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Actuarial Model for Wellness

LITERATURE SEARCH

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Sibson Consulting

SOCIETY OF ACTUARIES

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Literature Search

Overview

This report summarizes the key findings and data points from the articles selected for our literature review. For each article, we include the report's abstract along with any empirical data available from the study that can help support an actuarial model that identifies the relationship between lifestyle behaviors, health risk conditions and health outcomes.

Selection Criteria

Sibson Consulting utilized its Information Research Center (IRC) to identify 133 wellness-related research articles and surveys, which were primarily published over the past 10 years. The Sibson research team reviewed the abstracts of the studies to identify 32 articles, including at least three research articles for each of the major modifiable risk factors (weight, diet/nutrition, fitness/physical activity, cholesterol, blood pressure, addictive behavior and stress/anxiety/depression). We selected studies of large U.S.-based populations (more than 1,000 lives, when available) where the abstract summaries appeared to focus on a quantifiable impact of the health risks related to health costs, presenteeism, absence, disability, turnover, mortality and/or workers' compensation costs. We tried to avoid any articles primarily focused on the evaluation of a program or on return in investment, unless the article included associated data on prevalence, cost and the impact of the specific risk factor/wellness on outcomes.

Gaps in Research

There appears to be a limited amount of data on the impact of wellness on disability, workers' compensation claims and productivity. By major risk factor, there appears to be the least number of useful (and recent) studies on the impact of hypertension (elevated blood pressure) on health care costs, mortality, etc. Some of what we were able to find was based on studies in Japan or Europe, which may not be appropriate for a U.S.-based model.

There may be a need for further review of condition-specific research that identifies more data on the risks that lead to the condition and the impact each condition has on mortality, disability, morbidity and safety. It may make sense to leverage the Society of Actuaries' research on disease management. The research does not definitively identify the order of risk factors in the progression of health from the inception of being healthy (or having a current state of no risk factors or conditions) to the actuarial outcome of death, disability, etc.

The conceptual model may be a series of tables defining the relationship between lifestyle risks, health risks, conditions and actuarial outcomes that takes us from one end of the spectrum to the other. Research appears to be missing the following components.

- ***Progression of health:*** To build the model, we need to define the stages along the progression of health, which may begin with a healthy or risk-free status; define the environmental factors that influence a person's health status; and identify the modifiable factors that lead to deterioration of health (lifestyle factors).

- ***Impact of time:*** The research does not discuss the length of time it takes for risk factors to impact morbidity and mortality. It does not take into account the impact of risk factors over time, their cumulative impact or the development of their associated costs over time. The factor of time is a very important one and has an overarching relation to all aspects of a possible model.

- ***Relationships:*** We need an understanding of the relationships between the risks in the various stages of the progression of health (e.g., the quantifiable impact stress has on hypertension incidence and related health care costs).

- ***Comorbidity:*** Health risks and conditions rarely happen in a vacuum. As such, consideration will need to be given to comorbidities among the risk factors and conditions. The effect of two risks likely are not additive. It will be important to understand how the presence of multiple lifestyle factors, risk conditions and disease states influence actuarial outcomes and impact. The research does not take into account interdependencies between the various risk factors and the related outcomes. For example, we know that depression has been linked to a great many risk factors and would appear to have a comorbid impact on a significant percentage of outcomes.

- ***Measurement standards:*** There currently is not a national standard for measuring lifestyle risks. As can be seen throughout the research summaries, each study uses slightly different standards for measuring health status.

- ***Population distinctions:*** The research does not distinguish between different populations (research results could be distinct or vary based on different industries, time periods, geographic areas, etc.). What applies for some populations may not apply for others.

- ***Measurement across actuarial outcomes:*** The research primarily focuses on the health impact of lifestyle factors and risk conditions. As the actuarial model progresses, additional research may be necessary to understand the impact on mortality, disability, workers' compensation, etc.

- ***Environmental factors:*** There are other environmental factors, such as demographics, genetics, physical environment and culture, that influence health. While this study does not address them specifically, it will be important to recognize and perhaps understand how they impact the lifestyle factors, condition risks, disease states and, ultimately, the actuarial outcomes and impact.

- ***Data capture:*** To populate a model across all of the factors along the progression of health, a very large database of information will be required. While most of the databases currently capture lifestyle and condition risks and the corresponding impact on morbidity, health costs and mortality, data on the impact on other actuarial outcomes is sparse or nonexistent.

- ***Behaviors:*** There is a gap in research about how individual people and organizations actually behave in wellness situations. Who will participate in a given wellness program, who will comply with its exercise recommendations, and how will an employer react to poor participation and compliance? To these and many similar questions, we don't have adequate

answers. This is a fundamental problem. If we do not know how people and organizations will behave, how can we model them?

Key Researchers

Through our analysis of the research and input from the Project Oversight Group (POG), the key researchers to contact for the third phase of this study should include a combination of traditional researchers in the area of wellness, an epidemiologist, experts in the area of modeling and an actuary with experience in developing an actuarial model for wellness. As such, the committee identified a group of contacts for the researcher interview portion of this study.

Research Approaches and Limitations

This list of research and data challenges includes limitations brought to light in the following two articles:

"Conceptual Framework, Critical Questions and Practical Challenges in Conducting Research on the Financial Impact of Worksite Health Programs," by David R. Anderson, Seth A. Serxner and Daniel B. Gold, *American Journal of Health Promotion* 15, no. 5 (May/June 2001): 281–88.

"Getting Closer to the Truth: Overcoming Research Challenges When Estimating the Financial Impact of Worksite Health Promotion Programs," by Ronald J. Ozminkowski and Ron Z. Goetzel, *American Journal of Health Promotion* 15, no. 5 (May/June 2001): 289–95.

The following is a list of limitations and challenges within the research and data available that could impact any type of research or modeling. Note this is not in order of importance.

- ***Conflict of interest:*** Some program funders and/or administrators may seek evidence that either supports or refutes an initial bias (per Ozminkowski and Goetzel). For example, a manufacturer of weight loss drugs or equipment may fund studies on the impact of obesity, yet they also may profit from results that support the need for its products.

- ***Study methodology type:*** Studies of the financial impact of health promotion programs often have methodological flaws. Previous literature reviews are met with skepticism; early impact studies were descriptive-only. Reviewing past studies (e.g., metastudies) is not an ideal way to create a new study as it is restricted by all those limitations of the studies they review, including conclusions based on studies that do not use identical methodologies, terminologies and similar data sets. Without randomization, Ozminkowski and Goetzel feel that more sophisticated statistical approaches need to address the impact of selection bias (e.g., paired matching, regression, modeling, fitting a curve to data, etc.).

- ***Selection bias:*** It is hard to develop a truly randomized controlled sample when it comes to wellness. Participants can differ from nonparticipants in motivation to take care of themselves where studies include optional participation (per Ozminkowski and Goetzel).

- ***Accounting for time value of money:*** Most published financial analyses fail to include adjustments for inflation and the time value of money. For financial analyses, most studies tend to use cost-benefit ratios (also called return on investment [ROI] ratios). Ozminkowski and Goetzel go on to say that Net present value (NPV) calculations are preferred over the ROI method. The NPV method deals with negative economic benefits easier.

- ***Sample size of studies are not all ideal:*** Ozminkowski and Goetzel also point out that small sample sizes (not credible data) lead to large variations. Decreasing the level of confidence (in a confidence interval calculation to support the outcome) would increase or support credibility. Also, the use of a randomized testing methodology to ensure the data is random enough would help increase the validity of the study.

- ***Skewed financial data:*** Zero dollar claims and a few very large (outlier) claims can cause problems as the distribution of claims does not match a normal distribution. Two-part regression models have been used to overcome this, but they are not used very often yet (Ozminkowski and Goetzel).

- ***Inconsistent measures for conducting studies:*** Ozminkowski and Goetzel point out that documenting outcomes and research's financial merits would benefit from consistent nomenclature and common data measures or types. In some cases, data may not be in a usable/viable form, as it may not be consistent if it is not all from the same source.

- ***Data aggregation:*** Comparing data from multiple sources (e.g., claims data with survey data that may not have unique identifiers) presents challenges in drawing valid conclusions.

- ***Security, confidentiality and privacy of data:*** Appropriate confidentiality agreements and security measures would be required to view, handle and use the detailed claims or eligibility data due to the Health Insurance Portability and Accountability Act (HIPAA) (per Anderson, Serxner and Gold).

- ***Data preparation:*** Authos Anderson, Serxner and Gold go on to say that accuracy and completeness of data will often cause problems. Once reviewed for accuracy and completeness, information then needs to be summarized in a meaningful format (i.e., claims data would likely have multiple records within it that need to be summarized).

- ***Population bias:*** Anderson, Serxner and Gold raise the point that varying underlying mortality or attrition rates for disparate groups can cause different financial outcomes. This can be minimized if the researcher controlled the study for baseline differences of various population segments (age/gender, industry, demographics, race, geography, etc.), but it may not mitigate the problem. There needs to be some sort of external validity to the study results.

- ***Quality research/studies take time:*** During the time it takes to conduct the research, environmental factors—such as legislation (e.g., seat belt laws), plan design (e.g., shift to

high deductibles) and behaviors (e.g., absenteeism increases because more sick time is used for elder or child care)—may change (Anderson, Serxner, and Gold).

- ***Attribution of reasoning:*** It is hard to isolate the cause when multiple changes occur (Anderson, Serxner, and Gold).

- ***Unpublished work:*** Researchers tend not to publish unfavorable study results (Anderson, Serxer, and Gold).

- ***Self-reported data:*** Self-reported data tends to be voluntary and can contain selection bias from under- or over-reporting. It can also include entry errors or exclusions that could compromise accurate results. Voluntary studies (as described by Anderson, Serxner and Gold) where populations are not controlled and defined by the study researchers can lead to bias in the responses (also see **study methodology type** above).

- ***Changing data:*** Changes in data over the length of a study may prove to be a challenge to capture. Some studies may not capture data for employees moving from one strata of health status to another during the period of the study.

- ***Quality of survey data:*** Questions in surveys and studies may not be thorough enough to capture the data required to get an accurate picture of the results.

- ***Sample size of study as a deterrent:*** While a larger sample size is an important factor for a study's credibility, it can deter a researcher from being able to receive complete and detailed data (such as absenteeism data).

- ***Outside influences:*** Outside influences to the study may not be considered in advance. There may be additional factors not controlled in the study that explain why a change came about in a population or a study group.

- ***Memory recall:*** Studies that ask participants to recall their level of health, absence or productivity depend upon how much a participant can remember and how productivity is defined. Memory-related data can lead to underreporting.

- ***Reporting relative data:*** Data, including descriptive data, reported by individuals will suffer in accuracy due to each person's understanding of the definition of each data item. For example, productivity measures must be defined carefully and in a detailed manner for each respondent to provide similar measures, but there will still be different understandings and relativities between those answers as not every individual will understand or report those measures the same.

- ***"Improvement" is often difficult to measure:*** The impact of health interventions and the benefit of medication is often difficult to quantify when studying the outcomes of some of these studies. This may, however, be related to the type of study being performed.

General Wellness Research

"The Impact of Weight Gain or Loss on Health Care Costs for Employees at the Johnson & Johnson Family of Companies," by G. S. Carls, R. Z. Goetzel, R. M. Henke, J. Bruno, F. Isaac and J. McHugh, *Journal of Occupational and Environmental Medicine* 53, no. 1 (January 2011): 8–16, doi:10.1097/JOM.0b013e31820451fd.

OBJECTIVE

"To quantify the impact of weight gain or weight loss on health care costs," according to the abstract.

METHODS

"Employees completing at least two health risk assessments [HRAs] from 2002 to 2008 were classified as adding, losing or staying at high/low risk for each of the nine health risks including overweight and obesity," the abstract states. "Models for each risk were used to compare cost trends by controlling for employee characteristics."

LIMITATIONS

This study used two different health risk assessments where risks varied for nutrition, physical activity and mental health. Sample sizes for many of the risk categories did not allow for a statistically significant conclusion. The study did not adjust for combined health risks, which may impact the calculation of the true impact of the change in risk.

RESULTS/CONCLUSIONS

According to the abstract, "Employees who developed high risk for obesity (n = 405) experienced 9.9 percentage points higher annual cost increases (95 percent confidence interval: 3.0 percent–16.8 percent) than those who remained at lower risk (n = 8,015). Employees who moved from high to lower risk for obesity (n = 384), experienced annual cost increases that were 2.3 percentage points lower (95 percent confidence interval: −7.4 percent to 2.8 percent) than those who remained high risk (n = 1,699). Preventing weight gain through effective employee health promotion programs is likely to result in cost savings for employers."

Table 2 in the article provides information on the progression of health through changes in risk factors. Table 3 summarizes the relationship between risk factors. Table 4 summarizes the impact on health care costs for each risk, and Table 5 provides additional details on the cost impact of changing risk factors.

WHAT IT MEANS FOR A CONCEPTUAL MODEL

The sample size for a comprehensive analysis will need to be large enough to draw valid conclusions. Achieving the desired sample size with consistent definitions of risk may present some challenges; however, a reasonable approximation might be to define risk for each of the

risk categories as done in this study to allow some level of analysis across measurement instruments.

STUDY-RELATED QUESTIONS

1) What level of sample size is required to conduct a valid analysis of each of the risk factors?

2) How can we appropriately reflect the impact of combined risks?

"The Relationship Between Health Risks and Health and Productivity Costs Among Employees at Pepsi Bottling Group," by Rachel M. Henke, Ginger S. Carls, Meghan E. Short, Xiaofei Pei, Shaohung Wang, Susan Moley, Mark Sullivan and Ron Z. Goetzel, *Journal of Occupational and Environmental Medicine* 52, no. 5 (May 2010): 519–27, doi:10.1097/JOM.0b013e3181dce655.

OBJECTIVE

"To evaluate relationships between modifiable health risks and costs and measure potential cost savings from risk reduction programs," as stated in the abstract.

METHODS

More than 11,000 Pepsi employees completed HRAs and this information was "linked to medical care, workers' compensation and short-term disability cost data," according to the abstract. "Ten health risks were examined. Multivariate analyses were performed to estimate costs associated with having high risk, holding demographics and other risks constant. Potential savings from risk reduction was estimated."

Ten health risks used were: overweight/obesity, high blood pressure, high blood glucose, high total cholesterol, physical inactivity, poor diet, stress, depression, tobacco use and alcohol consumption. Those setting the study parameters defined all risk strata except weight.

Both an average and an adjusted average cost for each risk factor/condition were determined, as seen in the report's Table 4.

The authors state that "The first set of rows presents results for weight risk. Employees with class III obesity had average unadjusted costs of $5,208 compared to employees at normal weight whose average unadjusted costs were $1,991, a difference of $3,217 (162 percent higher costs). The second column shows adjusted average costs that control for differences between employees with class III obesity and normal weight."

LIMITATIONS

1) The study is cross-sectional and looks at a fixed point in time. Employees' risk profiles and costs change over time, and these changes were not measured.

2) Self-reporting of hypertension, diabetes and hyperlipidemia may misclassify people if those people who have received the diagnosis have managed their condition properly.

3) Not all employees completed the health risk assessment. Those who do not fill out HRAs tend to be sicker than those who take them.

4) The nonlinear nature of relationship between risk and cost resulted in lower cost impact estimates when calculated for the average at-risk employee. The study chose to report the more conservative estimates.

5) Long-term associations between risk and costs were not studied, and studies that extend longer have more stable estimates of savings.

RESULTS/CONCLUSIONS

"High risk for weight, blood pressure, glucose and cholesterol had the greatest impact on total costs. A one percentage point annual reduction in the health risks assessed would yield annual per capita savings of $83.02 to $103.39," according to the abstract.

The abstract concludes: "Targeted programs that address modifiable risks are expected to produce significant cost reductions in several benefit categories."

WHAT IT MEANS FOR A CONCEPTUAL MODEL

This is good data that addresses the rarely captured workers' compensation claims and short-term disability costs, in addition to the standard medical/drug costs. This report also captured 10 risk categories through a large/credible study. The study also provides prevalence of health risks in a large population, as well as prevalence of medical care, workers' compensation claims and short-term disability claims received. This type of prevalence data is not common.

STUDY-RELATED QUESTIONS

1) The study's title mentioned productivity costs, but the study did not address presenteeism or absenteeism. Are disability and workers' compensation costs a reasonable measure of productivity?

2) What is the impact on mortality?

3) How does genetics or environment impact health conditions? For example, some conditions or risks may not be modifiable.

4) What is the prevalence of short-term disability or workers' compensation claims for those with various risk factors or demographics?

"Emerging Research: A View From One Research Center," by Dee W. Edington, *American Journal of Health Promotion* 15, no. 5 (May/June 2001): 341–49.

OBJECTIVE

To review recent findings, show research trends and identify critical research questions that will impact future research.

METHODS

Review quantitative relationships, program strategies and analytical methods used in research to uncover emerging trends. More than 2 million individuals are tracked in this database.

Analytical methods

Longitudinal data: Generalized estimating equations (GEE) are used to correlate data. Controlling for age and gender, it appears psychological items such as stress, use of medications to relax and job dissatisfaction are most associated with health risk factors longitudinally.

Fuzzy logic: Most studies use dichotomous cut points for health risks, which are accommodated by logistic regression where the independent variables are high or low risk and the dependent variables are the occurrence or nonoccurrence of disease, or high- or low-cost. There is an important concept of "fuzziness," which when applied to this topic implies that not all high-, borderline or low-risk measures are equal, and could have different meanings in the context with status of other factors such as demographics, age, other risks or genetics. When this analysis is conducted with fuzzy, rather than dichotomous, cut points, better results are obtained.

Data mining techniques: These newer techniques allow us to mechanically learn and recognize patterns in raw data. New data mining techniques could help us understand when an individual will develop a disease or become high cost. This represents a major paradigm shift to time-oriented messages from simply identifying precursors to disease.

LIMITATIONS

Not provided.

RESULTS/CONCLUSIONS

Quantitative relationships

Program participation: Program participation should be viewed from a multiyear view, as evidence exists that a very high percentage of eligible employees will participate in some way, over time.

Medical care costs associated with health risks: High risk in any one risk factor is associated with higher medical costs. Type of data that gets captured includes alcohol use, blood pressure, cholesterol, job and life satisfaction, safety belt use, smoking and stress. "Annual Medical Charges for Different Ages and Health Risk Groups" are found in Figure 3 in the article. Figure 4 demonstrates that as age increases, cost increases. As risk level increases, cost increases.

Wellness score associated with cost: There is a direct correlation of wellness score to medical cost (based on the self-reported information collected in a health risk assessment and scored on a uniform scoring system). The wellness score is sensitive to age, gender and presence of an

existing condition. On average, a 10-point increase in the wellness score equates to about a $360 reduction in annual health care costs.

Changes in cost follow changes in risk: There is no way to measure early savings perfectly or guarantee success of a wellness program within a year's time. Early success can be difficult to prove and research is underway to determine how to partition outcomes to capture early returns on a design or program change.

Savings to cost ratios: Lower costing (less robust) wellness programs are more likely to achieve a savings-to-cost ratio of 3:1 within a three-year period (this assumes the plan is set up and communicated properly). The larger, more robust wellness plans are less likely to be able to achieve that savings-to-cost ratio within a three-year period. It could take as long as five years (or more) to achieve the 3:1 savings-to-cost ratio if the program is costly (large and intricate) to start with (note this still assumes the plan is set up and communicated properly).

Risk reduction and risk avoidance: Reducing the number of risks results in a reduction in annual medical care costs, and this has been shown to hold true in periods of less than one year. Figure 5 in the article shows changes in costs related to changes in risks over a two-year period based on HRA information, and this study results showed an average increase in cost of $350 per added risk per year vs. an average decrease of $150 per decreased risk factor per year.

Productivity costs associated with risks: Excess disability days are associated with excess risk. In one study, it was shown that while all diseases result in a loss of productivity, the low-cost diagnoses such as asthma, allergies, mental health and irritable bowl are associated with high loss of productivity, while alternatively, the cancers and heart diseases may result in higher medical costs but generate less loss of productivity.

Program strategies

The natural flow of a population: Results included in the report's Table 2 show risk prevalence vs. cost categories over a two-year period for a group of 5,121 employees, which was tracked at the beginning of a wellness program.

Table 1 in the article, presents high risk criteria for various health risk measures and defines overall risk as low if participant has 0-2 high risks, medium if 3-4 high risks and high as 5 or more high risks. Low cost is $0–$999, medium cost is $1,000–$4,999, and high cost is $5,000 or more. The goal of a wellness program should be to move the population into the low-cost or low-risk categories. For example, the data in Table 2 showed that 2,603 individuals were at low risk in year 1 and remained low risk in year 2; however, 423 individuals moved from low risk in year 1 to medium risk in year 2. If a program is to be successful, at the end of year 2, there should be more individuals at low risk. The researcher's analysis has shown that the most effective way to increase the portion of people in the low-risk category is to prevent those at low risk from moving to medium or high risk, or keep healthy people healthy.

Risks that cluster with others: One of the major issues facing health promotion professionals is how to most effectively reach large populations with a diverse set of health profiles. Although being overweight is almost always the most prevalent risk in a population, it is observed that overweight individuals are often in the overall low-risk category (one or two risks overall). It is

important to look at clusters of risks likely to travel with one another. Edington addresses risk clusters in another article he coauthored.[1]

WHAT IT MEANS FOR A CONCEPTUAL MODEL

1) The study provides estimated/approximated age by combined (aggregated) risk factor health cost data, which may allow us to factor in comorbid risks or build related assumptions in determining their impact on health costs and beyond.

2) The study provides a proven correlation of wellness scores to health care costs, which may provide a methodology for adjusting actuarial tables.

3) The study provides prevalence of multirisk states and average costs associated with each state at the point of a wellness program's inception. More precise data may be necessary to understand these averages to use them in a model.

4) An understanding of the "natural flow of a population" could be used as a baseline comparison for the introduction of a wellness and/or disease management program.

5) The study identifies newer analytic methodologies that can be used to obtain better results.

STUDY-RELATED QUESTIONS

1) Can data be made available from Edington's database to gather more precise measures and estimates? Even to put numbers to his charts would be helpful.

2) Was any work done on correlation of risk factors and their impact on disease state prevalence? Mortality? Disability? Injury? Other Edington research studies suggest that he captures these data points in his database.

3) Are there incremental costs for each risk factor available?

"The Relationship Between Modifiable Health Risks and Group-Level Health Care Expenditures," by David R. Anderson, R. William Whitmer, Ron Z. Goetzel, Ronald J. Ozminkowski, Jeffrey Wasserman and Seth Serxner, Health Enhancement Research Organization (HERO) Research Committee, *American Journal of Health Promotion* 15, no. 1 (September/October 2000): 45–52.

OBJECTIVE

"To assess the relationship between modifiable health risks and total health care expenditures for a large employee group," according to the abstract.

METHODS

[1] Alexandra Braunstein, Yi Li, David Hirschland, Tim McDonald, and Dee W. Edington, "Internal Associations Among Health-Risk Factors and Risk Prevalence," *American Journal of Health Behavior* 25, no. 4 (July 2001): 407–17.

The HERO database consists of 61,568 employees of six large employers: Chevron Corp., Health Trust Inc., Hoffmann-LaRoche Inc., Marriott Corp., and the states of Tennessee and Michigan.

"Risk data collected through voluntary participation in health risk assessment (HRA) and worksite biometric screenings and linked at the individual level to health care plan enrollment and expenditure data from employers' fee for service (FFS) plans over the six-year period," the abstract states.

About the subjects: "Of the 50 percent of employees who completed the HRA, 46,026 (74.7 percent) met all inclusion criteria for the analysis."

According to the abstract: "Eleven risk factors (exercise, alcohol use, eating, current and former tobacco use, depression, stress, blood pressure, cholesterol, weight and blood glucose) were dichotomized into high-risk and lower-risk levels. The association between risks and expenditures was estimated using a two-part regression model, controlling for demographics and other cofounders. Risk prevalence data was used to estimate group-level impact of risks on expenditures."

LIMITATIONS

There was a selection bias of 50 percent of employees voluntarily participating in HRA and biometric screening.

RESULTS/CONCLUSIONS

The study identified the marginal cost impact for each risk factor. In total, the evaluated "risk factors were associated with 25 percent of total expenditures. Stress was the most costly factor with tobacco use, overweight and lack of exercise also being linked to substantial expenditures," the abstract states.

"Modifiable risk factors contribute substantially to overall health care expenditures," the abstract concludes. "Health promotion programs that reduce these risks may be beneficial for employers in controlling health care costs."

WHAT IT MEANS FOR A CONCEPTUAL MODEL

1) The study provides prevalence data on health risk factors in the population and the marginal impact of the factors on health care costs.

2) The regression methodologies may be used to also identify the marginal impact of various lifestyle factors and risk conditions on the prevalence of disease states and actuarial outcomes and impact.

STUDY-RELATED QUESTIONS

1) What is the prevalence of multiple risk factors?

2) How does the presence of multiple risk factors affect the results?

3) Due to control for the presence of diseases, are the spurious results associated with nutrition also impacting the results shown for other risk factors, either positively or negatively?

"Exceptional Longevity in Men: Modifiable Factors Associated With Survival and Function to Age 90 Years," by Laurel B. Yates, Luc Djousse, Tobias Kurth, Jule E. Buring and J. Michael Gaziano, *Archives of Internal Medicine* 168, no. 3 (February 11, 2008): 284–90, doi:10.1001/archinternmed.2007.77.

OBJECTIVE

From the abstract: "Prospective data on nongenetic determinants of exceptional longevity are limited, and information on long-lived men and their functional status is particularly sparse. We examined modifiable factors associated with a life span of 90 or more years and late-life function in men."

METHODS

"In this prospective cohort study of 2,357 healthy men (mean age, 72 years) within the Physicians' Health Study (1981–2006), biological and lifestyle factors and comorbid conditions were assessed by self-report with baseline and annual questionnaires. Mortality and incidence of major diseases were confirmed by medical record review. Late-life function was assessed 16 years after baseline by the Medical Outcomes Study 36-Item Short-Form Health Survey," the abstract states.

LIMITATIONS

Information regarding biological/behavioral factors is self-reported. Restricting the population to initially healthy, white male physicians impacts the generalizability of the results but removes confounding factors from the equation. Some factors impacting longevity were not accounted for. The effect of possible changes in all risk factors and in functional status over the follow-up period was not captured.

RESULTS/CONCLUSIONS

"A total of 970 men (41 percent) survived to at least age 90 years," the abstract states. "Smoking was associated with increased risk of mortality before age 90 years (hazard ratio [HR]; 2.10; 95 percent confidence interval [CI], 1.75–2.51), and similar associations were observed with diabetes (HR, 1.86; 95 percent CI, 1.52–2.26), obesity (HR, 1.44; 95 percent CI, 1.10–1.90), and hypertension (HR, 1.28; 95 percent CI, 1.15–1.43). Regular exercise was associated with a nearly 30 percent lower mortality risk (HR, 0.72; 95 percent CI, 0.62–0.83). The probability of a 90-year life span at age 70 years was 54 percent in the absence of smoking, diabetes, obesity, hypertension or sedentary lifestyle. It ranged from 36 percent to 22 percent with two adverse factors and was negligible (4 percent) with five. Compared with nonsurvivors, men with exceptional longevity had a healthier lifestyle (67 percent vs. 53 percent had one adverse factor), had a lower incidence of chronic diseases, and were three to five years older at disease onset. They had better late-life physical function (mean ± SD score [maximum 100], 73 ± 23 vs. 62 ± 30; $P < .001$) and mental well-being (mean score, 84 ± 14 vs. 81 ± 17; $P = .03$). More than 68 percent (vs. 45 percent) rated their late-life health as excellent or very good, and less than 8

percent (vs. 22 percent) reported fair or poor health (P < .001 for trend). Regular exercise was associated with significantly better—and smoking and overweight with significantly worse—late-life physical function. Smoking also was associated with a significant decrement in mental function."

The abstract concludes: "Modifiable healthy behaviors during early elderly years, including smoking abstinence, weight management, blood pressure control and regular exercise, are associated not only with enhanced life span in men but also with good health and function during older age."

WHAT IT MEANS FOR A CONCEPTUAL MODEL

1) The study found relationships between lifestyle factors and mortality. Smoking abstinence, weight management, blood pressure control and regular exercise (all risk factors related to the model) all reduce mortality (one of the outcomes being measured), and comorbidities have a greater impact.

2) The study also found a relationship between lifestyle factors and secondary outcomes of major diseases such as major age-related diseases: cancer (excluding nonmelanoma skin cancer); coronary heart disease (myocardial infarction, coronary artery bypass graft or percutaneous coronary angioplasty); and stroke. These outcomes were confirmed through medical record review by the PHS end points committee according to previously described procedures. The authors also examined occurrence of heart failure, chronic obstructive pulmonary disease, peripheral vascular disease, Parkinson's disease and arthritis. Only the first event in each disease category was considered for analysis.

3) The study also found a relationship between lifestyle factors and function. The authors assessed functional status by the physical function and mental health subscales of the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36) included in the 16-year follow-up questionnaire (1998–99). Each subscale is scored separately from 0 (lowest level of functioning) to 100 (highest level). For this study, the authors also scored separately two questions from the mental health items relating to depression. They used the SF-36 question on self-rated health as a general measure of health-related quality of life. They assessed social contact by questions relating to frequency of contact with a close confidant and self-related health, both related to morbidity.

STUDY-RELATED QUESTIONS

1) Do these factors have a similar impact on cohorts at lower ages, given that the population studied would not necessarily be the target of wellness?

2) Is there a more concrete measure of morbidity, such as health care costs, that was examined as part of this group?

3) Does the prevalence of risk factors among this group reflect that of the typical working population?

4) Can the results of this study on men be generalized to women?

"The Association of Health Risks With On-the-Job Productivity," by Wayne N. Burton, Chin-Yu Chen, Daniel J. Conti, Alyssa B. Schultz, Glenn Pransky and Dee W. Edington, *Journal of Occupational and Environmental Medicine* 47, no. 8 (August 2005): 769–77.

OBJECTIVE

"Decreased on-the-job productivity represents a large yet poorly characterized indirect cost to employers. They studied the impact of employee health risk factors on self-reported worker productivity (presenteeism)," as stated in the abstract.

METHODS

"Using a brief version of the Work Limitation Questionnaire incorporated into a Health Risk Appraisal, 28,375 employees of a national company responded to the survey," according to the abstract. "The association between health risks and work limitation and each of the four domains [time, physical, mental and output] was examined. Percentage of lost productivity also was estimated."

LIMITATIONS

The authors listed several limitations of their study, including the assessment of presenteeism with a single question, which may not be sensitive enough. Also, that question has not been validated against other measures of productivity.

RESULTS/CONCLUSIONS

The abstract states: "Ten of 12 health risk factors studied were significantly associated with self-reported work limitations. The strength of the associations varied between risks and the four domains of work limitation. Perception-related risk factors such as life dissatisfaction, job dissatisfaction, poor health and stress showed the greatest association with presenteeism. As the number of self-reported health risk factors increased, so did the percentage of employees reporting work limitations. Each additional risk factor was associated with 2.4 percent excess productivity reduction. Medium and high-risk individuals were 6.2 percent and 12.2 percent less productive than low-risk individuals, respectively. The annual cost of lost productivity in this corporation is estimated at between $99 million and $185 million or between $1,392 and $2,592 per employee."

WHAT IT MEANS FOR A CONCEPTUAL MODEL

1) The study provides one methodology that may be used to analyze the impact of health on employee productivity.

2) This study demonstrates the impact of work limitations and health risk factors on presenteeism (productivity).

3) The data could be used to determine the impact of certain risk factors (and number of risk factors) on productivity.

4) The risk factors do not match up exactly to the items initially evaluated, butthe study could be helpful in determining the productivity impact.

STUDY-RELATED QUESTIONS

1) Will the risk factors used in this study be comparable to risk factors analyzed in other studies being reviewed?

2) The data analyzed is mostly from females. Will this skew the numbers used for the overall population?

"Health, Absence, Disability and Presenteeism Cost Estimates of Certain Physical and Mental Health Conditions Affecting U.S. Employers," by Ron Z. Goetzel, Stecey R. Long, Ronald J. Ozminkowski, Kevin Hawkins, Shaohung Wang and Wendy Lynch, *Journal of Occupational and Environmental Medicine* 46, no. 4 (April 2004): 398–412.

OBJECTIVE

The article compiles data from various approaches to measuring productivity losses in the workplace related to certain prevalent and costly health conditions. Using a standard yardstick that quantifies absence and on-the-job productivity loss, the authors examine various studies that attempt to quantify productivity impacts associated with multiple health conditions common to employees.

METHODS

Data sources:

- The Employer Health Coalition's Healthy People/Productive Community Survey was administered in 1998 and 1999 to employees of eight large employer members of the coalition.

- The American Productivity Audit (APA): Advance PCS's 15-minute telephone survey was administered over a 10-month period to more than 25,000 randomly selected U.S. workers and a random subsample of those who were not working for pay.

- The MacArthur Foundation Midlife Development in the United States Survey (MIDUS) presenteeism instrument survey was administered to 2,074 adults age 25 to 54. The research team was headed by Dr. Ron Kessler at Harvard University. The survey focused on work impairment related to several commonly occurring chronic conditions: arthritis, asthma, autoimmune disease, cancer, diabetes, general anxiety disorder, heart disease, hypertension, major depression, panic, substance dependence and ulcer.

- The Bank One Worker Productivity Index (WPI) recorded absence, short-term disability and presenteeism data for telephone customer service operators at its Elgin, IL location in 1995. Absence and disability time were used to measure actual time away from work. On-the-job productivity losses were calculated based on an electronic time-keeping system that

measured time spent away from the employee's workstation. Of the 1,039 employees at the site, 564 completed an HRA that recorded feelings of distress and risks for diabetes, hypertension, high cholesterol and being overweight.

- The Work Productivity Short Inventory (WPSI) was developed to estimate decrements in employee productivity with 15 common disease conditions. Eleven of these conditions pertain directly to employees, and four pertain to caregivers provided by employees to their spouses, dependents or elders. The 11 conditions include allergies, respiratory infection, arthritis, asthma, anxiety disorder, depression and bipolar disorder, stress, diabetes, hypertension, migraine and other major headaches, and coronary heart disease/high cholesterol.

- The Medstat MarketScan Health and Productivity Management (HPM) Database was used to generate metrics from administrative claims for this study. The database contains person-level information on 374,799 employees from 1997–99 and includes information about benefit plan enrollment, inpatient and outpatient health care services, pharmaceutical claims, absence records and short-term disability claims for workers at six large corporations with locations in 43 states.

- The study used HPM for an initial list of prevalent and costly conditions considered for the study. Analysis focused on a top 10 list of conditions that were common across surveys and highlighted in Goetzel et al.'s analysis of administrative claims. The top 10 conditions common across surveys were allergy, arthritis, asthma, any cancer, depression/sadness, diabetes, heart disease, hypertension, migraine/headache and respiratory infections. Absenteeism and presenteeism rates were converted into standard percentage metrics, and average, low and high values were examined. Differences between low and high were categorized by being high (greater than 20 percentage points), medium (between 11 percent and 19 percentage points) and low (10 or fewer percentage points).

  To monetize the absenteeism and presenteeism rates, they multiplied the number of unproductive hours by $23.15, which represents the year 2001 average hourly wages and benefits for all U.S. companies, as reported by the U.S. Bureau of Labor and Statistics (BLS).

  Next, they added the direct medical costs for the 10 diseases to the indirect costs (absenteeism and short-term disability). These were then added to the costs associated with presenteeism that were obtained by manipulating the results from the published presenteeism survey analysis. This resulted in an estimate of the total economic burden associated with certain physical and mental illness conditions.

LIMITATIONS

1) Absenteeism and short-term disability figures obtained from the HPM database came from the same employers but not always the same employees.

2) Absenteeism records either tend to be missing for exempt staff or tend to be decentralized; it was not feasible for employers to collect this information for all employees, so they used the more readily available data.

3) The average hourly wage benefit figure of $23.15 to measure impact of short-term disability and absenteeism could be conservative or not, depending on the level of employee, team environment, etc.

4) There was a lack of a standard metric for reporting presenteeism across the survey tools. There was a great deal of variability in how conditions were defined and presented to respondents.

RESULTS/CONCLUSIONS

Of the top 10 conditions examined in which more than one prevalence estimate was recorded, allergy and migraine/headache conditions were found to be most prevalent. However, there is relatively high variability across the survey instruments in the reported condition prevalence rates.

WHAT IT MEANS FOR A CONCEPTUAL MODEL

1) Prevalence data on various diseases was provided across several studies.

2) Cost estimates of the impact of these diseases on an employer, including health, absence, disability and presenteeism/productivity, was provided.

3) This article gives a discussion of the various tools available for assessing worker productivity, presenteeism and the impact of work limitations that may be helpful in the development of an appropriate measure for the actuarial model.

STUDY-RELATED QUESTIONS

1) With the variability of prevalence across the different data sources, could this be successfully integrated into the model? For those with low variability, this could be a good source.

2) Could we build in productivity loss costs based on the data provided?

3) Are we comfortable with the data sources used in this study to do these projections?

Weight

"The Cost of Obesity in the Workplace," by Eric A. Finkelstein, Marco daCosta DiBonaventura, Somali M. Burgess and Brent C. Hale, *Journal of Occupational and Environmental Medicine* 52, no. 10 (October 2010): 971–76, doi:10.1097/JOM.0b013e3181f274d2.

OBJECTIVE

As stated in the abstract: "To quantify the per capita and aggregate medical expenditures and value of lost productivity, including absenteeism and presenteeism, because of overweight" or obese, by the varying obese grades.

METHODS

A cross-sectional analysis of the 2006 Medical Expenditure Panel Survey (MEPS) and the 2008 National Health and Wellness Survey (NHWS) was used.

MEPS quantifies total annual medical spending by type of service and source of payment for a civilian noninstitutional population. It also includes a self-reported body mass index (BMI) for each household member. This study was then limited to full-time employees age 18 or older, less pregnant women and individuals with a BMI under 18.5. The final group consisted of 5,294 men and 3,581 women.

Absenteeism and presenteeism was assessed using the NHWS cross-sectional study of health status and health care attitudes, behaviors and outcomes of those age 18 or older. This is a self-administered Internet-based questionnaire filled out by 63,000 members of an Internet consumer panel stratified by race, gender and ethnicity. The same exclusions applied to MEPS were applied to NHWS; 13,878 men and 10,262 women were left in the sample.

LIMITATIONS

1) The data for BMI, medical expenditures, absenteeism and presenteeism was self-reported.

2) NHWS was an Internet-based study, and participants were more educated and had a higher degree of smokers. If the relationship between BMI and absenteeism/presenteeism differs by education level or smoking status, this may introduce bias.

3) The study focuses on full-time employees, as part-time employees often bear part of the cost resulting from excess weight by paying more into the system. There is also some evidence that obese employees, especially women, receive lower compensation than their normal weight counterparts, which suggests not all of the cost of obesity is borne by the firm. Also, those who move from full time to part time or unemployed due to their weight are not captured in this study.

RESULTS/CONCLUSIONS

"Among men, estimates range from −$322 for overweight to $6,087 for grade III obese men. For women, estimates range from $797 for overweight to $6,694 for grade III. In aggregate, the annual cost attributable to obesity among full-time employees is $73.1 billion. Individuals with a body mass index >35 represent 37 percent of the obese population but are responsible for 61 percent of excess costs," the abstract states. "Successful efforts to reduce the prevalence of obesity, especially among those with a body mass index >35, could result in significant savings to employers."

With the exception of overweight men, medical expenditures, absenteeism and presenteeism increase with BMI.

WHAT IT MEANS FOR A CONCEPTUAL MODEL

1) This study provides prevalence by gender, and separately by weight class. Either this data can be used to extrapolate gender by weight class, or another study can be used to capture this data. The Milliman study "Impact of Height, Weight and Smoking on Medical Claims Costs"[2] might be useful.

2) The per capita claims cost based on medical and drug claims, and self-reported presenteeism and absenteeism data, addresses the value or impact of being in a particular weight class to each of those aspects of an annual cost.

3) The study presents presenteeism and absenteeism data in terms of days, which provides an idea of the impact of obesity to the life cycle of an employee. Note this study is employee-based, not based on a general population, and it required those included be covered by medical and drug insurance.

4) MEPS and NHWS may be a source of data for the actuarial model.

STUDY-RELATED QUESTIONS

1) What is the probability of moving from one weight class to the next based on sedentary behavior vs. a healthy lifestyle (impact of diet/nutrition and exercise)?

2) What is the turnover rate (people moving in and out of the study)?

3) Can the prevalence data for levels or grades of obesity be used to make assumptions, or can other data be used to apply to this population?

4) What is the likelihood that a person is capable of moving from one weight class to another (vs. those who are predisposed by genetics or environment)?

5) What impact does obesity have on disability prevalence and life longevity?

6) What conditions or behaviors led to these people being in their weight class?

2 Jonathan Shreve and Mary van der Heijde, "Impact of Height, Weight and Smoking on Medical Claims Costs: Research from the annual update of Milliman's Medical Underwriting Guidelines," Milliman Research Report, April 2009.

"Individual and Aggregate Years-of-Life-Lost Associated With Overweight and Obesity," by Eric A. Finkelstein, Derek Brown, Lisa Wrage, Benjamin Allaire and Thomas Hoerger, *Obesity* 18, no. 2 (February 2010): 333–39, doi:10.1038/oby.2009.253.

OBJECTIVE

"This study presents nationally representative estimates of the individual and aggregate years-of-life-lost (YLLs) associated with overweight and three categories of obesity separately by age, race, smoking status and gender strata," according to the abstract.

METHODS

"Using proportional hazards analysis and data from the National Health Interview Survey (NHIS) Linked Mortality Files, we estimated life expectancies for each BMI strata and quantified YLLs by comparing differences between each strata and the normal BMI reference group," the abstract states.

NHIS is based on more than 100,000 individuals per year.

LIMITATIONS

1) Height and weight data was self-reported. Those figures are often underreported.

2) The study did not control for or provide results by race.

3) Other unobserved risks could have caused the premature mortality, including socioeconomic conditions, genetics, etc.

RESULTS/CONCLUSIONS

According to the abstract: "Results provide evidence that overweight and mildly obese are not associated with a reduction in life expectancy. However, higher BMI categories are associated with lower expected survival rates. … Unless something is done to reduce the rising prevalence of those with BMI >35, or to mitigate the impact of obesity or its correlates on YLLs, life expectancy for U.S. adults may decrease in the future."

The combined effect of a BMI over 35 and smoking greatly reduced the life length.

Table 1 in the article includes the various YLL estimates across several different studies; the studies had different samples, observation lengths, BMI cutpoints and statistical models.

WHAT IT MEANS FOR A CONCEPTUAL MODEL

This study addresses the impact of weight, smoking, gender and certain race distinctions on mortality.

STUDY-RELATED QUESTIONS

1) What is the corresponding impact on absenteeism, presenteeism, workers' compensation and disability?

2) What are the corresponding prevalence statistics? The study simply compared to the normal body weight/BMI and nonsmokers.

"Impact of Overweight on the Risk of Developing Common Chronic Diseases During a 10-Year Period," by Alison Field, Eugenie Coakley, Aviva Must, Jennifer Spadano, Nan Laird, William Dietz, Eric Rimm and Graham Colditz, *Archives of Internal Medicine* 161, no. 13 (July 9, 2001): 1581–66.

OBJECTIVE

"Overweight adults are at an increased risk of developing numerous chronic diseases," the abstract states.

The study tried to quantify probability (risk) for forming chronic diseases.

METHODS

The abstract says: "Ten-year follow-up (1986–96) of middle-aged women in the Nurses' Health Study and men in the Health Professionals Follow-up Study [HPFS] to assess the health risks associated with overweight."

Nurses' Health Study was responded to by 121,701 nurses. HPFS had 51,529 men in the study.

LIMITATIONS

1) There is debate as to whether the relationship between weight and risk of death is linear, j-shaped or U-shaped. Other studies have indicated it is closer to linear.

2) It is difficult to interpret mortality results; the main cause of death can be influenced by other factors, illnesses, etc., some of which may not be related to weight.

RESULTS/CONCLUSIONS

"The risk of developing diabetes, gallstones, hypertension, heart disease and stroke increased with severity of overweight among both women and men," according to the abstract.

Compared to those with BMI of 18.5–24.9, "those with BMI of 35.0 or more were approximately 20 times more likely to develop diabetes," the abstract states. Both women and men who were overweight but not obese "were also significantly more likely than those of normal weight to develop gallstones [1.9 times], hypertension [1.7 times], high cholesterol [1.1 times] and heart disease [1.4 times]."

"During 10 years of follow-up, the incidence of diabetes, gallstones, hypertension, heart disease, colon cancer and stroke (men only) increased with the degree of overweight in both men and women," the abstract continues.

Those who were overweight but not obese significantly increased risk of numerous health conditions.

WHAT IT MEANS FOR A CONCEPTUAL MODEL

1) This study provides data that can be directly applied to an interim step of the cost/impact process.

2) Risk factor of obesity and the probability that it leads to various chronic diseases or illnesses is part of the study. When the cost of those illnesses are taken into account, that will provide us with a step in the link to morbidity, mortality, disability, etc.

STUDY-RELATED QUESTIONS

1) What is the corresponding impact on cost of the illnesses/conditions and subsequently on morbidity, mortality and disability?

"Health Care Expenditures of Overweight and Obese Males and Females in the Medical Expenditures Panel Survey by Age Cohort," by Janice F. Bell, Frederick J. Zimmerman, David E. Arterburn and Matthew L. Maciejewski, *Obesity* 19, no. 1 (January 2011): 228–232, doi:10.1038/oby.2010.104.

OBJECTIVE

The purpose of this article is to better understand the rising prevalence of obesity at all ages and the associated health care expenditures. The authors sought to determine whether there is proof that health care expenditures increase with age within weight classes, and whether the expenditure differences between weight classes increase with age. Further, they investigated whether the BMI-expenditure relationship also varied by gender. The authors state that the goal was to estimate "health care expenditures across the life cycle to identify the age at which expenditures of overweight and obese males and females become greater than their normal-weight peers and to test whether this "crossover" age varies by sex and BMI class". The findings, per the authors, will "inform clinical practice by specifying where, when and for whom to target preventive and weight-loss interventions and could help payers make coverage decisions as new technologies are developed".

METHODS

The authors detail that the study data used was from the 2000–05 Medical Expenditure Panel Surveys (MEPS), a nationally representative survey of civilian noninstitutionalized population with an overlapping panel design. Excluded from the data used were children under age 6 whose

BMI was inconsistently available, observations missing height and weight or age, pregnant women whose expenditures were confounded by perinatal expenditures, and respondents classified as underweight (as there were too few for separate analysis). The final sample included 80,516 individuals (person-years). Taking this population, they estimated total expenditures (i.e., out-of-pocket/insurance payments for ambulatory, inpatient, outpatient prescription, home health, emergency room and other care) and expenditures in three subcategories: ambulatory care, inpatient services and outpatient prescription drugs. Expenditures were inflation-adjusted to 2005 levels using the consumer price index. BMI was computed from self-reported height and weight data. Normal was 18.5–24.9, overweight was 25–29.9, and obese was 30 or more. Special adjustments to these category cutoffs were made for children age 6–18. Quadratic and cubic specifications in age and their interactions with the clinical weight classifications were included to allow flexibility in the shape of the age-expenditure relationship. F-tests were used to test significance of the higher order terms jointly with the linear terms.

The authors go on to say that "The models were then adjusted for race/ethnicity, region, insurance status, education, survey year and family income as a percentage of the federal poverty line. Health status and obesity-associated comorbidities were not controlled statistically because they are in the causal pathways between BMI and expenditures".

Further, they say that expenditures were non-normally distributed. Two-part models were estimated in which the first part was a logit regression of incurring any expenditure, and the second part was the algorithm by Manning and Mullahy, which was used to select ordinary least squares regression on logged expenditures among users. "The Duan smearing factor was applied to retransform predicted expenditures to the dollar scale".

Age-stratified models were estimated. Per the authors, "Predicted expenditures were calculated from the sex-specific models by multiplying the predicted likelihood of having expenditures (from part one) by the retransformed expenditures (from part two). The estimates and bootstrapped 95 percent confidence intervals were graphed to illustrate per capita expenditures by age and establish the age at which expenditures became significantly higher for each weight class relative to normal weight".

Finally the authors say that expenditure differences were summarized by normal weight vs. overweight and normal weight vs. obese. Stata survey commands and person-level weights were used to correct standard errors for complex sampling design.

<u>LIMITATIONS (as defined by the authors)</u>

1) The study used a cross-sectional time-series design that enables comparison of older and younger people within the same time period.

2) Estimates are not lifetime costs and cannot inform the cost effectiveness of preventive interventions over the life course, but they can inform future longitudinal cohort studies.

3) The grouping of higher BMI classes may mask expenditure differences between obese and super-obese patients.

4) The use of self-reported height and weight underestimates BMI but is unlikely to impact the shape and slope of the BMI expenditure estimates.

5) MEPS expenditure data excludes uncollected liability, bad debt and charitable care, and may underestimate the true cost of care.

RESULTS/CONCLUSIONS

The abstract reads: "Age- and sex-specific annual health care expenditures (total, inpatient, ambulatory care and outpatient prescription drug) were estimated within established weight classifications in a nationally representative sample of children and adults aged 6–85 years (n = 80,516) in the Medical Expenditures Panel Survey (MEPS). The expenditures were estimated with two-part regression models and standard errors accounted for the complex survey design. Compared to their normal-weight counterparts, total expenditures were higher for overweight females between age 22 ($85; 95 percent CI: $1, $166) and age 77 ($623; 95 percent CI: $14, $1,259); overweight males between age 48 ($168; 95 percent CI: $9, $312) and age 67 ($612; 95 percent: $31, $1,139); obese females between age 21 ($88; 95 percent CI: $12, $207) and age 82 ($1,497; 95 percent CI: $212, $2,592); and obese males between age 25 ($88; 95 percent CI: $9, $158) and age 83 ($3,236; 95 percent CI: $378, $6,637). Differences were primarily due to higher ambulatory care and prescription drug expenditures and, for women only, higher inpatient expenditures. Overweight- and obesity-associated health care expenditures are substantial and emerge at younger ages for women than for men. Expenditures associated with obesity exceed those associated with overweight. Further research is required to elucidate factors underlying the differences by sex."

WHAT IT MEANS FOR A CONCEPTUAL MODEL

1) This data combines age and gender demographics and its stratification with the impact of obesity on health care costs. This could inform an actuarial study on how to adjust for age and gender differences among cost data stratified by BMI. This is the only study found that attempts to statistically recognize and quantify those differences. This data would need to be set up as an integral set of factors that we would apply to obesity data and the impact on health care costs over the lifetime of individuals.

2) Because comorbidities could not be factored out of the equation, they are a complicating factor—we still do not know the true nature of the higher health care expenditures. However, among all of the interdependencies, this research data and outcome can help solve for some of the connections between gender and age demographics and obesity.

3) This study does not address any lifestyle factors or their impact on obesity at all, nor does it take into account any the genetics of the population.

STUDY-RELATED QUESTIONS

1) In one sense, these results are very narrow, as it only addresses the relationship and "factor" between demographics (an environmental factor) and obesity (a risk condition). On the other hand, the results are very broad because they address overall health care expenditures without delving into the causes of those expenditures. Is obesity the root cause of those expenditures?

2) By going from an environmental factor to a risk condition, it ignores the lifestyle factors that could otherwise have an impact on those expenditures. It also ignores all other environmental factors we have identified in the conceptual model. Can this study be integrated with any other studies to help quantify more interdependencies in the model?

3) To what degree is MEPS a trustworthy and accurate measure of health care expenditures?

"Association of Additional Health Risks on Medical Charges and Prevalence of Diabetes Within Body Mass Index Categories," by Shirley Musich, Chifung Lu, Timothy McDonald, Laura J. Champagne and Dee W. Edington, *American Journal of Health Promotion* 18, no. 3 (January/February 2004): 264–68.

OBJECTIVE

"Examine the association of health risk levels on medical charges and prevalence of diabetes across BMI categories within a population," the abstract states.

METHODS

The abstract reads: "A cross-sectional study design utilized health risk appraisal data (30 percent response rate) to measure BMI levels, self-reported diabetes status and selected additional health risks among 38,841 active employees under age 65 of the General Motors Corporation. Associated average annual medical charges from 1996 to 2000 were calculated for defined health risk levels across five BMI categories (<18.5, 18.5–24.9, 25–29.9, 30–34.9 and >35)."

Twelve health-related factors were selected to establish five risk level categories (0, 1, 2, 3, 4+): physical activity (less than once/week), stress (stress-scale >18), life satisfaction (partially satisfied or not satisfied), perception of health (fair or poor), blood pressure (>139/89 or taking blood pressure medication), cholesterol (>239 mg/dl), HDL cholesterol (<35 mg/dl), smoking (current smoker), alcohol use (>14 drinks/week), safety belt use (<90 percent use), personal illness days (six or more days during past year), and medical problems (heart disease, cancer, diabetes, bronchitis/emphysema, past stroke).

LIMITATIONS

Voluntary HRA participation could create a biased study population, and self-reported measures of weight/diabetes status could be inaccurate. A longitudinal study would be needed to prove relationships.

RESULTS/CONCLUSIONS

"Higher medical charges were significantly associated with additional health risks (zero risks to four or more risks) across each of the BMI categories: $2,689 to $7,576 (<18.5); $2,655 to $6,555 (18.5–24.9); $3,239 to $7,118 (25–29.9); $3,579 to $7,758 (30–34.9); and $4,151 to $8,075 (35+). Likewise, higher prevalence of diabetes was significantly associated with additional health risks (zero risks to four or more risks) across the BMI categories: 2.6 percent to 7.0 percent (<18.5); 1.3 percent to 2.7 percent (18.5–24.9); 2.4 percent to 5.3 percent (25–29.9);

5.5 percent to 8.3 percent (30–34.9); and 7.7 percent to 15.8 percent (35+),” according to the abstract.

The abstract continues: “Medical costs and the prevalence of diabetes were lower when the numbers of additional health risks were lower, regardless of the BMI category. Programs to promote weight management have largely been unsuccessful in maintaining long-term weight control. The current results suggest that a strategy focused on reducing health risks within any weight category could provide an alternative strategy to achieve medical cost savings and a lower prevalence of diabetes.”

WHAT IT MEANS FOR A CONCEPTUAL MODEL

This study provides the impact of the quantity of risk factors on medical costs, which is one of the outcomes sought. It also relates to obesity, which is one of the modifiable risk factors. However, it indicates that weight (especially obesity) is difficult to modify, and rather implies that the modification of other risk factors, listed above, may be a better focus in terms of lowering health care costs. In addition, because diabetes affects health costs and mortality, there would also be secondary implications of the results, if tied to a study relating to the impact of diabetes on medical costs and mortality.

STUDY-RELATED QUESTIONS

1) How do specific health risk factors (of the 12 used in the study), as well as interaction between specific factors, impact medical costs and diabetes, as well as BMI itself?

2) What is the relationship between obesity and diabetes?

3) Is there more specific data related to the effectiveness of weight control programs?

4) Is there data related to managing the health risk factors used in this study and how they can be modified?

5) Has progression of the study population in terms of answers to HRA questions been looked at to see how factors change over time?

6) Are there any wellness programs in place at GM, which would affect the results of this study?

Diet/Nutrition

"Effects of Exercise and Diet on Chronic Disease," by Christian K. Roberts and R. James Barnard, *Journal of Applied Physiology* 98, no. 1 (January 2005): 3-30, doi:10.1152/japplphysiol.00852.2004.

OBJECTIVE

According to the abstract: "The purpose of this review is to 1) discuss the effects of exercise and diet in the prevention of chronic disease, 2) highlight the effects of lifestyle modification for both mitigating disease progression and reversing existing disease, and 3) suggest potential mechanisms for beneficial effects."

"This review will provide evidence that when daily physical activity of 1 hour is performed in combination with a natural food diet, high in fiber-containing fruits, vegetables, and whole grains, and naturally low in fat, containing abundant amounts of vitamins, minerals, and phytochemicals, the vast majority of chronic disease may be prevented," the authors write in the report. "It will discuss the effects of physical activity and diet on CAD [coronary artery disease], hypertension, diabetes, metabolic syndrome, and cancer; discuss the value of lifestyle modification for mitigating progression to clinical manifestations from chronic disease and reversal of existing disease as documented from the Pritikin lifestyle intervention and numerous other interventions; suggest potential mechanisms for beneficial effects; and give directions for future research."

METHODS

This appears to be a type of metastudy review of literature that exists on this topic.

"Overwhelming evidence from a variety of sources, including epidemiological, prospective cohort and intervention studies, links most chronic diseases seen in the world today to physical inactivity and inappropriate diet consumption," the abstract reads.

LIMITATIONS

1) Multiple sources are not connected—in study types, cohort types, assumptions or study timeframes. This study would take on all of the limitations of each of the individual studies as well, which for some studies may be significant.

2) Given the abundance of studies that achieve similar results, the point of the author is that such an abundance would not exist if the limitations at all significantly impacted the results.

RESULTS/CONCLUSIONS

Results are too numerous to list/produce as there are more than 400 articles cited. The following are some of the conclusions that would impact a conceptual model.

A) "In the Women's Health Initiative Observational Study[3] and the Nurses' Health Study,[4] 30–40 percent of CAD was prevented by simply walking briskly >2.5 hours/week, compared with less than this amount of physical activity."

B) "Stampfer et al.[5] noted that 82 percent of CAD events could be prevented by a combination of physical activity and diet, providing additional evidence for a combined effect. When comparing dietary intake, consumption of vegetables, fruit, legumes, whole grains, fish and poultry was associated with a decreased risk of CAD, whereas typical Westernized diet patterns high in red and processed meats, refined grains, sweets/desserts and high-fat dairy products was associated with increased risk independent of other lifestyle factors."

C) "One of the earliest intervention trials was the Oslo-Diet Heart Study, in which 412 men were randomized to either a cholesterol-lowering diet or a control diet one to two years after their first myocardial infarction.[6] Men consuming a diet lower in saturated fat and cholesterol had a 17.6 percent reduction in Total-C compared with 3.7 percent in the control group over five years and after 11 years, significantly fewer CAD-related deaths."

D) "The 4,587 men and women who completed the 26-day physical activity and diet intervention from 1977 to 1988 revealed an average Total-C reduction of 23 percent, from 234 to 180 mg/dl. LDL-C decreased by 23 percent, from 151 to 116 mg/dl, with male subjects exhibiting a greater reduction in Total-C (24 vs. 21 percent) and LDL-C (25 vs. 19 percent) compared with female subjects. HDL-C was reduced by 16 percent, but the ratio of Total-C to HDL-C was reduced by 11 percent. Serum TG decreased 33 percent, from 200 to 135 mg/dl, with male subjects showing a greater reduction than female subjects (38 percent vs. 23 percent)."[7] This was a good example of how diet and exercise had an impact on cholesterol levels, and so high cholesterol is not just a risk unto itself, it is also the byproduct of other lifestyle factors (poor nutrition and inactivity).

E) "Figure 1 indicates the effect of combined lifestyle modification vs. diet modification, as tested by using an NCEP [National Cholesterol Education Program] Step I or Step II diet, and suggests that more intensive dietary changes and the addition of exercise increase lipid reductions. Body weight was also reduced, 5.5 percent for male subjects and 4.4 percent for female subjects. Follow-up studies for 18 months on a subgroup documented that continued compliance with the program led to maintained Total-C values, documenting that reductions were not transient."

F) "Ascherio et al.[8] examined prospectively the relation between nutritional factors and blood pressure among 30,681 predominantly U.S. male health professionals, without hypertension.

[3] J. E. Manson, P. Greenland, A. Z. LaCroix, M. L. Stefanick, C. P. Mouton, A. Oberman, M. G. Perri, D. S. Sheps, M. B. Pettinger, and D. S. Siscovick, "Walking Compared With Vigorous Exercise for the Prevention of Cardiovascular Events in Women," *New England Journal of Medicine* 347, no. 10 (September 5, 2002): 716–25.
[4] J. E. Manson, F. B. Hu, J. W. Rich-Edwards, G. A. Colditz, M. J. Stampfer, W. C. Willett, F. E. Speizer, and C. H. Hennekens, "A Prospective Study of Walking Compared With Vigorous Exercise in the Prevention of Coronary Heart Disease in Women," *New England Journal of Medicine* 341 (August 26, 1999): 650–58.
[5] M. J. Stampfer, F. B. Hu, J. E. Manson, E. B. Rimm, and W. C. Willett, "Primary Prevention of Coronary Heart Disease in Women Through Diet and Lifestyle," *New England Journal of Medicine* 343 (July 6, 2000): 16–22.
[6] P. Leren, "The Oslo Diet-Heart Study: Eleven-Year Report," *Circulation* 42 (1970): 935–42.
[7] R. J. Barnard, "Effects of Life-Style Modification on Serum Lipids," *Archives of Internal Medicine* 151, no. 7 (July 1991): 1389–94.
[8] A. Ascherio, E. B. Rimm, E. L. Giovannucci, G. A. Colditz, B. Rosner, W. C. Willett, F. Sacks, and M. J. Stampfer, "A Prospective Study of Nutritional Factors and Hypertension Among U.S. Men," *Circulation* 86, no. 5 (November 1992):

During four years of follow-up, 1,248 men were diagnosed with hypertension, and, in men with a fiber intake of <12 g/day, the relative risk of hypertension was 1.57 compared with an intake of >24 g/day." Thus diet has an impact on hypertension, another risk condition.

G) "For physical activity, Blair et al.[9] measured physical fitness in over 6,000 men and women with no history of cardiovascular disease and who were normotensive at baseline. After an average four-year follow-up, those with low levels of physical fitness (72 percent of the group) had a relative risk of 1.52 for the development of hypertension when compared with highly fit persons, and the risk of developing hypertension also increased substantially with increased baseline blood pressure." Thus activity level also has an impact on hypertension.

H) "Manson et al.[10] examined the association between regular vigorous exercise and the subsequent incidence of diabetes in 87,253 U.S. women aged 34–59 years. During an eight-year follow-up, 1,303 cases of diabetes were noted, and women who engaged in vigorous exercise at least once/week had an age-adjusted relative risk of 0.67 compared with women who did not exercise weekly. The Physicians' Health Study followed 21,271 men 40–84 years of age and free of diagnosed diabetes for five years; men who exercised at least once/week had an age-adjusted relative risk for diabetes of 0.64 compared with those who exercised less frequently."

I) There was various evidence provided that diet and activity levels impact the prevalence of cancers, thus impacting health costs and mortality significantly.

J) Figure 5 in the report illustrates just one set of components involved in the chain of risks and events that involve probabilities of moving from one state of risk to another.

WHAT IT MEANS FOR A CONCEPTUAL MODEL

1) This study of studies tells us that diet/nutrition and exercise/physical activity are precursors to various risk conditions, and are the lifestyle factors that lead to risk conditions and disease.

2) While they are lifestyle factors, they influence other risk conditions such as high blood pressure, metabolic syndrome (weight/BMI issues) and cholesterol levels. These two lifestyle factors (diet and exercise), in combination with stress/depression/anxiety (mental health concerns) may form the basis for three primary risk factors off which all other risk factors and conditions are based.

3) This article also gave a nice pictorial example of how the chain or probabilistic events works, and just how in-depth a model would have to be in order to populate it with the kind of detail that may be necessary.

1475–84.

[9] S. N. Blair, N. N. Goodyear, L. W. Gibbons, and K. H. Cooper, "Physical Fitness and Incidence of Hypertension in Healthy Normotensive Men and Women," *Journal of the American Medical Association* 252, no. 4 (July 27, 1984): 487–90.

[10] J. E. Manson, M. J. Stampfer, G. A. Colditz, W. C. Willett, B. Rosner, C. H. Hennekens, F. E. Speizer, E. B. Rimm, and A. S. Krolewski, "Physical Activity and Incidence of Non-Insulin-Dependent Diabetes Mellitus in Women," *Lancet* 338, no. 8770 (September 28, 1991): 774–78.

4) Logic, and the results of the studies dictate that we may not have statistics/data for each individual step in the progression of health model, but we may have data on several steps that have been combined to move from a risk to an outcome.

STUDY-RELATED QUESTIONS

1) Is it possible to envision a complete and/or close-enough-to-complete model and populate it with data that is supportable and meaningful, or will the chain-of-events–type model leave too many holes in the equations, and cause for too many assumptions to be made?

"A Prospective Study of Variety of Health Foods and Mortality in Women," by Karin B. Michels and Alicja Wolk, International Epidemiological Association 2002 (February 8, 2002)

OBJECTIVE

"To assess the overall influence of diet on health and disease in epidemiological studies, the habitual diet of the study participants has to be captured as a pattern rather than individual foods or nutrients. The simplest way to describe dietary preferences is to separate foods considered beneficial to health from foods considered to promote disease, and separate individuals on the basis of their regular consumption of these foods," as stated in the abstract.

METHODS

The authors "used data from 59,038 women participating in the prospective Mammography Screening Cohort in Sweden to investigate the influence of variety of healthy and less healthy foods on all-cause and cause-specific mortality," according to the abstract.

LIMITATIONS

1) The study only includes data for women, so it cannot be extrapolated to the entire population.

2) Measurement error is inherent in the questionnaire-based dietary assessment.

3) The study ignores the impact of smoking habits, physical activity and dietary supplement use.

4) The study was conducted in Sweden.

RESULTS/CONCLUSIONS

"Women who followed a healthy diet defined as consumption of a high variety of fruits, vegetables, whole grain breads, cereals, fish, and low fat dairy products had a significantly lower mortality than women who consumed few of these foods (3,710 deaths total)," the abstract states. "Women who reported regularly consuming 16–17 healthy foods had a 42 percent lower all-cause mortality (95 percent CI: 32–50 percent) compared to women reporting consumption of 0–

8 healthy foods with any regularity (P for trend < 0.0001). For each additional healthy food consumed, the risk of death was about 5 percent lower (95 percent CI: 4–6 percent). Cardiovascular mortality was particularly low among women who reported consuming a high variety of health foods. A less healthy diet defined as consumption of a high variety of red meats, refined carbohydrates and sugars, and foods high in saturated or trans fats was not directly associated with a higher overall mortality. However, women who reported consuming many less healthy foods were significantly more likely to die from cancer than those who consumed few less healthy foods."

The abstract concludes: "A healthy diet can affect longevity. It appears more important to increase the number of healthy foods regularly consumed than to reduce the number of less healthy foods regularly consumed."

WHAT IT MEANS FOR A CONCEPTUAL MODEL

With data surrounding the impact of dietary intake on disease prevalence, we could potentially build in estimates of disease-based habits from an HRA.

STUDY-RELATED QUESTIONS

1) Could questions in an HRA about diet be included into a wellness model as a predictor for health outcomes?

2) Because the study was conducted in Sweden, would it be applicable to a model developed in the U.S. population, due to the dietary differences between countries?

3) The report details the impact of intake of certain high and low value foods on prevalence of disease. Knowing the prevalence of certain diseases, can nutritional programs be developed to track the impact?

"The Burden of Food Related Ill Health in the UK," by Mike Rayner and Peter Scarborough, *Journal of Epidemiology and Community Health* 59 (August 8, 2005): 1054–57, doi:10.1136/jech.2005.036491.

OBJECTIVE

"To quantify the burden of ill health attributed to food," according to the abstract.

METHODS

The abstract reads: "Review and further analysis of the results of work concerned with estimates of the burden of disease measured as morbidity, mortality, and in financial terms and with the proportion of that burden that can be attributed to food."

Only direct health costs were used as there is limited to little information in the United Kingdom on indirect costs of food related to health care costs. Mortality, morbidity and money are all

measurable by various means (number of deaths, years of life lost, days in hospital, number of incidence, days of certified incapacity, etc., but quantifying the burden in terms of attributing it to a cause is difficult. The best way to do so is to combine the results of studies on the effectiveness of interventions with information about the extent of the attribution burden.

LIMITATIONS

1) The estimates could be improved upon by using more sophisticated and systematic methods. Population attributable fractions (PAFs) could be calculated and applied to the burden of specific diseases rather than International Classification of Disease (ICD) chapters. No other limitations were discussed, and no conflicts of interest were raised.

2) The study was conducted in the United Kingdom.

RESULTS/CONCLUSIONS

"Food related illness is responsible for about 10 percent of morbidity and mortality in the [United Kingdom], and costs about 6 billion [British pounds] annually," the abstract states.

The abstract concludes: "The burden of food related ill health measured in terms of mortality and morbidity is similar to that attributable to smoking. The cost to the NHS is … more than twice the amount attributable to smoking. The vast majority of the burden is attributable to unhealthy diets rather than to food borne diseases."

Table 1 in the article shows that nutritional deficiency has an impact on morbidity and mortality. Additionally, there are several diseases for which it has been proven that diet has an impact on their prevalence and severity (such as cardiovascular disease, diabetes and cancer). The proportion of the impact in Table 1 then needs to be measured for these diseases.

The World Health Organization did a comparative risk assessment project to investigate the burden of disease attributable to risk factors such as low fruit and vegetable consumption, overweight, obesity, blood pressure and cholesterol levels. Assumptions were made to reflect what percentage of these risk factors are food-based.

Studies show that close to 10 percent of diseases previously mentioned are diet related. This is similar to the impact of smoking in terms of mortality/morbidity.

The study's Table 3 shows the cost associated with various diseases, and so some percentage of this table is the value of the cost of food on those diseases. The study tries to justify a certain percentage of these diseases being food related, and concludes that one third of the costs to the health service is identifiable as food related. They further say that this is a crude estimate.

WHAT IT MEANS FOR A CONCEPTUAL MODEL

1) It would be difficult to use this data as it is not specific enough and substantiated enough to use, outside of building our own assumption on the impact of food on diseases (in terms of mortality/morbidity and cost).

2) It does bring to light the very complicated interaction between food and diseases and health costs, which needs further study.

3) It also raises the point of overlapping statistics, where the impact of food effects two diseases, but the combination of both diseases would not be additive.

4) The "cause" and co-morbidity impacts seem nearly impossible to quantify, and may have to be approximated using assumptions.

STUDY-RELATED QUESTIONS

1) Will we be able to identify all of the "cause" connections (comorbidities), let alone assign some value to the magnitude of them, and be able to reasonably reduce the severity (degree of impact) of any overlapping risk factor outcomes?

2) Will any data we find on this topic be credible? Will we need to use data to set complicated assumptions? This article also points out a handful of comorbidities but is obviously not all-inclusive.

3) Will there be a source that has investigated this and will be able to address all of the relevant/significant comorbidities?

Physical Activity

"Physical Inactivity and Mortality Risk," by Peter Kokkinos, Helen Sheriff and Raya Kheirbek, *Cardiology Research and Practice* 2011 (January 20, 2011), doi:10.4061/2011/924945.

OBJECTIVE

Examine evidence from epidemiologic and intervention studies in support of the association between exercise/physical activity and health. Present the exercise effects on risk factors. Include dietary approaches and their impact on risk factors and overall mortality risk.

METHODS

Review of various studies, which indicated that physical activity and diet have an impact on other risk factors and on overall mortality risk.

LIMITATIONS

The studies are not identical in nature, cohorts, etc., and so the impact on a particular group may not be representative of the impact on a random sample. Study choice could play a role in some form of bias in the studied outcomes.

RESULTS/CONCLUSIONS

Physical activity and diet impact other risk factors and reduce the overall mortality risk. The following information was derived from this review of studies.

1) "The findings of occupational studies on 6,351 longshoremen and those of 16,963 Harvard alumni support an inverse association between physical work and cardiovascular mortality. The findings of these studies support a sharp reduction in fatal and nonfatal heart attack rates with increase in weekly energy expenditure of ≥2,000 [kilocalories] per week," the authors wrote.

   The authors continue: "In the next two reports that followed on the same cohort, a consistent, inverse, and graded trend towards lower all-cause mortality rate was noted. As physical activity-related caloric expenditure increased from 500 kcal to 2,000 kcal per week the mortality rate decreased. More specifically, the mortality risk for men whose weekly energy expenditure from leisure time activities total 2,000 kcal or more had about 25 percent to 33 percent lower mortality rate compared to those with caloric expenditure less than 2,000 kcal per week. An interesting observation of this study was that the mortality risk tended to increase slightly in those expending more than 3,500 kcal per week suggesting that exercise beyond a certain level may be harmful to some."

2) "In the more recent study, the relative risk of death based on different types of physical activity that included walking (miles/week), stair-climbing (floors) and sports playing in 10,269 Harvard alumni over a nine-year period was examined," the authors note. "Particularly noteworthy in this study was the 30 percent to 40 percent reduction in mortality

risk, evident in those individuals engaging in moderate to vigorous activity levels (≥4.5 METs) with only minimal additional benefits achieved by engaging in activities of greater intensity. The reduction was similar, when physical activity was expressed as kilocalories per week (the sum of walking, stair climbing and sports participation), suggesting that a 40 percent reduction in mortality occurs by engaging in modest levels of activity (1,000 to 2,000 kcal/week, equivalent to three to five one-hour sessions of activity)."

3) The authors find "mortality risk can be cut in half regardless of age or race by just engaging in brisk walk for two to three hours per week or 30 minutes per session four to five days per week. Collectively, the findings of the aforementioned studies support the concept that exercise capacity should be given as much attention by clinicians as other major risk factors."

4) "Support of the epidemiologic findings is provided by two interventional studies," Kokkinos et al. write. "In one study, overweight men … and women … with impaired glucose tolerance randomly assigned to either the intervention group or control group. The intervention group was instructed to follow a healthy diet, reduce weight and increase physical activity. At the end of the follow-up period (3.2 years), the cumulative incidence of diabetes was 11 percent for the intervention group and 23 percent in the control group. The risk for diabetes was reduced by 58 percent in the intervention group."

5) Another study "assessed the association between exercise capacity and mortality risk in African-American … and Caucasian … diabetic men during a mean follow-up period of over seven years," the authors write. The study "noted a graded reduction in mortality risk with increased exercise capacity for both races. The association was stronger for Caucasians. Each 1-MET increase in exercise capacity yielded 19 percent lower risk for Caucasians and 14 percent for African-Americans. Similarly, the risk was 43 percent lower for moderate-fit and 67 percent for high-fit Caucasians. The comparable reductions in African-Americans were 34 percent and 46 percent, respectively. … [The findings] also confirm a previous report in predominantly male Caucasian diabetics that the largest proportional reduction in risk occurs between the least fit and the moderate fit categories."

6) The authors write: "Both genetic factors and lifestyle are likely to contribute significantly to variability of body weight in humans. A chronic energy imbalance that favors weight gain may be the outcome of a complex interaction between genetic and environmental factors. However, it is virtually impossible to blame genes for the increase in obesity of epidemic proportion in the United States in the past 20 years, since the gene pool has not changed significantly. It is more likely that the genetic makeup may not necessarily cause obesity, but in the presence of powerful environmental influences, the propensity for obesity is enhanced. The predominant environmental factors for obesity appear to be over-consumption of calories and reduction in physical activity. Of the two, physical inactivity appears to play the predominant role. According to the [1998 National Institute on Health] report on obesity, total caloric intake over the last two decades has not substantially increased while physical activity has decreased significantly."

7) "Decreased saturated fats and cholesterol and increased consumption of fruits, vegetables, and whole grain products are advocated in most dietary approaches," Kokkinos et al. write. "In this regard, data from the Lyon Diet Heart Study supports as much as 50 percent to 70 percent reduction in recurrent heart disease and all-cause mortality and suggests that a

Mediterranean-style diet may be superior to the health benefits of step I diet advocated by the National Cholesterol Education Program (NCEP) committee. … The traditional Mediterranean diet is characterized by a high consumption of olive oil, legumes, cereals, fruits, vegetables, moderate to high consumption of fish, moderate consumption of wine, dairy products, mostly as cheese and yogurt, and low consumption of meat and meat products. This diet is low in saturated fat (less than about 9 percent of energy), with total lipid intake ranging from less than 30 percent to more than 40 percent of energy from one area to another. Moreover, the ratio of monounsaturated to saturated fats is about two. The high content in the diet of vegetables, fresh fruits, and cereals, and the liberal use of olive oil guarantee an adequate intake of carotene, vitamin C, tocopherols, a linolenic acid, and various important minerals."

The authors continue: "Such dietary pattern may be associated with lower risk of hypertension, coronary heart disease, and cancer. Recently, evidence from the CARDIO2000 study showed that the adoption of Mediterranean diet was related with an adjusted 7 percent to 10 percent reduction on the coronary risk in treated, untreated, or uncontrolled hypertensive subjects. In large prospective survey involving over 22,000 middle age and older Greeks, an inverse association was observed between death due to coronary heart disease and greater adherence to the Mediterranean diet regardless of sex, smoking status, level of education, body mass index, and level of physical activity.

"Although the evidence strongly supports that Mediterranean dietary patterns lead to health benefits, some doubt that such dietary pattern is practical or can be adopted by other populations due to differences in cultural and environmental conditions."

WHAT IT MEANS FOR A CONCEPTUAL MODEL

1) This review of other studies tells us that there is strong evidence that changing behavior from an inactive lifestyle to a moderately active lifestyle can result in a 30 percent to 40 percent reduction in mortality risk.

2) It tells us there is a limit to the maximum gain one can get from exercise, and there appears to be a law of diminishing returns when it comes to exercise.

3) It also gives us some of the interaction between the impact of exercise and hypertension and diabetes risk reduction.

4) In one study, physical activity was shown to decrease the risk for type 2 diabetes by 58 percent.

5) Exercise capacity needs to be taken into account to determine the right amount of exercise by individual.

6) Diet also contributes to a 7 percent–10 percent reduction in coronary risk and in some instances, 50 percent–70 percent reduction in recurrent heart disease and all-cause mortality. The impact on all-cause mortality may be the result of multiple lifestyle factors changing when one changes their diet.

7) A better understanding of the interaction of various lifestyle factors needs to be studied to isolate the marginal impact of exercise relative to other healthy lifestyle factors.

STUDY-RELATED QUESTIONS

How do we apply these general statistics to build the factors in change of behavior vs. impact to risk? It would seem that the risk factor reduction would need to take into account a recommended lifestyle level of exercise and a particular type of diet. This review of studies left the door open for interaction between exercise and diet and other risk factors, and did not discuss initial prevalence of various conditions, and outcomes in terms of health cost savings. The model would need to be developed in a way that reduces all-cause mortality tables by a factor developed from these studies.

"Effects of an Incentive-Based Online Physical Activity Intervention on Health Care Costs," by Chifung Lu, Alyssa B. Schultz, Stewart Sill, Ruth Petersen, Joyce M. Young and Dee W. Edington, *Journal of Occupational and Environmental Medicine* 50, no. 11 (November 2008): 1209–15, doi:10.1097/JOM.0b013e31818dc438.

OBJECTIVE

"To test whether participation in an incentive-based online physical activity program"—Virtual Fitness Center (VFC)—"for employees was associated with a moderation in health care costs," the abstract reads.

METHODS

According to the abstract: "Health care claims trends from 2003 to 2005 were analyzed among a matched sample of participants and nonparticipants" (28,290 in each population) at IBM. "Medical and pharmacy costs, hospital inpatient costs and emergency room costs were examined."

Table 1 in the article summarizes the demographics of the studied populations.

LIMITATIONS

There is a selection bias of self-selected participants, although matching mitigates this somewhat. The matched group was identical on average for all of the match criteria.

RESULTS/CONCLUSIONS

"The average annual health care costs for participants increased by $291 per year compared with an increase of $360 for nonparticipants (P=0.09)," the abstract states. "Higher levels of participation were associated with smaller increases in health care costs. Participants had a significantly smaller increase in inpatient hospital costs (+$20 vs. +$119), heart disease costs (−$8 vs. $46), and diabetic costs (+$1 vs. +$16) compared with nonparticipants."

Results from a previous study show that participating at a high level significantly reduced their physical inactivity risk (8.4 percentage points) and overall high-risk status (1.3 percentage points).

The abstract concludes: "Participation in an online employee physical activity intervention was associated with smaller increases in health care costs compared to nonparticipants."

While this study only focused on the impact on health care costs, reference was made to other studies demonstrating impact on productivity, short-term disability, turnover and absenteeism.

The authors cite the following: "Burton et al. recently reported that worksite physical activity programs were positively associated with enhanced employee productivity and a decreased number of short-term disability days.[11] Physical activity programs have also been associated with reduced employee turnover[12] and reduced absenteeism.[13] Thus, the authors concluded that further analyses would be needed to understand possible savings in these other areas and accurately examine return on investment."

WHAT IT MEANS FOR A CONCEPTUAL MODEL

Participation in a virtual physical activity intervention program indicates increased physical activity, which in turn leads to lower health care costs, thus showing the impact on health care cost outcome of a lifestyle factor, even if it is the result of the study of an intervention program. It also shows the impact on more specific segments of the population, including those with heart disease, back problems and diabetes. Finally, it shows that the biggest impact of the physical activity is a reduction in inpatient costs.

STUDY-RELATED QUESTIONS

1) Would the results be the same if we were looking at people's general physical activity without an intervention program? For example, just because someone didn't participate in the VFC, it doesn't mean that they weren't physically active on their own.

2) How does physical activity interact with other risk factors? Other lifestyle factors may have changed along with the physical activity.

3) What is the impact of physical activity on other outcomes, such as disability, absenteeism, turnover and productivity? Other references relating to these outcomes can be reviewed.

[11] W. N. Burton, K. T. McCalister, C. Y. Chen, and D. W. Edington, "The Association of Health Status, Worksite Fitness Center Participation, and Two Measures of Productivity," *Journal of Occupational and Environmental Medicine* 47, no. 4 (April 2005): 343–51.

[12] Shirley Musich, Laura Adams, Joanna Broder, and Dee W. Edington. "Benefits of Onsite Fitness," *Fitness Management* 15, no. 11 (October 1999): 54–57.

[13] Wendy D. Lynch, Thomas J. Golaszewski, Andrew F. Clearie, David Snow, and Donald Vickery, "Impact of a Facility-Based Corporate Fitness Program on the Number of Absences from Work Due to Illnesses," *Journal of Occupational and Environmental Medicine* 32, no. 1 (January 1990).

"The Relationship Between the Stages of Change for Exercise and Health Insurance Costs," by Tim Dunnagan, George Haynes and Vince Smith, *American Journal of Health Behavior* 25, no. 5 (September/October 2001): 447–59.

OBJECTIVE

"To determine the relationship between the stages of exercise participation and health insurance costs," the abstract states.

METHODS

"A hurdle model was used to examine health survey [48-question survey] and health insurance costs data by stage of exercise participation," according to the abstract. The five stages used were precontemplation, contemplation, preparation, action and maintenance. Data was further broken down by four health behaviors (tobacco use, smoker status, alcohol use and seatbelt use) and three degrees of health status (normal, at risk and at high risk). The study focuses on the relationship between health risks and health costs and the role of health promotion programs to control costs, the stages of change for exercise, and the methodological challenges related to health insurance cost analysis.

LIMITATIONS

1) There are some methodological problems in analysis of health cost data. There is a danger of overstating the cost of those with elevated risk due to the nature of the skewed medical claims. Taking averages within a risk classification may not be the most ideal representation of the higher risk folks, if a few people are throwing off that average to make it higher than it really should be. Data should be reviewed and aberrant claims separated out.

2) There is also potential for an adverse selection bias to cause high-cost users of health insurance to participate in worksite wellness programs.

3) There needs to be a way to measure the intensity of participation in wellness plans, as health-related costs may depend on that intensity.

4) Only 68 percent responded to the survey, and only 70 percent of that 68 percent agreed to allow their medical data to be tied to their survey data (which is about 48 percent of the total population). Only 25 percent of medical costs were captured in the 48 percent of the population.

5) Researchers used observational study design. Experimental design is better. Lack of true randomized designs does not compromise the validity of the researcher's results.

6) Data was collected through a survey tool and was thus self-reported. False positive results have been associated with self-reported results.

7) Data was only cross-sectional in nature and based on one year's worth of health insurance costs. It would be more accurate to track data over extended time (but this was cost prohibitive).

8) The wellness and nonwellness participants could differ in other ways that were not identified in the model. Many factors could influence health insurance use.

RESULTS/CONCLUSIONS

The results show that proportionally more of the employee wellness plan (EWP) participants were recruited for health-risk factors of concern than were EWP nonparticipants.

The abstract reads: "Employees classified in the maintenance stage (regular exercisers) of exercise adoption had lower costs and a lower probability of being classified in the high-cost group than did employees classified in the other stages of change for exercise participation."

Results did not reveal any substantive health cost differences between EWP participants and nonparticipants. Differences were observed, however, by stage of activity and previous utilization. Outcomes show the likelihood of being in the high-cost group was significantly lower if the employee was classified in the maintenance stage of physical activity. Health insurance costs were negatively associated with the maintenance stage of exercise.

Cost differences were not observed for all other classifications of exercise. Females and males in the maintenance stage with low prior health insurance use lowered the probability of being in the high-cost group more than lower mean/median cost folks who were not in the maintenance stage. Similar patterns existed for females who were previous high health care users, but not for males, which was quite the opposite, and this finding was odd.

In total, high previous utilization of health costs was associated with higher insurance costs (intuitive), and regular exercise participation is associated with lower costs.

WHAT IT MEANS FOR A CONCEPTUAL MODEL

The study shows that the link between exercise and health costs is real, and quantifies it between the maintenance group and nonmaintenance group.

The actuarial model may need to consider the intensity and stage of change for participants to accurately reflect the impact of exercise on other conditions/outcomes.

STUDY-RELATED QUESTIONS

The study does not stratify the degrees of exercise. While the study tries to stratify between different stages of exercise decisions and action, the results show there is no stratification other than exercises regularly (maintenance) vs. all other stages of exercise. While helpful, it would have been more useful to create strata around the length of time in vigorous exercise, as that strata seems to matter more.

Addictive Behavior/Smoking/Alcohol Abuse

"Effect of Smoking Status on Productivity Loss," by William B. Bunn, Gregg M. Stave, Kristen E. Downs, Jose Ma. J. Alvir and Riad Dirani, *Journal of Occupational and Environmental Medicine* 48, no. 10 (October 2006): 1099–1108, doi:10.1097/01.jom0000243406.08419.74.

OBJECTIVE

"To describe health-related productivity losses in nonsmokers, former smokers and current smokers using a large cross-sectional database of U.S. employees," according to the abstract.

METHODS

"Volunteers completed the Wellness Inventory survey, an instrument measuring productivity loss related to 11 health conditions affecting employee health," the abstract reads. "Results are aggregated, dollarized and reported by smoking group."

Although 45,630 respondents completed the Wellness Inventory, 10,696 records were excluded due to missing data.

LIMITATIONS

The survey was voluntary, and due to the size of the study (very large), medical records could not be validated, and no biochemical confirmation of smoking status was performed. Study results were not intended to measure prevalence, which could be underreported due to self-reporting and the voluntary nature of the study. Volunteers also have to remember if their productivity was influenced by a health condition—and the survey does not asked if the individual is already being treated for a condition. U.S. prevalence of smoking is said to be 20 percent across the country, but the database shows only 13 percent report smoking in this survey group. The survey underrepresents blue collar workers, which comprises only 16 percent of this group. Blue-collar workers typically have higher smoking prevalence. Adults over retirement ages were not represented as this was based on active employees.

RESULTS/CONCLUSIONS

"Current smokers missed more days of work and experienced more unproductive time at work compared with former smokers and nonsmokers," according to the abstract. "The average annual cost for lost productivity for nonsmokers was $2,623/year compared with $3,246/year for former smokers and $4,430/year for current smokers. More than half the costs were due to unproductive time at work."

The abstract concluded: "Current smokers incurred the highest productivity losses, which translated into higher cost to employers for current smokers. Costs were lower for former smokers and nonsmokers."

Former smokers are more similar to nonsmokers than to current smokers when it comes to productivity losses. Health costs were lowest for nonsmokers and highest for current smokers.

The same was true for days lost of productivity. Presenteeism is approximately 50 percent of total productivity losses based on this study (compared to 71 percent in a different study and 61 percent in a Goetzel study). This study used $34.25 as the mean hourly compensation to determine a dollar cost loss of productivity.

In the "Discussion" section of the article, the authors state that "This article focuses on the cost of lost productivity due to health-related absenteeism and presenteeism. Other costs borne by employers resulting from employees who smoke include direct medical costs associated with treating health conditions, lost productive time due to smoking breaks, increased number of accidents leading to higher workers' compensation costs and disability, and early retirement due to smoking-related health conditions. Employers are likely to incur higher health costs associated with nonsmoking employees who are exposed to second-hand smoke at work. Facilities where smoking is allowed are required to have better ventilation systems and incur higher maintenance and cleaning costs. These facilities are also more likely to experience a fire and/or have higher fire insurance costs."

WHAT IT MEANS FOR A CONCEPTUAL MODEL

This article is not a good representation of smoking prevalence but does give a usable cost associated with presenteeism and absenteeism in terms of relative lost productivity. It also raises good points in terms of additional cost for fire insurance (casualty insurance), workers' compensation and disability, but this article does not address what those costs would be.

STUDY-RELATED QUESTIONS

1) What is the prevalence of smokers?

2) What is the value of other costs that can occur, and what is the probability they do occur?

3) What are the quit rates and permanent success rates?

4) Will savings diminish as former smokers relapse?

"Impact of Height, Weight and Smoking on Medical Claims Costs: Research from the annual update of Milliman's Medical Underwriting Guidelines," by Jonathan Shreve and Mary van der Heijde, Milliman Research Report, April 2009.

OBJECTIVE

To determine if smoking changes the health claims cost by a significant enough impact.

METHODS

The researchers used nine years worth of data regarding age, gender, height, weight, smoking status, total health care expenditure and self-reported medical conditions from the Medical Expenditure Panel Survey (MEPS). There are 97,870 MEPS lives in the database, of which about 17,000 were over age 65 (and thus not used in the smoking portion of this report). All those included had commercial insurance.

LIMITATIONS

MEPS is based on self-reported data and there could be some underreporting of information or, potentially, the insurance applicant could misrepresent health information to try to get lower rates.

RESULTS/CONCLUSIONS

"Controlling for age and gender differences, [the researchers] found that smokers cost about 9 percent more than nonsmokers," as stated in the executive summary. "However, if an underwriter has information available about an applicant's other conditions, there is about a 5 percent difference in unexplained costs between smokers and nonsmokers."

They "assume that medical conditions are usually underreported to underwriters. … [They] assumed that only 70 percent of medical costs are actually reported on medical applications," the researchers continue.

WHAT IT MEANS FOR A CONCEPTUAL MODEL

This report provides credible prevalence for smoking and associated medical cost data. The same article also provides prevalence data for weight/BMI as well. That is not summarized above, but is easy to capture.

STUDY-RELATED QUESTIONS

1) The study did not capture outcomes other than health costs. How could the study be designed to capture a broader set of outcomes?

"The Combined Effect of Smoking Tobacco and Drinking Alcohol on Cause-Specific Mortality: A 30-Year Cohort Study," by Carole L. Hart, George Davey Smith, Lawrence Gruer and Graham C. M. Watt, *BioMed Central Public Health* 10 (2010): 789, doi:10.1186/1471-2458-10-789.

OBJECTIVE

"Smoking and consuming alcohol are both related to increased mortality risk. Their combined effects on cause-specific mortality were investigated in a prospective cohort study," the abstract states.

METHODS

"Participants were 5,771 men aged 35–64, recruited during 1970–73 from various workplaces in Scotland," according to the abstract. "Data were obtained from a questionnaire and a screening examination. Causes of death were all cause, coronary heart disease (CHD), stroke, alcohol-related, respiratory and smoking-related cancer. Participants were divided into nine groups according to their smoking status (never, ex or current) and reported weekly drinking (none, 1–14 units and 15 or more). Cox proportional hazards models were used to obtain relative rates of mortality, adjusted for age and other risk factors."

LIMITATIONS

The data related to alcohol consumption was self-reported. It wasn't possible to classify former drinkers with nondrinkers. There is no knowledge of how behaviors changed after the initial screening. It is unknown how many cigarettes the smokers smoked a day. Although adjustment was made for several covariates, the study did not record others such as dietary intake, family history of disease or adequate information on exercise.

RESULTS/CONCLUSIONS

"In 30 years of follow-up, 3,083 men (53.4 percent) died. Compared with never smokers who did not drink, men who both smoked and drank 15+ units/week had the highest all-cause mortality (relative rate = 2.71 [95 percent confidence interval 2.31–3.19])," the abstract reads. "Relative rates for CHD mortality were high for current smokers, with a possible protective effect of some alcohol consumption in never smokers. Stroke mortality increased with both smoking and alcohol consumption. Smoking affected respiratory mortality with little effect of alcohol. Adjusting for a wide range of confounders attenuated the relative rates but the effects of alcohol and smoking still remained. Premature mortality was particularly high in smokers who drank 15 or more units, with a quarter of the men not surviving to age 65. Thirty percent of men with manual occupations both smoked and drank 15+ units/week compared with only 13 percent with nonmanual ones."

The abstract concludes: "Smoking and drinking 15+ units/week was the riskiest behavior for all causes of death."

"Smokers who also drank 15+ units/week had the highest risk of dying from all the causes compared to the other groups," according to the authors. "Smoking had a greater adverse effect on mortality than alcohol consumption, and exsmokers who had stopped smoking before the screening examination had lower mortality risks than smokers. These findings reinforce the importance of continuing to prioritize smoking cessation across the whole population. Given the strong links between smoking and heavy drinking, it may also be helpful to devise policies aimed at reducing both smoking and alcohol consumption in population groups where this is common."

WHAT IT MEANS FOR A CONCEPTUAL MODEL

Risky behaviors, including smoking and drinking, are key risk factors that impact model outcomes. Mortality is a key outcome. Furthermore, the study was done on a population of workers, so the implications would apply to employers who would consider the impact of wellness initiatives.

STUDY-RELATED QUESTIONS

1) Can the results of the study be extrapolated to the United States? To women?

2) What other conditions are impacted by smoking and drinking?

3) How do smoking and drinking relate to health costs and disability?

4) How can the model capture the compounding impact of comorbid risk factors?

Stress/Anxiety/Depression

"The Direct and Indirect Costs of Employee Depression, Anxiety and Emotional Disorders—An Employer Case Study," by Kenton Johnston, William Westerfield, Soyal Momin, Raymond Phillippi and Allen Naidoo, *Journal of Occupational and Environmental Medicine* 51, no. 5 (May 2009): 564–77, doi:10.1097/JOM.0b013e3181a1f5c8.

OBJECTIVE

"To quantify the direct and indirect costs of employee depression, anxiety and emotional disorders at one large employer in 2004 using administrative data sources," the abstract reads.

METHODS

The author describes the participant population as follows: This study included 4,031 active employees of a large insurance company in the southwestern United States. Only those employed in calendar year 2004 who chose to elect the employer's group medical plan were included. Insured dependents and retirees were excluded. Medical and pharmacy claims and personnel, productivity and benefits data were merged at the individual level. A third party was used to merge and blind the data to protect for privacy. The authors describe the measures as both independent and dependent variables. The independent variable was the disease category of depression, anxiety and emotional disorders, and consisted of 11 episode treatment groups (ETGs). Dependent variables were the direct and indirect costs of the disease. Direct costs included inpatient, professional/outpatient and pharmacy claims. Indirect costs were labor resources lost by the employer and included absenteeism, presenteeism, short-term disability, long-term disability and family medical leave (FML). The following process is what the authors documented they used. Age, gender and disease status was collected throughout 2004. Claims were grouped by disease using the Episode of Care grouper by Ingenix. Eleven ETGs were identified to track depression, anxiety and emotional disorders. All claims dollars were classified into the ETGs to assure no double counting with other diseases. Administrative resources were used to track the five indirect costs. Absenteeism was counted as days taken off for inpatient and outpatient medical claims. Inpatient was considered eight hours and outpatient was considered four hours of absence. Sick and vacation days (from PTO plan) were used to convert lost absenteeism hours into indirect cost dollars (by multiplying the hours by hourly wages). A wage multiplier was used to account for excess value above their hourly wage. Then relative weights were created based on disease-specific population averages and individual comorbidity burdens, and attributed absentee dollars and hours to specific diseases for each employee. FML was counted in work days missed, and the same wage multiplier of value for time was applied to the wages. Then the dollars were attributed to specific diseases similar to absenteeism. Short- and long-term disability were measured from the employer's claims with their insurance vendor (total dollars paid per claim). Employee workdays on disability were not provided, so excess value of lost time above the hourly wage could not be calculated for these categories. The claims were then attributed to specific diseases. Presenteeism was estimated for customer service employees and from available productivity data. It was adjusted down by 14.5 percent to take

into account new hires and new terminations were excluded because they did not have enough tenure for a salary raise, were still in training, or their pay grades were not conducive to relative raise performance analysis. White collar employees who were not employed continuously for 12 months in 2004 were also excluded because they would potentially be missing raise data. Customer service employees made up 21 percent of the population.

Further, the authors describe that estimates of unproductive time were developed, and the lowest 25 percent of productivity was used as the cutoff to differentiate from productive and unproductive time. An unproductivity ratio is developed from this cutoff, and becomes the dependent variable in an ordinary least squares regression model that includes age, gender, disease conditions and independent variable to determine the impact of multiple disease conditions on productivity. A backward elimination model was used.

They go on to say that for those disease conditions that remained in the significant model, the parameter estimates were used to calculate the proportion of unproductive hours that were attributable to disease for each disease category. The parameter estimates represented the fraction of a diseased employee's unproductive hours that were attributable to the particular disease in question. Age and gender were used to risk adjust the impact of disease conditions on productivity.

Unproductive hours were converted into presenteeism dollars by applying the same methodology as described for absenteeism. White collar office employees were 79 percent of the population, and because productivity and performance scores were not available for this class of employee, the authors said that the "annual percent salary raise was used as a proxy for performance." Relative performance scores were calculated vs. their exempt and nonexempt peers, and converted into an unproductive ratio for employees in the lowest 25th percentile. Then a similar regression model could be used on this group as well, and the productivity dollars was assigned to particular diseases in the end.

Finally, the authors explain that the total direct and indirect cost components were summed to get a total health care cost dollar estimate for depression, anxiety and emotional disorders in the employee population. The impact on the company's overall productivity and revenues for 2004 was also estimated. Total revenue lost per full-time equivalent (FTE) employee was estimated as the difference between actual revenue produced in 2004 and potential revenue produced per FTE had there been no direct and indirect cost incurred by the employer. Potential revenue produced per FTE was estimated to be equal to total revenue divided by total FTE after subtracting the direct and indirect cost of depression, anxiety, and emotional disorders from the total payroll costs. Three scenarios demonstrating the impact of 10 percent, 20 percent and 30 percent total health care cost reductions on total corporate revenue in 2004 were simulated.

LIMITATIONS

All of the following limitations were reported by the authors.

1) The study was specific to a population of 80 percent women in the southeast and cannot be generalized.

2) Absenteeism estimates were conservative due to illnesses that did not bring about office visits or inpatient stays.

3) Employer short-term disability cost was underreported due to the disability vendor not providing days absent for employees on disability.

4) Additional variables could have been used to better explain the presenteeism hours and the associated dollar cost derived. It was difficult attributing presenteeism hours for white-collar and customer service employees to a particular disease condition—only 1.7 percent of their unproductive time was attributed to their condition.

5) Untreated conditions went undetected due to lack of recorded diagnoses in medical claims. This may account for an underreporting of prevalence in these mental disorders.

6) Cost was not determined or adjusted for care that can be distinguished as inappropriate treatment for a particular diagnosis. In general, a lack of consensus on a definitive approach for measuring total health care costs has led to confusion because cost estimates can vary widely depending on the research methodology. While this study does provide some prevalence and cost data, a lack of a baseline figure limits our ability to calculate the percentage impact relative to baseline.

7) Table 4 in the report summarizes the employee demographics in this study. It is notable that 80 percent of the participants were female, which will bias the results, and the vast majority of the employees were full time. The prevalence of the condition is 11.2 percent (464/4,152).

RESULTS/CONCLUSIONS

The abstract concludes: "The cost burden of depression, anxiety and emotional disorders is among the greatest of any disease conditions in the workforce. It is worth considering methods for quantifying direct and indirect costs that use administrative data sources given their utility."

The authors conclude that "The mean annual total health care cost attributable to depression, anxiety and emotional disorders per employee with the condition were $1,646, and the mean costs per employee - distributed evenly across the entire workforce - were $189. The largest cost areas were absenteeism, pharmacy utilization, professional and outpatient visits, and presenteeism - in that order." They also said that the $1,646 represents "those costs that were specifically attributable to the presence of depression, anxiety and emotional disorders in employees with the condition. In most cases, employees had additional costs that were attributable to additional conditions" (comorbidities were not quantified; they were seemingly and intentionally left out of this cost). These disorders were the fifth most costliest of all disease conditions across the entire employee population. It was estimated that $1,823 in potential revenue per FTE was lost by the employer due to these conditions. For this particular case, every 10 percent of total health cost reduction is worth a revenue gain of approximately $750,000.

Table 2 in the report documents methodology used to calculate the direct costs by component, and Table 3 documents methodology used to calculate the indirect costs by component.

The report's Figure 1 provides the prevalence and direct costs for depression, anxiety and emotional disorders and Figure 3 documents the combined total cost for depression, anxiety and depression.

WHAT IT MEANS FOR A CONCEPTUAL MODEL

A 2004 annual cost of condition of $1,646 per FTE with the condition, or $189 for an average FTE was determined. This cost per condition could be adjusted to current year costs, and takes into account a measure that includes absenteeism and presenteeism, which is difficult to quantify and often not attempted to capture. If we believe or count as reasonable the methods used to quantify these measures, we would still need a baseline average cost of health care (inclusive of absenteeism and presenteeism for this group) so that we can determine what percentage of the total lost cost/value is lost in a given year. Knowing a dollar amount, we could apply this to an independent average cost to come up with the impact percentage, but that is disjointed and likely would not produce reasonable results. If the authors were contacted and they have the overall cost numbers so percentages could be developed, then we would have something that could be applied directly to the model, with some caveating, of course.

STUDY-RELATED QUESTIONS

A baseline total cost (which would need to include all categories such as presenteeism and absenteeism) would need to be provided by those performing the study. The conclusion states that the burden of depression, anxiety and emotional disorders is among the greatest of any disease conditions, but we do not know if the comparison is accurate and all presenteeism and absenteeism costs were incorporated into those comparison illness models. Did the authors compare to studies that used like measures to determine a total cost for each of the conditions they raise? Are they really comparing apples to oranges? Can percentages of total annual cost per FTE be provided so we understand how sizable the $189 per FTE is compared to the total health related spend per FTE?

"Job Strain and Adverse Health Behaviors: The Finnish Public Sector Study," by Anne Kouvonen, Mika Kivimaki, Ari Vaananen, Tarja Heponiemi, Marko Elovainio, Leena Ala-Mursula, Marianna Virtanen, Jaana Pentti, Anne Linna and Jussi Vahtera, *Journal of Occupational and Environmental Medicine* 49, no. 1 (January 2007): 68–74.

OBJECTIVE

"To explore the association between job strain and the co-occurrence of adverse health behaviors of smoking, heavy drinking, obesity and physical inactivity," the abstract reads.

METHODS

"The authors studied cross-sectional data of 34,058 female and 8,154 male public sector employees. … Multinomial logistic regression models [were] adjusted for sex, age, basic education, marital status and type of job contract," according to the abstract.

LIMITATIONS

All of the following limitations were reported by the authors.

1) All health behaviors are self-reported.

2) No causal inferences can be made from a cross-sectional study such as this one. Because obese and sedentary workers who smoke and drink heavily are likely to be at some disadvantage in job selection, multiple risk factors could lead to a higher likelihood of getting a less desirable job rather than the reverse.

3) Other factors such as workplace culture and norms may be confounders, and were not taken into account.

4) Cutoff points were chosen arbitrarily. There are no clinical-based cutoff points for job control and demands, so strain and tertiles and categories were used instead.

5) The study had a 68 percent response rate, so some selection bias cannot be ruled out.

6) The Finnish version of job demands and control were derived from the Job Content Questionnaire but were not identical to the original measures and did not include a measure for social support, which could reduce the validity of the job strain assessment.

7) The study was comprised of 77 percent female, which does not correspond to general workforce population of 48 percent female.

RESULTS/CONCLUSIONS

High job strain and passive jobs had 1.3 to 1.4 times higher odds of having three or more adverse health behaviors (vs. 0). Among men, low job control was associated with 1.3 times the likelihood of having three or more adverse behaviors. Among women, active jobs were associated with 1.2 times the odds of having three or more adverse behaviors. High demands were associated with a higher likelihood of co-occurrence of one or two adverse behaviors among women.

The abstract states: "Adverse job conditions may increase the likelihood of co-occurrence of health risk behaviors, so by reducing work stress and increasing job control and decreasing psychological demands, this might help promote healthy lifestyles."

Association of job strain with a single risk behavior has been very weak.

Table 1 in the report shows the characteristics of the study population and what the starting number of adverse behaviors are, on average (0.9 for women, 1.2 for men). This mean number increased with age. The proportion with three or more adverse behaviors was 4 percent for women and 9 percent for men.

WHAT IT MEANS FOR A CONCEPTUAL MODEL

This study provides an interesting perspective on how the chain of impact may occur. Stress, and particularly certain types of job strain, can create adverse health behaviors. The study concluded

that job strain often can produce multiple adverse health behaviors at one time. So stress (job, in this case) is not just a risk factor itself, it is a predecessor to other risk factors.

STUDY-RELATED QUESTIONS

This study does not link the stress to a specific risk factor, but rather a bundle of up to four particular adverse health behaviors. Therefore, the study does not attribute stress to a particular behavior, so we would need to determine the relationship between stress and different conditions, or if stress naturally leads to all four in some way. As such, are there certain lifestyle factors or risk conditions that lead to a basket of conditions? This study also does not address cost of any kind, only the probability of acquiring the unhealthy behavior. So we need to link these probabilities to costs, and due to the nonspecificity of behaviors among each bundle of behaviors, this may be difficult with this study.

"Comparative and Interactive Effects of Depression Relative to Other Health Problems on Work Performance in the Workforce of a Large Employer," by Ronald Kessler, Leigh Ann White, Howard Birnbaum, Ying Qiu, Yohanne Kidolezi, David Mallett and Ralph Swindle, *Journal of Occupational and Environmental Medicine* 50, no. 7 (July 2008): 809–16, doi:10.1097/JOM.0b013e318169ccba.

OBJECTIVE

"To present data on the comparative and interactive workplace costs of depression relative to other health problems in the workforce of a large employer," according to the abstract.

METHODS

"The World Health Organization's Health and Work Performance Questionnaire [HPQ] was used to assess self-reported health problems and work performance. Survey data were linked to medical-pharmacy claims data. Regression analysis was used to assess comparative effects of depression in the absence and presence of comorbidities on Health and Work Performance Questionnaire measures of work performance," the abstract reads.

The sample size was 7,320 employees at a 20,000-employee national information technology (IT) firm.

LIMITATIONS

Work performance assessment was based upon self-reports rather than objective assessment. This is mitigated by prior findings that HPQ is representative of assessments. Also, a relatively low survey response rate (37 percent) could introduce selection bias.

RESULTS/CONCLUSIONS

"Depression had the largest individual level effect on work performance of any condition examined," according to the abstract. "Several comorbid conditions exacerbated the effect of depression, but had no effects in the absence of depression."

The abstract concludes: "Depression is a strong predictor of decrements in work performance. Other conditions that often co-occur with depression, including anxiety and fatigue-sleep disturbance, exacerbate the adverse effect of depression."

WHAT IT MEANS FOR A CONCEPTUAL MODEL

There is a strong adverse impact of depression, one of the risk conditions of focus for this study, on workplace productivity, one of the actuarial outcomes of focus, especially compared to other conditions. When comorbidities are introduced, the adverse impact on productivity increases (negative impact).

STUDY-RELATED QUESTIONS

1) What is the impact of depression on other outcomes, such as health costs and mortality?

2) How can mental health interventions reduce this impact?

3) What other risk factors, as opposed to the conditions studied here, have an impact on workplace productivity, and does the interaction between depression and these other factors exacerbate negative productivity?

Hypertension

"Uncontrolled Hypertension: Cost to Payers and Employers, An Actuarial Analysis," by Kathryn Fitch, Kosuke Iwasaki and Bruce Pyenson, Milliman Report, February 21, 2007.

OBJECTIVE

"Intended to give employers and payers usable facts about [high blood pressure] … [and] also give recommendations on what employers can do to better manage HBP," according to the executive summary.

METHODS

"To model the impact of controlling HBP," the report states, they "used landmark HTN [hypertension] studies as a 'backwards' application of Framingham BP risk points to create two scenarios for the reduction in CAD and stroke events possible with optimal HBP treatment:

> "Improved Treatment Scenario 1: Application of CAD and stroke reduction reported in landmark studies (55 percent reduction in stroke and 28 percent reduction in CAD)
>
> "Improved Treatment Scenario 2: Removing Framingham risk points assigned for BP ≥ 120/80 to recalculate the probability of CAD and stroke events with controlled HBP (BP < 120/80 is defined by the [Joint National Committee] 7 as normal)"

Analysis utilizes national survey data projected onto a typical employer population with 100,000 employees (and 47,210 spouses).

LIMITATIONS

The authors note that the report was commissioned by Novartis, a pharmaceutical manufacturer. Actuarial Standards of Practice were followed but work is based on many assumptions and cannot capture all influences. Actual experience will likely vary from what is presented in the report. The report should be used in its entirety, otherwise findings can be misleading.

RESULTS/CONCLUSIONS

Report shows a prevalence rate of HTN of 23 percent for the typical population. Of these, only ~40 percent have their BP at a controlled level. Members with HTN are linked to greater risks of CAD and stroke. Cost of members with HTN is high, mostly due to comorbidities.

WHAT IT MEANS FOR A CONCEPTUAL MODEL

The report contains prevalence rates of hypertension for different age groups. In addition, it supplies information on comorbidities that can be used for a conceptual model.

STUDY-RELATED QUESTIONS

Many of the recommendations in the report deal with the importance of complying with medication therapy as a hypertensive. Is medical compliance a wellness factor we will be measuring? Or, do we want to focus on ensuring that this state is not achieved, perhaps through diet and exercise?

"Impact of Hypertension on Medical Economics: A 10-Year Follow-Up Study of National Health Insurance in Shiga, Japan," by Koshi Nakamura, Tomonori Okamura, Hideyuki Kanda, Takehito Hayakawa, Takashi Kadowaki, Akira Kayama and Hirotsugu Ueshima, for the Health Promotion Research Committee of the Shiga National Health Insurance Organizations, Department of Health Science, Shiga University of Medical Science, Otsu, Japan, August 29, 2005.

OBJECTIVE

"To clarify the relationship between hypertension and long-term medical costs by a cohort study utilizing existing data as well as baseline blood pressure and medical costs over a 10-year period," according to the abstract.

METHODS

"The participants included 4,191 Japanese National Health Insurance beneficiaries, aged 40–69 years, living in one area, not taking hypertension medication and not having history of major cardiovascular disease," the abstract states. "They were classified into four categories according to their blood pressure. We evaluated the mean medical cost per month, cumulative hospitalization and all-cause mortality for each blood pressure category. Hypertension-related medical costs attributed to hypertensive individuals, as compared to normotensive individuals, were estimated."

LIMITATIONS

1) Population was selected from Shiga Prefecture, so socio-economic status and lifestyle could have an effect on their health.

2) The excess medical costs attributable to hypertension may be associated with metabolic syndrome, which is characterized by hypertension, high BMI, diabetes, hyperlipidemia and more. The BMI for the stage 2 hypertensives was the highest among the four blood pressure categories for both sexes, and the prevalence of participants with a history of diabetes with stage 2 hypertension was also highest among the women.

3) Details about medical diagnoses, medical treatment and cause of mortality were not available, thus it was unclear which disease in particular directly increased the medical costs and mortality among the hypertensive participants.

4) The extent to which anti-hypertensive medications were effective at reducing hypertension-related medical costs remained unclear with respect to the entire population.

5) The results of the present study may not be directly relevant or adaptable to Western populations.

6) It does not tell us what diseases were linked to the medical costs, so we cannot associate the risk factor with a disease state outcome based on this study.

RESULTS/CONCLUSIONS

"There was a positively graded correlation between blood pressure and personal total medical costs, especially for men," the abstract reads. "The odds ratio for cumulative hospitalization and hazard ratio for all-cause mortality in severe hypertensive men were also higher than those in normotensive men. However, the hypertensive-related medical costs for mild to moderate hypertensives were higher than those for severe hypertensives. Concomitant hypertension, regardless of grade, increased the medical costs of the Japanese National Health Insurance beneficiaries."

Based on the tables in the report, men have a far greater relationship between blood pressure and medical costs, hospitalization days and all-cause mortality. Women in the stage 2 blood pressure risk category had only a 6 percent increase in all-cause mortality, while those in stage 1 were 32 percent higher. Also, those women in the stage 1 BP risk category had 15 percent less cumulative hospitalization time than the normal category. The data on the women was not conclusive, although there is still evidence that high BP does impact the medical cost, hospitalization and all-cause mortality for women. For men, the data is far more obvious and conclusive, with high blood pressure playing a significant role and being a serious risk in relation to health cost, hospitalization and mortality.

WHAT IT MEANS FOR A CONCEPTUAL MODEL

It tells us there is a significant impact we can apply for having high blood pressure—this is a risk condition that influences other conditions. Confidence intervals of 95 percent were provided for the hospitalization and all-cause mortality data, which is beneficial to use when estimating a risk factor value.

STUDY-RELATED QUESTIONS

1) Can this be used for Western populations? Lifestyle, genetics and environment may play a significant role in why the impact of high blood pressure in Japanese men is different from the high blood pressure impact to a U.S.-based population.

2) What is the real impact of high blood pressure for women, and can we find those measures to reasonably determine the risk factor value for this portion of the population?

3) This article provided prevalence for four different blood pressure categories, but would U.S. populations match up similarly?

4) What risk factors lead to a particular disease state outcome.

"Epidemiology of Uncontrolled Hypertension in the United States," by Thomas J. Wang and Ramachandran S. Vasan, *Circulation, Journal of the American Heart Association* 112 (September 13, 2005): 1651–62, doi:10.1161/CIRCULATIONAHA.104.490599.

OBJECTIVE

The article explores the prevalence and impact of high blood pressure (hypertension) on the American population. It explores the definition of high blood pressure, the magnitude of the problem, public health implications and factors associated with inadequate blood pressure control.

METHODS

This research paper reviews a multitude of studies to summarize some of the findings in one central document. The studies reviewed span from 1986 to 2002.

LIMITATIONS

The article merely summarizes the results of various studies. There are some conclusions made in the paper, but ultimately it calls for more research before making serious advancements in the study of hypertension. The studies contain different groups of people, so sweeping conclusions based on the data summarized for the entire population cannot be made. There are different methodologies used across the studies to define hypertension.

RESULTS/CONCLUSIONS

The report includes various definitions of blood pressure control; a summary of studies on the subject; a review of the trends in awareness, treatment and control of hypertension in the United States; and patient and physician factors that are the main causes of uncontrolled hypertension.

Meta analyses of randomized placebo-controlled trials indicate that antihypertensive therapy reduces the risk of stroke by ~30 percent, coronary heart disease by 10 percent–20 percent, congestive heart failure by 40 percent–50 percent, and total mortality by 10 percent. Researchers have estimated that control of hypertension to levels recommended by the JNC could prevent 19 percent–56 percent of coronary heart disease in men, and 31 percent–57 percent of coronary heart disease in women, depending on the blood pressure achieved.

WHAT IT MEANS FOR A CONCEPTUAL MODEL

The article provides some insight into what may be causing the lack of control of hypertension by patients and the impact hypertension has on other disease states. These factors could be built into the model as a way to build an ROI based on certain targets within wellness programs.

The prevalence of controlled hypertension varies widely. Perhaps the model should consider the ranges of prevalence in a condition being controlled and the impact it has on outcomes.

STUDY-RELATED QUESTIONS

1) With inconsistent definitions of hypertension across studies, does the meta-analysis leave us with too many variables to make sound conclusions?

2) Will we be able to obtain a data source with a common enough definition to enable sound analysis?

Cholesterol

"Effects of Past and Recent Blood Pressure and Cholesterol Level on Coronary Heart Disease and Stroke Mortality, Accounting for Measurement Error," by Hendriek C. Boshuizen, Mariapaola Lanti, Allessandro Menotti, Joanna Moschandreas, Hanna Tolonen, Aulikki Nissinen, Srecko Nedejkovic, Anthony Karatos and Daan Kromhout, *American Journal of Epidemiology* 165, no. 4 (February 15, 2007): 398–406.

OBJECTIVE

"To quantify the effects of current systolic blood pressure (SBP) and serum total cholesterol on the risk of mortality in comparison with SBP or serum cholesterol 25 years previously, taking measurement error into account. The authors reanalyzed 35-year follow-up data on mortality due to coronary heart disease and stroke among subjects aged 65 years or more from nine cohorts of the Seven Countries Study," the abstract reads.

METHODS

According to the abstract: "The two-step method of Tsiatis et al.[14] was used to adjust for regression dilution bias, and results were compared with those obtained using more commonly applied methods of adjustment for regression dilution bias. It was found that the commonly used univariate adjustment for regression dilution bias overestimates the effects of both SBP and cholesterol compared with multivariate methods. Also, the two-step method makes better use of the information available, resulting in smaller confidence intervals."

LIMITATIONS

The study ignores the occurrence of nonfatal cardiovascular conditions, which might have weakened the effect observed for earlier SBP or cholesterol levels. Information on treatment of hypertension was only partly available and no information was available on treatment of hypercholesterolemia. Also, since high SBP 25 years previously (in the 1960s) was mostly untreated, this could have contributed to the strong effect observed for past SBP, as treatment might mask the effects of recent SBP.

The study only looked at mortality rates after age 65. How will this translate to a younger population and how applicable will this study be to an active population?

RESULTS/CONCLUSIONS

"Results comparing recent and past exposure indicated that past SBP is more important than recent SBP in terms of its effect on coronary heart disease mortality, while both recent and past values seem to be important for effects of cholesterol on coronary heart disease mortality and

[14] A.A. Tsiatis, Victor Degruttola, and M.S. Wulfsohn, "Modeling the Relationship of Survival to Longitudinal Data Measured with Error: Applications to Survival and CD4 Counts on Patients with AIDS," *Journal of the American Statistical Association* 90, no. 429 (1995): 27–37, doi:10.1080/01621459.1995.10476485.

effects of SBP on stroke mortality. Associations between serum cholesterol concentration and risk of stroke mortality are weak," the abstract reads.

WHAT IT MEANS FOR A CONCEPTUAL MODEL

This study speaks to the relationship between high blood pressure and high cholesterol and the impact on heart disease and stroke mortality.

STUDY-RELATED QUESTIONS

1) Is this data too outdated to be relevant in the model? Or do these conclusions hold true in the current population?

2) Does this study have enough information to make conclusions on comorbidities between high blood pressure and high cholesterol?

3) How does this study, which focused on mortality after age 65, apply to a working population?

"By How Much and How Quickly Does Reduction in Serum Cholesterol Concentration Lower Risk of Ischaemic Heart Disease?" by M. R. Law, N. J. Wald and S. G. Thompson, *British Medical Journa*l 308, no. 6925 (February 5,1994): 367–72, doi:10.1136/bmj.308.6925.367.

OBJECTIVE

"To estimate by how much and how quickly a given reduction in serum cholesterol concentration will reduce the risk of ischaemic heart disease," the abstract reads.

METHODS

"Data on the incidence of ischaemic heart disease and serum cholesterol concentration were analyzed from 10 prospective (cohort) studies, three international studies in different communities, and 28 randomized controlled trials (with mortality data analyzed according to allocated treatment to ensure the avoidance of bias)," according to the abstract.

The main outcome measure was a "decrease in incidence of ischaemic heart disease or mortality for a 0.6 mmol/l (about 10 percent) decrease in serum cholesterol concentration."

LIMITATIONS

There is less data available for the impact on women than on the impact on men, but the results are similar.

RESULTS/CONCLUSIONS

The abstract continues, "For men results from the cohort studies showed that a decrease of serum cholesterol concentration of 0.6 mmol/l (about 10 percent) was associated with a decrease in

incidence of ischaemic heart disease of 54 percent at age 40 years, 39 percent at age 50, 27 percent at 60, 20 percent at 70, and 19 percent at 80. The combined estimate from the three international studies (for ages 55–64 years) was 38 percent (95 percent confidence interval 33 percent to 42 percent), somewhat greater than the cohort study estimate of 27 percent. The reductions in incidence of ischaemic heart disease in the randomized trials (for ages 55–64 years) were 7 percent (0 to 14 percent) in the first two years, 22 percent (15 percent to 28 percent) from 2.1–5 years, and 25 percent (15 percent to 35 percent) after five years, the last estimate being close to the estimate of 27 percent for the long-term reduction from the cohort studies. The data for women are limited but indicate a similar effect."

The abstract listed the following conclusions: "The results from the cohort studies, international comparisons and clinical trials are remarkably consistent. The cohort studies, based on half a million men and 18,000 ischaemic heart disease events, estimate that a long-term reduction in serum cholesterol concentration of 0.6 mmol/l (10 percent), which can be achieved by moderate dietary change, lowers the risk of ischaemic heart disease by 50 percent at age 40, falling to 20 percent at age 70. The randomized trials, based on 45,000 men and 4,000 ischaemic heart disease events, show that the full effect of the reduction in risk is achieved by five years."

Public health implications include:

- The combined evidence from the 10 largest cohort studies, three international (ecological) studies, and 28 randomized trials shows conclusively that lowering a person's serum cholesterol concentration results in substantial protection from ischemic heart disease.
- The benefits of serum cholesterol reduction are related to age; a 10 percent reduction in serum cholesterol concentration produces a reduction in ischemic heart disease of 50 percent at age 40, 40 percent at age 50, 30 percent at age 60 and 20 percent at age 70.
- The benefit can be realized quickly—the greater part after two years and the full benefit after five years.
- Lowering serum cholesterol concentrations in a population is critical in reducing mortality from ischemic heart disease.
- Appropriate action is needed, including wider health education, labeling of foods and policies on food subsidies that are linked to health priorities.

Estimates from international studies of the percentage decrease in incidence of or mortality from ischemic heart disease per 0.6 mmol/l decrease in serum cholesterol concentration are contained in Table III and Table IV summarized randomized controlled trials of reduction in serum cholesterol concentration and the number of men with ischemic heart disease events (deaths or nonfatal infarcts) by time period.

WHAT IT MEANS FOR A CONCEPTUAL MODEL

The study evaluated high cholesterol, which is a risk condition, and its relationship with ischemic heart disease, a disease state, and mortality, an actuarial impact. Furthermore, high cholesterol is impacted by diet, a lifestyle factor, and reducing cholesterol levels results in reduced health risk.

STUDY-RELATED QUESTIONS

1) Is there more information available regarding how diet can influence serum cholesterol levels and hence the impact of diet on ischemic heart disease and mortality?

2) Beyond the incidence of ischemic heart disease and associated mortality, what is the impact of lowering serum cholesterol levels on health care costs?

3) What are general prevalence rates of various levels of serum cholesterol and ischemic heart disease?

"The Lipid Research Clinics Coronary Primary Prevention Trial Results: II. The Relationship of Reduction in Incidence of Coronary Heart Disease to Cholesterol Lowering," *Journal of the American Medical Association* 251, no. 3 (January 20, 1984): 365–74, doi:10.1001/jama.1984.03340270043026.

OBJECTIVE

The Lipid Research Clinics Coronary Primary Prevention Trial (LRC-CPPT) looked to show the impact of lowering cholesterol on coronary heart disease (CHD) incidence. Specifically, the wide range of reductions in Total-C (total plasma cholesterol levels) and LDL-C (low-density lipoprotein cholesterol) levels attained by those treated with cholestyramine resin is used to relate the degree of cholesterol reduction incidence of CHD. The relationship of changes in triglycerides (TG), HDL-C and HDL-C/Total-C levels to incidence of CHD is also examined. The article also addresses the following questions.

1) Was CHD incidence within the cholestyramine group related to the degree of reduction in Total-C and LDL-C levels?

2) Did differences in CHD incidence among men with different degrees of cholesterol reduction arise from an underlying "dose-response" relationship or from self-selection?

3) Might cholestyramine resin also have modified CHD risk by its effect on HDL-C or TG levels?

4) Are the LRC-CPPT results internally consistent?

5) Are the LRC-CPPT results consistent with those of observational studies and other clinical trials of cholesterol lowering?

METHODS

Incidence of CHD in hypercholesterolemic men treated with cholestyramine resin and diet was compared with that in similar men treated with placebo and diet. Estimation of adherence to the medication was based on the number of packets returned by each participant at bimonthly visits. Measurement of plasma lipid and lipoprotein levels were taken and compared to the patients' baseline levels. Missing data did occur and was dealt with as described in the article's appendix. Year by year descriptive tabulation and the proportional hazards model were used to gather and

analyze the data. Computation of risk reduction for strata of LDL-C then took place. This was also then compared to results of the other clinical trials lowering cholesterol.

LIMITATIONS

1) There was occasional failure of participants to attend the clinic, return unused packets of medication or fast for 12 hours, as well as infrequent lab problems, so the data was not ideal or 100 percent complete.

2) There may also be difficulty sustaining long-term trials over a period of years given the patients' and physicians' inability to modify treatment on an ongoing basis.

3) The study looks specifically at diet, cholesterol and CHD.

RESULTS/CONCLUSIONS

"In the Lipid Research Clinics Coronary Primary Prevention Trial (LRC-CPPT), a 19 percent lower incidence of coronary heart disease (CHD) in cholestyramine-treated men was accompanied by mean falls of 8 percent and 12 percent in plasma total (TOTAL-C) and low-density lipoprotein (LDL-C) cholesterol levels relative to levels in placebo-treated men," according to the abstract. "When the cholestyramine treatment group was analyzed separately, a 19 percent reduction in CHD risk was also associated with each decrement of 8 percent in TOTAL-C and or 11 percent in LDL-C levels ($P<.001$). Moreover, CHD incidence in men sustaining a fall of 25 percent in TOTAL-C or 35 percent in LDL-C levels, typical responses to the prescribed dosage (24 g/day) of cholestyramine resin, was half that of men who remained at pretreatment levels. Adherence to medication was associated with reduced incidence of CHD only when accompanied by falls in TOTAL-C and LDL-C levels. Small increases in high-density lipoprotein cholesterol levels, which accompanied cholestyramine treatment, independently accounted for a 2 percent reduction in CHD risk. Thus, a reduction of CHD incidence in the cholestyramine group seems to have been mediated chiefly by reduction of TOTAL-C and LDL-C levels."

WHAT IT MEANS FOR A CONCEPTUAL MODEL

Changing (reducing) cholesterol levels of Total-C and LDL-C, and increasing HDL-C/Total-C levels reduces the risk of coronary heart disease. This is a cause-and-effect study that tells us what we need to know about one connection of risk factor to disease, and the impact of changing these levels. Surprisingly, this article also gives us the impact of diet on high cholesterol and CHD (see the placebo group data).

STUDY-RELATED QUESTIONS

1) What is the initial incidence of high cholesterol, and its impact on diseases other than CHD?

2) What is the impact of changing the cholesterol levels as previously indicated may also occur for other reasons such as treatment for high BMI, diabetes and other conditions?