Excessive work and risk of haemorrhagic stroke: a nationwide case-control study

Beom Joon Kim[1,2], Seung-Hoon Lee[2], Wi-Sun Ryu[2], Chi Kyung Kim[2], Jong-Won Chung[2], Dohoung Kim[2], Hong-Kyun Park[2], Hee-Joon Bae[1], Byung-Joo Park[3], and Byung-Woo Yoon[2] for ABBA study investigators

Background Adverse effect of excessive work on health has been suggested previously, but it was not documented in cerebrovascular diseases.
Aim The authors investigated whether excessive working conditions would associate with increased risk of haemorrhagic stroke.
Methods A nationwide matched case-control study database, which contains 940 cases of incident haemorrhagic stroke (498 intracerebral haemorrhages and 442 sub-arachnoid haemorrhages) with 1880 gender- and age- (±5-year) matched controls, was analysed. Work-related information based on the regular job situation, including type of occupation, regular working time, duration of strenuous activity during regular work and shift work, was gathered through face-to-face interviews. Conditional logistic regression analyses were used for the multivariable analyses.
Results Compared with white-collar workers, blue-collar workers had a higher risk for haemorrhagic stroke (odds ratio, 1·33 [95% confidence interval, 1·06–1·66]). Longer regular working time was associated with increased risk of haemorrhagic stroke [odds ratio, 1·38 (95% confidence interval, 1·05–1·81) for 8–12 h/day; odds ratio, 1·95 (95% confidence interval, 1·33–2·86) for ≥13 h/day; compared with ≤4 h/day]. Exposure to ≥8 h/week of strenuous activity also associated haemorrhagic stroke risk [odds ratio, 1·61 (95% confidence interval, 1·26–2·05); compared with no strenuous activity]. Shift work was not associated with haemorrhagic stroke (*P* = 0·98). Positive associations between working condition indices and haemorrhagic stroke risk were consistent regardless of haemorrhagic stroke sub-types and current employment status.
Conclusions Blue-collar occupation, longer regular working time and extended duration of strenuous activity during work may relate to an increased risk of haemorrhagic stroke.

Key words: haemorrhagic stroke, intracerebral haemorrhage, occupation, sub-arachnoid haemorrhage, working condition, working hour

Correspondence: Byung-Woo Yoon, Department of Neurology, Seoul National University Hospital, 101 Daehak-ro, Jongno-gu, Seoul 110-744, Republic of Korea.
E-mail: bwyoon@snu.ac.kr
[1]Department of Neurology, Seoul National University Bundang Hospital, Seongnam-si, Gyunggi-do, Republic of Korea
[2]Department of Neurology and Clinical Research Centre for Stroke, Seoul National University Hospital, Seoul, Republic of Korea
[3]Department of Preventive Medicine, Seoul National University College of Medicine, Seoul, Republic of Korea

Conflicts of interest: None declared.

Funding: The ABBA study was primarily supported by the Korean Food and Drug Administration. This *post hoc* analysis was supported by research grants from the Korean Health 21 R&D Project, Ministry of Health and Welfare, Republic of Korea (A102065, A110490). The analyses and interpretations of the data and the final content of the article were produced independent of the financial sponsors.

DOI: 10.1111/j.1747-4949.2012.00949.x

Introduction

In modern times, more than 80% of adults in developed countries spend the majority of daily life in the workplace (1). So, occupation became not only being presentive of a person's social or economic status but being involved in the development of disease by health risk behaviours (2). Excessive burden of regular work has been indicated to have adverse effect on health, such as elevating risk of hypertension and cardiovascular events (3,4). Regarding this issue, occupation and excessive work were supposed to elevate a risk for chronic disease through psychological stress. However, objections have been raised due to the fact that direct biological links between psychological stress and disease risk are still hypothetical, and measurement of stress remains at the level of a subjective self-report (5). Hence, despite of its potential modifiability, working condition and labour burden are currently not accepted as documented risk factors for cardiovascular diseases or stroke (6,7).

Haemorrhagic stroke (HS), which comprises 15% to 20% of total stroke, is the most fatal and the least treatable stroke subtype, causing greater morbidity than ischaemic stroke (8). As HS is at the close juncture of hypertension and haemodynamic instability, it may be reasonable to assume that psychological stress is related to increased risk of HS. However, although the hypothetical association was documented in a recent international case-control study of ischaemic stroke, psychological stress was not associated with elevated risk of HS, possibly due to a limited number of HS subjects (9). Moreover, among the various aspects of life related to chronic stress, detailed investigations regarding the specific effect of work-related factors on the risk of stroke are scarce.

In this context, our objective was to evaluate the effect of various working condition indices on the risk of HS. To study this hypothesis, we investigated the Acute Brain Bleeding Analysis (ABBA) study population, which consisted of 940 cases of HS and 1880 matched controls collected from 33 hospitals with nationwide coverage (10).

Materials and methods

Patient recruitment and selection

The ABBA study was a prospective, nationwide, multicenter, and matched case-control study for the investigation of the effect of taking phenylpropanolamine (PPA) on the risk of HS in the Republic of Korea (10). Between October 2002 and March 2004, a total of 2710 HS patients from 33 participating centres were screened for eligibility of ABBA study. HS, including both intracerebral haemorrhage (ICH) and sub-arachnoid haemorrhage (SAH), was confirmed by imaging studies including computed

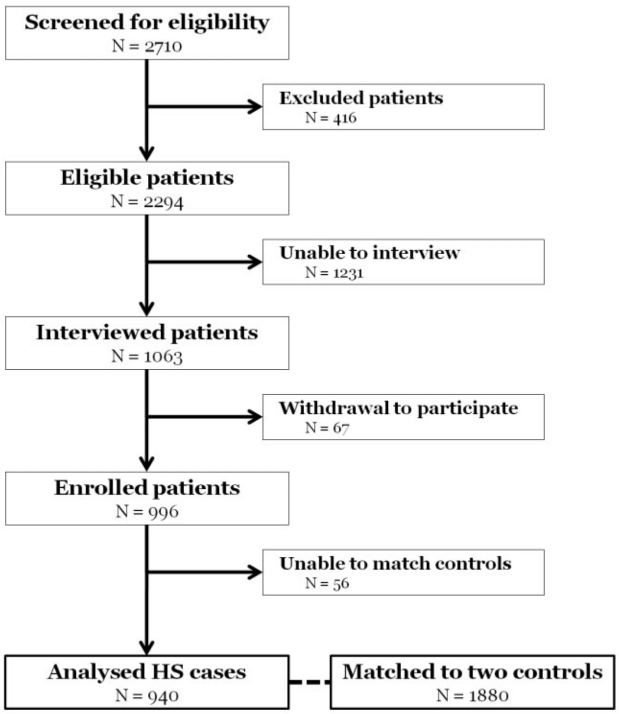

Fig. 1 Study profile. HS, haemorrhagic stroke.

tomography or magnetic resonance imaging scans, or by xanthochromia on lumbar puncture (11,12). Eligibility criteria were as follows: age ranges of 30 to 84 years, absence of history of stroke or haemorrhage-prone brain lesions, no traumatic bleeding, and the competence to communicate and complete face-to-face interview within 30 days after onset of HS. From 2710 initially screened HS patients, 940 HS cases were finally selected for matching their own controls (Fig. 1). Among cases, 498 subjects (53·0%) were ICH patients and 442 subjects (47·0%) had SAH. For each HS case, one hospital and one community controls were matched by gender and age (±5-year). Hospital controls were selected from non-neurological patients admitted to each participating centre, and community controls were selected from siblings, friends, or neighbours of each HS case in descending order of preference. Controls were required not to have dementia or stroke history, and also be competent to complete the interview as performed in HS cases. Distribution of PPA use before was as follows: 16 (1·7%) HS cases and 14 (0·7%) matched controls (10).

The original ABBA study was approved by the institutional review board of Seoul National University Hospital [0205-091-012], and the *post hoc* analyses of the ABBA study were also approved [H-0912-030-303]. All participants gave informed consent voluntarily.

Data collection

Demographic, clinical, and work condition information was gathered during face-to-face interviews administered by trained nurses, and the best effort was made to avoid information bias. Collected information included the following: gender, age, weight, height, year of education, family history of stroke, hypertension, diabetes mellitus, history of heart diseases, smoking habits, alcohol consumption habits, occupation, regular working time, duration of strenuous activities during regular work and shift work. Study participants were instructed to provide work-related information based on their regular job situation which they had been in for the longest period of time. Type of occupation was categorized as white-collar jobs (office worker, professional, and service industry), blue-collar jobs (farming/forestry, fishery, security, transportation/construction, and production), and housewives/none (housewife and unemployed during most of life) (13). Strenuous activities during regular work were defined as physically demanding and exhaustive activities that labourers should perform regularly during work. Shift work was defined as a day/night shift of work time on a regular basis. Interviewers were blind to the study hypothesis.

Statistical analysis

Baseline demographic, clinical, and work condition indices were compared between HS cases and controls using χ^2-tests or *t*-tests, as appropriate. The numbers of missing in cases: controls for each variable were as follows: years of education, 6 : 8; family history of stroke, 3 : 6; body mass index, 21 : 15; current habitual smoking, 2 : 17; current alcohol consumption, 5 : 19; occupation, 2 : 6; regular working time, 6 : 11; and duration of strenuous work, 4 : 25. In regression analysis, missing values were treated as additional categories for categorical variables and imputed by the mean values from the control group for continuous variables. Multivariable models were constructed using conditional logistic regression analyses with those variables whose univariate *P*-value <0·10 or with clinical importance, including years of education, family history of stroke, hypertension, diabetes, current habitual smoking, current habitual alcohol consumption, and PPA use. Each working condition index was entered into multivariable models independently. We also performed stratified analyses according to the sub-type of HS, and identical models were applied as from composite HS analysis. *P*-values for linear trends in odds ratios (ORs) were examined by likelihood ratio test for trend, using regular working time and duration of strenuous work as continuous variables. Type-specific associations, each for ICH and SAH, were also presented from the same multivariable-adjusted models. Significance was set at the two-tailed $P < 0{\cdot}05$ level. We presented the values as frequencies (percentages) or means ± standard deviations, as appropriate. IBM SPSS 19 (IBM Corp, Somers, NY, USA) was used for performance of all statistical analyses.

Results

The ABBA study included 940 cases of HS and 1880 matched controls. ABBA study participants were composed of 925 blue-collar workers (32·9%), 1405 white-collar workers (50·0%), and 482 housewives/none (17·1%; missing in eight subjects). The regular working time of study subjects was as follows: less than four-hours a day, 645 (23·0%); 4–8 h a day, 828 (29·5%); 8–12 h a day, 1088 (38·8%); more than 12 h a day, 242 (8·6%; missing in 17 subjects). The number of workers exposed to more than eight-hours/week of strenuous activity was 691 (24·8%), and the number of shift worker was 59 (2·1%).

Table 1 Baseline characteristics

Variables	Cases (n = 940)	Controls (n = 1880)	P-value
Demographic information			
Male gender	469 (49·9%)	938 (49·9%)	Matched
Age	54·1 ± 11·4	53·6 ± 11·6	Matched
Years of education			<0·01
No education	70 (7·5%)	108 (5·8%)	
1–6 year	59 (6·3%)	109 (5·8%)	
7–9 year	207 (22·2%)	372 (19·9%)	
10–12 year	151 (16·2%)	326 (17·4%)	
13–14 year	292 (31·3%)	553 (29·5%)	
≥15 year	155 (16·6%)	404 (21·6%)	
Family history of stroke	224 (23·9%)	281 (15·0%)	<0·01
PPA use	16 (1·7%)	14 (0·7%)	0·02
Clinical information			
Hypertension	442 (47·0%)	381 (20·3%)	<0·01
Diabetes mellitus	69 (7·3%)	172 (9·1%)	0·10
History of heart diseases	27 (2·9%)	68 (3·6%)	0·30
Body-mass index	23·6 ± 3·0	23·6 ± 2·9	0·77
Current habitual smoking	307 (32·7%)	489 (26·2%)	<0·01
Current habitual alcohol consumption	529 (56·6%)	861 (46·3%)	<0·01
Working condition indices			
Occupation			<0·01
White-collar job	439 (46·8%)	966 (51·5%)	
Blue-collar job	352 (37·5%)	573 (30·6%)	
Housewives/none	147 (15·7%)	335 (17·9%)	
Regular working time			<0·01
≤4 h/day	198 (21·2%)	447 (23·9%)	
5–8 h/day	246 (26·3%)	582 (31·1%)	
9–12 h/day	387 (41·4%)	701 (37·5%)	
≥13 h/day	103 (11·0%)	139 (7·4%)	
Duration of strenuous work			<0·01
None	556 (59·4%)	1249 (67·3%)	
≤7 h/week	100 (10·7%)	195 (10·5%)	
≥8 h/week	280 (29·9%)	411 (22·2%)	
Shift work	22 (2·3%)	37 (2·0%)	0·52

Percentages were calculated based on available data.

Compared with control subjects, HS cases showed elevated frequency of having blue-collar jobs, higher exposure to extended regular working time, and increased prevalence of more strenuous activities during regular work (Table 1). Conditional logistic regression models adjusted for relevant confounders resulted in that blue-collar workers had higher odds of having HS than their white-collar counterparts [adjusted OR, 1·33; 95% confidence interval (CI), 1·06–1·66; Table 2]. Extended working time was also associated with increased odds of HS. Compared with those who work less than four-hours a day, labourers who regularly work 8–12 h a day had an increased risk of HS (adjusted OR, 1·38; 95% CI, 1·05–1·81), and a more elevated risk of HS was observed in those who had more than 13 h of regular working time (adjusted OR, 1·94; 95% CI, 1·32–2·85). Higher risk of HS was associated with exposure to more than eight-hours/week of strenuous activities during regular work (adjusted OR, 1·77; 95% CI, 1·41–2·24), compared to those without such activities. Shift work was not associated with risk of HS ($P = 0{\cdot}94$). PPA use, as published previously (10) and included in all the multivariable models, was significantly associated with increased odds of HS in all tested models (results of full models are provided as a Supporting Information Table S1).

We also performed stratified analyses according to the sub-type of HS (Table 3). Positive associations between working condition indices and HS risk were largely comparable in both sub-types, in spite of wider confidence intervals due to smaller sample sizes. Dose-dependent associations between point estimates from each sub-type and increasing working time or duration of strenuous work were also preserved. Estimated ORs from confounding variables were generally comparable between HS sub-types and with composite HS models.

Additionally, we confined our analysis to those who were currently employed at the time of stroke onset. Despite statistical power reduced to a certain degree, overall associations remained unchanged. Blue-collar workers (adjusted OR, 1·22; 95% CI, 0·95–1·55; compared to white-collar workers), those who regularly worked ≥13 h/day (adjusted OR, 1·80; 95% CI, 1·18–2·75), and strenuous activities ≥8 h/week (adjusted OR, 1·79; 95% CI, 1·39–2·30) were significantly associated with increased odds of having HS.

Table 2 Results of conditional logistic regression analyses showing the associations between haemorrhagic strokes and working condition indices

Work conditions	Unadjusted OR [95% CI]	Age and PPA use-adjusted OR [95% CI]	Multivariable-adjusted OR [95% CI]
Occupation			
White-collar job	1·00 [reference]	1·00 [reference]	1·00 [reference]
Housewives/none	0·94 [0·72–1·23]	0·91 [0·69–1·19]	0·88 [0·65–1·19]
Blue-collar job	1·39 [1·15–1·67]	1·37 [1·13–1·65]	1·33 [1·06–1·66]
Regular working time			
≤4 h/day	1·00 [reference]	1·00 [reference]	1·00 [reference]
5–8 h/day	0·99 [0·77–1·27]	1·03 [0·80–1·32]	0·89 [0·67–1·18]
9–12 h/day	1·37 [1·07–1·74]	1·47 [1·15–1·87]	1·38 [1·05–1·81]
≥13 h/day	1·86 [1·33–2·60]	2·04 [1·45–2·86]	1·94 [1·32–2·85]
P for trend	<0·01	<0·01	<0·01
Duration of strenuous work			
None	1·00 [reference]	1·00 [reference]	1·00 [reference]
≤7 h/week	1·22 [0·92–1·61]	1·22 [0·92–1·62]	1·30 [0·95–1·77]
≥8 h/week	1·66 [1·36–2·03]	1·65 [1·35–2·02]	1·77 [1·41–2·24]
P for trend	<0·01	<0·01	<0·01
Shift work	1·20 [0·70–2·05]	1·20 [0·70–2·05]	1·02 [0·56–1·86]

ORs and CIs calculated from conditional logistic regression analyses. Multivariable models adjusted for age, education years, family history of stroke, hypertension, diabetes mellitus, current habitual smoking, current habitual alcohol consumption, and phenylpropanolamine-use. CI, confidence interval; OR, odds ratio; PPA, phenylpropanolamine.

Table 3 Stratified analyses of working condition indices according to haemorrhagic stroke sub-types

	ICH			SAH		
	Cases (*n* = 498)	Controls (*n* = 996)	Adjusted OR [95% CI]	Cases (*n* = 442)	Controls (*n* = 884)	Adjusted OR [95% CI]
Occupation						
White-collar job	234 (47·1%)	503 (50·6%)	1·00 [reference]	205 (46·5%)	463 (52·7%)	1·00 [reference]
Housewives/none	68 (13·7%)	157 (15·8%)	0·89 [0·55–1·42]	79 (17·9%)	178 (20·3%)	0·91 [0·60–1·35]
Blue-collar job	195 (39·2%)	335 (33·7%)	1·15 [0·84–1·58]	157 (35·6%)	238 (27·1%)	1·52 [1·09–2·11]
Regular working time						
≤4 h/day	119 (24·0%)	286 (28·9%)	1·00 [reference]	79 (18·0%)	161 (18·3%)	1·00 [reference]
5–8 h/day	127 (25·6%)	277 (28·0%)	1·19 [0·80–1·75]	119 (27·2%)	305 (34·7%)	0·66 [0·44–0·99]
9–12 h/day	200 (40·3%)	350 (35·4%)	1·63 [1·11–2·39]	187 (42·7%)	351 (39·9%)	1·11 [0·74–1·65]
≥13 h/day	50 (10·1%)	77 (7·8%)	1·72 [0·99–2·98]	53 (12·1%)	62 (7·1%)	1·97 [1·14–3·43]
P for trend			<0·01			<0·01
Duration of strenuous work						
None	302 (61·0%)	691 (70·2%)	1·00 [reference]	254 (57·6%)	558 (64·1%)	1·00 [reference]
≤7 h/week	50 (10·1%)	86 (8·7%)	1·35 [0·86–2·13]	50 (11·3%)	109 (12·5%)	1·17 [0·75–1·81]
≥8 h/week	143 (28·9%)	208 (21·1%)	2·01 [1·43–2·84]	137 (31·1%)	203 (23·3%)	1·51 [1·09–2·09]
P for trend			<0·01			0·01
Shift work	14 (2·8%)	15 (1·5%)	1·22 [0·52–2·83]	8 (1·8%)	22 (2·5%)	0·76 [0·31–1·84]

ORs and CIs calculated from multivariable conditional logistic regression analysis models, adjusted for age, year of education, family history of stroke, hypertension, diabetes mellitus, current habitual smoking, current habitual alcohol consumption and phenylpropanolamine use.

Discussion

From our nationally representative matched case-control sets of HS, we discovered that the risk of HS increased in those with blue-collar occupations, extended duration of working time and strenuous activities during regular work. These associations remained significant after controlling for the confounding effects of age, years of education, family history of stroke, and vascular risk factors. We also documented a dose-dependent relationship between risk of HS and duration of working time or strenuous activities, which may support the biological plausibility of our findings. In addition, the type-specific odds of having ICH or SAH were largely comparable in our population.

Straightforward biological mechanisms between laborious working conditions and increased risk of HS have not yet been clarified; however, a number of theories have been proposed. Workers in such working condition may be exposed to a laborious and arduous work load, and tend to have little control over their work in spite of a higher job demand, which may be a typical situation of a job strain model for work-related biological hazard (14–16). As demonstrated in our study, the association between longer working time and increased risk of cardiovascular diseases has been suggested repeatedly (3,17,18). Labourers devoted to extended regular work may be at risk of having insufficient time for recovery and unwinding after work (19–21), and even delay their hospital visit for health problems (22). Hence, longer working time, with a synergistic effect of a blue-collar occupation and strenuous activities during work, may lead to increased health risk behaviour, lowered help-seeking behaviour, poor compliance with medical treatment, and sickness presenteeism (23,24), all of which may contribute to insufficient management of their biological risk factors and ultimately lead to occurrence of HS.

Among the various biological risk factors, hypertension is one of the most important contributors to HS. Risk indices found in our study, extended duration of working time and strenuous activities during work, are repeatedly indicated in stimulation of sympathetic nervous activity and reduction of parasympathetic nervous activity, thereby increasing blood pressure (25). Blue-collar workers who are exposed to such laborious working conditions would be at a higher risk of protracted activation of the autonomic nervous system for a long period of time, thereby cumulating small vessel diseases or wear of the incidental aneurysmal wall in their brain (18,26–28). Likewise, work-related stress was summarized to increase cardiovascular disease and a combination of high demands at work and low job control was found to double the risk of cardiovascular mortality (29,30). In addition, from our study, we documented a dose-dependent relationship between working time and risk of HS as well as comparable sub-type-specific odds ratios between ICH and SAH, both of which may buttress the biological plausibility of laborious working conditions and risk of HS.

A few points require further clarification. First, as working condition data were gathered in a retrospective manner, the accuracy of self-reported information on working conditions information may be pointed out, such as recall bias. However, ABBA study participants were instructed to provide their information based on the regular job situation which they had been in for the longest period of time. Second, because indices for psychological stress in relation to disease were prone to be biased, we did not measure work-related stress itself (5). Third, our study was not adequately powered for sub-group analysis. Fourth, we were not able to collect information on other relevant social factors such as income level. Fifth, our results should be interpreted under consideration of particular economic, cultural, social, and ethnic background. Lastly, the possibility of residual confounding cannot be entirely ruled out.

Conventional risk factors, including hypertension, only account for part of the occurrence of HSs. Along with previous reports on longer work hours and cardiovascular disease risk, authors discovered that laborious working conditions, such as extended working time, strenuous activities during regular work, and blue-collar occupation, increased the risk of HS. As our study population was gathered through a nationwide multicenter prospective cohort, sufficient external validity may be assumed from our result. Although detailed causal links between excessive work and increased risk of stroke are yet to be fully clarified, our results suggest that demanding labour conditions may influence a vast number of workers, putting them at elevated risk of HS. Currently, we do not have much evidence for effective interventions to reduce hazardous working conditions associated with chronic diseases (31). In this context, our study may be utilized as evidence for creation of healthier labour conditions, and future research is needed in order to test the feasibility and efficacy of interventions for reducing hazardous working conditions that may increase the risk for chronic disease.

Acknowledgement

We are grateful to all the ABBA study investigators for their devotion and dedication in screening and managing HS patients.

References

1 Bureau of Labor Statistics, United States Department of Labor. Employment situation summary. [updated 4 May 2002]. Available at http://www.bls.gov/news.release/empsit.nr0.htm (accessed May 2012).
2 Kirk MA, Rhodes RE. Occupation correlates of adults' participation in leisure-time physical activity: a systematic review. *Am J Prev Med* 2011; **40:**476–85.
3 Nakanishi N, Yoshida H, Nagano K, Kawashimo H, Nakamura K, Tatara K. Long working hours and risk for hypertension in Japanese male white collar workers. *J Epidemiol Community Health* 2001; **55:**316–22.
4 Uchiyama S, Kurasawa T, Sekizawa T, Nakatsuka H. Job strain and risk of cardiovascular events in treated hypertensive Japanese workers: hypertension follow-up group study. *J Occup Health* 2005; **47:**102–11.
5 MaCleod J, Smith GD, Heslop P, Metcalfe C, Carroll D, Hart C. Psychological stress and cardiovascular disease: empirical demonstration of bias in a prospective observational study of Scottish men. *Brit Med J* 2002; **324:**1247–53.
6 British Cardiac Society, British Hypertension Society, Diabetes UK, Heart UK, Primary Care Cardiovascular Society, The Stroke Association. JBS 2: Joint British Societies' guidelines on prevention of cardiovascular disease in clinical practice. *Heart* 2005; **91**(Suppl. 5):v1–v52.
7 Goldstein LB, Bushnell CD, Adams RJ *et al.* Guidelines for the primary prevention of stroke. A guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke* 2010; **42:**517–84.
8 Caplan LR. Intracerebral haemorrhage. *Lancet* 1992; **339:**656–8.
9 O'Donnell MJ, Xavier D, Liu L *et al.* Risk factors for ischaemic and intracerebral haemorrhagic stroke in 22 countries (the INTERSTROKE study): a case-control study. *Lancet* 2010; **376:**112–23.
10 Yoon BW, Bae HJ, Hong KS *et al.* Phenylpropanolamine contained in cold remedies and risk of hemorrhagic stroke. *Neurology* 2007; **68:**146–9.
11 Kim BJ, Lee S-H, Ryu W-S, Kim CK, Lee J, Yoon B-W. Paradoxical longevity in obese patients with intracerebral hemorrhage. *Neurology* 2011; **76:**567–73.
12 Lee S-H, Kim BJ, Ryu W-S *et al.* White matter lesions and poor outcome after intracerebral hemorrhage. *Neurology* 2010; **74:**1502–10.
13 Honjo K, Tsutsumi A, Kayaba K, The Jichi Medical School Cohort Study G. Socioeconomic indicators and cardiovascular disease incidence among Japanese Community Residents: the Jichi Medical School Cohort Study. *Int J Behav Med* 2010; **17:**58–66.
14 Karasek R, Baker D, Marxer F, Ahlbom A, Theorell T. Job decision latitude, job demands, and cardiovascular disease: a prospective study of Swedish men. *Am J Public Health* 1981; **71:**694–705.
15 Johnson JV, Hall EM. Job strain, work place social support, and cardiovascular disease: a cross-sectional study of a random sample of the Swedish working population. *Am J Public Health* 1988; **78:** 1336–42.

16 Siegrist J, Peter R, Junge A, Cremer P, Seidel D. Low status control, high effort at work and ischemic heart disease: prospective evidence from blue-collar men. *Soc Sci Med* 1990; **31:**1127–34.
17 Sokejima S, Kagamimori S. Working hours as a risk factor for acute myocardial infarction in Japan: case-control study. *Brit Med J* 1998; **317:**775–80.
18 Rozanski A, Blumenthal JA, Kaplan J. Impact of psychological factors on the pathogenesis of cardiovascular disease and implications for therapy. *Circulation* 1999; **99:**2192–217.
19 Virtanen M, Ferrie JE, Singh-Manoux A *et al*. Overtime work and incident coronary heart disease: the Whitehall II prospective cohort study. *Eur Heart J* 2010; **31:**1737–44.
20 Jansen N, Kant I, van Amelsvoort L, Nijhuis F, van den Brandt P. Need for recovery from work: evaluating short-term effects of working hours, patterns and schedules. *Ergonomics* 2003; **46:**664–80.
21 van der Hulst M, van Veldhoven M, Beckers D. Overtime and need for recovery in relation to job demands and job control. *J Occup Health* 2006; **48:**11–9.
22 Fukuoka Y, Takeshima M, Ishii N *et al*. An initial analysis: working hours and delay in seeking care during acute coronary events. *Am J Emerg Med* 2010; **28:**734–40.
23 Artazcoz L, Cortès I, Escribà-Agüir V, Cascant L, Villegas R. Understanding the relationship of long working hours with health status and health-related behaviours. *J Epidemiol Community Health* 2009; **63:**521–7.
24 Kivimäki M, Head J, Ferrie JE *et al*. Working while ill as a risk factor for serious coronary events: the Whitehall II study. *Am J Public Health* 2005; **95:**98–102.
25 Van der Hulst M. Long workhours and health. *Scand J Work Environ Health* 2003; **29:**171–88.
26 Ariesen MJ, Claus SP, Rinkel GJE, Algra A. Risk factors for intracerebral hemorrhage in the general population: a systematic review. *Stroke* 2003; **34:**2060–5.
27 Teunissen LL, Rinkel GJ, Algra A, van Gijn J. Risk factors for subarachnoid hemorrhage: a systematic review. *Stroke* 1996; **27:** 544–9.
28 Landsbergis PA, Schnall PL, Belkic KL, Schwartz JE, Baker D, Pickering TG. Work conditions and masked (hidden) hypertension – insights into the global epidemic of hypertension. *Scand J Work Environ Health* 2008; **6:**41–51.
29 Kivimäki M, Leino-Arjas P, Luukkonen R, Riihimäki H, Vahtera J, Kirjonen J. Work stress and risk of cardiovascular mortality: prospective cohort study of industrial employees. *Brit Med J* 2002; **325:**857–61.
30 Kivimäki M, Virtanen M, Elovainio M, Kouvonen A, Väänänen A, Vahtera J. Work stress in the etiology of coronary heart disease – a meta-analysis. *Scand J Work Environ Health* 2006; **32:** 431–42.
31 Graham H, Kelly MP. Health Inequalities: Concepts, Frameworks and Policy. London, Health Development Agency, 2004.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. Full models from multivariable conditional logistic regression analyses for odds of having haemorrhagic stroke.