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Analysis of the Association between Metabolic Syndrome and Disease in a Workplace Population over Time

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ABSTRACT

Objectives: While research has confirmed an association between metabolic syndrome (MetS) and diseases such as heart disease and diabetes, none of these studies have been conducted in a worksite population. Because corporations are often the primary payer of health-care costs in the United States, they have a vested interest in identifying the magnitude of MetS risk factors in employed populations, and also in knowing if those risk factors are associated with other health risks or medical conditions.

Methods: This study identified the prevalence of MetS risk factors and self-reported disease in employees (N = 3285) of a manufacturing corporation who participated in a health risk appraisal and biometric screening in both 2004 and 2006. Health-care costs, pharmacy costs, and short-term disability costs were compared for those with and without MetS and disease.

Results: The prevalence of MetS increased from 2004 to 2006 in this employed population. Those with MetS were significantly more likely to self-report arthritis, chronic pain, diabetes, heartburn, heart disease, and stroke. Employees with MetS in 2004 were also significantly more likely to report new cases of arthritis, chronic pain, diabetes, and heart disease in 2006. The costs of those with MetS and disease were 3.66 times greater than those without MetS and without disease.

Conclusions: MetS is associated with disease and increased costs in this working population. There is an opportunity for health promotion to prevent MetS risk factors from progressing to disease status which may improve vitality for employees, as well as limit the economic impact to the corporation.

Keywords: diabetes, disease, health-care cost, heart disease, metabolic syndrome, workplace.

Background

Individuals with metabolic syndrome (MetS) are at increased risk of morbidity and mortality from a variety of health conditions, thus making MetS an important trait to recognize and treat. The definition of MetS changed over the past decade as researchers identified the most critical risk factors. The first widely used definitions were developed by the World Health Organization [1] and the National Institutes of Health [2]. Currently, the best regarded definition of MetS is that of the American Heart Association and National Heart, Lung and Blood Institute [3], which has a high utility in determining those at risk. Their definition confirmed the value of the Adult Treatment Panel III criteria [2] with some minor modifications, making the current standard for MetS risk criteria based on the following: waist circumference (≥102 cm in men, ≥88 cm in women, or body mass index [BMI] > 30 kg/m^2), triglycerides ≥150 mg/dl, high-density lipoprotein [HDL] cholesterol (<40 mg/dl for men or <50 mg/dl for women, or taking cholesterol medication), blood pressure (≥130/85 mmHg or blood pressure medication), and fasting glucose (≥100 mg/dl or glucose medication).

Because MetS is characterized by many of the accepted risk factors of cardiovascular disease (CVD), the former is thought to be a strong predictor of the latter. In fact, many researchers have found that the risks of developing CVD (and subsequent death) are higher among those with MetS compared to those without the syndrome [4–13]. But, because of the obvious overlap between MetS and CVD risk factors, some argue that MetS does not provide any additional information about cardiovascular risk factors [14]. Others contend that the combined effect of these risk factors is greater than the sum of its parts, and that knowledge of MetS is helpful and informative in predicting CVD [14].

Individuals with MetS are also at a higher risk of developing diabetes (five times higher in one study [14]) compared to those without MetS [15–17]. Again, this is not unexpected because of the MetS risk factor of elevated fasting glucose levels, a characteristic of diabetes. Other medical conditions found to be associated with MetS include the chronic pain condition fibromyalgia [18], carpal tunnel syndrome [19–21], asthma [22], and polycystic ovary syndrome [23,24].

None of these previously mentioned studies, however, were conducted in a worksite population. Corporations are the main payers of health-care costs in the United States; thus, they have a more vested interest than corporations in other countries in identifying the magnitude of MetS risk factors in employed populations and in knowing if these risks are associated with other health risks or medical conditions. Many companies offer wellness programs to encourage their employees to maintain a healthy lifestyle, thereby reducing health risks such as those that define MetS.

This study identified the prevalence of MetS risk factors in employees of a large manufacturing corporation who participated in a health risk appraisal (HRA) screening in 2004 and again in 2006. The presence of disease was assessed through self-report at time 1 in 2004 and at time 2 in 2006 to see if MetS risk factors were associated with increased rates of disease in an employed population. Furthermore, health-care costs, pharmacy costs, and short-term disability (STD) costs were measured among those who met the criteria for MetS, but did not yet have an associated disease to see if the risk factors alone are associated with higher costs.

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Methods

Population and Setting

Employees of a large manufacturing corporation headquartered in the Midwest were offered an annual HRA and wellness screening in 2004. The screening achieved extremely high participation rates (from 85 to 95% of employees) in 2004 to 2006. Of the 3635 individuals who were employed from 2004 to 2006 and participated in the company's medical plan, 3285 (90.4%) participated in the HRA in 2004 and again in 2006. The majority of employees during this time period were men (83.0%) and Caucasians (89.8%); the average age of the subjects was 40.8 years.

Health Risks

The HRA was an enhanced version of Healthier People, version 4.0 (The Carter Center of Emory University, Atlanta, GA, USA, 1991) including the most recent morbidity and mortality studies in cooperation with the University of Michigan's Health Management Research Center (Ann Arbor, MI, USA). Each participant who completed the HRA received a personalized report summarizing his or her health risks, and suggestions for health improvement directly from the University of Michigan Health Management Research Center.

The HRA included data from a biometric screening that utilized venipuncture for blood glucose and lipid panel variables, and measured height and weight. A third party laboratory was contracted for the venipuncture procedure. Blood pressure, fasting glucose, triglycerides, and HDL cholesterol were measured. Waist circumference was not measured, but BMI was used as a surrogate. As indicated in the current criteria for MetS, if an individual has a BMI greater than 30 kg/m^2, we can safely assume that his or her waist circumference exceeds the risk level [25]. If an individual had any three or more of these risk factors, he or she was classified as having MetS.

In addition to asking employees about the presence of 16 biological and lifestyle health risk factors (Table 1), we also asked the subjects if a doctor had ever told them that they had any of the following chronic conditions: 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, and stroke. Additionally, respondents were asked whether they were being treated by a physician and/or currently taking medications for any reported conditions. The University of Michigan's Institutional Review Board approved this study.

Medical and Pharmacy Claims

Medical and pharmacy claims were available for the study population and 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 2004 and 2006 via encrypted transmission. Claims from 2004 and 2006 were summed for each individual each year, and costs were adjusted for inflation to 2006 dollars using the medical consumer price index [26]. These claims data were then merged with employee health risk and personnel data.

STD Costs

STD absences were used as a measure of productivity loss. Absences in 2004 and 2006 were summed for each individual, as were the STD costs, as provided by the company. At this company, STD is designed to pay a weekly benefit when an employee has a nonoccupational illness or injury. This benefit covers full-time, hourly employees, and is paid at 100%. To qualify, the employee must be considered disabled and under the care of a physician. The benefit begins on the eighth consecutive day for an illness or injury that has not been treated within 72 hours. For accidental injuries that have been treated within 72 hours, the disability benefit would begin the first day of the disability. The maximum duration of STD benefits paid is 26 weeks. If the employee is still disabled after 26 weeks, he or she is eligible for another 26 weeks of unpaid STD. Long-term disability coverage is not offered to the majority of employees so that cost is not included in our study. As with medical and pharmacy claims, the STD data were merged with the employee health and personnel information.

Table 1 Description of health risks measured by HRA and screening

Risk	High-risk cutoff point
Alcohol	>14 drinks per week
Blood pressure*	≥130/85 mmHg (or taking BP medication)
Body mass index*	>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
Use of medication or drugs to relax	Almost every day or sometimes
HDL cholesterol*	<40 for men, <50 for women (or taking cholesterol medication)
Illness days	>5 days in the past year
Glucose*	≥100 mg/dl (or taking diabetes medication)
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 percent
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*	≥150 mg/dl

*MetS risk factors.
HRA, health risk appraisal.

Statistical Analyses

The change in prevalence of MetS risk factors from 2004 to 2006 was analyzed using the McNemar chi-square test that was used to analyze change in a dichotomous measure for paired observations of the same subjects. The 980 employees with MetS in 2004 were compared to the 2305 employees without MetS to determine differences in the demographics of the two groups using *t*-tests for continuous variables, and chi-square association for categorical variables. We used multiple linear regression methods to test the difference in demographics between those with and those without MetS while controlling for the confounders age and gender. Prior research has shown that age and gender are significant confounders in the study of MetS [27,28].

We also sought to determine whether or not MetS risk factors and MetS itself were associated with new cases of disease. For each MetS risk factor, a multiple logistic regression model was used to determine if the presence of that risk factor in 2004 was associated with the incidence of disease in 2006 (arthritis, chronic pain, diabetes, heartburn, or heart disease) after controlling for age and gender. Because of its extremely low prevalence in this population (only three new cases in 2006), the incidence of stroke was not modeled.

Table 2 Metabolic syndrome risk factors in 2004 and 2006 (N = 3285)

MetS risk factors	2004 (%)	2006 (%)	McNemar's statistic	*P*-value
Glucose	31.3	34.4	13.95	0.0002
HDL	32.2	32.6	0.36	0.55
Hypertension	36.7	38.8	6.38	0.01
Obesity	32.1	32.4	0.33	0.57
Triglycerides	43.0	44.3	2.84	0.01
0 MetS risk factors	23.5	21.3		
Any 1 MetS risk factor	24.1	24.8		
Any 2 MetS risk factors	22.6	21.9		
Any 3 MetS risk factors	16.7	17.7		
Any 4 MetS risk factors	9.7	10.8		
All 5 MetS risk factors	3.4	3.6		
MetS (3+ risk factors)	29.8	32.1	8.58	0.003
% reporting heart disease	2.4	2.6	0.53	0.47
% reporting diabetes	3.0	3.7	10.29	0.001

HDL, high-density lipoprotein cholesterol; MetS, metabolic syndrome.

Because we have evidence that MetS predicts certain diseases in an employed population, it was of interest to determine the costs of individuals with MetS and/or disease. In an employed population with health-care benefits, medical and pharmaceutical costs are relevant as are measures of productivity such as STD. The population was divided into four groups as follows: 1) those who did not have MetS in 2006 and did not have any of the five associated diseases (arthritis, chronic pain, diabetes, heartburn, or heart disease); 2) those who had MetS but did not have any of the five diseases; 3) those who did not have MetS but did have one of the five diseases; and 4) those who had both MetS and at least one of the five diseases. We used generalized linear models to determine significant differences in the costs of those four groups. The final analysis examined costs of those four groups again, but limited the diseases to just diabetes and heart disease, which are considered to be the most costly diseases associated with MetS [29]. Unless otherwise noted, the alpha level for this study was 0.05. All analyses were conducted using SAS 9.1 software (SAS Institute Inc., Cary, NC).

Results

Prevalence of MetS

The prevalence of MetS risk factors in 2004 and 2006 is shown in Table 2. The MetS risk factors of glucose, triglycerides, and hypertension increased in prevalence (*P*-value <0.01) from 2004 to 2006, as did the percent of employees with MetS (increasing from 29.8% in 2004 to 32.1% in 2006, *P*-value = 0.003), and those who self-reported diabetes (*P*-value <0.001).

Demographic Differences

Table 3 displays the demographics of those with and without MetS. Those with MetS were significantly older than the other employees (average age 44.5 vs. 41.3 in 2004, *P*-value <0.001) and a greater percentage was male (89.4% vs. 79.8%, *P*-value <0.001). Because of these differences, and because age and gender are known to be significant confounders in the analysis of MetS [27,28], all subsequent analyses controlled for these variables. There was no difference in the number of employees with MetS that completed college, had a higher income, were salaried, unmarried, or Caucasian compared to their counterparts in the other collected demographics after controlling for age and gender.

Table 3 Demographics of employees with and without MetS in 2004 who also participated in the HRA in 2006

	Without MetS (N = 2,305)	With MetS (N = 980)	*P*-value*
Average age	41.3 years	44.5 years	<0.0001
% male	79.8%	89.4%	<0.0001
Education level			
Some college or less	76.0%	79.9%	0.1765
College graduate or more	24.0%	20.1%	
Household income			
<$75,000	77.1%	80.7%	0.2425
≥$75,000	22.9%	19.3%	
Hourly employee status	77.2%	83.5%	0.1477
Married	75.9%	78.6%	0.5905
Caucasian	93.6%	92.1%	0.1204

*t-Test for age, chi-square for gender, generalized linear model testing difference in demographics controlling for age and gender.
MetS, metabolic syndrome; HRA, health risk appraisal.

Medical Conditions

Those with and those without MetS in 2004 were compared to assess differences in the presence of medical conditions in 2004, after controlling for age and gender (Table 4).

In this employed population, six of the thirteen health conditions were significantly more prevalent in the MetS population compared to other employees: arthritis (odds ratio [OR] 1.48, 95% CI 1.16, 1.90), chronic pain (OR 1.52, 95% CI 1.05, 2.21), diabetes (OR 5.50, 95% CI 3.46, 8.74), heartburn (OR 1.58, 95% CI 1.25, 1.99), heart disease (OR 2.26, 95% CI 1.42, 3.59), and stroke (OR 2.25, 95% CI 1.04, 4.62).

MetS Risk Factors and Prediction of Disease

In Table 5, we present the odds ratios and 95% confidence intervals for several multiple logistic regression models.

We found that people who met the risk criteria for obesity and triglycerides in 2004 were significantly more likely to self-report new cases of arthritis in 2006 (*P*-value <0.05). These same risk factors were significantly associated with the incidence of chronic pain in 2006 as well (*P*-value <0.05). All five of the risk factors were associated with the incidence of diabetes, while none were significantly associated with new cases of heartburn. Finally, hypertension and HDL were associated with the incidence of heart disease 2 years later (*P*-value <0.05). MetS was

Table 4 Prevalence of health conditions in 2004 among those with and without MetS in 2004

Health condition	Without MetS (N = 2305) (%)	With MetS (N = 980) (%)	Adjusted OR* (95% CI)
Allergies	20.5	19.5	0.96 (0.76–1.22)
Arthritis	**8.4**	**14.8**	**1.48 (1.16–1.90)**
Asthma	3.0	3.3	1.11 (0.71–1.75)
Back pain	13.7	13.3	0.98 (0.78–1.24)
Bronchitis/emphysema	0.7	0.5	0.99 (0.87–1.12)
Cancer	2.2	2.7	1.36 (0.89–1.99)
Chronic pain	**3.3**	**5.3**	**1.52 (1.05–2.21)**
Depression	3.3	4.1	1.33 (0.87–1.97)
Diabetes	**1.1**	**7.4**	**5.50 (3.46–8.74)**
Heartburn	**9.8**	**15.3**	**1.58 (1.25–1.99)**
Heart disease	**1.6**	**4.3**	**2.26 (1.42–3.59)**
Migraine	2.9	2.8	1.18 (0.72–1.92)
Stroke	**0.2**	**0.5**	**2.25 (1.04–4.62)**

*Multivariate logistic regression for each disease adjusted for age and gender.
Health conditions in bold font are statistically significant (*P* < 0.05).
MetS, metabolic syndrome.

Table 5 Odds of incident disease* in 2006 for those with each MetS risk factor in 2004

Risk factor in 2004	Arthritis in 2006 OR (95% CI)	Chronic pain in 2006 OR (95% CI)	Diabetes in 2006 OR (95% CI)	Heartburn in 2006 OR (95% CI)	Heart disease in 2006 OR (95% CI)
Obesity	2.100 (1.442–3.060)	1.695 (1.091–2.633)	3.831 (1.970–7.450)	1.105 (0.751–1.625)	1.475 (0.747–2.912)
Hypertension	1.463 (0.977–2.146)	1.004 (0.635–1.588)	3.829 (1.869–7.841)	1.021 (0.695–1.500)	2.071 (1.033–4.150)
Glucose	1.261 (0.849–1.874)	0.707 (0.996–1.044)	15.257 (5.834–39.902)	1.169 (0.789–1.734)	1.372 (0.685–2.747)
HDL	1.346 (0.917–1.977)	1.467 (0.943–2.280)	3.048 (1.605–5.788)	1.193 (0.818–1.738)	2.687 (1.371–5.265)
Triglycerides	1.737 (1.183–2.551)	2.621 (1.650–4.164)	3.749 (1.791–7.848)	1.294 (0.894–1.873)	1.559 (0.785–3.097)
MetS	1.999 (1.359–2.940)	1.607 (1.021–2.530)	13.191 (5.428–32.059)	1.172 (0.789–1.741)	2.355 (1.187–4.673)

*Logistic regression adjusted for age and gender.
HDL, high density lipoprotein cholesterol; MetS, metabolic syndrome.

significantly associated with the prediction of four out of five of the conditions (arthritis, chronic pain, diabetes, and heart disease) with odds ratios ranging from 1.607 for chronic pain to 13.191 for diabetes, after controlling for age and gender.

Figure 1 shows the costs (health care, pharmacy, and STD) for each of four groups in 2006: those without MetS or any of the five associated diseases; those with MetS but no disease; those without MetS but with a disease; and those with both MetS and a disease.

The average cost increases from a baseline of $1600 for employees without MetS and without any of the five diseases included here (arthritis, chronic pain, diabetes, heartburn, or heart disease). The next group of employees, those with MetS but none of the diseases, had an average cost of $2037. Those without MetS but at least one of the five diseases had an average cost of $4113 which was significantly higher than the previous two groups. Finally, those with both MetS and at least one of the diseases had the highest costs of $5857 which was significantly higher than the other three groups. This figure shows the high costs associated with disease among employed individuals.

The next analysis repeated the previous figure but limited the diseases to just diabetes and heart disease. Results are similar to the results found in Figure 1 with the highest costs occurring in the last two groups: those without MetS but who have diabetes or heart disease, and those with both MetS and at least one of those diseases (Fig. 2).

Discussion

The prevalence of MetS in this employed population is slightly higher than the prevalence found in nationally representative studies reporting rates of 23% to 25% [27,28]. Nevertheless, our study uses the most recent definitions of MetS which include people taking medication for glucose, triglycerides, HDL, and/or hypertension. The prevalence of MetS in this two-time participant population increased significantly from 2004 to 2006. The authors of another study of the NHANES data sets from 1988 to 1994, and from 1999 to 2000 have also indicated that rates of MetS are increasing in the United States [30].

As in other studies [27,28], employees who met the criteria for MetS were significantly older and more likely to be male than those without MetS. Other demographic differences in education level, income, marital status, and ethnicity were not significant after controlling for age and gender.

The main topic of this study was the relationship between MetS and disease in a working population. Those with MetS in 2004 were significantly more likely to report having arthritis, chronic pain, diabetes, heartburn, heart disease, and stroke in 2004 compared to those without MetS, after controlling for age and gender differences. Diabetes and heart disease are obviously associated, given the overlap between the risk factors for MetS and those for these two conditions. There is also evidence in the literature that chronic pain conditions are associated with MetS. In one study, fibromyalgia was associated with larger waist cir-

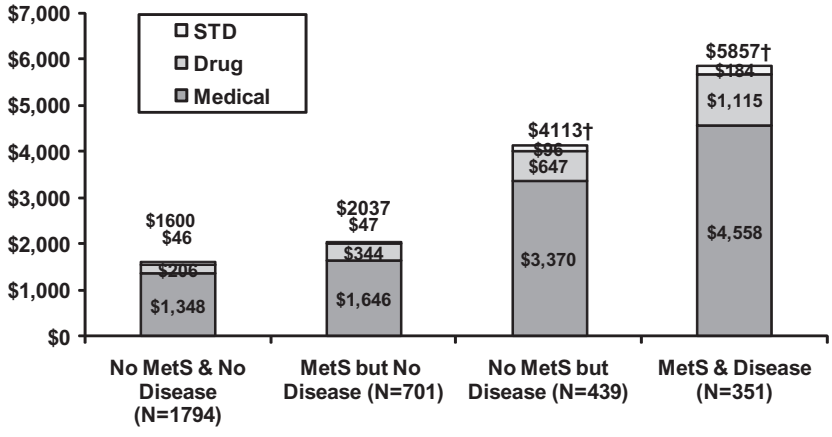

Figure 1 2006 cost by 2006 MetS and Disease* status. *Disease = self-reported heart disease, diabetes, arthritis, chronic pain, or heartburn. †$P < 0.0001$ significantly different from all other groups, adjusting for age and gender. MetS, metabolic syndrome.

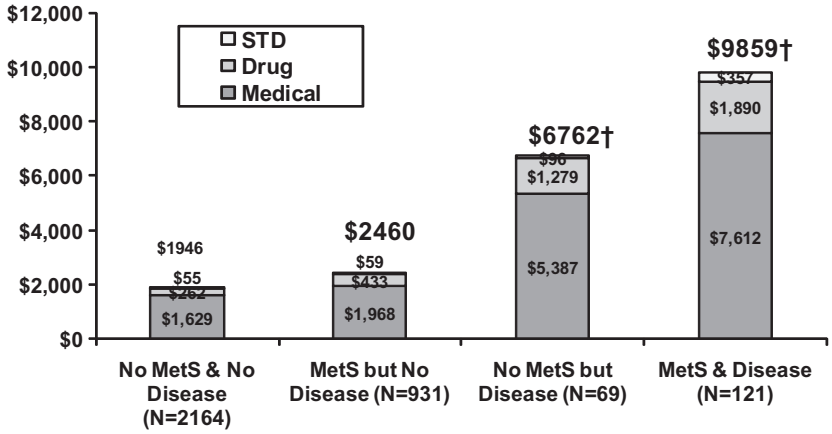

Figure 2 2006 cost by 2006 MetS and Diabetes/Heart Disease* status. *Disease = self-reported diabetes or heart disease. †$P < 0.0001$ significantly different from all other groups, adjusting for age and gender. MetS, metabolic syndrome.

cumference, higher glycosylated hemoglobin and triglyceride levels, and higher blood pressure [18]. The association found with heartburn and MetS may simply be an effect of the strong association between obesity and heartburn. The association with stroke has not been noted in the literature, but given the similar risk factors for heart disease and stroke, it is not surprising that a relationship with MetS would be identified. The very small prevalence of stroke in this working population limits the generalizability of these results, however.

Employees with MetS in 2004 were significantly more likely to report new cases of arthritis, chronic pain, diabetes, and heart disease, but not heartburn. To minimize the level of disease among employees, organizations should address MetS and its health risks. Rates of diagnosed diabetes are increasing in the United States [31,32], and working populations are no exception. Nevertheless, worksite health management programs have been shown to be effective in helping "prediabetic" employees reduce their risks to prevent full-blown diabetes even after 2 years of follow-up [33].

After examining these associations between MetS and disease, it was appropriate to examine the associated costs (health care, pharmacy, and STD). The cost of those with MetS and disease were 3.66 times greater than those without MetS and without disease. Results indicate that disease is certainly a significant factor in determining the costs associated with MetS. All of those with disease had higher costs than those without disease, but those with both MetS and disease had the highest cost of any group. What is most interesting to employers is the fact that employees with MetS but who had not yet developed one of the five health conditions had slightly higher costs, but they were not yet significantly different from the employees without MetS and without disease.

When the cost analysis was limited to just heart disease and diabetes, those with MetS and disease had costs five times higher than those without MetS and without disease, and four times higher than those with MetS but who had not yet developed diabetes or heart disease. Again, the encouraging finding for organizations is that the majority (88%) of those with MetS in this population had not yet developed diabetes or heart disease, and 67% had not yet developed any of the five conditions studied in Figure 1 (arthritis, chronic pain, diabetes, heartburn, or heart disease). The largest opportunity is in helping these individuals improve their risks so that those conditions are prevented.

There is an opportunity for health promotion to prevent the MetS risk factors from progressing to disease status which may improve vitality for employees, as well as limit the economic impact to the corporation. An integrated approach to mitigating the effects of health risks might include several components [34–37].

- An HRA offered on a regular basis to measure employee health;
- Analysis of the impact of health on work performance and all other pertinent outcome measures such as absenteeism, injuries, and health-care costs;
- Revision of policies and benefits to support work/life balance;
- Targeted lifestyle and disease management programs to mitigate risk factors and health conditions;
- Programs which help healthy employees stay healthy, such as fitness centers
- Evaluation of the work environment and ergonomics;
- Ensuring that employee assistance program providers are equipped to recognize and treat problems which impact employee health and on-the-job productivity;
- Enlisting the help of a pharmacy benefit plan to help manage and improve access to appropriate medication;
- Evaluating coverage for mental health benefits to ensure that employees have adequate resources to deal with those types of problems;
- Developing a work environment that discourages working while ill;
- Applying current programs such as disability case management and disease management to help employees with medical conditions remain productive.

Employers should implement educational and screening programs for their employees to prevent undiagnosed or misdiagnosed illnesses which will allow employees to better manage their medical conditions. The Wellness Council of America estimates that an effective, comprehensive program can cost about $100 to $150 per employee per year [38]. In addition to lower-cost educational programs, it is also necessary for employers to spend money on improving employee medical treatment to improve workplace productivity.

Previous studies have found associations between MetS and health conditions such as depression [39,40], and kidney disease [41] which were not identified in the current analysis. Because of the particular demographics of this working population (83% men, with an average age of 40.8 years), it may be unlikely to detect the association between MetS and depression which has primarily been studied in female samples. For example, only 3.5% of the study population self-reported depression compared

to national statistics of major depression affecting 6.6% of the adult US population in any 1 year [42]. Furthermore, because this is a population of working adults rather than a patient population, the rates of certain diseases such as kidney disease would be small or nonexistent. This is likely because of the healthy worker effect (HWE). The HWE most often is discussed in mortality studies because actively employed individuals consistently have a lower mortality rate than the general population [43]. Nevertheless, it also applies to studies such as this which examine disease and other health condition prevalence among employed individuals [44–46].

Limitations

This study is typical of most worksite health promotion studies in that the design is cross-sectional and retrospective. The ideal study design (i.e., a randomized, controlled study) is difficult or impossible to conduct in a worksite population because of the relationship between employees and employer. Another common limitation of worksite analyses is that the HRA participants are not representative of the entire employee population. Because of the near universal participation rate at this company, the population studied is very likely to be representative of the corporation as a whole although we are assuming that those who did not participate did so at random and that they represent nonimformative missing data. The results are unique to this corporation, however, and similar studies should be conducted in a variety of worksite industries to see if the findings are replicated in different demographic groups.

As was mentioned, waist circumference was not measured, so BMI was used as a surrogate. The current criteria of MetS states that if an individual has a BMI greater than 30 kg/m^2, we can safely assume that his or her waist circumference exceeds the risk level [25]. Nevertheless, it does leave the possibility that individuals with BMI < 30, but with central adiposity which meets the waist circumference risk cut point would not be identified here. A future study will compare the use of waist circumference and BMI as risk factors for MetS because the company added waist circumference to its screening in 2007.

The information on medical conditions in this study relied on self-reporting of participants. Each individual's criteria for reporting a certain condition may not have matched typical diagnostic criteria for each condition. Previous studies of self-report data have shown that relying on self-report for medical conditions can be a valid method [47–49], although in one study patients reported more conditions than could be verified in medical charts [50].

Conclusions

This study provides employers, health-care providers, and public health professionals with more information about the extent of MetS and its consequences in working populations. The medical conditions arthritis, chronic pain, diabetes, heartburn, and heart disease were significantly more prevalent in employees with MetS than those without MetS. Indeed, individuals with MetS but no disease in 2004 were more likely to newly report four of those five conditions (arthritis, chronic pain, diabetes, and heart disease) 2 years later. It was unknown whether the diseases associated with MetS in the general population would also be found in a working population because of the HWE [51] but it does appear to be the case.

Moreover, this study highlights the opportunity that is available to organizations seeking to improve the health of employees. While employees with MetS and a medical condition had significantly higher costs than other employees, the vast majority of employees with MetS in this study had not yet developed one of the five medical conditions studied here, and their costs were not significantly greater than those without MetS. If individuals take advantage of programs helping them to both maintain their low risks and reduce their high risks, their odds of experiencing disease will be reduced. This leads to improved vitality and quality of life for individuals, and cost avoidance for corporations in the form of lower health care, pharmacy, and STD costs.

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References

1 Alberti KG, Zimmet PZ. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1. Diagnosis and classification of diabetes mellitus, provisional report of a WHO consultation. Diabet Med 1998;15:539–53.
2 National Institutes of Health. Third Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). Executive Summary. Bethesda, MD: National Institutes of Health, National Heart, Lung and Blood Institute, 2001 (NIH publ. No. 01-3670).
3 Grundy SM, Cleeman JI, Daniels SR, et al. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. Circulation 2005;112:2735–52.
4 Hu G, Qiao Q, Tuomilehto J, et al. Prevalence of the metabolic syndrome and its relation to all-cause and cardiovascular mortality in nondiabetic European men and women. Arch Intern Med 2004;164:1066–76.
5 Hunt KJ, Resendez RG, Williams K, et al. San Antonio Heart Study. National Cholesterol Education Program versus World Health Organization metabolic syndrome in relation to all-cause and cardiovascular mortality in the San Antonio Heart Study. Circulation 2004;110:1251–7.
6 Isomaa B, Almgren P, Tuomi T, et al. Cardiovascular morbidity and mortality associated with the metabolic syndrome. Diabetes Care 2001;24:683–9.
7 Lakka H-M, Laaksonen DE, Lakka TA, et al. The metabolic syndrome and total and cardiovascular disease mortality in middle-aged men. JAMA 2002;288:2709–16.
8 McNeill AM, Rosamond WD, Girman CJ, et al. The metabolic syndrome and 11-year risk of incident cardiovascular disease in the atherosclerosis risk in communities study. Diabetes Care 2005;28:385–90.
9 Alexander CM, Landsman PB, Teutch SM, et al. NCEP-defined metabolic syndrome, diabetes, and prevalence of coronary heart disease among NHANES III participants age 50 years and older. Diabetes 2003;52:1210–14.
10 Malik S, Wong ND, Franklin SS, et al. Impact of the metabolic syndrome on mortality from coronary heart disease, cardiovascular disease, and all causes in United States adults. Circulation 2004;110:1245–50.
11 Wilson PWF, Kannel WB, Silbershatz H, et al. Clustering of metabolic factors and coronary heart disease. Arch Intern Med 1999; 259:1104–9.
12 Grundy S, Hansen B, Smith S, et al. Clinical management of metabolic syndrome: report of the American Heart Association/National Heart, Lung, and Blood Institute/American Diabetes Association conference on scientific issues related to management. Circulation 2004;109:551–6.

13 Ninomiya JK, L'Italien G, Criqui MH, et al. Association of the metabolic syndrome with history of myocardial infarction and stroke in the Third National Health and Nutrition Examination Survey. Circulation 2004;109:42–6.
14 Stern MP, Williams K, Gonzalez-Villalpando C, et al. Does the metabolic syndrome improve identification of individuals at risk of type 2 diabetes and/or cardiovascular disease? Diabetes Care 2004;27:2676–81.
15 Costa LA, Canani LH, Lisboa HRK, et al. Aggregation of features of the metabolic syndrome is associated with increased prevalence of chronic complications in type 2 diabetes. Diabet Med 2004; 21:252–5.
16 Lakksonen DE, Lakka H-M, Niskanen LK, et al. Metabolic syndrome and development of diabetes mellitus: application and validation of recently suggested definitions of the metabolic syndrome in a prospective cohort study. Am J Epidemiol 2002;156: 1070–7.
17 Hanson RL, Imperatore G, Bennett PH, Knowler WC. Components of the "metabolic syndrome" and incidence of type 2 diabetes. Diabetes 2002;51:3120–7.
18 Loevinger BL, Muller D, Alonso C, Coe CL. Metabolic syndrome in women with chronic pain. Metabolism 2007;56:87–93.
19 Balci K, Utku U. Carpal tunnel syndrome and metabolic syndrome. Acta Neurol Scand 2007;116:113–17.
20 Werner RA, Albers JW, Franzblau A, Armstrong TJ. The relationship between body mass index and the diagnosis of carpal tunnel syndrome. Muscle Nerve 1994;7:632–6.
21 Werner RA, Franzblau A, Albers JW, Armstrong TJ. Influence of body mass index and work activity on the prevalence of median mononeuropathy at the wrist. Occup Environ Med 1997;54:268–71.
22 Forbes L. Asthma and atopy: endocrine or metabolic conditions? Thorax 2005;60:793–4.
23 Ehrmann DA, Liljenquist DR, Kasza K, et al. Prevalence and predictors of the metabolic syndrome in women with polycystic ovary syndrome. J Clin Endocrinol Metab 2006;91:48–53.
24 Essah PA, Nestler JE. The metabolic syndrome in polycystic ovary syndrome. J Endocrinol Invest 2006;29:270–80.
25 Grundy S, Hansen B, Smith S, et al. Clinical management of metabolic syndrome: report of the American Heart Association/ National Heart, Lung, and Blood Institute/American Diabetes Association conference on scientific issues related to management. Circulation 2004;109:551–6.
26 Bureau of Labor Statistics. Consumer price index summary. Available from: http://www.bls.gov/news.release/cpi.nr0.htm [Accessed September 9, 2009].
27 Park Y-W, Zhu S, Palaniappan L, et al. The metabolic syndrome: prevalence and associated risk factor findings in the US population from the Third National Health and Nutrition Examination Survey, 1988–1994. JAMA 2002;163:427–36.
28 Ford ES, Giles WH. A comparison of the prevalence of the metabolic syndrome using two proposed definitions. Diabetes Care 2003;26:575–81.
29 Wild S, Roglic G, Green A, et al. Global prevalence of diabetes. Estimates for the year 2000 and projections for 2030. Diabetes Care 2004;27:1047–53.
30 Ford ES, Giles WH, Mokdad AH. Increasing prevalence of the metabolic syndrome among U.S. adults. Diabetes Care 2004;27: 2444–9.
31 Cowie CC, Rust KF, Byrd-Holt DD, et al. Prevalence of diabetes and impaired fasting glucose in adults in the U.S. population. Diabetes Care 2006;29:1263–8.
32 Venkat Narayan KM, Jack L Jr, Laine C. The evolving diabetes burden in the United States. Ann Intern Med 2004;140:945–50.
33 Aldana S, Barlow M, Smith R, et al. A worksite diabetes prevention program: two-year impact on employee health. AAOHN J 2006;54:389–95.
34 Lerner D, Allaire SH, Reisine ST. Work disability resulting from chronic health conditions. J Occup Environ Med 2005;47:253–64.
35 Pilette PC. Presenteeism in nursing: a clear and present danger to productivity. J Nurs Adm 2005;35:300–3.
36 Middaugh DJ. Presenteeism: sick and tired at work. Medsurg Nurs 2006;15:103–5.
37 Whitehouse D. Workplace presenteeism: how behavioral professionals can make a difference. Behav Healthc Tomorrow 2005;14: 32–5.
38 The Wellness Councils of America. The cost of wellness. Available from: http://www.welcoa.org/freeresources/pdf/goetzel_interview_cost.pdf [Accessed September 9, 2009].
39 Vaccarino V, McClure C, Johnson D, et al. Depression, the metabolic syndrome and cardiovascular risk. Psychosom Med 2008; 70:40–8.
40 Raikkonen K, Matthews KA, Kuller LH. The relationship between psychological risk attributes and the metabolic syndrome in healthy women: antecedent or consequence? Metabolism 2002;51:1573–77.
41 Chen J, Muntner P, Hamm LL, et al. The metabolic syndrome and chronic kidney disease in U.S. adults. Ann Intern Med 2004; 140:167–74.
42 Kessler RC, Berglund P, Demler O, et al. The epidemiology of major depressive disorder: results from the National Comorbidity Survey Replication (NCS-R). JAMA 2003;289:3095–105.
43 McMichael AJ. Standardized mortality ratios and the "healthy worker effect": scratching beneath the surface. J Occup Med 1976;18:165–8.
44 Le Moual N, Kauffmann F, Eisen EA, Kennedy SM. The healthy worker effect in asthma: work may cause asthma, but asthma may also influence work. Am J Respir Crit Care Med 2008;177: 4–10.
45 Radon K, Goldberg M, Becklake M. Healthy worker effect in cohort studies on chronic bronchitis. Scand J Work Environ Health 2002;28:328–32.
46 Hartvigsen J, Bakketeig LS, Leboeuf-Yde C, et al. The association between physical workload and low back pain clouded by the "healthy worker" effect: population-based cross-sectional and 5-year prospective questionnaire study. Spine 2001;26:1788–92.
47 Bourgeois FT, Porter SC, Valim C, et al. The value of patient self-report for disease surveillance. J Am Med Inform Assoc 2007; 14:765–71.
48 Simpson CF, Boyd CM, Carlson MC, et al. Agreement between self-report of disease diagnoses and medical record validation in disabled older women: factors that modify agreement. J Am Geriatr Soc 2004;52:123–7.
49 Miller DR, Rogers WH, Kazis LE, et al. Patients' self-report of diseases in the Medicare Health Outcomes Survey based on comparisons with linked survey and medical data from the Veterans Health Administration. J Ambul Care Manage 2008;31:161–77.
50 Corser W, Sikorskii A, Olomu A, et al. Concordance between comorbidity data from patient self-report interviews and medical record documentation. BMC Health Serv Res 2008;8:85–93.
51 Wen CP, Tsai SP, Gibson RL. Anatomy of the healthy worker effect: a critical review. J Occup Med 1983;25:283–9.