Steps to a Healthier U.S. Workforce

Integrating Occupational Health and Safety and Worksite Health Promotion: State of the Science

Glorian Sorensen, Ph.D., M.P.H.
Elizabeth Barbeau, Sc.D., M.P.H.
Harvard School of Public Health
Department of Society, Human Development and Health
Dana-Farber Cancer Institute
Center for Community-based Research

Commissioned paper for
The National Institute of Occupational Safety and Health
Steps to a Healthier U.S. Workforce symposium
October 26–28, 2004, Washington, D.C.

Preface

The health and well-being of working people and their families are greatly influenced by the quality of their work environments, whether resulting directly from exposures to physical hazards on the job and risks associated with the organizational context, or indirectly through the impact of work on health behaviors. In recognition of these shared influences, this paper was written for Steps to a Healthier U.S. Workforce symposium, sponsored by the National Institute for Occupational Safety and Health (NIOSH) in 2004. The paper provided an overview of the scientific evidence available at that time for enhancing worker and worksite health by integrating worksite health promotion and occupational health and safety, and it introduced a framework for future research in this arena. Since then, significant progress has been made in support of integrated approaches to worker health. Notably, NIOSH has expanded its commitment to this approach to worker health. It successfully initiated the Total Worker Health™ program (formerly the WorkLife Initiative), and as part of this initiative, NIOSH funded three Centers for Excellence, including at the University of Iowa, the University of Massachusetts/Lowell, and the Harvard School of Public Health. The three centers collaborated on a *Statement on National WorkLife Priorities*,[1] and findings from their research are becoming available. With input from experts in the field, NIOSH also developed a set of "essential elements" of effective workplace programs and policies for improving worker health and wellbeing, as described on their Web link.[2]

Attention to an integrated approach to worker health has extended well beyond NIOSH. The Institute of Medicine released a pivotal report articulating both the rationale for an integrated approach to worker health, and providing a structure for the implementation of such an approach.[3] The American Heart Association endorsed efforts to integrate worksite health protection and worksite health promotion for cardiovascular health promotion.[4] In addition, the National Institutes of Health established the Work, Family, and Health Network, which is developing and evaluating the effects of worksite work-family policies and practices that impact health of workers and their families.[5] In addition, in recent healthcare reform policies, an emphasis on workplace health has placed increased attention on the implementation of evidence-based workplace wellness programs in an effort to expand utilization of such programs.

In 2009, the National Heart, Lung, and Blood Institute; NIOSH; the Centers for Disease Control and Prevention; the National Institute for Child Health and Human Development; and the National Cancer Institute, together convened a workshop to set priorities for research to support chronic disease prevention in the workplace. The discussions focused on promoting healthy and safe individual behaviors; reducing physical, psychosocial, and organizational risks at the worksite; and promoting work-life balance. The resulting recommendations[6] articulate a research agenda addressing cross-cutting research themes across these three targets. The six broad priorities for future research identified by the workshop reinforce the research directions outlined in our original "Steps" paper:

Assessment of intervention efficacy and characteristics associated with efficacy: Much research on worker health conducted to date has continued to focus separately on one of the three targets—worker health behavior outcomes, the work environment, or the work-family interface. The workshop participants placed a high priority on future research to test the effects of integration across these three intervention targets, with a particular focus on identifying opportunities for synergy.

Attending to population, job, and worksite characteristics: Disparities in worker health outcomes, exposures on the job, and access to interventions underscore the need for research to identify strategies to reduce these inequalities. The recommendations included the need for attention to disparities by occupation, gender, age, socio-economic position, race/ethnicity, or other characteristics.

Use of appropriate study designs and methods: There remains a need for studies across phases of research, from hypothesis testing and methods development, to efficacy and effectiveness studies, to knowledge transfer and implementation science. Going beyond sole reliance on randomized controlled trials, it is important that our collective research portfolio also include natural experiments; in-depth, mixed methods, or comparative case studies; multi-level designs; and the application of participatory research methods.

Application of appropriate and expanded measures and metrics: With increasing research being conducted by researchers from diverse disciplines, it is important that common, standardized measures be used where possible to allow for comparisons across studies. The workshop participants stressed the need for improved occupational exposure assessments for integrated work environment and health promotion interventions, and for the development of standard measures of costs and evaluations of returns on investment.

Studying sustainability and knowledge transfer: In order to accelerate the adoption of tested interventions, there is a persistent need for worksite research on the processes of dissemination and implementation. Research directions include identifying effective ways to engage worksites and organizational leaders, examining the impact of financial and other incentives on motivating worksite participation in chronic disease prevention, and assessing barriers to effective intervention delivery.

Addressing global concerns: The increasing relevance of the global economy underscores the need for research on the use of effective worker health promotion and health protection efforts beyond the U.S. borders.

To advance this research agenda, the need for promoting trans-disciplinary research teams and improved collaboration remains. Collaborative efforts spanning disciplinary boundaries remain a core strategy in engaging the necessary diverse perspectives. Trans-disciplinary research additionally pushes toward the development of new common conceptual frameworks that synthesize models used in any one discipline.[7–9] The broadening base of institutional commitment and support for research on worker health and the work environment can serve as increased incentives for expanding beyond our disciplinary boundaries, and it holds promise for improving worker health outcomes.

References for Preface

1. Cherniack M, Henning R, Merchant JA, Punnett L, Sorensen GR, Wagner G. Statement on national worklife priorities. *Am J Ind Med.* 2011;54(1):10–20.

2. National Institute for Occupational Safety and Health. Essential elements of effective workplace programs and policies for improving worker health and wellbeing: http://www.cdc.gov/niosh/worklife/essentials.html. Accessed July 7, 2010.

3. Institute of Medicine, Committee to Assess Worksite Preventive Health Program Needs for NASA Employees, Food and Nutrition Board. Integrating employee health: A model program for NASA. Washington, DC: Institute of Medicine, National Academies Press; 2005.

4. Carnethon M, Whitsel LP, Franklin BA, Kris-Etherton P, Milani R, Pratt CA, Wagner GR. Worksite wellness programs for cardiovascular disease prevention: a policy statement from the American Heart Association. *Circulation.* 2009;120(17):1725–1741.

5. Kaiser Permanente Center for Health Research. Work, family and health network. http://www.kpchr.org/workfamilyhealthnetwork/public/default.aspx. Accessed March 11, 2010.

6. Sorensen G, Landsbergis P, Hammer L, Amick B, Linnan L, Yancey A, Welch L, Goetzel R, Flannery K, Pratt C. Preventing chronic Disease at the workplace: a workshop report and recommendations. *Am J Public Health.* 2011;Jul 21. [Epub ahead of print].

7. Holmes JH, Lehman A, Hade E, Ferketich AK, Gehlert S, Rauscher GH, Abrams J, Bird CE. Challenges for multilevel health disparities research in a transdisciplinary environment. *Am J Prev Med.* 2008;35(2 Suppl):S182–S192.

8. Stokols D, Hall KL, Taylor BK, Moser RP. The science of team science: overview of the field and introduction to the supplement. *Am J Prev Med.* 2008;35(2 Suppl):S77–S89.

9. Stokols D, Harvey R, Gress J, Fuqua J, Phillips K. InVivo studies of transdisciplinary scientific collaboration: Lessons learned and implications for active living research. *Am J Prev Med.* 2005;28(2 Suppl 2):202–213.

Acknowledgements

We greatly appreciate the dedication, persistence, and thoroughness of Christopher Speed, who made important contributions to this paper in the role of research assistant. We also thank Kerry Kokkinogenis for her work in production of the manuscript. We are indebted to the comments of reviewers on a draft of this manuscript, including Drs. Paul Landsbergis, Charles Levenstein, Margaret Quinn, and Gregory Wagner. Our thinking on this topic has been greatly informed by our collaborators, among them, Karen Emmons, Elizabeth Harden, Mary Kay Hunt, Anthony LaMontagne, Deborah McLellan, Anne Stoddard, Lorraine Wallace, and Richard Youngstrom, and by the worksites and unions collaborating on our research. We additionally appreciate the thoughtful comments of discussants of this paper at the NIOSH symposium, including Drs. Joan Eakin, Laura Linnan, and James Merchant.

Abstract

This paper presents the rationale and scientific evidence for coordinating and integrating worksite health promotion and occupational health and safety as a means of enhancing the effectiveness of efforts to promote and protect worker health. Commissioned by NIOSH for its 2004 Steps to a Healthier U.S. Workforce symposium, this paper is intended to stimulate discussion and improve communication between the fields of worksite health promotion and occupational safety and health. We describe the parameters of each approach and suggest common goals and areas to increase coordination, with special attention to the implications of a rapidly changing labor market on future research priorities. We present recommendations for future research, barriers to be overcome to advance knowledge in this area, and suggestions for creating additional opportunities for scientists from a broad range of disciplines to engage in integrated occupational health and safety/worksite health promotion research aimed at improving worker health.

workers. Alternatively, information asymmetries can arise if individuals underestimate the effect of employer investments in health. If either party is imperfectly informed about the investments in health by the other, this will prevent them from optimally negotiating the level of investment in the contractual agreement.[9]

When either party maximizes investment without considering the impact on the other's welfare, it will lead to sub-optimal levels of investment in health. The intuition for this result, derived formally in the appendix, is that the total social value comes from jointly maximizing both the welfare of shareholders and the welfare of workers. If workers only invest in health promotion without considering the welfare of shareholders, while firms only invest in injury reduction without considering the utility of workers, inadequate investment will result.

In many ways, the Occupational Safety and Health Act can be seen as addressing one half of this problem. Suppose workers do not perceive the benefits of employer health investments; they will not demand high levels of safety from employers. If employers are not given the incentives to sufficiently consider the benefits of their investments in workplace safety for their employees, then they will provide too little safety. Thus, by regulating a higher level of occupational safety, presumably the optimal level, then regulatory interventions such as the Occupational Safety and Health Act can solve the problem of too little investment in safety by employers.

However, simply giving employers the incentives to invest more in workplace safety does not address the corresponding problem with worker health investments. Without further intervention, workers may not consider the potential gains to personal investment in health for employers, and hence will not invest the optimal amount in their own health. This is why health promotion programs are potentially important; employers may be able to use them to improve worker investments in health. Suppose we altered the model to give employers the ability to subsidize employee investments in health with a dollar transfer for every dollar invested by the worker. In such a scenario, employers would be willing to spend exactly up to the amount that generated the optimal level of personal investment in health.[10]

This discussion illustrates why employers may choose to adopt health promotion programs and why workers benefit from regulatory involvement in injury reduction (in both cases so that the gains to the other are considered when choosing their investment decision). However, it still leaves open the central question of this paper: whether or not there are gains to coordinating these interventions. In the model developed here, gains to coordination exist if there are *spillovers* between nonoccupational and occupational health investments in their effect on health.

Spillovers arise if nonoccupational heath investment makes investment in occupational health either more or less beneficial to employers (if, in the parlance of economics, the two are *complements* or *substitutes*, respectively). Spillovers in health investments create gains to coordinating health promotion and injury and illness prevention activities, because changes in the investment behavior of an individual will then lead to a different optimal level of investment by the employer. If these spillovers are not recognized, and individual and employer investment decisions are made independent of each other, we would not expect to obtain the optimal level of investment. This will be true even with well-designed interventions, if they are implemented separately.

There are a number of possible explanations as to why spillovers of this sort might exist. There may be

9 The problem of unobservable health and safety measures has long been recognized to cause problems in contractual arrangements with regards to both nonoccupational and occupational health. Arrow (1968) discusses the problem of unobservable personal health habits for health insurance. Diamond (1977) focuses on the issue of unobservable safety precautions by workers. Rea (1981) discusses the problems that arise when workers misperceive the impact of employer investments in health.

10 We note that the conclusion that there is underinvestment in health is by no means inconsistent with the observation that the United States pays too much for healthcare. The high amount spent on healthcare could indeed be a reflection of inappropriate investment in health promotion, as it may be more expensive to treat health conditions after they emerge than to invest in health activities and programs that prevent the problems from emerging. The investment in health that we are describing in this paper is of the activity and program flavor, rather than the treatment flavor.

physiological mechanisms that lead to a combined effect of occupational and nonoccupational risk factors that increase or lessen the impact of either on health. There could be psychological effects, whereby an effort to increase one's health in the workplace made them more committed to maintaining good habits at home. From an employer's perspective, there could be administrative effectiveness gains in terms of measuring outcomes or motivating participation. It is important to note, however, that the extent to which such spillovers exist could vary significantly among any of the important dimensions of the problem: namely, the specific types of health outcomes, risk factors, and interventions.

Estimating Spillovers in the Impact of Occupational and Nonoccupational Risk Factors on Health Outcomes

The question of how cost effective injury and illness prevention and health promotion programs are, either separately or jointly, remains largely unanswered. Actually determining cost effectiveness would take a large research effort that carefully selected measurable outcomes and inputs, as well as cost variables, and some form of randomization. This would likely require either a group of participating employers or at least one very large employer with many establishments over which to randomize. Additionally, given the length of time over which it may take some health conditions to develop, it would require a long time-path for the study to fully capture the benefits to employers and workers. Even with all of these elements, there are substantial challenges in measuring the true cost of any given health affliction to an individual.[11]

A large-scale examination of the costs and benefits of an integrated injury and illness prevention and health promotion program is beyond the scope of this paper. Instead, we study how personal and job-related health risks affect health shocks, both individually and jointly. While our analysis will be largely descriptive, given that we will not be able to distinguish whether the effects we measure are causal or selective in nature, we believe it will highlight some of the important issues that need to be considered when studying the role of modifiable job and personal risk factors on health.

Data and Methods

We use data on health status, personal health habits and job-related risks from the HRS. The HRS is a nationally representative panel sponsored by the National Institute of Aging and conducted by the Institute for Social Research at the University of Michigan. The study targeted individuals (and their spouses) aged 51–61 at the time of the first wave (1992), and was intended to provide information on health and retirement issues for the older community-dwelling population. Follow-up surveys were conducted biennially after 1992. The survey oversampled blacks and Hispanics, and includes weights that can be used to make it nationally representative for the 48 contiguous states.

As discussed above, there are numerous potential individual and work-related variables that could impact health. To focus our analysis, we consider a single personal health habit, smoking behavior, and a single job-related factor, the exposure to potentially harmful materials at work. These are useful for our purposes because both are clearly distinct in terms of their work relatedness, and both are well known to be associated with poor health. In addition, it is generally recognized that there may be spillovers in the two in terms of their impact on health; it has been argued that the health risks from exposure to asbestos are far more likely to manifest

11 One of the key problems is how to measure the noneconomic harm to an individual in dollar terms. Viscusi and Evans (1990) attempt to estimate these effects using survey data, but there remain challenges to measuring such effects in practice.

in smokers than in nonsmokers (U.S. Department of Health, Education and Welfare, 1979; U.S. Department of Health and Human Services, 2001).

The smoking variable that we utilize asks if an individual ever smoked cigarettes. This was asked in the initial wave, and follow-on questions were asked regarding current (at the time of the survey) smoking behavior. The exposure question was also asked in wave 1, and read as follows.

Individuals are sometimes exposed to dangerous chemicals or other hazards at work. Have you ever had to breathe any kinds of dusts, fumes, or vapors, or been exposed to organic solvents or pesticides at work?

If the individual responded affirmatively to this question, follow-up questions were asked regarding the nature and duration of the exposure.

We consider the impact of smoking and exposure to toxic chemicals on four potential health outcomes: respiratory disease (chronic lung disease, except asthma, such as chronic bronchitis or emphysema), cancer or a malignant tumor of any kind except skin cancer, heart disease (heart attack, coronary heart disease, angina, congestive heart failure, or other heart problems), or arthritis (including rheumatism). We expect that both smoking and exposure to harmful substances could have an impact on the first three of these, particularly respiratory disease. Arthritis, on the other hand, is included as a robustness check. We expect that the risk of suffering arthritis because of either smoking or exposure to harmful chemicals should be small, given that neither is commonly recognized as a risk factor for arthritis. Therefore, any effect of smoking or exposure on arthritis that we observe should be due at least in part to correlation between these variables and unobserved variables indicating poor health status. Although this will not allow us to obtain causal estimates for the impact of smoking and exposure on health shocks, it will provide some insight as to whether selection appears to be prominent in our analysis.[12]

Results

Table 1 provides some summary statistics for the key variables used in our analysis. The summary statistics represent the characteristics of individuals in Wave 1 of the HRS. Most important for our analysis is to note that about 64 percent of individuals in our sample report ever smoking, while about 39 percent report ever being exposed to hazardous materials at work (about 27 percent report both). Almost 33 percent of individuals report being exposed to hazardous materials for more than 1 year.

12 All regression analyses account for the complex sampling design of the HRS using information on the survey weights, strata and primary sampling units as implemented in survey data estimation commands in Stata 7.0 (Stata Corporation, College Station, TX). The Huber/White nonparameteric correction is used to adjust standard errors for repeated observations on the same individuals.

Table 1. Summary Statistics

Variable	Mean	95% Confidence Interval
Age	55.6	[55.49, 55.63]
White	86.2%	[85.56, 86.75]
Female	52.4%	[51.30, 53.44]
Ever Smoked	63.90%	[62.91, 64.96]
Ever Exposed to Hazardous Substances	39.20%	[38.12, 40.30]
Smoked * Exposed	27.70%	[26.68, 28.68]
Exposure of Greater than 1 Year	32.70%	[31.68, 33.78]
Smoked * Long Exposure	23.20%	[22.25, 24.13]
Number of Observations: 9,771		

Notes: Number of observations represents the number of observations in Wave 1 of the HRS. The total number of observations in all waves in our data is 49,539. Note that some variables might have missing values, most notably the exposure to hazardous substances variable. Means and confidence intervals are calculated using weights reflecting the complex survey design of the HRS.

In Table 2 we illustrate the nature of the hazardous materials to which individuals report being exposed. The most common material was some form of chemical solvent, with the second most common being minerals and fumes other than asbestos (asbestos was the fifth-most common type of exposures). Note that individuals were allowed to report two forms of exposure, so we report the distribution of both exposure types in Table 2. For individuals exposed to hazardous materials, a separate question in the HRS indicates that approximately one-quarter felt that it had some adverse impact on their health.

Table 2. Types of Hazardous Materials Respondents Workers Report Being Exposed To

	First Category		Second Category	
	Number	Percent	Number	Percent
Solvents	832	29.4	477	33.73
Petroleum Products	202	7.1	121	8.56
Asbestos	293	10.3	68	4.8
Other Fumes and Dust	506	17.9	211	14.9
Biohazards (Incl. Wood and Paper)	191	6.7	65	4.6
Inorganic Materials (Incl. Acid)	199	7.0	143	10.1
Agricultural	296	10.4	124	8.8
Drugs and Explosives	20	0.7	9	0.6
Other	295	10.4	196	13.9
Total	2,834	100	1,414	100

Notes: There are 531 workers that do not report the type of exposure they faced. Workers are given the opportunity to list two types of materials to which they were exposed, and if they do this is reported above as the second exposure category.

In Figure 1 we examine the effect of exposure to hazardous materials on the prevalence of lung disease. For the figure, we use the response to the hazardous exposure question in Wave 1 and then examine the frequency of lung disease in all waves by current age (so we count individuals multiple times over different waves). The figure indicates a clear effect of reported exposure to hazardous materials on the reported prevalence of lung disease. The difference appears to be about a 4–5 percentage point increase in the frequency of lung disease for the exposed across all ages, with only a slightly higher gradient for the exposed category.

Figure 1. Frequency of Lung Disease by Age and Exposure Status

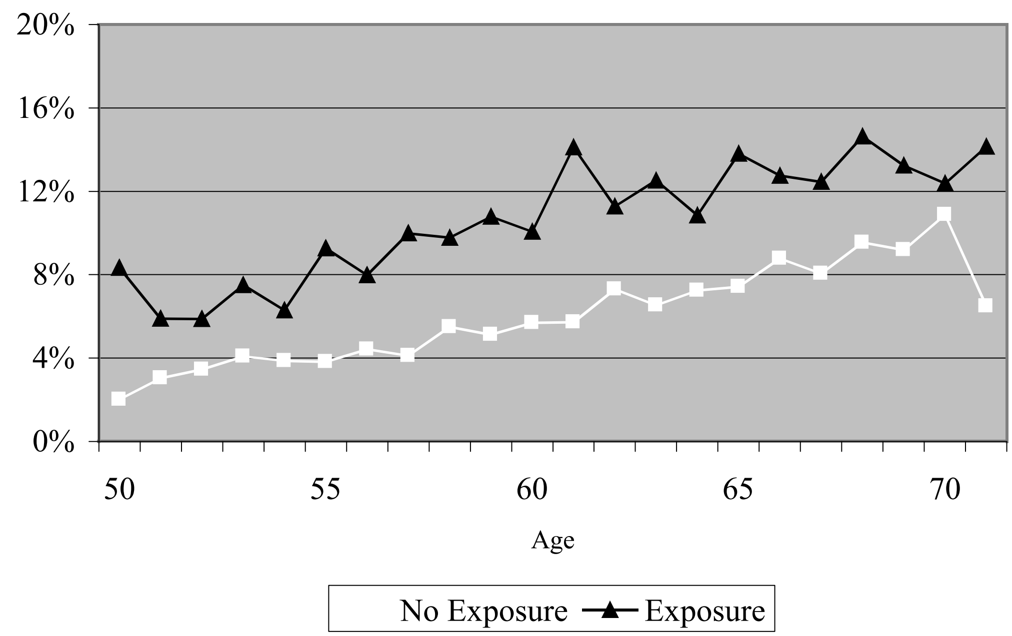
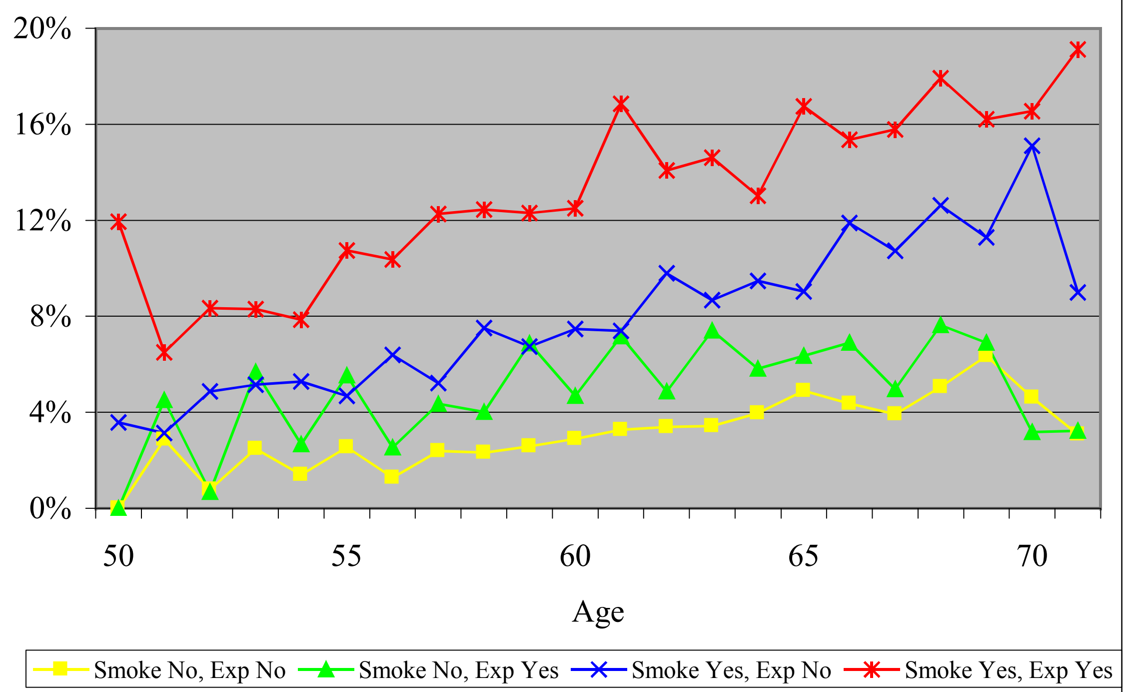


Figure 2 breaks down the data into four groups based on whether or not the individuals report ever smoking or ever being exposed to harmful materials. This allows us to examine the direct effect of our measures of individual and employer health risks, as well as the combined effect of the two. From the figure, we see that the combined effect is significant, indicating a propensity for lung disease of close to 10% in the early 50s and rising to nearly 20% at age 70. Both smoking and exposure appear to have an individual effect on lung disease, with the direct effect of smoking apparently larger.

Figure 2. Frequency of Lung Disease by Age and Exposure Status



Clearly, the danger of exposure to hazardous materials at work in terms of lung cancer appears worse for individuals who smoke. We now examine this relationship controlling for additional covariates (race, gender, education, and industry type), and examine the relationship for other health conditions. We do this with a series of estimated probit models, the results of which are reported in Table 3. The dependent variable in each of the probit models is whether an individual reported one of the four health conditions mentioned above (lung disease, cancer, heart disease or arthritis), either in the first wave or a later wave. We report results separately for any exposure to harmful chemicals, and for exposure that lasted longer than 1 year. We also report results with and without interaction terms between smoking and exposure.

Table 3. Impact of Smoking and Exposure to Harmful Substances on Health Shocks to Individuals

	Any Exposure		Exposure > 1 Year	
	I.	II.	III.	IV.
Lung Disease				
Exposed	0.2617	0.0736	0.2988	0.1397
	(6.28)**	(0.85)	(6.99)**	(1.57)
Ever Smoked	0.5087	0.4127	0.5100	0.4396
	(10.44)**	(6.62)**	(10.45)**	(7.32)**
Exposure*Smoked		0.2438		0.2049
		(2.49)*		(2.05)*
Cancer				
Exposed	0.1840	0.1868	0.1853	0.1493
	(4.46)**	(2.64)**	(4.38)**	(2.00)*
Ever Smoked	0.1590	0.1605	0.1590	0.1428
	(3.86)**	(3.09)**	(3.86)**	(2.89)**
Exposure*Smoked		-0.0040		0.0513
		(0.05)		(0.58)
Heart Disease				
Exposed	0.0811	0.1048	0.1213	0.1019
	(2.28)*	(1.68)+	(3.33)**	(1.58)
Ever Smoked	0.1784	0.1912	0.1776	0.1688
	(4.92)**	(4.16)**	(4.89)**	(3.85)**
Exposure*Smoked		-0.0338		0.0274
		(0.46)		(0.36)
Arthritis				
Exposed	0.1971	0.0452	0.1489	0.0343
	(5.93)**	(0.81)	(4.33)**	(0.59)
Ever Smoked	0.0803	-0.0009	0.0814	0.0312
	(2.47)*	(0.02)	(2.50)*	(0.81)
Exposure*Smoked		0.2272		0.1693
		(3.42)**		(2.43)*

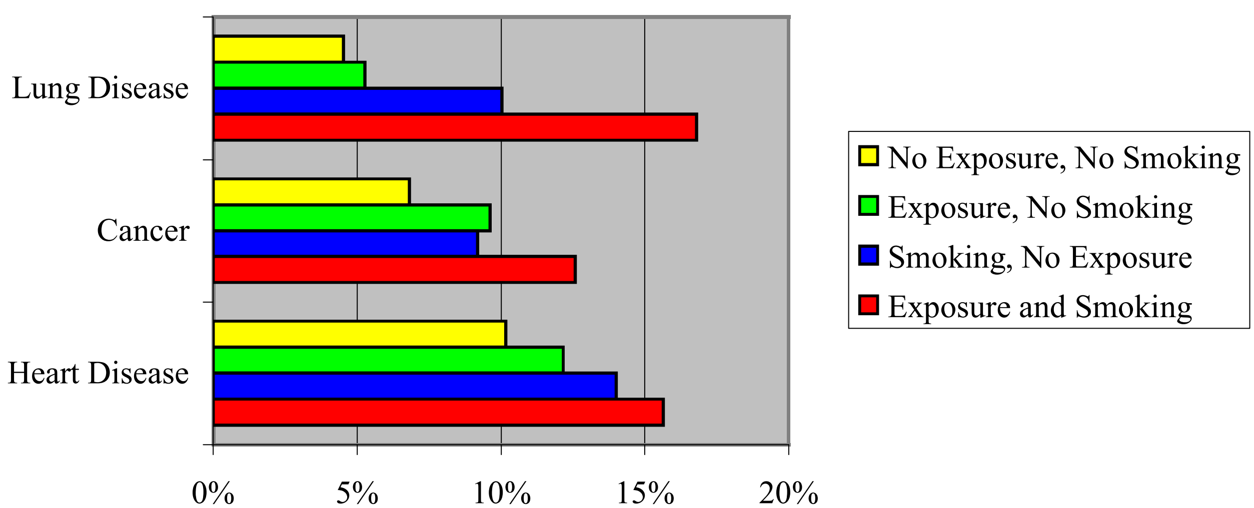
Notes: Each column and panel reports the estimated coefficients from a probit model taking into account the sampling in the HRS. t-statistics are reported in parentheses. A ** represents statistical significance at the 1% level, a * represents significance at the 5% level and a + represents significance at the 10% level. All regressions include dummy variables for the respondents' age, education, race, gender and the industry for which they worked the longest.

With reference to our earlier model, the variable for smoking represents the individual investment and the variable for exposure the private investment in reducing health shocks. We cannot say for sure what the impact of this investment on individual and employer value functions is, because we cannot translate from the health shock to the welfare of either party. Clearly these conditions will be negative for individuals, but it is less clear whether or not they will be so for employers (particularly for individuals at old age). The interaction term can be seen as a test for spillovers between the individual and employer investments.

Column I of Table 3 shows that both smoking and exposure are correlated with significantly increased risk for all conditions. Looking at Column III, we see that exposure for more than a year is associated with a larger risk for the three primary health risks, which we would expect, but the effect is not large. For all conditions except arthritis, the direct effect of smoking is larger than that of exposure. Table 3 also indicates that smoking and exposure are complements with regards to their impact on lung disease, though the interaction term is not statistically significant for heart disease or cancer. Note that the effects of any exposure and exposure for more than a year are nearly identical, likely reflecting the fact that most who were exposed were exposed for at least a year.

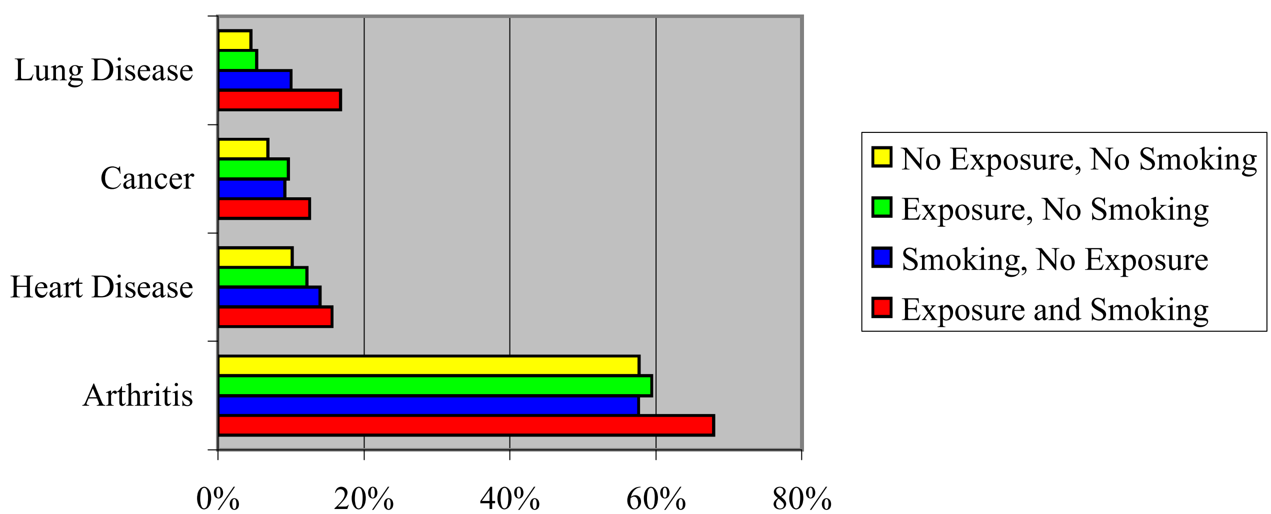
It is generally difficult to directly interpret probit coefficients in an intuitive manner, so in Figure 3 we report the predicted probabilities from the model by smoking and exposure (taking the other variables at their mean values). The figure suggests that there is a direct effect of both smoking and exposure, though the direct effect of exposure is small for lung disease (and not statistically significant in Table 3). The direct effects are larger for cancer and heart disease, though the interaction terms do not appear as large. In general, smoking and exposure appear to be complements with regards to their impact on these diseases, though the effect is only strong for lung disease.

Figure 3. Predicted Probability of Ever Suffering a Condition by Smoking and Exposure to Hazardous Materials



In Figure 4 we extend the analysis to display the predicted results for arthritis. Note that arthritis is far more common than the other three conditions, with our model predicting nearly 60 percent frequency for all four groups. In general, we see that there appears to be very little direct effect of smoking or exposure on the prevalence of arthritis, but there is a joint effect. Workers who smoked and report being exposed to hazardous materials appear roughly 8–10 percentage points more likely to suffer from arthritis. The most likely explanation for this would appear to be selection; smokers who are exposed to toxic chemicals could have more physically demanding jobs or worse baseline health characteristics that make them more susceptible to arthritis.

Figure 4. Predicted Probability of Ever Suffering a Condition by Smoking and Exposure to Hazardous Materials



The results for arthritis clearly suggest that one explanation for the strong impact of both smoking and exposure to hazardous materials on the other health conditions could be selective rather than causal. The causal interpretation is that exposure to hazardous materials at work and smoking combine to worsen health outcomes for individuals. The selective interpretation would suggest that individuals who are more vulnerable to poor health, perhaps because of heavier smoking or some other unobserved characteristic, are also more likely to be exposed to hazardous materials at work. This result raises important public policy concerns regardless of which interpretation is the correct one. However, the selection explanation does not as readily suggest that integrating health promotion and injury reduction programs will have multiplicative health benefits.

Overall, our analysis reinforces that there are large potential gains to individual health from modifying individual and employer risk variables. Furthermore, there is at least some evidence that the health outcomes for individuals could be made better off by jointly reducing smoking and exposure to harmful chemicals at work. We only consider two types of behaviors and a handful of health conditions, but there are many possible combinations that one could consider. Future work should expand the analysis to determining the effect of different behaviors on different kinds of individual health, but clearly must be careful to control for the possible selection on unobserved characteristics.

Conclusions

As long as we maintain a system in which the health and health care of individual workers are tied so closely to the employer, we will in all likelihood continue to see a strong interest in health promotion programs. And as long as the distinction between occupational and nonoccupational injuries continues to fade, it is likely that there will also be continued interest in coordinating health promotion and injury and illness prevention programs. However, there remain substantial gaps in our knowledge about just how cost-effective such programs are, taken in isolation or considered jointly.

This paper discusses some economic issues that need to be considered when studying health promotion and injury and illness prevention programs. We outline a model for discussion of how individuals and employers could benefit from investing in individual health. Our primary finding is that the gains, in terms of economic efficiency, to coordinating health promotion and injury and illness prevention programs arise if there are spillovers between the effects of occupational and nonoccupational risk factors on health. If positive spillovers are present, then recognition of the interaction between the two programs will be necessary in order to correctly evaluate the cost effectiveness of either programs, and there are likely to be health benefits from their coordination.

We also discuss some empirical issues related to estimating the gains to these programs, and illustrate these with an analysis of how smoking and exposure to toxic chemicals combine to affect the health of individuals. Our results suggest that workplace conditions and health habits both influence individual health, and that the effect appears more than additive for some health conditions (suggesting a positive spillover). However, the analysis is also suggestive of the possibility that sample selection could be contributing to the estimates of spillovers.

Clearly, much work remains to be done on this issue. The outcomes we focus on in this paper are restricted primarily to those directly related to the health of workers, but there are other potential gains to coordinating health promotion and injury and illness prevention programs that we do not consider. For instance, the administrative savings from a coordinated program could potentially be large, particularly for larger firms that self-insure both occupational and nonoccupational health-care costs.

However, even focusing on just the direct impact of interventions on health outcomes, it is no simple matter to determine cost-effectiveness. Given the various ways in which the costs of health and health risks may be transferred between individuals and employers through wage negotiations, it could be very difficult to obtain a complete accounting of the difference between employer costs with and without an integrated program. Also, given that our empirical results suggest that some of the impact of workplace safety investments may occur in older individuals (our sample of individuals were all age 50 or over), there are reasons to believe that the full benefits of prevention measures will not be recovered by employers (as most health-care costs for older individuals will likely be borne by Medicare). All of this suggests a need for a great deal of additional research aimed at determining the optimal intervention in health promotion and injury and illness prevention programs.

Technical Appendix

In this appendix, we present a formal model of investment in individual health by employers and workers. We then show how maximizing investment for each agent without considering the impact on the other agent's welfare will lead to sub-optimal levels of investment in health. If we think of integrated health promotion and injury and illness prevention programs as facilitating the joint maximization of investment, then such integration will be welfare enhancing for both parties. Here we focus primarily on the technical aspects of the model, and leave the intuition for the results to the text.

Model Setup

In this section we set up a model where both workers and employers have the ability to reduce the likelihood of adverse shocks to future health, though not eliminate them entirely. As we proceed, we also derive the equilibrium conditions for worker and employer investment levels *assuming that neither considers the possible impact of one's own investment on the other's welfare*.

We formulate the relationship between health in one time period to that in the previous time period with Equation 1

$$(1) \qquad H_{t+1} = (1-\partial)H_t - \theta_t ,$$

where H_t represents the stock of available health in time t, d is the rate of depreciation on health, and q is a random health shock.[1] This equation simply states that as an individual, your health in the future is equal to your health in the past minus any natural depreciation (through the aging process) and any adverse health shocks. We assume that the shock is a random variable distributed according to the distribution function $F(q \mid s, g)$, where s represents individual health habits (controlled by the worker) and g represents the quality of the work environment in terms of health (controlled by the employer). The likelihood of a health shock is decreasing in both individual health habits and workplace health investments at a decreasing rate.[2]

Individual utility is increasing concave in both consumption of goods and health subject to a budget constraint. Suppose that individual investment in reducing health shocks is costly, with a unit cost of m_s. Let individual utility in time t be given by the function

$$(2) \qquad U_t(z_t, H_t) ,$$

where z are goods consumed by the individual. Consumption is subject to the budget constraint

$$(3) \qquad z_t + m_\sigma \sigma_t \le w(H_t) ,$$

where $w(H)$ represents the individual's wages.[3]

Consider the value function $v(H_t) = U_t(c_t,H_t) + b\, v(H_{t+1})$, where b is the next period discount rate. In our model, health is known in time t, but individual current period investments in health only affect health shocks in the next period. Thus, in time t individuals choose c_t and σ_t to maximize $U_t(c_t,H_t) + b\, \mathrm{E}(v(H_{t+1}))$ subject to the resource constraint given by Equation 4. Carrying out this maximization yields the first order conditions $U_c = \lambda$ for c_t and $\frac{\beta}{\lambda}\left[\frac{\partial E(v(H_{t+1}) \mid \sigma_t, \gamma_t)}{\partial \sigma_t}\right] = m_\sigma$ for σ_t, where l is the Lagrange multiplier for the optimization problem. As long as $W_H > 0$, next period health and utility unambiguously increase in current period investments.[4] Given this, economic theory holds that individuals will invest in *s* until the discounted value of the marginal increase in expected, next-period utility equals m_s.

Now consider employers. Let employer profits be given by

$$(4) \qquad Y(H_t) - \{w(H_t) + c(H_t)\},$$

where $Y(H)$ is per-worker output and $c(H)$ represent the per-worker costs of poor worker health that are borne by the employer.[5] We assume that the marginal product of workers is increasing concave in their health, so $Y_H > 0$ and $Y_{HH} < 0$.[6] The cost function *c* is decreasing concave in health, so $c_H < 0$ and $c_{HH} > 0$. As long as wages do not increase too quickly with *H*, employer profits at time *t* are increasing in the health of workers at time *t*.

As with individuals, we assume employers make current period investments that only affect future health shocks. Employers choose some fraction of current period profits to devote to future reductions in health shocks and some fraction to give to shareholders. Letting s_t denote the value of profits given to shareholders in time *t*, we can define the resource constraint for per-worker investment in health as

$$(5) \qquad s_t + m_\gamma \gamma_t \le Y(H_t) - \{w(H_t) + c(H_t)\}.$$

Since we ignore savings, profits are fully distributed between investment and payments to shareholders.

Suppose that employers operate to maximize shareholder value, and the value function of shareholders is $X(H_t) = D(s_t) + \beta X(H_{t+1})$, where *D* represents the direct gain to shareholders from consuming current period surplus. As with the individual value functions, future surplus is uncertain because of health shocks. Taking expectations and maximizing shareholder value with respect to s_t and γ_t constrained by Equation 6 yields the first-order conditions $D_s = \eta$ for s_t and $\frac{\beta}{\eta}\left[\frac{\partial E(X(H_{t+1}) \mid \sigma_t, \gamma_t)}{\partial \gamma_t}\right] = m_\gamma$ for γ_t, where *h* is the Lagrange multiplier. Analogous to the case of individuals, employers invest in health until the discounted value of the marginal increase in expected next period surplus equals the marginal cost of investment.

Information Asymmetries and Spillovers

Here we examine the model under the assumption that information asymmetries prevent workers and employers from negotiating the optimal level of investment. We assume a complete failure, though analogous results are obtained if there is only a one-sided asymmetry (for example, if worker investments are unobservable but employer investments are not). Essentially, the failure of employers and workers to consider the effect of one's own investment on the other's welfare leads to externalities, and therefore the equilibrium levels of investment described above are sub-optimal. We then show that if there are spillovers, if worker and employer investments are strategic substitutes or complements, then interventions designed to promote investment will only be optimal if they choose the level of promotion jointly. This result lays the foundation for the economic argument in favor of integrating health promotion and injury and illness prevention programs.

Consider the value functions from before, $v(H_t)$ and $X(H_t)$. In the model discussed above, individuals and employers maximize only their respective value function irrespective of the other. A social planner who, for simplicity, places equal weight on both workers and employers would maximize the sum $v(H_t) + X(H_t)$ with respect to c_t, s_t, σ_t, and γ_t while taking Equations 3 and 5 as constraints. It is straightforward to show that the first order condition for σ_t in this maximization is $\frac{\beta}{\delta_1}\left\{\frac{\partial E(v(H_{t+1})\,|\,\sigma_t,\gamma_t)}{\partial\sigma_t}+\frac{\partial E(X(H_{t+1})\,|\,\sigma_t,\gamma_t)}{\partial\sigma_t}\right\}=m_\sigma$

and the first-order condition for γ_t is $\frac{\beta}{\delta_2}\left\{\frac{\partial E(v(H_{t+1})\,|\,\sigma_t,\gamma_t)}{\partial\gamma_t}+\frac{\partial E(X(H_{t+1})\,|\,\sigma_t,\gamma_t)}{\partial\gamma_t}\right\}=$, where δ_1 and δ_2 are the Lagrange multipliers for Equations 3 and 5, respectively. These equations clearly differ from the previous first-order conditions, because of the introduction of terms representing the externality that one agent's investment has on the other's welfare. Because both left-hand side terms in both first-order conditions are decreasing in *s* and *g*, respectively, the socially optimal equilibrium will involve higher levels of investment in safety than the privately optimal equilibrium.

It is important to emphasize that externalities such as these would normally only occur outside the context of a contractual relationship. The Coase Theorem tells us that externalities are only problematic if there are transaction costs of some sort that prevent the parties from negotiating a solution (Coase, 1960). However, information asymmetries create a market failure that can prevent these private negotiations from generating the efficient solution (because when investment is unobservable, incentives exist to report a higher level of investment than is actually taken).

Note that the social planner maximizes social welfare with respect to σ_t, and γ_t jointly. This means that any spillovers between the two will be incorporated into the estimation. In this context, spillovers arise when there is strategic complementarity or substitutability between the two types of investment. Consider the value functions $E(v(H_{t+1})\,|\,\sigma_t,\gamma_t)$ and $E(X(H_{t+1})\,|\,\sigma_t,\gamma_t)$. The investment variables *s* and *g* are considered strategic complements if $\frac{\partial^2 E(v(H_{t+1})\,|\,\sigma_t,\gamma_t)}{\partial\sigma_t\partial\gamma_t}>0$ and $\frac{\partial^2 E(X(H_{t+1})\,|\,\sigma_t,\gamma_t)}{\partial\sigma_t\partial\gamma_t}>0$, and strategic substitutes if the inequalities are reversed. If health promotion and injury and illness prevention programs are designed separately it is possible that they will be "myopic," in the sense that they will fail to consider these spillover effects.

Suppose that a government felt that *s* and *g* were below their optimal levels, and decided to implement separate programs to raise them. The natural solution for a myopic program is to design the intervention to raise each to the point that the private marginal benefit of investment with respect to *s* and *g* equaled their respective marginal cost. However, suppose that *s* and *g* are complements. If this is true, and the policies were implemented separately and without any coordination, then the programs would be designed to implement the optimal level of *s* assuming that *g* is fixed at its old level, and vice versa. But because of the complementarity of the two, this will result in a marginal value of investment that is greater than the marginal cost, so there will be too little investment in worker health. The opposite result will hold if the two are substitutes.

References for Technical Appendix

1. The health shock could be introduced in any number of ways, such as a jump in the level of depreciation, but we make it additive for simplicity.
2. Thinking in terms of the expected health shock, denoted $E(\theta\,|\,\sigma,\gamma)$, then we have

$$\frac{\partial E(\theta\,|\,\sigma,\gamma)}{\partial\sigma}<0\ ,\ \frac{\partial E(\theta\,|\,\sigma,\gamma)}{\partial\gamma}<0\ ,$$

$$\frac{\partial^2 E(\theta\,|\,\sigma,\gamma)}{\partial\sigma^2}<0 \text{ and } \frac{\partial^2 E(\theta\,|\,\sigma,\gamma)}{\partial\gamma^2}<0$$

3. Throughout this paper we assume that there is no borrowing, by individuals or by employers.

4. We expect that wages increase in health either because healthier workers have a higher marginal productivity or simply because they are able to work more. In practice, there are programs (such as workers' compensation and disability compensation programs) that reduce the economic impact of a disability. Nevertheless, these compensation mechanisms typically replace much less than 100% of lost wages.
5. In principle, employers should care about maximizing aggregate profits. For our analysis, we must assume identical workers and a production function that is linear homogeneous of degree one, allowing us to divide through by total employment and focus on the individual worker level.
6. Strictly speaking, we do not need the cost function for our analysis, so our results would be the same if $c(H) = 0$ for all H.

References

Aldana, SG (2001). "Financial Impact of Health Promotion Programs: A Comprehensive Review of the Literature." *American Journal of Health Promotion*, 15(5): 296–320.

Anderson, DR, RW Whitmer, RZ Goetzel, RJ Ozminkowski, RL Dunn, J Wasserman, S Serxner; Health Enhancement Research Organization (HERO) Research Committee (2000). "The Relationship Between Modifiable Health Risks and Group-Level Health Care Expenditures." *American Journal of Health Promotion*, 15(1): 45–52.

Arrow, KJ (1968). "The Economics of Moral Hazard: Further Comment." *American Economic Review*, 58(3): 537–538.

Berger, ML, R Howell, S Nicholson and C Sharda. (2003) "Investing in Healthy Human Capital." *Journal of Occupational and Environmental Medicine*, 45(12): 1213–1225.

Bly, J, RC Jones and JE Richardson (1986). "Impact of Worksite Health Promotion on Health Care Costs and Utilization: Evaluation of Johnson & Johnson's Live for Life Program." *Journal of the American Medical Association*, 256(23): 3235–3240.

Bull, SS, C Gillette, RE Glasgow and P Estabrooks (2003). "Work Site Health Promotion Research: To What Extent Can We Generalize the Results and What Is Needed to Translate Research to Practice?" *Health Education & Behavior*, 30(5): 537–549.

Case, A and A Deaton (2003). "Broken Down by Work and Sex: How our Health Declines." NBER WP w9821.

Coase, R (1960). "The Problem of Social Cost." *Journal of Law and Economics*, 1(1): 1–44.

Dannenberg, AL and CJ Fowler (1998). "Evaluation of Interventions to Prevent Injuries: An Overview." *Injury Prevention*, 4(2): 141–147.

Diamond, P (1977). "Insurance Theoretic Aspects of Workers' Compensation". In A Blinder and P Friedman (eds.), "Natural Resources, Uncertainty, and General Equilibrium Systems", (67–89). New York: Academic Press.

Fries, JF, DA Bloch, H Harrington, N Richardson and R Beck (1993). "Two-Year Results of a Randomized Controlled Trial of a Health Promotion Program in a Retiree Population: the Bank of America Study." *American Journal of Medicine*, 94(5): 455–462.

Fries, JF, H Harrington, R Edwards, LA Kent and N Richardson (1994). "Randomized Controlled Trial of Cost Reductions From a Health Education Program: the California Public Employees' Retirement System (PERS) Study." *American Journal of Health Promotion*, 8(3): 216–223.

Grossman, M (1972). "On the Concept of Health Capital and the Demand for Health." *Journal of Political Economy*, 80(2): 223–255.

Gruber, J and AB Krueger (1991). "The Incidence of Mandated Employer-Provided

Insurance: Lessons from Workers' Compensation Insurance." In David Bradford (ed.), *Tax Policy and the Economy, Volume 5*. Cambridge, MA: The MIT Press.

Hulshof, CT, JH Verbeek, FJ van Dijk, WE van der Weide and IT Braam (1999). "Evaluation Research in Occupational Health Services: General Principles and a Systematic Review of Empirical Studies." *Occupational Environmental Medicine*, 56(6): 361–377.

Krueger, AB and JF Burton, Jr. (1990). "The Employers' Costs of Workers' Compensation Insurance: Magnitudes, Determinants, and Public Policy." *The Review of Economics and Statistics,* 72(2): 228–240.

Lakdawalla, D and T Philipson (2004). "Work and Weight." Mimeo.

Leigh, JP, SB Markowitz, M Fahs, C Shin and PJ Landrigan (1997). "Occupational Injury and Illness in the United States. Estimates of Costs, Morbidity, and Mortality." *Archives of Internal Medicine*, 157(14): 1557–1568.

Leigh, JP, N Richardson, R Beck, C Kerr, H Harrington, CL Parcell and JF Fries (1992). "Randomized Controlled Study of a Retiree Health Promotion Program: The Bank of America Study." *Archives of Internal Medicine*, 152(6): 1201–1206.

Loomis, D, JF Bena, and AJ Bailer (2003). "Diversity of Trends in Occupational Injury Mortality in the United States, 1980–96." *Injury Prevention*, 9(1): 9–14.

Rea, SA (1981). "Workmen's Compensation and Occupational Safety Under Imperfect Information." *American Economic Review,* 71(1): 80–93.

Smith, GS (2003). "Injury Prevention: Blurring the Distinctions Between Home and Work." *Injury Prevention,* 9(1): 3–5

Stewart, WF, JA Ricci, E Chee, D Morganstein and R Lipton (2003). "Lost Productive Time and Cost Due to Common Pain Conditions in the U.S. Workforce." *Journal of the American Medical Association*. 290(18): 2443–2454.

United States Department of Health, Education and Welfare (1979). "Smoking and Health: A Report of the Surgeon General." DHEW Publication No (PHS) 79-50066. (Accessed at http://profiles.nlm.nih.gov/NN/B/C/M/D/ on 10/20/04)

U.S. Department of Health and Human Services (2001). "Toxicological Profile for Asbestos." (Accessed on the Web site for the Agency for Toxic Substances and Disease Registry at http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=30&tid=4 on 12/30/2004).

Viscusi, FK (1979). *Employment Hazards: An Investigation of Market Performance*. Cambridge, MA: Harvard University Press.

Viscusi, FK and WN Evans (1990). "Utility Functions That Depend on Health Status: Estimates and Economic Implications." *American Economic Review*, 80(3): 353–374.

Zwerling C, LH Daltroy, LJ Fine, JJ Johnston, J Melius and BA Silverstein (1997). "Design and Conduct of Occupational Injury Intervention Studies: A Review of Evaluation Strategies." *American Journal of Industrial Medicine*, 32(2): 164–179.

Abbreviations

ACOEM	American College of Occupational and Environmental Medicine
ADA	Americans with Disabilities Act
APQC	American Productivity and Quality Center
BLS	Bureau of Labor Statistics
BMI	Body Mass Index
CDC	Centers for Disease Control and Prevention
CDHP	Consumer Driven Health Plan
CRA	Cardiovascular Risk Assessment
EAP	Employee Assistance Program
EHM	Employee Health Management
EHS	Environmental, Health and Safety
EWC	Executive Wellness Council
FMLA	Family and Medical Leave Act
GDP	Gross Domestic Product
GM	General Motors
H&W	Health & Wellness
HPQ	Health Profile Questionnaire
HPM	Health and Productivity Management
HPM-EVT	Health and Productivity Management Economic Valuation Tool
HRA	Health Risk Appraisal
HRS	Health and Retirement Study
HSSP	Health, Safety, Security, and Productivity
IAM	International Association of Machinists & Aerospace
IFCN	International Fitness Club Network
IHPM	Institute for Health and Productivity Management
JSC	Johnson Space Center
NASA	National Aeronautics and Space Administration
NBGH	National Business Group on Health
NIOSH	National Institute for Occupational Safety and Health
NORA	National Occupational Research Agenda
OCHMO	Office of the Chief Health and Medical Officer
OHG	Occupational Health Group
OSH	Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
P&G	Proctor and Gamble
PPACA	Patient Protection and Affordable Care Act
ROI	Return on Investment
TANA	Trucking Across North America
TI	Texas Instruments
UAW	United Automobile, Aerospace and Agricultural Implement Workers of America
VFC	Virtual Fitness Center
VPP	Voluntary Protection Program
WBMS	Well-Being and Management System
WELCOA	Wellness Councils of America
WHP	Worksite Health and Promotion