METABOLIC SYNDROME AND WORKPLACE OUTCOMES

by

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List of Abbreviations

ATP III	Adult Treatment Panel III
BMI	Body Mass Index
HDL	High Density Lipoprotein
HRA	Health Risk Appraisal
HWe	Healthy Worker Effect
IDF	International Diabetes Federation
MetS	Metabolic Syndrome
NHANES	National Health and Nutrition Examination Survey
STD	Short-term Disability
WHO	World Health Organization
WLQ	Work Limitations Questionnaire

Chapter I

Introduction

Employee Health and Costs

More than two thousand years ago, the Greek physician and father of medicine Hippocrates said, “A wise man ought to realize that health is his most valuable possession”. This quote is just as true today as it was long ago. Without health, the basic activities of life are restricted or prohibited entirely. One of these basic life activities is work and a person’s ability to work is greatly affected by his or her health. As of January 2008, 146 million adults in the United States were employed.[1] Each one of those individuals exists on a continuum of health[2] ranging from optimum health on one extreme all the way to morbidity and death on the other extreme. In the middle, there are a wide variety of symptoms, health problems and diseases that may impede work ability to some degree. Of course, each person moves on this continuum throughout his or her life.

The worksite health management industry was borne of the need to help employees stay on the healthy end of the continuum. The health of the population is a major priority for American society and it is also a major priority for America’s corporations, since they are often the primary payer of health care costs. Because of many years of research, the idea that healthier individuals are better employees and provide gains for the organization has been widely accepted by corporate leaders and employees alike. [3,4,5,6,7,8] Since the 1970s, the goal of worksite health management programs has been to facilitate risk reduction.[9,10,11,12] One of the first steps in that process is measuring the health of employees. Since the 1980s the tool of choice for this task has been the health risk appraisal (HRA).[13] The HRA began as a paper and pencil questionnaire addressing health behaviors, health history, preventive services compliance, health risks and health measures such as weight, blood pressure and cholesterol. Increasingly, organizations are offering a computer-based questionnaire either instead of or in addition to the traditional paper version. HRA specifics vary widely. Some are very short, intended to be completed in less than five minutes while others used by physicians or health plans may be very detailed and include questions on many possible health symptoms and conditions.

Health Risks

Measuring the health risks of an employee population is an important step for corporations in assessing the impact of health on a variety of outcomes such as health care costs, absenteeism and other productivity measures. This measurement can then drive decisions about population health management at that organization.[14,15,16] As the name implies, population health management uses strategies to address the health of all members of a given population.[17] In the past, many worksite health promotion programs only targeted high risk individuals; those who smoked or had high blood pressure, for instance. However, over time it became clear that ignoring the larger population with few risks left the door open for those individuals to become high risk themselves. This is particularly true as an employee population ages over time.

Health Risks and Costs

Worksite health management programs became popular because it was hypothesized that a healthier workforce would have fewer diseases and, in turn, lower health care costs and greater productivity. Many studies have established the link between health risks and health conditions (as measured by HRAs) and health care costs.[7,18,19,20] These studies show a clear link between employees with more health risks and higher health care costs. While various studies showed that programs were successful in reducing health risks,[21,22,23,24,25,26,27,28,29] in 1997 the first study was published which gave evidence that risk reduction was indeed associated with health care cost reduction.

In this landmark study at Steelcase Inc. the impact of changes in health risks on medical claims costs between 1985-1987 and 1988-1990 was examined among 796 employees. Employees completed HRAs in both 1985 and 1988 and were categorized into health risk levels. It was found that changes in average health care costs followed changes in health risks. The largest increase in average costs occurred in employees who changed from low-risk to high-risk status. The greatest reduction in average costs occurred in employees who changed from high-risk to low-risk status. The findings from this and similar studies that followed[8,30] provided strong evidence that improving health risks was associated with financial benefits.

One of the first studies to examine the association between health risks and health care costs in the short-term (less than three years) was published by Pronk et al.[31] Members of a health plan (N=5689) who completed an HRA comprised the study group. Three specific health risks were analyzed (physical activity, overweight, and smoking). All three health risks were significantly associated with higher health care costs over 18 months. A never-smoker with a body mass index (BMI) less than 25 kg/m^2 who exercised 3 days per week had an annual mean health care cost 49% lower than physically inactive smokers with BMI ≥ 27.5 kg/m^2.

Because of the skewed nature of health care costs, a two-part model was used by one group of researchers to analyze costs and their association with health risks.[32] This type of analysis first uses logistic regression to identify the odds of having any claims (since many individuals have $0 of claims in any given year) and the second-part uses linear regression to model the magnitude of cost for those who do have claims. Their analysis of 46,026 HRA participants from six large employers over six years found associations between health risks and health care costs. In this estimation, health risk factors were associated with 25% of the total health care expenditures for these organizations. In a second study of this population seven of the ten risk factors studied were significantly associated with higher health care costs for up to three years after the HRA. These risks were depression, high stress, glucose, body weight, smoking, blood pressure, and physical inactivity. The three risks which did not show associations with cost were alcohol use, nutrition and cholesterol.

The concept of "excess costs associated with excess risks" was then developed. In an effort to establish a benchmark for the field, analyses of six corporations were conducted to identify the excess health care costs associated with excess health risks in each population.[33] A total of 165,770 employees were included in the study, 21,124 of whom participated in an HRA. Results showed that as health risks increased, costs also increased. Excess health care costs due to excess health risks (high-risk individuals compared to low-risk individuals) ranged from 15% to 30% across the six organizations which varied by industry type, geographical location, company size and demographics of employees.

Productivity Costs

However, costs to the corporation due to excess health risks are not limited to health care costs. Large productivity costs have also been found to be associated with health risks.[8,34,35,36,37,38] Studies of the impact of some common chronic conditions suggest that the costs of lost productivity could far exceed the costs of medical care.[39]

Absences, short-term disability, and workers' compensation were combined into a sum of the cost of time away from work and compared with the health risks of 6,220 hourly workers at Steelcase Inc. Of the total costs of time away from work, 36.2% was attributed to the excess risks of the medium- and high-risk individuals or HRA non-participants compared with low-risk participants. It was calculated that excess time away from work due to health risks cost this corporation $1.7 million per year.

Recent reports have led employers to consider a second measure of productivity: presenteeism.[40,41,42,43] That is, the health-related reduction in productivity while an employee is at work. Presenteeism measures the reduction in productivity for the majority of employees whose health problems have not necessarily led to absenteeism. It also measures the decrease in productivity for ill or injured employees before and after an absence period. Presenteeism is often measured as the costs associated with reduced work output, errors on the job, and failure to meet company production standards due to impaired health. Bank One (now JPMorgan Chase) estimated presenteeism to be as much as 84% of their lost productivity costs, with absenteeism and disability comprising the other 16%.[44]

One study at a telecommunications firm found average presenteeism losses of 5% to 7%, estimated to be about $2000 to $2800 per employee per year. These productivity losses were associated with perceived health status and medical conditions.[45] In a meta-analysis, health care costs, absences, short-term disability and presenteeism were combined and analyzed for ten health conditions. The total cost of disease per year per eligible employee ranged from $392 for hypertension to $100 for asthma. A large financial services corporation examined productivity losses among 564 HRA participants. In this case, presenteeism was objectively measured among telephone customer service representatives and combined with absenteeism and disability records. As the number of health risks increased, an employee's productivity decreased. Disease states were also associated with productivity reduction. Other studies similarly documented the major role of presenteeism in productivity loss. [46,47,48,49,50,51,52,53]

Metabolic Syndrome and Risks

One particular combination of health risks known as metabolic syndrome (MetS) is receiving significant attention in the medical community. This cluster of metabolic indicators was first called “syndrome X” in 1988.[54] Syndrome X was described as the presence of multiple risk factors such as overweight, glucose intolerance, hyperinsulinemia, increased triglycerides, decreased HDL cholesterol, and hypertension. People with MetS are three times as likely to have a heart attack or stroke compared to those without the syndrome.[55] MetS is thought to be one of the drivers of the growing problems of diabetes and cardiovascular disease.[56]

In the past decade precise definitions of MetS were developed by the World Health Organization (WHO) [57] and the National Institutes of Health in conjunction with the American Heart Association.[58,59] The first definition was initially proposed by the WHO in 1998. According to this definition, an individual has MetS if he or she has diabetes, impaired glucose tolerance, impaired fasting glucose, or insulin resistance plus two or more of the following: blood pressure ≥160-90 mmHg; triglycerides ≥150 mg/dl and/or HDL cholesterol <35 mg/dl in men and <39 mg/dl in women; waist-to-hip ratio of >0.90 in men or >0.85 in women and/or BMI>30kg/m^2; and urinary albumin excretion rate ≥20 µg/min or an albumin-to-creatinine ratio ≥20mg/g. These WHO criteria are obviously heavily weighted for diabetics.

The second definition of MetS was developed in the 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 or ATP III). According to their criteria, an individual has MetS if he or she has three or more of the following criteria: waist circumference >102 cm in men and >88 cm in women; triglycerides≥150 mg/dl; HDL cholesterol <40 mg/dl in men and <50 mg/dl in women; blood pressure ≥130/85 mmHg; and fasting glucose ≥110 mg/dl.

In 2005, the International Diabetes Federation (IDF) issued its own definition of MetS.[60] Their criteria were similar to the ATP III definition with a few notable differences. Since the definition would be applied worldwide, different levels of waist circumference were used for different ethnic groups in order to assess obesity. Furthermore, the obesity risk factor was a requirement for MetS. The other change was that individuals being medically treated for triglycerides or HDL cholesterol were considered at risk for those factors, even if their screened values were below the cut points. Finally, if individuals were diagnosed with type 2 diabetes, they also met the criteria for fasting glucose, even if their value was below 100 mg/dL. The IDF was hopeful that the new definition would be more useful in clinical practice in order to diagnose individuals earlier, before reaching disease states of diabetes or heart disease.

Recently the American Heart Association and National Heart, Lung and Blood Institute have also confirmed the value of the ATP III criteria with some minor modifications similar to those proposed by the IDF. Therefore, the current worldwide standard for MetS risk criteria means that individuals are classified as having MetS if they meet three of the following criteria: waist circumference (≥102 cm in men, ≥88 cm in women, or BMI>30 kg/m^2), triglycerides ≥ 150 mg/dl or taking medication for that condition, HDL cholesterol <40 mg/dl for men or <50 mg/dl for women or taking medication for that condition, blood pressure ≥ 130/85 mmHg or taking medication for that condition, and fasting glucose ≥ 100 mg/dl or taking medication for that condition.[61] The inclusion of those who are taking medication for each of the risk factors is an important step in assessing the true risks in a population.

Several studies have compared the prevalence of MetS using the ATP III and WHO definitions.[62] Prevalence in the United States using the ATP III definition have been reported at 23.9%, 22.7%[63] and 23.7%[64]. The WHO definition has yielded a prevalence of 25.1%. About 85% of people are classified the same by both definitions.[62] MetS has been shown to have different prevalence rates in different population sub-groups. For example, among African-American men, 16.5% had MetS using the ATP III criteria and 24.9% met the definition of the WHO.[62]

Among individuals who already have type 2 diabetes, results indicated that 81% of subjects met the WHO definition of MetS while 78% satisfied the ATP III criteria.[65] Consistent with previous research, 83% of subjects were classified the same with both criteria.

The multiple definitions of MetS have caused confusion and resulted in many studies and publications comparing the merits of each definition.

Furthermore, it is difficult to assess the population prevalence of MetS when such a variety of definitions are being used. It is hoped that the newest definition by the American Heart Association will be useful in not only clinical settings, but also in community or worksite settings where some measurements only available in research settings are not practical to obtain. In light of the confusion caused by changing definitions, it is accepted that MetS is likely to be present in 20-25% of the world's population.

Few studies have determined the prevalence of MetS risks in working populations. One such study of civil service departments in Britain found a MetS prevalence of only 9%.[66] This result is significantly less than the population-based studies that were mentioned previously[62,63] and is due to the exclusion of obese employees and those with diagnosed heart disease at baseline. The main purpose of the study was to examine the relationship between stress and MetS so the authors wanted to eliminate the effects of the obesity-stress relationship. However, that also severely limited the metabolic syndrome risk prevalence. Another study in an aerospace worksite population found a prevalence rate of 27%[67] which is more in line with population-based studies.

The real danger of MetS is its association with health conditions such as heart disease and diabetes.[68,69,70,71,72] To further explore that relationship, researchers evaluated the predictive ability of cardiovascular events in diabetic and nondiabetic individuals in a population-based sample using MetS definitions of WHO, ATP III and the IDF criteria.[73] With 10 years of follow-up, the WHO and ATP III definitions had the greatest ability to predict cardiovascular disease in individuals without diabetes and the WHO definition was the best predictor of cardiovascular events among diabetics. However, if prevention and health promotion are the goals, the IDF criteria may be most useful in addressing the risks that comprise MetS.[74] As corporations are the main payers of health care costs in the U.S., they have a vested interest in identifying the magnitude of MetS risks in employed populations and also in knowing if those risks are associated with other health risks or medical conditions. Many companies offer wellness programs to encourage employees to maintain their health and reduce health risks such as those which comprise MetS.

MetS Component Costs

While many studies have found increased costs (including health care and in some cases, productivity) associated with the component risk factors such as obesity[75,76,77,78,79,80] or hypertension,[81,82] no study, as of yet, has evaluated the costs associated with MetS as a whole.

Study Purpose

The literature on MetS to date is focused on the prevalence of the condition. Studies examining costs and outcome measures have not considered the cluster of risks as a whole, but instead focus on one or more of the individual risk factors. Furthermore, few studies on this topic have been conducted in a worksite population. Since corporations are often the primary payer of health care costs, they have a vested interest in understanding the burden of MetS in their employee populations and in determining the financial burden posed by

MetS. Therefore, this dissertation shall characterize the prevalence and impact of MetS in an employed population. The three studies that follow will:

1. Analyze the association between the MetS risk cluster and workplace outcomes such as health care costs (including medical and pharmacy) and productivity (presenteeism and short-term disability absenteeism).
2. Examine changes in MetS risks and their association with changes in costs.
3. Since the real danger of MetS is its association with disease, the final manuscript will examine the prospective relationship between MetS risks with disease in a worksite population.

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Chapter II

Metabolic Syndrome in a Workplace: Prevalence, Comorbidities and Economic Impact

Introduction

Several definitions of MetS have been published which makes it difficult to compare prevalence rates estimated by different studies. This cluster of metabolic risk factors was first called "syndrome X" in 1988[1] and included overweight, glucose intolerance, hyperinsulinemia, increased triglycerides, decreased HDL cholesterol, and hypertension. In 1998, the WHO[2] proposed its definition with a requirement of diabetes, insulin resistance or impaired glucose tolerance combined with two or more of the following risks: hypertension, hypertriglyceridemia and/or decreased HDL cholesterol levels, obesity and microalbuminuria. The National Cholesterol Education Program developed its own definition in 2001 known as ATP III.[3] With a greater emphasis on cardiovascular risk rather than diabetes, a person was considered to have MetS if he or she had three of the following five components: central obesity, elevated blood pressure, fasting hyperglycemia, elevated triglycerides and low HDL cholesterol.

In 2005, the IDF introduced yet another definition requiring the presence of abdominal obesity plus two or more factors (triglycerides, HDL, blood pressure and glucose).[4] The WHO definition included a higher cutpoint for blood pressure, a lower HDL limit and the additional component of microalbuminuria. The IDF definition differed from the ATP III criteria by a lower limit for waist circumference.

Finally, the American Heart Association and National Heart, Lung and Blood Institute have recently confirmed the value of the ATPIII criteria with some minor modifications including the addition of a medication component. Therefore, the current worldwide standard for MetS risk criteria are three or more of the following criteria: waist circumference (≥102 cm in men, ≥88 cm in women, or BMI >30 kg/m^2), triglycerides ≥ 150 mg/dl or taking medication for triglycerides, HDL cholesterol <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 MetS with these different criteria. One study compared the prevalence of MetS using the WHO and ATP III definitions among 8,608 subjects.[6] Using the ATP III definition, 23.9% of study participants met the criteria for having MetS while 25.1% of participants qualified when using the WHO definition. About 86% of people were classified the same by both definitions. Although the overall estimates were very similar, significant differences were noted among certain population sub-groups. For example, among African-American men, 16.5% had MetS using the ATP III criteria while 24.9% met the definition of the WHO. The ATP III definition of MetS is more focused on its relationship to cardiovascular disease, which may account for some of the difference with the WHO definition.

A German study compared the WHO, ATP III and IDF definitions of MetS to identify the difference in prevalence rates among individuals who already had type 2 diabetes.[7] Because this was a population already diagnosed with diabetes, the prevalence rates of MetS were higher than in a general population sample (26.1% using WHO, 79.3% using ATP III and 82.6% using IDF). The degree of agreement was much stronger between the ATP III and IDF definitions (kappa=0.69) compared to the WHO vs. IDF (kappa=0.12) and WHO vs. ATP III (kappa=0.17).

Other studies using the ATP III definition of MetS among nationally-representative datasets have found prevalence rates in the U.S. ranging from 22.7%[8] to 23.7%.[9] In both of those studies, prevalence rates varied widely in ethnic sub-groups.

Few studies have determined the prevalence of MetS risks in working populations. One such study of civil service departments in Britain found a MetS prevalence of only 9%.[10] This result is significantly less than the population-based studies[6,8,9] that were mentioned previously and is due to the exclusion of obese employees and those diagnosed with heart disease at baseline. Another study in a worksite population found a prevalence rate of 27%[11] which is more in line with population-based studies. One study of a working population in 2001 identified groups of risks measured by an HRA using cluster analysis. One of the four identified clusters was termed the “biometric cluster”.[12] It was apparent to these 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 MetS risks with both heart disease and diabetes.[13,14,15,16,17,18,19,20,21,22] But again, none of these studies were 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 MetS will be lower in this study. As corporations are the main payers of health care costs in the U.S., they have a vested interest in identifying the magnitude of MetS 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 which comprise MetS.

This study will identify the prevalence of MetS risks in employees of a large manufacturing corporation. Furthermore, the association between MetS and other health risks and conditions will also be 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 MetS risks will also be investigated.

Methods

Population and Setting

Employees of a large manufacturing corporation headquartered in the Midwest 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 worksite by staff of the company's medical department and completed on company time. Each screening took about 15 minutes to complete. Of the 5,277 individuals who were employed in 2006, 5,243 (99.4%) participated in the HRA. Of the HRA participants, 4,188 (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%) with an average age of 40.8 years. About 80% of employees are hourly and 20% are 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 based on 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 cutpoints measured by the HRA can be found in Table 2.1.

Table 2.1. Description of Health Risks Measured by HRA

Risk	High Risk Cut
Alcohol	> 14 drinks per week
Blood Pressure*	≥130/85 mmHg
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
Drug Use to Relax	Almost everyday or sometimes
HDL Cholesterol*	<40 for men, <50 for women
Illness Days	> 5 days in the past year
Glucose*	≥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 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.

The HRA also included data from a biometric screening which utilized 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 MetS risk factors. In this study, the risks currently accepted as the best indicators of MetS 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 cholesterol <40 mg/dl in men and <50 mg/dl in women. Waist circumference was not measured at this company's screening until 2007, so body mass index (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. Individuals with at least three of the risks were considered to have MetS.

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 of the chronic conditions 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 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.

<u>Medical and Pharmacy Claims</u>

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 non-pregnancy STD cost during the study time period. Those with non-pregnancy STD costs were significantly more likely to be female (25.9% vs. 16.2%, $p<.0001$) compared to those without an STD cost. They were also significantly older (42.9 years vs. 40.4 years, $p<.05$). Most common reasons for STD absences were injury/poisoning (26.0% of claims) and musculoskeletal system/connective tissue (23.6%). At this company, STD is designed to pay a weekly benefit when an employee has a non-occupational 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 8th 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 1st day of the disability. 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 in order to assess the health-related impact on work productivity. Eight questions (2 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.[23,24,25,26] 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] The eight items can be found in Table 2.2. Employees were asked to base their answers on the previous two weeks of work and to rate any impairment on a five-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 non-missing. A dichotomous score (yes/no) indicated whether or not any work limitations were noted for any domain (i.e., amount of limitation >0%).

Table 2.2. Description of eight-item WLQ

In the past two weeks, how much of the time did your physical health or emotional problems make it difficult for you to do the following?	
Item	Subscale
Work the required number of hours	Time management
Start on your job as soon as you arrived at work	
Repeat the same hand motions over and over again while working	Physical work
Use your equipment (e.g. phone, pen, keyboard, computer mouse)	
Concentrate on your work	Mental/interpersonal
Help other people to get work done	
Do the required amount of work on your job	Output
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.	

Statistical Analyses

Differences in continuous and categorical variables in individuals with and without MetS were tested using t-tests and χ^2 analyses, respectively. Logistic and generalized linear models were used to identify factors associated with the presence of MetS 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 MetS health risks in this employed population was explored. Table 2.3 shows the percentage of employees with each of the five MetS risk factors as well as by number of MetS risks.

Table 2.3. Prevalence of MetS Risks in Employed Population in 2006

	Percentage of Study Population (N=4,188)		% with self-reported Diabetes or Heart Disease
	N	%	
Blood Pressure ≥130/85 (or blood pressure meds)	1534	36.6%	9.8%
BMI >30	1339	32.0%	8.7%
Fasting Glucose ≥100 (or diabetes meds)	1341	32.0%	13.7%
HDL<40 (male), <50 (female)	1385	33.1%	6.9%
Triglycerides≥150	1769	42.2%	8.7%
None of the Conditions	968	23.1%	1.1%
Any One of the Conditions	1042	24.9%	2.9%
Any Two of the Conditions	912	21.8%	5.2%
Any Three of the Conditions	706	16.9%	7.4%
Any Four of the Conditions	416	9.9%	13.7%
All Five of the Conditions	144	3.4%	26.4%
<3 of the Conditions	2922	69.8%	3.0%
3+ of the Conditions (MetS)	1266	30.2%	11.6%

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 cholesterol, 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 seventy percent of the population (N=2922, 69.8%) had less than three of the risk factors while 1266 individuals (30.2%) are considered to have MetS because they had three or more of the risks.

Because of the strong association between MetS and heart disease and diabetes, the percent of individuals self-reporting either of those conditions is also shown in Table 2.3. Most striking is the increase in percent reporting disease as the number of MetS risks increases. Only 1.1% of employees with none of the risk factors self-reported diabetes or heart disease compared to 26.4% of those with all five risk factors.

The demographics of individuals with and without MetS were then analyzed and the results are shown in Table 2.4. Those with MetS (N=1266) were nearly 4 years older than those without the syndrome (43.1 vs. 39.6 years, p<.0001). A significantly greater percentage of those with MetS were male compared to those without MetS (89.6% vs. 80.7%, p<.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 MetS had education less than a college degree (79.2% vs. 73.3%, $p=.0462$ after controlling for age and gender). Hourly employee status, marital status and ethnicity were not significantly different after controlling for age and gender.

Table 2.4. Demographics of Employees with and without MetS

	Without MetS (N=2922)	With MetS (N=1266)	p-value*
Average Age	39.6 years	43.1 years	<.0001
% Male	80.7%	89.6%	<.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%	<.0001
Job dissatisfaction	11.6%	12.9%	0.4183
Life dissatisfaction	14.8%	16.4%	0.2012
Use relaxation medication	11.6%	17.7%	<.0001
Poor or fair physical health	8.7%	18.1%	<.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%	<.0001
MetS Risks			
Blood Pressure ≥130/85 (or meds)	21.4%	71.9%	<.0001
BMI >30	14.9%	71.4%	<.0001
Fasting Glucose ≥100 (or meds)	17.2%	66.3%	<.0001
HDL<40 (male), <50 (female) (or meds)	19.8%	63.7%	<.0001
Triglycerides≥150	24.9%	82.3%	<.0001
Wellness Score	84.1	73.8	<.0001

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

The additional health risks measured by the HRA were also compared for those with and without MetS. Those with MetS were significantly more likely to also 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 MetS had a significantly lower wellness score compared to those without MetS (73.8 compared to 84.1, $p<.0001$). 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, high-density lipoprotein cholesterol, 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 US Preventive Services Task Force Guidelines[28] according to participants' age and gender.

Additional medical conditions were then compared for those with and without MetS and results are found in Table 2.5. Those with MetS were significantly more likely to report having arthritis, chronic bronchitis/emphysema, chronic pain, depression, diabetes, heart problems, heart burn/acid reflux, and stroke compared to employees without MetS, after controlling for age and gender. After counting up all health conditions, the average number of conditions reported by participants was significantly greater ($p<.0001$) for those with MetS (1.01 conditions per person) compared to those without MetS (0.68 conditions per person).

Table 2.5. Health Conditions of Employees with and without MetS

	Without Metabolic syndrome (N=2922)	With Metabolic syndrome (N=1266)	Adjusted OR* (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)
Avg. # of conditions**	0.68	1.01	p< .0001

* multivariate logistic regression model adjusting for age and gender.
** multivariate linear regression model adjusting for age and gender.

Workplace outcomes were then considered. The health care and pharmaceutical costs of those with and without each of the MetS risks were compared, as were the costs of STD absences and the percent of employees reporting any presenteeism. Table 2.6 contains those results.

Table 2.6. Workplace Outcomes associated with MetS Risk Factors

	Not at Risk				At Risk			
	Annual Health Care Costs	Annual Pharmacy Costs	Annual STD Cost	% reporting any presenteeism	Annual Health Care Costs	Annual Pharmacy Costs	Annual STD Cost	% reporting any presenteeism
Blood Pressure ≥130/85 or meds	$1637	$258	$59	33.7%	$3330*	$538*	$97*	35.5%
BMI >30	$2114	$316	$60	33.6%	$2561	$455*	$101*	36.1%
Fasting Glucose ≥100 or meds	$1837	$258	$57	33.5%	$3148	$578*	$108*	36.2%
HDL<40 (male), <50 (female)	$2289	$362	$74	34.6%	$2192	$358	$71	33.9%
Triglycerides≥150	$1755	$253	$60	33.1%	$2944*	$507*	$91*	36.1%*

* Generalized linear model p-value comparing those with and without the risk, <.05 controlling for age and gender.

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 cost 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 one year and the cost of that claim is spread over all employees in each category. The percent of employees reporting any presenteeism was significantly higher for those at risk for triglycerides compared to those not at risk for triglycerides.

Table 2.7 shows those cost outcomes by number of MetS risks and also compares those with and without MetS.

Table 2.7. Workplace Outcomes associated with Number of MetS 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*	$66	33.2%
Any Three Risks	706	$3169*	$480*	$70	35.7%
Any Four Risks	416	$3683*	$618*	$148*	39.2%*
All Five Risks	144	$3190*	$875*	$160*	37.0%*
No MetS (<3 risk factors)	2922	$1788	$270	$59	33.4%
MetS (3+ risk factors)	1266	$3340**	$570**	$106**	36.9%**

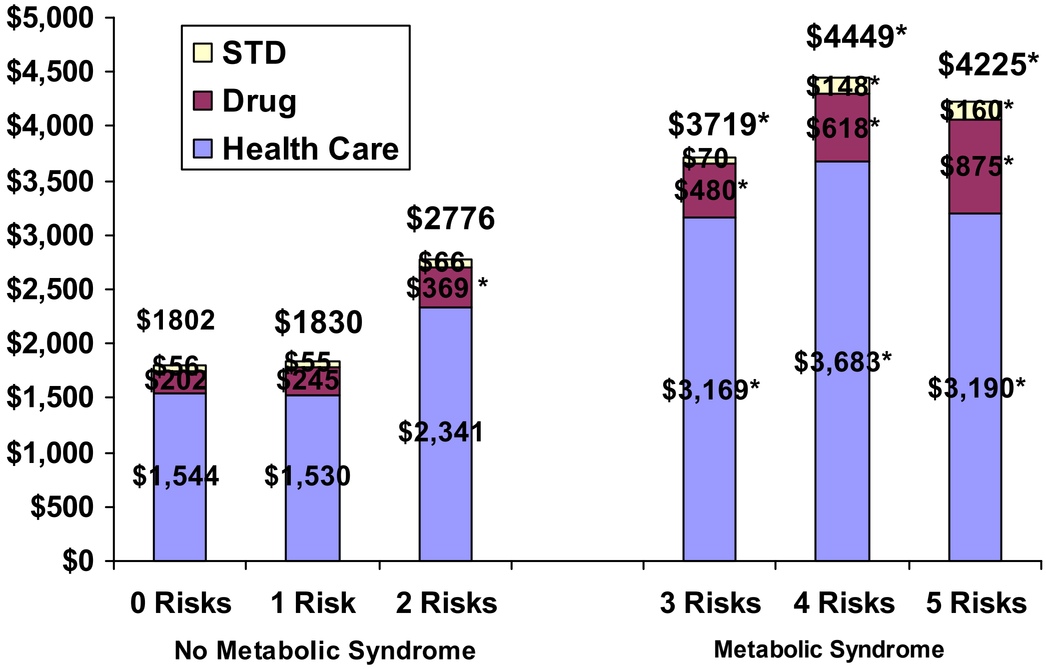
* Generalized linear model p-value <.05 compared to those with zero risks, controlling for age and gender.

** Generalized linear model p-value <.05 compared to those without MetS, controlling for age and gender.

Those who met the criteria for MetS (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 did not meet the criteria for MetS. Also, 36.9% of employees with MetS reported any presenteeism compared to 33.4% of those without MetS (p<.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), those at risk for MetS had costs of $4016 compared to $2117 for those not at risk for MetS, a difference of $1899 (p<.0001 adjusting for age and gender).

Figure 2.1 shows the costs of individuals with zero, one, two, three, four and five of the MetS 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.

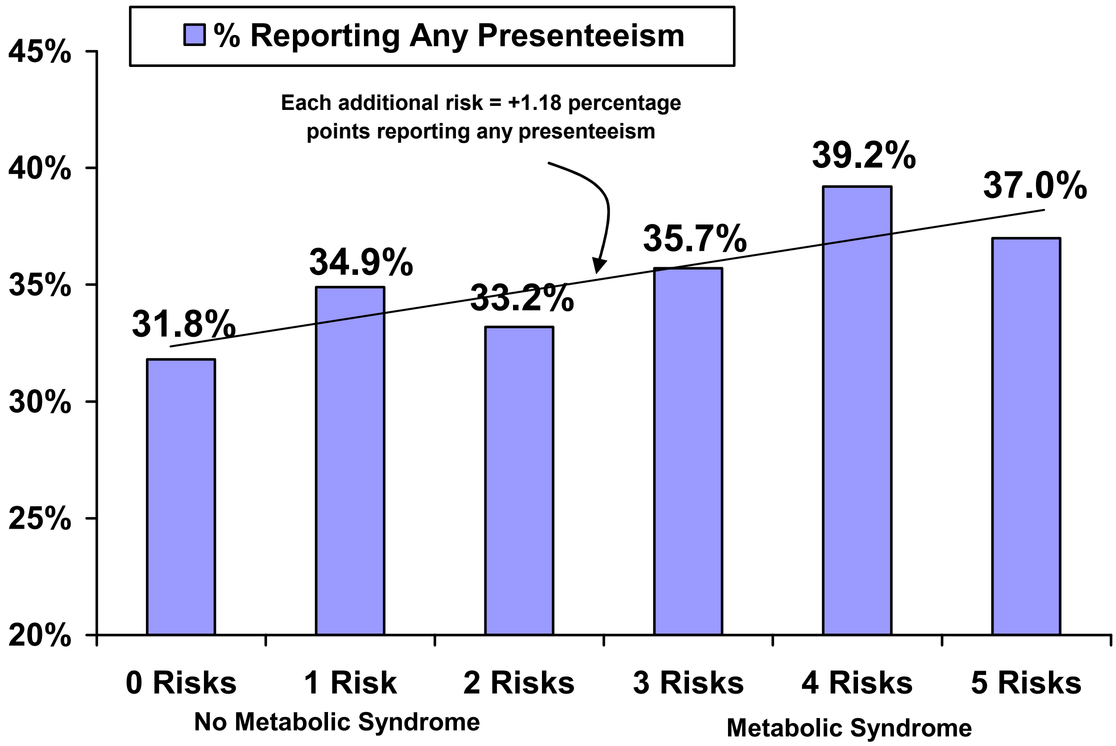
Figure 2.1. Annual Costs by Number of MetS Risk Factors



* Significantly different from 0 risk category, p<.01 GLM adjusting for age and gender.

Figure 2.2 presents the percent of employees reporting any presenteeism by the number of MetS risk factors. The Cochran-Armitage test for trend is significant (p<.05) for increasing numbers of employees reporting presenteeism as the number of risk factors increases. Since researchers are not yet confident of the appropriate way to convert presenteeism losses to dollars,[29,30,31] that conversion was not made here either.

Figure 2.2. Percent Reporting Any Presenteeism by Number of MetS Risks*



*Cochran-Armitage test for trend p<.05.

Discussion

In this study population employed by a manufacturing company, the prevalence of MetS was 30.2%, which is higher than the prevalence reported in nationally-representative samples as well as worksite studies in companies in the aerospace/defense and chemical[32] sectors which report MetS prevalence of 23.5% to 27%. Differences in the company studied here may be related to geography. This company is headquartered in the Midwest United States which is known to have higher rates of obesity and diabetes than some other regions of the country.[33] Also, most previous studies of MetS used either the WHO or ATPIII criteria. The latest definition of MetS which is used here identifies more individuals with MetS because of the additional medication component. That is, those with normal 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 MetS. It is surprising that, in this population which enjoys a relatively high income and excellent access to low-cost health care, the prevalence of MetS 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[34] (HWE) has no impact on the prevalence of MetS risks in this population.

A prevalence comparison study in Germany found that while the ATPIII criteria identified about 20% of the population as having MetS, the definition proposed by Grundy et al. and used in the current study identified around 29% of the population as having MetS.[35] Furthermore, one study of a National Health and Nutrition Examination Survey (NHANES) stratified sample found a MetS prevalence of 34.5% using the ATPIII criteria and 39.0% using the IDF criteria which requires the presence of central obesity.[36]

Employees in this study population with MetS are significantly more likely to be male and older compared to those without MetS. After controlling for these factors, those with MetS were significantly less likely to be college graduates compared to those without MetS. Furthermore, those with MetS 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 MetS 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 MetS (73.8) compared to those without MetS (84.1, p<.0001). Organizations that identify individuals with MetS would be wise to offer a wide variety of health promotion activities to help improve the diverse health risks of those employees.

Individuals with MetS not only have additional health risks, they also have additional health conditions. Out of 14 possible health conditions measured on the HRA, those with MetS 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 MetS[13-22], a few studies have also shown a relationship between chronic pain and MetS. Loevinger, et al. found that women with the chronic pain condition fibromyalgia were 5.6 times more likely to have MetS than healthy controls.[37] Another study indicated that individuals with the painful condition carpal tunnel syndrome were three times more likely to also have MetS and their carpal tunnel was also more severe compared to others.[38] The relationship between MetS and carpal tunnel syndrome is not surprising given that increased BMI is a key risk factor in both conditions.[39,40]

Although the HRA does not specify type of arthritis (rheumatoid or osteoarthritis), some researchers have found that MetS and rheumatoid arthritis share some of the same characteristics such as insulin resistance and dyslipidemia.[41,42] The relationship between mental health and MetS is not well understood and requires more research.[43,44]

The results shown in Figure 2.1 indicate that workplace cost outcomes are significantly higher for those with MetS compared to those without MetS. Figure 2.2 also shows that increasing numbers of MetS health risks are associated with greater numbers of employees reporting on-the-job productivity losses (presenteeism).

However, as was shown in Table 2.5, those with MetS are also more likely to have other health conditions compared to those without MetS. This is undoubtedly a factor in the higher costs associated with MetS. The contribution of disease will be explored in a following chapter. However, since more than half (54.4%) of employed individuals with MetS 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 Midwest, which may limit the generalizability of the results. 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 in most, if not all worksite analyses of health, it is impossible to conduct a randomized, prospective study on employees. 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. While 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.[45] 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 MetS obesity risk factor) in men as determined by magnetic resonance imaging.[46] Results showed that waist circumference is the anthropometric index that 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 and BMI was a stronger predictor than waist-to-hip ratio. 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

MetS 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 MetS. These employees with MetS are significantly more likely to have a variety of other health risks and health conditions compared to those without MetS. 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 which help individuals improve their health and receive appropriate health screenings and medical care.

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Chapter III

The Association between Changes in Metabolic Syndrome and Changes in Cost in a Workplace Population

Introduction

Health risks as identified by health risk appraisals (HRAs) have been found to be associated with outcome measures such as health care costs and productivity measures by many researchers.[1,2,3,4,5] Past research at the Steelcase Corporation has also shown that changes in a person's total number of risk factors as determined by the HRA are also associated with changes in health care costs.[6] In that landmark study, health risks were measured in 1985 and 1988 and average annual medical claims costs were compared for two time periods: 1985-1987 and 1988-1990. The result was that changes in overall risk level were associated with corresponding changes in cost. That is, the largest increase in average costs was observed in employees who moved from low risk to high risk status. The greatest reduction in costs occurred in employees who reduced their risks.

Since that initial study of health care costs, other researchers have found similar results in public sector employees[7,8] as well as the finding that changes in risks were associated with changes in absenteeism[9,10] and presenteeism (on-the-job productivity losses).[11,12]

While employee health and health care costs continue to be of interest to employers, some specific groups of risks are garnering much attention in the literature. Specifically, metabolic syndrome (MetS) is increasingly claimed to be a dangerous cluster of health risks, both in terms of increased risk of disease and also increased health care costs. Also, many of the risk factors underlying MetS are modifiable or treatable. Because it has only recently been examined in the literature, not much is known about the long term nature of risk for metabolic syndrome in individuals. Specifically, are changes in the risk for MetS occurring? And, if so, are those changes associated with changes in health care costs and other economic outcomes such as short-term disability absences? It is hypothesized that the risks for MetS will increase over time due to aging. It is also hypothesized that changes in MetS risks will be associated with similar changes in health care costs and STD costs. That is, if the number of MetS risks increase over time, it is theorized that costs will also increase.

Methods

<u>Population and Setting</u>

Employees of a large manufacturing corporation headquartered in the Midwest 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. Of the 3635 individuals who were continuously employed from 2004 to 2006 and selected the company's medical plan coverage, 3270 (90.0%) participated in the HRA and screening all three years. This is the population of interest in this study. A slightly greater percentage of these participants were female compared to the non-participants (17.4% vs. 15.7%, Chi-square p=0.06). The average age was not significantly different (44.2 years vs. 44.7 years).

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 based on 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 HRA also included data from a biometric screening which utilized 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 MetS risk factors. In this study, I employed the risks currently accepted as the best indicators of MetS:[13] blood pressure ≥130/85 mmHg or blood pressure medication, fasting glucose ≥100 mg/dl or glucose medication, triglycerides ≥150 mg/dl, and HDL cholesterol <40 mg/dl in men and <50 mg/dl in women. Waist circumference was not measured, so body mass index >30 kg/m^2 was used as a surrogate. As indicated in the current criteria of MetS, if individuals have a BMI greater than 30 kg/m^2, it can safely be assumed that their waist circumference exceeds the risk level.[14] Individuals with at least three of the risks were considered to have MetS.

In addition to asking employees about the presence of 16 biological and lifestyle health risk factors, the HRA included questions about the presence of several chronic diseases.

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, 2005 and 2006 via encrypted transmission. Medical claims from 2004, 2005 and 2006 were summed for each individual each year as were pharmacy claims. Claims costs were then adjusted for inflation to 2006 dollars using the medical consumer price index.[15] 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 2004, 2005, and 2006 were summed for each individual for each year, as was their STD cost. At this company, STD is designed to pay a weekly benefit when an employee has a non-occupational 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 8th 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 would benefit begin the 1st day of the disability. 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 Short Term Disability, 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.

Statistical Analyses

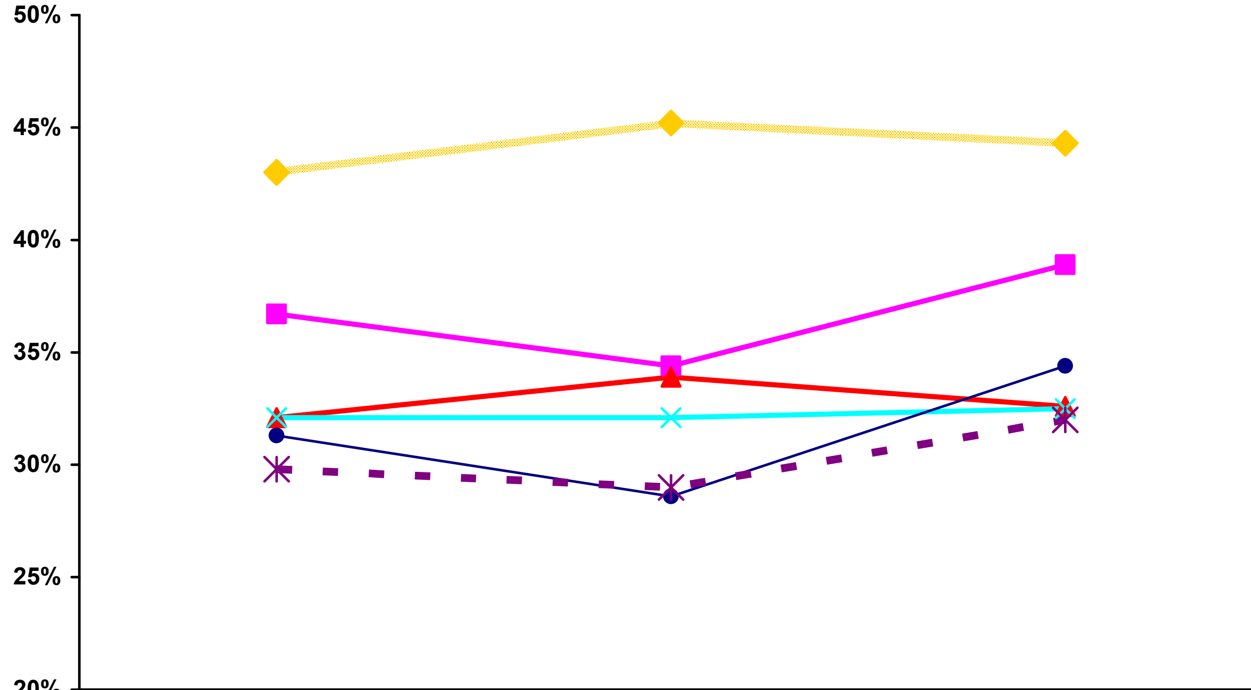
Cost changes were calculated for each person and then averaged for all subjects. A t-test was used to compare differences in the average cost change among groups of employees based on the number of MetS risks that were changed over time. Differences in cost changes were also compared using multivariate regression analysis and controlled for age and sex which are known confounders in the analysis of MetS.[18,19] Ethnicity is also a known confounder but 92% of the employees at this company are Caucasian and ethnicity was not significantly different between those with and without MetS. 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

Prevalence of MetS Risks over Time

The prevalence of each of the five MetS risks was calculated for each year of the study and are shown in Figure 3.1. It was hypothesized that the prevalence rates of each risk factor would increase over time due to aging of the population. However, this was not the case. The rates of each of the five risk factors remained relatively consistent for all years of the study, as did the overall prevalence rate of MetS in this population.

Figure 3.1. Prevalence Rates of Each Risk Factor and MetS



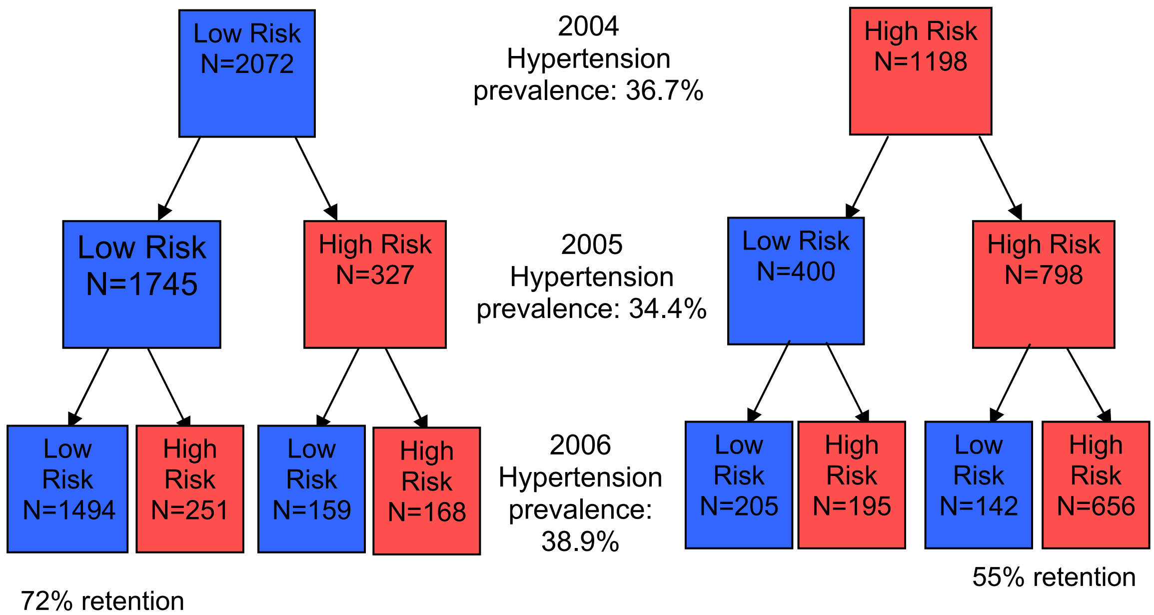
	2004	2005	2006
Triglycerides	43.0%	45.2%	44.3%
Hypertension	36.7%	34.4%	38.9%
HDL	32.1%	33.9%	32.6%
Obesity	32.1%	32.1%	32.5%
Glucose	31.3%	28.6%	34.4%
Metabolic Syndrome	29.8%	29.0%	32.0%

Triglycerides had the highest prevalence of all of the MetS risk factors in each of the three study years with 43%, 45% and 44% of participants at risk for triglycerides in 2004, 2005 and 2006, respectively. The second most prevalent risk was hypertension, with 37%, 34% and 39% of participants at risk in the three study years. HDL and obesity had similar prevalence rates of around 32% to 33% while the risk with the smallest prevalence was glucose (31%, 29% and 34%). Finally, the prevalence of MetS (those with three or more of the risk factors) was 30% of participants in 2004, 29% in 2005 and 32% in 2006.

However, even though the prevalence rates do not appear to change much over time, there are changes taking place on an individual level. From one year to the next, some employees reduce their risk while others' risks increase. This churn in the population has been demonstrated in other studies as well.[16,17] For example, 2072 employees were low risk for hypertension in 2004. In 2005, 84% of them remained low risk and 16% moved to high risk. See Figure 3.2 for a display of the hypertension risk transition in this population. Similarly, 1198 employees were high risk for hypertension in 2004 but 33% of them (N=400) moved to low risk in 2005. While the overall prevalence of hypertension changed from 37% of employees to 34% of employees during that time, in reality, 22% (N=727) of employees experienced a change (either positive or negative) in their risk for hypertension. The same types of changes occur from 2005 to 2006 as well so that, by 2006, 72% of those who were low risk for hypertension in 2004 remained low risk for the whole study and 55% of those who were high risk in

2004 remained high risk for all three years. These are the retention rates for low and high risk for hypertension.

Figure 3.2. Hypertension Risk Transition in 2004, 2005 and 2006.



The retention rates for obesity are 91% for low risk and 81% for high risk. The retention rates for low and high risk for glucose are 74% and 51%, for HDL they are 78% and 61%, and for triglycerides they are 71% and 68%. These numbers indicate much more risk change is taking place among individuals than is evidenced by the change in overall population prevalence of a risk factor.

The next analysis examines these risk changes in MetS and compares the cost changes which are associated with those risk changes. Costs include medical and pharmacy claims for each respective year, adjusted for inflation to reflect 2006 dollars. Results can be found in Table 3.1.

Table 3.1. Cost (Health Care + Pharmacy) in Each Year associated with MetS Status in that Year

	2004 No MetS				**2004 MetS**			
N	N=2297				N=973			
2004 Cost	$1611				$3148			
	$1588		$1781		$2587		$3392	
	2005 No MetS		**2005 MetS**		**2005 No MetS**		**2005 MetS**	
N	N=2030		N=267		N=294		N=679	
2005 Cost	$1727		$2175		$3104		$3439	
	$1705	$1946	$1225	$3179	$2240	$4165	$4258	$3298
	2006 No MetS	**2006 MetS**	**2006 No MetS**	**2006 MetS**	**2006 No MetS**	**2006 MetS**	**2006 No MetS**	**2006 MetS**
N	N=1822	N=208	N=137	N=130	N=162	N=132	N=101	N=578
2006 Cost	$2493	$2777	$2501	$2704	$1943	$4109	$3446	$4632

In Table 3.1, it can be seen that while the prevalence of MetS in this employed population was 30% in 2004, 29% in 2005 and 32% in 2006, many more changes were occurring in individuals that cannot be seen by simply examining the group prevalence rates. Furthermore, these risk changes in MetS were associated with commensurate cost changes. For example, the costs of those who did not have MetS (having <3 of the MetS risk factors) in 2004 were $1611. This compares with a cost of $3148 for those with MetS. In 2005, those who remained without MetS had lower costs than those who moved to having MetS ($1727 vs. $2175). It can also be seen that, even in 2004, those who were to become positive for MetS in 2005 had a higher group average cost ($1781) compared to those who would remain without MetS in 2005 (2004 average cost of $1588). This is also true of those who moved from having MetS in 2004 to not having it in 2005 or remaining with the syndrome in 2005 ($3104 vs. $3439). In each case, those who moved or remained low risk had smaller cost increases (and sometimes reductions) compared to those who moved to high risk or remained high risk.

Another observation of cost changes associated with risk changes is that costs tend to increase faster with an associated increase in risks compared to the change in costs that occur when risks are decreased. For example, those who were high risk in 2004 had an average cost of $3148. The group of employees who moved to low risk in 2005 saw their costs moderate to $3104, a decrease of $44 or 1.4%. On the other hand, those who were low risk in 2004 had an average cost of $1611. Those who moved to high risk in 2005 had a cost increase of $564 or 35.0%. Costs appear to increase much faster following a risk increase compared to the rate of cost decrease associated with a risk decrease. What is true in every year, however, is that low risk individuals have lower average costs than high risk individuals.

As a second outcome measure, the costs and incidence of STD absences were then examined in a similar fashion (Table 3.2).

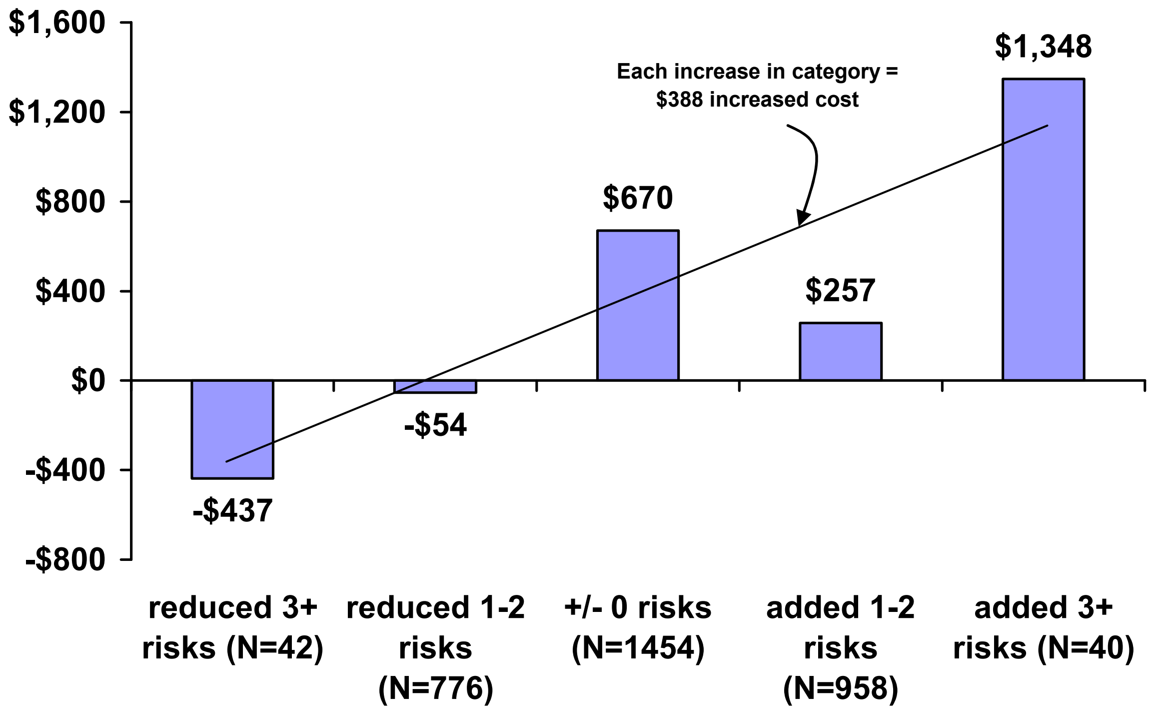
Table 3.2. MetS Risk Change and STD Incidence and Cost Change

2004 No MetS				**2004 MetS**			
N=2297				N=973			
4.4% with any STD absence				6.2% with any STD absence			
$52 avg. STD cost				$80 avg. STD cost			
$1211 avg. STD cost of those with STD				$1304 avg. STD cost of those with STD			
2005 No MetS		**2005 MetS**		**2005 No MetS**		**2005 MetS**	
N=2030		N=267		N=294		N=679	
5.0%		6.7%		5.1%		7.8%	
$56		$69		$82		$124	
$1130		$1207		$1501		$1597	
2006 No MetS	**2006 MetS**	**2006 No MetS**	**2006 MetS**	**2006 No MetS**	**2006 MetS**	**2006 No MetS**	**2006 MetS**
N=1822	N=208	N=137	N=130	N=162	N=132	N=101	N=578
4.4%	5.3%	4.4%	5.4%	5.6%	8.3%	8.8%	7.1%
$52	$57	$52	$70	$62	$108	$104	$106
$1028	$1152	$962	$1613	$1110	$1293	$1203	$1483

As with the health care cost changes, those who move or remain without MetS have lower STD incidence and cost than those who move to or continue to have MetS. This is true for both the percent of employees with any STD occurrence, the average STD cost for the entire group, as well as the STD cost solely among those with an STD claim.

The total costs (health care plus pharmacy plus STD) associated with changes in the number of MetS risk factors were then analyzed. The cost change from 2004 to 2006 was calculated for each individual (2004 cost was subtracted from 2006 cost for each person to calculate the cost change over time). Employees were then grouped based on the change in their MetS risk factors from a reduction of five risks to an increase of five risks. Figure 3.3 displays those results.

Figure 3.3. Adjusted Cost Change* from 2004 to 2006 associated with Changes in Number of MetS Risk Factors from 2004 to 2006



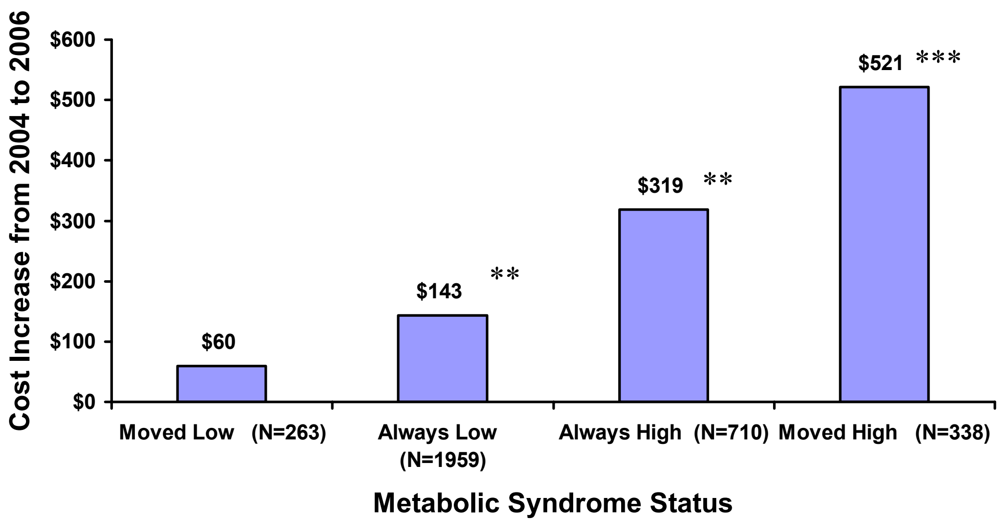
* Cost change (health care + pharmacy + STD) adjusted for age, sex and baseline costs.

As can be seen in Figure 3.3, those who reduced three or more MetS risk factors had an average cost reduction of $437 from 2004 to 2006 (after adjusting for age, sex and baseline costs) while those who reduced 1-2 risk factors had a cost reduction of $54. On the other hand, those who added 1-2 MetS risk factors had a cost increase of $257 and those who added 3 or more risks had the largest cost increase of $1348. A t-test found that the cost increase for those who added 3 or more risk factors was significantly greater than the cost change observed in each of the other four groups (p<.001).

A final group is comprised of those with no change in their number of MetS risk factors (N=1454 with a cost increase of $670). After plotting a regression line across groups, the slope of the line equaled $388. The group of employees who had a zero net change in risks experienced a cost increase of $670. This is a difficult group to analyze since it includes a wide variety of people. Those who had all five MetS risks in 2004 and 2006 as well as those who had zero of the risks in both time periods are included in this group, plus everyone in between. Also, those who reduced one risk but added a different risk are also in this category. Therefore, it is difficult to interpret the results for this group.

To further display the cost change associated with risk change, the employees were divided into four groups based on their MetS risk status in 2004 and 2006. Those who were “always low”, that is they were low risk for MetS in both 2004 and 2006 (irrespective of their risk in 2005), those who “moved low” from high risk in 2004 to low risk in 2006, those who were “always high” in both 2004 and 2006 and those who moved from low risk in 2004 to high risk in 2006 (“moved high”). Then, health care, pharmacy, and STD costs were combined to create an overall cost measure. See Figure 3.4 for these results.

Figure 3.4. MetS Change and Adjusted Cost Change* (Health Care, Pharmacy, STD) from 2004 to 2006



* Cost change adjusted for age, sex and baseline costs.
** p<.001 compared to "moved low" group.
*** p<.001 compared to the other three groups.

A trend is observed so that the costs of those who moved to low risk from 2004 to 2006 had the smallest cost increase ($60) compared to those who remained low risk during that time ($143). The cost increase of those who were high risk at both times ($319) and those who moved from low risk to high risk ($521) were higher. The cost increase of the "moved low" group was significantly smaller than each of the other three groups and the cost increase of the "moved high" group was significantly higher than the other three groups after adjusting for age, sex and baseline costs. It could be that a recent change in health, such as awareness of high blood pressure discovered at a screening, prompted physician visits and pharmacy expenditures. That would potentially explain why those who move from low risk to high risk see the largest increase in costs of any group.

The question then arises, which of the five individual risks are changing so that an overall change in MetS is observed? Table 3.3 shows the individual risk reductions taking place among those who moved from high risk to low risk for MetS from 2004 to 2006 compared to those who remained high risk for MetS during that time period.

Table 3.3. Odds of Reducing Individual Risks associated with Overall Change in MetS from 2004 to 2006

Odds of	**MetS in 2004 → No MetS in 2006 (High to Low) (N=263) compared to MetS in both 2004 and 2006 (High to High) (N=710)**	
	OR	**95% CI**
Reduced Risk for Obesity	33.87	(15.99, 71.86)
Reduced Risk for HDL	31.15	(17.34, 55.97)
Reduced Risk for Triglycerides	27.84	(14.98, 51.74)
Reduced Risk for Glucose	21.70	(12.00, 39.22)
Reduced Risk for Hypertension	15.31	(8.46, 27.72)
Sex	1.03	(0.52, 2.05)
Age	0.99	(0.97, 1.02)

It appears that reductions in the risk for obesity and HDL have the strongest association with reductions in the overall risk for MetS. Among those who had MetS in 2004 but did not meet the criteria for MetS in 2006, they were 34 times more likely to reduce their risk for obesity and 31 times more likely to reduce their risk for HDL compared to employees who met the criteria for MetS in both time periods. Individuals who improved their MetS status (moving from MetS to no MetS) were also 28 times more likely to reduce their risk for triglycerides, 22 times more likely to reduce their risk for glucose and 15 times more likely to reduce their risk for triglycerides compared to individuals who had MetS in both

2004 and 2006. Obesity may be the driving force behind improvements in MetS status. If the risk for obesity is reduced, perhaps other risk factors are simultaneously improved which lowers the overall risk for MetS.

Similarly, the risk increases were examined for those who moved to high risk or remained low risk from 2004 to 2006 and are shown in Table 3.4. Individuals who did not have MetS in 2004 but met the criteria in 2006 were compared to employees who did not have MetS in both time periods.

Table 3.4. Odds of Individual Risk Increases associated with Overall Change in MetS from 2004 to 2006

Odds of	**No MetS in 2004 → MetS in 2006 (Low to High) (N=338) compared to No MetS in both 2004 and 2006 (Low to Low) (N=1959)**	
	OR	**95% CI**
Increased Risk for Obesity	16.99	(9.91, 29.10)
Increased Risk for Glucose	16.47	(11.22, 24.28)
Increased Risk for HDL	14.42	(9.61, 21.61)
Increased Risk for Hypertension	14.10	(9.70, 20.53)
Increased Risk for Triglycerides	10.21	(7.03, 14.88)
Sex	1.39	(0.88, 2.23)
Age	0.97	(0.95, 0.98)

Again, obesity appears to be the leading risk factor driving changes in MetS. Those who developed MetS were 17 times more likely to increase their risk for obesity, 16 times more likely to increase their risk for glucose, 14 times more likely to increase their risk for HDL and hypertension and 10 times more likely to increase their risk for triglycerides compared to employees who did not have MetS in both 2004 and 2006.

Discussion

The prevalence of MetS in this Midwest worksite population (30% in 2004, 29% in 2005 and 32% in 2006) is slightly higher than the rates reported in nationally-representative samples which have ranged from 22.7%[18] to 23.9%[19]. However, these previous studies did not use the currently accepted definition of MetS that was used in this study. A MetS study in an aerospace worksite population located in the Northeastern United States found a prevalence rate of 27%[20] which is similar to the rates found here. However, their MetS criteria did not include individuals who were taking medication for glucose, triglycerides, HDL or hypertension as the current study does.

What is demonstrated in this study is that risks for MetS are in a constant state of change. The percent of individuals who were low risk for each of the MetS risks in 2004 and remained low risk for 2005 and 2006 ranged from 71% for triglycerides, 72% for hypertension, 74% for glucose, 78% for HDL, and 91% for obesity. The percent of individuals who were high risk for each of the risks in 2004 and remained high risk for 2005 and 2006 were 51% for glucose, 55% for hypertension, 61% for HDL, 68% for triglycerides, and 81% for obesity. For MetS overall, the low risk retention rate was 79% and the high risk retention rate was 59%. These numbers indicate that it is not enough to encourage risk reduction among those who are at risk. Because low risk individuals are moving to high risk, they need interventions which help them remain low risk, effectively cutting off the incidence of high risk employees.

The next analyses matched the health care, pharmacy and STD costs in each study year with the MetS risk status in each year. As in previous studies of health risk change and cost change, changes in risk were associated with changes in cost. That is, in each year, those who were low risk for MetS had lower costs than those who were high risk for MetS. Moreover, those who moved to low risk had lower costs than those who remained high risk and those who moved to high risk had higher costs than those who remained low risk. This gives further evidence that MetS is associated with the workplace outcome measures of health care cost, pharmacy cost and STD absences.

After counting up the number of MetS risks that were changed from 2004 to 2006, employees were collapsed into five groups and cost changes were calculated. The two groups who reduced MetS risks had a reduction in total costs ($437 reduction for those who reduced 3+ risks and $54 reduction for those who reduced 1-2 risks) while those who increased their MetS risks had cost increases of $258 (1-2 risks added) and $1348 (3+ risks added). The employees who had zero net change in MetS risks had a cost increase of $670. The $1348 cost increase was significantly different from all other groups. Again, these results provide evidence that MetS risks are associated with costs in an employed population.

The MetS status in both 2004 and 2006 was then compared with the cost change in that time period. The population was split into four groups: those who were high risk for MetS (having 3+ of the MetS risk factors) in 2004 but low risk in 2006 (called “moved low”); those who remained low risk in both time periods (“always low”); those who were high risk in both time periods (“always high”); and those who moved from low risk to high risk (“moved high”). In this analysis, the cost change was adjusted for age, sex and baseline costs. Results showed that those who moved low had the smallest cost increase of $60 which was significantly lower than all other groups. The “always low” group had a cost increase of $143. Those who were “always high” had a cost increase of $319 while the “moved high” group had a cost increase of $521 which was significantly greater than the other three groups after adjusting for age, sex and baseline costs. It appears that MetS status changes over time are significantly associated with cost changes even after adjusting for age, sex and baseline costs.

The individual risks that are associated with changes in MetS status overall were then analyzed. That analysis indicated that obesity may be more responsible for MetS status changes than any other risks. The risk factor which was least likely to be associated with changes in MetS status was triglycerides. It may be true that changes in obesity (both positive and negative) lead to changes in the other risk factors which then change the MetS risk overall. While most worksite-based weight improvement programs have not been found to be very successful over the long term,[21,22,23] population health management programs should continue to address people as whole systems so that low risks are maintained and high risks are reduced.

Limitations

This study was conducted in an employee population of a single large manufacturing corporation headquartered in the Midwest. Again, the results may not be generalizable because it is based on only a single company. 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 in most, if not all worksite analyses, it is impossible to conduct a randomized, prospective study on employees. HRA participation is voluntary so the population studied may not always be representative of the entire employee population. However, in this study, a near-universal participation rate indicates that this study population is representative of the corporation as a whole. However, the findings are specific to this population demographic which will be different from the population of employees in other types of industries such as banking or insurance, for example.

Another potential limitation of this study is the lack of data available on waist circumference. For a surrogate, BMI was used, which was measured in a screening. While the currently used definitions of MetS all rely on waist circumference as a measure of central adiposity, this measurement has been found to be subject to large amounts of error, particularly in men. Some researchers have suggested that if BMI is greater than 30, there is no need to measure waist circumference, as over 96% of those individuals would have a waist circumference above the gender- and ethnic-specific threshold values.[24] One study of MetS used both BMI and waist circumference and found the two measures to be highly correlated.[25] Another study compared waist circumference, BMI and waist-to-hip ratio in their ability to predict abdominal adipose tissue in men as determined by magnetic resonance imaging.[26] Results showed that waist circumference is the anthropometric index that 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 and BMI was a stronger predictor than waist-to-hip ratio.[26] 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

This worksite analysis gives employers information on the potential impact of MetS in employed populations over time. Of particular interest to employers, it was found that individuals with MetS had higher workplace outcome measures (health care, pharmacy and STD costs and STD occurrences) compared to those without MetS. Furthermore, changes in MetS over time are associated with commensurate changes in these costs. That information is encouraging to employers who are investing time and capital helping employees reduce their health risks and maintain their good health. Also, results indicate that obesity may be the risk factor most associated with changes in overall MetS status so employers need to identify successful health promotion programs to address that risk. If organizations are successful in encouraging high risk individuals to reduce their risks while also helping low risk employees remain low risk, they will improve the health and vitality of employees while also improving cost and productivity outcomes.

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Chapter IV

The Association between MetS and Disease in a Workplace Population

Introduction

Why is metabolic syndrome (MetS) important to recognize and treat? One reason is because individuals with this combination of risk factors are at increased risk of morbidity and mortality from a variety of health conditions. The definition of MetS has changed over the past decade as researchers identify 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] From the standpoint of its utility in determining those at risk for future disease, the currently best regarded definition of MetS has been published by Grundy et al. in association with the American Heart Association and National Heart, Lung and Blood Institute.[3] This definition confirmed the value of the ATP III criteria with some minor modifications, making the current standard for MetS risk criteria as follows: waist circumference (≥102 cm in men, ≥88 cm in women, or BMI >30 kg/m^2), triglycerides ≥ 150 mg/dl, HDL cholesterol <40 mg/dl for men or <50 mg/dl for women, blood pressure ≥ 130/85 mm Hg or blood pressure medication, and fasting glucose ≥ 100 mg/dl or glucose medication.

Since MetS includes many of the accepted risk factors for cardiovascular disease, it is expected to be a strong predictor of that medical condition.

Research does bear this out, with many studies finding that the risks of developing cardiovascular disease and cardiovascular mortality are higher among those with MetS compared to those without the syndrome.[4,5,6,7,8,9,10,11,12,13] But because of this obvious overlap between MetS and cardiovascular disease risk factors, some have argued that MetS does not provide any additional information over and above the individual well-known 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.

Non-diabetic individuals with MetS are at a higher risk of developing diabetes (five times higher in one study) compared to those without MetS.[15,16,17] Again, this is not unexpected due to the MetS risk factor of elevated fasting glucose levels. Other medical conditions found to be associated with MetS include the chronic pain condition fibromyalgia,[18] carpal tunnel syndrome,[19,20,21] asthma,[22] and polycystic ovary syndrome.[23,24]

But none of the above-mentioned studies were conducted in a worksite population. As corporations are the main payers of health care costs in the U.S., they have a vested interest in identifying the magnitude of MetS risks in employed populations and also in knowing if those risks are associated with other health risks or medical conditions. Many companies offer wellness programs to encourage employees to maintain their health and reduce health risks such as those which comprise MetS.

This study will identify the prevalence of MetS risks in the 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 will be assessed through self-report at time 1 in 2004 and at time 2 in 2006 to see if MetS risks are associated with increased rates of disease in an employed population. Furthermore, health care costs, pharmacy costs, and STD costs will be measured among those who meet the criteria for MetS but do not yet have disease to see if the risks themselves are associated with higher costs.

Methods

Population and Setting

Employees of a large manufacturing corporation headquartered in the Midwest were offered an annual HRA and wellness screening beginning in 2004. The screening achieved extremely high participation rates (from 85 to 95% of employees) in 2004, 2005 and 2006. Of the 3,635 individuals who were employed from 2004 to 2006 and participated in the company's medical plan, 3,285 (90.4%) participated in the HRA in 2004 and again in 2006. This is the population of interest in this study. The majority of employees during this time period were male (83.0%) and Caucasian (89.8%) with an average age of 40.8 years.

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 based on 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 directly from the University of Michigan Health Management Research Center.

The HRA also included data from a biometric screening which utilized 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 MetS risk factors. Blood pressure (≥130/85 mmHg), fasting glucose (≥110 mg/dl), triglycerides (≥150 mg/dl) and HDL cholesterol (<40 mg/dl in men and <50 mg/dl in women) were all measured. Waist circumference was not measured, so body mass index (>30 kg/m^2) was used as a surrogate. As indicated in the current criteria of MetS, if individuals have a BMI greater than 30 kg/m^2, it can safely be assumed that their waist circumference exceeds the risk level.[25] If an individual had any three or more of these risks they were classified as having MetS.

In addition to asking employees about the presence of 16 biological and lifestyle health risk factors (see Table 2.1 for a list of the risks and their criteria), the HRA included the following question about the presence of several chronic diseases: Has your doctor ever told you that you have had any of the following? The list of the chronic conditions 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, and stroke. Additionally, respondents were asked whether they were either being treated by a physician or currently taking medications for conditions that they had reported. This study was approved by the University of Michigan's Institutional Review Board.

Medical and Pharmacy Claims

Medical and pharmacy claims were also 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

Short-term disability (STD) absences were used as a measure of productivity loss. STD absences in 2004 and 2006 were summed for each individual, as was their STD cost, which was provided by the company. At this company, STD is designed to pay a weekly benefit when an employee has a non-occupational 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 8th 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 would benefit begin the 1st day of the disability. The maximum duration of Short Term Disability benefits paid is 26 weeks. If the employee is still disabled after 26 weeks, they are eligible for another 26 weeks on Short Term Disability, 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.

Statistical Analyses

The change in MetS risks from 2004 to 2006 was analyzed using χ^2 analysis. Differences in continuous and categorical variables in individuals with and without the MetS were tested using t-tests and χ^2 analyses, respectively. Generalized linear modeling tested the difference in demographics between those with and without MetS while controlling for age and gender differences. Logistic regression analysis was used to identify diseases associated with the presence of MetS. Generalized linear modeling was also used to determine significant differences in the costs of employees with MetS and disease while controlling for age and gender. All analyses were conducted using SAS 9.1 software. (SAS Institute Inc., Cary, NC)

Results

Prevalence of MetS

The prevalence of MetS risks in 2004 and 2006 are shown in Table 4.1.

Table 4.1. MetS Risks in 2004 and 2006 (N=3285)

MetS Risk	2004	2006
Glucose	31.3%	34.4%*
HDL	32.2%	32.6%*
Hypertension	36.7%	38.8%*
Obesity	32.1%	32.4%*
Triglycerides	43.0%	44.3%*
0 MetS Risks	23.5%	21.3%
Any 1 MetS Risk	24.1%	24.8%
Any 2 MetS Risks	22.6%	21.9%
Any 3 MetS Risks	16.7%	17.7%
Any 4 MetS Risks	9.7%	10.8%
All 5 MetS Risks	3.4%	3.6%
MetS (3+ Risks)	29.8%	32.1%*
% Reporting Heart Disease	2.4%	2.6%*
% Reporting Diabetes	3.0%	3.7%*

*Chi-square p<.001

The prevalence of each of the MetS risk factors increased significantly (Chi-square p<.001) from 2004 to 2006. So did the percent of employees with MetS (increasing from 29.8% in 2004 to 32.1% in 2006), and those who self-reported heart disease and diabetes.

Demographic Differences

The 980 employees with MetS in 2004 were compared to the 2305 employees without MetS to see differences in the demographics of the two groups. See Table 4.2 for a result of this comparison.

Table 4.2. Demographics of Employees with and without MetS in 2004 who also participated in the HRA in 2006

	Without MetS (N=2305)	With MetS (N=980)	p-value*
Average Age	41.3 years	44.5 years	<.0001
% Male	79.8%	89.4%	<.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 and health risks controlling for age and gender.

Those with MetS were significantly older than the other employees (average age 44.5 vs. 41.3 in 2004) and a greater percentage was male (89.4% vs. 79.8%). Because of these differences, and since age and gender are known to be significant confounders in the analysis of MetS,[28,29] all analyses control for these demographic variables. A smaller percentage of employees with MetS completed college, had household income ≥$75,000, were salaried status, were not married, or were Caucasian compared to other employees but the differences were not significant after controlling for age and gender.

Medical Conditions

Those with and without MetS in 2004 were compared to assess differences in the presence of medical conditions in 2004, while controlling for age and gender (see Table 4.3).

Table 4.3. Prevalence of Health Conditions 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 controlling for age and gender.

In this employed population, six of the thirteen health conditions were significantly more likely to occur in the MetS population compared to other employees. These six conditions were arthritis (14.8% vs. 8.4%, OR=1.48), chronic pain (5.3% vs. 3.3%, OR=1.52), diabetes (7.4% vs. 1.1%, OR=5.50), heartburn (15.3% vs. 9.8%, OR=1.58), heart disease (4.3% vs. 1.6%, OR=2.26), and stroke (0.5% vs. 0.2%, OR=2.25).

<u>MetS Risks and Prediction of Disease</u>

It was of interest to determine whether or not MetS risks and MetS itself were associated with new cases of disease. Table 4.4 shows the odds ratios and 95% confidence intervals for several multiple logistic regression models. 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) while controlling for age and gender. These were the diseases found to be significantly associated with MetS in the previous analysis (see Table 4.3). Therefore, each model excluded individuals who had that particular disease in 2004. Because of its extremely low prevalence in this population (three new cases in 2006), the incidence of stroke was not modeled.

Results found that persons at high risk for obesity and triglycerides were significantly more likely to self-report arthritis in 2006 (and none of them reported arthritis in 2004). These same risk factors were significantly associated with the incidence of chronic pain in 2006 as well. All five of the risk factors were associated with the incidence of diabetes while none of the risks were significantly associated with new cases of heartburn. Finally, hypertension and HDL were associated with the incidence of heart disease two years later.

Table 4.4. Odds of Newly Reporting Disease* in 2006 for those with each MetS Risk Factor in 2004

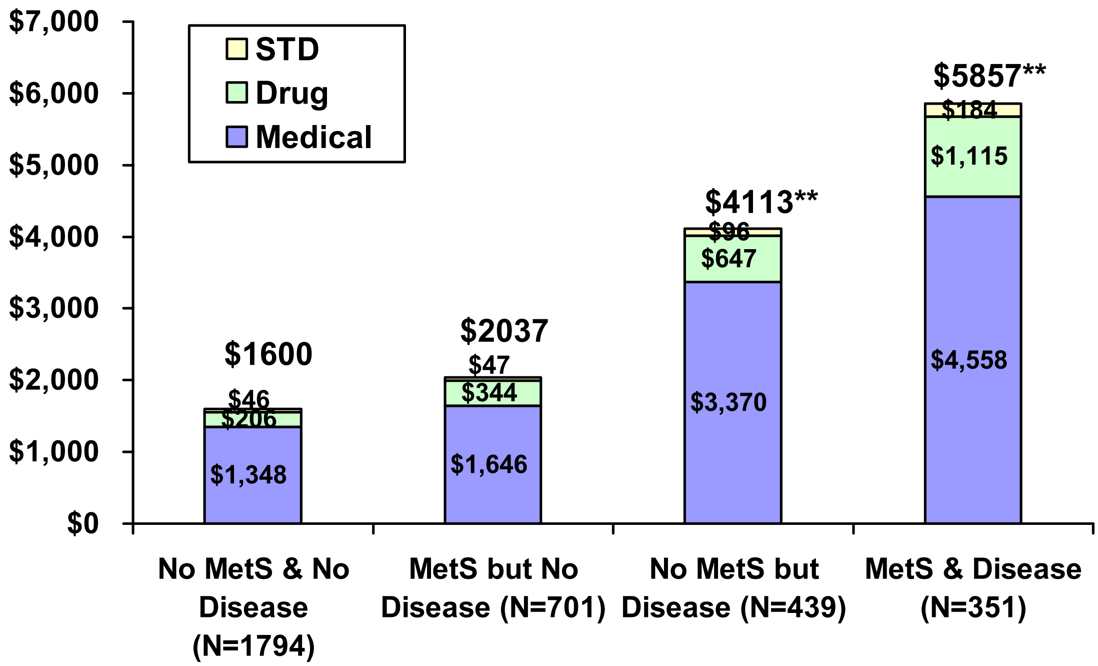
Risk Factor in 2004	Odds of Newly Reporting Arthritis in 2006 OR (95%CI)	Odds of Newly Reporting Chronic Pain in 2006 OR (95% CI)	Odds of Newly Reporting Diabetes in 2006 OR (95% CI)	Odds of Newly Reporting Heartburn in 2006 OR (95% CI)	Odds of Newly Reporting Heart Disease in 2006 OR (95% CI)
Obesity	**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 controlling for age and gender.**

MetS was 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.

Now that a relationship is indicated between MetS and certain diseases in an employed population, it is 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 disease. Figure 4.1 shows the costs (health care, pharmacy and STD) for each of those four groups in 2006.

Figure 4.1. 2006 Cost by 2006 MetS and Disease* Status

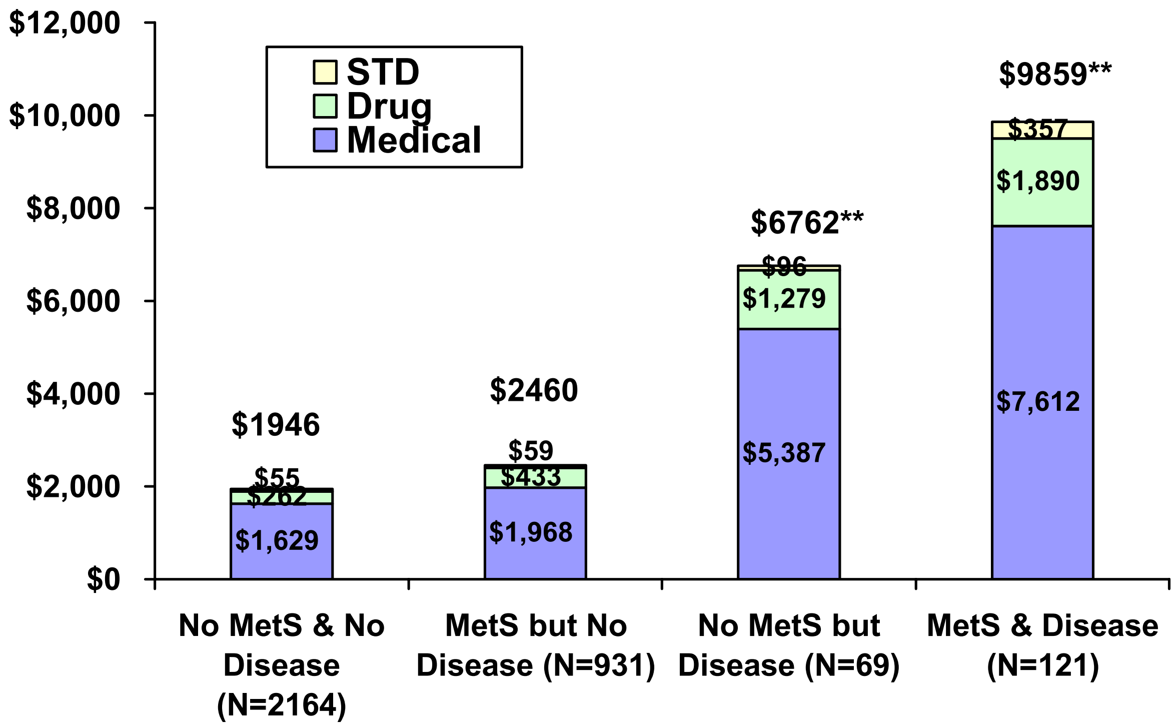


*Disease = self-reported heart disease, diabetes, arthritis, chronic pain, or heartburn.
** p<.0001 significantly different from all other groups.

As can be seen in the figure, the average costs increase from a low 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 in this case the diseases were limited to just diabetes and heart disease, which are considered to be the most costly diseases associated with MetS.[27] Results can be seen in Figure 4.2 and are similar to the results found in Figure 4.1 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.

Figure 4.2 2006 Cost by 2006 MetS and Diabetes/Heart Disease* Status



* Self-reported diabetes or heart disease.
** p<.0001 significantly different from all other groups.

Discussion

The prevalence of MetS in this employed population was 29.8% in 2004 and 32.1% in 2006. This is slightly higher than the prevalence found in nationally-representative studies reporting rates of 23% to 25%.[28,29] However those studies did not use the most recent definitions of MetS which include people taking medication for glucose, triglycerides, HDL and hypertension. The prevalence of MetS in this two-time participant population increased significantly from 2004 to 2006. Another study of the NHANES datasets from 1988-1994 and 1999-2000 have also indicated that rates of MetS are increasing in the U.S.[30]

As in other studies,[28,29] 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. The HRA used by this company asked employees about the presence of thirteen medical conditions. 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 an obvious association, given the overlap between the risks for MetS and the risks for those two conditions. There is also evidence in the literature that chronic pain conditions are associated with MetS. In one study, the chronically painful condition of fibromyalgia was associated with larger waist circumference, higher glycosylated hemoglobin and triglyceride levels, and higher blood pressure. The association found with heartburn and MetS may simply be an effect of the strong association between obesity and heartburn. However, when the five individual MetS risks, age and gender were included in a model predicting heartburn, both obesity and triglycerides were significant predictors. So perhaps the association with heartburn is due to more than just obesity. 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.

Given the associations found between MetS and these health conditions, it was of interest to determine whether MetS in 2004 was associated with new cases of arthritis, chronic pain, diabetes, heartburn and heart disease in 2006. Therefore, individuals who reported those conditions in 2004 were excluded from the analysis. The extremely small number of new cases of stroke precluded it from this analysis.

Employees with MetS in 2004 were significantly more likely to report new cases of arthritis (OR=1.999; 95% CI=1.359, 2.940); chronic pain (OR=1.607; 95% CI=1.021, 2.530); diabetes (OR=13.191; 95% CI=5.428, 32.059); and heart disease (OR=2.355; 95% CI=1.187, 4.673); but not heartburn (OR=1.172' 95% CI=0.789, 1.741). In order to minimize the level of disease among employees, organizations should address MetS and its health risks. Rates of diagnosed diabetes are increasing in the U.S.[31,32] and working populations are no exception. However, worksite health management programs have been shown to be effective in helping "pre-diabetic" employees reduce their risks to prevent full-blown diabetes even after two 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). First, all five of the associated diseases (arthritis, chronic pain, diabetes, heartburn or heart disease) were considered and individuals were grouped based on their MetS status and disease status. Those without MetS and without any of those diseases had the lowest costs ($1600). Those with MetS but no disease had higher costs ($2037) but they were not significantly different from the first group. Employees without MetS but who had a disease had significantly higher costs of ($4113) while those with both MetS and disease had the highest costs ($5857, $p<.001$ compared to all other groups). The costs of those with MetS and disease were 3.66 times greater than those without MetS and without disease. These 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. There is an opportunity for health promotion to prevent the MetS risks 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 these components.[34,35,36,37]

- A health risk appraisal (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 in order 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 these 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 Councils 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 in order to improve workplace productivity.

This analysis was repeated a second time but the disease category was limited to just diabetes or heart disease which are considered the most troubling consequences of MetS. The results in Figure 4.2 remained similar to the results in Figure 4.1 but the magnitude of costs changed. In this case, 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 4.1 (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.

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 U.S. population in any one 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 due to the healthy worker effect (HWE). The HWE most often is discussed in mortality studies since actively employed individuals consistently have a lower mortality rate than the general population.[43] However, it also applies to studies such as this which examine disease and other health condition prevalence among employed individuals.[44,45,46]

Limitations

A common limitation of worksite analyses is that the HRA participants in a company are not representative of the entire employee population. However, because of the near universal participation rate at this company, the population studied is representative of the corporation as a whole. 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.

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[47,48,49] 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 likely to occur 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) in 2006. It was unknown whether the diseases associated with MetS in the general population would also be found in a working population because of the healthy worker effect[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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Chapter V

MetS and Workplace Outcomes: Conclusions

This dissertation explored the prevalence and associated costs of MetS in an employed population. Results found that MetS appears to be just as prevalent in working populations as in nationally-representative samples. In the case of this predominantly male population of manufacturing employees, around 30% met the criteria for MetS. The employees with MetS were significantly more likely to have a variety of other health risks and health conditions compared to those without MetS. They also had significantly higher health care, pharmacy and STD absence costs and were more likely to report presenteeism (lost productivity while at work).

All three studies found that individuals with MetS consistently had higher costs (health care, pharmacy, and STD) than those without MetS. The final study also found that those with MetS were more likely to develop medical conditions than those without MetS. These results confirm that MetS is an important issue for corporate medical departments and worksite health promotion practitioners.

Studies of other diseases and health conditions have found them to be associated with higher costs as well. For example, while not conducted in a specific worksite setting, researchers reviewed studies on the health care costs of the overweight and obese compared to normal weight patients. Results found that as BMI category increased, costs ranged from 21-54% (BMI 30-35), 43-57% (BMI 35-40), and 78-111% (BMI >40) higher than normal weight individuals (BMI 20-24.9).[1] That study also found increased pharmacy costs (77-227% higher) compared to normal weight people.[1]

In a similar fashion, researchers have examined the workplace costs associated with medical conditions such as allergies. One such study found that those with allergies had significantly greater absenteeism, workers compensation, injuries, and health care costs compared to employees without allergies.[2]

Of course, the HRA has long been known to identify health risks which are associated with higher workplace costs.[3] So it is not surprising that the current study also found that individuals with MetS were more costly in terms of STD, health care, pharmacy and presenteeism compared to employees who did not meet the criteria for MetS. The findings here indicate that those with MetS have a total cost (health care, pharmacy and STD) 1.9 times higher than those without MetS ($4016 compared to $2117, p<.05). This is similar to the result in the allergy study which found that those with allergies had health care costs which were 1.8 times higher than employees without allergies. Another study of rheumatoid arthritis in the workplace used a set of matched controls and found that employees with rheumatoid arthritis had total costs (absenteeism, STD, health care and pharmacy) about 1.9 times higher than the matched controls.[4] Yet another study utilizing cases and matched controls found that those with irritable bowel syndrome had total costs (health care, absenteeism and presenteeism) 1.5 times higher than employees without the condition.[5]

In fact, a similar number was found when excess costs associated with excess health risks were calculated for six varied corporations. The health care cost of HRA participants who were at low-risk was compared to the cost of those at medium- and high-risk. After combining results across all six companies, the average ratio was found to be 1.7.[6] That is, employees who were medium- or high-risk had health care costs about 1.7 times higher (range of 1.4 to 2.1) than employees who were low-risk.

What is promising for those seeking to lessen the effects of MetS is that in the second study of this dissertation, cost changes were associated with MetS risk changes. That is, those who moved from high-risk to low-risk had lower costs than those who remained high-risk. Therefore, programs that are effective in helping individuals reduce their MetS risks may improve health and help mitigate the high increases in health and productivity costs that companies experience today. On the other hand, individuals who moved from low-risk to high-risk experienced higher costs than those who remained low-risk. Since most employees are low-risk for MetS (around 70% in this company), programs and benefit designs need to be geared for these individuals as well so that they can maintain their low-risk status and prevent movement into the high-risk group. While the costs of wellness programs range widely from as little as $10 per employee per year up to thousands of dollars per employee, The Wellness

Councils of America estimates that an effective, comprehensive program can cost about $100 to $150 per employee per year.[7]

Lastly, the third study focused on the association between MetS and disease in this working population. It was unknown whether or not the diseases associated with MetS in the general population would also be found in working people because of the healthy worker effect (HWE). The HWE most often is discussed in mortality studies since actively employed individuals consistently have a lower mortality rate than the general population.[8] However, it also applies to studies such as this which examine disease and other health condition prevalence among employed individuals.[9,10,11]

Results found that those with MetS were significantly more likely to also self-report arthritis, chronic pain, diabetes, heartburn and heart disease. Moreover, employees with MetS in 2004 were significantly more likely to self-report new cases of arthritis, chronic pain, diabetes and heart disease in 2006, showing the predictive power of MetS.

Clearly MetS is a cluster of health risks which require attention from the medical community as well as those involved in employee health. Employers would be wise to address the health risks of employees through health promotion programs and benefit plan designs which help individuals improve their health and receive appropriate health screenings and medical care.

Current guidelines for treating MetS focus on lifestyle changes as the first line of treatment followed by pharmacotherapy with lipid-lowering, antiplatelet, antihypertensive, or diabetic agents for those at higher risk.[12,13,14,15,16,17]

Awareness of side effects of drugs on coexisting disorders is important as well. The worsening of blood glucose levels caused by beta-blockers and diuretics is something to be avoided.[18] Physical activity, through its improvements in weight, blood pressure, and the utilization of glucose and free fatty acids, may reduce the progression from impaired glucose tolerance to type 2 diabetes that is often associated with MetS.[19,20] The overall quality of women's dietary profiles was also found to be associated with risks of MetS during a 12-year study of the Framingham Offspring-Spouse study.[21] Those in the worst nutritional tertile were 3 times as likely to develop MetS after 12 years of follow-up compared to those in the best tertile of nutritional profile.

Weight loss is an important component of any program addressing MetS risks[22] and was found in Chapter 3 to be closely tied to changes in overall MetS status. A randomized controlled trial of weight loss interventions examined the impact of weight loss on MetS risks in men and women with a BMI of 30-45 kg/m^2.[23] Patients were randomized to pharmacotherapy alone (sibutramine), lifestyle modification counseling alone, or the two treatments together. At the start of the program 34.8% of patients met the ATP III criteria for MetS. After one year of treatment, the average weight loss was 8.0 kg and there was a significant decrease in MetS prevalence to 27.2% ($p<.02$). Lifestyle modification alone and in combination with sibutramine significantly reduced the prevalence of MetS compared to sibutramine alone. The effect on MetS disappeared after controlling for weight loss.

Another study compared the effects of pharmacotherapy with a lifestyle intervention. In this case, 1711 adults with impaired glucose tolerance were randomized to receive metformin therapy, or intensive lifestyle intervention aimed at maintaining a 7% weight loss and 150 minutes of exercise per week, or a control group. After an average of three years of follow-up, MetS prevalence was reduced by 41% in the lifestyle group ($p<.001$) and by 17% in the metformin group ($p<.03$) compared to controls. The three-year cumulative incidence of MetS was also lowest in the lifestyle group.

A review of MetS intervention studies found that weight loss and exercise training were the two most effective lifestyle improvement programs in reducing risks for MetS. [24] Since long-term maintenance of those risks is important, programs with multiple follow-up sessions have shown more effectiveness than one-time programs. A second review of lifestyle interventions for MetS notes that interventions tailored to the specific needs of each person will maximize the chances of success.[25] Such programs focus on problem-solving skills, goal-setting, self-monitoring, stress management, and social support.

A lifestyle intervention for 375 dysmetabolic patients in Italy was evaluated for its effectiveness in preventing MetS.[26] All patients received general information from their physician regarding the importance of healthy lifestyle behaviors. The randomly selected intervention patients also received at least five one-hour education sessions covering diet, exercise and behavior modifications by health professionals. The intervention was associated with significantly reduced odds of developing MetS after one year (OR=0.28; 95%CI =

0.18, 0.44), as well as the prevalence of diabetes, central obesity and hypertriglyceridemia.

Another randomized study in Finland was part of the Diabetes Prevention Study and compared an intensive lifestyle intervention with standard care in overweight men and women with impaired glucose tolerance. After 3.9 years of follow-up, a significant reduction in the prevalence of obesity (OR=0.48; 95% CI 0.28, 0.81) and MetS was found in the intervention group compared to controls (OR= 0.62; 95% CI 0.40,0.95).[27]

Future research in this area should attempt to replicate the findings from this dissertation in industries with different employee demographics. Furthermore, cost-effectiveness research on interventions or other programs which help employees maintain their low-risks or improve their MetS risks would be valuable as organizations take steps to prevent MetS and its consequences among employees.

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