HHS Public Access

Author manuscript

Int J Stroke. Author manuscript; available in PMC 2019 August 24.

Published in final edited form as:

Int J Stroke. 2017 October ; 12(8): 815–826. doi:10.1177/1747493017702663.

Neighbourhood Socioeconomic Status at the Age of 40 Years and Ischemic Stroke before the Age of 50 Years – a Nationwide Cohort Study from Sweden

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Abstract

OBJECTIVE—We aimed to study the association between neighborhood socio-economic status (SES) at the age of 40 years and risk of stroke before the age of 50 years.

METHODS—All individuals in Sweden were included if their 40th birthday occurred between 1998 and 2010. National registers were used to categorize neighborhood SES into high, middle and low, and to retrieve information on incident ischemic strokes. Hazard ratios (HR) and their 95% confidence intervals (CI) were estimated using Cox regression.

RESULTS—A total of 1,153,451 adults (women: 48.9%) were included and followed for a mean of 5.5 years (SD 3.5 years); 1777 strokes among men and 1374 strokes among women were recorded. In sex-adjusted models adjustments for marital status, education level, immigrant status, region of residence in Sweden and local services in the neighbourhoods, there was a lower risk of stroke in neighbourhoods with high socio-economic status (HR 0.87, 95% CI 0.78–0.96), and an increased risk of stroke in neighbourhoods with low socio-economic status (HR 1.16, 95% CI 1.06–1.27), when using those living in middle SES neighbourhoods as referents. After further

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Conflict of interest

The authors report no relationships that could be construed as a conflict of interest.

adjustment for hospital diagnoses of hypertension, diabetes, heart failure and atrial fibrillation prior to the age of 40, the higher risk in neighbourhoods with low socio-economic status was attenuated, but remained significant (HR 1.12, 95% CI 1.02–1.23). The risk estimates were higher in women in sex-stratified models.

CONCLUSIONS—In a nation-wide study, we found that the risk of stroke differed depending on neighbourhood socio-economic status, which calls for increased efforts to prevent cardiovascular diseases in deprived neighbourhoods.

Keywords

neighborhood deprivation; epidemiology; national registers; socio-economic status

Introduction

Neighbourhood socio-economic status has been shown to have a profound effect on various health outcomes, and neighbourhood socio-economic status has repeatedly been shown to be a risk factor that is independent on the individual level socio-economic status [1, 2]. There are several studies showing that neighbourhood level socio-economic status is a risk factor for stroke [3–7], but controversy exist with regard to its independence of individual level socio-economic status [4]. Interestingly, ischaemic stroke among young people in Sweden, i.e. in the ages 18–44 years of age, has increased while decreasing in ages 45 years and above [8]. Furthermore, mental ill-health is increasing among teenagers in Sweden, and this has also been linked to a higher incidence of early stroke [9].

Most studies have explored the risks among individuals of all ages [3–7], or in the elderly [10]; studies where data on younger individuals will have a marginal effect on the risk estimates. Yet, interaction between age groups and gender have been reported, and should according to the authors be explored in further detail [6]. Whether neighbourhood socio-economic status has an effect on incident stroke among young individuals is therefore not known.

In the present study, we aimed to explore the relationship between neighbourhood SES and incident stroke in individuals below 50 years; and whether that relationship is independent of individual-level socio-economic factors such as education level, marital status, immigrant status and region in Sweden at the age of 40 years. Data from National Swedish registers enable us to include all individuals in Sweden with nearly complete socio-economic data at their 40th birthday [11], and to follow them for hospitalization due to stroke before the age of 50 years. We hypothesized that the risk of stroke is higher in neighborhoods with lower SES, and lower in neighborhoods with higher SES.

Methods

Data used in this study were retrieved from a national database that contains information on the entire population of Sweden for a period of 40 years. This database is based on several Swedish registers and contains comprehensive nationwide individual-level data and data on neighbourhood SES. The registers used in the present study were the Total Population

Register, and the Patient Register. The Swedish nationwide population and health care registers have exceptionally high completeness and validity [9]. Individuals were tracked using the personal identification numbers, which are assigned to each resident of Sweden. These identification numbers were replaced with serial numbers to provide anonymity. The follow-up period ran from January 1, 1998 until hospitalisation/out-patient treatment of stroke at age of diagnosis before 50 years, death, emigration or the end of the study period on December 31, 2010.

Ethical considerations

This study was approved by the Regional Ethics Committee in Lund, Sweden.

Neighbourhood-level socio-economic status

The home addresses of all Swedish individuals have been coded to small geographic units with boundaries defined by homogeneous types of buildings. These neighbourhood areas, called small area market statistics, or SAMS, each contain an average of 1,000 residents and were created by the Swedish Government-owned statistics bureau Statistics Sweden. SAMS were used as proxies for neighbourhoods, as they were in previous research [12, 13]. Neighbourhood of residence is determined annually using the National Land Survey of Sweden register.

A summary index was calculated to characterise neighbourhood-level deprivation. The neighbourhood index was based on information about female and male residents aged 20 to 64 years because this age group represents those who are among the most socioeconomically active in the population (i.e. a group that has a stronger impact on the socioeconomic structure in the neighbourhood compared to children, younger women and men, and retirees). The neighbourhood index was based on four items: low education level (<10 years of formal education), low income (income from all sources, including interest and dividends, that is <50% of the median individual income), unemployment (excluding full-time students, those completing military service, and early retirees), and receipt of social welfare. The index of the year 2000 was used to categorise neighbourhood deprivation as low (more than one SD below the mean), moderate (within one SD of the mean), and high (more than one SD above the mean) [14]. The neighborhood SES each individual resided in at the age of 40, when the individuals entered the study, was used as exposure in the present study.

Individual level socio-demographic variables

Inclusion: all individuals in Sweden entered the cohort at their 40th birthday. Individual-level socio-demographic variables of marital status, educational level, and region of residence were defined according to the year of inclusion in the study.

Marital status was categorized as (1) married/cohabitating or (2) never married, (3) widowed, or (4) divorced.

Education levels were categorised as completion of compulsory school or less (≤9 years), practical high school or some theoretical high school (10–12 years) and completion of theoretical high school and/or college (>12 years).

Immigrant status was categorised as born outside Sweden vs. Swedish-born.

Region of residence was included because incidence of MI varies according to urban/rural status. Individuals were classified as living in a large city, a middle-sized town, or a small town/rural area. Large cities were those with a population of ≥200,000 (Stockholm, Gothenburg and Malmö); middle-sized towns were towns with a population of ≥ 90,000 but <200,000; small towns were towns with a population of ≥ 27,000 and <90,000; and rural areas were areas with populations smaller than those of small towns. We choose to categorize region of residence into big cities, northern Sweden and southern Sweden, yielding three equally-sized groups.

Outcome variable:

The outcome variable in this study included incident ischemic stroke. These were based on discharge diagnoses after a hospital stay or diagnoses at an out-patient visit to a specialist clinic (primary health care not included) of stroke during the study period. Data on in-patient and out-patient diagnoses were retrieved from the Patient Register, which contains information on all hospital stays, and visits to out-patient clinics for specialised care. We searched these two registers for the following International Classification of Diseases (ICD)-10 codes: ischemic stroke I63.

Statistical analysis

Person-years were calculated from the start of the follow-up (January 1st 1998) until diagnosis of outcomes before age 50 years, death, emigration, or closing date on December 31st 2010. The rate of hospitalisation for MI and CHD was calculated for the total study population and for each subgroup after assessment of neighbourhood SES of individuals.

Cox regression models were used to estimate hazards ratios (HRs) and 95% confidence intervals (CIs). To determine the crude risks of stroke by level of neighbourhood SES, an unadjusted model (model A) that included only neighbourhood SES was calculated. In the next step a model (model B) was created comprising both neighbourhood SES and individual-level variables. Model B included educational level, marital status, immigrant status and region of residence in Sweden. In model C, we adjusted for the factors in model B and neighbourhood goods and services (fast food restaurants, bars/pubs, physical activity facilities and health care resources). We also performed a secondary analyses, model D, adjusted for all the factors in model C and registered hospital discharge diagnoses of diabetes, hypertension, atrial fibrillation and heart failure prior to the age of 40.

The analyses were performed using the SAS statistical package (version 9.3; SAS Institute, Cary, NC, USA).

Results

A total of 1,153,451 adults (women: 48.9%) living in low, middle and high income neighbourhoods were included and followed for a mean of 5.5 years (SD 3.5 years). Baseline characteristics of study participants are presented in Table 1. Men and women living in high-SES neighbourhoods were more likely to be married, have a higher level of

formal education and to be born in Sweden compared to their counterparts living in middle- and low-SES neighbourhoods. In contrast, adults living in low-SES neighbourhoods were more likely to be hospitalized for hypertension and diabetes compared to those living in middle- and high-SES neighbourhoods.

There were a total of 1777 strokes among men and 1374 strokes among women during follow-up, Supplementary Table 1.

The cumulative rates of stroke (per 1000 individuals) are presented in Table 2. Within each of the categories of marital status (except for a widowed category), education level, immigrant status, region of residence, and hospitalization for hypertension cumulative rates of stroke were higher in men and women living in low-SES neighbourhoods compared to those living in middle- and high-SES neighbourhoods. Cumulative stroke rates were also higher in men and women with a registered diagnosis of hypertension, and women with a registered diagnosis of diabetes and atrial fibrillation who lived in low-SES neighbourhoods. However, cumulative stroke rates among men hospitalized for diabetes and atrial fibrillation who lived in middle-SES neighbourhoods were higher than the rates of men from low- and high-SES neighbourhoods.

The relationship between neighbourhood SES and stroke is presented in Table 3. There was significantly higher risks of stroke in neighbourhoods with low SES and lower risks of stroke in neighbourhoods with high SES when using neighbourhoods with middle SES as referents in all primary analyses models tested.

The associations were attenuated in the secondary analysis (adjusted for hospital diagnoses of hypertension, diabetes, atrial fibrillation and heart failure prior to the age of 40), however, the higher risk in low SES neighbourhoods remained significant.

There was no significant interaction with sex, p=0.303.

The relationship between neighbourhood SES and stroke is presented in men and women separately in Table 4. In a crude model, compared to individuals living in middle-SES neighbourhoods, risk of stroke was lower among men and women living in high-SES neighbourhoods and higher among those living in low-SES neighbourhoods. After adjustment for potential confounders, the difference in risk of stroke between women remained significant, but was attenuated among men from low- and middle-SES neighbourhoods and was no longer significant. Similarly, no significant difference in risk of stroke was observed between women living in high-and middle-SES neighbourhoods after adjustment for potential confounders. However, the difference in risk of stroke between men from high- and middle-SES remained significant after the adjustment for socio-demographic variables and neighbourhood goods and services, but was no longer significant after the additional adjustment for hospital diagnoses of hypertension, diabetes, atrial fibrillation and heart failure prior to the age of 40. In addition, the higher risk of stroke among women living in low-SES neighbourhoods compared to women living in middle-SES neighbourhoods was attenuated after the adjustment for confounders but remained significant throughout all models.

Discussion

There was in accord with our hypothesis a lower risk of stroke among individuals below the age of 50 years in neighbourhoods with high socio-economic status; and a higher risk of stroke in neighbourhoods with low socio-economic status with no sign of a sex-interaction. We confirmed a lower risk among men in neighbourhoods with high socio-economic status as well as the increased risk among women in neighbourhoods with low socio-economic status after adjustments for marital status, education level, immigrant status, and region of residence in Sweden and local goods and services in the neighbourhoods. The higher risk among women in neighbourhoods with low socio-economic status was attenuated but remained significant after further adjustments, diabetes and atrial fibrillation prior to the age of 40.

Comparisons with other studies

We have recently shown that living in middle neighbourhood SES at the age of 40 was significantly associated with a higher risk of myocardial infarction (MI) and coronary heart disease (CHD) before the age of 50 years, and that lower risks of both MI and CHD were seen in individuals living in high SES neighbourhoods [11]. The present study expands the role of neighbourhood socio-economic status in individuals below 50 years from coronary heart disease outcomes to ischemic strokes. Others have shown that neighbourhood low socio-economic status is a risk factor for stroke among whites but not among blacks in Texas, USA [3], that personal income explain the stroke risk associated with neighbourhood socio-economic status in New Zealand [4], that the differences in the stroke rates in different Swedish neighbourhoods in addition to socio-economic status can be explained by higher rates of established cardiovascular risk factors in these neighbourhoods [5], different stroke rates in different postal code areas in Australia [7], and that age and gender interactions in the risk of stroke in neighbourhoods with different levels of socio-economic status exist [6]. We did not, however, find any significant interaction with sex in the present study. In contrast to theses previous studies and to our study, that were all conducted in western countries, a recent study from China found that stroke is more common in wealthier villages [15], where a more “western lifestyle” is common. However, as far as we know there are no previous studies on the risk of stroke in individuals residing in neighbourhoods with different socio-economic status that has been conducted solely in individuals below 50 years.

Possible explanation to our findings

The results of the present observational study cannot be regarded as causal, but there are several potential mechanisms that may explain our findings. Stroke preventive anticoagulant pharmacotherapy for high risk individuals, i.e. patients with atrial fibrillation, have been shown to be less optimal in neighbourhoods with low socio-economic status [16], and could explain some of our findings; as all our findings were attenuated when adjusted for registered diagnoses prior to the age of 40. However, when it comes to risk stratification for anticoagulant treatment among individuals with atrial fibrillation, the guidelines used during the follow-up ($CHADS_2$) do not support anticoagulant treatment in those below 75 years of age without comorbidities [17]. The current guidelines for stroke prevention in patients with

atrial fibrillation do not support anticoagulant treatment in men below 65 years of age without comorbidities (CHA_2DS_2-VASc) [18, 19], as they are considered to have a low risk. Thus, younger individuals with atrial fibrillation are seldom prescribed anticoagulant treatment. The number of fast food restaurants has been shown to have an effect on incident strokes [20], and could potentially explain our findings, yet, the lower risk among men in neighbourhoods with high socio-economic status as well as the increased risk among women in neighbourhoods with low socio-economic status remained significant after adjustments for fast food restaurants, bars/pubs, physical activity facilities and health care resources in the neighbourhoods. Furthermore, mental ill-health is increasing among teenagers in Sweden, especially among individuals with low-educated parents, and the mental ill-health has also been linked to a higher incidence of early stroke [9]. Another factor of possible interest is congenital heart defects, exerting a 10-fold risk of stroke [21]. Congenital heart defects are shown to be modestly associated to maternal low socio-economic status [22], and maternal smoking [23], factors that are likely to be more common in neighbourhoods with low socio-economic status.

The most important risk factors for cardiovascular diseases are also somewhat different in different age-groups, but whether the neighbourhood SES increase these differences remains to be studied.

Clinical implications

Even in a county with a healthcare system approaching socialized medicine, Sweden, psychosocial factors have repeatedly been shown to have an effect on the cardiovascular health [24]. In fact we have previously shown that pharmacotherapy in patients with atrial fibrillation [16], mortality in atrial fibrillation [25], and that coronary heart disease in individuals below the age of 50 is determined to some extent of the neighbourhood socio-economic status [11]. Thus, to claim that equal opportunities for long-term health exists; directed screenings and interventions are warranted for identified vulnerable groups. One such group is those living in low SES neighborhoods. To reduce the risk, established cardiovascular risk factors should be closely monitored [26, 27]. In fact, risk prediction models for coronary heart disease such as QRISK2 that included residing in neighborhoods with different SES scores have been developed [28, 29]. The performance of the QRISK score has in fact been shown to be better than the Framingham model in identifying high risk for cardiovascular disease. Accordingly, we think that both neighborhood and individual level SES should be given more attention in the clinical setting, when physicians and other health care workers estimate the risk of serious cardiovascular events such as stroke in their patients. Neighbourhood SES may also be used in risk assessment in patients with atrial fibrillation when clincians are in doubt of initiating treatment with anticoagulants or not [16].

Limitations and strengths

Because of the design of the neighbourhood SES variable, we decided to use middle SES neighbourhood as referents as they were within one standard deviation of the mean neighbourhood SES. Using one of the extremes would have yielded more dramatic but less robust risk estimates in the tables.

One of the limitations of this study was lack of data on established cardiovascular risk factors, as these were not available in the nationwide registers of the entire Swedish population. Yet, we did have access to registered hospital diagnoses and adjusted for diabetes, hypertension and atrial fibrillation. Furthermore, the results of this study may not be generalizable to other age-groups. However, we believe it is important to study risk of events in younger middle-aged adults separately, as these often leave debilitating consequences to the individuals themselves with profound impact on their family members; and long treatment and rehabilitation related to this chronic disease result in high health care costs. Despite the limitations, one of the major strengths of the present study was that we were able to include all individuals residing in Sweden at their 40th birthday with data on their neighborhood SES as well as data on individual level SES, and follow them for cardiovascular events until the age of 50. We believe that the internal validity is higher with this methodology, than if all individuals below 50 would have been included, since many people live on different locations in their early years of adulthood. The use of the total population may be of particular importance, since individuals in low resource settings have lower participation rates in surveys. Another strength is the Patient Register and the Cause of Death Register in Sweden, which are nearly complete (99.8%) [30], and thus enable long-term evaluation without any significant loss to follow-up.

Given the high internal validity of the study, we believe that the study also has external validity and that the results may be generalizable for estimating the risks in high and low SES neighbourhoods in other western countries.

Conclusions

The results of the present study suggest that

Acknowledgments

This work was supported by grants to Kristina Sundquist and Jan Sundquist from the Swedish Research Council as well as ALF funding to Jan Sundquist and Kristina Sundquist from Region Skåne.

Research reported in this publication was also supported by the National Heart, Lung, And Blood Institute of the National Institutes of Health under Award Number R01HL116381 to Kristina Sundquist. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

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Int J Stroke. Author manuscript; available in PMC 2019 August 24.

Table 1.

Baseline characteristics in 40 year-old men and women in neighborhoods with high/middle/low SES

	Men (N=589247)							Women (N=564204)						
	High (n=112534)		Middle (n=379186)		Low (n=97527)		All	High (n=115229)		Middle (n=362309)		Low (n=86666)		All	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Year at entry																
1998-2000	20230	18.0	63636	16.8	19614	20.1	103480	17.6	20812	18.1	61786	17.1	17164	19.8	99762	17.7
2001-2003	23861	21.2	84921	22.4	22628	23.2	131410	22.3	24272	21.1	80466	22.2	20055	23.1	124793	22.1
2004-2006	30870	27.4	102988	27.2	24997	25.6	158855	27.0	31306	27.2	97964	27.0	22501	26.0	151771	26.9
2007-2010	37573	33.4	127641	33.7	30288	31.1	195502	33.2	38839	33.7	122093	33.7	26946	31.1	187878	33.3
Marital status																
Married	63804	56.7	163856	43.2	38405	39.4	266065	45.2	70602	61.3	183358	50.6	38770	44.7	292730	51.9
Unmarried	41533	36.9	181847	48.0	45759	46.9	269139	45.7	34136	29.6	132962	36.7	29793	34.4	196891	34.9
Divorced	7061	6.3	33014	8.7	13212	13.5	53287	9.0	10105	8.8	44430	12.3	17441	20.1	71976	12.8
Widowed	136	0.1	469	0.1	151	0.2	756	0.1	386	0.3	1559	0.4	662	0.8	2607	0.5
Educational level																
Compulsory	8394	7.5	54648	14.4	19468	20.0	82510	14.0	6049	5.2	37809	10.4	17694	20.4	61552	10.9
Secondary school	39897	35.5	180299	47.5	40517	41.5	260713	44.2	33467	29.0	143769	39.7	31130	35.9	208366	36.9
College/university	62051	55.1	134442	35.5	29285	30.0	225778	38.3	73656	63.9	170864	47.2	29893	34.5	274413	48.6
Unknown	2192	1.9	9797	2.6	8257	8.5	20246	3.4	2057	1.8	9867	2.7	7949	9.2	19873	3.5
Immigrant status																
Born in Sweden	104242	92.6	339553	89.5	61464	63.0	505259	85.7	105466	91.5	319750	88.3	53592	61.8	478808	84.9
Immigrant	8292	7.4	39633	10.5	36063	37.0	83988	14.3	9763	8.5	42559	11.7	33074	38.2	85396	15.1
Region of residence																
Big cities	48741	43.3	146786	38.7	48424	49.7	243951	41.4	50633	43.9	142216	39.3	42565	49.1	235414	41.7
Southern Sweden	40680	36.1	147382	38.9	33552	34.4	221614	37.6	41250	35.8	139840	38.6	30237	34.9	211327	37.5
Northern Sweden	23097	20.5	84954	22.4	15492	15.9	123543	21.0	23329	20.2	80192	22.1	13826	16.0	117347	20.8
Unknown	16	0.0	64	0.0	59	0.1	139	0.0	17	0.0	61	0.0	38	0.0	116	0.0
Hospital diagnosis of hypertension																
Non	109884	97.6	367738	97.0	94228	96.6	571850	97.0	113096	98.1	354113	97.7	84102	97.0	551311	97.7
Yes	2650	2.4	11448	3.0	3299	3.4	17397	3.0	2133	1.9	8196	2.3	2564	3.0	12893	2.3

	Men (N=589247)								Women (N=564204)							
	High (n=112534)		Middle (n=379186)		Low (n=97527)		All		High (n=115229)		Middle (n=362309)		Low (n=86666)		All	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Hospital diagnosis of diabetes																
Non	110777	98.4	371233	97.9	94540	96.9	576550	97.8	114002	98.9	356965	98.5	84650	97.7	555617	98.5
Yes	1757	1.6	7953	2.1	2987	3.1	12697	2.2	1227	1.1	5344	1.5	2016	2.3	8587	1.5
Hospital diagnosis of atrial fibrillation																
Non	111589	99.2	375892	99.1	96756	99.2	584237	99.1	114970	99.8	361367	99.7	86378	99.7	562715	99.7
Yes	945	0.8	3294	0.9	771	0.8	5010	0.9	259	0.2	942	0.3	288	0.3	1489	0.3
Hospital diagnosis of heart failure																
Non	112295	99.8	377928	99.7	97031	99.5	587254	99.7	115092	99.9	361784	99.9	86432	99.7	563308	99.8
Yes	239	0.2	1258	0.3	496	0.5	1993	0.3	137	0.1	525	0.1	234	0.3	896	0.2
All	112534	100.0	379186	100.0	97527	100.0	589247	100.0	115229	100.0	362309	100.0	86666	100.0	564204	100.0

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Table 2.

Cumulative rates of stroke (per 1000 individuals) in men and women in neighborhoods with high/middle/low SES

	Men				Women			
	High	**Middle**	**Low**	**All**	**High**	**Middle**	**Low**	**All**
Year at entry*								
1998-2000	4.05	5.08	6.27	5.10	2.93	3.71	5.01	3.77
2001-2003	3.27	3.89	4.33	3.85	2.22	2.63	4.54	2.86
2004-2006	2.01	2.68	3.36	2.66	1.76	2.34	3.20	2.35
2007-2010	1.25	1.66	2.05	1.64	1.21	1.55	1.82	1.52
Marital status								
Married	2.19	2.49	3.38	2.55	1.76	2.10	2.94	2.13
Unmarried	2.87	3.26	3.69	3.27	1.73	2.55	3.59	2.56
Divorced	1.42	4.24	5.15	4.09	3.17	2.90	4.30	3.28
Widowed	0.00	2.13	0.00	1.32	5.18	3.85	3.02	3.84
Educational level								
Compulsory	4.17	4.41	5.29	4.59	3.80	4.07	4.46	4.16
Secondary school	2.28	3.21	4.15	3.21	2.45	2.82	4.59	3.02
College/university	2.24	2.24	2.60	2.29	1.51	1.67	2.07	1.67
Unknown	1.82	2.04	2.42	2.17	0.49	1.52	1.76	1.51
Immigrant status								
Born in Sweden	2.35	3.04	3.92	3.00	1.94	2.45	3.92	2.50
Born outside	2.89	2.78	3.49	3.10	1.23	1.79	2.66	2.06
Region of residence								
Big cities	2.54	3.02	4.09	3.14	1.70	2.51	3.15	2.45
Southern Sweden	1.92	2.74	3.16	2.65	1.82	2.22	3.77	2.37
Northern Sweden	2.90	3.46	4.07	3.43	2.40	2.38	3.62	2.53
Unknown				0.00				0.00
Hospital diagnosis of hypertension								
Non	1.75	2.14	2.54	2.13	1.59	1.84	2.45	1.88
Yes	29.06	30.84	38.80	32.07	17.35	25.26	35.88	26.06
Hospital diagnosis of diabetes								

	Men				Women			
	High	**Middle**	**Low**	**All**	**High**	**Middle**	**Low**	**All**
Non	2.23	2.65	3.33	2.68	1.81	2.14	2.97	2.20
Yes	12.52	19.62	17.41	18.11	8.96	17.59	23.31	17.70
Hospital diagnosis of atrial fibrillation								
Non	2.33	2.87	3.66	2.90	1.86	2.31	3.30	2.37
Yes	9.52	18.82	16.86	16.77	11.58	27.60	45.14	28.21
Hospital diagnosis of heart failure								
Non	2.30	2.90	3.58	2.90	1.86	2.32	3.32	2.38
Yes	46.03	35.77	40.32	38.13	21.90	36.19	47.01	36.83
All	2.39	3.01	3.76	3.02	1.88	2.37	3.44	2.44

Table 3.

Sex-adjusted Hazard ratios (HR) of stroke (ICD-10 I63) before the age of 50 years in individuals with different neighborhood SES at the age of 40 years.

Group	Individuals at risk	First events	Incidence rate per 10000 person-years			Model A			Model B			Model C			Model D		
	N	N	IR	95% CI		HR	95% CI		HR	95% CI		HR	95% CI		HR	95% CI	
High	227763	486	3.91	3.56	4.25	0.77	0.69	0.85	0.87	0.78	0.96	0.87	0.78	0.96	0.91	0.82	1.01
Middle	741495	2000	4.99	4.77	5.21	ref.			ref.			ref.			ref.		
Low	184193	665	6.46	5.96	6.95	1.25	1.14	1.37	1.19	1.08	1.30	1.16	1.06	1.27	1.12	1.02	1.23

HR: Hazard ratios; CI: Confidence interval. There was no significant interaction with sex, p=0.303.

Model A: adjusted for gender; Model B: adjusted for gender, marital status, educational level, immigrant status, and region of residence. Model C: adjusted for factors in Model B and neighbourhood goods and services (fast food restaurants, bars/pubs, physical activity facilities and health care resources). Model D: adjusted for factors in Model C and hospital diagnoses for hypertension, heart failure, and diabetes prior to the age of 40.

Table 4.

Hazard ratios (HR) of stroke (ICD-10 I63) before the age of 50 years in men and women with different neighborhood SES at the age of 40 years.

Group	Individuals at risk	First events	Incidence rate per 10000 person-years			Model A			Model B			Model C			Model D		
	N	N	IR	95% CI		HR	95% CI		HR	95% CI		HR	95% CI		HR	95% CI	
Men																	
High	112534	269	4.38	3.86	4.91	0.77	0.67	0.88	0.87	0.76	0.99	0.87	0.76	0.99	0.92	0.80	1.05
Middle	379186	1141	5.60	5.27	5.92	ref.			ref.			ref.			ref.		
Low	97527	367	6.78	6.08	7.47	1.17	1.03	1.31	1.09	0.97	1.24	1.05	0.93	1.20	1.05	0.92	1.19
Women																	
High	115229	217	3.44	2.99	3.90	0.77	0.66	0.89	0.87	0.74	1.01	0.87	0.74	1.01	0.90	0.78	1.05
Middle	362309	859	4.37	4.07	4.66	ref.			ref.			ref.			ref.		
Low	86666	298	6.10	5.41	6.79	1.37	1.20	1.56	1.31	1.14	1.51	1.30	1.13	1.49	1.22	1.06	1.40

HR: Hazard ratios; CI: Confidence interval.

Model A: adjusted for gender; Model B: adjusted for gender, marital status, educational level, immigrant status, and region of residence. Model C: adjusted for factors in Model B and neighbourhood goods and services (fast food restaurants, bars/pubs, physical activity facilities and health care resources). Model D: adjusted for factors in Model C and hospital diagnoses for hypertension, heart failure, and diabetes prior to the age of 40.