International Comparison of Poststroke Resource Use: A Longitudinal Analysis in Europe

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Background: Long-term costs often represent a large proportion of the total costs induced by stroke, but data on long-term poststroke resource use are sparse, especially regarding the trajectory of costs by severity. We used a multinational longitudinal survey to estimate patterns of poststroke resource use by degree of functional disability and to compare resource use between regions. *Methods:* The Survey of Health, Ageing and Retirement in Europe (SHARE) is a multinational database of adults 50 years and older, which includes demographic information about respondents, age when stroke first occurred, current activity of daily living (ADL) limitations, and health care resource use in the year before interview. We modeled resource use with a 2-part regression for number of hospital days, home nursing hours, and paid and unpaid home caregiving hours. *Results:* After accounting for time since stroke, number of strokes and comorbidities, age, gender, and European regions, we found that poststroke resource use was strongly associated with ADL limitations. The duration since the stroke event was significantly associated only with inpatient care, and informal help showed significant regional heterogeneity across all ADL limitation levels. *Conclusions:* Poststroke physical deficits appear to be a strong driver of long-term resource utilization; treatments that decrease such deficits offer substantial potential for downline cost savings. Analyzing internationally comparable panel data, such as SHARE, provide valuable insight into long-term cost of stroke. More comprehensive international comparisons will require registries with follow-up, particularly for informal and formal home-based care. **Key Words:** Poststroke resource utilization—long-term care services—regional heterogeneity—SHARE—2-part model—stroke registry.
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Introduction

The value of stroke prevention and treatment strategies depends not only on the nature of the acute event and the effectiveness of the intervention but also on the type and volume of resources used. Such economic evaluations typically take the form of cost-effectiveness analyses, a foundation for clinical and policy decision making. Costs relevant to economic evaluations include short-term costs (eg, acute hospitalization) and long-term costs (eg, rehabilitation, nursing home, and home-based services).[1] The economic case for interventions that reduce stroke severity is based on the extent to which the therapies reduce institutional and home-based long-term care costs. If not cost saving, even treatments that are modestly effective in reducing stroke severity can be cost effective.[2]

Although long-term costs often represent a large proportion of the total costs induced by stroke,[3] data on long-term poststroke resource use are sparse, especially regarding the trajectory of costs by severity. Longitudinal studies, which are ideal for assessing long-term stroke costs, can be difficult and expensive.[4] Moreover, resource use is highly variable, often reflecting idiosyncratic regional patterns based on clinical training, resource availability, and reimbursement.[1,5,6] Because policy decisions are often local, resource-use studies should capture this diversity by addressing issues of regional variations.[7]

This article aims to quantify the estimated poststroke utilization of inpatient and home-based services as a function of disability and European regions, using the first 2 waves' data of Survey of Health, Ageing and Retirement in Europe (SHARE)[8] and to contribute to the current understanding of long-term resource utilization for stroke by projecting and comparing the resource-use patterns in Europe.

Methods

Data Source and Study Population

Our study population was chosen from the respondents of the first 2 waves (wave 1 in 2004/2005 and wave 2 in 2006/2007) of the SHARE, which is a cross-national longitudinal survey of individuals dwelling in the community aged at least 50 years on their health, socioeconomic status, and social and family networks (n = 62,127). SHARE is notably consistent with the US Health and Retirement Study and the English Longitudinal Study of Ageing.[8]

We selected respondents who answered affirmatively to the question of whether a doctor had ever told respondents that they had a stroke or cerebral vascular disease no longer than 5 years from the interview date in both waves and excluded permanent nursing home residents. We focused on service utilization over a 5-year period since the last stroke episode as we assumed that utilization would have plateaued over this period.[9] When the respondents who were interviewed in both waves reported that they had another stroke event between the 2 interviews, we updated their stroke status in wave 2 to capture all stroke events (n = 1256); 37% of our study sample responded to wave 1 only, 46% responded to both waves, and 17% were wave 2 newcomers. We did not include Israeli respondents (n = 2598) because they did not fit into European regional categories. This study was approved by Ethics Committee of the National University of Singapore.

Outcome Variables

SHARE records information on frequency and length of inpatient stay and intensity of home-based care for the year preceding the survey. We generated 4 outcome measures of monthly health care utilization: number of days spent in hospital, hours of paid home nursing, hours of paid home help, and hours of informal help from family members and someone outside the household. We assumed that these health care services were continuously used in the previous year.

We imputed missing values for frequency among users based on linear regression models, and in total, 10 observations for inpatient care, 12 for paid home nursing, 8 for paid home help, and 51 for informal help were replaced with the fitted values of the models.

Explanatory Variables

Two main variables of interest are severity of activity of daily living (ADL) limitations and geographical regions in Europe. The participants were asked if they have any difficulties that would last longer than 3 months for each item on the Katz scale of ADL.[10] Severity of ADL limitations was categorized into 3 levels to approximate the modified Rankin Scale (mRS)[11]: none (mRS score 0-1), moderate (mRS score 2-3), and severe (mRS score 4-5). An individual who has difficulties walking across a room, bathing, eating, or using the toilet is classified as having severe ADL limitations. An individual who does not have difficulties in the earlier mentioned 4 activities but has difficulties in dressing or getting in and out of bed is classified as having moderate ADL limitations. An individual who does not have difficulties in any of the 6 activities is classified as having no ADL limitations. The countries participated in SHARE for waves 1 and 2 were categorized into 3 geographical regions: Northern (Sweden, Denmark, and Ireland), Central (Austria, Germany, The Netherlands, France, Switzerland, Belgium, Czech Republic, and Poland), and Southern (Spain, Italy, and Greece) Europe.[12]

Another important variable is the number of years since stroke occurred, which we defined as the number of years between the year of the most recent stroke episode and the interview date. We assumed that strokes

had occurred in the middle of their year of age, and for individuals who reported having had a stroke in the same year of age as when they were interviewed, we assumed that the stroke occurred midway through that year.

We also controlled for the number of comorbidities (heart attack, hypertension, high blood cholesterol, diabetes, chronic lung disease, asthma, arthritis, osteoporosis, cancer, stomach or duodenal ulcer, Parkinson disease, cataracts, hip or femoral fracture, other fractures, Alzheimer disease, dementia, senility, and benign tumor). Number of stroke events was also included in the model and age and gender.

Multivariate Statistical Analyses

We modeled each outcome variable with a 2-part regression approach. We applied generalized estimating equations to both parts to account for the longitudinal nature of the data using the exchangeable variance–covariance structure (except for paid home nursing where observations had to be assumed independent in the second part of the model because of insufficient sample size). The first part was specified as a logistic regression for the probability of using any resources and the second as a log-gamma regression for the number of units used by the users. We included all covariates described earlier in both parts of the model. After estimating the model coefficients, we computed the overall marginal effect (or incremental effect for binary variables) that each covariate has on average utilization. Note that our calculations account for the effect that each covariate has both on the likelihood of using any care and on the amount of care used when there is utilization. Furthermore, we computed similar marginal effects for each European region with the only difference being that we aggregated the moderate and severe ADL limitations categories to gain in statistical power for the estimation of interactions terms between ADL limitations and European regions. Finally, we computed the standard error of each marginal effect by bootstrapping with 1000 repetitions.

Analyses were performed in Stata, v.13 (StataCorp, College Station, TX). Statistical significance was set at P value less than .05.

Results

Sixty percent of our study sample resided in Central Europe, and the rest of the population was balanced between Northern (21%) and Southern Europe (19%; Table 1). The average duration since stroke was 25.9 months; it was similar across all the regions (P value = .983); 30.2% of our study population had moderate ADL limitations; 6.6% had severe ADL limitations. About 6% of the study population had more than 1 stroke at the interview date, which was relatively homogenous across all regions (P value = .191). Other sample statistics are further described in Table 2.

After accounting for the probability of service use and its intensity, we found that greater functional dependence would require a considerable increase in consumption of poststroke resource across all health services analyzed. Compared with those without any limitations, those

Table 1. *Baseline characteristics of study population*

Different regions in Europe	Northern Europe (n = 263)	Central Europe (n = 751)	Southern Europe (n = 242)	Total population (n = 1256)
Number of respondents				
Wave 1 only	37.26	36.09	38.84	36.86
Waves 1 and 2	47.91	43.41	52.07	46.02
Wave 2 only	14.83	20.51	9.09	17.12
Age	71.41 ± 11.17 [47.83, 94.92]	70.87 ± 10.60 [46.17, 96.75]	73.60 ± 9.40 [51.83, 96.83]	71.51 ± 10.56 [46.17, 96.83]
Years since stroke	2.17 ± 1.32	2.16 ± 1.36	2.16 ± 1.32	2.16 ± 1.34
ADL limitations				
No	72.24	62.72	54.96	63.22
Moderate	24.71	32.72	29.75	30.18
Severe	3.04	5.06	15.29	6.61
Number of comorbidities	2.44 ± 1.60	2.36 ± 1.67	2.53 ± 1.90	2.41 ± 1.70
Number of strokes				
1	92.78	94.94	92.15	93.95
2+	7.22	5.06	7.85	6.05
Gender				
Female	42.21	49.80	49.59	48.17
Male	57.79	50.20	50.41	51.83

Abbreviation: ADL, activity of daily living.
Categorical data are presented as percentage of respondents. Continuous data are presented as median and range in brackets.

Table 2. *Monthly health care utilization of study population*

Different regions in Europe	Northern Europe	Central Europe	Southern Europe	Total population
Hospital days	.61 ± 2.22 [0, 25.67]	.80 ± 2.25 [0, 30]	.78 ± 1.84 [0, 16.67]	.76 ± 2.17 [0, 30]
n	262	751	240	1253
(Nonzero utilization)	1.56 ± 3.36 [.08, 25.67]	2.05 ± 3.22 [.08, 30]	2.02 ± 2.50 [.08, 16.67]	1.94 ± 3.13 [.08, 30]
n	102	293	93	488
Paid home nursing hours	1.06 ± 7.96 [0, 112.67]	4.19 ± 24.19 [0, 373.33]	6.94 ± 55.48 [0, 733.09]	3.96 ± 30.26 [0, 733.09]
n	251	639	196	1086
(Nonzero utilization)	14.78 ± 26.76 [.42, 112.67]	24.55 ± 54.33 [.83, 373.33]	48.58 ± 141.90 [.08, 733.09]	27.76 ± 76.06 [.08, 733.09]
n	18	109	28	155
Paid home help hours	5.87 ± 47.50 [0, 728]	4.85 ± 24.22 [0, 373.33]	10.28 ± 72.60 [0, 728]	6.06 ± 42.62 [0, 728]
n	251	639	196	1086
(Nonzero utilization)	27.77 ± 101.13 [.17, 728]	28.71 ± 52.97 [.08, 373.33]	111.89 ± 220.06 [1.33, 728]	36.79 ± 99.67 [.08, 728]
n	53	108	18	179
Informal help hours	5.42 ± 19.53 [0, 134.58]	31.48 ± 113.48 [0, 1460]	77.30 ± 252.23 [0, 2575]	33.68 ± 139.36 [0, 2575]
n	203	546	159	908
(Nonzero utilization)	22.01 ± 34.63 [.45, 134.58]	87.25 ± 175.83 [.37, 1460]	215.62 ± 386.20 [.40, 2575]	100.59 ± 226.67 [.37, 2575]
n	50	197	57	304

Data are presented as median and range in brackets.

with severe ADL limitations spent, on average, 1.45 more days in the hospital, used 14.86 more hours of paid home nursing, and required 100 more hours of informal help per month. The predicted number of hours for paid home nursing and paid home help was similar among individuals with moderate and severe ADL limitations. Note that for home help, the increase in paid hours resulting for severe ADL limitations (10.98, P value = .119) is not statistically significant, whereas the effect of moderate ADL limitations (10.57, P value<.001) is strongly significant. The former result is likely because of the reduced statistical power caused by the small percentage of respondents with severe ADL limitations in our sample not to the absence of effects from severe ADL limitations on utilization of paid home help. On the other hand, the difference in the predicted magnitude of inpatient care and informal help utilization was more distinct between moderately and severely impaired respondents; respondents with severe ADL limitations would use informal care (100.01, P value = .001) approximately 3 times more than those with moderate ADL limitations (39.96, P value <.001), for instance.

Poststroke resource utilization was not statistically significantly associated with regions except for informal help (P value <.001). Compared with Northern Europeans, Central and Southern Europeans, respectively, use 31.3 (P value <.001) and 60.0 (P value<.001) more hours of informal help.

The number of strokes and comorbidities and the duration since the stroke were significantly associated with inpatient care only (P value <.001). An increase in the number of years since the stroke predicted a decrease in the number of days spent in hospital across all ADL limitation levels (Fig 1). Our results show that for each additional year since the stroke event, hospital use decreases by .31 (P value <.001) days per month on average (Table 3). Greater age only significantly affects the utilization of paid home help and informal care. As for gender, our results showed that women used significantly less paid home nursing, paid home help, and informal help.

Finally, to analyze regional heterogeneity in the marginal effects of ADL limitations on health services utilization, we combined the moderate and severe ADL limitation groups into an aggregated group of stroke survivors with any ADL limitation and compared it with those with no ADL limitations (Table 4). Only the utilization of informal help showed regional heterogeneity in the effect of ADL limitations (P value = .0159), with Southern Europeans using far more home-based care than the Northern and Central Europeans as a result of poststroke disability.

Discussion

In this study, we primarily found that poststroke resource use across all European regions was positively

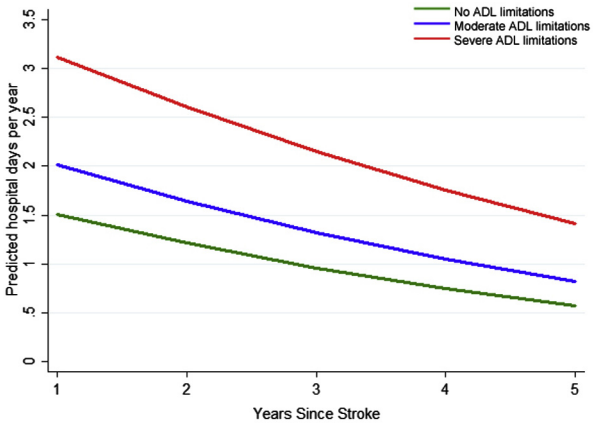

Figure 1. *Trajectory of predicted yearly hospital utilization by ADL. The duration since the stroke event was significantly associated with inpatient care only (P value <.001), and the trajectory of poststroke inpatient care utilization at each level of ADL limitation (green: no ADL limitations; blue: moderate ADL limitations; red: severe ADL limitations) is plotted against the number of years since the stroke. Abbreviation: ADL, activity of daily living.*

and strongly associated with the level of ADL limitations with patients' demographic information and the type of acute and/or subacute treatment received; several studies in the countries participating in SHARE have highlighted the effect of functional disability on poststroke resource utilization. A cohort study of stroke patients in the Netherlands found that one of the most important determinants for medical cost was patient's disability status,[13] and similar studies in Spain[14] and Denmark[15] confirmed the general trend of worsening of one's functional status associated with an increase in poststroke resource utilization. Besides these studies, there are a number of extensive economic reviews on poststroke cost in Europe have been conducted, which have studied the factors associated with resource utilization among stroke survivors.[16,17]

In addition to illustration of this well-perceived trend, we quantified the effect of poststroke physical limitations on long-term resource utilization among stroke survivors. Stroke survivors with severe functional disabilities were predicted to stay in the hospital 3 times longer than those with moderate functional disabilities (Table 3). Also, more functional deficits resulted in significantly higher number of informal caregiving hours. Thus, proper interventions with stroke patients during the acute phase of the disease that would decrease such deficits may offer substantial downline cost savings. This may be especially true in regions such as Northern Europe where paid poststroke resource use is relatively high.[18] Together, these findings reinforce the importance of focusing on disability level as an important clinical and policy target.

Among those with ADL limitations, regional differences in informal help utilization were observed. In contrast to Northern and Central Europeans, Southern Europeans tend to use home-based service (unpaid and paid) more readily than inpatient service. Our results uphold the extant North–South gradient of family dynamics in Europe; the Scandinavian countries generally have the least traditional family structure, whereas the Southern European countries present the culture of strong family responsibilities, for instance, where family members are expected to supply caregiving, with the other continental countries lying somewhere in between.[9,10] In this cultural context, it will be worthwhile to investigate on more tailored policies targeting the carers of stroke survivors since the projected number of informal caregiving hours among those with severe functional deficits was more than twice longer than among those with fewer functional deficits (Table 3). On the other hand, other potential explanation of this phenomenon lies in different formal care structures in Europe. Informal care is more widespread and formal services are funded less in

Table 3. *Predicted poststroke monthly resource utilization*

Different resource types	Hospital (d)	Paid home nursing (h)	Paid home help (h)	Informal help (h)
ADL limitation				
Moderate	.45* [.17, .72]	10.66 [−1.16, 22.49]	10.57† [4.89, 16.25]	39.96* [22.75, 57.18]
Severe	1.45† [.68, 2.22]	14.86 [5.13, 24.60]	10.98 [−2.83, 24.78]	100.01† [39.02, 161.00]
Geographical regions				
Central Europe	.15 [−.19, .49]	3.33 [−4.82, 11.49]	1.46 [−2.09, 5.01]	31.30† [17.69, 44.91]
South Europe	−.09 [−.42, .24]	10.26 [−22.88, 43.39]	14.45 [−5.31, 34.21]	60.02† [28.38, 91.66]
Years since stroke	−.31† [−.43, −.20]	−1.19 [−2.48, .10]	1.51 [−.14, 3.16]	1.46 [−4.09, 7.00]
Number of comorbidities	.08* [.03, .13]	.29 [−.50, 1.07]	.67 [−.20, 1.54]	2.77 [−1.57, 7.10]
Number of strokes	−.56* [−.94, −.19]	−2.46 [−7.63, 2.71]	1.73 [−4.52, 7.99]	14.05 [−20.73, 48.82]
Age	.00 [−.01, .01]	.12 [−.04, .29]	.40† [.17, .62]	1.08* [.36, 1.80]
Female	.16 [−.06, .37]	−4.73‡ [−9.19, −.27]	−5.20* [−8.86, −1.54]	−26.02* [−42.31, −9.74]
n			1086	

Abbreviation: ADL, activity of daily living.
*P value <.01.
†P value <.001.
‡P value <.05.

Table 4. *Region-specific predicted poststroke monthly resource utilization: no ADL limitations versus any ADL limitations*

Different resource types	Hospital (d)	Paid home nursing (h)	Paid home help (h)	Informal help (h)
Northern Europe	.57 [−.06, 1.21]	6.10‡ [1.99, 10.21]	13.64* [5.25, 22.04]	22.65* [5.69, 39.60]
Central Europe	.71† [.36, 1.07]	10.44† [5.62, 15.25]	9.94† [5.48, 14.40]	41.68† [21.93, 61.44]
Southern Europe	.42‡ [.03, .81]	15.76‡ [.25, 31.26]	27.82‡ [4.94, 50.71]	107.08* [44.97, 169.18]
P value	.5231	.2191	.2208	.0159
n	1253	1086	1086	908

Abbreviation: ADL, activity of daily living.
*P value $<.01$.
†P value $<.001$.
‡P value $<.05$.

Central and Southern European countries than in the Northern European countries, which provide well-organized formal care.[19] Thus, stroke patients with severe functional disabilities in Northern Europe are more likely to be institutionalized, which resulted in exclusion from the SHARE sample population.

Our work has limitations. Because of the lack of high-quality data on poststroke resource use from clinical sources, we used a self-reported population-based survey data, which is often prone to heterogeneity and selection bias. To control for this, objective measures of health status (ie, functional disability or comorbidities) would need to be included in our analysis; however, such measures were unavailable in SHARE. Although a self-reported population-based survey is a less-than-ideal means of controlling for health status and needs, the data used in our analysis came only from stroke patients, who are likely to share similar risk factors. These limitations highlight the need to conduct a high-quality, clinical counterpart of SHARE, that is, a study for which data are not self-reported but obtained by more objective means. For example, the establishment of a relational database (ie, stroke registry for Europe) in which stroke patients' clinical and social needs are measured regularly would provide the data necessary for more detailed economic analyses and regional policy formulation.[20] Also, it is possible to conduct regional longitudinal collection of clinical and health care services utilization data with standardized metrics.[21]

In addition, the lack of sufficient data on nursing home care in SHARE weakens our predictions of poststroke long-term resource utilization. Our results are only potentially generalizable to stroke survivors living in the community with similar stroke characteristics. Given the general purpose of SHARE and that the different prevalence of institutions for elderly in Europe, it was desirable to include individuals living in institutions for elderly. However, it was possible in only few countries.[22,23] We identified 23 permanent nursing home residents who had a stroke within the last 5 years from the interview date in the first 2 waves. In comparison with our study population, 39.1% and 43.5% of nursing home residents had moderate and severe ADL limitations, respectively. Almost half of this cohort was Northern Europeans (52.2%), whereas only 4.4% of them were from Southern Europe. This marked difference of regional distribution between informal care and nursing home care was expected because nursing home care constitutes a large share of the health care and social care sectors in most European countries. Although it was found that informal care could substitute for nursing home care,[19] it is still challenging to accurately assess poststroke long-term resource expenditure based on informal care utilization. This challenge can be mitigated by linking databases, such as SHARE with databases of nursing home residents assessed by standardized metrics (eg, InterRAI instrument for Long Term Care Facilities).[24,25] These limitations reinforce that scarcity of data on long-term poststroke resource use, especially regarding the trajectory of costs by severity, and the need for a multinational stroke registry that captures both short- and long-term health care expenditures in various care settings.[23]

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