American Journal of Epidemiology
Vol. 165, No. 2
DOI: 10.1093/aje/kwj355
Advance Access publication October 27, 2006

Original Contribution

Work Characteristics and Incidence of Type 2 Diabetes in Women

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Received for publication March 31, 2005; accepted for publication May 31, 2006.

The authors prospectively investigated associations between potentially stressful work characteristics and type 2 diabetes incidence in 62,574 young and middle-aged women, aged 29–46 years at baseline in 1993, from the Nurses' Health Study II; 365 cases of type 2 diabetes accrued over 6 years of follow-up. Cox proportional hazards regression was used to simultaneously evaluate associations of hours per week in paid employment, years of rotating night-shift work, and job strain with incidence of type 2 diabetes. In multivariate-adjusted analyses, women working less than 20 hours per week had a lower risk of diabetes (relative risk = 0.80, 95% confidence interval: 0.50, 1.30), and those working overtime (≥41 hours/week) had an elevated risk of diabetes (relative risk = 1.23, 95% confidence interval: 0.98, 1.55) compared with women working 21–40 hours/week (referent) in paid employment (p_{trend} = 0.03). In subsequent analysis, the elevated association appeared stronger in unmarried women ($p_{interaction}$ = 0.02). A positive association between years in rotating night-shift work and diabetes was mediated entirely by body weight. Job strain was unrelated to risk of type 2 diabetes. In conclusion, working overtime predicted a slightly elevated risk of type 2 diabetes in young and middle-aged female nurses.

diabetes mellitus, type 2; nursing staff; stress, psychological; women; work schedule tolerance

Abbreviations: CI, confidence interval; RR, relative risk.

Numerous studies have examined work characteristics, particularly stress, and cardiovascular outcomes, mostly in men. In men, overtime work has been linked to higher and lower cardiovascular risk depending on occupational status (1). In addition, job strain from work characterized by high job demands and low job decision latitude has typically been related to increased coronary heart disease (2), though not uniformly (3). In women, studies of job strain have generally found no association with coronary heart disease (4, 5), though shift work has been related to an elevated risk of this disease (6). Job strain has also been examined with cardiovascular risk factors and has been both positively (7, 8) and not (9, 10) associated with blood pressure or hypertension in women. Similarly, job strain has been positively associated with an adverse lipid profile (11), but not consistently (12). Importantly, however, positive associations with blood pressure or hypertension have come from longitudinal studies of change in job strain.

There has been limited study of work characteristics and metabolic regulation, particularly in women. Low job control has been cross-sectionally associated with a higher risk of diabetes in women (13). Job strain and stressors including

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a lack of worksite social support have been associated with elevated levels of glycosylated hemoglobin and markers of metabolic dysregulation in nondiabetic populations (14, 15), though only weakly with body weight (16). Shift work and rotating night-shift work (1) have been linked to increased serum glucose (17), higher body mass (18), and other signs of metabolic dysregulation (6, 18).

The only prior studies of work hours and diabetes have been in Japanese men, and findings are inconsistent. One study of male industrial workers found a higher risk of type 2 diabetes among those working more than 50 hours versus those working less than 25 hours per week or more than 11.0 hours versus less than 8.0 hours per day (19). A second study by Nakanishi et al. (20), however, found a strong inverse association of hours of paid work and type 2 diabetes in male office workers.

Type 2 diabetes, characterized by impaired secretion of and resistance to insulin, affects over 9 million women in the United States (21). Given that 60 percent of women and 80 percent of young women are in the US workforce (22) and up to 17 percent of all full-time wage and salary workers work alternating shifts (23), work-related stress could have a substantial influence on the burden of type 2 diabetes in the US population. Of course, this relation would be better understood with more knowledge about the context of women's pattern of employment. Compared with men, women may be more likely to work part-time and cycle in and out of the workforce across the life span, and these factors may moderate the effects on women's health (24). Nonetheless, we found no prior studies of work characteristics and diabetes in women.

Because mandatory overtime for nurses has been reported to be stressful (25, 26), consistent with an adverse effect of stress, we hypothesized that high work hours (>40 hours per week) would be prospectively associated with an increased risk of type 2 diabetes compared with working 40 or fewer hours per week in a cohort of nurses. We further hypothesized that high job strain and rotating night-shift work would be associated with a higher risk of diabetes.

MATERIALS AND METHODS

Study population

The Nurses' Health Study II is a prospective cohort study of 116,608 female nurses from 15 US states who were 25–42 years of age at baseline in 1989. Ninety-four percent of the Nurses' Health Study II population is White. Participants have provided detailed lifestyle and medical history information biennially through mailed questionnaires. Of the full cohort, 87,238 completed a psychosocial assessment in 1993. Women from the full cohort and those who responded to the psychosocial assessment were similar with regard to age, body mass index, waist:hip ratio, family history of diabetes, physical activity, caffeine, alcohol, *trans*-fat consumption, glycemic load, aspirin use, postmenopausal status, and parity (a proxy for number of children in the home). However, compared with the full cohort, those who completed the psychosocial assessment were more likely to take a vitamin supplement (45 vs. 36 percent), were less likely to smoke (10 vs. 12 percent), and were more likely to be married (80 vs. 65 percent).

We excluded women with prior diabetes (n = 874). At each time point, as information was updated, we excluded additional women with any prior cardiovascular disease (defined as myocardial infarction, angina, coronary artery bypass graft, or stroke) or cancer, those not reporting paid employment or who indicated they were housewives or students, and those missing information on work hours or body mass index or reporting a body mass index less than 16 kg/m^2 or greater than 50 kg/m^2. Those women who were missing information on paid employment or body mass index or who indicated they were not engaged in paid employment were reentered into the sample at the next time point if they reported this information or became employed in paid work. After exclusions, 62,574 women, aged 29–46 years in 1993, who contributed a total of 351,364 years of person-time, were included in the analysis. The average follow-up was 69.3 months.

Data collection

Ascertainment of type 2 diabetes. Cases of incident type 2 diabetes, accrued between 1993 and 1999, were ascertained by biennial mailing of the questionnaire to participants and verified through a validated supplemental questionnaire (27). Women were additionally asked about the date of diagnosis at the time of the survey. A case of diabetes was considered confirmed if at least one of the following was reported on the supplementary questionnaire: 1) one or more classic symptoms (excessive thirst, polyuria, weight loss, hunger, or pruritis) plus fasting plasma glucose of 140 mg/dl or more (≥7.8 mmol/liter) or random plasma glucose of 200 mg/dl or more (≥11.1 mmol/liter); 2) at least two elevated plasma glucose concentrations on different occasions (fasting glucose of ≥140 mg/dl (≥7.8 mmol/liter) or random plasma glucose of ≥200 mg/dl (≥11.1 mmol/liter) and/or a concentration of ≥200 mg/dl after ≥2 hours of oral glucose tolerance testing) in the absence of symptoms; or 3) treatment with hypoglycemic medication (insulin or oral hypoglycemic agent). Ninety-eight percent of a subsample of these cases, defined using these criteria, were verified through medical records (27).

Measurement of job characteristics. We collected data on several job characteristics. In 1989, women were asked how long they had worked rotating night-shift work (never, 1–2 years, 3–5 years, 6–9 years, 10–14 years, 15–19 years, ≥20 years), and in 1991, 1993, and 1997, women were asked how many months in the previous 2 years they had worked rotating night-shift work (none, 1–4, 5–9, 10–14, 15–19, ≥20 months). We assigned and added together midpoint values in years and categorized the duration of shift work as none, 1–<12 months, 1–<2 years, 2–<5 years, 5–<10 years, and 10 or more years. In 1991, women were asked how many hours per week they spent sitting at work (0, 1, 2–5, 6–10, 11–20, 21–40, 41–60, 61–90, >90 hours). In 1993, participants were asked, "How many hours per week do you work, on average, in your job?" with the following response options: <15 hours, 15–20 hours, 21–40 hours, 41–60 hours, 61–80 hours, and more than 80 hours. Women were further

TABLE 1. Work characteristics' data collection, Nurses' Health Study II, 1989–1997

Year				
1989	1991	1993	1995	1997
Data on rotating night-shift work collected	Data on rotating night-shift work collected	Data on rotating night-shift work collected		Data on rotating night-shift work collected
	Data on sitting at work collected			
		Data on hours per week worked on average at a job		
		Data on type of nursing employment		Data on type of nursing employment
		Data on job strain collected		Data on job strain collected

asked how long they had worked in their current job (<6 months, 6–11 months, 1–2 years, 3–4 years, 5–9 years, ≥10 years). In 1993 and 1997, women were asked what type of employment they were in, including inpatient or emergency room nursing, outpatient or community nursing, nursing education, nursing administration, other nursing, or nonnursing employment.

Job strain was measured by the 27-item Karasek Job Content Questionnaire in 1993 and 1997 (28). The instrument measures the psychological workload "demands" (the need to work hard and fast with insufficient time to accomplish job tasks) and the level of "control" (combined measure of job decision authority and skill discretion) to manage the workload. Jobs high in demands and low in control ("high strain" jobs) are posited to have the most deleterious health effects. The remaining three categories of jobs are high demands/high control ("active"), low demands/high control ("low strain"), and low demands/low control ("passive"). We further collected information on work-related social support from supervisors and coworkers.

Table 1 provides a summary of when collection of data on work characteristics occurred.

Measurement of covariates. Data on numerous biomedical, lifestyle, psychosocial, and hormonal factors have been collected through previous Nurses' Health Study II surveys. Age was assessed at baseline in 1989. In 1993, women were asked, "How many hours per week do you spend in housework (including cooking, cleaning, shopping for food, doing laundry and dishes, doing repairs, paying bills, and making arrangements and caring for children): 0–19, 20–39, 40–59, 60–79, 80–100 hours?" Women were asked about their marital status (married, divorced, widowed, separated, never married) in 1993 and 1997. Dietary variables including alcohol (g/day), *trans*-unsaturated and saturated fat consumption (g/day), glycemic load, and caffeine consumption (mg/day) were assessed by food frequency questionnaire in 1991 and 1995. Physical activity was assessed in 1991 and 1997 in terms of metabolic equivalent hours per week or the sum of the average reported hours per week engaged in eight activities (walking or hiking outdoors, jogging (>10 minutes per mile (1.6 km)), running, biking, racquet sports, lap swimming, calisthenics, aerobics, and other aerobic activity) over the past year multiplied by the assigned metabolic equivalent score. Family history of diabetes was measured in 1989 and 1997. Other covariates including body mass index, smoking, pregnancies, menopausal status, aspirin use, and multivitamin intake were assessed biennially. Covariates were updated by use of the most recent prior report in analyses.

Statistical analyses

Few women indicated working in the two highest categories of job hours (60–80 hours/week and >80 hours/week); therefore, we collapsed these. To assess the association of known or suspected risk factors for diabetes and poor glycemic control with job hours, we regressed potential confounding variables against categories of job hours, adjusted for age as a continuous variable (table 2).

We used Cox proportional hazards regression to evaluate the relative risk of incident type 2 diabetes in relation to categories of hours worked reported by the nurses, the different job strain categories, and years of rotating night-shift work, with updating of covariates. We also assessed the associations of incident type 2 diabetes with other work characteristics including hours per week sitting at work, job support, and work hours at home. In further analyses, we simultaneously adjusted analyses of hours per week worked with job strain and other work characteristics and years of shift work. At each new time period, we updated exposures and covariates to reflect the most recently measured information.

We additionally explored possible modification of the association between hours worked and risk of incident type 2 diabetes by categories of job strain, whether or not women had ever engaged in rotating night-shift work, level of support at work, length of time at one's current job (<5 years, ≥5 years), type of nursing position (administration and teaching vs. positions with patient contact), time sitting at work (<20 vs. ≥20 hours/week), and amount of time spent in household obligations (0–19, 20–39, ≥40 hours/week), through stratified analysis. We used likelihood ratio tests to test for effect modification, using a standard of significance of $p < 0.05$.

To determine how to best model the covariates age and body mass index, we examined the possibly nonlinear relation between age and body mass index and the relative hazard of diabetes nonparametrically with restricted cubic splines (29). Tests for nonlinearity used the likelihood ratio test. Age was linearly related to diabetes and therefore entered as a continuous variable in models. Body mass index was nonlinearly related, and we included two spline terms in models.

Age-adjusted results were compared with those obtained adjusting for multiple factors indicated in tables 3, 4, and 5. Indicator variables were created and added to models to

TABLE 2. Selected characteristics across categories of work hours in 1993 among 62,574* subjects from the Nurses' Health Study II†

	Work hours per week in 1993				
	<15	15–20	21–40	41–60	≥61
No. in 1993*	3,093	6,255	29,441	18,816	1,482
Person-years, 1993–1999 (no.)	18,300	37,211	175,341	111,730	8,781
Incident diabetes cases, 1993–1999 (no.)	3	18	161	170	13
Mean age (years)	37	38	39	39	40
Family history of diabetes (%)	13	15	16	17	17
Postmenopausal (%)	3	3	4	5	6
Lifestyle factors					
Body mass index (kg/m^2)	24	24	25	26	26
Waist:hip ratio	0.78	0.78	0.78	0.78	0.77
Leisure-time physical activity (metabolic equivalent hours/week)	21	21	21	22	25
Alcohol (g/day)	2	3	3	4	4
Saturated fat (g/day)	22	22	22	23	22
trans-Fat consumption (g/day)	3	3	3	3	3
Glycemic load (units/day)‡	124	123	122	120	119
Aspirin (%)	7	8	9	10	10
Vitamin supplementation (%)§	46	44	45	45	46
Current smoking (%)	6	7	10	13	13
Caffeine consumption (mg/day)	181	200	233	266	270
Home-related characteristics					
No. of children	2	2	2	1	1
Married (%)	97	96	81	69	69
Housework (hours/week)	59	54	39	29	30
Sitting at home (hours/week)	20	20	19	17	18
Work-related characteristics					
Ever shift work (%)	63	64	66	72	75
Sitting at work (hours/week)	9	10	13	16	17
Job strain					
Low strain (%)§	20	22	24	24	17
Passive (%)	47	40	31	14	15
Active (%)	8	12	18	38	48
High strain (%)	19	22	22	20	16
High support (%)	33	35	35	40	37
Job type¶					
Inpatient/emergency room nurse (%)#	6	13	60	20	2
Outpatient/community nurse (%)#	6	12	53	27	1
Operating room nurse (%)	3	9	46	40	2
Nursing education (%)	4	9	39	45	3
Nursing administration (%)	1	3	23	69	5
Other registered nurse (%)	6	11	51	30	2
Nonnursing employment (%)	8	10	35	40	7

* In 1993, 59,087 women contributed data. The number of study participants varied slightly across time intervals. The total number of participants was 62,574.

† All variables except for age were age standardized.

‡ Glycemic load reflects the extent to which diet raises blood glucose levels.

§ Except for vitamin supplementation and low-strain job type, all age-adjusted covariates were significantly associated with work hours (i.e., $p_{trend} < 0.05$ across categories of work hours in 1993). This was due mostly to the large Nurses' Health Study II sample size.

¶ Mantel-Haenszel χ^2: $p < 0.01$.

Doesn't sum to 100% because of rounding.

TABLE 3. Relative risk of incident type 2 diabetes between 1993 and 1999 by categories of 1993 work hours in 62,574 young and middle-aged women, Nurses' Health Study II

	Hours worked per week in 1993					p_{trend}*
	<15	15–20	21–40	41–60	≥61	
Person-years (no.)	18,300	37,211	175,341	111,730	8,781	
Cases (no.)	3	18	161	170	13	
Total						
Age-adjusted relative risk	0.20	0.57	Referent	1.57	1.49	<0.001
95% confidence interval	0.06, 0.63	0.35, 0.92		1.26, 1.94	0.85, 2.63	
Multivariate-adjusted relative risk†,‡	0.44	0.94	Referent	1.24	1.14	0.033
95% confidence interval	0.14, 1.40	0.56, 1.56		0.98, 1.57	0.63, 2.07	

* *p* value, test for linear trend.

† Multivariate-adjusted model adjusted for age (continuous), body mass index (spline), family history of diabetes (yes/no), rotating night-shift work (never (referent), 0–<1 year, 1–<2 years, 2–<5 years, 5–<10 years, ≥10 years), job strain (low strain (referent), active, passive, high strain), job support (low support (referent), high support), hours at work sitting (<20 hours/week (referent), ≥20 hours/week), hours per week of work at home (0–19 (referent), 20–39, 40–59, ≥60), leisure-time physical activity (quartiles), smoking (never (referent), past, current), alcohol intake (0 (referent), 1–14, ≥15 g/day), *trans*-unsaturated fat intake (quartiles), glycemic load (quartiles), caffeine intake (quartiles), marital status (married/other), number of children (0 (referent), 1, 2, ≥3), menopausal status (premenopausal (referent), postmenopausal, unsure), vitamin supplementation (yes/no), and aspirin use (yes/no).

‡ In an evaluation of effect modification, the association of working overtime (vs. working ≤40 hours) with risk of diabetes was stronger in unmarried women (relative risk = 1.48, 95% confidence interval: 1.07, 2.04) ($p_{interaction}$ = 0.02).

represent missing covariate information. Less than 5 percent were missing data for any covariate, and excluding women with any missing data did not qualitatively alter analyses. All tests of statistical significance were two sided. This research was approved by the Institutional Review Board at Brigham and Women's Hospital in Boston, Massachusetts.

RESULTS

The incidence rate of diabetes in the study population was 103.9 per 100,000 person-years. Compared with women working fewer than 40 hours per week in paid employment, women who worked 40 hours per week or more tended to be

TABLE 4. Relative risk of incident type 2 diabetes between 1993 and 1999 by categories of job strain in 62,574* young and middle-aged women, Nurses' Health Study II

	Category of job strain			
	Low strain	Passive	Active	High strain
Person-years (no.)	82,995	94,064	84,133	75,054
Cases (no.)	92	72	98	86
Total				
Age-adjusted relative risk	Referent	0.72	1.09	1.13
95% confidence interval		0.53, 0.99	0.82, 1.45	0.84, 1.51
Multivariate-adjusted relative risk†	Referent	0.84	1.01	1.11
95% confidence interval		0.60, 1.17	0.75, 1.37	0.80, 1.52

* A total of 15,118 missing person-years.

† Multivariate-adjusted models adjusted for age (continuous), body mass index (spline), family history of diabetes (yes/no), work hours (<15 hours/week, 15–20 hours/week, 21–40 hours/week (referent), 41–60 hours/week, ≥61 hours/week), rotating night-shift work (never (referent), 0–<1 year, 1–<2 years, 2–<5 years, 5–<10 years, ≥10 years), hours at work sitting (<20 hours/week (referent), ≥20 hours/week), job support (low support (referent), high support), hours per week of work at home (0–19 (referent), 20–39, 40–59, ≥60), leisure-time physical activity (quartiles), smoking (never (referent), past, current), alcohol intake (0 (referent), 1–14, ≥15 g/day), *trans*-unsaturated fat intake (quartiles), glycemic load (quartiles), caffeine intake (quartiles), marital status (married/other), number of children (0 (referent), 1, 2, ≥3), menopausal status (premenopausal (referent), postmenopausal, unsure), vitamin supplementation (yes/no), and aspirin use (yes/no).

TABLE 5. Relative risk of incident type 2 diabetes between 1993 and 1999 by categories of rotating night-shift work in 62,574* young and middle-aged women, Nurses' Health Study II

	Duration of rotating night-shift work						p_{trend}†
	None	1–<12 months	1–<2 years	2–<5 years	5–<10 years	≥10 years	
Person-years (no.)	106,170	12,670	85,361	71,167	42,127	19,345	
Cases (no.)	108	11	70	70	62	35	
Total							
Age-adjusted relative risk	Referent	0.99	0.83	1.04	1.59	1.64	<0.001
95% confidence interval		0.53, 1.83	0.61, 1.11	0.76, 1.39	1.15, 2.16	1.11, 2.37	
Multivariate-adjusted relative risk 1‡	Referent	0.92	0.87	1.04	1.50	1.41	0.001
95% confidence interval		0.49, 1.71	0.64, 1.17	0.77, 1.40	1.10, 2.05	0.96, 2.06	
Multivariate-adjusted relative risk 2§,¶	Referent	0.75	0.81	0.88	1.14	0.98	0.30
95% confidence interval		0.40, 1.46	0.59, 1.10	0.64, 1.20	0.82, 1.57	0.66, 1.45	

* A total of 14,525 missing person-years.

† *p* value, test for linear trend.

‡ Multivariate-adjusted model 1 adjusted for age (continuous), family history of diabetes (yes/no), work hours (<15 hours/week, 15–20 hours/week, 21–40 hours/week (referent), 41–60 hours/week, ≥61 hours/week), job strain (low strain (referent), active, passive, high strain), job support (low support (referent), high support), hours at work sitting (<20 hours/week (referent), ≥20 hours/week), hours per week of work at home (0–19 (referent), 20–39, 40–59, ≥60), leisure-time physical activity (quartiles), smoking (never (referent), past, current), alcohol intake (0 (referent), 1–14, ≥15 g/day), *trans*-unsaturated fat intake (quartiles), glycemic load (quartiles), caffeine intake (quartiles), marital status (married/other), number of children (0 (referent), 1, 2, ≥3), menopausal status (premenopausal (referent), postmenopausal, unsure), vitamin supplementation (yes/no), and aspirin use (yes/no).

§ Multivariate-adjusted model 2 adjusted for body mass index (two spline terms) in addition to the covariates in multivariate-adjusted model 1.

¶ In an analysis with restricted cubic splines, $p = 0.48$ for significance of the overall curve.

older, were less likely to be married, and spent less time on household obligations. They had greater job latitude and support from coworkers and higher job demands. They drank more alcohol, were more likely to smoke, spent less time sitting at home, engaged in higher amounts of leisure-time physical activity, and were more likely to report active job type. Despite these characteristics and despite a lower glycemic load diet, they weighed more than did women who worked fewer hours per week and were more likely to report more hours sitting at work. Differences in consumption of saturated and *trans*-unsaturated fats across categories of work hours were small (table 2).

Women working as inpatient/emergency room or outpatient/community nurses were most likely to be working fewer than 40 hours per week. Women working more than 40 hours per week were more likely to be operating room nurses, educators, and especially administrators (table 2).

Job hours were positively associated with type 2 diabetes risk in both age- and calendar time-adjusted and multivariate-adjusted models (table 3). In multivariate-adjusted analyses, women working 20 hours per week or less had a lower risk of diabetes (relative risk (RR) = 0.80, 95 percent confidence interval (CI): 0.50, 1.30), and those working 41 hours per week or more had an elevated risk of diabetes (RR = 1.23, 95 percent CI: 0.98, 1.55) compared with women working 21–40 hours per week (referent) in paid employment ($p_{trend} = 0.03$). In contrast, job strain was unrelated to diabetes (table 4).

Years of rotating night-shift work were positively associated with diabetes in age-adjusted analyses ($p_{trend} < 0.001$). However, this linear association disappeared upon adjustment for body mass index; results were similar with multivariate adjustment ($p_{trend} = 0.30$) (table 5). Nevertheless, because of the apparent positive linear association among shift workers, we tested for possible linear and nonlinear components with restricted cubic splines. Again, we found no evidence for an association between years of rotating night-shift work and type 2 diabetes (overall significance of the curve: $p = 0.48$). When we additionally excluded women reporting no history of shift work, we still found no apparent association (overall significance of the curve: $p = 0.20$). Because body mass may mediate the relation between shift work and diabetes risk, we conducted an additional multivariate-adjusted analysis, unadjusted for body mass index. In this analysis, shift work was positively related to diabetes, similar to age-adjusted analyses though somewhat attenuated ($p_{trend} = 0.001$).

In models simultaneously adjusted for multiple work characteristics, neither adjustment for hours per week sitting at work, rotating night-shift work, job strain, job support, nor level of household obligations explained the positive association of work hours with diabetes. Furthermore, there was no significant modification of the relation between hours worked and risk of diabetes by any of these factors or by type of nursing position or time at one's job (data not shown).

DISCUSSION

We found a positive relation of hours worked with incidence of type 2 diabetes in a population of young and middle-aged women. The association was independent of body weight. Adjustment for possible confounding variables including hours at work sitting down, years of rotating night-shift work, or job strain (control, latitude, and support) did not explain these results. In contrast, the association between rotating night-shift work and diabetes appeared to be mediated by body weight, and job strain was unrelated to type 2 diabetes risk. This is the first prospective study examining stressful work characteristics and diabetes in women.

Work stress may influence the development of diabetes through effects on behaviors as well as through direct effects on metabolic regulation. Stress activates the hypothalamic-pituitary-adrenal axis and the sympatho-adrenal-medullary axis, which leads to increases in blood pressure and blood glucose, designed to aid in the fight-or-flight response. Frequent cortisol release that occurs with chronic stress may lead to persistently high cortisol levels (30), resulting in central accumulation of body fat, dyslipidemia, hypertension, and insulin resistance. The link between work stress and diabetes may in part be mediated by body weight. Rotating night-shift work and the associated stress and disruptions in circadian rhythms may lead to overweight through increases in intake of energy, fat, refined carbohydrate, and sugar (31, 32) and possible reductions in physical activity due to increased fatigue and disruptions in social activities.

If stress at work influences diabetes, there appear to be other elements of the workplace besides job control, demands, or lack of support at work, suggested by Karasek's job strain model, that explain our positive findings between work hours and diabetes. In the current economy, nurses face long work hours, mandatory overtime, double shifts (33), and other unfavorable working conditions (25, 26). Overtime work may be stressful, or long work hours may reflect duration of exposure to stressful conditions.

Evidence linking long work hours to the risk of diabetes is limited, in both men and women. The conflicting results in the two studies in Japanese men (19, 20) are consistent with a differential effect of work hours and diabetes by occupational and socioeconomic status. Lower occupational grade and socioeconomic status have consistently been linked to cardiovascular risk and metabolic disturbance (34, 35). Nevertheless, it is difficult to compare our results directly with these previous studies in men because socioeconomic status in women may often be more strongly determined by marital status than job type (36), because the effects of status in the workplace may differ for men and women in traditional hierarchical structures (with males in top leadership positions) (37, 38), and because of the differing roles of women and men at home.

In high-status positions, women who work many overtime hours as a strategy to retain their jobs may have higher cardiovascular risk than do women who work fewer hours (37), counter to the relation seen in men. Still, though hours per week at work were positively associated with risk of diabetes overall, women who worked 60 hours per week or more did not have the highest risk, albeit there were relatively few women in this group. These women were more likely to hold positions in teaching and administration than those working fewer hours and may have had less exposure to the stressful conditions that often occur at the same time with patient contact. The healthy worker effect (39) might also mask the relation between stress from overtime work and risk of diabetes; only women who are healthy may be able to work so many hours.

Women working overtime may have additional responsibilities in the home that men do not have. Goode's role strain (40) perspective suggests that role combinations of work and family may be detrimental to women's well-being, introducing competing demands on time, energy, and involvement. We did not have sufficient data (e.g., time spent in informal caregiving, percent of housework done by spouse) to fully examine this hypothesis. Nonetheless, our data did not lend support to this theory. In stratified analyses, the combination of high hours of work per week at home and high hours of work per week in paid employment was not more predictive than paid work hours alone ($p = 0.89$). Some have reported that paid work in combination with children is stressful, but we found no additional risk of diabetes among women with children compared with those without ($p = 0.32$). Interestingly, the association between working overtime (vs. working $\leq$40 hours) and risk of diabetes appeared to be stronger among unmarried women (RR = 1.48, 95 percent CI: 1.07, 2.04) ($p_{\text{interaction}} = 0.02$). Social and instrumental support in marriage could serve to buffer the adverse effects of stress at work.

The strengths of the study include the use of prospective data and the use of updated covariates, providing control of important confounding variables. Additional strengths are the validation of diabetes diagnosis and the ability to explore associations by several work characteristics.

A limitation is possible residual confounding by a third variable such as time for self-care. Nevertheless, though women working overtime hours were more likely to smoke and had higher body mass indexes than women working fewer hours, they also reported higher physical activity, higher alcohol intake, and lower dietary glycemic load, factors related to lower diabetes risk. Furthermore, the lack of additional risk with hours of work in the home suggests that some aspect of the workplace rather than lack of time for self-care may be more important.

Another potential problem is underascertainment of diabetes outcome. In the general population, much prevalent diabetes is as yet undiagnosed (41). This is a serious concern if there is differential detection of diabetes by categories of work hours. However, when analyses were restricted to symptomatic cases of type 2 diabetes, findings were not materially altered, suggesting that surveillance bias by work hours was unlikely. One of the benefits of this study is that it is conducted in a group of health-care providers who may be better at seeking appropriate medical care and reporting diagnoses.

Among other limitations, work hours were assessed at one time point only, and the reasons for long hours at work were unknown. We were thus unable to explore specific issues, such as the effects of mandatory overtime and double shifts, or aspects of the psychosocial work environment.

Additionally, we did not have data on income prior to diabetes outcome. However, we adjusted for marital status as a proxy for socioeconomic status, since women's socioeconomic status may be influenced by whether or not she is married (36) and, if so, her husband's education and income.

Additional adjustment for husband's education had little effect on associations.

In summary, higher work hours in paid employment predicted an elevated risk of type 2 diabetes in young and middle-aged female nurses, particularly in those who were unmarried. Results were consistent with an impact of job stress on diabetes outcome, and hours worked per week may reflect the extent of exposure to stressful conditions. Further development of stress models and research examining overtime work in women and what conditions at work are stressful may be warranted.

ACKNOWLEDGMENTS

This research was supported by grant CA87969 supplied by the National Cancer Institute, National Institutes of Health, Bethesda, Maryland, and by the Robert Wood Johnson Foundation. C. H. K. is a Robert Wood Johnson Health and Society Scholar at the University of California in San Francisco and Berkeley, California.

The authors would like to thank Ellen Herzmark for her invaluable statistical and programming expertise.

Conflict of interest: none declared.

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