METABOLIC SYNDROME AND RELATED DISORDERS
Volume 7, Number 5, 2009

Pp. 459–468
DOI: 10.1089/met.2009.0008

ORIGINAL ARTICLE

Metabolic Syndrome in a Workplace: Prevalence, Co-Morbidities, and Economic Impact

Alyssa B. Schultz, Ph.D., and Dee W. Edington, Ph.D.

Abstract

Background: Although the prevalence of metabolic syndrome has been studied in nationally representative populations, little is known about its prevalence specifically among working adults. Because corporations are often the primary payers of health-care costs in the United States, they have a vested interest in knowing the impact of metabolic syndrome in employed individuals.
Methods: A total of 4188 employees (83.4% male, 92.1% Caucasian, average age 40.8 years) of a midwestern U.S. manufacturing corporation participated in a health risk appraisal and biometric screening in 2006 and also used the company's medical plan. Those with metabolic syndrome were compared to those without metabolic syndrome in terms of their 2006 health risks, health conditions, health-care costs, pharmacy costs, short-term disability costs, and a measure of on-the-job productivity loss known as presenteeism.
Results: A total of 30.2% of employees met the criteria for metabolic syndrome and were more likely to also have a variety of additional health risks and health conditions compared to those without metabolic syndrome. For example, 9.4% of those with metabolic syndrome self-reported having diabetes compared to 1.4% of those without metabolic syndrome. Health-care costs, pharmacy costs, and short-term disability costs were significantly higher for those with metabolic syndrome compared to those without metabolic syndrome, and increasing numbers of metabolic syndrome health risks were associated with greater numbers of employees reporting on-the-job productivity losses (presenteeism).
Conclusions: Because metabolic syndrome is prevalent among the employees of this manufacturing company and is associated with significant economic costs, employers would be wise to address the health risks of employees through health promotion programs and benefit plan designs that help individuals improve their health and receive appropriate health screenings and medical care.

Introduction

Several definitions of metabolic syndrome have been published, making it difficult to compare prevalence rates estimated by different studies. This cluster of metabolic risk factors was first called "syndrome X" in 1988.[1] Ten years later the World Health Organization (WHO)[2] proposed its definition. The National Cholesterol Education Program (NCEP) developed its own definition in 2001 known as Adult Treatment Panel III (ATP III)[3] and in 2005, the International Diabetes Federation (IDF) introduced yet another definition.[4] Finally, the American Heart Association and National Heart, Lung and Blood Institute have recently confirmed the value of the ATP III definition with some minor modifications, including the addition of a medication component. Therefore, the current worldwide standard for metabolic syndrome is three or more of the following criteria: waist circumference (≥102 cm in men, ≥88 cm in women, or body mass index (BMI) >30 kg/m^2), triglycerides ≥150 mg/dL or taking medication for triglycerides, high-density lipoprotein cholesterol (HDL-C) <40 mg/dL for men or <50 mg/dL for women or taking medication for HDL, blood pressure ≥130/85 mmHg or taking medication for blood pressure, and fasting glucose ≥100 mg/dL or taking medication for glucose.[5]

Some research has compared the prevalence of metabolic syndrome with these different criteria. One study compared the prevalence of metabolic syndrome using the WHO[2] and ATP III[3] definitions among 8608 subjects.[6] About 86% of people were classified the same by both definitions.[6]

University of Michigan Health Management Research Center, Ann Arbor, Michigan.

Although the overall estimates were very similar (23.9% and 25.1% prevalence rates), significant differences were noted among certain population subgroups. For example, among African-American men, 16.5% had metabolic syndrome using the ATP III criteria whereas 24.9% met the definition of the WHO. The ATP III definition of metabolic syndrome is more focused on its relationship to cardiovascular disease, which may account for some of the difference with the WHO definition.[2]

A German study compared the WHO, ATP III, and IDF definitions of metabolic syndrome to identify the difference in prevalence rates among individuals who already had type 2 diabetes.[7] The degree of agreement was much stronger between the ATP III and IDF definitions ($\kappa = 0.69$) compared to the WHO versus IDF ($\kappa = 0.12$) and WHO versus ATP III ($\kappa = 0.17$). An epidemiological study in India also compared the WHO, ATP III, and IDF definitions and found the three definitions identified different individuals. While 841 of the 2350 subjects were positively identified as having metabolic syndrome by at least one of the definitions, only 224 were identified by all three definitions.[8] Other studies using the ATP III definition of metabolic syndrome among nationally representative datasets have found prevalence rates in the United States ranging from 22.7%[9] to 23.7%.[10] In both of those studies, prevalence rates varied widely in ethnic subgroups.

Few studies have determined the prevalence of metabolic syndrome risks in working populations. One such study in a worksite found a prevalence rate of 27%,[11] which is in line with population-based studies. Another study of a working population in 2001 identified groups of risks measured by a Health Risk Appraisal (HRA) questionnaire using cluster analysis. One of the four identified clusters was termed the "biometric cluster."[12] It was apparent to those researchers that a cluster of health risks, including blood pressure, cholesterol, and overweight, often traveled together, as did other clusters of risks such as a psychological cluster (life satisfaction, stress, perceived health) and a risk-taking cluster (alcohol use, safety belt use, smoking).

Many studies have found a strong association between metabolic syndrome risks with both heart disease and diabetes.[13–22] But again, none of these studies was conducted specifically in a working population. Considering that employees at this corporation have access to low-cost health care as well as a relatively large income compared to many subjects in nationally representative samples, it is hypothesized that the prevalence of metabolic syndrome will be lower in this population. As corporations are the main payers of health-care costs in the United States, they have a vested interest in identifying the magnitude of metabolic syndrome risks in employed populations and also in knowing if those risks are associated with other health risks or medical conditions or economic outcomes such as health-care costs or productivity. Many companies offer wellness programs to encourage employees to maintain their health and reduce health risks, such as those that comprise metabolic syndrome.

The aim of this study was to identify the prevalence of metabolic syndrome risks in employees of a large manufacturing corporation. Furthermore, the association between metabolic syndrome and other health risks and conditions was also determined in this employed population. The economic costs (health-care costs, pharmaceutical costs, short-term disability absenteeism, and on-the-job productivity loss) associated with metabolic syndrome risks were also investigated.

Materials and Methods

Population and setting

Employees of a large manufacturing corporation headquartered in the midwestern United States were offered an annual HRA and wellness screening beginning in 2004. Likely due to the use of a $600 benefits incentive, the screening achieved extremely high participation rates (from 85% to 95% of employees) since the program began in 2004. The HRA and screening was conducted at the work site by staff of the company's medical department and completed on company time. Each screening took about 15 minutes to complete. Of the 5277 individuals who were employed in 2006, 5243 (99.4%) participated in the HRA. Of the HRA participants, 4188 (79.9%) participated in the company's medical plan. This is the population of interest in this study. The majority of employees were male (83.4%) and Caucasian (92.1%) and an average age of 40.8 years old. About 80% of employees were hourly and 20% were salaried.

Health risks

The HRA was based on Healthier People, Version 4.0 (The Carter Center of Emory University, Atlanta, GA, 1991), and enhanced over time on the basis of the most recent morbidity and mortality studies in cooperation with the University of Michigan's Health Management Research Center (Ann Arbor, MI). Each participant completing the HRA received an individualized report summarizing their health risks and suggestions for health improvement. The health risks and their cut points can be found in Table 1.

The HRA also included data from a biometric screening that used venipuncture for blood glucose and lipid panel variables and measured height and weight. A third-party laboratory was contracted for the venipuncture procedure. The screening results provided the information on metabolic syndrome risk factors. In this study, the risks currently accepted as the best indicators of metabolic syndrome were used.[5] Therefore, in this employed population, the following risks were used: blood pressure ≥130/85 mmHg, fasting glucose ≥100 mg/dL, triglycerides ≥150 mg/dL, and HDL-C <40 mg/dL in men and <50 mg/dL in women. Waist circumference was not measured at this company's screening until 2007, so a BMI >30 kg/m^2 was used as a surrogate. As indicated in the current criteria of metabolic syndrome, if individuals have a BMI greater than 30 kg/m^2, it can safely be assumed that their waist circumference exceeds the risk level.[17] Individuals with at least three of the risks were considered to have metabolic syndrome.

In addition to asking employees about the presence of 16 biological and lifestyle health-risk factors, the HRA included the following question about the presence of several chronic diseases: Do you currently have any of the following? The list included: seasonal allergies, asthma, arthritis, back pain, cancer (any type), chronic bronchitis/emphysema, depression, diabetes mellitus, heartburn, heart disease, high cholesterol, hypertension, irritable bowel syndrome, kidney disease, migraine, osteoporosis, and stroke. Additionally, respondents were asked whether they were either being treated by a physician or currently taking medications for

Table 1. Description of Health Risks Measured by a Health Risk Appraisal Questionnaire and Screening

Risk	*High-risk cut*
Alcohol	>14 Drinks per week
Blood pressure[a]	≥130/85 mmHg
Body mass index[a]	>30.0 kg/m^2
Cholesterol	>239 mg/dL
Disease	Seasonal allergies, asthma, arthritis, back pain, cancer (any type), chronic bronchitis/emphysema, depression, diabetes mellitus, heartburn, heart disease, high cholesterol, hypertension, irritable bowel syndrome, kidney disease, menopause, migraine, osteoporosis, or stroke
Drug use to relax	Almost every day or sometimes
High-density lipoprotein cholesterol[a]	<40 for men, <50 for women
Illness days	>5 Days in the past year
Glucose[a]	≥100 mg/dL
Job satisfaction	Partly or not satisfied
Life satisfaction	Partly or not satisfied
Perceived health	Fair or poor
Physical activity	<1 Time per week
Safety belt use	<100%
Smoking	Current cigarette smoker
Stress	Score >18 (based on a composite score from answers to marital status, personal loss, life satisfaction, perception of health, hours of sleep, and social ties)
Triglycerides[a]	≥150 mg/dL

[a]Metabolic syndrome risk factors.

conditions that they had reported. If an individual reported either currently having a given condition, or being under medical care or taking medication, they were considered to have that particular condition. If employees reported taking medication for diabetes, high blood pressure, or high cholesterol, those criteria were considered in the metabolic syndrome risk determination as well.

Medical and pharmacy claims

Medical and pharmacy claims were also available for the population studied and were provided by a third-party administrator. The medical insurance provider and pharmacy benefit manager for this company provided each claim incurred by each employee in 2006 via encrypted transmission. Medical claims from 2006 were summed to create a total for each individual as were pharmacy claims. These claims data were then merged with employee health-risk and personnel data.

Short-term disability absences

Short-term disability (STD) absences were used as a measure of productivity loss. STD absences in 2006 were summed for each individual, as was their STD cost, which was provided by the company. A total of 232 individuals (5.5% of the study population) incurred a nonpregnancy STD cost during the study time period. Those with nonpregnancy STD costs were significantly more likely to be female (25.9% vs. 16.2%, $P < 0.0001$) compared to those without an STD cost. They were also significantly older (42.9 years vs. 40.4 years, $P < 0.05$). At this company, STD pays a weekly benefit for full-time, hourly employees and is paid at 100%. The maximum duration of STD benefits paid is 26 weeks. If the employee is still disabled after 26 weeks, they are eligible for another 26 weeks on STD, but will not be paid. Long-term disability coverage is not offered to the majority of employees, so the cost of that benefit is not included here. As with medical and pharmacy claims, the STD data were merged with the employee health and personnel information.

Presenteeism

On-the-job productivity was measured by a subset of the Work Limitations Questionnaire (WLQ) included in the HRA to assess the health-related impact on work productivity. Eight questions (two from each WLQ work domain) were selected from the original 25 WLQ questions and the eight-item subset of questions have been used in previous studies.[23–26] These questions evaluated the percentage of time at work that a physical or emotional problem interfered with any of the following work areas: time management (working the required number of hours, starting work on time); physical work (repeating the same hand motions, using work equipment); mental/interpersonal activities (concentration, teamwork); and output demand (completing the require amount of work, working to your capability). More detail on the eight-item WLQ questionnaire can be found in a previous study[27] and the eight items can be found in Table 2. Employees were asked to base their answers on the

Table 2. Description of Eight-Item Work Limitations Questionnaire

In the past 2 weeks, how much of the time did your physical health or emotional problems make it difficult for you to do the following?	
Item	*Subscale*
1. Work the required number of hours	Time management
2. Start on your job as soon as you arrived at work	
3. Repeat the same hand motions over and over again while working	Physical work
4. Use your equipment (eg, phone, pen, keyboard, computer mouse)	
5. Concentrate on your work	Mental/interpersonal
6. Help other people to get work done	
7. Do the required amount of work on your job	Output
8. Feel you have done what you are capable of doing	
Possible answers: None of the time (0%), some of the time, half of the time (50%), most of the time, all of the time (100%), does not apply to my job.	

previous 2 weeks of work and to rate any impairment on a 5-point scale with options of "none of the time (0%)," "some of the time," "half of the time (50%)," "most of the time," and "all of the time (100%)." Additionally, employees were able to select a response of "does not apply to my job," which was treated as a missing answer for that item. The response for each domain was judged to be valid if at least one of the two items was nonmissing. A dichotomous score (yes/no) indicated whether or not any work limitations were noted for any domain (ie, amount of limitation >0%).

Statistical analyses

Differences in continuous and categorical variables in individuals with and without metabolic syndrome were tested using *t*-tests and chi-squared analyses, respectively. Logistic and generalized linear models were used to identify factors associated with the presence of metabolic syndrome while controlling for demographic variables. The Cochran–Armitage test for trend was used to analyze whether or not the percentage of employees reporting any presenteeism was higher as the number of metabolic syndrome risks increased. All analyses were conducted using SAS 9.1 software. (SAS Institute Inc., Cary, NC). This study was approved by the University of Michigan's Institutional Review Board.

Results

First the prevalence of the five metabolic syndrome health risks in this employed population was explored. Table 3 shows the percentage of employees with each of the five metabolic syndrome risk factors as well as by number of metabolic syndrome risks.

In this group of people employed in a manufacturing company, 36.6% had high blood pressure or reported the use of blood pressure medication, 32.0% had a BMI >30, 32.0% had a fasting glucose level greater than or equal to 100 or reported using diabetes medication, 33.1% had low HDL-C or reported taking cholesterol medication, and 42.2% met the criteria for high triglycerides. In all, only 23.1% ($n = 968$) of the population had none of the five risks, while 3.4% ($n = 144$) had all five risks. Almost 70% of the population ($n = 2922$, 69.8%) had less than three of the risk factors while 1266 individuals (30.2%) were considered to have metabolic syndrome because they had three or more of the risks.

The demographics of individuals with and without metabolic syndrome were then analyzed, and the results are shown in Table 4. Those with metabolic syndrome ($n = 1266$) were nearly 4 years older than those without the syndrome (43.1 vs. 39.6 years, $P < 0.0001$). A significantly greater percentage of those with metabolic syndrome were male compared to those without metabolic syndrome (89.6% vs. 80.7%, $P < 0.0001$). Because of these significant differences, and also because other researchers have identified that age and gender are significant confounding variables,[8,9] all further analyses controlled for age and gender. A greater percentage of those with metabolic syndrome had education less than a

Table 3. Prevalence of Metabolic Syndrome Risks in Employed Population in 2006

	Percentage of study population (n = 4188)	
	n	%
Blood pressure ≥130/85 mmHg (or blood pressure meds)	1534	36.6%
Body mass index >30 kg/m^2	1339	32.0%
Fasting glucose ≥100 (or diabetes meds)	1341	32.0%
High-density lipoprotein <40 (male), <50 (female) (or cholesterol meds)	1385	33.1%
Triglycerides ≥150	1769	42.2%
None of the risks	968	23.1%
Any one of the risks	1042	24.9%
Any two of the risks	912	21.8%
Any three of the risks	706	16.9%
Any four of the risks	416	9.9%
All five of the risks	144	3.4%
<3 of the risks	2922	69.8%
3+ of the risks (metabolic syndrome)	1266	30.2%

Table 4. Demographics of Employees With and Without Metabolic Syndrome

	Without metabolic syndrome (n = 2922)	*With metabolic syndrome (n = 1266)*	*P value*[a]
Average age	39.6 years	43.1 years	<0.0001
% Male	80.7%	89.6%	<0.0001
Education level			
Some college or less	73.3%	79.2%	0.0462
College graduate or more	26.7%	20.8%	
Household income			
<$75,000	74.0%	73.8%	0.2458
≥$75,000	26.0%	26.2%	
Hourly employee status	78.2%	84.0%	0.1264
Married	70.2%	75.8%	0.8748
Caucasian	92.1%	92.0%	0.4257
Health risks			
Alcohol drinks >14 per week	5.6%	4.3%	0.0353
Cholesterol >240 mg/dL	12.5%	17.2%	0.0011
>5 Illness days in past year	4.4%	7.0%	<0.0001
Job dissatisfaction	11.6%	12.9%	0.4183
Life dissatisfaction	14.8%	16.4%	0.2012
Use relaxation medication	11.6%	17.7%	<0.0001
Poor or fair physical health	8.7%	18.1%	<0.0001
Physical inactivity	12.6%	16.4%	0.0007
Safety belt use	31.2%	32.9%	0.0377
Smoking	19.8%	18.5%	0.9000
High stress	21.2%	26.6%	<0.0001
Metabolic syndrome risks			
Blood pressure ≥130/85 (or meds)	21.4%	71.9%	<0.0001
Body mass index >30	14.9%	71.4%	<0.0001
Fasting glucose ≥100 (or meds)	17.2%	66.3%	<0.0001
High-density lipoprotein <40 (male), <50 (female) (or meds)	19.8%	63.7%	<0.0001
Triglycerides ≥150	24.9%	82.3%	<0.0001
Wellness score	84.1	73.8	<0.0001

[a]*t*-test for age, chi-squared for gender, generalized linear model testing difference in demographics and health risks controlling for age and gender.

college degree (79.2% vs. 73.3%, $P = 0.0462$ after controlling for age and gender). Hourly employee status, marital status, and ethnicity were not significantly different after controlling for age and gender.

The additional health risks measured by the HRA were also compared for those with and without metabolic syndrome. Those with metabolic syndrome were significantly more likely also to be at risk for high total cholesterol, illness days, the use of relaxation medication, perceived physical health, physical inactivity, safety belt use, and high stress after controlling for age and gender. When the overall wellness score calculated for each HRA participant was compared, employees with metabolic syndrome had a significantly lower wellness score compared to those without metabolic syndrome (73.8 compared to 84.1, $P < 0.0001$). The wellness score is on a scale of 0 to 100 and includes components of behavioral health risks, mortality risks, and preventive services usage. Behavioral health risks are weighted the most among the three components in the wellness score and preventive services weighted the least. The behavioral health risks are selected from 10 variables that demonstrate strong associations with future medical claims costs as determined by multiple research studies. These variables include smoking status, physical activity, alcohol consumption, safety belt usage, blood pressure, total cholesterol, HDL-C, body weight, illness days, and self-assessment of health. The mortality risks are calculated as a function of the rates between achievable and appraised probabilities of the deaths from all causes in the next 10 years according to a HRA participant's age, gender, and health risks. The preventive services selected are based on the findings and recommendations of the U.S. Preventive Services Task Force Guidelines[28] according to participants' age and gender.

Additional self-reported medical conditions were then compared for those with and without metabolic syndrome and results are found in Table 5. Those with metabolic syndrome were significantly more likely to report having arthritis, chronic bronchitis/emphysema, chronic pain, depression, diabetes, heart problems, heartburn/acid reflux, and stroke compared to employees without metabolic syndrome, after

Table 5. Health Conditions of Employees With and Without Metabolic Syndrome

	Without metabolic syndrome (n = 2922)	*With metabolic syndrome (n = 1266)*	*Adjusted OR*[a] *(95% CI)*
Allergies	18.0%	19.0%	1.14 (0.96–1.34)
Arthritis	7.4%	14.3%	1.68 (1.35–2.09)
Asthma	2.5%	3.2%	1.41 (0.94–2.11)
Back pain	11.9%	13.0%	1.12 (0.92–1.38)
Cancer	0.6%	0.6%	0.90 (0.38–2.14)
Chronic bronchitis/ emphysema	0.2%	0.9%	3.44 (1.29–9.15)
Chronic pain	3.7%	6.2%	1.55 (1.14–2.10)
Depression	3.9%	6.2%	1.75 (1.29–2.38)
Diabetes	1.4%	9.4%	5.64 (3.92–8.13)
Heart problems	2.2%	5.5%	1.89 (1.31–2.67)
Heartburn or acid reflux	9.1%	14.9%	1.66 (1.35–2.03)
Migraine headaches	3.5%	2.9%	1.06 (0.71–1.57)
Stroke	0.1%	0.5%	6.85 (1.32–35.53)
Other condition	3.9%	4.1%	0.99 (0.70–1.40)
Average number of conditions[b]	0.68	1.01	$P < 0.0001$

[a]Multivariate logistic regression model adjusting for age and gender.
[b]Multivariate linear regression model adjusting for age and gender.

controlling for age and gender. After counting up all health conditions, the average number of conditions reported by participants was significantly greater ($P < 0.0001$) for those with metabolic syndrome (1.01 conditions per person) compared to those without metabolic syndrome (0.68 conditions per person).

Workplace outcomes were then considered. The health-care and pharmaceutical costs of those with and without each of the metabolic syndrome risks were compared, as were the costs of STD absences and the percent of employees reporting any presenteeism. Table 6 contains those results.

When examining the health-care costs, those at risk for triglycerides and blood pressure had significantly higher health-care costs compared to those not at risk for those factors after controlling for age and gender. For four of the risk factors (HDL was the exception), those with the risk had significantly higher pharmacy costs compared to those not at risk for each factor. STD costs were significantly higher among those with four of the five risks (again, HDL was the exception). The annual STD cost is relatively low compared to health-care and pharmacy costs because only a small percentage of employees incur an STD claim in any 1 year, and the cost of that claim is spread over all employees in each category. The percentage of employees reporting any presenteeism was significantly higher for those at risk for triglycerides compared to those not at risk for triglycerides.

Table 7 shows those cost outcomes by number of metabolic syndrome risks and also compares those with and without metabolic syndrome. Those who met the criteria for metabolic syndrome (3+ risk factors) had significantly higher health-care ($3340 vs. $1788), pharmacy ($570 vs. $270), and STD ($106 vs. $59) costs compared to those who

Table 6. Workplace Outcomes Associated With Metabolic Syndrome Risk Factors

	Not at risk	*At risk*
Annual health care costs		
Blood pressure ≥130/85 or meds	$1637	$3330[a]
BMI >30	$2114	$2561
Fasting glucose ≥100 or meds	$1837	$3148
HDL <40 (male), <50 (female)	$2289	$2192
Triglycerides ≥150	$1755	$2944[a]
Annual pharmacy costs		
Blood pressure ≥130/85 or meds	$258	$538[a]
BMI >30	$316	$455[a]
Fasting glucose ≥100 or meds	$258	$578[a]
HDL <40 (male), <50 (female)	$362	$358
Triglycerides ≥150	$253	$507[a]
Annual STD costs		
Blood pressure ≥130/85 or meds	$59	$97[a]
BMI >30	$60	$101[a]
Fasting glucose ≥100 or meds	$57	$108[a]
HDL <40 (male), <50 (female)	$74	$71
Triglycerides ≥150	$60	$91[a]
% Reporting any presenteeism		
Blood pressure ≥130/85 or meds	33.7%	35.5%
BMI >30	33.6%	36.1%
Fasting glucose ≥100 or meds	33.5%	36.2%
HDL <40 (male), <50 (female)	34.6%	33.9%
Triglycerides ≥150	33.1%	36.1%[a]

[a]Generalized linear model *P* value comparing those with and without the risk, <0.05 controlling for age and gender.

Abbreviations: HDL, high-density lipoprotein; BMI, body mass index; STD, short-term disability.

Table 7. Workplace Outcomes Associated With Number of Metabolic Syndrome Risks

	n	*Annual health care costs*	*Annual pharmacy costs*	*Annual STD cost*	*% Reporting any presenteeism*
None of the risks	968	$1544	$202	$56	31.8%
Any one risk	1042	$1530	$245	$55	34.9%
Any two risks	912	$2341	$369[a]	$66	33.2%
Any three risks	706	$3169[a]	$480[a]	$70	35.7%
Any four risks	416	$3683[a]	$618[a]	$148[a]	39.2%[a]
All five risks	144	$3190[a]	$875[a]	$160[a]	37.0%[a]
No metabolic syndrome (<3 risk factors)	2922	$1788	$270	$59	33.4%
Metabolic syndrome (3+ risk factors)	1266	$3340[b]	$570[b]	$106[b]	36.9%[b]

[a]Generalized linear model P value <0.05 compared to those with zero risks, controlling for age and gender.

[b]Generalized linear model P value <0.05 compared to those without metabolic syndrome, controlling for age and gender.

Abbreviation: STD, short-term disability.

did not meet the criteria for metabolic syndrome. Also, 36.9% of employees with metabolic syndrome reported any presenteeism compared to 33.4% of those without metabolic syndrome ($P < 0.05$ after controlling for age and gender). When all monetary costs were added together to create a total cost for each individual (not shown in Table 7), those at risk for metabolic syndrome had costs of $4016 compared to $2117 for those not at risk for metabolic syndrome, a difference of $1899 ($P < 0.0001$ adjusting for age and gender).

Figure 1 shows the costs of individuals with zero, one, two, three, four, and five of the metabolic syndrome risk factors. As can be seen in the figure, health-care, pharmacy, and total costs are significantly greater for those with three, four, or five risks compared to those with none of the risks. STD costs are significantly higher for those with four or five risks compared to those with none of the risks.

Figure 2 presents the percentage of employees reporting any presenteeism by the number of metabolic syndrome risk factors. The Cochran–Armitage test for trend is significant ($P < 0.05$) for increasing numbers of employees reporting presenteeism as the number of risk factors increases. Because researchers are not yet confident of the appropriate way to convert presenteeism losses to dollars, [29–31] that conversion was not made here either.

Discussion

In this manufacturing company population, the prevalence of metabolic syndrome was 30.2%, which is higher than rates reported in nationally representative samples[6] as well as work site studies in financial,[32] aerospace/defense,[10] and chemical[33] sectors, which report metabolic syndrome prevalence of 22.6% to 27%. Differences seen here may be related to geography. This company is headquartered in the midwestern United States, which is known to have higher rates of obesity and diabetes than some other regions of the country.[34] Also, most previous studies of metabolic syndrome used either the WHO or ATP III criteria. The latest definition of metabolic syndrome,

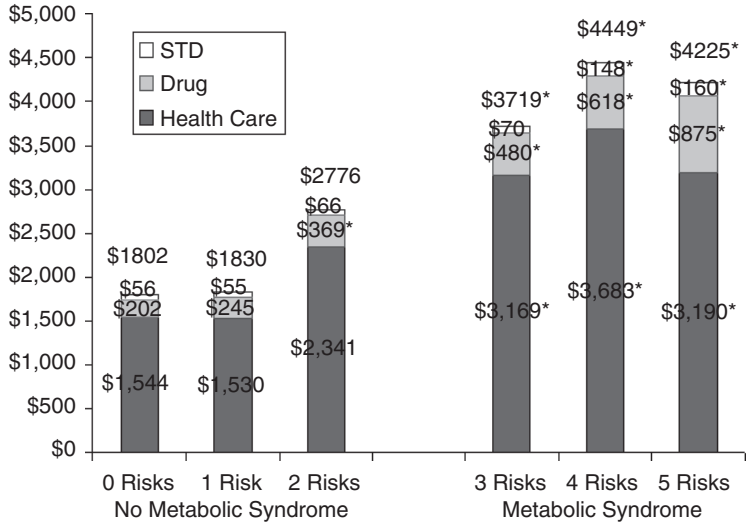

FIG. 1. Annual costs by number of metabolic syndrome factors. *Significantly different from 0 risk category, $P < 0.01$. Generalized Linear Model adjusting for age and gender. Abbreviation: STD, short-term disability.

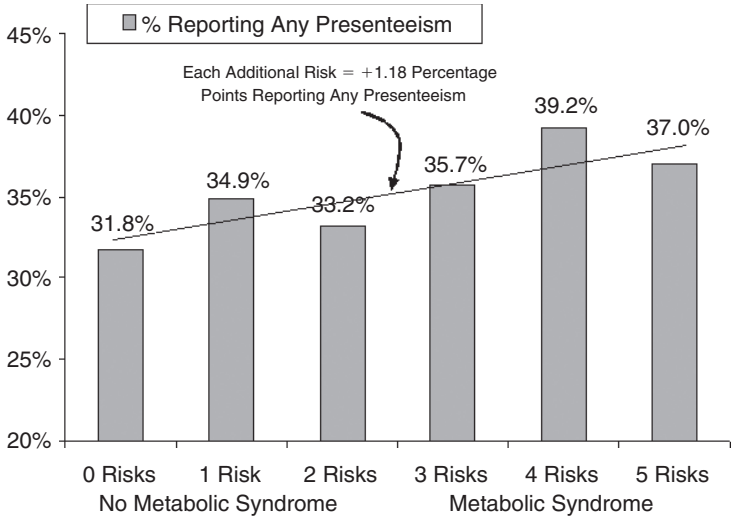

FIG. 2. Percent reporting any presenteeism by number of metabolic syndrome risks. Cochran–Armitage test for trend, $P < 0.05$.

which is used here, identifies more individuals with metabolic syndrome because of the additional medication component. That is, those with normal glucose, blood pressure, or HDL but who are taking medication for those conditions to keep their values normal will now be counted as high risk for metabolic syndrome. It is surprising that in this population, which enjoys a relatively high income and excellent access to low-cost health care, the prevalence of metabolic syndrome is not substantially lower than that found in nationally representative studies, which include lower-income adults as well as those without health insurance. It appears that the healthy worker effect[35] (HWE) has no impact on the prevalence of metabolic syndrome risks in this population.

A prevalence comparison study in Germany found that while the ATP III criteria identified about 20% of the population as having metabolic syndrome, the definition proposed by Grundy et al.[5] and used in the current study identified around 29% of the population as having metabolic syndrome.[36] Furthermore, one study of a National Health and Nutrition Examination Survey (NHANES) stratified sample found a metabolic syndrome prevalence of 34.5% using the ATP III criteria and 39.0% using the IDF criteria, which requires the presence of central obesity.[37]

Employees in this study population with metabolic syndrome are significantly more likely to be male and older compared to those without metabolic syndrome. Furthermore, those with metabolic syndrome were more likely to also be at risk for the health risks of high total cholesterol, illness absence days, the use of relaxation medication, perceived physical health, physical inactivity, and high stress. Clearly, individuals with metabolic syndrome also have other health risks they are dealing with. Indeed, the wellness score, which is an overall measure of health risks, is significantly lower for individuals with metabolic syndrome (73.8) compared to those without metabolic syndrome (84.1, $P < 0.0001$). Organizations that identify individuals with metabolic syndrome would be wise to offer a wide variety of health promotion activities to help improve the diverse health risks of those employees.

Individuals with metabolic syndrome not only have additional health risks, they also have additional health conditions. Out of 14 possible health conditions measured on the HRA, those with metabolic syndrome were significantly more likely to report having arthritis, chronic bronchitis/emphysema, chronic pain, depression, diabetes, heart problems, heartburn, and stroke. While the literature provides many examples of the link between heart disease and diabetes with metabolic syndrome,[12–21] a few studies have also shown a relationship between chronic pain and metabolic syndrome. Loevinger, et al. found that women with the chronic pain condition fibromyalgia were 5.6 times more likely to have metabolic syndrome than healthy controls.[38] Another study indicated that individuals with carpal tunnel syndrome were three times more likely to also have metabolic syndrome.[39] The relationship between metabolic syndrome and carpal tunnel syndrome is not surprising given that increased BMI is a key risk factor in both conditions.[40,41]

Although the HRA does not specify type of arthritis (rheumatoid or osteoarthritis), some researchers have found that metabolic syndrome and rheumatoid arthritis share some of the same characteristics such as insulin resistance and dyslipidemia.[42,43] The relationship between mental health and metabolic syndrome is not well understood and requires more research.[44,45]

The results shown in Fig. 1 indicate that workplace cost outcomes are significantly higher for those with metabolic syndrome compared to those without metabolic syndrome. Figure 2 also shows that increasing numbers of metabolic syndrome health risks are associated with greater numbers of employees reporting on-the-job productivity losses (presenteeism).

However, as was shown in Table 5, those with metabolic syndrome are also more likely to have other health conditions compared to those without metabolic syndrome. This is undoubtedly a factor in the higher costs associated with metabolic syndrome. However, since more than half (54.4%) of employed individuals with metabolic syndrome do not yet have a medical condition, they also require interventions to help improve their health risks so they do not reach the level of disease.

Limitations

This study was conducted in an employee population of a single large manufacturing corporation headquartered in the midwestern United States, which may limit the

generalizability of the results. Similar studies should be conducted in a variety of industries to see if the findings are replicated in different demographic and geographic groups. As in most worksite studies, HRA participation is voluntary so the population studied may not always be representative of the entire employee population. However, in this study, a nearly universal participation rate (99%) eliminates that problem. The cross-sectional nature of this study also does not allow for any inference of cause–effect about the associations found.

Another potential limitation of this study is the lack of data available on waist circumference. Although the currently used definitions of metabolic syndrome all rely on waist circumference, this measurement has been found to be subject to large amounts of error, particularly in men. One study of metabolic syndrome used both BMI and waist circumference and found the two measures to be highly correlated.[46] Another study compared waist circumference, BMI, and waist-to-hip ratio in their ability to predict abdominal adipose tissue (which is the true aim of the metabolic syndrome obesity risk factor) in men as determined by magnetic resonance imaging.[47] Results showed that waist circumference most uniformly predicts the distribution of adipose tissue in the abdominal region but that the relative strengths of waist circumference and BMI in predicting abdominal adiposity did not differ significantly. The company studied here has added waist circumference to its biometric screening in 2007, so a future study will compare those results with BMI.

Conclusions

Metabolic syndrome is prevalent in working populations in the manufacturing industry. In the case of this predominantly male population of manufacturing employees, 30.2% met the criteria for metabolic syndrome. These employees with metabolic syndrome are significantly more likely to have a variety of other health risks and health conditions compared to those without metabolic syndrome. They also have significantly higher health-care, pharmacy, and STD absence costs and are more likely to report presenteeism. Employers would be wise to address the health risks of employees through health promotion programs and benefit plan designs that help individuals improve their health and receive appropriate health screenings and medical care.

Acknowledgments

The authors wish to thank Kathy Babiak, Ph.D., Alfred Franzblau, M.D., and David Moore, Ph.D., for their valuable contributions to the design and execution of this study and manuscript.

Author Disclosure Statement

No competing financial interests exist for either author.

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Address correspondence to:
Alyssa B. Schultz, Ph.D.
University of Michigan Health Management Research Center
1015 E. Huron St.
Ann Arbor, MI 48104-1688

E-mail: abelaire@umich.edu