There is marked social inequality with regard to risk for stroke, disfavoring people with low socioeconomic position.\textsuperscript{1-3} As patients with stroke in lower socioeconomic groups have more severe strokes and more comorbid conditions, higher poststroke mortality would also be expected.\textsuperscript{4} Yet, it is still unclear whether such an association exists. Low socioeconomic position was associated with higher mortality after a stroke in some studies,\textsuperscript{5-12} whereas in others no\textsuperscript{13-17} or only a partial association\textsuperscript{18-22} was found. Variations among the studies in design, measures of socioeconomic position, healthcare system organization, demography, stroke severity, and comorbidity may explain the inconsistencies.

The aim of this investigation was to determine whether socioeconomic position is associated with death after a stroke.

Materials and Methods
All patients from the Danish Stroke Register >40 years of age were included. Information on stroke outcome was obtained from the Danish Stroke Register, as described in detail elsewhere.\textsuperscript{23,24} Danish hospitals are obliged to report a predefined set of data to the register for all patients admitted for acute stroke, including age, sex, stroke severity on admission measured on the Scandinavian Stroke Scale,\textsuperscript{25} stroke subtype, and a cardiovascular profile. The Scandinavian Stroke Scale is a validated neurological scale of stroke severity from 0 to 58, lower scores indicating more severe strokes.\textsuperscript{26} Ischemic stroke was distinguished from hemorrhagic stroke by computed tomography or magnetic resonance scanning. The cardiovascular profile included information on alcohol consumption (≤14/21 and >14/21 drinks/wk for women and men, respectively, corresponding to under/over the limit set by the Danish National Board of Health), current daily smoking, body mass index, diabetes mellitus, atrial fibrillation (chronic or paroxystic), arterial hypertension, previous myocardial infarction, previous stroke, and intermittent arterial claudication. In March 2012, the recommended limit for alcohol intake was lowered to 7 drinks/wk for women and 14 for men. Diseases were diagnosed on current Danish standards\textsuperscript{27} and were either known before the onset of stroke or diagnosed during hospitalization. Stroke was defined according to the World Health Organization criteria.\textsuperscript{26}

We included only patients with no record of previous stroke. For all people in the study population, we obtained information on highest level of attained education and disposable income from national registries.\textsuperscript{27} Information on education and disposable income of the study cohort was obtained by data linkage to the population-based Integrated Database for Labor Market Research in Statistics Denmark, which contains yearly data for the study period.
Information on education and disposable income were derived by linkage with the central population register, the taxation authorities, the register for education statistics, the register relating to unemployment, and a register of all companies with >1 employee. For all persons in the study population, we obtained information at the individual level the year before diagnosis. Information on income of all family members was obtained to estimate family income. Disposable income was defined as household income after taxation and interest per person, adjusted for number of persons in the household and deflated according to the 2000 value of the Danish crown (DKK) with the following formula from the Danish Ministry of Finance: deflated household income/(number of persons in household)\(^{2,3,4}\). In the analysis education was grouped into 3 categories: basic/high school (7–12 years of primary, secondary, and grammar-school education), vocational (10–12 years including vocational training), and higher (≥13 years). People for whom information on education was missing in the registries were not included (14%). Missing information on education was more often missing for people who immigrated to Denmark and for people with high age. Disposable income was categorized into the 20th, 40th, 60th, and 80th percentiles of distribution, that is, 5 groups from lowest to highest income.

We included incident hospital admissions for stroke (ischemic and hemorrhagic) between January 1, 2003, when the Danish Stroke Register was fully established, and July 28, 2012. For patients with multiple hospital admissions, only the first admission was included. Transient ischemic attacks were not included. Patients aged <40 years were excluded, as were patients for whom scanning was not performed (0.4%) or for whom the results were not available (0.7%). The coverage of the Stroke Register is currently estimated (by professional consensus) to be ≈80% of all admissions for stroke in Denmark; yearly audits by Danish health authorities indicate that the registration rate is fairly uniform throughout the country.\(^{2,3,4}\) Acute stroke treatment and care in Denmark are solely undertaken by public hospitals. A population-based study found that 90% of Danish patients with stroke in 1990 were hospitalized.\(^{2,3,4}\) Since establishment of the Danish Stroke Registry, immediate hospitalization in stroke units has been an officially recognized quality marker of stroke management in Denmark. Most probably, therefore, the stroke hospitalization rate is now even higher. The study protocol was approved by the boards of the Danish Stroke Register and the Danish Data Protection Agency (journal number 2012-41-0719).

**Statistical Analysis**

First, we estimated the prevalence of comorbid conditions and risk factors in the patients with incident stroke according to the educational and income level. We applied Cox regression models to estimate the relative risks of death by education and disposable income. We applied censoring for end of follow-up or loss to follow-up, whichever came first. We used time since admission for incident stroke as the time scale and conducted both unadjusted and adjusted analyses. In the adjusted analysis, we accounted for age, sex, stroke severity, and cardiovascular risk profile, as well as education and disposable income. Age and stroke severity were included as continuous variables by means of restricted cubic splines to account for potential nonlinear effects. All other factors were included as categorical variables in the model. In subanalyses, we studied the effects of length of education and disposable income on short-term survival, that is, with censoring of patients who were still alive after 1 and 3 months. Also, to compare our findings with previously published work,\(^{1,3,4}\) we ran subanalysis only including patients below and above the age of 65 years, which is typically the age at retirement in Denmark. Effect estimates were reported as hazard ratios with 95% confidence intervals. All statistical tests were 2-sided and based on the likelihood ratio test. A significance level of 5% was applied. The statistical software R\(^{2,3}\) was used in all analyses.

**Results**

In total, 56581 Danes for whom information on education and disposable income was available and who were >40 years of age were registered in the nationwide Stroke Registry as having been hospitalized during the 9.5-year study period, giving 150000 person-years. The median follow-up time was 3.1 years. The mean age was 71.9 years, 47.5% were women, 8.3% had had hemorrhagic stroke, and the mean Scandinavian Stroke Scale Score was 44.1. Of the total, 18816 (33.2%) died during follow-up, and, of these, 4456 (7.9%) died within the first month after the stroke and 6015 (10.6%) within the third month. Patient characteristics, stroke severity, and prevalence of risk factors by socioeconomic group are shown in Table 1. Patients with the lowest income and with only basic education were older, more often women, had more severe strokes, and had a higher prevalence of most risk factors than patients with higher income and longer education. Only alcohol consumption over the recommended level was more prevalent in those with the highest income and the longest education. The prevalence of hemorrhagic stroke did not differ by income or education.

**Table 1. Prevalence of Comorbid Conditions and Risk Factors in Patients With Incident Stroke >40 Years of Age by Length of Education and Disposable Income, 2003 to 2012**

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Education, n (%)</th>
<th>Income Group, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basic</td>
<td>Vocational</td>
</tr>
<tr>
<td>Women</td>
<td>11922 (53.1)</td>
<td>10410 (39.9)</td>
</tr>
<tr>
<td>Age &lt;71 y (median)</td>
<td>8228 (36.8)</td>
<td>16028 (61.6)</td>
</tr>
<tr>
<td>SSS ≤51</td>
<td>13114 (59.8)</td>
<td>12345 (48.2)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>11242 (50.1)</td>
<td>12503 (47.9)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>3165 (14.1)</td>
<td>3250 (12.5)</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>3659 (16.3)</td>
<td>3180 (12.2)</td>
</tr>
<tr>
<td>Previous myocardial infarction</td>
<td>2080 (9.3)</td>
<td>2027 (7.8)</td>
</tr>
<tr>
<td>Intermittent claudication</td>
<td>665 (3.0)</td>
<td>667 (2.6)</td>
</tr>
<tr>
<td>Smoking</td>
<td>7786 (34.7)</td>
<td>10244 (39.3)</td>
</tr>
<tr>
<td>Alcohol</td>
<td>1355 (6.0)</td>
<td>2692 (10.3)</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>1940 (8.6)</td>
<td>2134 (8.2)</td>
</tr>
</tbody>
</table>

SSS indicates Scandinavian Stroke Scale.
Disposable Income, 2003 to 2012

Danish Patients >40 Years of Age by Length of Education and Disposable Income, 2003 to 2012

Table 2. Relative Risks for Death After Incident Stroke in Danish Patients >40 Years of Age by Length of Education and Disposable Income, 2003 to 2012

<table>
<thead>
<tr>
<th>Education</th>
<th>n</th>
<th>Dead, n (%)</th>
<th>HR Unadjusted (95% CI)</th>
<th>HR Adjusted* (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic</td>
<td>22435</td>
<td>9435 (42.1)</td>
<td>Reference</td>
<td>...</td>
</tr>
<tr>
<td>Vocational</td>
<td>26085</td>
<td>7304 (28.0)</td>
<td>0.63 (0.61–0.65)</td>
<td>0.99 (0.96–1.03)</td>
</tr>
<tr>
<td>Higher</td>
<td>8061</td>
<td>2077 (25.8)</td>
<td>0.58 (0.56–0.61)</td>
<td>1.02 (0.97–1.07)</td>
</tr>
</tbody>
</table>

Income

1 13888 | 6187 (44.5) | Reference | ... |
2 17419 | 6645 (38.1) | 0.85 (0.82–0.88) | 0.98 (0.94–1.01) |
3 9544 | 2798 (29.3) | 0.60 (0.57–0.63) | 0.88 (0.84–0.92) |
4 7544 | 1689 (22.4) | 0.44 (0.41–0.46) | 0.84 (0.80–0.89) |
5 8186 | 1497 (18.3) | 0.34 (0.32–0.36) | 0.70 (0.65–0.74) |

CI indicates confidence interval; and HR, hazard ratio.

*Adjusted for age, sex, stroke severity score, hypertension, diabetes mellitus, atrial fibrillation, previous myocardial infarction, intermittent claudication, smoking, alcohol consumption, and stroke type.

**Income**

The risk for death after a stroke throughout follow-up associated with disposable income is shown in Table 2, with and without adjustment for age, sex, calendar year, level of education, and the cardiovascular risk factors listed in Table 1. A highly significant stepwise relation was found between income and risk for death after stroke, the risk being 30% higher for patients in the lowest than in the highest income group. Analyses performed for patients above and below the age of 65 years gave similar results but with amplified risks in younger patients: the risk for death after a stroke within the age of 65 years gave similar results but with amplified risks in younger patients; the risk for death after a stroke within the age of 65 years was less strongly associated with survival after a stroke. In 3 studies on neighborhood income, however, deprived area was not associated with poorer survival after stroke. In a previous Danish study of patients above and below the age of 65 years, those aged <65 years had a significant 15% increase in risk for death if they had only basic education when compared with those with higher education (1.15; 95% confidence interval, 1.02–1.30). For patients aged >65 years, there was no difference by educational level (data not shown). The risk for death within 1 and 3 months of the stroke did not differ by length of education (Tables 3 and 4).

**Level of Education**

The risk for death after stroke throughout the follow-up period was not related to the educational level (Table 2). In a sub-analysis of patients above and below the age of 65 years, those aged <65 years had a significant 15% increase in risk for death if they had only basic education when compared with those with higher education (1.15; 95% confidence interval, 1.02–1.30). For patients aged >65 years, there was no difference by educational level (data not shown). The risk for death within 1 and 3 months of the stroke did not differ by length of education (Tables 3 and 4).

**Discussion**

Lower income was significantly associated with poorer survival after a stroke. The survival disadvantage applied, however, only to patients who survived the first few months; thus, early death was independent of income. Level of education was less strongly associated with survival after a stroke and had no influence for most stroke patients (>65 years of age).

In several area-based ecological studies, living in a socially deprived area was not associated with poorer survival after a stroke. In 3 studies on neighborhood income, however, living in a low-income area was associated with poorer survival especially among patients >65 years of age. As in our study, almost all individual-based cohort studies found an association between low income and poorer survival after stroke. In a previous Danish study based on 14,545 patients with stroke <65 years included in the Danish Stroke Registry, no association was found between income and length of education and 1-year survival after a stroke. This study is, however, not directly comparable with our study. We studied first ever strokes and our follow-up...
period was mean 3.1 years. This study included also recurrent strokes, follow-up was 1 year, the study population was 3× less than ours, and only patients aged <65 years were studied.

In most individual-based cohort studies, there was no relation between survival after a stroke and length of education. However, findings of a Swedish registry-based study on 62,000 hospitalized patients with stroke <75 years of age, however, found that patients with the shortest education had a modest but significant 13% poorer chance of surviving 1 year after a stroke. We also found a modestly (15%) reduced chance of survival associated with short education among patients with stroke <65 years but not among those aged >65 years.

The accumulated evidence from the literature and the results of our study provide a basis for concluding that there is social inequality in survival after a stroke. The inequality is primarily because of differences in income, whereas the level of education seems to play a lesser role. How social inequality mediates survival after stroke is unclear. Several factors may play a role: people of lower socioeconomic position have a heavier load of cardiovascular risk factors and strokes in these groups are also more severe, as was the case in our study. Even after adjustment for these risk factors, however, inequality in survival by income was still present, albeit reduced.

Multivariate models of survival after stroke with adjustment for stroke severity and risk factors account for only parts of the observed variation in survival, and it is likely that, apart from possible residual confounding and mediation, other, yet unknown factors also play a role.

People of low socioeconomic position may receive less adequate treatment than those of higher socioeconomic position, as shown in a previous Danish study. That study did not, however, show any association between income and education and 1-year survival after stroke. Although prophylactic measures at discharge from hospital were also accounted for, differential compliance with such measures according to the socioeconomic position cannot be ruled out. Although inclusion of indicators of the quality of physiotherapy and occupational therapy during the hospital stay did not affect the results of the Danish study, patients in higher socioeconomic groups might better maintain physical activity and thereby reduce the risk for complications.

It is surprising that level of education plays a much smaller role than income in survival after stroke, as seen in our and most other studies. It is well known that income is more strongly associated with survival than education, perhaps because income is a better proxy for accumulated socioeconomic position at the time of the event. In Denmark, the association between education and income is weaker than in many other countries, and the association between survival and education seen in our study was independent of income.

Early death after stroke was not associated with socioeconomic position in our study. In earlier studies on socioeconomic position and death within the first month after a stroke, low income was reported to be associated with a higher risk for death. None of those studies, however, included adjustment for stroke severity, which is the most important predictor of early death; death within the first month is mainly because of the index stroke, whereas later deaths are because of other comorbid conditions or recurrent cardiovascular events. Thus, the results of our study indicate that the survival disadvantage of low-income groups might be because of their heavier burden of comorbid conditions and cardiovascular risk factors associated with subsequent deaths not directly related to the index stroke.

Our study has strengths and weaknesses. One strength is the large sample size, which gave sufficient statistical power. We included patients without limitations on age (>40 years), sex, or stroke severity. Stroke severity was measured on admission to hospital on a well-validated neurological scale, and all patients underwent a standardized risk factor evaluation. Finally, we had survival data on nearly all patients, with <0.2% lost to follow-up.

Although the Danish Stroke Register is a nationwide register of all patients admitted to hospital for acute stroke, its coverage is not yet complete (presently ≥80%). Nevertheless, data completeness exceeds 85% for almost all individual variables; the completeness of data on diabetes mellitus, previous myocardial infarction, atrial fibrillation, and hypertension was >97%, and that for alcohol consumption, smoking, and intermittent arterial claudication was >85%. Data completeness on income was 100%, and that on educational attainment was 86%. Furthermore, treatment was uniform, as 96% of patients were treated in a stroke unit. Thus, we consider that our data set is appropriate for establishing a survival model with high statistical validity, as the large sample size allowed us to adjust reliably for differences in age, sex, stroke severity, socioeconomic position, and risk factor profile. We cannot exclude the possibility of bias because of variables not recorded in the Danish Stroke Register, and, as we studied only all-stroke mortality and the data are for patients hospitalized with stroke, our conclusions pertain only to the hospitalized Danish stroke population. Although we recorded mortality within the follow-up period, we had no information on treatments or interventions that might have influenced survival.

Conclusions

In Denmark, there is free, equal access to medical services, including treatment and rehabilitation after stroke. Nevertheless, we found marked social inequality in outcome after stroke, disfavoring patients of low income, whose risk for death after a stroke was 30% higher than that of patients in the highest income group. The finding that the impact of low income was on late but not on early poststroke death indicates that the heavier burden of comorbid conditions and cardiovascular risk factors of low-income groups (associated with subsequent deaths not directly related to the index stroke) plays a major role in their higher mortality. A focus on secondary prevention during treatment of patients with stroke in low-income groups will, therefore, be of particular importance for reducing mortality. Although income was significantly related to poststroke death, the association with level of education was modest and seen only for patients aged <65 years. The reason for this finding is unknown, and more research is needed.

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Disclosures

None.
References


Socioeconomic Position and Survival After Stroke in Denmark 2003 to 2012: Nationwide Hospital-Based Study
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