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Incidence of Stroke among Swedish-Born and Migrant Women

—The Role of Socio-Economic Status, Smoking, and Physical Activity

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Abstract

Introduction: The incidence of stroke has decreased in Sweden as well as in most developed countries, but a high number of migrants have arrived in Sweden, during the last decades, which may have influenced the incidence. Aim: The aim of this study was to examine the incidence of stroke in women, born outside as well as in Sweden. Furthermore, the aim was to examine how socio-economic factors, smoking, and physical activity could modify the risk for stroke. Method: Data from the "Malmö Diet and Cancer Study" was used for the analysis. In total, 16,857 women were included (14,849 of them born in and 2,008 born outside Sweden), aged 45 - 73 years with a mean age of 57.4 years. Result. A significantly increased relative risk (RR) was found for the incidence of stroke for current smokers in both Swedish-born and migrant women. In Swedish-born women the RR was 1.98 (CI: 1.66 - 2.36) and for migrant women the RR was 1.83(CI: 1.13 - 2.96). The adjusted relative risk for the incidence of stroke in Swedish-born women performing moderate/high physical activity was RR 0.71 (CI: 0.61 - 0.84) and for migrant women it was RR 0.77 (CI: 0.49 - 1.20). The relative risk in relation to low socio-economic circumstances (SES) was significant only for Swedish-born women (RR 0.85 [CI: 0.73 - 0.99]). Among currently smoking Swedish-born women with a low SES the RR was 1.27 (CI: 1.03 - 1.57) in comparison with smoking migrant women, whose RR was 1.68 (CI: 0.92 - 3.09). Conclusion: No differences were found indicating that migrant women in this population had a higher risk as compared to Swedish-born women. However, migrant smoking women were more vulnerable to stroke compared to Swedish-born women. Physical activity was effective in reducing the risk of stroke among the total population and especially in the Swedish-born women. To increase physical activity in middle-aged women, in both migrant and Swedish-born women, is a highly recommended public health strategy.

Keywords

Migration, Stroke, Socio-Economic Factors, Physical Activity, Smoking, Women

1. Introduction

Stroke is a major cause of disability and death, not only in Sweden but also in Europe as a whole [1] [2]. Stroke is the result of either an obstruction in the blood flow to one part of the brain (ischemic stroke) or bleeding into and around the brain due to a ruptured artery that feeds the brain (intracerebral or subarachnoid hemorrhage). Most often (85%) strokes are ischemic [1] [2].

In 2008, cardiovascular diseases, including stroke, accounted for approximately one fourth of all deaths within Europe, though the figure varied between countries. On average 64/100,000 women and 82/100,000 male inhabitants died from stroke that year [3]. According to the Swedish National Board of Health and Welfare, a reduction in the incidence of mortality due to cardiovascular diseases and stroke in both male and female inhabitants in Sweden between 1987 and 2012 has been reported, from 128 to 49 per 100,000 women and 352 to 113 per 100,000 men among the age group 15 - 74 [4].

Needless to say, in the last few decades there has been an increased migration influx in Sweden that has become an important factor in balancing the aging population of Sweden, and which could also be an important factor behind possible changes in the incidence of stroke, especially among women, Swedish-born as well as migrant. Furthermore, it has previously been discussed that there are substantial differences in stroke incidence and stroke subtypes between migrants from different countries among the urban population in Sweden [5], but to what extent this could be accounted for by exposure to various biological risk factors, as well as demographic and socio-economic factors, has not been in focus when it comes to middle-aged migrant women in Sweden, and this, thus, remains to be explored. Previous studies have shown the association between stroke and many individual behavioral risk factors, including smoking, alcohol consumption, exercise, and body mass index (BMI) [6]-[10]. Therefore, from a public health perspective, it is interesting to further study the probability of a possible increase in the prevalence of stroke, especially in migrant women, in the future.

2. Aim

The aim of this study was to examine the incidence of stroke in women born outside as well as in Sweden. Furthermore, the aim was to examine how socio-economic factors, smoking, and physical activity could modify the risk.

3. Material and Methods

3.1. Study Population

This project was conducted using data from the population-based Malmo Diet and Cancer Study (MDCS), which has been described in detail previously [11]. Complete birth cohorts were invited to a cardiovascular screening by mail invitations. The data collection was conducted between March 1991 and September 1996, and included a total of 28,449 individuals aged 45 - 73 years at Malmo University Hospital, where the participation rate was 40.8%, representing 38.3% men and 42.6% women [12]. Since this study has been focusing only on women's risk of stroke, men were excluded.

In the present study, 16,857 women participants (14,849 born in Sweden and 2,008 born outside Sweden) remained in the study after exclusion of 130 women with a previous history of stroke and of another 216 due to missing values for country of birth, hypertension, marital status, body mass index (BMI), and smoking habits. The mean age was 57.4 ± 7.9 years. During the follow-up, 705 Swedish-born women and 90 migrant women developed stroke. The mean follow-up time was 13.8 ± 4 years.

The MDCS was approved by the Ethics Committee at Lund University. Each participant gave informed consent (D: LU51-90 [1990-01-12]).

3.2. Baseline Examination

Socio-economic status. The data on SES was based on a modified questionnaire adapted from Statistics Sweden [13], with a classification based on information about the educational level required for the job held by the participant, the level of responsibility in the work organization, and the actual work tasks. The participants were classified into five categories: high-level non-manual employees (business executives, engineers with a university degree, university teachers), medium level non-manual employees (registered nurses, computer operators,

high school teachers), low-level non-manual employees (office assistants, sales staff, secretaries), skilled manual workers (vehicle mechanics, metal workers, cleaners), and unskilled manual workers (factory workers and waiters) [13] [14]. In this cohort study, the participants were stratified into two groups. High- and medium-level non-manual workers and self-employed individuals were marked as "high socio-economic level" [socio-economic index (SEI); SEI group 46 - 89]. Low-level non-manual workers, manual workers, and unspecified occupational groups (housewives, students, unemployed) were marked as "low socio-economic level"Low SES, (SEI groups 11 - 36 and 91 - 99) [13]-[15].

Smoking habits. Smoking habits were assessed by means of the self-administered questionnaire, with the question "Are you smoking? (yes/no)", and the participants were categorized into never-smokers, ex-smokers, and current smokers [11].

Demographic variables. The migration status was assessed by asking "Were you born in Sweden?" and the marital status by asking "Do you live alone?" [11].

Biological risk factors. Subjects were considered to be hypertensive if the systolic pressure ≥ 140 mmHg, and the diastolic pressure ≥ 90 mmHg and measured twice in the right arm of the patient, in supine position, after 10 min of rest, or if they were in treatment with antihypertensive medicine [16]. Participants who reported that they had diabetes (fasting blood glucose ≥ 6.7 mmol/l), or used anti-diabetic medication, were considered to have diabetes mellitus [17]. Participants who were taking lipid-lowering medicine were considered as dyslipidaemic [11].

Physical activity. A modified questionnaire based on The Minnesota Leisure Time Physical Activity Questionnaire was used for collecting data on PA [18]. The variables were dichotomized into no/low (Q1 - Q2) and moderate/high PA (Q3 - Q4), which has been described in detail previously [19].

3.3. Statistics

Age and BMI were modeled as continuous variables; hypertension, antihypertensive treatment, diabetes mellitus, and anti-diabetic treatment, anti-dyslipidemic treatment, smoking habits, socio-economic level, and marital status were modeled as categorical variables. The SES was compared with individual factors for continuous variables by an independent sample t-test. Person's chi-squared test was performed ($X2$ test) in order to compare the SES with other independent categorical variables. A p value < 0.05 was considered statistically significant. Significance (p value) was categorized into three categories, *i.e.*, <0.05; <0.01; <0.001, and presented in tables.

The Cox proportional hazards model was performed to assess the relative contribution of different risk factors on stroke rates in both Swedish-born and migrant women. A crude analysis of the material with the Cox proportional hazards model was performed in the first model. In the second model, the Cox proportional hazards model was performed to evaluate the role of socio-economic status and smoking habits after adjustment for age. In the third model, further adjustment was made for differences with regard to medical personal history. In a final model, additional adjustment was made simultaneously for physical activity and marital status.

An additional stratified analysis of the incidence rates in relation to socio-economic status and smoking habits was also done in both Swedish-born and non-Swedish-born participants. The above-mentioned methodology was also followed for the analysis, *i.e.*, it was crude and needed three further steps with adjustments. Results from the Cox proportional hazards model were presented as relative risk (RR) with 95% confidence intervals (CI). PASW statistics Data Editor (version 18.0) has been used to conduct the statistical analysis.

4. Results

After exclusion of 130 women (0.8%) with a previous history of stroke and of another 216 (1.3%) due to missing values for country of birth (160), hypertension (22), marital status (164), BMI (25), and smoking habits (158), a total of 16,857 women, where 14,849 were born in and 2,008 outside Sweden, remained in the study. During the follow-up, 705 (4.7%) women born in Sweden and 90 (4.5%) women born outside Sweden developed stroke ($p = 0.60$) (**Figure 1**).

4.1. Distribution of Risk Factors in All Women

The mean age of the total study population was 57.4 ± 7.88 years, where Swedish-born women were a little older than the migrant women ($p = 0.000$) (**Table 1**). The mean BMI of the total study population was 25.4 ± 4.2
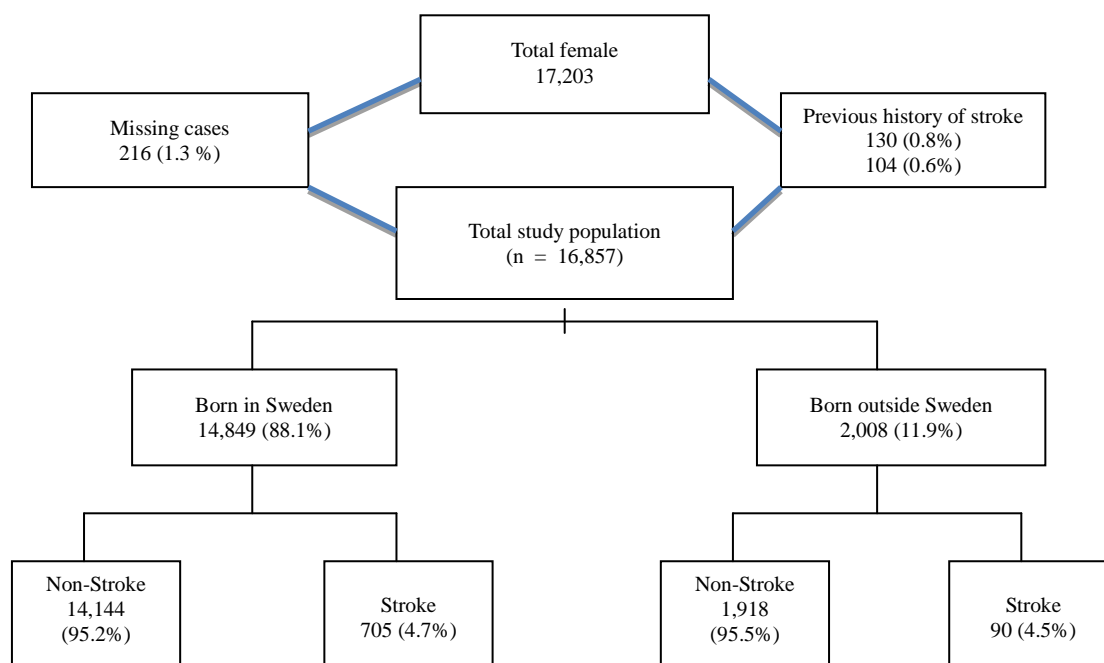
Figure 1. Diagram of study population and inclusion of participants in the study.

Table 1. Descriptive statistics of a study population of 16,857 women.

Continuous Variables	Total Population (N = 16,857)		Swedish-Born (n = 14,849)		Non-Swedish-Born (n = 2,008)		P-Value
Age (yrs) mean (SD)	57.43 (7.88)		57.6 (7.9)		56.5 (7.7)		**0.000**
BMI, mean (SD)	25.4 (4.2)		25.3 (4.2)		26.3 (4.5)		**0.000**
Categorical Variables	Sample (n)	Percentage (%)	Sample (n)	Percentage (%)	Sample (n)	Percentage (%)	
Hypertension	9,517	56.5	8,428	56.8	1,089	54.2	**0.032**
Use of BP-lowering treatment	2,706	16.1	2,374	16.0	332	16.5	0.531
Diabetes mellitus	405	2.4	347	2.3	58	2.9	0.130
Anti-diabetic treatment	177	1.1	151	1.0	26	1.3	0.252
Lipid-lowering treatment	344	2.0	306	2.1	38	1.9	0.617
Smoking habits							
Never-smoker	7,469	44.3	6,589	44.4	880	43.8	0.112
Ex-smokers	4,661	27.7	4,133	27.8	528	26.3	
Current smoker	4,727	28.0	4,127	27.8	600	29.9	
Socio-economic level							
Low	10,217	60.6	9,136	61.5	1,081	53.8	**0.000**
High	6,640	39.4	5,713	38.5	927	46.2	
Marital status							
Married	10,223	60.6	9,068	61.1	1,155	57.5	**0.002**
unmarried/widow	6,634	39.4	5,781	38.9	853	42.5	
Physical activity							
No/low	4,018	23.8	3,462	23.3	556	27.7	**0.000**
Moderate/high	12,839	76.2	11,387	76.7	1,452	72.3	

Data presented as non-adjusted, percentages, mean, standard deviation (SD).

and the migrant women were heavier than the Swedish-born women ($p = 0.000$) (**Table 1**). A total of 9,517 (56.5%) women had hypertension, but only 2,706 (16.1%) were on antihypertensive medication, 405 women (2.4%) were diabetic with 177 (1.1%) of them being on anti-diabetic medication, and 344 (2%) women were under anti-dyslipidaemic medication. A total of 6,640 (39.4%) had a high SES and 10,217 (60.6%) a low SES. Migrant women had a higher SES status than Swedish-born women ($p = 0.000$) (**Table 1**). Finally, a total of 10,223 (60.6%) women were married, the majority of whom were Swedish-born ($p = 0.002$) (**Table 1**).

There were 7,469 (44%) never-smokers, 4,661 (27.7%) ex-smokers, and 4,727 (28%) current smokers. A total of 12,839 (76.2%) were moderately/highly physically active and 4,018 (23.8%) performed no/low physical activity. Swedish-born women were more physically active than migrant women ($p = 0.000$) (**Table 1**).

4.2. Prevalence and Distribution of Risk Factors in Relation to Socio-Economic Status and Migration

The Swedish-born women with a high SES were significantly younger than those with a low level of SES ($p < 0.001$). The Swedish-born women with a low SES had a higher weight as compared to those with a high SES ($p < 0.001$). Moreover, there were significant differences in relation to hypertension ($p < 0.001$), hypertensive medication ($p < 0.001$), and lipid-lowering treatment ($p < 0.05$) among Swedish-born women. No such significant differences were seen among migrant women (**Table 2**). Among migrant women, significant differences were present in relation to anti-diabetic treatment ($p < 0.05$) and smoking habits ($p < 0.05$) (**Table 2**). There were also significant differences for smoking habits ($p < 0.001$), marital status ($p < 0.001$), and PA ($p < 0.001$) among Swedish-born women (**Table 2**). Significant differences were, furthermore, seen in Swedish-born women in relation to physical activity level (No/low $p < 0.001$; Moderate/High $p < 0.001$), but no significant differences among the migrant women were found (**Table 2**).

Table 2. Prevalence and distribution of different risk factors in relation to socio-economic status and migration in 16,857 women.

	Women born in Sweden (n = 14,849)			Women born outside Sweden (n = 2,008)		
	Low SES	High SES	p-value	Low SES	High SES	p-value
Age, mean (SD), years	57.3 ± 7.7	57.9 ± 7.1	**<0.001**	56.3 ± 7.5	56.8± 7.8	0.124
BMI, mean (SD)	25.5 ± 4.3	25.0 ± 4.0	**<0.001**	26.5 ± 4.6	26.1 ± 4.4	0.06
Hypertension %	35.7 (5,305)	21.0 (3123)	**<0.001**	29.2 (586)	25.0 (503)	0.981
Use of BP-lowering treatment %	10.1 (1,505)	5.9 (869)	**<0.05**	8.5 (171)	8.0 (161)	0.352
Diabetes Mellitus %	1.5 (219)	0.9 (128)	0.539	1.9 (38)	1.0 (20)	0.07
Anti-diabetic treatment %	0.6 (94)	0.4 (57)	0.854	1.0 (20)	0.3 (6)	**<0.05**
Lipid-lowering treatment %	1.4 (210)	0.6 (96)	**<0.05**	1.1 (22)	0.8 (16)	0.612
Smoking habits						
Never-smoker %	27.8 (4,124)	16.6 (2,465)	**<0.001**	24.0 (482)	19.8 (398)	**<0.05**
Ex-smoker %	15.8 (2,340)	12.1 (1,793)		12.9 (260)	13.3 (268)	
Current smoker %	18.0 (2,672)	9.8 (1,455)		16.9 (339)	13.0 (261)	
Marital status						
Married %	38.4 (5,705)	22.6 (3,363)	**<0.001**	31.1 (625)	26.4 (530)	0.771
unmarried/ widow %	23.1 (3,431)	15.8 (2,350)		22.7 (456)	19.8 (397)	
Variables	15.6 (2,310)	7.8 (1,152)	**<0.001**	15.4 (310)	12.3 (246)	0.285
	46.0 (6,826)	30.7 (4,561)		38.4 (771)	33.9 (681)	

Data presented as non-adjusted, percentages, mean ± SD & p-value.

4.3. Incidence of Stroke Events

In the total population, the relative risk (RR) for incidence of stroke events increased by RR 1.28 (95% CI 1.09 - 1.50) in current smokers as compared to the never-smokers group (**Table 3**). Moreover, this incidence of stroke increased approximately twice to RR 196, (95% CI 1.66 - 2.32) after further adjustments for risk factors including age, BMI, biological and socio-economic factors. Similar findings were observed among Swedish-born and migrant women separately (**Table 3**).

The incidence of stroke among the total study population increased significantly among women with a high SES as compared to the women with a low SES(RR 0.82 [95% CI 0.72 - 0.97]). Similarly, the incidence of stroke was lower among Swedish-born women with a high SES as compared to women with a low SES (RR 0.90, 95% CI 0.70 - 0.96) (**Table 4**). There were no significant differences in RR for incidence of stroke among migrant women in a comparison of events between high and low SES (RR 0.90 [95% CI 0.59 - 1.36]) (**Table 4**).

The incidence of stroke among the total study population decreased significantly among women who performed moderate/high PA as compared to women who performed no/low PA. RR 0.68 (95% CI 0.58 - 0.79) and stayed low even after adjustments for risk factors. Similarly, the incidence for stroke decreased significantly among Swedish-born women, RR 0.76, (95% CI 0.57 - 0.79) and stayed low after adjustments, but no significant

Table 3. Incidence of stroke events in relation to smoking habits in 16,857 women.

Models	Total Population (N = 16,857)			Swedish-Born (n = 14,849)			Non-Swedish-Born (n = 2,008)		
	Never-Smoker (n = 7,469)	Ex-Smoker (n = 4,661)	Current Smoker (n = 4,727)	Never-Smoker (n = 6,589)	Ex-Smoker (n = 4,133)	Current Smoker (n = 4,127)	Never-Smoker (n = 880)	Ex-Smoker (n = 528)	Current Smoker (n = 600)
RR (95%CI)	1.0	0.84 (0.71 - 1.01)	1.28 (1.09 - 1.50)	1.0	0.83 (0.69 - 1.01)	1.25 (1.06 - 1.48)	1.0	0.95 (0.55 - 1.65)	1.47 (0.92 - 2.34)
RR (95%CI)[a]	1.0	1.02 (0.85 - 1.22)	1.83 (1.55 - 2.15)	1.0	1.04 (0.86 - 1.26)	1.84 (1.55 - 2.19)	1.0	0.88 (0.51 - 1.51)	1.72 (1.07 - 2.75)
RR (95%CI)[ab]	1.0	1.03 (0.86 - 1.24)	1.99 (1.68 - 2.34)	1.0	1.06 (0.87 - 1.28)	2.00 (1.68 - 2.39)	1.0	0.88 (0.51 - 1.53)	1.82 (1.13 - 2.93)
RR (95%CI)[abc]	1.0	1.04 (0.87 - 1.25)	1.96 (1.66 - 2.32)	1.0	1.07 (0.88 - 1.29)	1.98 (1.66 - 2.36)	1.0	0.89 (0.51 - 1.54)	1.83 (1.13 - 2.96)

Relative Risk RR. CI 95% confidence interval. Model 1 unadjusted. Model 2 adjusted for [a]age. Model 3 adjusted for model 2 + [b]hypertension, use of BP-lowering treatment, diabetes, anti-diabetic treatment, cholesterol, and BMI. Model 4 adjusted for model 2 + 3 + [c]SES, and marital status.

Table 4. Incidence of stroke events in relation to SES and physical activity in 16,857 women.

Socio-Economic Status (SES)	Total Female Population (N = 16,857)		Swedish-Born (n = 14,849)		Non-Swedish-Born (n = 2,008)	
	Low SES (n = 10,217)	High SES (n = 6,640)	Low SES (n = 9,136)	High SES (n = 5,713)	Low SES (n = 1,081)	High SES (n = 927)
RR (95%CI)	1.0	0.86 (0.74 - 0.99)	1.0	0.85 (0.73 - 0.99)	1.0	0.80 (0.60 - 1.37)
RR (95%CI)[a]	1.0	0.80 (0.69 - 0.92)	1.0	0.79 (0.67 - 0.92)	1.0	0.86 (0.57 - 1.30)
RR (95%CI)[ab]	1.0	0.82 (0.71 - 0.95)	1.0	0.81 (0.69 - 0.95)	1.0	0.89 (0.58 - 1.35)
RR (95%CI)[abc]	1.0	0.83 (0.72 - 0.97)	1.0	0.82 (0.70 - 0.96)	1.0	0.90 (0.59 - 1.36)
Physical Activity (PA)	No/Low PA (n = 4,018)	Mod/High PA (n = 12,839)	No/Low PA (n = 3,462)	Mod/High PA (n = 11,387)	No/Low PA (n = 556)	Mod/High PA (n = 1,452)
RR (95%CI)	1.0	0.68 (0.58 - 0.79)	1.0	0.76 (0.57 - 0.79)	1.0	0.73 (0.47 - 1.13)
RR (95%CI)[a]	1.0	0.68 (0.58 - 0.79)	1.0	0.68 (0.58 - 0.79)	1.0	0.70 (0.45 - 1.08)
RR (95%CI)[ab]	1.0	0.71 (0.61 - 0.83)	1.0	0.71 (0.60 - 0.83)	1.0	0.76 (0.49 - 1.19)
RR (95%CI)[abc]	1.0	0.72 (0.62 - 0.84)	1.0	0.71 (0.61 - 0.84)	1.0	0.77 (0.49 - 1.20)

Relative Risk RR. CI 95% confidence interval. Model 1 unadjusted. Model 2 adjusted for [a]age. Model 3 adjusted for model 2 + [b]hypertension, use of BP-lowering treatment, diabetes, anti-diabetic treatment, cholesterol, and BMI. Model 4 adjusted for model 2 + 3 + [c]physical activity, and marital status.

differences were found unadjusted among migrant women, 0.73, (95% CI 0.47 - 1.13) and did not reach significant levels after adjustments (**Table 4**).

There was a significantly increased incidence of stroke among the total population who were current smokers. The adjusted RR of stroke events among current smoking women with a high SES had the RR 1.84 (95% CI 1.39 - 2.44), whereas the adjusted RR of stroke events among current smoking women belonging to groups with low SES had the RR 2.22 (95% CI 1.76 - 2.81) (**Table 5**).

There was a significantly increased RR for stroke for all current smokers, both among those with a high SES and those with a low SES in Swedish-born women and among those with a low SES in migrant women. The RR of stroke events in Swedish-born women with a high SES in combination with current smoking was 1.21 (95% CI 0.90 - 1.62). After further adjustments for risk factors including age, BMI, biological and socio-economic factors, the RR for Swedish-born women increased to 1.90 (95% CI 1.40 - 2.56) and increased further to 2.23 (95% CI 1.74 - 2.87) in the group of Swedish-born women with a low SES (**Table 5**). Similarly, the RR of stroke events among those who were migrant current smokers within low SES groups was 1.72 (95% CI 0.90 - 3.27). After further adjustments for risk factors including age, BMI, biological and socio-economic factors, the RR for migrant women was increased (still insignificantly) to 2.18 (95% CI 1.13 - 4.20), and among migrant women with a high SES the RR was 1.51 (95% CI 0.71 - 3.21) (**Table 5**).

The likelihood of suffering a stroke varied both in the groups with a low SES and in the groups with a high SES among Swedish-born women and migrant women. The relative risk for migrant women who smoked and

Table 5. Cox proportional analysis of stroke event rate among the total population (N = 16,857), consisting of women born in Sweden (n = 14,849) and migrant women (n = 2,008), in relation to socio-economic status and smoking habits.

	High socio-economic status			Low socio-economic status		
	Never-smoker	Ex-smoker	Current smoker	Never-smoker	Ex-smoker	Current smoker
Total population (N = 16,857)						
Events, n/n (%)	123/2,863(4.3)	69/2,061 (3.3)	86/1,716 (5.0)	225/4,606 (4.9)	111/2,600 (4.3)	181/3,011 (6.0)
RR (95% CI)	1.0	0.78 (0.58 - 1.05)	1.20 (0.91 - 1.59)	1.08 (0.87 - 1.35)	0.97 (0.75 - 1.25)	1.42 (1.13 - 1.79)
RR (95% CI)[a]	1.0	0.96 (0.71 - 1.28)	1.72 (1.31 - 2.27)	1.17 (0.94 - 1.46)	1.27 (0.98 - 1.65)	2.21 (1.75 - 2.79)
RR (95% CI)[ab]	1.0	0.97 (0.73 - 1.31)	1.90 (1.44 - 2.51)	1.14 (0.92 - 1.42)	1.24 (0.96 - 1.61)	2.31 (1.83 - 2.92)
RR (95% CI)[abc]	1.0	0.97 (0.72 - 1.30)	1.84 (1.39 - 2.44)	1.13 (0.91 - 1.41)	1.23 (0.95 - 1.59)	2.22 (1.76 - 2.81)
Swedish-born (n = 14,849)						
Events, n/n (%)	107/2,465 (4.3)	58/1,793 (3.2)	74/1,455 (5.1)	205/4,124(5.0)	102/2,340 (4.4)	159/2,672 (6.0)
RR (95% CI)	1.0	0.74 (0.54 - 1.02)	1.21 (0.90 - 1.62)	1.09 (0.86 - 1.37)	0.98 (0.75 - 1.28)	1.38 (1.08 - 1.77)
RR (95% CI)[a]	1.0	0.94 (0.68 - 1.29)	1.78 (1.32 - 2.40)	1.19 (0.94 - 1.50)	1.35 (1.02 - 1.77)	2.22 (1.73 - 2.85)
RR (95% CI)[ab]	1.0	0.96 (0.70 - 1.32)	1.96 (1.45 - 2.65)	1.16 (0.91 - 1.46)	1.31 (1.00 - 1.73)	2.33 (1.82 - 3.00)
RR (95% CI)[abc]	1.0	0.96 (0.69 - 1.32)	1.90 (1.40 - 2.56)	1.15 (0.91 - 1.45)	1.30 (0.99 - 1.71)	2.23 (1.74 - 2.87)
Migrants (n = 2,008)						
Events, n/n (%)	20/482 (4.1)	9/260 (3.5)	22/339 (6.5)	16/398 (4.0)	11/268 (4.1)	12/261 (4.6)
RR (95% CI)	1.0	1.08 (0.50 - 2.32)	1.19 (0.56 - 2.51)	1.02 (0.53 - 1.97)	0.86 (0.38 - 1.94)	1.72 (0.90 - 3.27)
RR (95% CI)[a]	1.0	1.05 (0.49 - 2.27)	1.38 (0.65 - 2.92)	1.11 (0.57 - 2.14)	0.80 (0.36 - 1.82)	2.20 (1.15 - 4.21)
RR (95% CI)[ab]	1.0	1.05 (0.49 - 2.27)	1.52 (0.72 - 3.23)	1.08 (0.56 - 2.09)	0.80 (0.35 - 1.82)	2.20 (1.15 - 4.24)
RR (95% CI)[abc]	1.0	1.07 (0.49 - 2.31)	1.51 (0.71 - 3.21)	1.07 (0.55 - 2.07)	0.80 (0.35 - 1.82)	2.18 (1.13 - 4.20)

Relative Risk RR. CI 95% confidence interval. Model 1 unadjusted. Model 2 adjusted for [a]age. Model 3 adjusted for model 2 + [b]hypertension, use of BP-lowering treatment, diabetes, anti-diabetic treatment, cholesterol, and BMI. Model 4 adjusted for model 2 + 3 + [c]physical activity, and marital status.

had a low SES, it was 1.72 (CI: 0.90 - 3.27), as compared to smoking Swedish-born women with a low SES (RR 1.38 [CI: 1.08 - 1.77]). In contrast, the relative risk in migrants who both smoked and had a high SES was RR 1.19 (CI: 0.56 - 2.51), and was comparable to smoking Swedish-born women with a high SES (RR 1.21 [CI: 0.90 - 1.62]) (**Table 5**).

5. Discussion

In Europe, socio-economic inequalities in health have been targeted as one of the most important issues to be tackled by public health policy [20]. Socio-economic status is considered as an influential predictor for health and is usually measured by determining education, income, occupation, or a combination of these dimensions [21]. Individuals with higher education and a high income tend to adopt a healthier lifestyle, which might reduce the risk of having a stroke. About 16% of the women, regardless of migration status, were treated for high blood pressure. High blood pressure is well known to be a high risk factor for stroke [22] but can be modified by increased physical activity [23]. It is assumed that there is an inverse relationship between socio-economic status and stroke, *i.e.*, lower socioeconomic status is associated with a higher risk of stroke [22]. According to Kuper *et al*., the risk of stroke was significantly inversely related to years of education completed [24]. Similarly, in the present study it was shown that among the total population. Another study conducted by Li *et al*. also supported these findings [22].

Migrant women with a high SES in their own country might unfortunately not be able to keep the same SES in the new country and most often slide down to a lower socio-economic group due to difficulties in being assimilated into the labor market. They experience limited access to education, employment, housing, and health care facilities. They report that they feel isolated in their homes and lack social support [25], aspects that are part of the social determinants of health, and uncertainty about jobs and financial conditions puts extra stress in their life, which heightens the risk of developing stroke. According to Sundquist *et al*., both migration status and low social position are independent risk factors associated with poor health [26]. Still, in the present study we could not support any significant differences for the incidence of stroke between migrant women and Swedish women of the same socio-economic level, but belonging to a group with a low level of socio-economic status was nevertheless a risk factor in all the women.

Previous studies have shown that smoking acts as a substantial risk for the occurrence of stroke [6] [7]. In the present study it was possible to observe that smoking is indeed an important precursor for stroke. This study revealed that women who had never smoked had less probability of getting a stroke compared to ex-smokers and current smokers in both groups of Swedish-born and non-Swedish-born women. Smoking, when combined with other risk factors, such as hypertension, diabetes mellitus, and cholesterol, acts synergistically to increase the risk of CVD [25]. Similarly, in this study, the risk of stroke for current smokers was increased after adjustment for biological and socio-economic risk factors.

The present study also showed that there was a significantly increased incidence of stroke for all current smokers, both among those with a high SES and those with a low SES in Swedish-born women, and among those with a low SES in migrant women. Interestingly, the likelihood of suffering a stroke varied in both groups of low and high SES among Swedish-born women as well as migrant women. The relative risk of getting a stroke was higher for migrant women who smoked and had a low SES, as compared to Swedish-born women who smoked and had a low SES, but this was inversed after adjusting for risk factors. A possible explanation could be that in the present study migrant women had a higher SES than the Swedish-born women.

It is well known that regular physical activity is an important determinant for maintaining good health, and it does not only improve bodily functions and mental health but also assists in maintaining a healthy lifestyle. Furthermore, it has been earlier reported that moderate and high levels of physical activity reduced the risk of total, ischemic, and hemorrhagic stroke [23]. In the present study it was observed that women performing moderate/high physical activity had less risk of suffering a stroke than those who performed no/low physical activity among the total population. This finding indicates that physical activity can modify the risk of having a stroke, which is in line with the findings of the above-mentioned study.

6. Methodological Considerations

The limitations of this study need to be highlighted. In the MDCS study, the participants were divided into only Swedish-born and non-Swedish-born women, regardless of their individual country of origin, but information

about the non-Swedish participants' countries of origin could most likely have given a better idea of the risk factors for stroke. Furthermore, many migrants were missing in the study due to the language barrier, which resulted in a low number of migrant participants. Therefore, the potential relationship between modes of recruitment and socio-demographic characteristics as well as lifestyle factors raises the question of bias. As there has been an increased influx in numbers of migrants into the city of Malmo since 2000, the results would probably have been stronger if data had been collected today. Moreover, the reliability and validity of the PA score need to be discussed.

Additionally, in the present study, in spite of the fact that all the participants were women, data on the menopause, the use of oral contraceptives, and the use of estrogen, was missing, so this could not be adjusted for. We did not relate the prevalence of smoking to treatment of blood pressure in the groups, but earlier studies have shown that smoking in combination with high blood pressure increases the risk of CVD considerably by synergy [25].

The main strength of this cohort study is the large sample size with a long follow-up period, which in turn helps to get results with a high confidence interval. Moreover, the overall participation rate in the MDCS was 40.8 percent, with a majority of women participants (42.6 percent), and 38.3 percent men [12]. The study has, furthermore, been compared to another population-based survey in Scania, and the results were evaluated and found compatible with regard to socio-economic factors, BMI, mortality, and smoking habits [12].

Public Health Implications

This study confirms the results of other studies reporting that women with a low SES were at a higher risk of suffering a stroke than those with a high SES. Initiatives should be taken for educating individuals with a low SES, providing information regarding different risk factors as well as encouraging them to adopt healthy life styles. Besides, it is extremely important to ensure migrant women's access to health care facilities and inform them about the health sector organization in Sweden. Informing them about where to go in case of disease, and also about disease prevention, that it is a normal task included in the Swedish system, that is not the case in many other countries.

Smoking, high blood pressure, low socio-economic circumstances (low SES), and low physical activity were some of the potential risk factors of stroke, as has been described before. In this study, smoking migrant women were more vulnerable to stroke than the Swedish-born women. In another, earlier, study, the group has reported that migrant women often have a higher BMI and are less physically active and therefore need special consideration from a public health perspective, especially in order to reduce their tobacco consumption, lower their BMI, and increase their physical activity. This is not an easy public health task, due to differences in cultural understanding of what it means to be physically active and in perceptions about weight and overweight.

In the present study it was shown that PA can reduce the risk of stroke even in smokers. Promoting physical activity is, thus, important, and it is not only efficacious but also easy and comparatively inexpensive to implement. Furthermore, it is part of the Swedish national public health goal that stipulates the importance of increasing the level of physical activity in all of the population, including all age groups and migrants. This study contains of women between 45 and 73 years of age, and it is well known that performing physical activity is reduced with age, especially among migrant women [25] [26]. Moreover, many women born outside Sweden are unaware of the positive effects of physical activity. Studies show that they are less physically active and that they report that performing physical activity is merely for the youth [25] [26]. In this study, about a third of the total population performed low or no PA, and the figure was probably even lower at the oldest end of the age group. Increasing age is a large risk factor for stroke and as PA is protective, lives could be saved and both pain and various handicaps avoided, as well as costs for society, by targeting middle-aged and older women with health-promoting physical activity interventions.

Multidisciplinary actions, involving media, knowledge-raising activities, as well as increased possibilities for migrant women, regardless of age and cultural needs, to be active in sport classes, are needed in order to promote physical activity among the total population and not least among the vulnerable group of middle-aged migrant women.

7. Conclusion

This study confirms that all women with low socio-economic circumstances have a higher risk of stroke. No sta-

tistically significant differences were found indicating that migrant women in this population had a higher risk as compared to Swedish-born women. Still, smoking migrant women were more vulnerable to stroke compared to Swedish-born women. Physical activity was shown to be effective in reducing the risk of getting a stroke among the total population and especially among the Swedish-born women. To increase physical activity in middle-aged women, in both migrant and Swedish-born women, is a highly recommended public health strategy in order to maintain the positive trend of a decrease in the incidence of stroke.

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Conflict of Interest

There is no conflict of interest.

Authors' Contributions

EA wrote an earlier manuscript, RK participated in the design, did the analyses, and drafted the second version of the manuscript. EJ conceived/designed the study and critically examined and finalized the manuscript.

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