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Research Article

Prevalence of Diabetes and Other Cardiovascular Risk Factors among US Autoworkers

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Keywords

- Auto workers; Cardiovascular risk factors; Diabetes; Obesity

Abstract

Background: This study was done in response to a request for proposal from a joint company/union research fund.

Aims: To determine the prevalence of diabetes and cardiovascular (CV) risk factors among a group of US auto workers in whom, CV disease was thought to be the most common cause of premature mortality and disability, based on insurance data.

Methods: Subjects completed a health questionnaire, including a question if they attended the company wellness program. A *fasting blood* sample was obtained for assay of HbA1c, fasting glucose, and lipid profile (total cholesterol, Triglycerides, HDL-c and LDL-c), C - reactive protein and homocysteine. Height, weight, Blood pressure and percentage body fat was also determined. Subjects without previously known diabetes underwent a glucose tolerance test. A work related stress index was also calculated for all subjects.

Results: 190 subjects were studied. The prevalence of diabetes and prediabetes was 15.3%, and45.9% respectively. Total cholesterol,LDL-c, Triglycerides and HDL-c levels were at the desirable levels in 60%, 67.9%, 62.6% and 56.3% subjects respectively. The prevalence of diabetes, smoking, obesity and high LDL-c levels and the subjects who had their blood pressure controlled was higher compared to the US population. Only 47%attended the company wellness program.

Conclusions: Despite the better control of blood pressure, the additive effects of other risk factors may explain the increased CV morbidity and mortality in this group. Increased efforts to reduce the CV risk factors may reduce the CV mortality and morbidity found in this population.

INTRODUCTION

Although the National Health and Nutrition Examination Survey (NHANES) regularly publishes data on the overall health status of the nation (USA) and specific ethnic groups [1], the health status of specific socioeconomic groups of people is rarely published. We recently had an opportunity to evaluate the prevalence of diabetes and cardiovascular risk factors in a group of blue collar auto workers and this paper provides a summary of that effort.

METHODS

This study was done in response to request for a proposal from a joint company/union research fund. Medical insurance data from the company showed that cardiovascular (CV) disease was the most common cause of "the sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability" for all their employees, and diabetes was the 4th leading cause in their male and 8th most common cause in their female employees. We hypothesized that alternative explanations to explain the increased CV morbidity and mortality in this population could be an increased prevalence of diabetes and/or other cardiovascular risk factors among these workers or that the control of diabetes and CV risk factors was not optimal or a combination of both factors.

After meeting with representatives of the joint union/company research fund, two facilities (Lansing, Michigan and Pontiac, Michigan) within close proximity to our institution were identified for study. A letter was sent to all the employees 35 years or older, explaining the study and inviting their participation in 2006-2008. Those who agreed were asked to report after an overnight fast of at least 8 hours to a clinic at their work site, or in case of employees who were laid off, at the site where the laid off workers were required to report daily. A standardized questionnaire was developed and completed by the participants. Participants were asked if they had been previously diagnosed with diabetes. If subjects had previously diagnosed diabetes, a

blood sample was drawn for assays of HbA1c, lipid profile (total cholesterol, HDL-c, triglycerides and LDL-c), homocysteine, and c- reactive protein (CRP). Subjects without previously diagnosed diabetes had a fasting plasma glucose collected and then underwent a 75 gram glucose tolerance test, where plasma glucose 2 hours after ingestion of 75 gram glucose load was measured. Diabetes was diagnosed according to the American Diabetes Association (ADA) criteria [2]. They also had their plasma assayed for the same measures listed above for people with previously diagnosed diabetes. All participants also had their height, weight, percentage body fat and blood pressure measured. Percentage body fat was determined using bioelectric impedance (Tanita Corporation, Arlington Heights, IL). Blood pressure was measured by an aneroid sphygmomanometer with the subject seated in a chair after 5 minutes of rest. Additional questions in the standardized questionnaire completed by all subjects provided information about their demographics (age, gender, race, education, employment history at the auto manufacturing facility), their health habits (cigarette smoking, alcohol intake, exercise), cardiovascular risk factors (family history of CV disease, history of hypertension, hypercholesterolemia, personal history of coronary artery disease), work related "stress" and work and leisure time physical activity (classified as low, medium and high intensity) [3,4]. For those with a known history of diabetes, questions were asked about frequency of recommended testing (eye exams, foot exams), mode of treatment (oral agents or insulin) and complications (retinopathy, nephropathy, and neuropathy).

The population invited to participate had health insurance for both inpatient and outpatient care. In order to assess whether participants had a similar prevalence of known diabetes as nonparticipants, diabetes related health care claims were assessed for all individuals who were invited but declined to participate in the medical evaluation.

The study was limited to Caucasians and African American subjects and was approved by the Michigan State University Institutional Review board. All participants signed an informed consent form.

STATISTICAL ANALYSIS

Descriptive statistics are presented as frequencies and percentages for categorical variables, and means and standard deviations for continuous variables. Comparison of proportions was based on the one or two sample binomial test as appropriate. All analysis were conducted in SAS software ver9.3 (SAS Institute Inc., Cary NC)

RESULTS

A total of 192 subjects were evaluated. Out of these, two subjects were Hispanics and were excluded from further analysis.

Out of the remaining 190 subjects, 132 (69.5%) were male and 58 (30.5%) were female. The mean age was 52.1 ± 7.0 years (Range 25-69). There were 158 Caucasian and 27 African American subjects. Race was not identified in five subjects. Baseline characteristics of the population studied as shown in (Table 1).

Prevalence of Diabetes: Eighteen subjects had previously diagnosed diabetes. According to the ADA, diabetes may be diagnosed by an elevated fasting plasma glucose (FPG ≥ 126 mg/dl [7 mmol/L]) or an elevated 2 hour post 75 gm glucose load (glucose ≥ 200 mg/dl [11.1mmol/L]) or an elevated HbA1c (≥6.5%) [2]. Subjects with a FPG between 100 and 125 mg/dl (5.5 to 6.9 mmol/L), or 2 hour post 75 gm glucose value between 140 and 199 mg/dl, or a HbA1c level between 5.7 and 6.4% were classified as being at an increased risk for diabetes (or pre-diabetes). Using these criteria, the distribution of diabetes and pre-diabetes is shown in (Table 2). When any of these three criteria are applied, 11/172 (6.4%) subjects had newly diagnosed diabetes, 79/172 (45.9%) had newly diagnosed pre-diabetes and 18 had previously diagnosed diabetes. Thus the total prevalence of diabetes (previously diagnosed, plus newly diagnosed diabetes) in this population was 29/190 (15.3%). When subjects were classified as < 50 years of age or ≥ 50 years, the prevalence of diabetes in the younger group was 7.9%, compared to 20.2% in the older group. The prevalence of previously diagnosed diabetes in the participant group was 9.5% and 10.6% in the nonparticipant group (Table 3). This difference is not statistically significant (p = 0.71).

Prevalence of other cv risk factors

BMI and Percentage of Body Fat: Only 20 (10.5%) subjects had a BMI in the "normal range" (<25 kg/m^2); 68 (35.8%) subjects had a BMI ≥25 kg/m^2, but less than 30 kg/m^2, and 102 subjects (53.7%) were obese with a BMI of ≥30 kg/m^2. Only 16.8% had normal body fat percentage (increased body fat defined as >33% for females and >25% for men).

Table 1: Baseline Characteristics of the Participants (n=190).

Variable	Mean	± Std Dev
AGE	52.07	± 7.00
BMI	32.57	± 19.20
Systolic BP	118.20	± 13.70
Diastolic BP	72.49	± 8.18
Total Cholesterol	189.73	± 39.91
HDL Cholesterol	46.01	± 12.65
LDL Cholesterol *	115.43	± 33.20
Triglycerides	147.22	± 91.87
Glucose Fasting **	95.05	± 14.45
HgbA1c	5.72	±0.73
Homocysteine	9.50	± 3.25
CRP	0.38	± 0.59

* n=187, ** n=175

Table 2: Prevalence of Newly Diagnosed Diabetes and Pre-Diabetes.

Criterion	DIABETES	PRE-DIABETES	NO DM
HbA1c	8 (4.7%)	66 (38.4%)	98 (57.0%)
GTT	6 (4.1%)	17 (11.6%)	124 (84.4%)
FPG	6 (3.5%)	38 (22.1%)	128 (74.4%)

Abbreviation: DM = diabetes mellitus, GTT=glucose tolerance test, FPG=fasting plasma glucose

Table 3: Non-Participants with Claims for Diabetes from 2006-2008*.

	LANSING		PONTIAC		BOTH	
Race/Gender	Diabetics	Total	Diabetics	Total	Diabetics	Total
White Women	6	145 (4.1%)	4	95 (4.2%)	10	240 (4.2%)
Black Women	3	43 (7.0%)	8	67 (11.9%)	11	110 (10.0%)
White Men	31	377 (8.2%)	87	673 (12.9%)	118	1,050 (11.2%)
Black Men	3	75 (4.0%)	36	198 (18.2%)	39	273 (14.3%)
ALL	43	640 (6.7%)	135	1,033 (13.1%)	178	1,673 (10.6%)

*Individuals with at least one fee for service insurance claim for diabetes during 2006 to 2008 but does not include individuals who received medical care from an HMO

Smoking status

Overall there were 31 (16.3%) subjects who were current smokers. 57.9% were former smokers and 25.8% were never smokers. The prevalence of current smokers among pre-diabetes and diabetic subjects was 12.7% and 27.6% respectively, whereas 15.9% subjects without diabetes were current smokers.

Stress index

A stress index calculated as a ratio of effort/reward was determined. According to this ratio, a value close to zero indicates a favorable situation (i.e. relatively low effort and relatively high reward), whereas a ratio close to 1 indicates high effort/low reward. Approximately a third of the subjects fell into low, medium and high effort/reward ratio. Similarly the level of commitment to work was calculated using 6 different items, as a score ranging from 6-24. The higher the score, the more likely the subject experienced over-commitment at work. Overall, 41.9% subjects experienced over-commitment at work, whereas 58% subjects experienced low or medium commitment at work.

Physical activity

A measure of physical activity was available only in 166 subjects. Physical activity at work was extremely variable, ranging from sedentary among office workers to heavy physical activity among workers who worked on the assembly/production line. We found no relationship of the prevalence of diabetes and the levels of physical activity in this group (p =0.46) (Table 4).

Blood pressure (BP)

The prevalence of hypertension defined as blood pressure (BP) ≥ 140/90 mmHg or taking antihypertensive medication was 27.4%. The overall prevalence of controlled BP (< 140/90 mmHg for normal subjects and < 130/80 mmHg for subjects with diabetes and prediabetes) was 79.0%. 32.9% of subjects with pre-diabetes, 41.4% of subjects with diabetes and 3.4% of normal subjects had uncontrolled BP.

Plasma lipids

Total cholesterol was elevated (defined as ≥ 200 mg/dl [5.17 mmol/L] or taking cholesterol lowering medication) in 40% of subjects. Similarly, elevated LDL-c, defined as a level of ≥ 100 mg/dl (2.58 mmol/L), was present in 67.9%. Overall, 60% subjects had their total cholesterol controlled. Triglycerides were controlled in 62.6% subjects (defined as < 150 mg/dl [1.69 mmol/L]). HDL-c was at a desirable level (defined as > 40 mg/dl [1.03 mmol/L] for men and > 50 mg/dl [1.29 mmol/L] for women) in 56.3 % of subjects.

Table 4: Job Physical Activity and Diabetes Status.

Job Physical Activity	DIABETES STATUS[1]			
	No DM	Pre-DM	DM	Total[2]
High	26 (46.4%)	25 (44.6%)	5 (8.9%)	56
Medium	28 (43.1%)	24 (36.9%)	13 (20.0%)	65
Low	28 (48.9%)	18 (40.0%)	5 (11.1%)	45
Total	76	67	23	166

[1]Entries are frequency and percent by row total.
[2]Employees who served in unspecified job categories are excluded.

CRP and homocysteine

92.6% subjects had normal CRP (<1.0) and 89.5% subjects had homocysteine levels within the normal range (<13.9 µmol/L).

Worksite wellness program

Out of 190 subjects, 181 answered the question "Have you ever attended the Wellness Screening Program". One hundred and four (57.5%) had never attended the worksite wellness screening program and 77 did. The reasons individuals gave for not using the worksite wellness screening program were: saw their own doctor 51 (49%), did not know it existed 26 (25%), no reason 15 (14.4%), not interested 9 (8.7%), not convenient 2 (1.9%), do not believe results 1 (1%). The prevalence of diabetes and pre diabetes was 7.5% and 43.3%, respectively, among those who attended wellness screening program while the prevalence of diabetes and prediabetes was 6.2% and 48.0%, respectively, among those not attending the program. Blood pressure measurements were available in 148 subjects. Blood pressure was normal in 60 out of 67 (89.5%) among those who attended versus 65 of 81 (80.2%) among those who did not attend the Wellness Screening Program (p=0.12). The prevalence of obesity was similar among those who did or did not attend the Wellness Screening Program, 56 of 67 (83.5%) and 81 of 97 (83.5%) had high body fat (for men >25%, women >33%).

DISCUSSION

The prevalence of diabetes among autoworkers in our study was 15.3%, out of whom 37.9% (11/29) were unaware that they had diabetes. The prevalence of diabetes was 7.9% in those age < 50 and 20.2% in those ≥ 50 years of age. Although we invited the subjects in age range 35-64, we have 5 individuals in the

age range 25-34, and 4 individuals in age range 65-69. All of our subjects were examined in the years 2006-2008; and two-thirds were examined in the year 2006. Comparable data from the US general population from 2006 showed that in the age group 25-69 years, the prevalence of diabetes was 7.5% (95% CI: 6.3% - 8.7%) [1]. The prevalence of diabetes in the US in age group 35-64 was 8.3% (95% CI: 6.6% -9.9%). There was a significant difference in the prevalence of diabetes in our study compared to that of the US general population (15.3% Vs 7.5%, $p < .001$ in the age group 25-69, and 15.3% vs 8.3%, $p < .005$ in the age group 35-64). The prevalence of undiagnosed diabetes (37.9% Vs 24.2%, p=0.14) was not statistically different.

Similarly, we found the prevalence of pre-diabetes to be 42.5% and 48.5% among subjects in age group 35 to 50 years and over 50 years respectively. In 2005-2008 based on fasting glucose or A1c, 35% of US adults aged 20 years or older and 50% of those older than 65 had prediabetes. These differences are not significantly different from our study.

In our study, 35.8% subjects in our study were overweight (BMI ≥ 25, but less than 30 kg/m^2) and 53.7% subjects were obese with a BMI of ≥ 30 kg/m^2. By comparison, 36.7% of US adults in the age group 45-64 years were overweight and 32.8% were obese. Thus, the prevalence of obesity, but not overweight, in this group was significantly higher (53.7% Vs 32.5%, p<0.0001) [12].

The prevalence of hypertension, defined as blood pressure ≥ 140/90 mmHg or taking antihypertensive medication was 27.4% in our study. In 2007-2008, the prevalence of hypertension in the US was 29% (95% CI: 27.6% – 30.5%). This reflects an increase from 23.9% (95% CI: 22.7% – 25.2%) in 1988-1994. The control of blood pressure also increased from 27.3% (95% CI: 25.6% – 29.1%) in 1988-94 to 50.1% (95% CI: 46.8% – 53.5%) in 2007-2008 [5]. Thus, the percentage of people with controlled blood pressure (79%) in this group of auto workers was significantly higher than that of the national average (p-value<0.001).

Total cholesterol, HDL-c, triglycerides and LDL-c were at the desired level in 56%, 59%, 68%, and 26% of subjects with neither diabetes nor pre-diabetes. For subjects with diabetes, these numbers were 66%, 41%, 41%, and 55% respectively (p-values=0.51, 0.17, 0.02 and 0.01, respectively.) The prevalence of total cholesterol ≥ 200 mg/dl (5.17 mmol/L) in our study was 40%, whereas among adults ≥ 20 years of both sexes it was 44% in the US data.(p=0.22) The prevalence of LDL ≥ 100 mg/dl (2.58 mmol/L) in our study was 67.9% compared to a prevalence of 31.9% with LDL ≥ 130 mg (3.36 mmol/L) (p< 0.001) among US adults ≥ 20 years of age [6].

Low HDL-c and increased triglycerides are independent cardiovascular risk factors [7,8]. Data from NHANES survey has shown that the prevalence of low HDL-c was 37.9% in 1988-94 (NHANES III) and 39.9% in 1999-2000. The prevalence of high triglycerides during these two periods was 30.2% and 32.6% respectively [9]. The prevalence of low HDL-c and high triglycerides among autoworkers was 43.7% and 37.4% respectively (p=0.29 and 0.16 respectively).

Multiple risk factors are involved in the pathogenesis of cardiovascular disease [10,11]. These include age, gender, family history, smoking, high blood pressure, diabetes, obesity, physical activity, and stress. There were 16.3 % current smokers and 57.9% former smokers among the auto workers. In the NHANES data, there were 21.1% current smokers and 25.6% were former smokers among the age group 45-64 in 2010 [12]. We also attempted to obtain a measure of "stress" and over-commitment at work by a questionnaire that was given to all participants. There was no relationship of stress and over-commitment to diabetes or pre-diabetes (p=0.11 and 0.67 respectively). Similarly there was no relationship with physical activity to diabetes or pre-diabetes (p-value=0.46) (Table 4). In addition to the conventional risk factors mentioned above, several other risk factors for cardiovascular disease have been proposed including c-reactive protein [13,14] and homocysteine [15]. We, therefore, measured C - reactive protein and homocysteine, but in most of the subjects, the levels of these risk factors were in the normal range.

There are only a few studies that have evaluated the health status of automobile industry employees [16-18]. Rose et al. [16] evaluated work related life events, psychological well-being, and cardiovascular risk factors in male Swedish automotive workers and observed that the blue collar workers showed a profile indicating increased cardiovascular risk with a higher proportion of smokers, a higher waist to hip ratio, and higher triglycerides. The auto workers also self reported having worse general health and less emotional self control but were less anxious than the white collar workers. Schneider et al [17] evaluated the prevalence of cardiovascular risk factors in middle-aged employees with diabetes in Germany and noted that only a negligible proportion of working people with diabetes achieved the recommended target values. Yen et al [18] demonstrated that participation in a multi-component worksite health promotion program resulted in lowering of overall health risk. In the two facilities we studied less than half (42.5%) of the subjects participated in the available worksite wellness program that. The provision of comprehensive health insurance which facilitated the use of personal health care providers (49%) and lack of awareness of the program (25%) were the two major reasons for non participation. There was no evidence that participation in the wellness program resulted in early diagnosis of diabetes or reduced obesity or better control of blood pressure.

The strength of our study is that we have evaluated a representative sample of autoworkers from our area (Michigan). We compared the diabetes related claims among those workers, who did not participate with those who participated and there were no differences noted.

To put our findings in perspective, we compared our data with National US data. Ninety five percent of our subjects were in the age group 35-64. We have been able to compare the prevalence of diabetes in our population with the corresponding age group. However, for some other comparisons corresponding data was not available. Therefore we have used the closest age group for which US data was available namely either adults with ≥ 20 years of age or age group 45-64.This could be considered a limitation of our study. Another limitation of our study may be that although our sample is representative for our region, the findings may not apply to all the US autoworkers and autoworkers in other countries.

In conclusion, the population studied by us is at a higher cardiovascular risk compared to national US general population. Subjects in our study had a higher proportion of individuals with diabetes, current or former smokers, overweight, obese, low HDL-c, increased triglycerides, and high LDL-c levels. Despite the better control of blood pressure in this group of auto workers in comparison to the US general population, the additive effect of these other risk factors may explain the increased cardiovascular morbidity and mortality previously recognized in this population. Increased effort at primary and secondary prevention to address the elevated cardiovascular risk factors identified in this population of auto workers has the potential to reduce the elevated cardiovascular morbidity and mortality found in the this population.

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