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Associations of socioeconomic status with migraine and non-migraine headache

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Abstract

Background—Migraine has been linked with several measures of socioeconomic status (SES). However, results are inconsistent and data on the association between SES and non-migraine headache, migraine subtypes and migraine frequency are sparse.

Methods—We conducted a cross-sectional study among 36,858 participants in the Women's Health Study. As proxy for SES, we calculated an SES index using annual household income and education. Migraine, migraine aura, and non-migraine headache were self-reported with good validation rates. Multinomial logistic regression models were used to evaluate the association between SES index and the various headache forms.

Results—12,140 (32.9%) women reported any history of headache, 6,801 women (18.4%) reported any history of migraine and 5,339 (14.5%) reported non-migraine headache. Women with low SES had an increased risk for all headache forms. The multivariable-adjusted OR (95% CI) were 1.22 (1.10–1.36) for non-migraine headache, 1.40 (1.28–1.54) for any migraine, 1.44 (1.23–1.69) for migraine with aura, and 1.38 (1.21–1.58) for migraine without aura. Among active migraineurs, low SES was associated with an increased OR for $\geq$ weekly attack frequency (1.77, 1.26–2.49).

Conclusions—In this large cohort of female health professionals, low SES was associated with an increased prevalence for all headache forms and an increased migraine attack frequency.

Keywords

Migraine; non-migraine headache; migraine frequency; socioeconomic status

Introduction

The impact of socioeconomic inequalities on various health statuses has been studied frequently (1), particularly to identify potential targets for prevention or to initiate prevention strategies. The underlying mechanisms by which socioeconomic status (SES) might be linked to diverse health outcomes are still unclear.

From a public health perspective, especially, a relationship between SES and diseases with a high prevalence is of interest. Primary headache disorders are highly prevalent and particularly migraine headaches are resulting in large personal and societal burden (2). Approximately 18% of females and 6% of males experience at least one migraine attack per year (3). The prevalence of active migraine changes over lifespan with a peak in both sexes at ages 25–55, the most productive years of adulthood (4). The economic consequences of migraine is mainly reduced productivity caused by absenteeism or reduced performance at work (2).

The potential association between SES and migraine has been frequently studied with inconsistent results (5–11) and only two cross-sectional studies have evaluated migraine subtypes (12, 13). In addition, studies suggest an association between low SES and chronification of headache forms (14–16). One potential mediator for this association is an increased migraine attack frequency, but only few studies have especially addressed the relation between SES and migraine attack frequency (6, 17, 18), also with inconsistent results.

The most commonly used indicators for SES are income, education and occupation (3, 5, 6, 8–10, 17, 19–21). However, socioeconomic status is a multidimensional concept, which may not be well represented by single indicator variables. Combining SES proxies into an index has been proposed as an alternate method to measure SES and addresses the issue of multidimensionality (22–25).

We therefore aim to evaluate the association of SES, represented by an SES index, with prevalence of migraine and non-migraine headache as well as with migraine attack frequency in a cohort over 39,000 female health professionals.

Methods

Study population

Study subjects were all participants in the Women's Health Study (WHS), a completed randomized trial designed to test the benefits and risks of low-dose aspirin and vitamin E in the primary prevention of cardiovascular disease and cancer among apparently healthy women. The design, methods, and results have been described in detail previously (26, 27). In brief, a total of 39,876 U.S. female health professionals aged ≥ 45 years at baseline (1993–1995) and without a history of cardiovascular disease, cancer, or other major illnesses were randomly assigned to active aspirin (100mg on alternate days), active vitamin E (600 IU on alternate days), both active agents, or both placebos. All participants provided written informed consent and the Institutional Review Board of the Brigham and Women's Hospital, Boston, Massachusetts approved the procedures of the WHS. Baseline information was self-reported and collected by a mailed questionnaire that asked about many cardiovascular risk factors and lifestyle variables. Twice in the first year and yearly thereafter, participants were sent follow-up questionnaires asking about study outcomes and other information during the study period. Since the trial's termination in 2004, observational follow-up is still ongoing.

Assessment of migraine

On the baseline questionnaire, participants were asked: "Have you ever had migraine headaches?" and "In the past year, have you had migraine headaches?" We distinguished between women without migraine history, who reported any migraine history, who reported active migraine (migraine in the year prior completing the baseline questionnaire), and who reported prior migraine, which includes women who reported ever having had a migraine but none in the year prior to completing the questionnaire. Our any migraine category

included women with active migraine (migraine with aura, migraine without aura) and prior migraine. Those participants who reported active migraine were further asked details about their migraine attacks, including attack duration of 4 to 72 hours; unilateral location and pulsating quality of pain; inhibition of daily activities; aggravation by routine physical activity; nausea or vomiting; and sensitivity to light or sound. Furthermore, participants who reported active migraine were asked whether they had an “aura or any indication a migraine is coming”. Responses were used to classify women who reported active migraine into migraine with aura and migraine without aura, similar to previous studies (28, 29). In addition, active migraineurs were asked details about the frequency of their migraine attacks (daily, weekly, monthly, every other month, < 6 times/year).

In previous studies of the WHS, we have shown good agreement between migraine classification based on International Headache Society criteria. Specifically, we have shown in a substudy of the WHS that over 87% of women with active migraine could be diagnosed as migraine without aura (71.5%) or probable migraine without aura (16.2%) when applying current revised criteria (30).

Ascertainment of non-migraine headache

Participants were asked to report on the 6-month follow-up questionnaire whether they have ever had headaches. We subsequently categorized women in having non-migraine headache, if a women reported headache but did not indicate any history of migraine similar to a previous study (29). Women who reported both migraine and non-migraine headache were classified as migraineurs.

Assessment of socioeconomic status

At enrollment, participants were asked to report the total annual household income in the year prior the baseline questionnaire and their highest level of education. We defined 6 categories of income ($\leq \$19,999$, $\$20,000-29,999$, $\$30,000-39,999$, $\$40,000-49,999$, $\$50,000-99,999$, and $\geq \$100,000$), and 6 levels of education (< 2 years of nursing education, 2 years of nursing education, 3 years of nursing education, a bachelor's degree, a master's degree, and a doctoral degree). Based upon this information, we created a SES index (Table 1).

Point values of 0 to 5 were assigned to each individual variable category as follows: the highest point value (5) was assigned to the lowest income and education categories, respectively. The assigned point values decreased with increasing income and education levels. The highest income and education categories received the lowest point value (0). We then combined the income and education variable to an overall SES index which ranged from 0–10. We divided the overall SES index into quintiles. The lowest quintile represented the highest level of SES and was used as reference category in further analysis. The assigned point scheme and the distribution of the SES variables according to the SES index categories are presented in Table 1.

Studies analyzing data from the general population often additionally include a proxy for occupation in their SES index (23, 24). Since our cohort consists of health professionals, our education and professional occupation variables are very closely related. We decided not to include occupation in our index because of a rather small variation in this traditional SES indicator.

Statistical methods

Of the 39, 876 women, a total of 3,018 women were excluded (missing data on migraine status (n=119), education (n=669) or income (n=2,230)), leaving 36, 858 participants for this

analysis. Because age differed according to SES index, we used direct standardization to adjust categorical variables for age in 5 year increments to compare baseline characteristics according to SES index categories.

Multinomial logistic regression models were calculated to evaluate the association between SES index categories and headache subtypes with SES index as the independent and headache subtypes as the dependent variable. We run two multinomial models, one including information on any migraine, non-migraine headache, and no history of headache (reference group) and the other one including migraine with aura, migraine without aura, prior migraine, non-migraine headache, and no history of headache (reference group). Multinomial logistic regression is an extension of binary logistic regression that allows the dependent variable to have more than two categories and then simultaneously compares each of these categories to a reference category. Women within the lowest SES quintile and no history of any headache were used as reference group. Prevalence odds ratios (ORs) and 95% confidence intervals (CIs) were calculated for the association between SES index and the various headache forms.

We further evaluated the association between SES index and migraine attack frequency (daily and weekly, monthly, every other month, <6 times per year) using multinomial logistic regression models. Because of low case counts, we collapsed the SES index quintiles into a binary variable (SES index point values 8–10 versus SES index point values 0–7) for this part of the analysis. Women with a SES index between 0 and 7 with a migraine attack frequency of less than 6 times per year serve as reference category.

We run age- and multivariable-adjusted models. We selected covariates as potential confounder if they were related with migraine and SES status. The multivariable models were adjusted for age (continuous), race (white, non-white), marital status (single, married, divorced, widowed), geographic region (Northeast, Southeast, Midwest, West), history of hypertension, postmenopausal hormone use (never, past, current), and postmenopausal status (premenopausal, postmenopausal, biologically uncertain, unclear). To determine whether the associations are influenced by life style factors, we additionally adjusted the multivariable models for smoking status (never, current, past), body mass index (<25 kg/m², 25.0–<30.0 kg/m², ≥30 kg/m²), exercise (never, <1/week, 1–3 times/week, ≥4 times/week) and alcohol consumption (never, 1–3 drinks/month, 1–6 drinks/week, ≥1 drink/day).

To assess the impact of each single SES indicator separately, we additionally calculated multinomial logistic regression models with income and education as exposure variable.

A missing value indicator was included for all covariates if the number of women with missing information was ≥100. We assigned participants with missing values to the reference category of the covariate if the number of missing information was less than 100. The total number of missing values for all covariates was 2,375 (6.4%).

For all analysis, we used SAS (version 9.1; SAS Institute Inc., Cary, NC, USA). All p-values were two-tailed and p < 0.05 was considered statistically significant.

Results

Of the 36,858 women, a total of 12,140 (32.9%) women reported any history of headache, of whom 6,801 (18.4%) women reported any history of migraine and 5,339 (14.5%) reported non-migraine headache. Among the 4,791 (13.0%) active migraineurs (migraine in the year previous to baseline), 1,906 (39.8%) women indicated migraine with aura.

In Table 2, participants' age-adjusted baseline characteristics according to SES index categories are presented. Women with low SES status (SES index 8–10) had a mean age of 57.6 years and were older compared to women with high SES status (SES index 0–3). They were more likely to have a history of migraine and non-migraine headache. Compared to women with higher SES statuses, women with low SES status were more likely to have BMI values $\geq 30\text{kg/m}^2$, to currently smoke, to rarely/never consume alcohol and to rarely/never exercise.

Table 3 summarizes the associations between the SES index and headache types. Women with the lowest SES status had a multivariable-adjusted OR for any migraine (OR: 1.40, 95% CI: 1.28–1.54), active migraine with aura (OR: 1.44, 95% CI: 1.23–1.69), active migraine without aura (OR: 1.38, 95% CI: 1.21–1.58), prior migraine (OR: 1.36, 95% CI: 1.17–1.58) and non-migraine headache (OR: 1.22, 95% CI: 1.10–1.36), compared to women with the highest SES status who did not have a headache history (Model 1). These associations did not substantially change after additional adjustment for life style factors (Model 2) and were mainly driven by income (Appendix Table 1).

In Table 4, the associations between SES index and migraine attack frequency are summarized. Compared with women with higher SES status (SES index 0–7) and a migraine attack frequency of less than 6 times per year, women with low SES status (SES index 8–10) had a multivariable-adjusted OR of 1.77 (1.26, 2.49) for having at least one migraine attack per week. This association between SES index and the various headache forms was not attenuated by life style factors (Model 2). In the analysis evaluating single SES proxies, income and not education was associated with an increased attack frequency (data not shown).

Discussion

In this large cross-sectional study of women with a profession in the health sector, low SES status was associated with an increased OR for any evaluated headache form, including migraine with aura, migraine without aura and non-migraine headache. Furthermore, active migraineurs with low SES had an increased OR for $\geq$ weekly migraine attack frequency. Additional adjustment for life style factors did not substantially change the effect estimate suggesting that the observed associations is unlikely explained by lifestyle habits in our cohort. When comparing the two SES proxies, income and education, income predominately contributed to the observed relationship between SES status, headache prevalence and migraine attack frequency.

The relationship between SES and migraine prevalence has been studied frequently. Several studies support our finding of an association between low SES and overall migraine prevalence (3, 8, 12, 19, 31). The majority of studies assessed the association between SES and migraine in general. In a cross-sectional study of 12,750 participants from the United States distinguishing between migraine subtypes, low income was associated with an increased OR for migraine with aura (OR: 1.68, 95% CI: 1.07–2.64), migraine without aura (OR: 1.56, 95% CI: 1.14–2.14) and other headaches with aura (OR: 1.89, 95% CI: 1.14–3.13) (12). In a Danish cohort of 31,865 participants, low educational levels were associated with an increased multivariable-adjusted OR of 1.30 (1.08–1.56) for migraine without aura in women (13). In contrast, studies from Canada (9) Netherlands (17) and Sweden (5) found no association between SES assessed by income or education and migraine prevalence.

We have additionally evaluated data on non-migraine headache. Our non-migraine headache category includes participants with headache other than migraine but the cases are not further classified according to diagnostic criteria. However, as along with migraine, tension-

type headache is the most common primary headache disorder and other headache forms are very rare in the general population, we believe that our non-migraine headache group is driven by tension-type headache. Several studies report an association between either low or high educational levels and tension-type headache (32–34). Other studies could not confirm these results and found no association between SES and TTH or other non-migraine headache forms (18, 20, 32, 35, 36).

Only few studies have evaluated the relationship between SES and migraine attack frequency (6, 17, 18). Two studies are in line with our finding and report an association between low SES and frequent headache with migrainous features (18) and frequent headache (migraine and non-migrainous headache) (6) while a study from the Netherlands found no significant differences in attack frequency by SES (17). Data on headache frequency in the non-migraine headache group was not available in our study.

SES is a complex, multidimensional concept and hard to measure. Most studies evaluating the association between SES and headache have used either income or education as a single proxy for SES. The application of a SES index instead of one single measure has several advantages. Firstly, the SES index addresses SES as a multidimensional concept. Secondly, using a SES index reduces the dominance of one single SES measure and allows variation across categories. Indeed, the average contribution of income and education varies according to our SES index categories (Table 1). In the high SES index category, both income and education contribute about half to the combined SES index score while in the low SES index category education contributes about two thirds. Single measures, e.g. education or income, represent different dimensions when used as indicators for SES. Education reflects a person's individual intellectual abilities and may also be associated with different health behaviors. Compared to other SES proxies, education is stable measure, but may rather represent earlier life circumstances. Annual household income is an economic indicator and several family members may unequally contribute and have access to it. Although income is a more recent indicator for SES, it is prone to fluctuations and may be a result of prevalent health problems (37).

The mechanisms by which SES might be related to migraine prevalence and migraine frequency are unclear. Stress linked to economic hardship and working conditions, diverse diet patterns and different access to medical care may influence this association. Furthermore, the direction of the association still has to be determined. Bigal and colleagues have evaluated two opposing hypothesis, social causation and social selection, for the association between SES and migraine (38). The social causation hypothesis suggests that factors associated with low SES increase disease prevalence. In contrast, according to the social selection theory, the disease itself affects the individual's educational and occupational abilities and subsequently leads to lower SES (39). Results of the study suggest that social causation rather than social selection might contribute to the relationship between SES and migraine prevalence (38). However, most of the studies assessing SES and migraine, including our study, have a cross-sectional design not allowing addressing the directionality and causative pathways of the association.

Our study has several strengths including the large number of participants and the large number of individuals with various headache forms. Our migraine assessment has been shown to be valid (30) and we could distinguished migraine subtypes as well as migraine attack frequency. The WHS provides information about a large number of potential confounders allowing us to adjust the association between SES and migraine.

The following limitations should be considered when interpreting our results. Firstly, information on migraine, migraine features and migraine frequency is self-reported and

underreporting or misclassification is possible. Secondly, information on the SES variables and the potential confounders is also self-reported. However, as information on education and income are related to headache-specific information, such misclassification is expected to be random. Lastly, our cohort consists of female health professional aged ≥ 45 years which may limit the generalizability of our results to other populations.

In conclusion, data from this large cohort of female health professionals indicate an association between low SES status and any headache form. In addition, we found an association between low SES status and migraine attack frequency. These results support further targeted research on potential triggering factors of headache in lower SES groups and exploration of potential preventive strategies.

Appendix table 1

Association between annual household income levels and headache subtypes (N=36,858)

Income categories (USD)	No of subjects with the specific headache type	Age-adjusted OR (95% CI)	Model 1 (95%CI)	Model 2 (95%CI)
Any migraine (n=6,801)				
≤ 19,999	376	1.28 (1.11, 1.47)	1.35 (1.17, 1.57)	1.24 (1.07, 1.45)
20,000–29,999	668	1.10 (0.98, 1.23)	1.13 (1.00, 1.27)	1.05 (0.92, 1.18)
30,000–39,999	946	1.04 (0.94, 1.16)	1.07 (0.96, 1.19)	1.00 (0.89, 1.12)
40,000–49,999	1,113	1.00 (0.91, 1.11)	1.01 (0.91, 1.12)	0.95 (0.86, 1.06)
50,000–99,999	2,795	0.99 (0.91, 1.07)	0.98 (0.90, 1.07)	0.94 (0.86, 1.03)
≥ 100,000	903	1.00	1.00	1.00
Migraine with aura (n=1,906)				
≤ 19,999	86	1.04 (0.80, 1.34)	1.19 (0.91, 1.55)	1.06 (0.81, 1.40)
20,000–29,999	191	1.07 (0.88, 1.30)	1.17 (0.95, 1.43)	1.06 (0.86, 1.30)
30,000–39,999	252	0.92 (0.77, 1.10)	0.99 (0.83, 1.19)	0.91 (0.75, 1.10)
40,000–49,999	322	0.94 (0.80, 1.11)	0.99 (0.83, 1.17)	0.91 (0.77, 1.09)
50,000–99,999	770	0.87 (0.75, 1.00)	0.88 (0.76, 1.01)	0.83 (0.72, 0.96)
≥ 100,000	285	1.00	1.00	1.00
Migraine without aura (n=2,885)				
≤ 19,999	119	1.14 (0.92, 1.43)	1.25 (1.00, 1.58)	1.13 (0.89, 1.43)
20,000–29,999	264	1.15 (0.97, 1.36)	1.21 (1.02, 1.45)	1.10 (0.92, 1.32)
30,000–39,999	394	1.11 (0.95, 1.29)	1.15 (0.99, 1.35)	1.06 (0.90, 1.24)
40,000–49,999	458	1.02 (0.88, 1.17)	1.04 (0.90, 1.21)	0.96 (0.82, 1.11)
50,000–99,999	1,270	1.07 (0.95, 1.21)	1.08 (0.96, 1.22)	1.02 (0.90, 1.15)
≥ 100,000	380	1.00	1.00	1.00
Prior Migraine (n=2,010)				
≤ 19,999	171	1.55 (1.25, 1.93)	1.47 (1.17, 1.85)	1.42 (1.12, 1.80)
20,000–29,999	213	1.06 (0.87, 1.29)	1.00 (0.81, 1.22)	0.97 (0.79, 1.19)
30,000–39,999	300	1.09 (0.91, 1.30)	1.03 (0.86, 1.24)	1.01 (0.84, 1.22)
40,000–49,999	333	1.05 (0.88, 1.25)	1.01 (0.84, 1.20)	0.98 (0.82, 1.18)
50,000–99,999	755	0.99 (0.85, 1.15)	0.96 (0.82, 1.11)	0.94 (0.81, 1.10)
≥ 100,000	238	1.00	1.00	1.00
Non-migraine headache (n=5,339)				
≤ 19,999	306	1.55 (1.33, 1.82)	1.63 (1.38, 1.92)	1.51 (1.28, 1.79)
20,000–29,999	516	1.26 (1.11, 1.44)	1.29 (1.13, 1.48)	1.21 (1.05, 1.39)
30,000–39,999	749	1.23 (1.09, 1.39)	1.26 (1.11, 1.42)	1.18 (1.04, 1.34)
40,000–49,999	860	1.15 (1.02, 1.29)	1.16 (1.03, 1.31)	1.09 (0.97, 1.23)
50,000–99,999	2,299	1.20 (1.09, 1.33)	1.20 (1.09, 1.33)	1.15 (1.04, 1.27)
≥ 100,000	609	1.00	1.00	1.00

Results from multinomial logistic regression models with the headache categories as dependent and SES index categories as independent variables. One model had the headache categories any migraine, non-migraine headache, and no headache as outcomes and another model had the migraine subgroups instead of any migraine as outcome. Women without headache and who have an income of ≥ 100,000 served as reference group.

Model 1: adjusted for age, race, marital status, geographic region, menopausal status, hormone use, history of hypertension

Model 2: Model 1 plus alcohol, smoking, BMI, exercise

Appendix table 2

Association between highest education levels and headache subtypes (N=36,858)

Education categories	No of subjects with the specific headache type	Age-adjusted OR (95% CI)	Model 1 (95%CI)	Model 2 (95%CI)
Any migraine (n=6,801)				
< 2 years of nursing education	1,160	1.16 (1.01, 1.33)	1.10 (0.96, 1.27)	1.06 (0.92, 1.22)
2 years of nursing education	935	1.06 (0.92, 1.22)	1.00 (0.87, 1.16)	0.97 (0.84, 1.12)
3 years of nursing education	1,879	0.79 (0.69, 0.90)	0.78 (0.68, 0.88)	0.76 (0.67, 0.87)
Bachelor's degree	1,531	0.84 (0.74, 0.96)	0.83 (0.73, 0.95)	0.81 (0.71, 0.93)
Master's degree	934	0.78 (0.68, 0.90)	0.78 (0.68, 0.89)	0.77 (0.67, 0.87)
Doctorate/MD	362	1.00	1.00	1.00
Migraine with aura (n=1,906)				
< 2 years of nursing education	339	1.02 (0.82, 1.27)	0.98 (0.79, 1.23)	0.93 (0.74, 1.17)
2 years of nursing education	283	0.95 (0.76, 1.19)	0.90 (0.71, 1.13)	0.86 (0.68, 1.08)
3 years of nursing education	465	0.60 (0.49, 0.74)	0.60 (0.48, 0.74)	0.58 (0.47, 0.72)
Bachelor's degree	431	0.71 (0.57, 0.87)	0.70 (0.56, 0.86)	0.68 (0.55, 0.84)
Master's degree	268	0.67 (0.53, 0.84)	0.67 (0.54, 0.84)	0.66 (0.53, 0.83)
Doctorate/MD	120	1.00	1.00	1.00
Migraine without aura (n=2,885)				
< 2 years of nursing education	468	1.24 (1.02, 1.53)	1.24 (1.01, 1.53)	1.20 (0.97, 1.48)
2 years of nursing education	395	1.16 (0.94, 1.42)	1.14 (0.92, 1.41)	1.10 (0.89, 1.36)
3 years of nursing education	805	0.93 (0.77, 1.13)	0.95 (0.78, 1.16)	0.93 (0.76, 1.13)
Bachelor's degree	683	0.99 (0.81, 1.20)	1.01 (0.83, 1.23)	0.98 (0.81, 1.20)
Master's degree	399	0.88 (0.71, 1.08)	0.89 (0.72, 1.09)	0.88 (0.71, 1.08)
Doctorate/MD	135	1.00	1.00	1.00
Prior Migraine (n=2,010)				
< 2 years of nursing education	353	1.21 (0.96, 1.51)	1.06 (0.84, 1.33)	1.04 (0.83, 1.32)
2 years of nursing education	257	1.07 (0.85, 1.36)	0.95 (0.75, 1.21)	0.94 (0.74, 1.20)
3 years of nursing education	609	0.82 (0.67, 1.02)	0.76 (0.61, 0.94)	0.75 (0.61, 0.94)
Bachelor's degree	417	0.82 (0.66, 1.02)	0.77 (0.61, 0.96)	0.76 (0.61, 0.95)
Master's degree	267	0.80 (0.63, 1.00)	0.76 (0.60, 0.97)	0.76 (0.60, 0.97)
Doctorate/MD	107	1.00	1.00	1.00
Non-migraine headache (n=5,339)				
< 2 years of nursing education	799	1.14 (0.98, 1.34)	1.11 (0.95, 1.30)	1.04 (0.88, 1.22)
2 years of nursing education	628	1.02 (0.87, 1.20)	0.98 (0.84, 1.16)	0.93 (0.79, 1.10)
3 years of nursing education	1,550	0.94 (0.81, 1.08)	0.94 (0.81, 1.09)	0.90 (0.77, 1.04)
Bachelor's degree	1,283	1.01 (0.87, 1.18)	1.01 (0.87, 1.17)	0.97 (0.84, 1.13)
Master's degree	827	0.99 (0.85, 1.16)	1.00 (0.85, 1.17)	0.98 (0.83, 1.14)
Doctorate/MD	252	1.00	1.00	1.00

variables. One model had the headache categories any migraine, non-migraine headache, and no headache as outcomes and another model had the migraine subgroups instead of any migraine as outcome. Women without headache and who have a doctorate/MD degree served as reference group.

Model 1: adjusted for age, race, marital status, geographic region, menopausal status, hormone use, history of hypertension

Model 2: Model 1 plus alcohol, smoking, BMI, exercise

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References

1. Mackenbach JP, Stirbu I, Roskam AJ, Schaap MM, Menvielle G, Leinsalu M, Kunst AE. Socioeconomic inequalities in health in 22 European countries. *N Engl J Med*. 2008; 358:2468–2481. [PubMed: 18525043]
2. Maki K, Vahtera J, Virtanen M, Elovainio M, Pentti J, Keltikangas-Jarvinen L, Kivimaki M. Sickness absence among female employees with migraine and co-existing conditions. *Cephalalgia*. 2008; 28:1136–1144. [PubMed: 18644038]
3. Lipton RB, Bigal ME, Diamond M, Freitag F, Reed ML, Stewart WF. Migraine prevalence, disease burden, and the need for preventive therapy. *Neurology*. 2007; 68:343–349. [PubMed: 17261680]
4. Lipton RB, Bigal ME. The epidemiology of migraine. *Am J Med*. 2005; 118 Suppl 1:3S–10S. [PubMed: 15841882]
5. Dahlof C, Linde M. One-year prevalence of migraine in Sweden: a population-based study in adults. *Cephalalgia*. 2001; 21:664–671. [PubMed: 11531898]
6. Hagen K, Vatten L, Stovner LJ, Zwart JA, Krokstad S, Bovim G. Low socio-economic status is associated with increased risk of frequent headache: a prospective study of 22718 adults in Norway. *Cephalalgia*. 2002; 22:672–679. [PubMed: 12383064]
7. Kryst S, Scherl E. A population-based survey of the social and personal impact of headache. *Headache*. 1994; 34:344–350. [PubMed: 7928313]

8. Lipton RB, Stewart WF, Diamond S, Diamond ML, Reed M. Prevalence and burden of migraine in the United States: data from the American Migraine Study II. *Headache*. 2001; 41:646–657. [PubMed: 11554952]
9. O'Brien B, Goeree R, Streiner D. Prevalence of migraine headache in Canada: a population-based survey. *Int J Epidemiol*. 1994; 23:1020–1026. [PubMed: 7860153]
10. Queiroz LP, Peres MF, Piovesan EJ, Kowacs F, Ciciarelli MC, Souza JA, Zukerman E. A nationwide population-based study of migraine in Brazil. *Cephalalgia*. 2009; 29:642–649. [PubMed: 19187337]
11. Stang PE, Yanagihara T, Swanson JW, Beard CM, Melton LJ 3rd. A population-based study of migraine headaches in Olmsted County, Minnesota. Case ascertainment and classification. *Neuroepidemiology*. 1991; 10:297–307. [PubMed: 1798433]
12. Carson AP, Rose KM, Sanford CP, Ephross SA, Stang PE, Hunt KJ, et al. Lifetime prevalence of migraine and other headaches lasting 4 or more hours: the Atherosclerosis Risk in Communities (ARIC) study. *Headache*. 2004; 44:20–28. [PubMed: 14979879]
13. Le H, Tfelt-Hansen P, Skytthe A, Kyvik KO, Olesen J. Association between migraine, lifestyle and socioeconomic factors: a population-based cross-sectional study. *J Headache Pain*. 2011; 12:157–172. [PubMed: 21390550]
14. Buse DC, Manack A, Serrano D, Turkel C, Lipton RB. Sociodemographic and comorbidity profiles of chronic migraine and episodic migraine sufferers. *J Neurol Neurosurg Psychiatry*. 2010; 81:428–432. [PubMed: 20164501]
15. Lipton RB. Tracing transformation: chronic migraine classification, progression, and epidemiology. *Neurology*. 2009; 72:S3–S7. [PubMed: 19188564]
16. Scher AI, Stewart WF, Ricci JA, Lipton RB. Factors associated with the onset and remission of chronic daily headache in a population-based study. *Pain*. 2003; 106:81–89. [PubMed: 14581114]
17. Launer LJ, Terwindt GM, Ferrari MD. The prevalence and characteristics of migraine in a population-based cohort: the GEM study. *Neurology*. 1999; 53:537–542. [PubMed: 10449117]
18. Scher AI, Stewart WF, Liberman J, Lipton RB. Prevalence of frequent headache in a population sample. *Headache*. 1998; 38:497–506. [PubMed: 15613165]
19. Fernandez-de-Las-Penas C, Hernandez-Barrera V, Carrasco-Garrido P, Alonso-Blanco C, Palacios-Cena D, Jimenez-Sanchez S, Jimenez-Garcia R. Population-based study of migraine in Spanish adults: relation to socio-demographic factors, lifestyle and co-morbidity with other conditions. *J Headache Pain*. 2010; 11:97–104. [PubMed: 20012124]
20. Lyngberg AC, Rasmussen BK, Jorgensen T, Jensen R. Incidence of primary headache: a Danish epidemiologic follow-up study. *Am J Epidemiol*. 2005; 161:1066–1073. [PubMed: 15901627]
21. Molarius A, Tegelberg A, Ohrvik J. Socio-economic factors, lifestyle, and headache disorders - a population-based study in Sweden. *Headache*. 2008; 48:1426–1437. [PubMed: 18624712]
22. Clarke CA, Miller T, Chang ET, Yin D, Cockburn M, Gomez SL. Racial and social class gradients in life expectancy in contemporary California. *Soc Sci Med*. 2010; 70:1373–1380. [PubMed: 20171001]
23. James-Todd T, Tehranifar P, Rich-Edwards J, Titievsky L, Terry MB. The impact of socioeconomic status across early life on age at menarche among a racially diverse population of girls. *Ann Epidemiol*. 2010; 20:836–842. [PubMed: 20933190]
24. von Lengerke T, John J, Mielck A. Excess direct medical costs of severe obesity by socioeconomic status in German adults. *Psychosoc Med*. 2010; 7 Doc01.
25. Yang J, Carmichael SL, Canfield M, Song J, Shaw GM. Socioeconomic status in relation to selected birth defects in a large multicentered US case-control study. *Am J Epidemiol*. 2008; 167:145–154. [PubMed: 17947220]
26. Rexrode KM, Lee IM, Cook NR, Hennekens CH, Buring JE. Baseline characteristics of participants in the Women's Health Study. *J Womens Health Gend Based Med*. 2000; 9:19–27. [PubMed: 10718501]
27. Ridker PM, Cook NR, Lee IM, Gordon D, Gaziano JM, Manson JE, et al. A randomized trial of low-dose aspirin in the primary prevention of cardiovascular disease in women. *N Engl J Med*. 2005; 352:1293–1304. [PubMed: 15753114]

28. Kurth T, Kase CS, Schurks M, Tzourio C, Buring JE. Migraine and risk of haemorrhagic stroke in women: prospective cohort study. *BMJ*. 2010; 341:c3659. [PubMed: 20736268]
29. Kurth T, Slomke MA, Kase CS, Cook NR, Lee IM, Gaziano JM, et al. Migraine, headache, and the risk of stroke in women: a prospective study. *Neurology*. 2005; 64:1020–1026. [PubMed: 15781820]
30. Schurks M, Buring JE, Kurth T. Agreement of self-reported migraine with ICHD-II criteria in the Women's Health Study. *Cephalalgia*. 2009; 29:1086–1090. [PubMed: 19735535]
31. Stewart WF, Lipton RB, Celentano DD, Reed ML. Prevalence of migraine headache in the United States. Relation to age, income, race, and other sociodemographic factors. *Jama*. 1992; 267:64–69. [PubMed: 1727198]
32. Koseoglu E, Nacar M, Talaslioglu A, Cetinkaya F. Epidemiological and clinical characteristics of migraine and tension type headache in 1146 females in Kayseri, Turkey. *Cephalalgia*. 2003; 23:381–388. [PubMed: 12780769]
33. Queiroz LP, Peres MF, Piovesan EJ, Kowacs F, Ciciarelli MC, Souza JA, Zukerman E. A nationwide population-based study of tension-type headache in Brazil. *Headache*. 2009; 49:71–78. [PubMed: 18793211]
34. Schwartz BS, Stewart WF, Simon D, Lipton RB. Epidemiology of tension-type headache. *Jama*. 1998; 279:381–383. [PubMed: 9459472]
35. Katsarava Z, Dzagnidze A, Kukava M, Mirvelashvili E, Djibuti M, Janelidze M, et al. Primary headache disorders in the Republic of Georgia: prevalence and risk factors. *Neurology*. 2009; 73:1796–1803. [PubMed: 19933983]
36. Rasmussen BK. Migraine and tension-type headache in a general population: psychosocial factors. *Int J Epidemiol*. 1992; 21:1138–1143. [PubMed: 1483819]
37. Duncan GJ, Daly MC, McDonough P, Williams DR. Optimal indicators of socioeconomic status for health research. *Am J Public Health*. 2002; 92:1151–1157. [PubMed: 12084700]
38. Bigal ME, Lipton RB, Winner P, Reed ML, Diamond S, Stewart WF. Migraine in adolescents: association with socioeconomic status and family history. *Neurology*. 2007; 69:16–25. [PubMed: 17606878]
39. Hudson CG. Socioeconomic Status and Mental illness: Tests of the Social Causation and Selection Hypotheses. *American Journal of Orthopsychiatry*. 2005; 75:3–18. [PubMed: 15709846]

Table 1

Distribution of SES variables according to SES Index categories* in the Women's Health Study (N=36,858)

SES variable	Points [†]	SES Index					Total N=36,858	p-value <.0001
		0-3 n=12,805 34.7%	4 n=6,870 18.6%	5 n=5,281 14.3%	6-7 n=7,380 20.0%	8-10 n=4,522 12.3%		
Income, %								
≤ 19,999	5	0.0	0.0	0.3	4.0	39.3	5.7	
20,000-29,999	4	0.0	0.6	4.0	24.2	38.6	10.3	
30,000-39,999	3	0.7	7.6	19.7	35.5	22.1	14.3	
40,000-49,999	2	7.3	21.1	38.7	22.5	0.0	16.5	
50,000-99,999	1	59.0	66.3	35.9	13.8	0.0	40.8	
≥ 100,000	0	33.0	4.6	1.4	0.0	0.0	12.5	
Contribution to index [‡]	-	0.34	0.33	0.38	0.44	0.48	-	
Education, %								<.0001
< 2 years of nursing education	5	0.0	0.0	1.4	25.0	72.8	14.1	
2 years of nursing education	4	0.0	4.6	35.9	20.5	12.1	11.6	
3 years of nursing education	3	7.8	66.3	38.7	44.1	15.1	31.3	
Bachelor's degree	2	41.8	21.1	19.7	9.2	0.0	23.1	
Master's degree	1	36.8	7.6	4.0	1.1	0.0	15.0	
Doctorate/MD	0	13.6	0.6	0.3	0.0	0.0	4.9	
Contribution to index [¶]	-	0.66	0.67	0.62	0.56	0.52	-	

* Percentages may not add up to 100 because of rounding.

[†] Assigned point value to create SES index.

[‡] Mean SES index score from income in SES index category divided by mean SES index score in the category.

[¶] Mean SES index score from education in SES index category divided by mean SES index score in the category.

Table 2

Age-adjusted baseline characteristics according to SES index categories* in the Women's Health Study (N=36,858)

	SES Index					p-value
	0-3 n=12,805 34.7%	4 n=6,870 18.6%	5 n=5,281 14.3%	6-7 n=7,380 20.0%	8-10 n=4,522 12.3%	
Demographic information						
Mean age in years (SD)	52.9 (5.8)	53.8 (6.3)	54.4 (6.8)	56.5 (7.9)	57.6 (8.3)	<.0001
Ethnicity, %						<.0001
White	93.8	96.2	96.0	95.7	91.9	
Hispanic	1.0	0.9	0.8	1.3	2.2	
African American	2.1	1.5	2.2	2.0	5.0	
Other [†]	3.1	1.4	1.0	1.1	0.9	
Geographic location, %						<.0001
Northeast	20.8	20.7	18.0	18.1	16.4	
Southeast	22.3	23.1	24.3	23.3	24.9	
Midwest	32.3	35.8	34.6	38.9	41.6	
West	24.6	20.4	23.1	19.7	17.1	
Marital Status, %						<.0001
Single	6.8	5.6	5.5	5.1	6.6	
Married	80.1	79.2	72.7	67.0	53.1	
Divorced	9.5	10.9	15.7	19.5	28.0	
Widowed	3.6	4.4	6.2	8.4	12.3	
West	24.6	20.4	23.1	19.7	17.1	
Headache history, %						
Migraine with aura	5.2	4.3	5.4	5.4	6.4	
Migraine without aura	7.3	7.9	7.7	8.3	8.9	
Prior migraine	5.1	5.2	5.0	5.6	7.1	
Non-migraine headache	14.3	13.7	14.6	14.2	16.0	
No history of headache	68.1	68.9	67.4	66.5	61.6	
Life style variables, %						
Body mass index (kg/m ²)						<.0001

	SES Index					p-value
	0-3 n=12,805 34.7%	4 n=6,870 18.6%	5 n=5,281 14.3%	6-7 n=7,380 20.0%	8-10 n=4,522 12.3%	
<25	57.4	51.0	49.1	45.8	38.3	
25-29.9	28.6	31.0	32.2	32.2	33.5	
≥30	13.9	18.0	18.7	22.0	28.3	
Smoking status						<.0001
Never	54.2	48.9	51.2	49.2	46.2	
Past	38.0	39.6	34.5	32.7	28.5	
Current	7.8	11.5	14.3	18.1	25.2	
Alcohol consumption						<.0001
Rarely/never	33.9	41.2	47.9	54.5	65.2	
1-3 drinks/month	13.7	13.7	13.3	13.0	10.8	
1-6 drinks/week	38.4	33.9	30.3	25.5	18.4	
≥1 drink/day	14.0	11.2	8.6	7.0	5.5	
Exercise						
Rarely/never	31.6	38.2	38.8	43.7	49.2	<.0001
<1/week	19.2	19.8	21.2	20.6	19.3	
1-3 times/week	35.4	31.3	30.9	27.4	25.2	
≥4 times/week	13.7	10.8	9.1	8.3	6.2	
Other covariates, %						
History of hypertension	21.9	25.1	26.1	27.7	35.2	<.0001
Menopausal status						<.0001
Premenopausal	30.1	28.7	26.5	25.5	21.8	
Postmenopausal	54.0	54.3	55.0	54.6	54.6	
Biological uncertain	11.7	13.2	14.8	16.2	19.4	
Unclear/subject unsure	4.1	3.9	3.8	3.6	4.1	
Postmenopausal hormone use						<.0001
Never	47.4	48.1	46.5	47.5	48.3	
Past	7.7	9.4	9.7	12.8	15.3	
Current	44.9	42.5	43.8	39.7	36.4	

* Percentages may not add up to 100 because of rounding or missing values

Table 3

Association between SES index and headache types (N=36,858)

SES index categories and points	No of subjects with the specific headache type	Age-adjusted OR (95% CI)	Model 1 (95%CI)	Model 2 (95%CI)
Any migraine				
0-3 (n=12,805)	2,334	1.00	1.00	1.00
4 (n=6,870)	1,211	0.98 (0.90, 1.06)	0.97 (0.90, 1.05)	0.96 (0.89, 1.04)
5 (n=5,281)	955	1.04 (0.95, 1.13)	1.03 (0.95, 1.12)	1.00 (0.92, 1.09)
6-7 (n=7,380)	1,359	1.12 (1.04, 1.21)	1.12 (1.04, 1.22)	1.09 (1.01, 1.18)
8-10 (n=4,522)	942	1.41 (1.29, 1.54)	1.40 (1.28, 1.54)	1.36 (1.23, 1.49)
Migraine with aura				
0-3 (n=12,805)	685	1.00	1.00	1.00
4 (n=6,870)	308	0.86 (0.75, 0.98)	0.86 (0.75, 0.99)	0.85 (0.74, 0.98)
5 (n=5,281)	286	1.08 (0.93, 1.24)	1.08 (0.94, 1.25)	1.05 (0.90, 1.21)
6-7 (n=7,380)	369	1.08 (0.95, 1.24)	1.11 (0.97, 1.27)	1.06 (0.93, 1.22)
8-10 (n=4,522)	258	1.39 (1.19, 1.61)	1.44 (1.23, 1.69)	1.38 (1.17, 1.62)
Migraine without aura				
0-3 (n=12,805)	1,000	1.00	1.00	1.00
4 (n=6,870)	561	1.08 (0.96, 1.20)	1.08 (0.96, 1.20)	1.06 (0.95, 1.18)
5 (n=5,281)	408	1.06 (0.94, 1.20)	1.07 (0.94, 1.21)	1.03 (0.91, 1.17)
6-7 (n=7,380)	561	1.15 (1.03, 1.29)	1.17 (1.05, 1.31)	1.13 (1.00, 1.26)
8-10 (n=4,522)	355	1.34 (1.18, 1.53)	1.38 (1.21, 1.58)	1.33 (1.16, 1.62)
Prior migraine				
0-3 (n=12,805)	649	1.00	1.00	1.00
4 (n=6,870)	342	0.96 (0.84, 1.10)	0.93 (0.81, 1.07)	0.93 (0.81, 1.07)
5 (n=5,281)	261	0.96 (0.83, 1.12)	0.93 (0.80, 1.08)	0.91 (0.79, 1.07)
6-7 (n=7,380)	429	1.12 (0.98, 1.27)	1.07 (0.93, 1.22)	1.05 (0.92, 1.20)
8-10 (n=4,522)	329	1.47 (1.28, 1.70)	1.36 (1.17, 1.58)	1.34 (1.15, 1.56)
Non-migraine headache				
0-3 (n=12,805)	1,912	1.00	1.00	1.00
4 (n=6,870)	963	0.95 (0.87, 1.03)	0.95 (0.87, 1.03)	0.93 (0.85, 1.01)
5 (n=5,281)	774	1.03 (0.94, 1.13)	1.02 (0.93, 1.12)	0.99 (0.90, 1.08)
6-7 (n=7,380)	1,009	1.02 (0.93, 1.11)	1.01 (0.93, 1.11)	0.97 (0.89, 1.07)
8-10 (n=4,522)	681	1.24 (1.12, 1.36)	1.22 (1.10, 1.36)	1.16 (1.04, 1.29)

Results from multinomial logistic regression models with the headache categories as dependent and SES index categories as independent variables. One model had the headache categories any migraine, non-migraine headache, and no headache as outcomes and another model had the migraine subgroups instead of any migraine as outcome. Women without headache and who have a SES index of 0.3 served as reference group.

Model 1: adjusted for age, race, marital status, geographic region, menopausal status, hormone use, history of hypertension

Model 2: Model 1 plus alcohol, smoking, BMI, exercise

Table 4

Association between SES index and migraine frequency (n=4,731)

SES Index categories and points	No of subjects	Age-adjusted OR	Model 1	Model 2
Daily and weekly migraine attack frequency				
0–7 (n=4,125)	195	1.00	1.00	1.00
8–10 (n=606)	51	1.74 (1.25, 2.43)	1.77 (1.26, 2.49)	1.65 (1.16, 2.35)
Monthly migraine attack frequency				
0–7 (n=4,125)	833	1.00	1.00	1.00
8–10 (n=606)	102	0.88 (0.70, 1.11)	0.94 (0.74, 1.20)	0.96 (0.75, 1.22)
Every other months				
0–7 (n=4,125)	420	1.00	1.00	1.00
8–10 (n=606)	50	0.82 (0.60, 1.13)	0.88 (0.64, 1.22)	0.95 (0.69, 1.32)
< 6 times/year				
0–7 (n=4,125)	2,677	1.00	1.00	1.00
8–10 (n=606)	403	1.00	1.00	1.00

Model 1: adjusted for age, race, marital status, geographic region, menopausal status, hormone use, history of hypertension

Model 2: Model 1 plus alcohol, smoking, BMI, exercise