment than healthier patients.[1,11,12]

On the basis of strong scientific evidence, there is broad consensus among experts that all patients with stroke should be admitted to specialized stroke units for diagnostic workup, treatment, care, and rehabilitation.[13–17] A specialized stroke unit is a hospital department or unit that is exclusively or primarily dedicated to patients with stroke and characterized by multidisciplinary team care.[18] However, several questions still remain with regard to the optimal organization of stroke units.[13,19] Stroke units may be established in department of neurology, geriatric medicine, or general medicine,[19] but the impact of stroke unit setting on quality of care and patient outcome is unknown.[7] Therefore, we examined whether stroke unit setting (neurological vs. non-neurological) is associated with quality of care and outcome among patients with stroke. Outcomes examined were 30-day and 1-year mortality, length of stay (LOS), 30-day readmission, and 30-day death or

readmission. We also examined whether these associations depend on the severity of comorbid disease.

METHODS

This nationwide population-based follow-up study was based on prospectively collected data from Danish medical registries. Since 1968, all Danish residents have been assigned a unique civil registration number which is used in all health databases and permits unambiguous record linkage between databases.[20] The Danish National Health Service provides tax-supported health care for all inhabitants of Denmark, including free access to hospital care.[21] All medical emergencies, including stroke, are exclusively treated at public hospitals.

Data Sources

Patients were identified, and data were obtained from the Danish National Indicator Project (DNIP).[22] Information on vital status was acquired from the Civil Registration System,[20] and information on readmissions and comorbid disease was acquired from the Danish National Registry of Patients.[21]

DNIP was established in 2000 as a nationwide quality improvement project.[22] Participation is mandatory in all hospital units in Denmark treating patients with specific diseases, including stroke (DNIP-stroke).[22] The DNIP-stroke database encompasses data on patient characteristics, including sociodemographic and clinical data, and data on quality of care that indicates whether patients receive specific evidence-based processes of care in the acute phase of stroke. Data are, prospectively, collected on hospital admission as part of daily clinical work by the health care professionals taking care of the patients, using a standardized registration form with data specifications for each item. The Danish Civil Registration System has registered all persons alive and living in Denmark since 1968 and includes daily updated information on vital status.[20] Furthermore, the Danish National Registry of Patients has registered all patients admitted to Danish somatic hospitals since 1977.[21] The database includes information on date of admission and discharge, and discharge diagnoses for each hospitalization through life, classified according to the International Classification of Diseases (eighth revision until December 31, 1993 and 10th revision thereafter).

Patient Population

Patients, 18 years of age or older, are eligible for inclusion in the DNIP-stroke database if they are hospitalized with acute stroke according to the World Health Organization criteria, that is, rapidly developing symptoms and signs of focal or global neurological dysfunction of presumed vascular etiology lasting more than 24 hours or leading to death.[23] Only patients with intracerebral hemorrhage, cerebral infarction, or unspecified stroke are included. We identified 45,884 patients with acute stroke that were first-time registered in the DNIP-stroke database and discharged from a stroke unit in Denmark between January 13, 2003 and December 31, 2007. Patients who were lost to follow-up (n = 304, 0.7%) and patients who were registered as hospitalized for more than 1 year (n = 59, 0.1%) were excluded, leaving a total of 45,521 patients available for analyses. There were 41,876 patients available for the analyses of 30-day readmission and 30-day death or readmission since follow-up started on the day of hospital discharge, and 3645 patients died during hospitalization.

Stroke Unit Setting

Stroke unit setting refers to the medical department in which the stroke unit was established. The medical setting was classified according to the official Danish Classification of Danish Hospitals and Departments which uniquely identifies all Danish hospitals, hospital departments, and hospital units, and includes information on the primary medical specialty of each department/unit.[24] Accordingly, stroke units in neurological settings were located within departments of neurology, some of them also included neurosurgery and neurophysiology. Stroke units in non-neurological settings were located within departments of internal medicine, geriatrics, cardiology, hematology, nephrology, gastroenterology, endocrinology, oncology, respiratory medicine, infectious medicine, and rheumatology.

Processes of Acute Stroke Care

The processes of care covering the acute phase of stroke were identified by a national expert panel including physicians, nurses, physiotherapists, and occupational therapists based on a systematic literature review done in accordance with the methodology used by the Scottish Intercollegiate Guidelines Network.[22,25] The feasibility of collecting the required data in routine clinical settings and the ability of the processes to reflect the multidisciplinary efforts involved in modern stroke care were also considered.

A time frame was defined for each process to capture the timeliness of the interventions. The processes included admission to a stroke unit by the second day of hospitalization (yes/no), initiation of antiplatelet therapy by day 2 (yes/no), initiation of anticoagulant therapy by day 14 (yes/no), computed tomographic (CT) scan or magnetic resonance imaging (MRI) on the day of admission (yes/no), physiotherapy assessment by day 2 (yes/no), occupational therapy assessment by day 2 (yes/no), and assessment of nutritional risk by day 2 (yes/no). Furthermore, overall quality of care was measured as the proportion of received relevant processes of care (0 to 1). Initiation of antiplatelet and anticoagulant therapy was defined as continuous use of the drugs and not merely a single dose. Assessment by a physiotherapist and an occupational therapist was defined as formal bed-side assessment of the patient's need for rehabilitation, and assessment of nutritional risk was defined as assessment following the recommendations of the European Society for Parenteral and Enteral Nutrition.[26] Patients were classified as eligible or ineligible for each individual process of care depending on whether the stroke team identified contraindications, such as gastrointestinal bleeding precluding early antiplatelet therapy and rapid spontaneous recovery of motor symptoms making early

assessment by a physiotherapist irrelevant. Only patients who were considered eligible for the specific process of care were included in the analyses on quality of care. No criteria for thrombolysis were defined, as only 334 patients (0.7%) were treated with tissue plasminogen activator during the study period.

Patient Outcomes

Patients were classified as either dead or alive by 30 days and 1 year after hospital admission. LOS was defined as the time span from hospital admission, or stroke occurrence if already hospitalized, until death or discharge. Any acute readmission with overnight stay (all causes) by 30 days after hospital discharge was considered a readmission.

Covariates

The following patient and hospital characteristics were included as covariates: age, sex, marital status (living with someone, living alone, other form of marital status), housing (own home, nursing home/institution, other form of housing), alcohol intake (women, $\leq$14/>14 drinks per week and men, $\leq$21/>21 drinks per week), smoking habits [daily, occasionally, former (>½ year since quitting), or never], atrial fibrillation, hypertension, Charlson comorbidity index (0, no comorbidity; 1 to 2, low comorbidity; $\geq$3, high comorbidity), Scandinavian stroke scale score (SSS) on admission (0 to 58), stroke subtype (infarction, intracerebral hemorrhage, unspecified stroke), calendar year (2003, 2004, 2005, 2006, 2007), hospital type (university vs. non-university), and departmental patient volume (average number of stroke patients per year). The Charlson comorbidity index quantifies the severity of comorbid disease in a summary score based on the presence or absence of 19 medical conditions.[27] We used an adapted version of the index that uses International Classification of Diseases codes by identifying all hospital diagnoses for each patient from 1994 onward in The Danish National Registry of Patients.[28] The Charlson comorbidity index is a useful score to adjust for comorbid disease in stroke outcome studies.[29] SSS is used to assess stroke severity on admission.[30,31] This scale is a validated and widely-used neurological stroke scale for evaluating the level of consciousness, eye movement, power in arm, hand, and leg, orientation, dysphasia, facial paresis, and gait. SSS can be assessed reliably either face to face or from routine hospital admission records.[32] The study was approved by the Danish Data Protection Agency (J# 2007-41-1297).

Statistical Analysis

Logistic regression was used to obtain odds ratios for the association between stroke unit setting and fulfillment of the individual processes of care, 30-day and 1-year mortality, 30-day readmission, and 30-day death or readmission. Linear regression was applied to examine the association between stroke unit setting and LOS and the proportion of received processes of care. To correct for the right skewness in LOS, a natural log transformation was used. At reporting the final results, the estimates were exponentiated back into the original units and thereby, the ratios between medians of LOS were obtained.[33] In multivariable analyses of patient outcomes, the associations were adjusted for the aforementioned patient (model 1) and patient plus hospital characteristics (model 2). Age, SSS, and departmental patient volume were included as natural cubic splines.[34] All associations were stratified for the severity of comorbid disease (Charlson comorbidity index: no 0, moderate 1 to 2, severe $\geq$3), and differences between the strata were examined using the Wald test.

In all the analyses, we corrected for clustering of patients within stroke units by using robust estimates of the variance derived from the Huber/White/sandwich estimator of variance.[35] Furthermore, as a total of 17,964 patients (39.5%) had missing data on one or more of the patient characteristics (Table 1), we used multiple imputation in all of the multivariable analyses to impute missing values assuming that data were missing at random (Stata command: ice).[36,37] We imputed 5 datasets using the following variables: age, sex, marital status, housing, alcohol, smoking habits, atrial fibrillation, hypertension, SSS, stroke subtype, calendar year, hospital university status, patient volume, stroke unit identifier, proportion of received processes of care, 1-year mortality, 30-day readmission, and an interaction term between stroke unit setting (neurological, non-neurological) and Charlson comorbidity index (0, 1 to 2, $\geq$3).

All of the analyses were performed both with and without the imputed data (complete case analysis). We also did an analysis of the association between stroke unit setting and patient outcome where we further adjusted for the proportion of received processes of care to assess whether differences in acute stroke care mediated any differences in patient outcome between patients admitted to stroke units in neurological and non-neurological settings. Data were analyzed using Stata 10.1 (StataCorp LP, College Station, TX).

RESULTS

Table 1 presents characteristics of the 45,521 patients with stroke according to stroke unit setting and severity of comorbid disease, and shows the original data before multiple imputation was applied. Data were obtained from 22 stroke units in neurological and 35 stroke units in non-neurological settings. In general, patients in neurological settings had a more favorable prognostic profile compared with patients in non-neurological settings. These patients tended to be younger, were less likely to have atrial fibrillation and hypertension, and had less severe strokes. However, more patients in neurological settings suffered from comorbid disease (ie, 69.6% of the patients in neurological settings had moderate or severe comorbid disease compared with 65.1% in non-neurological settings). Table 2 shows some key structural differences between the stroke units in neurological and non-neurological settings. Neurologists were only found in stroke units located in neurological settings, whereas the units located in non-neurological settings were served by general internists, cardiologists, geriatrists, and endocrinologists. Stroke units in neurological settings also tended to have a higher patient volume, easier access to intensive care unit facilities and

were more often located at university hospitals compared with units in non-neurological settings.

Table 3 presents the association between stroke unit setting and processes of acute stroke care, assessed only among patients who were considered eligible for the specific process of care. Overall, patients in neurological settings received more processes of care than patients in non-neurological settings [unadjusted absolute difference in percentage points 5.08; 95% confidence interval (CI), 0.43-9.73]. Patients in neurological settings had higher odds of receiving early antiplatelet therapy [unadjusted odds ratio (OR), 1.68; 95% CI, 1.10-2.56] and early CT or MRI scan (unadjusted OR, 1.77; 95% CI, 1.29-2.45), but differences for the remaining 5 processes of care did not reach statistical significance. The association between stroke unit setting and the processes of care was unrelated to the severity of comorbid disease (data not shown).

According to Table 4, there was no overall association between stroke unit setting and patient outcomes. Patients in neurological settings suffering from moderate comorbid disease did have a statistically significant increased odds for 1-year mortality (adjusted OR, 1.18; 95% CI, 1.02-1.36), but

TABLE 1. Descriptive Characteristics of 45,521 Patients With Stroke According to Stroke Unit Setting (Neurological/Non-neurological) and Severity of Comorbid Disease

	Charlson Comorbidity Index = 0		Charlson Comorbidity Index = 1–2		Charlson Comorbidity Index = ≥ 3	
Characteristic	Neurological n = 9246	Non-neurological n = 5292	Neurological n = 14843	Non-neurological n = 6885	Neurological n = 6268	Non-neurological n = 2987
Age, mean (SD)	67.7 (14.3)	71.1 (13.0)	71.8 (13.2)	73.9 (11.9)	73.7 (11.6)	74.8 (10.9)
Sex, n (%)						
Male	4879 (52.8)	2663 (50.3)	7630 (51.4)	3576 (51.9)	3421 (54.6)	1607 (53.8)
Female	4367 (47.2)	2629 (49.7)	7213 (48.6)	3309 (48.1)	2847 (45.4)	1380 (46.2)
Marital status, n (%)						
Living with someone	5429 (58.7)	2906 (54.9)	7392 (49.8)	3426 (49.8)	2953 (47.1)	1387 (46.4)
Living alone	3348 (36.2)	2184 (41.3)	6299 (42.4)	3048 (44.3)	2715 (43.3)	1375 (46.0)
Other form of marital status	129 (1.4)	100 (1.9)	387 (2.6)	221 (3.2)	224 (3.6)	127 (4.3)
Missing data	340 (3.7)	102 (1.9)	765 (5.2)	190 (2.8)	376 (6.0)	98 (3.3)
Housing, n (%)						
Own home	8198 (88.7)	4755 (89.9)	12448 (83.9)	5899 (85.7)	5000 (79.8)	2460 (82.4)
Nursing home/institution	321 (3.5)	240 (4.5)	996 (6.7)	549 (8.0)	628 (10.0)	334 (11.2)
Other form of housing	179 (1.9)	99 (1.9)	338 (2.3)	132 (1.9)	150 (2.4)	55 (1.8)
Missing data	548 (5.9)	198 (3.7)	1061 (7.2)	305 (4.4)	490 (7.8)	138 (4.6)
Drinks/week, n (%)						
>14 for women and > 21 for men	742 (8.0)	338 (6.4)	1066 (7.2)	430 (6.3)	374 (6.0)	195 (6.5)
≤14 for women and ≤21 for men	7380 (79.8)	4235 (80.0)	11223 (75.6)	5091 (73.9)	4608 (73.5)	2124 (71.1)
Missing data	1124 (12.2)	719 (13.6)	2554 (17.2)	1364 (19.8)	1286 (20.5)	668 (22.4)
Smoking habits, n (%)						
Never	2970 (32.1)	1678 (31.7)	4212 (28.4)	1804 (26.2)	1590 (25.4)	702 (23.5)
Daily	3357 (36.3)	1854 (35.0)	4765 (32.1)	2213 (32.1)	1787 (28.5)	840 (28.1)
Occasionally	154 (1.7)	86 (1.6)	235 (1.6)	106 (1.5)	98 (1.6)	42 (1.4)
Former (>½ y)	1528 (16.5)	869 (16.4)	2681 (18.1)	1346 (19.6)	1293 (20.6)	704 (23.6)
Missing data	1237 (13.4)	805 (15.2)	2950 (19.9)	1416 (20.6)	1500 (23.9)	699 (23.4)
Atrial fibrillation, n (%)						
Yes	896 (9.7)	630 (11.9)	2336 (15.7)	1312 (19.1)	1351 (21.6)	745 (24.9)
No	7798 (84.3)	4462 (84.3)	11273 (76.0)	5249 (76.2)	4348 (69.4)	2097 (70.2)
Missing data	552 (6.0)	200 (3.8)	1234 (8.3)	324 (4.7)	569 (9.1)	145 (4.9)
Hypertension, n (%)						
Yes	3601 (39.0)	2396 (45.3)	6545 (44.1)	3316 (48.2)	3229 (51.5)	1624 (54.4)
No	5059 (54.7)	2621 (49.5)	6882 (46.4)	3079 (44.7)	2387 (38.1)	1154 (38.6)
Missing data	586 (6.3)	275 (5.2)	1416 (9.5)	490 (7.1)	652 (10.4)	209 (7.0)
Scandinavian stroke scale, n (%)						
Mild (45-58)	5683 (61.5)	3172 (59.9)	6897 (46.5)	3274 (47.6)	2470 (39.4)	1208 (40.4)
Moderate (30-44)	1211 (13.1)	874 (16.5)	2428 (16.4)	1434 (20.8)	1139 (18.2)	687 (23.0)
Severe (15-29)	549 (5.9)	457 (8.6)	1374 (9.3)	750 (10.9)	670 (10.7)	361 (12.1)
Very severe (0-14)	485 (5.3)	356 (6.7)	1510 (10.2)	780 (11.3)	747 (11.9)	380 (12.7)
Missing data	1318 (14.3)	433 (8.2)	2634 (17.8)	647 (9.4)	1242 (19.8)	351 (11.8)
Type of stroke, n (%)						
Ischemic	6600 (71.4)	3806 (71.9)	10165 (68.5)	4695 (68.2)	4441 (70.9)	2086 (69.8)
Intracerebral hemorrhage	698 (7.6)	474 (9.0)	1816 (12.2)	767 (11.1)	640 (10.2)	279 (9.3)
Unspecified	1948 (21.1)	1012 (19.1)	2862 (19.3)	1423 (20.7)	1187 (18.9)	622 (20.8)
Year of admission, n (%)						
2003	1290 (14.0)	890 (16.8)	2277 (15.3)	1374 (20.0)	839 (13.4)	504 (16.9)
2004	1695 (18.3)	1167 (22.1)	3110 (21.0)	1534 (22.3)	1223 (19.5)	670 (22.4)
2005	1846 (20.0)	1206 (22.8)	2944 (19.8)	1502 (21.8)	1278 (20.4)	690 (23.1)
2006	2252 (24.4)	1073 (20.3)	3356 (22.6)	1305 (19.0)	1531 (24.4)	559 (18.7)
2007	2163 (23.4)	956 (18.1)	3156 (21.3)	1170 (17.0)	1397 (22.3)	564 (18.9)

TABLE 2. Descriptive Characteristics of Stroke Units in Neurological and Non-neurological Settings

Characteristics	Neurological Setting	Non-neurological Setting
Senior neurologist, n (%)		
Yes	22 (100)	—
No	—	35 (100)
Stroke patients/year*	365 (298-539)	203 (118–282)
ICU in hospital, n (%)		
Yes	22 (100)	21 (60.0)
No	—	14 (40.0)
University hospital, n (%)		
Yes	12 (54.5)	9 (25.7)
No	10 (45.5)	26 (74.3)

*Median (interquartile range).
ICU indicates intensive care unit.

the differences between the individual strata of comorbid disease did not reach statistical significance. Table 4 also shows that adjustment for patient characteristics (model 1) and hospital characteristics (model 2) had considerable impact in the analyses on mortality and LOS, whereas the odds estimates remained virtually unchanged when adjustment was also made for the proportion of received processes of care (data not shown). Complete case analysis (without the imputed data) yielded, in general, the same results as shown in Table 4 and showed no apparent association between stroke unit setting and patient outcome (data not shown).

DISCUSSION

We found no evidence that stroke units in neurological and non-neurological settings overall differ with regard to a broad range of essential processes of acute stroke care and patient outcome. Neurological stroke unit setting was, however, positively related to receiving antiplatelet therapy and CT or MRI scan in the early phase of stroke.

Stroke care requires expertize from several medical fields, including neurology, vascular medicine, internal medicine, and rehabilitation medicine, and it has been widely debated who should treat patients with stroke.[38] Our study suggests that stroke units encompass the required medical expertize since we found no difference in several essential processes of acute stroke care and patient outcome between neurological and non-neurological stroke unit settings. Stroke units are characterized by intensive stroke specialization through continuous education of the staff and a well-established clinical practice, including the use of CT or MRI scan and multidisciplinary rehabilitation,[18,19] and these characteristics may be among the components that diminish the potential basic differences between the primary medical specialties in stroke units. Nevertheless, this study did indicate that not only clinical and sociodemographic characteristics, but also health service characteristics may be important in relation to the prognosis of stroke, as adjustment for hospital characteristics, including departmental patient volume and hospital university status, had considerable impact in the analyses on mortality and LOS.

Strengths and Limitations

The main strength of this study lies in its prospective population-based design with almost complete follow-up and therefore, low risk of selection and information bias. By using multiple imputation to impute missing values, we also limited the risk of bias from missing data,[37] and our results were further confirmed by a complete case analysis.

As this is an observational study, results may be affected by unaccounted confounding or residual confounding. However, several precautions were taken to minimize the impact of possible confounding. We adjusted for a wide range of known prognostic factors, including age, atrial fibrillation, and initial stroke severity.[39–42] Furthermore, only patients considered eligible for care were included in analyses of the individual processes of care, minimizing the risk of confounding by indication. We also corrected for clustering of patients within stroke units, thereby taking into account unmeasured characteristics of the stroke units that may be associated with outcome. LOS represented a specific problem, as both acute stroke units and comprehensive

TABLE 3. Stroke Unit Setting (Neurological/Non-neurological) and Processes of Acute Stroke Care

Process of Care	Neurological Setting	Relevant Patients, n*	Process of Care Received, %	Unadjusted OR (95% CI)†
Stroke unit (by day 2)	Yes	30352	91.9	1.47 (0.84–2.59)
	No	15161	88.5	
Antiplatelet therapy (by day 2)	Yes	19223	84.3	1.68 (1.10–2.56)
	No	9876	76.1	
Anticoagulant therapy (by day 14)	Yes	2341	57.8	0.73 (0.46–1.18)
	No	1481	65.1	
CT/MRI scan (by day 1)	Yes	29286	56.8	1.77 (1.29–2.45)
	No	14891	42.5	
Physiotherapy (by day 2)	Yes	23939	60.0	0.89 (0.65–1.23)
	No	13580	62.7	
Occupational therapy (by day 2)	Yes	24104	54.7	0.86 (0.66–1.11)
	No	13511	58.4	
Nutritional assessment (by day 2)	Yes	21520	61.8	1.35 (0.97–1.86)
	No	11796	54.6	

*Patients who were considered eligible for the specific process of care.
†95% CIs were calculated using robust estimates of the variance that allowed for clustering of patients within stroke units.
CI indicates confidence interval; CT, computed tomography; MRI, magnetic resonance imaging; OR, odds ratio.

TABLE 4. Stroke Unit Setting (Neurological/Non-neurological) and Patient Outcome According to the Severity of Comorbid Disease

	Neurological Setting	Study Population, n	Events, P*	Unadjusted Ratio (95% CI)†	Adjusted Ratio (95% CI), Model 1†‡	Adjusted Ratio (95% CI), Model 2†§	P
30-day mortality	Yes	30357	9.7	0.96 (0.82–1.14)	1.00 (0.85–1.18)	1.12 (0.89–1.40)	
	No	15164	10.0				
Charlson comorbidity index = 0	Yes	9246	4.7	0.79 (0.62–1.01)	0.97 (0.76–1.23)	1.06 (0.81–1.40)	0.38
	No	5292	5.9				
Charlson comorbidity index = 1-2	Yes	14843	10.3	0.98 (0.80–1.19)	1.06 (0.88–1.29)	1.19 (0.92–1.54)	
	No	6885	10.5				
Charlson comorbidity index = ≥ 3	Yes	6268	15.6	0.95 (0.79–1.14)	0.93 (0.77–1.12)	1.04 (0.82–1.32)	
	No	2987	16.3				
1-year mortality	Yes	30357	20.9	0.95 (0.84–1.07)	1.02 (0.92–1.13)	1.10 (0.98–1.24)	
	No	15164	21.8				
Charlson comorbidity index = 0	Yes	9246	10.4	0.77 (0.65–0.92)	0.94 (0.81–1.09)	1.01 (0.87–1.18)	0.16
	No	5292	13.0				
Charlson comorbidity index = 1-2	Yes	14843	21.9	0.96 (0.84–1.08)	1.09 (0.96–1.23)	1.18 (1.02–1.36)	
	No	6885	22.7				
Charlson comorbidity index = ≥ 3	Yes	6268	34.1	0.94 (0.81–1.08)	0.97 (0.83–1.12)	1.04 (0.89–1.22)	
	No	2987	35.6				
Length of stay	Yes	30357	—	0.68 (0.51–0.89)	0.71 (0.55–0.91)	0.86 (0.64–1.15)	
	No	15164	—				
Charlson comorbidity index = 0	Yes	9246	—	0.62 (0.49–0.80)	0.68 (0.54–0.85)	0.85 (0.66–1.10)	0.32
	No	5292	—				
Charlson comorbidity index = 1-2	Yes	14843	—	0.69 (0.51–0.92)	0.71 (0.55–0.93)	0.86 (0.63–1.17)	
	No	6885	—				
Charlson comorbidity index = ≥ 3	Yes	6268	—	0.71 (0.52–0.98)	0.74 (0.55–0.99)	0.87 (0.64–1.20)	
	No	2987	—				
30-day readmission	Yes	27986	8.5	1.04 (0.90–1.21)	1.02 (0.88–1.18)	1.03 (0.91–1.15)	
	No	13890	8.2				
Charlson comorbidity index = 0	Yes	8893	5.2	0.91 (0.74–1.12)	0.91 (0.75–1.11)	0.91 (0.77–1.07)	0.11
	No	5026	5.6				
Charlson comorbidity index = 1-2	Yes	13613	9.2	1.07 (0.90–1.28)	1.44 (1.20–1.72)	1.08 (0.94–1.24)	
	No	6289	8.6				
Charlson comorbidity index = ≥ 3	Yes	5480	12.4	1.01 (0.84–1.22)	1.01 (0.85–1.21)	1.02 (0.86–1.22)	
	No	2575	12.3				
30-day death or readmission	Yes	27986	11.8	1.02 (0.89–1.17)	1.03 (0.91–1.16)	1.04 (0.93–1.16)	
	No	13890	11.6				
Charlson comorbidity index = 0	Yes	8893	6.7	0.88 (0.73–1.06)	0.92 (0.77–1.09)	0.92 (0.78–1.09)	0.13
	No	5026	7.6				
Charlson comorbidity index = 1-2	Yes	13613	12.6	1.04 (0.89–1.21)	1.08 (0.93–1.25)	1.10 (0.95–1.26)	
	No	6289	12.2				
Charlson comorbidity index = ≥ 3	Yes	5480	17.9	1.01 (0.85–1.19)	1.03 (0.88–1.20)	1.04 (0.90–1.21)	
	No	2575	17.8				

*The median length of stay was 6 days (interquartile range, 3 to 14) in neurological settings and 10 days (interquartile range, 5 to 22) in non-neurological settings.

†95% CIs were calculated using robust estimates of the variance that allowed for clustering of patients within stroke units.

‡Ratio between medians if length of stay, and odds ratio otherwise. Adjusted for age, sex, marital status, housing, alcohol intake, smoking habits, Charlson comorbidity index (except for the stratified analyses), atrial fibrillation, hypertension, Scandinavian stroke scale score by admission, stroke subtype, and calendar year.

§Further adjusted for hospital university status and departmental patient volume in addition to model 1.

CI indicates confidence interval.

stroke units (ie, units covering both the acute and rehabilitation phase) were included in the study. Some inherent variation in LOS between the departments could therefore be expected, but this variation was found among units in both neurological and non-neurological settings and was therefore unlikely to explain the relative differences in LOS. Another potential weakness of the study lies in the risk of misclassification because data were collected in routine clinical settings. However, DNIP regularly carries out structured audit processes on a national, regional, and local basis to ensure the validity of the data.[22]

Comparison With Other Studies

To best of our knowledge, this study is the first to specifically address the association between stroke unit setting and timely evidence-based care. However, our findings are in accordance with a number of follow-up studies, not restricted to stroke units. These studies found that stroke patients seen by neurologists are more likely than those not seen by neurologists to receive diagnostic tests, including MRI scan, and secondary medical prophylaxis, including ticlopidine, warfarin, heparin, and heparinoid.[2–6,12] Furthermore, a number of studies found that stroke patients have better survival when cared for by neurologists compared with other specialists,[2,4,5,8,9] but not all studies confirm such association.[3,6,10] Only 1 other study has specifically addressed the relationship between the medical specialty in stroke units and patient outcome.[7] This Italian follow-up study of 11,572 patients with acute stroke found no difference in the risk of death or disability whether or not stroke units had neurological beds only (OR, 0.88; 95% CI, 0.55-1.39), but the study did find a reduced risk of death and disability in conventional wards with only neurological beds (the wards had no beds or staff dedicated to stroke patients) (OR, 0.64; 95% CI, 0.55-0.75). The study was limited by including only 31 stroke units and making incomplete or no adjustment for potential important confounding factors, such as stroke severity and comorbid disease. Even so, our study supports their findings, that is, that stroke unit setting has no overall association with patient outcome.

Only few other studies have focused on the relationship between specialization of hospital care and comorbid disease, and these studies suggest that patients with comorbid disease profit less by specialized treatment than healthier patients.[2,11,12] A study on patients undergoing coronary artery bypass graft surgery showed that patients with comorbid disease experienced worse 30-day post discharge mortality when treated at cardiac specialty hospitals compared with patients treated at less specialized hospitals.[11] In contrast, there was no association between specialization and mortality among healthier patients. Furthermore, a study on patients with stroke showed that patients with atrial fibrillation had worse survival when cared for on neurology services compared with general services, whereas patients without atrial fibrillation had better survival when cared for on neurology services.[12] Another study on stroke patients showed that patients in neurology services compared with general services had increased risk of rehospitalization with heart disease.[2] Although we were unable to show any statistically significant differences between patients with no, moderate, and severe comorbid disease, our results did indicate a potentially worse outcome among patients with moderate comorbid disease. These results may be chance findings, but it cannot be ruled out that stroke patients with moderate comorbid disease are not treated optimally in specialized neurological settings. Further studies appear warranted to further clarify this issue.

In conclusion, neurological stroke unit setting was positively related to receiving antiplatelet therapy and CT or MRI scan in the early phase of stroke. The medical setting was, however, not associated with any other substantial differences in essential processes of acute stroke care and patient outcome. No medical setting related differences were found according to comorbidity, but indications of a worse outcome among patients with moderate comorbid disease treated in neurological stroke unit settings warrant further investigation.

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