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Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2012-000860
Article Type:	Research
Date Submitted by the Author:	13-Jan-2012
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Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Occupational and environmental medicine, Public health
Keywords:	EPIDEMIOLOGY, OCCUPATIONAL & INDUSTRIAL MEDICINE, PUBLIC HEALTH, GERIATRIC MEDICINE

Job strain among blue-collar and white-collar employees as a determinant of total mortality: A 28-year population-based follow-up

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Keywords: job strain, job demand, job control, mortality, occupational groups, aging, cohort study

Word count: 2967

ABSTRACT

Objectives: To investigate the effect of job demand, job control and job strain on total mortality among white-collar and blue-collar employees working in the public sector.

Design: 28-year prospective population-based follow-up.

Setting: Several municipals in Finland.

Participants: 5733 public sector employees from the Finnish Longitudinal Study on Municipal Employees (FLAME) study aged 44 to 58 years at baseline.

Outcomes: Total mortality from 1981 to 2009 among individuals with complete data on job strain in midlife, categorized according to job demand and job control: high job strain (high job demands and low job control), active job (high job demand and high job control), passive job (low job demand and high job control) and low job strain (low job demand and low job control).

Results: 1838 persons died during the follow-up. High job demand and low job control predicted total mortality, age-adjusted HR 1.14 (95% CI 1.02 to 1.28) and HR 1.26 (95% CI 1.12 to 1.42), respectively. Adjustment for occupational group, lifestyle and health factors attenuated these associations. In the analyses stratified by occupational group, high job strain increased the risk of mortality among white-collar men (HR 1.50, 95% CI 1.07 to 2.09) and passive job among blue-collar men (HR 1.25, 95% CI 1.03 to 1.52) compared to men with low job strain. Adjustment for lifestyle and health factors attenuated the risk among blue-collars with passive job. Job strain was not associated with mortality among women.

Conclusions: Mortality risk among men differed according to occupational group and job strain, but was higher for blue-collars than for white-collars. Job strain had a different effect on mortality among occupational groups which warrants further investigation.

Article focus

- High job strain and its components, high job demand and low job control, predict cardiovascular and total mortality.
- Although lower socioeconomic position is a risk factor for premature total mortality, few studies have explored the effect of job strain on mortality within socioeconomic groups and the ones that exist, report conflicting findings.

Key message

- Mortality risk differed according to occupational group and job strain and was higher for men working in blue-collar professions than for men working in white-collar professions in the public sector.
- High job strain increased the risk of mortality among white-collar men and passive job among blue-collar men compared to men with low strain job.
- Job strain did not predict total mortality among women working in the public sector and there were also no differences according to occupational groups.

Strengths and limitations of the study

- A major strength was the representative large sample of public sector employees working both in white-collar and blue-collar professions and the long follow-up time on mortality collected from the national mortality register.
- A limitation is the self-reported job strain, however, high correlations between subjective and expert ratings on work conditions have been reported. The assessment of job strain was measured at a single time point in midlife which might imperfectly reflect long-term job strain, however, the municipal employees in our cohort had stable work histories indicating stability probably also for job strain during their earlier working life.

INTRODUCTION

A constant stressful situation, such as job strain, is associated with an increased prevalence of disease and accelerated aging process [1]. Epidemiological studies have shown that high job strain particularly among men is associated with the risk of cardiovascular morbidity and mortality [2-9]. However, notable negative findings have also been reported and findings among women are inconsistent [10, 11].

Job demand and job control differs according to occupational class [5, 12, 13]. A lack of job control has been shown to be more frequently present in blue-collar professions and high job demand among white-collar employees [13, 14]. The effect of occupation on the relation between job strain and mortality has in most studies been accounted for by adjusting the analyses for at least one of the common socioeconomic indicators; occupational class, education and income. However, the effect of job strain on cardiovascular morbidity and mortality has been less studied within socioeconomic groups and the ones that exist, report conflicting findings [8, 14, 15]. Furthermore, few studies have investigated the effect of job strain in midlife on total mortality with follow-up extending to old age.

We defined job strain according to the model described by Karasek [16]. In the model, high job strain, indicated by high job demands and low job control, is considered to be the most detrimental type of job strain in terms of subsequent health. Other job strain categories are active job (high job demand and high job control), passive job (low job demand and high job control) and low job strain (low job demand and low job control). We report findings on the individual effects of job demand, job control and job strain as well as the combined effect of job strain on total mortality among middle aged municipal employees in a representative cohort with a 28-year follow-up. We present results also separately for white-collar and blue-collar employees.

METHODS

Study design and population

The Finnish Longitudinal Study on Municipal Employees (FLAME) was established in 1981 by the Finnish Institute of Occupational Health [17]. The 6257 (44.7% men) baseline participants were aged 44 to 58 years. Participants were randomly selected municipal employees who were working in all municipal professions in Finland. Data has been collected in 1981, 1985, 1992, 1997 and 2009 with questionnaires on various work-related factors and health and lifestyle. At baseline, data was available for 5733 (91.6%) participants on job strain. The Ethical Committee of the Finnish Institute of Occupational Health has approved the Finnish Longitudinal Study of Ageing Municipal Employees.

Job strain

We created four job strain categories according to the job demand-control model described by Karasek [16, 18]. Job demands were assessed with 8 questions (Cronbach's alpha =0.77) requesting participants to indicate how much ('not at all=0', 'little=1', 'somewhat=2' or 'a lot=3') did the following factors decrease their satisfaction with work: job repetitious and uninteresting; job include responsibility; job hectic and schedule tight; job tasks and responsibility unclearly defined; superior's control and intervene with the job; unable to influence job pace; afraid of failing and doing errors in the job; and job isolated or lonely. A summary score ranging between 0 and 24 was calculated for the job demand with high scores indicating high job demand. Job control was assessed with 10 questions (Cronbach's alpha=0.86) requesting participants to indicate to what extent ('not at all=0', 'little=1', 'somewhat=2' or 'enough=3') they were able to: have guidance in the job; influence the work environment; participate in planning the work; get a promotion; get further training to maintain and develop professional abilities; chance to use ones abilities and talents; learn new things and develop oneself; get recognition and respect; work with co/workers; and to see the meaning of the work. A summary score ranging between 0 and 30 was

calculated for job control, with higher scores indicating a high level of control over work done. The job demand and job control variables were dichotomized at the median and four quadrants of job strain were constructed: passive job (low job demands and low job control); low strain (low job demands and high job control); high strain (high job demands and low job control) and active job (high job demands and high job control).

Mortality data

Data on total mortality were obtained from the Finnish National Population Register. The study population was followed up for mortality between January 1, 1981 and July 31, 2009. Survival time was calculated as the number of days between January 1, 1981 and death or end of the follow-up, whichever happened first.

Covariates

The covariates measured at baseline in 1981 included age, smoking history (current or former smoker vs. never smoked), alcohol consumption (at least once a week vs. less) and physical activity during previous year (vigorous physical activity at least once a week vs. less). Socioeconomic status was controlled with occupational group defined as the participants' position of employment at baseline. The 133 different identified occupational titles were clustered into 13 occupations based on job analysis at the work places [19]. These were further collapsed and divided into white-collar (e.g. teachers, doctors, registered nurses, managers) and blue-collar (e.g. cleaners, plumbers, construction workers) according to objective assessments of the job characteristics. The physician-diagnosed or -treated cardiovascular diseases (e.g. hypertension and angina pectoris) and metabolic disorders (e.g. diabetes and obesity) were included to control for the employees' health.

Statistical analyses

Baseline characteristics of the participants according to job strain categories were compared using χ^2 tests for categorical variables and analysis of variance for continuous variables. The interaction between gender and job strain on total mortality was significant (p=0.036), thus analyses were stratified by gender. Proportional hazards assumption was tested to identify variables over time to see whether the associations were moderated by the time elapsed between the survey and death [20]. Cox regression models were used to analyze first the independent effects of job demand and job control and then their combined effect (job strain) on mortality for men and women. The Cox regression analyses were adjusted for age, then occupational group and finally also for lifestyle factors such as smoking, alcohol intake and physical activity and health factors such as prevalent cardiovascular disease and metabolic disorder. The employees with low job strain served as the reference group. We did further analyses stratifying by occupational group to see whether the effect of job strain on mortality differed. Mortality rates per 1000 person-years and 95% confidence intervals according to job strain for white-collar and blue-collar employees were calculated from January 1, 1981 to the date of death or the end of follow-up July 31, 2009 whichever occurred first. In Cox regression models, the base model was adjusted for age and the fully adjusted model for smoking, alcohol intake, physical activity and prevalent cardiovascular disease and metabolic disorder. Analyses were carried out with SPSS version 15.0.1 software (SPSS Inc., Chicago, IL, USA).

For those missing at most four items out of eight for job demands (4.4%) or five items out of ten for job control (5.0%), missing values were imputed with a median value calculated from the other items included in the scale. In sensitivity analyses, we excluded the first year of follow-up in the Cox regression models to avoid reverse causation, but, as this hardly affected the HRs, all participants were included in the analyses.

RESULTS

Mean age of the participants at baseline was 50.5 (standard deviation [SD] 3.6) and mean length of follow-up was 25.3 (range 0.04-28.6) years. During the follow-up 1838 (32.1%) of the 5733 baseline participants died. Mean age of those who died was 72.0 (SD 7.9) years for women and 69.8 (SD 8.0) years for men.

Table 1 presents the baseline distribution of socio-demographic, lifestyle and health factors for the four job strain groups for men and women. Among men, more than 80% of those with passive or high job strain were blue-collar employees while half of those with active or low job strain worked in blue-collar professions. Men with passive jobs were the oldest. The group of men with low job strain had smoked less, consumed less alcohol, was more frequently physically active and had the lowest number of cardiovascular disease and metabolic disorders compared to the other job strain groups. More than 60% of women with passive or high job strain were blue-collar employees while a third of those with active and low job strain were working in blue-collar professions. The groups with active or low strain jobs were more frequently physically active and had smoked less compared to those with passive and high job strain. The group of women with low job strain had the lowest number of cardiovascular disease and metabolic conditions compared to the others.

Mortality rates for men and women according to job strain for white-collar and blue-collar work are presented in Table 2. For men in white-collar work, total mortality was lowest for those with low job strain and highest for those with high job strain, but the differences were not statistically significant (Log-rank test p=0.11). For men in blue-collar work, the lowest mortality rate 17.1 per 1000 person-years was observed among those with low job strain and the highest 22.4 per 1000 person-years for those in passive jobs (Log-rank test p=0.023). Among women in white-collar work, the mortality rate was highest for those with low job strain (Log-rank test p=0.59) and

among women in blue-collar work for those in passive jobs (Log-rank test p=0.18), but the differences were not statistically significant.

Table 3 shows the gender stratified individual effects of job demand, job control and finally job strain (i.e. combined job demand and job control) on total mortality. Among men, job demand predicted total mortality in the model adjusted for age hazard ratio (HR) 1.14 (95% confidence interval [CI] 1.02 to 1.28). Adjusting for occupational group and lifestyle and health factors attenuated the association (HR 1.07, 95% CI 0.95 to 1.20). Job control was associated with mortality in men (age-adjusted HR 1.26, (%% CI 1.12 to 1.42), however, the strength of the association was decreased when the model was adjusted for the covariates (HR 1.09, 95% CI 0.96 to 1.23). For the effect of job strain, compared to men with low job strain, those with passive, active and high job strain had a statistically significantly increased risk for death, but adjustment for lifestyle and health factors attenuated the association, see Table 3. Job strain and its components were not associated with mortality among women.

Table 4 shows the hazard ratios for total mortality for white-collar and blue-collar work according to job strain. For men in white-collar work, high job strain was a significant predictor of total mortality (HR 1.50, 95% CI 1.07 to 2.09) compared to those with low job strain. The observed association was little changed by adjustment for lifestyle and health factors. For men with blue-collar work, high job strain was associated with an increased risk of death (age-adjusted HR 1.25, 95% CI 1.03 to 1.52) compared to those with low job strain. Adjustment for lifestyle and health factors diminished the effect of high job strain on total mortality (HR 1.18, 95% CI 0.97 to 1.44). Job strain was not associated with total mortality among women in the analyses stratified according to white-collar and blue-collar work. Including older employees has been shown to decrease the relation between job strain and cardiovascular disease [21] which is why we conducted analyses stratified by age at 44-50 and 51-58 years (data not shown). In the analyses

confined to younger men in white-collar work, high job strain was a significant predictor of mortality after adjustment for lifestyle and health factors (HR 2.05, 95% CI 1.22 to 3.46). Among the younger men in blue-collar work, passive job increased the risk of total mortality (HR 1.33, 95% CI 1.00 to 1.76), but adjustment for lifestyle and health factors diminished the association. Among the older men these associations were less evident.

DISCUSSION

This prospective 28-year follow-up showed high job demand and low job control to be predictive of total mortality among middle aged men working in the public sector. Stratifying the analyses by occupational class showed that high job strain increased the risk of mortality among men in white-collar work while passive job increased the risk among men in blue-collar work compared to the ones with low job strain. Job strain did not correlate with total mortality among women and there were also no differences according to occupational groups. Our findings support in part the existing body of knowledge and showcase new findings on the effect of job strain on total mortality in different occupational groups.

Low job control and high job demand individually were associated with total mortality among men paralleling earlier findings on the effect of job control and job demand on coronary heart disease and mortality in various cohorts [2, 4, 8, 22]. Our findings concerning the effect of job strain within occupational groups on the risk of mortality among men support the findings of Kuper & Marmot [8] who found that job strain increased the risk of coronary heart disease especially among the administrative workers. Unlike Johnson et al. [2] we did not find an increased risk for mortality among those with high job strain compared to the ones with low job strain for men working in blue-collar professions. This might, however, in part be due to the different measure of job strain as our analyses did not include job support.

We found that high job strain increased the risk of mortality among men in white-collar work and the association was stronger when the analyses were confined to the younger men aged 44 to 50 years at baseline. One plausible explanation for the observed association might be the overall effect of increased stress level such as high job strain which may lead to cumulative wear and tear potentially suppressing immune function over time, increasing general susceptibility, reducing systemic regulation and increasing broad disease risk and decline in health [23]. Although we did

not measure the duration of job strain, we know that the participants had a relatively stable job history. Among male employees, more than 69% had worked in one or two professions during their work career and more than 70% had held the current job position for more than 10 years, (data not shown). This gives us reason to believe that the duration of exposure to high job strain was probably long and that it might have in part resulted in adverse stress-related events among the men with high job strain which might have contributed to their increased risk of mortality.

Passive job has been shown to predict mortality in the U.S Panel Study of Income Dynamics cohort [22]. In our study, the mortality rate for men in blue-collar work with passive jobs was two times higher and the risk of mortality was also increased compared to those with low job strain. This might on the one hand reflect reverse causation in that lower socioeconomic position led to lower job status compared to the employees with higher socioeconomic position. Blue-collar employees with lower education and income are more likely to have been exposed to an unhealthy lifestyle, poorer living conditions and to physical job strain and exposure to physical hazards at the workplace than employees in white-collar work [24] which in turn increase the risk of chronic illnesses such as diabetes and cardiovascular disease and decreased functioning [25, 26]. On the other hand, the healthy worker selection effect in which employees change jobs or leave the workforce due to health reasons and those who are healthy continue working [27] might have caused persons with health problems and chronic conditions to quit working in high strain and active jobs and transfer to a passive job with lower job demand already before this study began.

We found no association between job strain and total mortality among women in white-collar and blue-collar work. This result is in line with the study of Lee et al. [11] which investigated the effect of job stain on cardiovascular disease and mortality using data from the large Nurses' Health Study. The non-significant findings regarding work-related factors and mortality among women could partly be explained by the fact that it was typical at that time for women to stay at home for

longer periods of time to take care of the off-spring. However, the present working life has changed so that women have very similar career paths and work trajectories than men [24], which could indicate that the present study findings for men might be applicable to women who a currently part of the workforce.

Study strengths and weaknesses

The strengths of our study include the representative large sample of municipal employees working both in white-collar and blue-collar professions. In addition, the follow-up on mortality was long and the data was collected from the national mortality register. Some limitations of the study should be recognized. The data on job strain was self-reported which might yield possible reporting bias however, high correlations between subjective and expert ratings on work conditions have been reported [28]. The assessment of job strain was measured at a single time point in midlife which might imperfectly reflect long-term job strain and result in an underestimation of the association between job strain and mortality [29]. However, the municipal employees in our cohort had stable work histories thus indicating stability possibly also for job strain during their earlier working life. Our study cohort included persons who worked in the public sector which should be considered when generalizing the results to the entire working population in the Western countries.

Conclusions

Our evidence suggests that high job strain is an independent risk factor of total mortality among white-collar men and passive job for blue-collar men. The effect of job strain on total mortality in different occupational groups is not well-known, which warrants further investigations into these differences.

Conflict of interest statement

No conflict of interest was declared by any of the authors.

Acknowledgements

FLAME was supported by the Finnish Institute of Occupational Health and The Local Governments Pension Institution. von Bonsdorff MB was supported by Academy of Finland grant no. 132597, University Alliance Finland, University of Jyväskylä, Yrjö Jahnsson Foundation; von Bonsdorff ME was supported by the University Alliance Finland, University of Jyväskylä; Nygård C-H was supported by the Signe and Ane Gyllenberg Foundation.

AUTHOR CONTRIBUTIONS

JI, C-HN, JS and TR contributed substantially to conception and design of the FLAME study. JS, MEvB and MBvB contributed to the data collection. MBvB and TR interpreted the data. MBvB analyzed the data and drafted the manuscript. All of the authors critically revised the article and gave final approval of the version to be published.

REFERENCES

1. McEwen BS. Protective and damaging effects of stress mediators. *N Engl J Med* 1998;338:171-9.

2. Johnson JV, Stewart W, Hall EM, et al. Long-term psychosocial work environment and cardiovascular mortality among Swedish men. *Am J Public Health* 1996;86:324-31.

3. Kivimäki M, Leino-Arjas P, Luukkonen R, et al. Work stress and risk of cardiovascular mortality: Prospective cohort study of industrial employees. *BMJ* 2002;325:857.

4. Bosma H, Marmot MG, Hemingway H, et al. Low job control and risk of coronary heart disease in Whitehall II (prospective cohort) study. *BMJ* 1997;314:558-65.

5. Marmot MG, Bosma H, Hemingway H, et al. Contribution of job control and other risk factors to social variations in coronary heart disease incidence. *Lancet* 1997;350:235-39.

6. Sacker A, Bartley MJ, Frith D, et al. The relationship between job strain and coronary heart disease: Evidence from an English sample of the working male population. *Psychol Med* 2001;31:279-90.

7. Bourgkard E, Wild P, Massin N, et al. Association of physical job demands, smoking and alcohol abuse with subsequent premature mortality: A 9-year follow-up population-based study. *J Occup Health* 2008;50:31-40.

8. Kuper H, Marmot M. Job strain, job demands, decision latitude, and risk of coronary heart disease within the Whitehall II study. *J Epidemiol Community Health* 2003;57:147-153.

9. Belkic KL, Landsbergis PA, Schnall PL, et al. Is job strain a major source of cardiovascular disease risk? *Scand J Work Environ Health* 2004;30:85-128.

10. Eaker ED, Sullivan LM, Kelly-Hayes M, et al. Does job strain increase the risk for coronary heart disease or death in men and women? The Framingham offspring study. *Am J Epidemiol* 2004;159:950-8.

11. Lee S, Colditz G, Berkman L, et al. A prospective study of job strain and coronary heart disease in US women. *Int J Epidemiol* 2002;31:1147-53.

12. Alterman T, Shekelle RB, Vernon SW, et al. Decision latitude, psychological demand, job strain, and coronary heart disease in the Western Electric Study. *Am J Epidemiol* 1994;139:20-7.

13. Hallqvist J, Diedrichsen F, Theorell T, et al. Is the effect of job strain on myocardial infarction due to interaction between high psychological demand and low decision latitude? Results from Stockholm Heart Epidemiology Program (SHEEP). *Soc Sci Med* 1998;46:1405-15.

14. Johnson JV, Hall EM, Theorell T. Combined effect of job strain and social isolation on cardiovascular disease morbidity and mortality in a random sample of the Swedish male working population. *Scand J Work Environ Health* 1989;15:271-9.

15. Lynch J, Krause N, Kaplan GA, et al. Workplace conditions, socioeconomic status, and the risk of mortality and acute myocardial infarction: The Kuopio ischemic heart disease risk factor study. *Am J Public Health* 1997;87:617-22.

16. Karasek RA. Job demands, job decision latitude, and mental strain: Implications for job redesign. *Administrative Science Quarterly* 1979;24:285-308.

17. Ilmarinen J, Tuomi K, Eskelinen L, et al. Background and objectives of the Finnish research project on aging workers in municipal occupations. *Scand J Work Environ Health* 1991;17 Suppl 1:7-11.

18. Karasek RA, Theorell T. *Healthy Work. Stress, Productivity, and the Reconstruction of Working Life.* New York: Basic Books: 1990.

19. Ilmarinen J, Suurnakki T, Nygard CH, et al. Classification of municipal occupations. *Scand J Work Environ Health* 1991;17 Suppl 1:12-29.

20. Cox RD, Oakes D. *Analysis of Survival Data.* New York: Chapman and Hall: 1984.

21. Kivimaki M, Theorell T, Westerlund H, et al. Job strain and ischaemic disease: Does the inclusion of older employees in the cohort dilute the association? The WOLF Stockholm study. *J Epidemiol Community Health* 2008;62:372-4.

22. Amick BC 3rd, McDonough P, Chang H, et al. Relationship between all-cause mortality and cumulative working life course psychosocial and physical exposures in the United States labor market from 1968 to 1992. *Psychosom Med* 2002;64:370-81.

23. McEwen BS, Stellar E. Stress and the individual mechanisms leading to disease. *Arch Intern Med* 1993;153:2093-101.

24. Clougherty JE, Souza K, Cullen MR. Work and its role in shaping the social gradient in health. *Ann N Y Acad Sci* 2010;1186:102-24.

25. Lynch JW, Kaplan GA, Shema SJ. Cumulative impact of sustained economic hardship on physical, cognitive, psychological, and social functioning. *N Eng J Med* 1997:337:1889-95.

26. Davey Smith G, Hart C, Blane D. Lifetime socioeconomic position and mortality: prospective observational study. *BMJ* 1997:314:547-52

27. Wunsch G, Duchene J, Thiltges E, et al. Socio-economic differences in mortality. A life course approach *Eur J Popul* 1996;12:167-85

28. Huuhtanen P, Nygard CH, Tuomi K, et al. Changes in stress symptoms and their relationship to changes at work in 1981-1992 among elderly workers in municipal occupations. *Scand J Work Environ Health* 1997;23 Suppl 1:36-48.

29. Kivimäki M, Head J, Ferrie J, et al. Why is evidence on job strain and coronary heart disease mixed? An illustration of measurement challenges in the Whitehall II Study. *Psychosom Med* 2006;68:398-401.

Table 1 Baseline characteristics according to job strain in midlife in the FLAME study

Characteristics	Low strain		Passive		Active		High strain		p-value*
Deaths during follow-up, n (%)									
Men	281	(36.6)	299	(48.9)	217	(44.5)	325	(46.1)	<0.001
Women	254	(23.0)	153	(24.6)	145	(20.4)	164	(22.7)	0.33
Age, mean (SD)									
Men	50.2	(3.6)	50.8	(3.6)	50.4	(3.7)	50.2	(3.5)	0.006
Women	50.4	(3.6)	50.6	(3.6)	50.1	(3.5)	50.2	(3.6)	0.12
White-collar profession, %									
Men	46.7		12.7		45.7		17.0		<0.001
Women	62.0		35.9		56.6		34.4		<0.001
Never smoked, %									
Men	31.1		25.5		31.4		26.1		0.028
Women	76.6		74.0		76.5		78.3		0.32
Alcohol intake ≥ 1 per week, %									
Men	17.8		19.3		24.4		20.9		0.036
Women	2.3		2.7		3.8		3.5		0.22
Vigorous physical activity ≥ 1 per week, %									
Men	52.3		41.4		49.9		43.0		<0.001
Women	53.1		45.4		54.5		48.0		0.002
Cardiovascular disease, %									
Men	16.9		23.5		29.1		27.1		<0.001
Women	17.5		18.8		22.0		25.0		0.001
Metabolic disorder, %									
Men	5.6		8.2		9.6		11.2		0.001
Women	8.7		11.9		12.7		13.1		0.009

*Continuous variables tested with ANOVA (analysis of variance) and categorical variables with χ^2 test

Table 2 Mortality rates per 1000 person-years and 95% confidence intervals according to occupational group and job strain in midlife among men and women in the 28-year follow-up of the FLAME study

	Men (95% CI)				Women (95% CI)			
Job strain	**White-collar**		**Blue-collar**		**White-collar**		**Blue-collar**	
Low strain	12.1	(10.0 to 14.4)	17.1	(14.5 to 19.9)	8.8	(7.5 to 10.3)	8.5	(6.5 to 10.3)
Passive	13.5	(9.0 to 19.0)	22.4	(19.8 to 25.2)	7.9	(5.7 to 10.5)	10.1	(8.2 to 12.2)
Active	15.5	(12.4 to 19.0)	20.9	(17.4 to 24.7)	7.8	(6.2 to 9.6)	7.3	(5.5 to 9.4)
High strain	16.9	(12.4 to 22.1)	20.2	(17.9 to 22.7)	7.3	(5.4 to 9.5)	9.1	(7.6 to 10.9)
Log-rank test* p value	0.11		0.023		0.59		0.18	

* Degrees of freedom = 3

Table 3 Hazard ratios (HR) and 95% confidence intervals (CI) for the 28-year mortality for individual effects of job demand, job control and job strain in the 28-year follow-up of the FLAME study

	HR (95% CI) adjusted for age		HR (95% CI) adjusted for age and occupational group		HR (95% CI) adjusted for age, occupational group, lifestyle and health factors*	
Men						
Job demand						
Low	1.00	-	1.00	-	1.00	-
High	1.14	(1.02 to 1.28)	1.12	(1.00 to 1.26)	1.07	(0.95 to 1.20)
Job control						
Low	1.26	(1.12 to 1.42)	1.11	(0.98 to 1.22)	1.09	(0.96 to 1.23)
High	1.00	-	1.00	-	1.00	-
Job strain						
Low strain	1.00	-	1.00	-	1.00	-
Passive job	1.41	(1.20 to 1.66)	1.24	(1.05 to 1.47)	1.20	(1.01 to 1.43)
Active job	1.28	(1.07 to 1.52)	1.26	(1.06 to 1.51)	1.18	(0.98 to 1.41)
High strain	1.39	(1.19 to 1.63)	1.24	(1.05 to 1.46)	1.16	(0.98 to 1.38)
Women						
Job demand						
Low	1.00	-	1.00	-	1.00	-
High	0.93	(0.80 to 1.07)	0.92	(0.79 to 1.07)	0.91	(0.78 to 1.06)
Job control						
Low	1.07	(0.93 to 1.24)	1.05	(0.91 to 1.22)	1.06	(0.91 to 1.23)
High	1.00	-	1.00	-	1.00	-
Job strain						
Low strain	1.00	-	1.00	-	1.00	-
Passive job	1.06	(0.87 to 1.30)	1.04	(0.85 to 1.28)	1.03	(0.84 to 1.27)
Active job	0.90	(0.73 to 1.10)	0.98	(0.73 to 1.09)	0.87	(0.71 to 1.07)
High strain	0.96	(0.82 to 1.21)	0.89	(0.80 to 1.19)	0.97	(0.79 to 1.19)

* Lifestyle factors=smoking, alcohol intake and physical activity, health factors=cardiovascular disease and metabolic disorders

Table 4 Hazard ratios and 95% confidence intervals for mortality according to job strain in midlife stratified by occupational group among men and women in the 28-year follow-up of the FLAME study

	White-collar					Blue-collar				
		Model 1		Model 2			Model 1		Model 2	
	No./deaths	HR	(95% CI)	HR	(95% CI)	No./deaths	HR	(95% CI)	HR	(95% CI)
Men										
Job strain										
Low strain	369/115	1.00		1.00		399/166	1.00		1.00	
Passive	78/27	1.07	(0.71 to 1.63)	1.04	(0.67 to 1.59)	534/272	1.25	(1.03 to 1.52)	1.18	(0.97 to 1.44)
Active	223/85	1.31	(0.99 to 1.73)	1.28	0.96 to 1.71)	265/132	1.23	(0.98 to 1.55)	1.11	(0.88 to 1.40)
High strain	120/49	1.50	(1.07 to 2.09)	1.42	(1.01 to 1.99)	585/276	1.18	(0.98 to 1.43)	1.10	(0.90 to 1.34)
Women										
Job strain										
Low strain	685/159	1.00		1.00		420/95	1.00		1.00	
Passive	223/47	0.88	(0.63 to 1.21)	0.89	(0.64 to 1.24)	399/106	1.18	(0.89 to 1.56)	1.13	(0.86 to 1.50)
Active	402/84	0.92	(0.71 to 1.20)	0.93	(0.71 to 1.21)	308/61	0.86	(0.63 to 1.19)	0.83	(0.60 to 1.15)
High strain	249/84	0.87	(0.63 to 1.20)	0.87	(0.62 to 1.20)	474/115	1.07	(0.82 to 1.41)	1.06	(0.80 to 1.39)

Model 1 adjusted for age

Model 2 adjusted for age, smoking, alcohol intake and physical activity, prevalent cardiovascular disease and metabolic disorders

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Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2012-000860.R1
Article Type:	Research
Date Submitted by the Author:	23-Feb-2012
Complete List of Authors:	von Bonsdorff, Mikaela; University of Jyvaskyla, Gerontology Research Centre, Department of Health Sciences Seitsamo, Jorma; Finnish Institute of Occupational Health, von Bonsdorff, Monika; University of Jyvaskyla, Gerontology Research Centre, Department of Health Sciences Ilmarinen, Juhani; Finnish Institute of Occupational Health, Nygard, Clas-Hakan; University of Tampere, School of Health Sciences Rantanen, Taina; University of Jyvaskyla, Gerontology Research Centre, Department of Health Sciences
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Occupational and environmental medicine, Public health
Keywords:	EPIDEMIOLOGY, OCCUPATIONAL & INDUSTRIAL MEDICINE, PUBLIC HEALTH, GERIATRIC MEDICINE

Job strain among blue-collar and white-collar employees as a determinant of total mortality: A 28-year population-based follow-up

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Keywords: job strain, job demand, job control, mortality, occupational groups, aging, cohort study

Word count: 3320

ABSTRACT

Objectives: To investigate the effect of job demand, job control and job strain on total mortality among white-collar and blue-collar employees working in the public sector.

Design: 28-year prospective population-based follow-up.

Setting: Several municipals in Finland.

Participants: 5731 public sector employees from the Finnish Longitudinal Study on Municipal Employees (FLAME) study aged 44 to 58 years at baseline.

Outcomes: Total mortality from 1981 to 2009 among individuals with complete data on job strain in midlife, categorized according to job demand and job control: high job strain (high job demands and low job control), active job (high job demand and high job control), passive job (low job demand and low job control) and low job strain (low job demand and high job control).

Results: 1836 persons died during the follow-up. Low job control among men increased (age-adjusted HR 1.26 95% CI 1.12 to 1.42) and high job demand among women decreased the risk for total mortality HR 0.82 (95% CI 0.71 to 0.95). Adjustment for occupational group, lifestyle and health factors attenuated the association for men. In the analyses stratified by occupational group, high job strain increased the risk of mortality among white-collar men (HR 1.52, 95% CI 1.09 to 2.13) and passive job among blue-collar men (HR 1.28, 95% CI 1.05 to 1.47) compared to men with low job strain. Adjustment for lifestyle and health factors attenuated the risks. Among white-collar women having an active job decreased the risk for mortality, HR 0.78 95% CI 0.60 to 1.00.

Conclusions: The impact of job strain on mortality was different according to gender and occupational group among middle-aged public sector employees.

Article focus

- High job strain and its components, high job demand and low job control, predict cardiovascular and total mortality.
- Although lower socioeconomic position is a risk factor for premature total mortality, few studies have explored the effect of job strain on mortality within socioeconomic groups and the ones that exist, report conflicting findings.

Key message

- In a population-based cohort of middle-aged public sector employees, low job control among men increased and high job demand among women decreased the risk of mortality during a 28-year follow-up.
- High job strain increased the risk of mortality among white-collar men and passive job among blue-collar men compared to men with low job strain.
- Active job among white-collar women decreased the risk for mortality compared to those with low job strain.

Strengths and limitations of the study

- A major strength was the representative large sample of public sector employees working both in white-collar and blue-collar professions and the long follow-up time on mortality collected from the national mortality register.
- A limitation is the self-reported job strain, however, high correlations between subjective and expert ratings on work conditions have been reported. The assessment of job strain was measured at a single time point in midlife which might imperfectly reflect long-term job strain, however, the municipal employees in our cohort had stable work histories indicating stability probably also for job strain during their earlier working life.

INTRODUCTION

A constant stressful situation, such as job strain, is associated with an increased prevalence of disease and accelerated aging process [1]. Epidemiological studies have shown that high job strain particularly among men is associated with the risk of cardiovascular morbidity and mortality [2-9]. However, notable negative findings have also been reported and findings among women are inconsistent [10, 11].

Job demand and job control differs according to occupational class [5, 12, 13]. A lack of job control has been shown to be more frequently present in blue-collar professions and high job demand among white-collar employees [13, 14]. The effect of occupation on the relation between job strain and mortality has in most studies been accounted for by adjusting the analyses for at least one of the common socioeconomic indicators; occupational class, education and income. However, the effect of job strain on cardiovascular morbidity and mortality has been less studied within socioeconomic groups and the ones that exist, report conflicting findings [8, 14, 15]. Furthermore, few studies have investigated the effect of job strain in midlife on total mortality with follow-up extending to old age.

We defined job strain according to the model described by Karasek [16]. In the model, high job strain, indicated by high job demands and low job control, is considered to be the most detrimental type of job strain in terms of subsequent health. Other job strain categories are active job (high job demand and high job control), passive job (low job demand and low job control) and low job strain (low job demand and high job control). Based on earlier research, we hypothesized that the association between high job strain and total mortality was more pronounced among the white-collar employees because of overall differences in the work. In this study, we examine the effects of job demand, job control and job strain on total mortality among middle aged white- and blue-collar public sector employees in a representative cohort with a 28-year follow-up.

METHODS

Study design and population

The Finnish Longitudinal Study on Municipal Employees (FLAME) was established in 1981 by the Finnish Institute of Occupational Health [17]. The 6257 (44.7% men) baseline participants were aged 44 to 58 years. Participants were randomly selected municipal employees who were working in all municipal professions in Finland. Data has been collected in 1981, 1985, 1992, 1997 and 2009 with questionnaires on various work-related factors and health and lifestyle. At baseline, data was available for 5731 (91.6%) participants on job strain. Compared to those with no information on job strain at baseline (n=526), the analytical sample (n=5731) of this study did not differ statistically according to gender (p=0.35), but they were younger and more frequently white-collar employees (p-values <0.001). The Ethical Committee of the Finnish Institute of Occupational Health has approved the Finnish Longitudinal Study of Ageing Municipal Employees.

Job strain

We created four job strain categories according to the job demand-control model described by Karasek [16, 18]. Job demand was assessed with 5 questions (Cronbach's alpha =0.73) dealing with pressures related to the job: work pace fast and time schedule tight; responsibility; conflicting demands regarding work tasks and responsibility; pressure and interference with the job by the supervisor; and pressure of failing or doing errors on the job. Answering alternatives were 'not at all=0', 'little=1', 'somewhat=2' or 'a lot=3'. A summary score ranging between 0 and 15 was calculated for job demand with high scores indicating high job demand. Job control was assessed with 10 questions (Cronbach's alpha=0.86) requesting participants to indicate to what extent ('not at all=0', 'little=1', 'somewhat=2' or 'enough=3') they were able to: have guidance in the job; influence the work environment; participate in planning the work; get a promotion; get further training to maintain and develop professional abilities; chance to use ones abilities and talents;

learn new things and develop oneself; get recognition and respect; work with co/workers; and to see the meaning of the work. A summary score ranging between 0 and 30 was calculated for job control, with higher scores indicating a high level of control over work done. There was a significant interaction between job demand and control on total mortality (p=0.005). The job demand and job control variables were dichotomized at the median and four quadrants of job strain were constructed: passive job (low job demands and low job control); low strain (low job demands and high job control); high strain (high job demands and low job control) and active job (high job demands and high job control).

Mortality data

Data on total mortality were obtained from the Finnish National Population Register. The study population was followed up for mortality between January 1, 1981 and July 31, 2009. Survival time was calculated as the number of days between January 1, 1981 and death or end of the follow-up, whichever happened first.

Covariates

The analyses were adjusted with covariates known to modify the association between job strain and mortality [3]. At baseline in 1981 age, smoking history (current or former smoker vs. never smoked), alcohol consumption (at least once a week vs. less) and physical activity during previous year (vigorous physical activity at least once a week vs. less) were assessed. Socioeconomic status was controlled with occupational group defined as the participants' position of employment at baseline. The 133 different identified occupational titles were clustered into 13 occupations based on job analysis at the work places [19]. These were further collapsed and divided into white-collar (e.g. teachers, doctors, registered nurses, managers) and blue-collar (e.g. cleaners, plumbers, construction workers) according to objective assessments of the job characteristics. The self-reported physician-diagnosed or -treated cardiovascular diseases (e.g. hypertension and angina

pectoris), metabolic disorders (e.g. diabetes and obesity) and cancer (malignant tumors at any site) were included in the models to control for the employees' health.

Statistical analyses

Baseline characteristics of the participants according to job strain categories were compared using χ^2 tests for categorical variables and analysis of variance for continuous variables. The interaction between gender and job strain on total mortality was significant (p=0.002), thus analyses were stratified by gender. Proportional hazards assumption was tested to identify variables over time to see whether the associations were moderated by the time elapsed between the survey and death [20]. Cox regression models were used to analyze first the independent effects of job demand and job control and then their combined effect (job strain) on mortality for men and women. The Cox regression analyses were adjusted for age, then occupational group and finally also for lifestyle factors such as smoking, alcohol intake and physical activity and health factors such as prevalent cardiovascular disease, metabolic disorders and cancer. The employees with low job strain served as the reference group. There was no significant interaction between occupational group and job strain on total mortality (p>0.299) so we stratified analyses by occupational group to see whether the effect of job strain on mortality differed for the occupational groups. Mortality rates per 1000 person-years and 95% confidence intervals according to job strain for white-collar and blue-collar employees were calculated from January 1, 1981 to the date of death or the end of follow-up July 31, 2009 whichever occurred first. In Cox regression models, the base model was adjusted for age and the fully adjusted model for smoking, alcohol intake, physical activity and prevalent cardiovascular disease, metabolic disorders and cancer. Analyses were carried out with SPSS version 15.0.1 software (SPSS Inc., Chicago, IL, USA).

For those missing at most two items out of five for job demands (3.3%) or five items out of ten for job control (5.0%), missing values were imputed with a median value calculated from the other

items included in the scale. In sensitivity analyses, we excluded the first year of follow-up in the Cox regression models to avoid reverse causation, but, as this hardly affected the HRs, all participants were included in the analyses.

RESULTS

Mean age of the participants at baseline was 50.5 (standard deviation [SD] 3.6) and mean length of follow-up was 25.3 (range 0.04-28.6) years. During the follow-up 1836 (32.0%) of the 5731 baseline participants died. Mean age at death was 72.1 (SD 7.9) years for women and 69.7 (SD 8.0) years for men.

Table 1 presents the baseline distribution of socio-demographic, lifestyle and health factors for the four job strain groups for men and women. Among men, more than 80% of those with passive or high job strain were blue-collar employees while half of those with active or low job strain worked in blue-collar professions. Men with passive jobs were the oldest. The group of men with low job strain had smoked less, consumed less alcohol, was more frequently physically active and had the lowest number of cardiovascular disease, metabolic disorders and cancer compared to the other job strain groups. Sixty percent of women with passive or high strain jobs were blue-collar employees while a third of those with active and low strain jobs were working in blue-collar professions. The groups with active jobs or low job strain were more frequently physically active than the other job strain groups. The group of women with low job strain had the lowest number of cardiovascular disease and metabolic conditions compared to the others.

Mortality rates for men and women according to job strain for white-collar and blue-collar employees are presented in Table 2. For men in white-collar work, total mortality was lowest for those with passive jobs and low job strain and highest for those with high job strain, but the differences were not statistically significant (Log-rank test p=0.13). For men in blue-collar work, the lowest mortality rate 17.1 per 1000 person-years was observed among those with low job strain and the highest 22.5 per 1000 person-years for those in passive jobs (Log-rank test p=0.033). Among women in white-collar work, the mortality rate was highest for those with low job strain

(Log-rank test p=0.079) and among women in blue-collar work for those in passive jobs (Log-rank test p=0.029).

Table 3 shows the gender stratified individual effects of job demand, job control and finally job strain (i.e. combined job demand and job control) on total mortality. Among men, high job demand increased the risk of total mortality in the follow-up, but the risk was not statistically significant, hazard ratio (HR) 1.10 (95% confidence interval [CI] 0.98 to 1.28). Adjusting for occupational group and lifestyle and health factors further attenuated the association. Job control was associated with mortality in men (age-adjusted HR 1.26 95% CI 1.12 to 1.42). Adjusting for covariates decreased the strength of the association, but it remained statistically significant. For the effect of job strain, compared to men with low job strain, those with passive, active and high job strain had a statistically significantly increased risk for death, but adjustment for lifestyle and health factors attenuated the association. Among women, high job demand decreased the risk for mortality during the follow-up compared to those with low job demands and adjusting for covariates had little effect on the association (HR 0.82 95% CI 0.71 to 0.95), see Table 3. Job control was not associated with mortality among women. For the effect of job strain, compared to women with low job strain, those with active job had a statistically significantly increased risk for death (HR 0.77 95% CI 0.63 to 0.95).

Table 4 shows the hazard ratios for total mortality for white-collar and blue-collar work according to job strain. For men in white-collar work, high job strain was a significant predictor of total mortality compared to those with low job strain, HR 1.52, 95% CI 1.09 to 2.13. For men in blue-collar work, passive job was associated with an increased risk of death compared to those with low job strain, HR 1.28, 95% CI 1.05 to 1.56. These observed associations were attenuated by adjustment for lifestyle and health factors. Active job among white-collar female employees decreased the risk of mortality during the follow-up compared to those with low job strain, HR

0.77 95% CI 0.59 to 1.00. Job strain was not associated with total mortality among women in blue-collar work. Including older employees has been shown to decrease the relation between job strain and cardiovascular disease [21] which is why we conducted analyses stratified by age at 44-50 and 51-58 years (data not shown). In the analyses confined to younger men in white-collar work, high job strain was a significant predictor of mortality after adjustment for lifestyle and health factors (HR 2.26, 95% CI 1.16 to 4.42). Among the younger men in blue-collar work, passive job increased the risk of total mortality (HR 1.42, 95% CI 1.00 to 2.02). Among younger white-collar women in active jobs the risk of mortality was lower than for those with low job strain (HR 0.59 95% CI 0.36 to 0.96). Among the older men and women these associations were less evident.

DISCUSSION

This prospective 28-year follow-up showed that low job control among men increased and high job demand among women decreased the risk of total mortality among middle aged employees working in the public sector. Stratifying the analyses by occupational class showed that high job strain increased the risk of mortality among men in white-collar work while passive job increased the risk among men in blue-collar work compared to the ones with low job strain. Active job decreased the risk of mortality among white-collar women. Our findings support in part the existing body of knowledge and showcase new findings on the effect of job strain on total mortality in different occupational groups.

Low job control was associated with total mortality among men paralleling earlier findings on the effect of job control on coronary heart disease and mortality in various cohorts [2, 4, 22]. Our findings concerning the effect of job strain within occupational groups on the risk of mortality among men support the findings of Kuper & Marmot [8] who found that high job strain increased the risk of coronary heart disease especially among administrative workers. Unlike Johnson et al. [2] we did not find an increased risk for mortality among those with high job strain compared to the ones with low job strain for men working in blue-collar professions. This might, however, in part be due to the different measure of job strain as our analyses did not include job support.

We found the effects of job strain on total mortality to be more evident in the analyses confined to the younger employees, aged 44 to 50 years at baseline. One plausible explanation for the observed association might be the overall effect of an increased stress level such as high job strain which may lead to cumulative wear and tear potentially suppressing immune function over time, increasing general susceptibility, reducing systemic regulation and increasing broad disease risk and decline in health [23]. This is probably more evident among the younger employees while the healthy worker survivor effect might dilute the association between job strain and mortality in the

older employees because the ones who are healthier are more likely to participate in the study [21, 24]. In addition, in a long follow-up other factors influencing mortality may dilute the association between job strain and mortality more among the older workers particularly toward the end of the follow-up. Although we did not measure the duration of job strain, we know that the participants had a relatively stable job history. Among male employees, more than 69% had worked in one or two professions during their work career and more than 70% had held the current job position for more than 10 years, (data not shown). This gives us reason to believe that the duration of job strain exposure had been long.

Passive job has been shown to predict mortality in the U.S Panel Study of Income Dynamics cohort [22]. In our study, among blue-collar men, the mortality rate for those with passive job was higher compared to those with low job strain. A potential explanation for this is that those blue-collar men with health problems might have had to quit working in high strain and active jobs and transfer to a passive job with low job demand and control already before this study began as stated in the healthy worker survivor effect [25]. Blue-collar men who have lower education and income level are more likely to have been exposed to an unhealthy lifestyle, poorer living conditions and a physically strenuous work environment than white-collars [26]. This increases the risk of chronic illnesses such as diabetes and cardiovascular disease and disability, which, in turn, increase the risk for death [27, 28]. It is plausible that this negative exposure has been highest among those blue-collar men who worked in passive jobs with low job demand and low control, which typically outline the lowest professions.

The effect of job strain and its components job demand and control on coronary heart disease and mortality have been less studied in women and the findings have been inconsistent [4, 9, 10,11,]. We found a protective effect of high job demand compared to low demand on total mortality among women working in the public sector. The finding of Eaker et al. [10] on job demand and

total mortality is similar but not statistically significant (adjusted RR 0.96 95% CI 0.91 to 1.01). We found in white-collar women with active jobs the mortality risk to be lower compared to the women with low strain jobs. The finding might reflect socioeconomic differences in mortality [27, 29] while white-collar women in active jobs with high job demands and control represent the highest socioeconomic gradient known to have lowest pre-mature mortality rates. However, there is little information on the effect of job strain on health within the occupational classes and these associations need to be investigated in different populations.

Study strengths and weaknesses

The strengths of our study include the representative large sample of municipal employees working both in white-collar and blue-collar professions. In addition, the follow-up on mortality was long and the data was collected from the national mortality register. Some limitations of the study should be recognized. We did not have data available on job support to investigate the effect of job strain and low social support at the work place, which have been shown to correlate highly with CVD mortality [30]. Using another job stress models such as the effort-reward balance model [31], in which imbalance between personal efforts and rewards has been shown to predict coronary heart disease [32] would have further strengthened the analyses. The data on job strain was self-reported which might yield possible reporting bias however, high correlations between subjective and expert ratings on work conditions have been reported [24, 33]. The assessment of job strain was measured at a single time point in midlife which might imperfectly reflect long-term job strain and result in an underestimation of the association between job strain and mortality [34]. However, the municipal employees in our cohort had stable work histories thus indicating stability possibly also for job strain during their earlier working life. Our study cohort included persons who worked in the public sector which should be considered when generalizing the results to the entire working population in the Western countries. Non-response in this study was relatively small (8%) and those who did not participate were older. According to the healthy worker survivor effect, those

who are older and potentially less healthy more frequently fail to participate in the study. This might on the one hand cause underestimation of the effects of job strain on mortality but on the other hand including older employees might dilute these effects while older participants have a higher prevalence of other age-related health problems that are not related to job strain [21].

Conclusions

Our evidence suggests that high job strain was associated with mortality in middle-aged public sector employees, but that it differed according to gender and occupational class. The effect of job strain on total mortality in different occupational groups is not well-known, which warrants further investigations into these differences.

Conflict of interest statement

No conflict of interest was declared by any of the authors.

Acknowledgements

FLAME was supported by the Finnish Institute of Occupational Health and The Local Governments Pension Institution. von Bonsdorff MB was supported by Academy of Finland grant no. 132597, University Alliance Finland, University of Jyväskylä, Yrjö Jahnsson Foundation; von Bonsdorff ME was supported by the University Alliance Finland, University of Jyväskylä; Nygård C-H was supported by the Signe and Ane Gyllenberg Foundation.

AUTHOR CONTRIBUTIONS

JI, C-HN, JS and TR contributed substantially to conception and design of the FLAME study. JS, MEvB and MBvB contributed to the data collection. MBvB and TR interpreted the data. MBvB analyzed the data and drafted the manuscript. All of the authors critically revised the article and gave final approval of the version to be published.

REFERENCES

1. McEwen BS. Protective and damaging effects of stress mediators. *N Engl J Med* 1998;338:171-9.

2. Johnson JV, Stewart W, Hall EM, et al. Long-term psychosocial work environment and cardiovascular mortality among Swedish men. *Am J Public Health* 1996;86:324-31.

3. Kivimäki M, Leino-Arjas P, Luukkonen R, et al. Work stress and risk of cardiovascular mortality: Prospective cohort study of industrial employees. *BMJ* 2002;325:857.

4. Bosma H, Marmot MG, Hemingway H, et al. Low job control and risk of coronary heart disease in Whitehall II (prospective cohort) study. *BMJ* 1997;314:558-65.

5. Marmot MG, Bosma H, Hemingway H, et al. Contribution of job control and other risk factors to social variations in coronary heart disease incidence. *Lancet* 1997;350:235-39.

6. Sacker A, Bartley MJ, Frith D, et al. The relationship between job strain and coronary heart disease: Evidence from an English sample of the working male population. *Psychol Med* 2001;31:279-90.

7. Bourgkard E, Wild P, Massin N, et al. Association of physical job demands, smoking and alcohol abuse with subsequent premature mortality: A 9-year follow-up population-based study. *J Occup Health* 2008;50:31-40.

8. Kuper H, Marmot M. Job strain, job demands, decision latitude, and risk of coronary heart disease within the Whitehall II study. *J Epidemiol Community Health* 2003;57:147-153.

9. Belkic KL, Landsbergis PA, Schnall PL, et al. Is job strain a major source of cardiovascular disease risk? *Scand J Work Environ Health* 2004;30:85-128.

10. Eaker ED, Sullivan LM, Kelly-Hayes M, et al. Does job strain increase the risk for coronary heart disease or death in men and women? The Framingham offspring study. *Am J Epidemiol* 2004;159:950-8.

11. Lee S, Colditz G, Berkman L, et al. A prospective study of job strain and coronary heart disease in US women. *Int J Epidemiol* 2002;31:1147-53.

12. Alterman T, Shekelle RB, Vernon SW, et al. Decision latitude, psychological demand, job strain, and coronary heart disease in the Western Electric Study. *Am J Epidemiol* 1994;139:20-7.

13. Hallqvist J, Diedrichsen F, Theorell T, et al. Is the effect of job strain on myocardial infarction due to interaction between high psychological demand and low decision latitude? Results from Stockholm Heart Epidemiology Program (SHEEP). *Soc Sci Med* 1998;46:1405-15.

14. Johnson JV, Hall EM, Theorell T. Combined effect of job strain and social isolation on cardiovascular disease morbidity and mortality in a random sample of the Swedish male working population. *Scand J Work Environ Health* 1989;15:271-9.

15. Lynch J, Krause N, Kaplan GA, et al. Workplace conditions, socioeconomic status, and the risk of mortality and acute myocardial infarction: The Kuopio ischemic heart disease risk factor study. *Am J Public Health* 1997;87:617-22.

16. Karasek RA. Job demands, job decision latitude, and mental strain: Implications for job redesign. *Administrative Science Quarterly* 1979;24:285-308.

17. Ilmarinen J, Tuomi K, Eskelinen L, et al. Background and objectives of the Finnish research project on aging workers in municipal occupations. *Scand J Work Environ Health* 1991;17 Suppl 1:7-11.

18. Karasek RA, Theorell T. *Healthy Work. Stress, Productivity, and the Reconstruction of Working Life.* New York: Basic Books: 1990.

19. Ilmarinen J, Suurnakki T, Nygard CH, et al. Classification of municipal occupations. *Scand J Work Environ Health* 1991;17 Suppl 1:12-29.

20. Cox RD, Oakes D. *Analysis of Survival Data.* New York: Chapman and Hall: 1984.

21. Kivimäki M, Theorell T, Westerlund H, et al. Job strain and ischaemic disease: Does the inclusion of older employees in the cohort dilute the association? The WOLF Stockholm study. *J Epidemiol Community Health* 2008;62:372-4.

22. Amick BC 3rd, McDonough P, Chang H, et al. Relationship between all-cause mortality and cumulative working life course psychosocial and physical exposures in the United States labor market from 1968 to 1992. *Psychosom Med* 2002;64:370-81.

23. McEwen BS, Stellar E. Stress and the individual mechanisms leading to disease. *Arch Intern Med* 1993;153:2093-101.

24. Theorell T, Tsutsumi A, Hallqvist J, et al. Decision latitude, job strain, and myocardial infarction: A study of working men in Stockholm. *Am J Public Health* 1998;88:382-8.

25. Wunsch G, Duchene J, Thiltges E, et al. Socio-economic differences in mortality. A life course approach *Eur J Popul* 1996;12:167-85

26. Clougherty JE, Souza K, Cullen MR. Work and its role in shaping the social gradient in health. *Ann N Y Acad Sci* 2010;1186:102-24.

27. Davey Smith G, Hart C, Blane D. Lifetime socioeconomic position and mortality: prospective observational study. *BMJ* 1997:314:547-52.

28. Lynch JW, Kaplan GA, Shema SJ. Cumulative impact of sustained economic hardship on physical, cognitive, psychological, and social functioning. *N Eng J Med* 1997:337:1889-95.

29. Mackenbach JP, Stirbu I, Roskam AJ et al. Socioeconomic inequalities in health in 22 European countries. *N Engl J Med* 2008;358:2468-81.

30. Johnson JV, Stewart W, Hall EM, et al. Long-term psychosocial work environment and cardiovascular mortality among Swedish men. *Am J Public Health* 1996;86:324-31.

31. Siegrist J. Adverse health effects of high-effort/low-reward conditions. *J Occup Health Psychol* 1996;1:27-41.

32. Bosma H, Peter R, Siegrist J, Marmot M. Two alternative job stress models and risk of coronary heart disease. *Am J Public Health* 1998;88:68-74.

33. Huuhtanen P, Nygard CH, Tuomi K, et al. Changes in stress symptoms and their relationship to changes at work in 1981-1992 among elderly workers in municipal occupations. *Scand J Work Environ Health* 1997;23 Suppl 1:36-48.

34. Kivimäki M, Head J, Ferrie J, et al. Why is evidence on job strain and coronary heart disease mixed? An illustration of measurement challenges in the Whitehall II Study. *Psychosom Med* 2006;68:398-401.

Table 1 Baseline characteristics according to job strain in midlife in the FLAME study

Characteristics	Low strain		Passive		Active		High strain		p-value*
Deaths during follow-up, n (%)									
Men	250	(36.8)	283	(48.5)	248	(43.1)	338	(46.2)	<0.001
Women	238	(24.3)	164	(25.9)	162	(19.2)	153	(21.7)	0.01
Age, mean (SD)									
Men	50.3	(3.6)	50.7	(3.6)	50.3	(3.7)	50.3	(3.5)	0.104
Women	50.4	(3.6)	50.6	(3.6)	50.1	(3.6)	50.2	(3.6)	0.049
White-collar profession, %									
Men	46.6		11.6		47.7		17.5		<0.001
Women	59.0		33.9		60.9		36.2		<0.001
Never smoked, %									
Men	30.7		24.6		31.8		26.6		0.028
Women	76.6		73.6		76.6		78.7		0.32
Alcohol intake ≥ 1 per week, %									
Men	16.9		19.9		24.6		20.3		0.01
Women	2.4		3.0		3.6		3.3		0.47
Vigorous physical activity ≥ 1 per week, %									
Men	50.7		41.5		42.9		52.2		<0.001
Women	52.8		45.2		54.9		48.5		0.001
Cardiovascular disease, %									
Men	16.9		22.3		27.3		27.8		<0.001
Women	18.4		20.3		20.0		23.8		0.056
Metabolic disorder, %									
Men	5.6		8.2		10.9		9.0		0.004
Women	8.4		12.8		12.3		12.3		0.01
Cancer at any site, %									
Men	0.3		1.2		1.4		1.0		0.15
Women	1.1		1.3		0.3		0.5		0.88

*Continuous variables tested with ANOVA (analysis of variance) and categorical variables with χ^2 test

Table 2 Mortality rates per 1000 person-years and 95% confidence intervals according to occupational group and job strain in midlife among men and women in the 28-year follow-up of the FLAME study

	Men (95% CI)				Women (95% CI)			
Job strain	**White-collar**		**Blue-collar**		**White-collar**		**Blue-collar**	
Low strain	12.2	(9.8 to 16.1)	17.1	(14.4 to 20.1)	9.6	(8.0 to 11.2)	8.8	(7.2 to 10.7)
Passive	12.0	(7.5 to 17.8)	22.5	(19.8 to 25.3)	8.3	(6.0 to 10.9)	10.7	(8.8 to 12.8)
Active	14.8	(12.0 to 17.9)	20.4	(17.2 to 23.8)	7.2	(5.8 to 8.7)	7.0	(5.4 to 8.9)
High strain	17.1	(12.6 to 22.2)	20.2	(17.8 to 22.6)	7.1	(5.2 to 9.3)	8.6	(7.1 to 10.4)
Log-rank test* p value	0.13		0.033		0.079		0.029	

* Degrees of freedom = 3

Table 3 Hazard ratios (HR) and 95% confidence intervals (CI) for mortality for individual effects of job demand, job control and job strain in the 28-year follow-up of the FLAME study

	HR (95% CI) adjusted for age		HR (95% CI) adjusted for age and occupational group		HR (95% CI) adjusted for age, occupational group, lifestyle and health factors*	
Men						
Job demand						
Low	1.00	-	1.00	-	1.00	-
High	1.10	(0.98 to 1.23)	1.09	(0.97 to 1.23)	1.05	(0.93 to 1.18)
Job control						
Low	1.26	(1.12 to 1.42)	1.11	(0.98 to 1.26)	1.08	(0.95 to 1.22)
High	1.00	-	1.00	-	1.00	-
Job strain						
Low strain	1.00	-	1.00	-	1.00	-
Passive job	1.43	(1.21 to 1.70)	1.26	(1.06 to 1.50)	1.21	(1.01 to 1.44)
Active job	1.23	(1.03 to 1.46)	1.23	(1.03 to 1.46)	1.15	(0.97 to 1.38)
High strain	1.36	(1.16 to 1.60)	1.21	(1.02 to 1.43)	1.14	(0.96 to 1.35)
Women						
Job demand						
Low	1.00	-	1.00	-	1.00	-
High	0.82	(0.71 to 0.95)	0.82	(0.71 to 0.95)	0.82	(0.71 to 0.95)
Job control						
Low	1.07	(0.93 to 1.24)	1.05	(0.91 to 1.22)	1.06	(0.91 to 1.23)
High	1.00	-	1.00	-	1.00	-
Job strain						
Low strain	1.00	-	1.00	-	1.00	-
Passive job	1.05	(0.86 to 1.28)	1.04	(0.85 to 1.27)	1.03	(0.84 to 1.26)
Active job	0.78	(0.64 to 0.95)	0.78	(0.64 to 0.95)	0.77	(0.63 to 0.95)
High strain	0.88	(0.72 to 1.08)	0.87	(0.71 to 1.07)	0.89	(0.72 to 1.09)

* Lifestyle factors=smoking, alcohol intake and physical activity, health factors=cardiovascular disease, metabolic disorders and cancer

Table 4 Hazard ratios and 95% confidence intervals for mortality according to job strain in midlife stratified by occupational group among men and women in the 28-year follow-up of the FLAME study

	White-collar					Blue-collar				
		Model 1		Model 2			Model 1		Model 2	
	No./deaths	HR	(95% CI)	HR	(95% CI)	No./deaths	HR	(95% CI)	HR	(95% CI)
Men										
Job strain										
Low strain	317/99	1.00		1.00		363/151	1.00		1.00	
Passive	68/21	0.95	(0.60 to 1.53)	0.99	(0.61 to 1.59)	516/262	1.28	(1.05 to 1.56)	1.20	(0.98 to 1.47)
Active	275/101	1.26	(0.96 to 1.66)	1.21	0.91 to 1.61)	301/147	1.21	(0.96 to 1.52)	1.12	(0.89 to 1.41)
High strain	128/53	1.52	(1.09 to 2.13)	1.38	(0.98 to 1.95)	603/285	1.16	(0.95 to 1.41)	1.09	(0.89 to 1.33)
Women										
Job strain										
Low strain	577/144	1.00		1.00		401/94	1.00		1.00	
Passive	215/47	0.84	(0.61 to 1.17)	0.83	(0.59 to 1.16)	419/117	1.20	(0.91 to 1.57)	1.17	(0.89 to 1.55)
Active	513/99	0.78	(0.60 to 1.00)	0.77	(0.59 to 1.00)	330/63	0.78	(0.57 to 1.08)	0.77	(0.56 to 1.07)
High strain	255/49	0.78	(0.56 to 1.08)	0.81	(0.59 to 1.13)	450/104	0.96	(0.73 to 1.27)	0.97	(0.73 to 1.29)

Model 1 adjusted for age

Model 2 adjusted for age, smoking, alcohol intake and physical activity, prevalent cardiovascular disease, metabolic disorders and cancer