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Socioeconomic Differences in Stroke Among Dutch Elderly Women

The Rotterdam Study

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Background and Purpose—We sought to assess the association between socioeconomic status and the risk of stroke among elderly women.

Methods—The association between socioeconomic status and stroke emerged in cross-sectional and longitudinal data on 4274 female participants of the Rotterdam Study, a prospective, population-based, follow-up study in the Netherlands among older subjects.

Results—A history of stroke was more common among women in lower socioeconomic strata. The same trend was observed for the relationship between the lowest socioeconomic groups and the incidence of stroke. Risk factors for stroke were not related to socioeconomic status in a consistent manner. Smoking, history of cardiovascular diseases, and overweight were more common in lower socioeconomic groups. However, socioeconomic differences in hypertension, antihypertensive drug use, prevalence of atrial fibrillation, and prevalence of left ventricular hypertrophy were not observed. The complex of established risk factors could only partly explain the association between socioeconomic status and stroke.

Conclusions—There is a strong association among elderly women between socioeconomic status and stroke. The association could only partly be explained by known risk factors. Our findings indicate that not only the actual risk profile but also risk factors earlier in life may be of importance. (*Stroke*. 1999;30:357-362.)

Key Words: aged ■ risk factors ■ socioeconomic factors ■ stroke

Stroke is a major contributor to cardiovascular mortality and one of the most important causes of disability in the Netherlands.¹ Several studies have shown that people with a lower socioeconomic status are at greater risk of cardiovascular morbidity and mortality.² The lower socioeconomic groups also appear to have more risk of dying of a stroke.³⁻¹⁵ Most of the evidence for the association between socioeconomic status and stroke is based on studies of stroke mortality and its geographic variations.^{4,10-15} Studies on this association at an individual level have been performed mainly among middle-aged men. Because cardiovascular morbidity and mortality generally decrease in younger age groups and an increasing proportion of the population is reaching advanced age, health inequalities among elderly people are an important public health concern. This applies especially to women, because in contrast to coronary heart disease, stroke together with its associated invalidity is, in absolute numbers, more pronounced among older women than among men.¹⁶

We examined the association between indicators of socioeconomic status and the prevalence and incidence of stroke

among elderly women. We also studied the association between socioeconomic status and the main risk factors for stroke among elderly women.

Subjects and Methods

Study Population

The Rotterdam study is a prospective, population-based, follow-up study of the determinants of chronic and disabling cardiovascular, neurogeriatric, locomotor, and ophthalmologic diseases among persons aged ≥ 55 years, living in one defined geographic area in Rotterdam, Netherlands.¹⁷ The present analysis focuses on female participants, totaling 4878 women (response rate=78%) at baseline. Of these women, 188 (4%) did not sign an informed consent to allow collection of data from their medical records. In addition, at the time of this analysis 416 persons had not (yet) been completely followed up because of link-up problems between their general practitioners' medical records on their computer systems and our computerized registration system. Thus, on April 1, 1996, completed follow-ups were available for 4274 women, covering an average period of 4.0 (SD, 0.8) years.

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Measurements

Trained interviewers obtained information on education, occupation, and income as indicators of socioeconomic status during a home visit at baseline of the study (1990–1993).

Education

The participants were asked about their formal education, the number of years in each type of education, and whether education had been completed. From this information, the attained highest level of education was defined and classified into 4 categories: primary education; lower/intermediate general and lower vocational education; higher general and intermediate vocational education; higher vocational education and university.

Occupation

For this analysis we classified women on the basis of the current or last occupation of the head of the household. Partners were assumed to be head of the household when women lived with a partner or were widowed. We assume that this is a plausible assumption for our elderly population. Other women, divorced or without partner, were themselves considered to be head of the household. The classification was set up according to the international Erikson-Goldthorpe-Portocarero scheme.^{18,19} Four levels are distinguished: higher- and lower-grade professionals; routine nonmanual employees; small entrepreneurs; and manual workers.

Household Income

Income represents mainly the material dimension of socioeconomic status; therefore, it is likely that this is determined by the income of the whole household. Household income was classified into 13 precoded categories. Equivalent household income was computed by dividing the midpoint of each household income category by the number of persons living on that income to the 0.36 power.²⁰ Institutionalized participants were excluded from the analysis ($n=493$) because their financial situation differs from that of noninstitutionalized participants. Four categories of equivalent household income were defined, corresponding approximately to quartiles of the distribution of the total noninstitutionalized population.

Data on education, occupation, and income were missing for 4%, 8%, and 11% of the participants, respectively.

Stroke

Participants were considered to have a history of stroke on the basis of self-reported history of stroke at the time of baseline measurements. This was confirmed by data from medical records of the general practitioner or neurologist involved. Of the 4274 women, 112 appeared to have a history of stroke.

Detailed information on incident cases of stroke and on vital status was obtained from participants' general practitioners. Most general practitioners involved have their practice computerized, and digital information on, among other events, all possible incident cases of stroke and deaths is sent regularly to the Rotterdam research center. Information on vital status was also obtained from the Rotterdam municipal authorities. When a stroke or death was reported, additional information was obtained by interviewing the relevant general practitioner and by consulting hospital discharge records in case of admittance or referral. Information was furthermore retrieved by research physicians from participants' medical records held at medical practices that were not linked to the computer system. Two research physicians independently classified (eg, date of event, certainty of diagnosis, International Classification of Primary Care [ICPC] code, or *International Statistical Classification of Diseases, 10th Revision* code) all suspected cases on the basis of all the available information. When they disagreed, the physicians would discuss the case until consensus was reached. Finally, a neurologist reviewed all suspected cerebrovascular cases and classified them into definite, probable, and possible stroke. On April 1, 1996, 168 women were diagnosed as having had a first stroke (ICPC-code K90) in the follow-up period.

Risk Factors

Behavioral and physiological risk factors are often regarded as the mediators through which socioeconomic status is related to cardiovascular diseases. Several risk factors were assessed in the baseline phase of the study. In this analysis, we focused on the established risk factors for stroke, eg, systolic blood pressure, hypertension, drug use for hypertension, atrial fibrillation, left ventricular hypertrophy, diabetes mellitus, body mass index, and smoking.²¹ Systolic and diastolic blood pressure were measured twice on one occasion, with participants sitting down, on their right upper arm, with a random-zero sphygmomanometer. Hypertension was considered to be present with a systolic blood pressure of ≥ 160 mm Hg, a diastolic blood pressure of ≥ 95 mm Hg, or because of current antihypertensive drug use for the indication of hypertension. We assessed atrial fibrillation and left ventricular hypertrophy by ECG using an automatic diagnostic classification system. Smoking history was assessed during an interview at home and was categorized as never, former, or current smoker. Body mass index was calculated by dividing weight by squared height. Plasma fibrinogen levels were determined according to Von Claus.²² Diabetes was considered present when subjects were on oral blood glucose-lowering drugs or received insulin treatment. Participants were considered to have a history of cardiovascular diseases when they had a self-reported history of myocardial infarction, coronary artery bypass operation, angina pectoris, intermittent claudication, or percutaneous transluminal angioplasty at the time of the baseline examinations. Alcohol intake and other dietary factors were assessed with a semiquantitative food frequency questionnaire.²³

Data Analysis

Our data analysis approach was 3-fold. First, logistic regression analyses were performed to explore the relationship between socioeconomic status and history of stroke at baseline. To examine the association between socioeconomic status and incidence of stroke, Cox proportional hazard regression analyses were applied, excluding all women with a history of stroke at baseline. The individual follow-up period was defined as the period between the first home interview until date of incident stroke, until date of death, or until April 1, 1996. Second, age-adjusted means and proportions of risk factors according to socioeconomic groups were computed on the basis of ANCOVA or logistic regression analysis. Finally, the associations between socioeconomic status and stroke were adjusted for these risk factors by adding them to the regression models. Missing values were included in the models by the indicator method.

In general, all analyses were age adjusted (eight 5-year age groups). To obtain more stable estimates, the lowest socioeconomic groups were used as reference groups, since the incidence of stroke in the highest groups was small. Statistical testing for trends was done with linear or logistic regression, including education, occupation, or income in the model as a continuous variable (eg, values 1, 2). All analyses were performed with the statistical program SPSS.

Results

In our study population, the majority of women was classified in the lower socioeconomic groups (Table 1). At time of the baseline measurements, only 7% were still employed. Most women were aged >65 years and already retired. On average, they had their last paid job 28 years ago. The majority of the women were or had been employed as manual workers (43%) or routine nonmanual workers (43%). Six percent mentioned that they were never employed. The mean age at baseline of the study was 71 (SD 10) years. On average, subjects in lower socioeconomic groups were older than those in higher socioeconomic groups. For example, among women aged ≥ 70 years, 29% had lower educational levels, as opposed to 10% for those who were aged <70 years. In addition, the mean age

TABLE 1. Risk of Having a History of Stroke by Socioeconomic Status, Adjusted for Age

Socioeconomic Status	n	No. of Cases	Adjusted for Age			Adjusted for Age and Risk Factors*		
			OR	CI	P	OR	CI	P
Educational level								
Primary	1961	72	1	...	0.011	1	...	0.07
Lower/intermediate general, lower vocational	1188	23	0.79	0.48–1.30	...	0.89	0.54–1.49	...
Higher general, intermediate vocational	794	9	0.47	0.23–0.96	...	0.56	0.27–1.17	...
University, higher vocational	158	1	0.24	0.03–1.73	...	0.32	0.04–2.35	...
Occupational level of head of household								
Manual workers	1507	57	1	...	0.18	1	...	0.51
Small entrepreneurs	224	10	1.21	0.60–2.44	...	1.25	0.60–2.60	...
Routine nonmanual employees	1112	10	0.79	0.48–1.30	...	0.85	0.51–1.42	...
Professionals†	1080	19	0.72	0.42–1.24	...	0.84	0.47–1.47	...
Equivalent household income								
Quartile 1	1070	30	1	...	0.005	1	...	0.006
Quartile 2	819	17	0.80	0.44–1.47	...	0.72	0.38–1.35	...
Quartile 3	862	10	0.55	0.26–1.17	...	0.53	0.24–1.16	...
Quartile 4	625	2	0.16	0.04–0.70	...	0.15	0.03–0.68	...

OR indicates odds ratio.

*Adjusted for systolic blood pressure, hypertension, drug use for hypertension, smoking, cardiovascular diseases, left ventricular hypertrophy, atrial fibrillation, diabetes mellitus, fibrinogen, body mass index, and alcohol consumption.

†This occupational group includes lower- and higher-grade administrators and officials, higher-grade technicians, managers in small business and industrial establishments, proprietors of large businesses, and supervisors of nonmanual employees.¹⁸

of the stroke cases was higher than that of the noncases. All analyses were therefore adjusted for age.

History of Stroke

Age-adjusted associations between socioeconomic status and history of stroke are shown in Table 1. A history of stroke was less common among the highest socioeconomic groups. The relative risk of having a history of stroke was 0.24 (95% CI, 0.03 to 1.73) for the most highly educated women and 0.16 (95% CI, 0.04 to 0.70) for the highest income group compared with the lowest socioeconomic groups. Linear trends were statistically significant for education and income.

Incidence of Stroke

In Table 2, age-adjusted relative risks of incidence of stroke with socioeconomic status are presented. Similar to the cross-sectional analyses, the highest socioeconomic groups also had a lower risk of stroke. However, statistical significance was only reached for the association between incidence of stroke and occupation of the head of the household. The intermediate educational and occupational groups did not differ in their risk of stroke compared with the lowest groups.

Risk Factors for Stroke

In Tables 3, age-adjusted means and proportions of the main risk factors for stroke according to income are presented. The associations between the other indicators of socioeconomic status are not shown, but for those that are not mentioned specifically, findings were similar to the associations with income. Blood pressure and hypertension were not associated with socioeconomic status. However, smoking was more common in the lower socioeconomic groups compared with

higher socioeconomic groups. A history of cardiovascular disease and diabetes mellitus was more frequent in the lower socioeconomic groups (this was not observed for educational level). For all 3 indicators of socioeconomic status, no associations were observed for left ventricular hypertrophy and atrial fibrillation. Similarly, there was no socioeconomic gradient for plasma fibrinogen levels, with the exception of a trend for education. Body mass index decreased with increasing socioeconomic status. Use of alcohol was positively associated with socioeconomic status.

To examine whether these risk factors could explain the association between incidence of stroke and socioeconomic status, the association between socioeconomic status and stroke was adjusted for these risk factors. The associations between socioeconomic status and stroke remained almost unchanged (Tables 1 and 2). In addition, differences in other dietary factors, such as dietary fat consumption and antioxidants, could not explain the association between socioeconomic status and stroke (results not shown).

Discussion

The results of our study suggest that stroke is substantially more common among women in the lower socioeconomic strata. In addition, the incidence of stroke is higher in the lower socioeconomic groups. However, risk factors were not associated with socioeconomic status in a consistent manner and could only partly explain the association between socioeconomic status and stroke.

A number of issues need to be addressed before results can be interpreted. First, selective participation must be considered. It is likely that the population represents a relatively healthy cohort, since people with health problems are less

TABLE 2. Risk of First Stroke by Socioeconomic Status, Adjusted for Age

Socioeconomic Status	n	No. of Cases	Adjusted for Age			Adjusted for Age and Risk Factors*		
			RR	CI	P	RR	CI	P
Educational level								
Primary	1889	97	1	...	0.32	1	...	0.53
Lower/intermediate general, lower vocational	1165	32	0.81	0.54–1.22	...	0.86	0.57–1.30	...
Higher general, intermediate vocational	785	27	1.08	0.70–1.67	...	1.17	0.75–1.82	...
University, higher vocational	157	1	0.18	0.02–1.28	...	0.19	0.03–1.36	...
Occupational level of head of household								
Manual workers	1457	74	1	...	0.054	1	...	0.064
Small entrepreneurs	214	8	0.68	0.33–1.41	...	0.65	0.31–1.38	...
Routine nonmanual employees	1088	46	1.02	0.71–1.48	...	1.05	0.72–1.52	...
Professionals†	1061	24	0.60	0.38–0.96	...	0.59	0.37–0.95	...
Equivalent household income								
Quartile 1	1040	53	1	...	0.12	1	...	0.14
Quartile 2	802	30	0.96	0.62–1.49	...	0.81	0.51–1.29	...
Quartile 3	852	22	0.83	0.55–1.35	...	0.81	0.48–1.36	...
Quartile 4	623	8	0.55	0.25–1.16	...	0.57	0.26–1.24	...

RR indicates relative risk.

*Adjusted for systolic blood pressure, hypertension, drug use for hypertension, smoking, cardiovascular diseases, left ventricular hypertrophy, atrial fibrillation, diabetes mellitus, fibrinogen, body mass index, and alcohol consumption.

†See definition in Table 1.

capable of visiting the research center and thus less likely to participate in the study.^{24,25} In addition, the exclusion of persons with incomplete follow-ups may have influenced the results. Most people who did not sign the informed consent were simply not able to do so because of their reduced cognitive function. These subjects were slightly older and had a lower socioeconomic status compared with the overall study population. Another cause for loss to follow-up (ie, link-up problems) was not associated with socioeconomic status (results not shown). In our opinion, selective partici-

pation only slightly influenced the results or led to an underestimation of the real differences.

Second, the nature of measuring stroke, risk factors, and socioeconomic status needs to be considered. Information bias in the measurement of socioeconomic status was minimized by collecting this information in a standardized manner. However, for older subjects, assessment of socioeconomic status may involve specific difficulties. For instance, although educational level remains relatively stable over time, it may be subject to cohort effects. Also, social status of

TABLE 3. Risk Factors According to Equivalent Household Income, Adjusted for Age

Risk Factor	Equivalent Household Income				Total		P
	Quartile 1 (n=1040)	Quartile 2 (n=802)	Quartile 3 (n=852)	Quartile 4 (n=623)	Mean	n*	
Systolic blood pressure, mm Hg	139.6	140.1	141.0	140.0	140.2	3028	0.45
Hypertension, %	34.9	36.4	38.0	33.7	35.8	3030	0.93
On antihypertension medication, %	20.2	23.6	24.2	19.1	21.9	2676	0.79
Current smokers of cigarettes, %	23.0	19.8	16.0	16.1	18.7	3217	0.0001
Never smokers, %	50.5	51.2	54.0	53.7	52.4	3277	0.12
Cardiovascular diseases,† %	13.5	11.0	11.2	9.3	11.3	3317	0.016
Left ventricular hypertrophy on ECG, %	4.2	6.3	4.0	5.4	5.0	1507	0.96
Atrial fibrillation, %	1.4	1.0	1.8	1.3	1.4	1552	0.76
Diabetes mellitus, %	4.7	6.6	4.0	2.7	4.5	3231	0.041
Fibrinogen, adjusted for use of vitamin K antagonists, g/L	2.78	2.88	2.78	2.78	2.81	1438	0.80
Body mass index, kg/m ²	26.9	27.2	26.6	26.3	26.8	3052	0.005
Use of alcohol, %	69.3	72.3	72.7	80.2	73.6	2687	0.0002

*Not all risk factors are available for each participant.

†Self-reported history of myocardial infarction, coronary artery bypass operation, angina pectoris, intermittent claudication, or percutaneous transluminal angioplasty.

a certain occupation may have changed over time because of changes in the structure of society.²⁶ These problems were solved by including age in the multivariate analyses. A disadvantage of measuring income is that it may be affected by a recent divorce or spouse's death. Such a misclassification of socioeconomic status may have led to an underestimation of the association between socioeconomic status and stroke. Although the indicators of socioeconomic status represent different dimensions of socioeconomic status, their associations with stroke were quite similar.

The measurement of stroke may have been affected by inaccuracies in general practitioners' diagnoses. A number of stroke cases may be assigned to other cardiovascular diseases, whereas other diseases may have been wrongly coded as stroke. It is nevertheless unlikely that this has influenced our estimates to a large extent. Another source of bias lies in socioeconomic differences in use of healthcare facilities. It was found that people with a lower socioeconomic status more often consult a general practitioner than people whose socioeconomic status is higher, even with the illness taken into account.²⁷ For that reason, we decided not to exclude strokes that were less likely (possible) in the neurologists' opinion. Exclusion of these events would have resulted in bias, since the classification depends on whether an event has led to hospitalization and the availability of information about signs and symptoms in patient records. Unfortunately, the number of strokes was too small for stratified analyses to be performed. In addition, it can be hypothesized that the proportion of strokes that go unnoticed by general practitioners is associated with socioeconomic status. However, this nonrandom misclassification will not be as large for socioeconomic differences in stroke, since all stroke patients in the Netherlands will be seen by a general practitioner because of the severity of this disease.

Furthermore, a limitation of our analyses is the relatively short follow-up period. As a result, the number of strokes might be too small to assess a significant association. However, the fact that a similar and statistically significant association between the socioeconomic status and history of stroke is observed confirmed the inverse relationship between the lowest socioeconomic groups and stroke. Nevertheless, it is of concern that despite the larger number of events for incident disease relative to prevalent disease, the pattern of association, especially for the intermediate groups, is not as clear. The question arises of whether the association between socioeconomic status and history of stroke might be biased, because women of a lower socioeconomic groups with a prevalent stroke might be more willing to participate in this study, believing it to be a source of health care. However, in the Netherlands, where health care is easily available for everyone, this is not a likely explanation. Another explanation might be that the association between socioeconomic status and stroke declines with age.

Finally, our study population is rather homogeneous because the extreme socioeconomic groups are slightly underrepresented in the study area.²⁸ In other words, the range of socioeconomic factors was more limited than that in a study that also includes extreme socioeconomic groups. In fact, the true inequalities would probably be larger still, even if more extreme socioeconomic groups had been included.

A number of studies have reported an inverse association between socioeconomic status and stroke.^{3-15,29-31} However, most reports are based on geographic variation in occurrence of stroke by socioeconomic differences.^{4,9,12-15,30} Nevertheless, a number of studies at the individual level observed a socioeconomic gradient in stroke, although these studies typically focused on socioeconomic differences in risks to die from stroke among men and among younger age groups.^{3,5-8,10,29,31} The present study is the first to describe socioeconomic differences in stroke morbidity among elderly women. Even though our study design and methods differ from previous studies, similar trends in the association between socioeconomic status and stroke risk were observed.

The observed trends are strong compared with those in previous studies. The study population only comprised persons aged ≥ 55 years. On the one hand, socioeconomic differences at older ages may diminish compared with younger ages, because people from lower socioeconomic groups who live on into old age may represent a very healthy elite; less viable individuals may have died sooner.³² However, this survival effect would be less among women because of a lower mortality rate at younger ages. On the other hand, older persons from lower socioeconomic groups are exposed for a longer time to factors that contribute to socioeconomic differences in health.³² The accumulation of disadvantages over a person's course of life might result in larger socioeconomic differences at older ages.

In this study we focused on the differences among women, since Dutch women suffer from stroke more than men do, and since less is known about socioeconomic inequalities among women. Nevertheless, data on socioeconomic differences in stroke for men were also available in the Rotterdam study. For men, we found no association between socioeconomic status and history of stroke or incidence of stroke (results not shown). This difference between associations for men and women or the difference with results from other studies among younger men could be caused by the fact that the survival effect is more pronounced among elderly men, resulting in smaller socioeconomic differences for stroke. A second cause might be that distribution of risk factors may be different for men and women and for (younger) men in other countries. For example, hypertension, one of the major risk factors for stroke, was positively related with socioeconomic status among men in the Rotterdam study (van Rossum, unpublished data, 1998).

We expected the established risk factors for stroke to explain at least part of the socioeconomic differences in stroke occurrence. However, in our study population, these risk factors may give some explanation for the higher incidence of stroke, but as in other studies, a large proportion of the socioeconomic influence remained unexplained. There are several explanations for this. First, in this study there were some significant socioeconomic differences in risk factors, such as smoking, diabetes, cardiovascular disease, and elevated body mass index, but we did not observe socioeconomic differences in the main risk factors for stroke, such as hypertension, use of antihypertensive drugs, atrial fibrillation, or left ventricular hypertrophy. These results contrast with most other studies on socioeconomic differences in risk factors, which makes further research necessary.^{2,33-35} Sec-

ond, it is well known that with increasing age, established risk factors play a less important role. For example, in our study the regression coefficient of age is 50% higher than the coefficient in the risk profile of stroke based on the Framingham Study, which is based on a younger study population.²¹ It is possible that at older ages the impact of risk factors on the explanation of socioeconomic differences in stroke may be different. Also, in the present setting, risk factors were measured by a single assessment at old age. It is possible that the impact of these risk factors on socioeconomic differences in stroke would be larger when measured earlier in life. Finally, it is possible that other unmeasured risk factors are better able to explain the differences. For example, Davey Smith¹⁴ suggested that risk factors earlier in life, such as birth weight or head circumference, which are both associated with socioeconomic status, are directly related to blood pressure and the occurrence of stroke in adult life.

The large socioeconomic differences in stroke observed in this study warrant further research that focuses on changes in risk factors that are helpful in elucidating the etiology of inequalities. These studies may provide information on potential interventions with respect to determinants of diseases and selection of risk groups to improve the overall health of a population and to reduce differences in health between socioeconomic groups in a society.

In conclusion, elderly women in the lowest socioeconomic groups have a higher risk of stroke compared with those in the higher socioeconomic groups. Established risk factors can only partly explain this association.

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