AMERICAN JOURNAL OF INDUSTRIAL MEDICINE 56:755–764 (2013)

Disability Rates for Cardiovascular and Psychological Disorders Among Autoworkers by Job Category, Facility Type, and Facility Overtime Hours

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Background *We examined the association between long work hours, assembly line work and stress-related diseases utilizing objective health and employment data from an employer's administrative databases.*

Methods *A North American automobile manufacturing company provided data for claims for sickness, accident and disability insurance (work absence of at least 4 days) for cardiovascular disease (CVD), hypertension and psychological disorders, employee demographics, and facility hours worked per year for 1996–2001. Age-adjusted claim rates and age-adjusted rate ratios were calculated using Poisson regression, except for comparisons between production and skilled trades workers owing to lack of age denominator data by job category. Associations between overtime hours and claim rates by facility were examined by Poisson regression and multi-level Poisson regression.*

Results *Claims for hypertension, coronary heart disease, CVD, and psychological disorders were associated with facility overtime hours. We estimate that a facility with 10 more overtime hours per week than another facility would have 4.36 more claims for psychological disorders, 2.33 more claims for CVD, and 3.29 more claims for hypertension per 1,000 employees per year. Assembly plants had the highest rates of claims for most conditions. Production workers tended to have higher rates of claims than skilled trades workers.*

Conclusions *Data from an auto manufacturer's administrative databases suggest that autoworkers working long hours, and assembly-line workers relative to skilled trades workers or workers in non-assembly facilities, have a higher risk of hypertension, CVD, and psychological disorders. Occupational disease surveillance and disease prevention programs need to fully utilize such administrative data.* Am. J. Ind. Med. 56:755–764, 2013. © *2013 Wiley Periodicals, Inc.*

KEY WORDS: autoworkers; work hours; overtime; assembly line work; cardiovascular disease

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Contract grant sponsor: UAW-DaimlerChrysler National Joint Committee on Health and Safety (NJC); Contract grant sponsor: National Institute for Occupational Safety and Health; Contract grant number: R01 OH07577.
Disclosure Statement: The authors report no conflicts of interests.
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Accepted 1 March 2013
DOI 10.1002/ajim.22191. Published online 12 April 2013 in Wiley Online Library (wileyonlinelibrary.com).

INTRODUCTION

Long work hours have been associated with cardiovascular disease (CVD) [van der Hulst, 2003; Virtanen et al., 2012], injuries [Wagstaff and Sigstad Lie, 2011], disability retirement and other health outcomes [van der Hulst, 2003], although not consistently associated with depression [Virtanen and Kivimaki, 2012] or blood pressure elevation [Hayashi et al., 1996; Iwasaki et al., 1998; Nakamura et al., 2012].

In limited research, assembly-line work has been associated with blood pressure elevation [Fouriaud et al., 1984; Melin et al., 1999], although not with depression symptoms [Tsutsumi et al., 2001], sleep disturbances or drug consumption [Jacquinet-Salord et al., 1993]. The elevated risk of CVD in blue-collar (vs. white-collar) workers has been well-documented [Gonzalez et al., 1998]. However, the job titles, job characteristics or other job exposures which explain this elevated risk remain to be fully understood. No studies published in English were found which examined work organization factors and CVD comparing assembly-line workers to other blue-collar workers. If elevated CVD risk among assembly-line workers were documented, a key explanation would likely be job strain (jobs which combine high demands and low control [Karasek and Theorell, 1990]), a risk factor for CVD [Belkic et al., 2004] and a fundamental feature of assembly-line work.

We hypothesized that overtime work and assembly-line work would be associated with stress-related diseases such as hypertension [Schnall et al., 1998], CVD [Schnall et al., 2000; Belkic et al., 2004], and psychological disorders [Stansfeld and Candy, 2006]. We tested these hypotheses by analyzing data from administrative databases of a large manufacturing employer. Previous studies utilizing employer administrative databases have focused on conditions expected to be caused by occupational chemical and physical exposures, such as cancers, respiratory conditions, or musculoskeletal disorders. Several have examined sickness absence in relation to downsizing [Vahtera et al., 2004], workplace expansion [Westerlund et al., 2004] and patient overcrowding [Virtanen et al., 2010]. Only two prior studies using administrative data have examined work organization factors in relation to heart disease [Park et al., 1996; Park, 2001b]. This is also the first study to examine associations between long work hours and illness using data from employer records.

METHODS

The following data were available from administrative databases of a major North American automobile manufacturing company:

(1) Claims for *Sickness, Accident and Disability Insurance* (SADI), 1996–2001, by year, facility, bargaining unit, ICD9 code, age, and gender. Company employees are eligible for this program starting the fourth day of absence due to illness.
(2) *Employment information*, including the total number of employees by facility, bargaining unit, and year, 1996–2001 (denominator data) were made available. Data on the number of employees by facility, bargaining unit, sex, and age were made available for 2002 and multiplied by 6 to estimate the 1996–2001 population. Data were also available on the racial and occupational distribution of employees in each facility by year.
(3) *Employee hours worked per year* by facility and bargaining unit, for 23 manufacturing and assembly facilities, 1996–2000.

Diagnostic Categories

ICD9 (diagnostic) codes chosen for analysis were for conditions for which previous research has shown an association with work stressors: coronary heart disease (410.0–414.9), cardiac dysrhythmias (427.0–427.9), stroke (430.0–436.9), and atherosclerosis (440.0–445.9) [Belkic et al., 2004], hypertension (401.0–404.9) [Schnall et al., 1998] and psychological disorders, including mood disorders (296.0–296.9, 298.0), neurotic disorders (300.0–300.9), adjustment disorders (309.0–309.9), and reactions to stress (308.0–308.9) [Stansfeld and Candy, 2006].

Incident Claims for Disease

The first claim per person during the 6-year study period within each disease category was considered an incident claim and included in the dataset for analysis (as in Park et al. [1996]). For a claim to be eligible for analysis, employees had to have been employed for at least 6 months at the company prior to the date of the claim. Between 1996 and 2001, 9,224 incident claims within the eligible disease categories were filed by hourly bargaining unit employees.

Facility Groupings

The company grouped its facilities into the following categories, which were used in analysis: vehicle assembly plants, component plants, parts distribution, powertrain (engine, transmission, and foundry) plants, general offices, and stamping plants.

Occupational Categories

Company data on hourly workers' occupational categories were classified into either: (a) Skilled Trades workers

(craft workers (skilled)); or (b) Production workers (operatives (semi-skilled), laborers (unskilled), and service workers). Data for 1996–2001 sickness, accident and disability insurance claimants included 599 possible job titles. The company's Human Resource Department classified these job titles into six categories: Assemblers; Off-line workers including operators and painters; Skilled trades; Technical, clerical, and professional; Full-time union representatives; Supervisors. We classified Assemblers and Off-line workers as Production worker claimants and Skilled trades as Skilled Trade worker claimants.

Institutional Review Board

This study was approved by the Institutional Review Board of the Mount Sinai School of Medicine, New York, NY. No signed or written consent was necessary since this study was a secondary analysis of a de-identified data set.

Data Analysis

To compare claim rates between facilities, 6-year average claim rates (1996–2001) were computed and age-adjusted to the total hourly employee population using 10-year age groups. Age-adjusted rates could not be computed for comparisons between production and skilled trades workers because data on the age distribution of production and skilled trades were unavailable. Rates from facilities or occupational groups with 25 or fewer claims were considered unreliable. Age-adjusted rate ratios were calculated using Poisson regression (SAS proc genmod).

Rates of claims for each diagnostic category were computed for each year across all facilities and tested for linear trend using linear regression (SAS proc reg).

To assess the association between overtime hours and claim rates by facility, Poisson regression was conducted with average age-adjusted 1996–2000 claim rates as the dependent variable, average 1996–2000 facility overtime hours as the independent variable with proportion of female employees within a facility as a covariate (SAS proc genmod). In addition, to assess the effect of change in overtime hours and claim rates each year during this period, multi-level Poisson regression (SAS proc glimmix) was used to analyze the association between overtime hours and facility (group level variable) and change in age-adjusted claim rates within facilities with proportion of female employees within a facility as a covariate [SAS Institute, 2003]. Both these analyses of the association of overtime hours and claim rates were also conducted adjusted for proportion of African-American employees in a facility, and were conducted at the group (facility) level and not at the individual level.

RESULTS

From 1996 to 2001, across 51 facilities with 64,533 hourly workers, there were 7.0 heart disease and stroke claims, 4.1 hypertension claims, and 12.8 claims for psychological disorders per 1,000 employees per year. Age-adjusted rates of heart disease and stroke claims were higher for men (7.6 claims/1,000 employees/year) than for women (5.1). However, rates of hypertension claims were higher for women (5.6) than for men (3.7). Rates of claims for psychological disorders were much higher for women (29.2) than for men (8.4).

Variation in Claim Rates Between Production and Skilled Trades Workers

In the 28 largest facilities with denominator data for job type, male production workers had substantially higher rates of hypertension and psychological claims and slightly higher rates of heart disease and stroke claims than male skilled trades workers (Table I). Female production workers had substantially higher rates of hypertension and heart disease and stroke claims (but a lower rate of psychological claims) than female skilled trades workers. Age adjustment of rates for these occupational groups was not possible with available data. However, since skilled trades workers averaged 49.7 years of age compared to only 43.4 years for production workers, age adjustment would have produced an even higher risk of claims by production workers than that of skilled trades workers.

Variation in Claim Rates Across Facilities

Age-adjusted rates of heart disease and stroke claims ranged fourfold from 3.6 to 14.4 claims, with a median of 7.3 claims per 1,000 employees per year ($n = 26$ facilities). Rates of hypertension claims ranged sixfold across facilities from 1.6 to 9.6 claims, with a median of 5.8 claims per 1,000 employees per year ($n = 17$ facilities). Finally, rates of psychological disorders ranged nearly eightfold across facilities from 3.6 to 27.4 claims, with a median of 10.1 claims per 1,000 employees per year ($n = 28$ facilities).

Variation in Claim Rates Across Facility Groups

Among men, those working in assembly plants had the highest rates of claims (Tables II–IV). Relative to stamping plants (the reference group), men in assembly plants had an increased risk of about 30% of filing a claim for heart disease and stroke (rate ratio (RR) = 1.3, 95% CI 1.1–1.5), about

TABLE I. Rates of Sickness, Accident and Disability Insurance (SADI) Claims for Production Versus Skilled Trades Employees per 1,000 Employees, per Year, 1996–2001

	All employees			Females			Males		
	Claims/6 years	Employees	Rate/1,000/ year	Claims/6 years	Employees	Rate/1,000/ year	Claims/6 years	Employees	Rate/1,000/ year
Hypertension claims									
Production	1,215	47,603	4.25	383	10,731	5.95	832	36,872	3.76
Skilled trades	102	11,692	1.45	4	189	3.53	98	11,503	1.42
Total	1,317	59,295		387	10,920		930	48,375	
Rate ratio			2.93			1.68			2.65
Heart disease and stroke claims									
Production	1,836	47,603	6.43	352	10,731	5.47	1,484	36,872	6.71
Skilled trades	428	11,692	6.10	3	189	2.65	425	11,503	6.16
Total	2,264	59,295		355	10,920		1,909	48,375	
Rate ratio			1.05			2.06			1.09
Psychological claims									
Production	3,746	47,603	13.12	1,834	10,731	28.48	1,912	36,872	8.64
Skilled trades	253	11,692	3.61	42	189	37.07	211	11,503	3.06
Total	3,999	59,295		1,876	10,920		2,123	48,375	
Rate ratio			3.64			0.77			2.83

Note: Denominator (numbers of employees) based on data from Equal Employment Opportunity (EEO) reports.
Production worker claims are all claims from hourly employees with job titles in categories "Assemblers" and "Off-line workers." Skilled trade worker claims are all claims from hourly employees with a "Skilled Trade" job category.

20% for hypertension (RR = 1.2, 95% CI 1.0–1.4), and about three times as high for psychological disorders (RR = 2.9, 95% CI 2.4–3.4). Among women, those working in assembly plants also had the highest rates of claims for heart disease and stroke (RR = 1.5, 95% CI 1.1–2.2) and psychological disorders (RR = 2.4, 95% CI 1.9–3.0), relative to women in stamping plants. However, women working in assembly plants had a slightly lower rate of hypertension claims than women in stamping plants (RR = 0.8, 95% CI 0.6–1.1), which had the highest rate of any industry group.

When examining occupational differences by facility type, the higher hypertension claim rate among male production (vs. skilled trades) workers was most pronounced in assembly plants, component parts, and stamping operations. Heart disease and stroke claim rates were similar for male production and skilled trades workers in assembly plants and powertrain operations, but higher for male production (vs. skilled trades) workers in component parts and stamping operations. Psychological claim rates were higher for male production (vs. skilled trades) workers in assembly plants, powertrain operations. and stamping operations (data not shown). There were small numbers of male skilled trades workers and claims by male skilled trades workers in other types of facilities, making comparisons unreliable. Small numbers of female skilled trades workers

TABLE II. Age-Adjusted Rates of Claims for Heart Disease and Stroke by Facility Type per 1,000 Employees, per Year, 1996–2001

	All employees			Females			Males		
Facility type	Claims	Employees	Rate	Claims	Employees	Rate	Claims	Employees	Rate
Car and truck assembly	1,119	26,949	7.7	194	6,198	6.1	925	20,751	8.1
Powertrain operations	749	20,465	6.8	90	4,160	4.5	659	16,305	7.4
Component parts/trim	284	5,723	6.7	71	1,869	4.1	213	3,854	7.9
General offices/manufacturing/engineering	63	1,262	6.2	7	163	3.9	56	1,099	6.9
Mopar (motor parts) parts/distribution	102	3,165	6.2	22	757	4.7	80	2,362	6.7
Stamping operations	360	6,969	5.8	34	1,004	3.8	326	5,954	6.3

TABLE III. Age-Adjusted Rates of Claims for Hypertension by Facility Type per 1,000 Employees, per Year, 1996–2001

	All employees			Females			Males		
Facility type	**Claims**	**Employees**	**Rate**	**Claims**	**Employees**	**Rate**	**Claims**	**Employees**	**Rate**
Car and truck assembly	776	26,949	5.0	205	6,198	6.1	1,416	20,751	4.7
Stamping operations	237	6,969	4.3	60	1,004	7.5	145	5,954	3.8
Component parts/trim	166	5,723	4.3	75	189	5.1	184	3,854	3.6
Mopar (motor parts) parts/distribution	57	3,165	3.3	27	757	5.8	110	2,362	2.4
Powertrain operations	335	20,465	2.9	93	4,160	4.3	650	16,305	2.6
General offices/mfg/engineering	21	1,262	2.4	5	163	4.3	28	1,099	2.1

and claims by female skilled trades workers in all facility types made comparisons between female production and skilled trades workers within facility type unreliable.

Increase in Claim Rates Over Time

Figures 1 and 2 show trends in claim rates over the 1996–2001 time period. Significant or borderline significant increases in claims were observed for coronary heart disease ($P = 0.03$), cardiac dysrhythmias ($P = 0.01$), atherosclerosis ($P = 0.07$), mood disorders ($P < 0.01$), neurotic disorders ($P = 0.08$), and adjustment disorders ($P = 0.04$). Rates of psychological disorders, in particular, increased between 1996 and 2001, an increase of over 21 times for mood disorders, over 350 times for neurotic disorders and over 34 times for adjustment disorders.

Management staff could not provide any administrative reasons to explain the large between facility differences in claim rates or the large increase in claims during the 1996–2001 time period. Therefore, we hypothesized that differences between facilities or changes over time in work stressors may explain the observed results. Aside from production work and facility type (assembly plant), the only other measure of work stressors available in company databases was number of hours worked by facility by year. As can be seen in Figure 3, overtime hours also increased over the 1997–1999 time period but then declined somewhat during 2000, a recession year.

Work Hours and Claim Rates

Average overtime worked at a facility (hours >40 per week) ranged from 1 to 20 hr per week. Table V presents associations between claim rates and overtime hours worked by facility both averaged over the 1996–2000 time period for 23 manufacturing and assembly plants. The total number of hourly workers in these plants in any year during this period ranged from 52,046 to 55,322. Claims for all four disease outcomes were significantly associated with increased overtime hours, with the strongest association for hypertension. Ten overtime hours per week were associated with 4.36 more claims for psychological disorders, 2.33 more claims for CVD, 1.47 more claims for coronary heart disease, and 3.29 more claims for hypertension per 1,000 employees per year (based on regression coefficients for models with 10 vs. 0 overtime hours per week).

Since claim rates and overtime hours increased during the study period, a multi-level analysis presented in Table VI takes into account the changing levels of overtime hours and claim rates each year during the 1996–2000 time period. Only 14 manufacturing and assembly plants, with a total of 39,453–42,026 hourly employees, had sufficient data to be

TABLE IV. Age-Adjusted Rates of Claims for Psychological Disorders by Facility Type per 1,000 Employees, per Year, 1996–2001

	All employees			Females			Males		
Facility type	**Claims**	**Employees**	**Rate**	**Claims**	**Employees**	**Rate**	**Claims**	**Employees**	**Rate**
Car and truck assembly	2,677	26,949	16.7	1,261	6,198	34.5	1,416	20,751	11.5
Component parts/trim	503	5,723	15.1	319	1,869	32.6	184	3,854	8.0
Mopar (motor parts) parts/distribution	212	3,165	11.3	102	757	22.5	110	2,362	7.9
Powertrain operations	1,270	20,465	10.2	620	4,160	25.2	650	16,305	6.6
General offices/mfg/engineering	51	1,262	6.2	23	163	21.1	28	1,099	4.0
Stamping operations	230	6,969	5.2	85	1,004	13.7	145	5,954	3.8

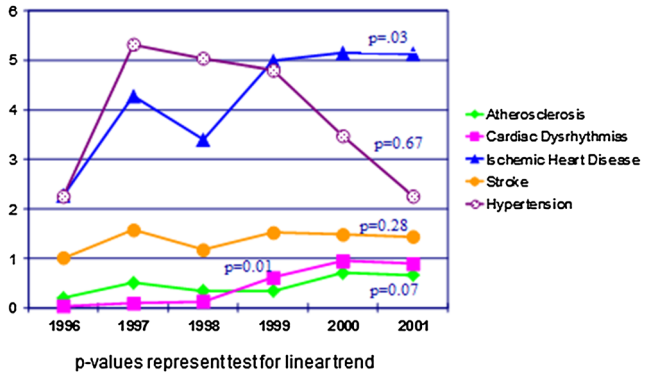

FIGURE 1. Age-adjusted disability claims for cardiovascular disease per year per 1,000 hourly employees, 1996–2001.

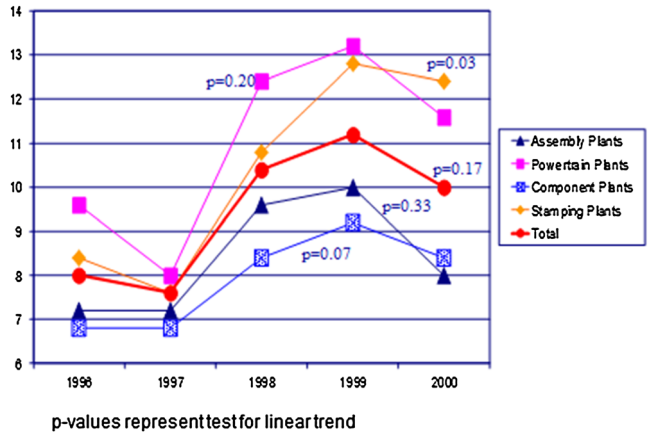

FIGURE 3. Average overtime hours per week by facility type and year.

included in this analysis (at least 25 claims per year). Claims for all four disease outcomes were significantly associated with overtime hours (in the same year that claims were filed), with the exception of hypertension.

We also conducted an analysis, presented in Table VI, in which we examined overtime hours one or two years before claims were filed. However, associations between "lagged" overtime hours and claims were no longer statistically significant for heart disease and stroke and for coronary heart disease. Overtime hours one or two years before claims were filed were still significantly and positively associated with psychological disorders; however, they were significantly and inversely associated with hypertension.

Proportion of a facility workforce that was African-American was positively associated with facility overtime hours ($r = 0.36$, $n = 22$, $P = 0.098$) and with rates of all four categories of claims. Controlling for proportion of a facility workforce that was African-American in reduced the association between overtime hours and all four categories of claims ($n = 22$ facilities). After adjustment, rate ratios remained significant only for hypertension (PR = 1.58, 95% CI 1.06, 2.36, $P = .03$). In multi-level analyses ($n = 14$ facilities), after adjustment, prevalence rate ratios were statistically significant and positive for all four types of claims.

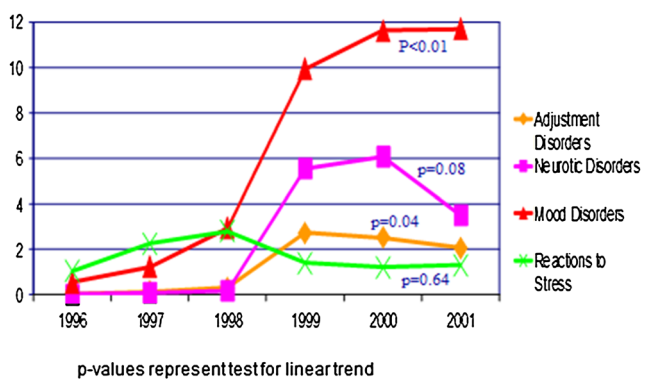

FIGURE 2. Age-adjusted disability claims for psychological disorders per year per 1,000 hourly employees, 1996–2001.

DISCUSSION

Among hourly employees of a major automaker, production (vs. skilled trades) workers and workers in assembly plants (our proxy measures for assembly-line work) had higher rates of sickness, accident and disability claims for diseases potentially caused by work stressors—hypertension, heart disease and stroke, and psychological disorders. Overtime hours were associated with an increased rate of claims. These claims represent more severe medical conditions since they are for cases of absence of at least 4 days duration. All data analyzed were objective health or employment data recorded by the employer.

Assembly-Line Work and Sickness, Accident and Disability Insurance Claims for Diseases Likely Associated With Work Stressors

Workers in assembly (vs. other types of) plants, and production (vs. skilled trades) workers had higher rates of sickness, accident and disability insurance claims in most comparisons. Age-adjusted claim rates were available for comparisons between types of plants. However, data were not available to produce age-adjusted rates of claims for production (vs. skilled trades) workers. Such adjustment likely would have widened the divergence in rates. Further analyses need to include age adjustment for occupational group comparisons.

Production workers, notably assemblers and machine operators likely face greater exposure to work organization

TABLE V. Increased Risk of Sickness, Accident and Disability Claims Associated With 10 Versus 0 Facility Overtime Hours per Week, Based on 5-Year Average Claim Rates

Type of claim	Rate ratio[a]	95% CI	*P*	Number of additional claims/year/1,000 employees associated with 10 facility overtime hours/week	Total number of claims 1996–2000
Heart disease and stroke	1.51	1.18, 1.94	0.001	2.33	1,680
Coronary heart disease	1.51	1.11, 2.05	0.009	1.47	1,076
Hypertension	4.83	3.53, 6.62	<0.0001	3.29	1,099
Psychological disorders	1.80	1.46, 2.20	<0.0001	4.36	2,448

[a]Rate ratio from Poisson regression for the association of claim rates averaged over a 5-year period, 1996–2000 and 10 versus 0 facility overtime hours for 23 manufacturing and assembly plants. Adjusted for claimant age and proportion of female employees in a facility.

stressors such as machine-paced work, low job control, job monotony, and job strain than skilled trades workers. However, production work is also likely associated with substantially greater exposure to risk factors for musculoskeletal disorders, and higher rates of musculoskeletal pain and acute injury. Pain may contribute to depression [Bair et al., 2003; McWilliams et al., 2003; Strine et al., 2005] and hypertension [McWilliams et al., 2003; Bruehl et al., 2005]. Thus, biomechanical risk factors (and resulting pain) may, to some extent, confound the association between work organization stressors and psychological disorders and hypertension. In contrast, skilled trades workers are presumed to work more overtime than production workers. A previous study of autoworkers found slightly (but non-significantly) lower heart disease mortality among skilled trades versus other workers [Park, 2001a]. Another study compared various departments within auto plants on heart disease risk [Park et al., 1996]. This is the first study we are aware of showing increased risk of CVD and psychological disorders in production (primarily assembly-line) workers compared to other blue-collar workers.

Our findings are also consistent with the literature on socioeconomic gradients in health, including increased risk in lower (vs. higher) socioeconomic groups of CVD [Kaplan and Keil, 1993], hypertension [Kanjilal et al., 2006], and psychological disorders [Hasin et al., 2005].

Overtime Hours and Stress-Related Diseases

The current results are consistent with other studies that have found increases in blood pressure with increased overtime work and among men working greater than 55 hr per week [Hayashi et al., 1996; Iwasaki et al., 1998; Nakamura et al., 2012], although null [Park et al., 2001] and inverse [Nakanishi et al., 2001; Wada et al., 2006] associations have also been reported. Facility work hours in the current study ranged from 40 to 60 hr per week between 1996 and 2000. However, the hours worked by individual claimants were not available and thus it is unknown how many may have consistently worked more than 55 hr per week. The association between long work hours and CVD observed in the current study is consistent with a recent meta-analysis, which found a significant although modest association between long work hours and coronary heart disease [Virtanen et al., 2012]. Other studies of the association between overtime hours and psychological

TABLE VI. Increased risk of Sickness, Accident and Disability Claims Associated With 10 Versus 0 Facility Overtime Hours per Week, Based on Annual Claim Rates

				1 year lag			2 year lag		
Outcome	Rate ratio[a]	95% CI	*P*	Rate ratio[a]	95% CI	*P*	Rate ratio[a]	95% CI	*P*
Heart disease and stroke	1.33	1.08, 1.63	0.009	1.26	1.00, 1.58	0.057	1.20	0.90, 1.58	0.22
Coronary heart disease	1.38	1.08, 1.76	0.014	1.20	−1.23, 1.35	0.18	0.92	0.67, 1.28	0.63
Hypertension	1.23	0.95, 1.59	0.13	0.71	0.52, 0.97	0.04	0.52	0.32, 0.82	0.01
Psychological disorders	2.35	1.93, 2.86	<0.0001	6.11	4.89, 7.62	<0.0001	2.42	1.89, 3.11	<0.0001

[a]Rate ratio from multi-level Poisson regression for the association of claim rates for each year during 1996–2000 by 10 versus 0 facility overtime hours, for 14 manufacturing and assembly plants. Adjusted for claimant age and proportion of female employees in a facility.

disorders (which we observed) have been inconsistent [Virtanen and Kivimaki, 2012]. We were not able to examine associations between long work hours and other outcomes such as injuries [Wagstaff and Sigstad Lie, 2011] and disability retirement [van der Hulst, 2003].

Race, Occupational Status, Overtime, and Hypertension

Proportion of a facility workforce that was African-American was associated with facility overtime hours and also with rates of claims, consistent with their increased risk of hypertension [Fryar et al., 2010], CVD [American Heart Association, 2012], and psychological disorders (http://www.cdc.gov/omhd/amh/factsheets/mental.htm) among African-Americans compared to whites in the U.S. Individual data on claimants' race was not available. While the association between facility overtime and claims would lead us to hypothesize an association between an individual's level of overtime and increased risk of filing a claim, alternative hypotheses need to be considered. Facilities with greater overtime levels (and/or a higher proportion of African-American workers) might have a higher proportion of stressful jobs, which can contribute to the development of hypertension, CVD, and psychological disorders. Further research is needed to test this hypothesis. However, there was no significant correlation between facility overtime and facility proportion of production (vs. skilled trades) jobs ($r = -0.16$), that is, no potential confounding by socioeconomic status.

Use of Administrative Databases for Occupational Disease Surveillance

This study demonstrates the utility of linking sickness, accident and disability data to job and demographic information for identifying job exposures contributing to disease, similar to previous efforts linking sickness absence to workplace exposures [Vahtera et al., 2004; Virtanen et al., 2010; Westerlund et al., 2004]. Previously, in the U.S., disease data have been obtained, primarily in the automobile industry, from employer records of disability insurance other than workers' compensation (or sickness and accident insurance) [Park et al., 1996], medical insurance claims [Park et al., 1992; Park, 2001b; Dement et al., 2004; Cullen et al., 2006] or mortality based on union pension records, a company mortality registry, life insurance claims, or state death records [Park et al., 1994; Park and Mirer, 1996; Park, 2001a]. A recent study of medical claim data from a large regional U.S. health insurer compared industry groups across a large number of disease outcomes [Bushnell et al., 2011]. In Scandinavian countries, data have been obtained from a national patient registry [Westerlund et al., 2004], national insurance databases [Westerlund et al., 2004; Virtanen et al., 2010], national pharmacy records [Oksanen et al., 2011], employers' records and a national mortality register [Vahtera et al., 2004].

Further analysis of employer data is needed to provide possible explanations for the findings in the current study, and to assess the costs associated with claims for sickness, accident and disability insurance. For example, the immediate financial savings to the company from using overtime during high demand periods instead of hiring new staff needs to be measured and weighed against the costs of diseases, such as hypertension, that may be produced by excessive overtime. In addition, we need to identify facility-level factors that might explain the large differences in illness rates between facilities, such as health care access and utilization, medical management, employee assistance programs, factors associated with rural versus urban residence, or levels of stressful work organization.

Further detailed information on workplace exposures also needs to be collected. Individual level work hours and shifts of all employees need to be included in a surveillance database. In addition, periodic surveys of work organization risk factors, such as job demands, job decision-making authority, use of skills on the job, social support from coworkers and supervisors, job security, and promotion prospects, could be conducted. These risk factors have been associated with CVD [Belkic et al., 2004], hypertension [Schnall et al., 1998], and psychological disorders [Stansfeld and Candy, 2006] in previous studies. Novel exposure measures include patient overcrowding as a source of stress for hospital workers [Virtanen et al., 2010] and extent of downsizing of personnel [Vahtera et al., 2004]. Industrial hygiene data related to cardiovascular outcomes, such as noise levels, carbon monoxide, carbon disulfide or lead, should also be included in such data sets to ensure that associations between psychosocial stressors and CVD are not confounded by physical or chemical exposures [Park et al., 1996].

Study Limitations

The 1996–2001 claim trend analysis did not adjust for age and gender, since population age and gender data were only available for 2002. However, this should not substantially affect the observed trends unless there were major changes in the age and gender distribution of the workforce during the 1996–2001 period. Neither company nor union representatives reported any such major changes. During the 6-year study period, 11,169 claims were made by hourly workers, 1,945 (17%) of which were repeat claims and thus 9,224 were first or "incident" claims. The small proportion of repeat claims filed throughout the company suggests that few of the claims we defined as incident cases were for diseases

that had resulted in extended (>3 days) lost time before the start of the 6-year study period. However, such a possibility exists [Park, 2001b]. If initial onset occurred before 1996, then work exposures during the study period, such as overtime, could not be considered as causes of the condition, only perhaps as factors exacerbating the condition. Therefore, investigations of disease etiology need to gather information on onset date or at least obtain many more years of data.

Data were not available on the race of or overtime hours worked by individual claimants, only data on the racial distribution of the workforce and overtime hours worked by facility. These were ecological measures, with all their inherent limitations [Diez-Roux, 1998]. Confounding by individual-level race or other factors may potentially explain some or all of the association observed between overtime hours worked and hypertension. Similarly, we were not able to adjust for individual-level race or overtime in analyses of occupational category and disease claims. To overcome such limitations, more detailed collection of individual level data is necessary. While such ecologic measures may be limited in their utility for hypothesis testing, they remain useful for the purpose of occupational health surveillance—elucidating burdens of disease in varying groups of employees and facilities, and targeting and evaluating interventions.

CONCLUSIONS

Our conclusions are tempered by the limitations of the current study, particularly the ecological design. Using employer administrative data bases, we found evidence linking overtime work and assembly-line (production) work with stress-related diseases such as hypertension, CVD, and psychological disorders. Given competitive pressures in the global economy, automakers may be tempted to increasingly utilize systems of work organization such as lean production (also known as the Toyota Production System) [Landsbergis et al., 1999], or other work systems which increase job demands in the context of limited job control and repetitive work. The current study and other studies suggest that the human and financial costs (e.g., medical claims, workers compensation, absenteeism, and turnover) of the assembly-line form of job design along with long work hours may negate any savings from increased productivity or even impose greater costs.

In contrast, a comprehensive surveillance system that combines demographic measures, data on diseases and injuries, and data on work organization and other work exposures, can help employers, union representatives, and occupational health experts meet a variety of goals: (1) identify groups of workers at increased risk of disease, injury or work hazard exposure; (2) estimate the number of cases of and trends in work-related injury or disease; (3) generate hypotheses on the causes of injury and disease at work, including forms and systems of work organization; (4) evaluate the impact of prevention programs [Dement et al., 2004]; and (5) design safer and healthier work.

ACKNOWLEDGMENTS

This project was funded in part by joint funds from the UAW-DaimlerChrysler National Joint Committee on Health and Safety (NJC). The results presented herein represent the conclusions and opinions solely of the authors. Its publication does not necessarily imply endorsement by the International Union UAW or DaimlerChrysler. We gratefully acknowledge the assistance of Dale Hemmingway, Vinita Agarwal, Al Barbaglia, Kevin Waszak, and Keith Miller of DaimlerChrysler, Decoris Glenn and Todd Penn, UAW Chrysler Department, the Scientific Advisory Committee of the National Joint UAW-DaimlerChrysler Committee on Health and Safety, and John Meyer of SUNY-Downstate School of Public Health. Funding was also received from the National Institute for Occupational Safety and Health, grant number R01 OH07577.

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