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Health and Productivity. A Review of the State-of-the-Art and Implications for Occupational and Environmental Medicine

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ABSTRACT. In an age when the economic success of any organization, corporation or country is increasingly dependent upon improvements in productivity, the significant contributors to productivity enhancement are being closely scrutinized and critically evaluated. This has led to a growing awareness of the major contribution of workers' health to their productivity. Although the worker health-productivity paradigm was suspected even in the times of Bernardino Ramazzini and Adam Smith, it has only been in the past several years that extensive rigorous study of this linkage has occurred. As reviewed here, a growing body of literature has now evolved that begins to demonstrate the many instances where investing in workers' health results in improved productivity and significant financial benefit for the organization. However, much more can be done along these lines, and the occupational/environmental physician is well positioned to lead the way. A state-of-the-art corporate medical department can now provide the synthesis and analysis of a broad range of health and productivity data which will demonstrate the financial benefits of its activities to the organization while further enhancing its traditional roles of preventing worker disease and promoting worker health and safety. But this vital role need not be constrained to any single organization. In the future, the occupational/ environmental physician can play an equally critical role in resolving many of the health problems in the poor countries of the world that limit the productivity of their populations and thus hinder them from achieving sustainable development.

Key words: worker healthy-productivity paradigm, future occupational/environmental physician, worker productivity management, financial benefits.

RIASSUNTO. SALUTE E PRODUTTIVITÀ. UNA REVISIONE DELLA CONDIZIONE LAVORATIVA E DELLE SUE IMPLICAZIONI NELL'AMBITO DELLA MEDICINA DEL LAVORO E DELL'AMBIENTE. In un'era in cui il successo economico di ciascuna organizzazione, società e paese è sempre più dipendente dai progressi della produttività, si è iniziato a giudicare severamente e con critica coloro che hanno in modo più significativo contribuito ad ampliare la resa lavorativa. Tutto ciò ha condotto ad una crescente consapevolezza del maggiore contributo derivante dalla salute dei lavoratori nei confronti della produttività.
Sebbene il paradigma salute-produttività del lavoratore fosse già noto ai tempi di Bernardino Ramazzini e di Adam Smith, soltanto col trascorrere di diversi anni è stato condotto uno studio esteso e rigoroso in merito a tale rapporto.
Come viene qui evidenziato, una buona parte della letteratura ha soltanto ora elaborato questo aspetto iniziando a proporre molti casi in cui la salvaguardia della salute dei lavoratori si traduce in uno sviluppo della produttività ed in benefici significativi di carattere finanziario per l'azienda.
Comunque si può fare molto di più seguendo queste linee ed il medico competente è ben disposto a percorrere questa strada. Il dipartimento di Medicina del Lavoro può ora fornire una sintesi ed analisi di un ampio gruppo di dati sulla salute e produttività dai quali potranno essere dimostrati i benefici finanziari che derivano alla società da tali attività finché ci sarà il continuo sviluppo dei due ruoli tradizionali della Medicina del Lavoro ossia prevenire le malattia professionali e promuovere la salute e la sicurezza dei lavoratori. Tuttavia questo ruolo così importante non deve essere visto in un'ottica ristretta esclusivamente alla singola azienda. Nel futuro il medico dell'ambiente e del lavoro potrà svolgere il suo compito critico anche nel risolvere i molti problemi di salute dei paesi poveri del mondo che limitano la produttività della loro popolazione, impedendone in tal modo la realizzazione di uno sviluppo duraturo.

"Ne consegue che le tessitrici, voglio dire quelle donne che si dedicano completamente a tale attività del tessere, dovrebbero essere particolarmente di sana e robusta costituzione, mentre sono talmente oppresse dal sovraccarico di lavoro che, col passare degli anni, sono costrette ad abbandonare questa attività di tipo commerciale".
Bernardino Ramazzini, *Le malattia dei lavoratori*, 1713.

"...non sembra affatto possibile che gli uomini in generale lavorino meglio quando sono denutriti piuttosto che sazi, quando sono disorientati invece che in buone condizioni di salute mentale, quando sono frequentemente malati piuttosto che sempre in buona salute.
Gli anni di carestia, come si è visto, coincidono esattamente con gli anni della morbidità e della mortalità, nonché con la riduzione del profitto derivante dal settore industriale".
Adam Smith, *Il benessere delle nazioni*, 1776.

Parole chiave: paradigma produttività e salute del lavoratore, futuro medico del lavoro, gestione della produttività del lavoratore, benefici economici.

"It follows that women weavers, I mean those who are engaged wholly in this occupation, ought to be particularly healthy and robust, otherwise they break down from overwork and as they get on in years are compelled to abandon this trade."

Bernardino Ramazzini, *Diseases of Workers*, 1713

"...that men in general should work better when they are ill fed than when they are well fed, when they are disheartened than when they are in good spirits, when they are frequently sick than when they are generally in good health, seems not very probable. Years of dearth, it is to be observed, are generally among the common years of sickness and mortality, which cannot fail to diminish the produce of the industry."

Adam Smith, *The Wealth of Nations*, 1776

Introduction

Bernardino Ramazzini, the father of occupational medicine, noted the importance of workers' health to their productivity in his treatise entitled *Diseases of Workers* in 1713 (1). Similarly, Adam Smith, the father of economics, noted the importance of workers' health to the economy of the country as a whole (2). However, until recently, the health-productivity paradigm has received little systematic study. Early measurements of worker health and productivity were published for labor and manufacturing jobs where there is a clear connection to work and an objective measure of output, i.e., the number of widgets produced per unit time, such as anemia in factory workers (3), and nutritional status in tea pickers (4) and road construction workers (5). Productivity evaluation of the white collar worker and the emerging knowledge worker has been and continues to be a less exact science. Nevertheless, the link between worker health and worker productivity has recently received increasing attention as a growing number of employers recognize that workforce health can have a measurable impact on business performance. For example, a 2007 survey by Mercer/Marsh of 600 U.S. employers found that 80% agreed or strongly agreed that improving employee health is a core business value, primarily because it is "clear that if your employees are not at work – or at work but not 100% healthy – productivity suffers" (6). The field of health and productivity is still developing the tools, metrics, and methodologies to measure the impact of health on employee performance. Whereas the prevention and treatment of illnesses and injuries related to work is at the core of occupational medicine, understanding the role of health in facilitating high levels of productivity promises to be an important future role for occupational medicine. The purpose of this review is to describe the emerging body of research on the relationships between health and worker productivity and its implications for the future of occupational and environmental medicine. For the corporation, this link has been made possible by the development of new measurement and data management techniques and the linking of diverse healthcare and productivity databases leading to an integrated health and productivity management strategy, as shown in Figure 1.

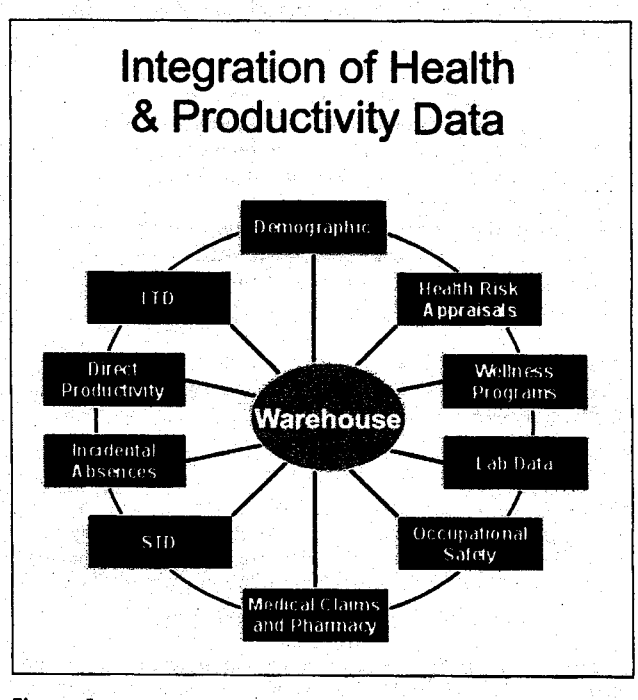

Figura 1

Components of the Worker Health-Productivity Paradigm

Direct healthcare costs to a society or to an organization, including expenses relating to inpatient hospitalization care, outpatient medical care and the cost of medications both prescription and non-prescription, are relatively well recognized. However, the decrements in worker productivity due to health-related problems are an indirect cost to corporations and society that are largely unmeasured. Absenteeism, disability and impaired on-the-job productivity (also termed "presenteeism") costs are significant contributors to an incomplete estimate of the total loss of productivity resulting from impaired health. Of these, time off-the-job contributors are the most common measurable components of productivity in most work environments. Even in measuring time off-the-job, one does not always capture the true loss of productivity, since many work tasks, especially with white collar workers or knowledge workers, remain on someone's desk until the person returns to work. Thus, often the task still gets done but the time frame is delayed, which may or may not cause productivity decreases downstream from the original affected worker. Nevertheless, time-off-the job is the most commonly accepted measure of worker productivity loss.

As an example, Figure 2 shows the relative contributions of direct and indirect costs of poor employee health to productivity for a financial services company in the United States, including absenteeism, short- and long-term disability and presenteeism.

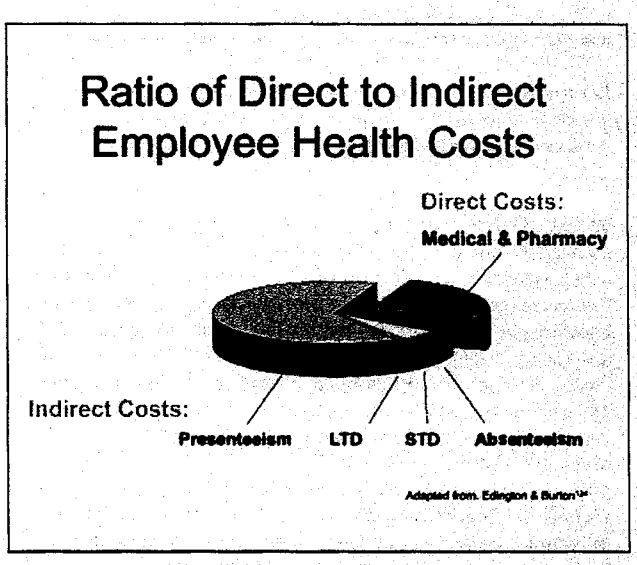

Figura 2

Absenteeism

Absenteeism represents a wide variety of reasons for absences from the worksite including scattered or incidental absences, sick days, jury duty, military leave, public service leave, discretionary leaves and unpaid leaves. Absenteeism is generally unrelated to events such as business reasons, vacations or holidays. The lost productivity related to absences associated with sick days and incidental absences is usually limited and either not tracked or poorly tracked by most organizations. The relationship between health and these incidental illness-related absences is largely under-appreciated. Employees with various chronic medical conditions, such as asthma, diabetes, depression and arthritis, experience brief episodes of absenteeism which do not lead to more extended short-term disability absences, and, therefore, their impact on lost productivity is underestimated by most organizations. However, engaging such employees with chronic medical conditions in appropriate disease management programs may decrease the likelihood of a short- or long-term disability event.

Disability

Short-Term Disability (STD) benefits are salary continuation income for workers generally beginning after 5 or more consecutive workdays off for illness or injury. Such income replacement widely varies between countries and organizations, as well as the length of employment of the worker (8). Usually the income replacement is between one-half and two-thirds, although the range is from 0% to 100%. These benefits are paid when a worker is unable to perform the job and generally continue for 3 to 6 months, at which time the worker may be eligible for Long-Term Disability (LTD) benefits. LTD income replacement may come from a variety of sources depending on the country, including LTD insurance, Social Security benefits and others. Management of both STD and LTD benefits is important in order to achieve the most appropriate duration for the STD event and to return the employee to the workplace as fully productive as possible. It is common to categorize STD and LTD events according to major diagnostic categories (MDC), such as mental health, heart disease and cancer. For an organization, the prevalence of each MDC should include the number of workdays lost and the average number of workdays lost per STD event, which can be compared with disability duration guidelines. This information can be used to design, implement and evaluate the success of interventions which decrease the likelihood of such events and lead to earlier return to work, both serving to impact lost worker productivity.

Work-related disability from on-the-job injuries and accidents can not be completely avoided, but it is well documented that when safety is a high priority of an organization the accident rates typically decline dramatically. The health of workers has been associated with the risk of on-the-job injury. Effective safety programs can reduce on-the-job accident rates and workers' compensation expenditures. Furthermore, participation in worksite health promotion programs has been demonstrated to lower workers' compensation claims. For example, among those with workers' compensation claims, health risk appraisal participants at Xerox were found to have an average savings of $1,238 per worker per year compared to those wellness program non-participants (7). Health risk status as calculated from a health risk assessment questionnaire (e.g., exercise, blood pressure, body mass index, etc.) is also related to individual costs for workers' compensation. Nearly 85% of the costs of workers' compensation could be related to excess health risks in the population at Xerox. The implication is that an organization could manage workers' compensation costs by providing workers with programs that result in health risk reduction and the avoidance of additional risks.

According to the U.S. Bureau of Labor Statistics, in 2000, a total of 1.7 million injuries and illnesses occurred in private industry which required recuperation away from work beyond the day of the incident (8). In 1999, the National Safety Council estimated the total annual cost of occupational injuries at $125 billion: $62.0 billion for wage and productivity losses, $19.9 billion in medical costs, $25.6 billion in administrative expenses, and $16.7 billion in additional employer costs (9). A U.S. government initiative, Healthy People 2010, has established a goal of further reducing work-related injuries to 4.6 injuries per 100 full–time workers (10). The Occupational Safety and Health Administration (OSHA) recordable injuries and illnesses and lost time cases data is available for most industries. OSHA recordable data can be expressed as cases per 200,000 hours worked which is the number of events per 100 employees working for one year.

One of the most measurable ways to improve worker productivity is by reducing work-related injuries and illnesses. Comprehensive management of workers' compensation losses includes prevention by the identification of potential workplace hazards, early provision of appropriate medical services and flexible return-to-work policies and programs. Transitional return to work from a work-related illness or injury can be beneficial to both the worker and to the employer (11). Thus, safety is an important component of a total corporate health and productivity management program for many companies. These programs may include safety program training, regulatory compliance and management of workers' compensation benefits.

Presenteeism

Presenteeism is the decrement in a worker's productivity because of illness, injury or a variety of other factors including caregiving (12). Medical conditions which result in presenteeism may be relatively benign and self-limiting, such as a cold or influenza. However, most research has focused on chronic or episodic medical conditions, such as diabetes mellitus, seasonal allergies, asthma, migraine headache, depression, arthritis and gastrointestinal disorders. A worker with these conditions may perform at a fraction of their normal capacity, although earning the same wages and benefits as a worker performing at 100% of capacity. Several estimates have indicated the costs of presenteeism greatly exceed the costs related to absenteeism and disability expenditures to a company. While the concept is relatively straight-forward, the measurement of

presenteeism is a major challenge for any organization. In fact, nearly every job classification has inherent definitions that require a unique solution in order to get a true measure of productivity. The decrease in productivity measured by presenteeism is typically unrelated to absenteeism or disability absences. Presenteeism could be measured in terms of costs associated with decreased or slowed output, failure to maintain a production standard, additional training time and errors in the work produced.

It is perfectly reasonable to assume that a worker's health is related to his or her ability to be maximally productive. For example, a worker with diabetes who is experiencing blurred vision and fatigue related to poor blood glucose control probably will have a difficult time viewing a computer screen all day. A worker suffering with low back pain may be limited in the weight he or she can lift or in the postures that he or she can be expected to maintain on the job. A worker with carpal tunnel syndrome may be limited in the amount of keyboard work that can be performed. A worker suffering from a depressive disorder may be limited in tasks requiring cognitive speed and interpersonal skills.

In order to approximate the decrease in productivity for workers with chronic medical conditions who remain at work, studies have utilized both objective measures of productivity as well as self-reported measures. With very few exceptions, presenteeism is being measured by organizations utilizing questionnaires which determine the prevalence of illnesses in a population with calculation of the related loss in productivity related to these conditions, as discussed further below. Organizations can then use this information to determine cost-effective ways to address such losses.

Health-Productivity Metrics

As noted, measurement of the loss of on-the-job productivity, termed "presenteeism", is usually the most difficult task for health-productivity evaluation (13). Productivity metrics are dependent on distinct job classifications. Specific measurement tools will have to be developed for unique job classifications within a corporation. An organization has the challenge of developing specific job productivity measures for a variety of job classifications or determining if a self-administered questionnaire can be applied across several job categories or even the whole company to approximate the work lost due to lower productivity. In general, worker productivity is related to a worker's health and job requirements. A job may be classified as primarily working with people, things (tools) or data. For example, a customer service worker is primarily interacting with people but also may need to enter information into a computer (tool) and review information about the customer (data). A disease such as depression could profoundly impact customer service worker's presenteeism. However, a mechanic suffering from depression might experience significantly less job productivity impact from depression. However, the mechanic with low back pain might be significantly impaired in the ability to complete tasks that involve the use of tools. Different health disorders and disease can have a differential impact on the worker's presenteeism.

Objective Measures of Worker Productivity

If a worker's task can be exactly modeled and measured then that job is a good candidate for the development of an objective measure of worker productivity. A good example of this type of productive measure was conducted at a credit card telephone call center (14). A Worker's Productivity Index was developed to measure the productivity of customer service call center operators. A major credit card company employed the customer service operators. Employers at this facility answer inquires from customers about their credit card accounts, make customers and potential customers aware of product offerings, and perform several other customer service tasks. These employees' workstations have a telephone connected to a computer system. The computer is programmed to record data elements of each and every telephone call to the workstation including: the time that a customer waits in the queue, the length of time the customer spends on the call with the service representative, the amount of time spent holding, the amount of time between calls when the employee is doing paperwork or researching information, and the amount of time the employee spends logged off the system. This information was analyzed and placed into algorithms to determine the performance goals among the employees with similar telephone call center tasks. A Worker's Productivity Index (WPI) was calculated using the algorithms derived from the employee's presenteeism together with absenteeism and short term disability absence.

Productivity Measurement Questionnaires

Objective measures of an individual worker's productivity in the workplace are rarely available and when available are usually specific to a specific occupation. There are relatively few jobs that involve tasks that are easily counted and that have such records available. Some occupations where such tracking of individual worker productivity is done include telephone call center operators, insurance claims processors, package deliverers and assembly line pieceworkers. However, such objective measures where available are important to validate self-reported measures of presenteeism. Some validation of self-reported productivity has been conducted at workplaces involving such objective measures of productivity.

There are several self-reported productivity questionnaires available. These instruments vary in length from 3 to 44 questions depending on whether the focus is on a single medical condition or a multiple disorders. The recall period generally varies from 1 to 4 weeks. All of the questionnaires except the Stanford Presenteeism Scale, the Health and Work Questionnaire and the Work Limitations Questionnaire measure absenteeism in addition to presenteeism. Most are proprietary with the exception of the Migraine Disability Assessment Questionnaire, the Work Productivity and Activity Impairment Questionnaire and the Work Productivity and Activity Impairment Questionnaire - Allergic Rhinitis, although approval to use many of the

other instruments is possible at little or no fee depending on their specific use. Recent publications (15-18) have reviewed the strengths and weaknesses of several of these questionnaires including the following:

American Productivity Audit and Work and Health Interview (19)
Angina-Related Limitations at Work Questionnaire (20)
Endicott Work Productivity Scale (EWPS) (21)
Health and Labor Questionnaire (HLQ) (22)
Health and Productivity Questionnaire (23)
Health and Work Performance Questionnaire (HPQ) (24, 25)
Health-Related Productivity Questionnaire Diary (26)
Migraine Disability Assessment Questionnaire (27)
Migraine Work and Productivity Loss Questionnaire (28)
Stanford Presenteeism Scale (SPS-34 and SPS-13) (29, 30)
Work and Health Interview (WHI) (31)
Work Limitations Questionnaire (WLQ) (32)
Work Productivity and Activity Impairment Questionnaire (WPAI) (33)
Work Productivity and Activity Impairment Questionnaire - Allergic Rhinitis (18)
Work Productivity Short Inventory (WPSI) (34)
Worker Productivity Index (14).

Schultz and Edington reported on a total of 113 published research studies that explored the link between employee health and on-the-job productivity (13). They concluded that medical conditions such as allergies and arthritis were associated with decrements in worker productivity. Similarly, they indicated that certain health risk factors which are self-reported on a health risk appraisal (HRA) questionnaire, such as physical activity, and body weight, are associated with lost on-the-job productivity. The self-reported recall period on such questionnaires varies and is important for the accuracy of the information entered on these forms. Stewart et al. evaluated three versions of the WHI and reported that a 2-week recall period may be the most optimal to minimize self-reporting error (35).

At this time, the HPQ and the WLQ appear to be the most widely used self-reported productivity instruments in a general employee population. The HPQ assesses four dimensions of work including: 1. absenteeism, 2. job performance, 3. job turnover, and 4. critical workplace incidents or injuries, as well as other events such as receiving a promotion. The WLQ assesses four major domains of job performance including: 1. physical, 2. mental/interpersonal, 3. time limitations, and 4. output. The WLQ is generally linked to a health risk appraisal questionnaire. The results from both questionnaires have been monetized, and both questionnaires have been used in a wide range of work settings. There have not been any published head-to-head comparisons of these two instruments which ideally would be a topic of future research.

Worker Replacement Costs

Calculating the cost of replacing workers off-the-job is critical to understanding the implications of lost productivity. There are several methods available for making this calculation (36). The most straightforward method is called the lost wages method. This is simply the number of hours/days absent times the rate of compensation. Ideally, one would have the exact rate of compensation for the individual worker, or, at least, a rate per job classification. Total compensation, to include both direct and indirect benefits, would be an even better metric. The authors discuss the valuation of work loss and present a model to more fully incorporate indirect costs attributed to the company and society. The result of the additional costs of on-the-job time substantially increases the costs attributed to work replacement.

Worker Productivity and Health Risk Factors

There is now a wealth of information relating health risk factors to future disease and to levels of productivity. Published studies relate excess absent days and short-term disability to risk factors and participation in wellness programs (37-42). Ideally, organizations would attempt to promote and protect the health of their employees at as early an age as possible. Compliance with and adherence to preventive services is one of the least expensive and effective strategies to contribute to the good health of employees. Health Risks Appraisals and Health Fair Screenings for preventive services and risk factors raise employees' awareness of their current and future health status. Once awareness is raised the employer has an opportunity to facilitate maintenance of healthy preventive services and good health status.

The opportunities for proactive health management occur throughout a typical worksite population. The literature indicates where disease management, screening and preventive services, and low-risk maintenance and risk reduction programs can be most effective in maintaining and improving health status within the workforce (43). Each employee is somewhere on the continuum from no risk factors to recovery from the acute effects of the disease and/or learning to live with the chronic nature of the disease. Essentially, there are health management services for everyone. The overall objective is to maintain low-risk status or to facilitate risk-reduction in each individual. At the no-risk end of the continuum, preventive services and low-risk maintenance programs can be provided to these individuals to maintain their already good health status. At the diseased end of the continuum, case management and disease management programs are appropriate, as well as other programs to help employees maintain and improve their health status. The vast majority of employees are in the middle section of the continuum, and here preventive services, screening, low-risk maintenance, and risk-reduction programs are appropriate to allow employees the opportunity to improve their health status through a variety of options. The same risk factors that are precursors for disease impact hours of lost productivity. In a study of call center operators, the presence of each of the several individual risk factors was assessed for its impact on hours of lost productivity, as shown in Figure 3 (14). In this case, it should be noted the impact of the risk factors on illness days and short-term disability was considerably less than their impact on presenteeism.

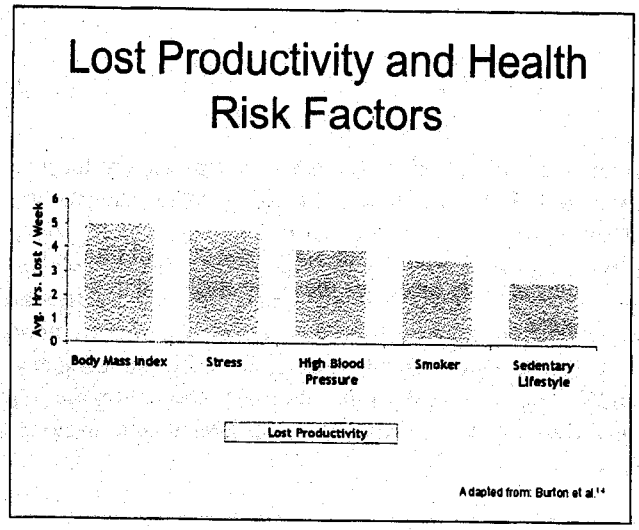

Figura 3

Worker Productivity and Disease

Chronic medical conditions account for significant medical, disability and lost productivity costs for corporations. As the workforce ages in many countries over the next several decades, appropriate management of these conditions will be important to assure a healthy and productive workforce. The World Health Organization estimates the impact of chronic diseases in the developed world on mortality and morbidity using the following metrics: disability-adjusted life years (DALYs), the years of life lost (YLL) and the years lived with disability (YLD), where DALY = YLL + YLD for a particular medical condition (44) Years lost because of a death related to a specific medical condition is defined as YLL. Years lost because of a disability which results in less than optimal health status resulting in a restriction or lack of the ability to perform an activity is defined as YLD. The top 10 medical disorders in terms of DALYs include: ischemic heart disease (19,825,214), depression (15,584,834), chronic obstructive pulmonary disease (5,611,173), dementia (5,000,789), osteoarthritis (4,473,875), cirrhosis (3,395,801), asthma (2,511,178), bipolar affective disorder 92,314,074), and migraine headache (1,895,811). However in terms of YLD, depression is the most costly to society with 15,570,558 years lived with disability, followed by osteoarthritis (4,464,264), dementia (4,343,314), chronic obstructive pulmonary disease (3,380,396), diabetes (2,410,508), and bipolar affective disorder (2,311,367). Falagas et al. have pointed out that these are probably significant underestimates of the actual impact of these chronic diseases in the developed world due to under-diagnosis of these conditions. These measures have been applied to individual countries, such as the Netherlands (45), as well as specific cities, such as Los Angeles (46).

One group of investigators examined the number of work-loss days and work-cutback days attributable to the presence of 29 common medical conditions in the U.S. population using data from a nationwide survey of 3,032 individuals aged 25-74 years. Participants were questioned regarding how many days out of the past 30 days they were "totally unable to work or carry out your normal household work activities because of your physical health or mental health" and how many additional days in the past 30 they were able to work but had to "cut back on work or how much you got done because of your physical or mental health." Data on absenteeism that included scattered sick days and short-term disability absence were combined with lost productivity data. The average number of work-impaired days for employed individuals was 0.9 workdays per month. The authors noted a dose-response relationship between the number of chronic medical conditions and the probability of any work impairment. At least one illness-related work-loss or work-cutback day was recorded by 22.4% of the respondents. Participants with cancer reported the highest prevalence of impairment (66.2%) within the past 30 days and the greatest number of days with impairment in the past 30 days (16.4 days). Additional common causes of impairment included ulcers, major depression, and panic disorder. As noted, other researchers have demonstrated a dose-response relationship between self-reported health risk factors recorded on a health risk appraisal questionnaire with medical claim costs, short-term disability workdays lost, scattered absence workdays lost, and on-the-job productivity for workers (14). To date, there have been relatively few international reports on work limitations and medical conditions outside of the U.S. One study at a British University reported that 40% of employees with a self-reported chronic medical condition reported a work limitation on one of three scales, physical, cognitive or social (47). A study of Swedish computer workers estimated the mean loss of productivity to be 17 hours per month for those with musculoskeletal symptoms compared with those without such symptoms (48).

The primary disease drivers of health care costs are heart disease, cancer, diabetes, depression, stroke, and others. What has recently become clear is that the primary disease drivers of productivity are arthritis, asthma, digestive disorders, headaches, flu, stress, back pain, and others. The latter set of diseases is relatively low in health care costs but high in productivity loss. This relationship is illustrated in Figure 4 which shows the contribution of the presence of several diseases to illness days, short-term disability and presenteeism from the study of call center operators (14) The set of diseases impacting hours of lost productivity include those typically associated with high medical costs plus those chronic diseases most often associated with lower long-term medical costs, including allergies, asthma, digestive disorders and mental health.

There has been a proliferation of new and more expensive therapies for diseases. Evaluation of the value of such therapies should include their impact in reducing worker absenteeism and increasing worker productivity (49, 50) because there is increasing concern about the rise in pharmaceutical costs by workers, employers, pharmacy benefits managers, managed care companies and other purchasers of healthcare. Corporate medical directors are frequently asked by benefit managers about the value of new medications or more expensive medications to treat a va-

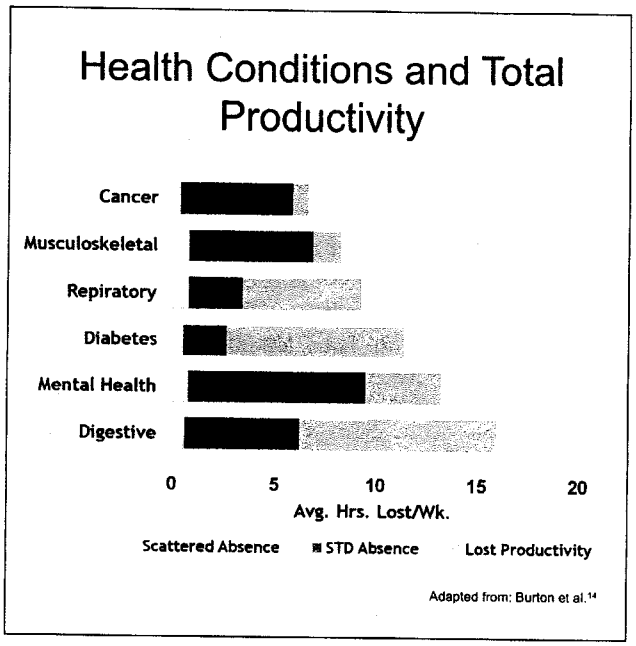

Figura 4

riety of diseases. Over $100 billion are now spent in the U.S. annually on prescription medications. Costs for older workers and the retiree population have been skyrocketing for many reasons including increased utilization of medications, identification of new patients, and new medications to treat previously untreated conditions. Hence, the valuation of pharmaceuticals needs to take into consideration many factors, including the potential impact on worker productivity (51). For example, does a newer medication allow a worker to return to work sooner and to be more productive? Two decades ago, acquired immune deficiency syndrome (AIDS) was, in general, not treatable with a relatively short life span after diagnosis. Today, with treatment, AIDS is considered a chronic disease with a significant life span for most workers. Several other examples are presented below where, with appropriate treatment, chronic diseases can be controlled with significant improvement in worker productivity. Significant challenges for U.S. corporations will remain the control of health care costs and the increase in worker productivity. An evolving new perspective by companies is to view health care as a strategic investment in the health and productivity of a workforce. Some newer treatments and medications have been demonstrated to not only improve the health of workers but also to improve their productivity. Thus, the ability of appropriate pharmaceutical solutions to influence worker output is likely critical to high levels of productivity in most workforces.

Allergies

Seasonal allergies are common, affecting an estimated 15 to 39 million individuals in the U.S. and are responsible for approximately 10 million physician office visits annually in the U.S. It is estimated that 12% of American working women and 10% of working men suffer from allergic disorders. The impact of allergies on medical expenses, workplace absence days and, perhaps more importantly, on-the-job worker productivity is a major expense for employers. The productivity loss associated with allergic disorders is generally related to a decrement in on-the-job lost productivity rather than to absences from the workplace. Workers with allergies have a decline in on-the-job productivity with increasing pollen counts during allergy season. Computerized worker productivity measurements in a credit card telephone call center were combined with self reported allergic disorder symptoms and medication use prior to and during allergy season (52). The indirect cost of allergies in telephone customer service representatives was shown to be a 10% reduction in presenteeism during the height of the pollen season. For those customer service representatives on effective medication the decreased productivity was not observed during the pollen season.

The effect of allergies on worker productivity will be of continuing interest, including the effects of interventions to control the allergic reaction. Seasonal allergic symptoms can be controlled with a variety of interventions including allergy desensitization injections, sedating and non-sedating antihistamines, nasal corticosteroids and other medications. One group of investigators used a retrospective database that linked medical claims, including prescription medication claims, for workers of a large insurance company who were medical claims processors. They observed that workers prescribed a sedating antihistamine were up to 13% less productive than workers prescribed non-sedating antihistamines (53). First-generation antihistamines, which are generally available without a prescription, may be effective in controlling symptoms but can cause drowsiness and impairment in the performance of various tasks. For example, a randomized, placebo-controlled trial in the Iowa driving simulator compared the effects of diphenhydramine (50 mg), a first-generation antihistamine, fexofenadine (60 mg), a second generation antihistamine, placebo and alcohol (approximately 0.1% blood alcohol concentration) on driving performance (54). The authors reported that participants had significantly better performance after using alcohol or fexofenadine than after taking diphenhydramine. However, self-reported drowsiness ratings were not a good predictor of impairment. The older antihistamines have also been linked to accidents and injuries in the workplace (55). Some authors have recommended the use of non-sedating antihistamines to avoid work-related accidents and injuries (56). Thus, newer non-sedating antihistamines may increase worker productivity with fewer side effects.

Arthritis

Arthritis is a term that includes more than 100 different diseases affecting the joints and other connective tissues of the body. It can result in pain, stiffness and reduced flexibility of the joints in addition to other symptoms. Arthritis and related conditions affect nearly 43 million Americans, making it one of the most common diseases in adults. By 2020, an estimated 60 million Americans will be affected with arthritis. Arthritis is a leading cause of disability, and cost-effective treatments are now available to reduce the economic burden of arthritis in the workplace (57).

Osteoarthritis (OA), the most common form of arthritis, results in an estimated 4,473,875 DALYs lost in developed countries. Fourteen percent of employed women and nine percent of employed men report having arthritis (58). While osteoarthritis is more prevalent among older workers, affecting 80% of adults over the age of 55, rheumatoid arthritis (RA) affects a younger working age population between the ages of 35 and 50. The direct and indirect costs of those with disease are approximately three times those without the disease (59). For example, the estimated direct and indirect costs for a worker disabled with RA to the employer were $17,822 vs. $6,131 for non-RA employees. The annual total employer cost per RA employee for medical, pharmaceutical and work loss was estimated to be $9,693. Ergonomically designed jobs and, when indicated, prescription medications have now enhanced the quality of life of these patients and allow most workers with appropriate treatment to be productive in the workplace.

Asthma

The WHO estimates that the prevalence of asthma in the developed world ranges from 4 to 17% with an underdiagnosis of 30 to 66%. DALYs lost related to asthma for developing countries is 2,511,178. Asthma affects more than 27 million American adults and is one of the leading causes of lost productivity in the workplace with an estimated 14 million workdays lost annually in the U.S. (60). At-work productivity loss has been estimated at 8.2 days per year per employee suffering with asthma working at less than 90% of capacity (61). Asthma is a controllable disease for the vast majority of sufferers. The value of worksite-based asthma education and disease management programs has been demonstrated (62, 63). These investigators reported on the value of a worksite-based program that improved asthma control and improved worker productivity as measured by self-reported decrease in worker absenteeism. An individualized asthma care training program for adults with severe or uncontrolled asthma demonstrated statistically significant increases in functional status and productivity and decreases in the number of days absent from work due to asthma (64). Participants reported a decline in absenteeism due to asthma from 5.7 days in the prior month at baseline to 2.4 days. The number of days of reduced productivity declined from 4.3 days per month at baseline to 2.0 days per month at 12-month follow-up. A study in the managed care setting showed that patients treated by physicians with expertise in treating asthma had better control of asthma and were less likely to miss work (65).

The National Institutes of Health has published treatment guidelines for the treatment of asthma (66). These guidelines are the basis for most disease management programs and include the following general recommendations: (1) initiate a partnership with the patient with asthma; (2) reduce inflammation, symptoms and exacerbations; (3) monitor and manage asthma over time; and (4) promptly treat asthma exacerbations. Following these treatment guidelines should result in reduced absenteeism and increased worker productivity.

Headache

Common forms of headaches include tension, cluster and migraines. Migraines are the most debilitating, and nearly 60% of the missed workdays due to headaches are related to migraines. The WHO estimates the prevalence of migraine in developed countries at 6-18% accounting for 1,895,811 DALYs. The non-migraine headaches are not as debilitating, however they are more likely to result in lower productivity when the patient is on the job. The non-migraine headaches account for over 60% of reduced effectiveness on the job. Thus, although the direct costs of headaches are relatively low, except for the chronic migraine patient, the indirect cost of headaches is relatively substantial (67).

The complexity of the several phases of migraines increases the extent of its impact on worker productivity. The pre-headache phase, which could last for 24 hours or more, plus the headache phase and the post-headache phase, indicate that a single migraine could impact productivity for as many as eight days. Although the direct costs related to migraine are relatively small, the costs in terms of lost productivity are high. Up to 40% lost productivity has been reported during the eight days of the attack. It has also been estimated that the indirect cost of migraines account for approximately 75% of the total costs, with medical costs accounting for the direct costs (68). In a large U.S. population survey involving over 20,000 respondents to a questionnaire, 17.6% of women and 5.7% of men reported having one or more headaches a year that met the International Headache Society criteria for migraine. Similar results were confirmed in a survey of a major financial services company in the U.S. (69). This condition peaks during the prime working years, ages 25 to 55 years. The majority of the economic burden to employers is attributable to lost on-the-job productivity. Migraineurs report an average of 3.2 actual lost workdays and 4.9 workdays lost annually due to reduced effectiveness on the job. The cost to U.S. employers is approximately $13 billion annually because of missed workdays and impaired work function.

Migraineurs can prevent some attacks by eliminating triggers for the headaches. Non-prescription and prescription medications are available for the treatment once a migraine headache occurs. For employees with frequent migraines, medications are available which may actually prevent migraines.

Two questionnaires have been developed for specific use in migraineurs. The Migraine Adaptive Cost-Effectiveness Model combines the costs of time lost both from work and non-work activities with medical resource and medication use. The Migraine Work and Productivity Loss Questionnaire (MWPLQ) estimates the impact of migraine and migraine treatment and was found useful in comparing the effectiveness of different drugs for the treatment of migraine (70, 71).

Diabetes Mellitus

Diabetes Mellitus affects approximately 7-18% of the population in developed countries and 5.9% of Americans. It is undiagnosed in a further 2.7% of the population. In

1997 in the U.S. it accounted for $44 billion in direct and $54 billion in indirect costs (72). The Diabetes Control and Complications Trial (DCCT) demonstrated that good control of diabetes could delay the onset and slow the progression of many diabetic complications and thereby result in avoidance of costs related to these complications. There are an estimated 8 million Americans diagnosed with diabetes and another 8 million undiagnosed. Of the 8 million diagnosed Americans, up to 800,000 have type 1 diabetes and over 7 million have type 2 diabetes. In 1997, workers with diabetes accounted for approximately 14 million disability days lost, as well as an average of 8.3 days off from work annually, compared with 1.7 days for people without diabetes or other chronic conditions (73). Corporations are in a unique position to proactively address the potential complications of diabetes through worksite-based educational programs (74).

It has been shown that diabetes can significantly impact worker productivity in a telephone call center employee population (74, 75). A worksite-based diabetes education program can result in improved control of diabetes in workers and would be expected to result in decreased complications and disability over time.

Influenza

Influenza occurs annually in the United States and the impact of this disease on workplace productivity can be significant (77). Although the burden of this disease can be great, the potential for prevention is high, especially with a worksite influenza vaccination program. Influenza causes increased work absenteeism, decreased productivity and increased health care costs during flu season. Several studies have now demonstrated the effectiveness of worksite-based flu shot programs, and some studies have shown a return on investment (ROI). Vaccinating healthy working adults was on average cost-effective, with mean savings of $13.66 per person vaccinated (78). Workers with influenza-like illness missed 2.8 days of work per episode of illness and reported reduced effectiveness and inability to resume normal work activities for a mean of 3.5 days after the onset of symptoms (78). Workers who received an influenza vaccine, through a randomized control trial, reported 25% fewer episodes of upper respiratory illness than workers given the placebo and 43% fewer days of sick leave from work due to upper respiratory illness. The authors estimated a cost savings of $46.85 per worker vaccinated (80).

The value of a worksite influenza vaccination program was shown to be more effective in employees over the age of 45 (81). Others reported a cost per saved lost workday for an influenza vaccination program of $22.36 and a reduction in sick days (82). Influenza vaccination reduced lost workdays by 32%; however, it was not necessarily found to be economically beneficial in most years (83). An intranasal flu vaccine was found to be safe and effective in healthy, working adults in a year when influenza A was the predominate virus. This vaccine resulted in fewer lost days of work, including 17.9% reduction for severe febrile illness and 28.4% reduction for febrile upper respiratory tract illnesses (84).

Gastrointestinal Disorders

A variety of gastrointestinal disorders can result in absenteeism and lost worker productivity, such as gastroesophageal reflux disease (GERD), peptic ulcer disease PUD) and irritable bowel syndrome (IBS). Approximately 60 million Americans have GERD symptoms which in most cases are mild. One study reported that 45% of a population had GERD symptoms at any point in time, and approximately 18% had symptoms on a weekly basis (85). In addition to lifestyle modification a variety of highly effective medications are now available to treat this disorder. GERD and PUD have been reported to affect worker productivity (86, 87). Researchers found that 42% of patients with PUD and 41% with GERD reported lost work productivity accounting for an estimated $606 and $237, respectively, in wage costs over a three-month period of time. Untreated patients reported a 6% productivity loss in those with PUD and a 3% productivity loss in those with GERD (88).

Historically, treatment for GERD included lifestyle changes, such as changes in diet, and the use of medications, such as over-the-counter antacids and/or the use of H2-receptor antagonists like ranitidine or cimetidine, to control stomach acid. In rare situations, surgery was performed. More recently, proton pump inhibitors (PPIs), such as omeprazole, have been used for the treatment of GERD. The role of the bacterium H. pylori in GERD is controversial at this time, as well as its potential eradication in the control of GERD symptoms. PPIs tend to be more expensive than other medications, however they may be more effective in controlling symptoms in some patients. Various cost-effective analyses have reported that in some patients, PPIs may be more cost effective (89).

Similarly, IBS has been reported to be second only to the common cold as a cause of absenteeism from work and school. Approximately 20% of the general population have reported symptoms of IBS. It is characterized by alterations in bowel habits and abdominal pain or discomfort. Women are affected more commonly with a female to male ratio of 2:1 or 3:1 (90). A survey of 5,430 U.S. households found that individuals with IBS symptoms reported missing work or school an average of 13 days per year (91). Hahn et al. examined a random sample of 1000 patients in the U.S. and the U.K. and found that one-third of the IBS patients reported an average of 1 to 2 workday absence every 4 weeks (92). At the present time there are a limited number of pharmaceutical treatments available for IBS.

Mental Health Disorders

Depression is major global health problem with a lifetime prevalence ranging from 2-15% that is often unrecognized and under-treated (93). It accounted for 4.4% of DALYs in 2000, which made it the fourth leading cause of disease burden. In 2020 it is projected to be the second leading cause of disease burden globally after heart disease. The WHO World Health Survey (WHS) cross-sectional study of 245,404 adults aged 18 years and older in 60 countries reported the overall 1-year prevalence for ICD-10 depressive episodes alone to be 3.2% compared to 4.5%

for angina pectoris, 4.1% for arthritis, 3.3% for asthma, and 2.0% for diabetes mellitus (94). Greenberg et al. estimated the annual cost to employers in the U.S. for major depression to be $43 billion in terms of work loss and reduced productivity (95). Munir et al. studied work limitations in a U.K. university employee population (96). Respondents with depression and anxiety reported the most significant work limitations compared with employees with a variety of other chronic medical conditions. In addition, there is significant co-morbidity of depression with other chronic medical conditions including arthritis, diabetes, asthma and angina pectoris. The global co-morbidity of depression with diabetes, arthritis, angina and asthma was reported to be 9.3%, 10.7%, 15.0%, and 18.1%, respectively (94). The health score calculated for respondents without any medical condition was 90.6 compared with scores for those with asthma, angina, arthritis or diabetes alone of 80.3, 79.6, 79.3, and 78.9, respectively.

There are a variety of treatment options currently available for depressive and anxiety disorders with response rates to medication and/or psychotherapy that may approach 80-90%. Nevertheless there remains significant treatment gaps from evidenced based medicine guidelines for both of these medical conditions (97-99).

Major depression is associated with a significant increase in both absenteeism and lost worker productivity. Studies have indicated that major depression is one of most impairing condition in the U.S. with regard to work loss and decreased worker productivity (100, 101). For an individual employer, the financial burden for mental health disorders such as depression is derived from medical claims data where indirect costs go largely unmeasured. Berndt et al. examined the healthcare resource utilization and at-work productivity for employees with and without anxiety and other mental health disorders (102). The authors studied 2,222 workers at a large U.S. insurance claims processing company at multiple nationwide locations. Inpatient, outpatient and pharmaceutical medical claims and objective productivity information on these workers, as measured by the number of medical claims processed by each worker each day, were analyzed. Over a thirty-month time period, 14.9% of the workers were diagnosed with a mental disorder with the most prevalent being depression (7.4%). Although workers with mental health disorders accounted for less than 15% of the population, they accounted for 31% of all worker medical costs. However, no significant difference was noted in annualized absenteeism for workers with and without a diagnosed mental health disorder with the exception of workers with depression plus another mental health disorder. In addition, no difference in on-the-job worker productivity was demonstrated for workers with and without a mental health disorder. On the other hand, Burton et al.'s study of telephone call center workers did demonstrate a difference in worker productivity for employees who had returned from a short-term disability absence for a mental health disorder, although even here the difference was not as great as for other medical disorders such as diabetes mellitus (103).

How can the finding that workers with mental health disorders have relatively normal at-work job productivity be explained? The most logical explanation is that workers treated for mental health disorders have effective treatment, and the productivity of these workers reflects the improvement of productivity from such therapy. In fact, a recent literature review supports such an explanation (104). Four clinical trials in the 1980s documented a significant reduction in the prevalence of self-reported decreased at-work productivity with treatment for mental health disorders (105). Such research is important for benefit plan design decisions in regard to parity for mental health benefits (106).

Medications and Worker Productivity

Medications have been associated with improved worker productivity for both acute and chronic medical conditions (107). The extent to which these productivity losses can be reduced by pharmacologic therapy is important to employers and society who bear the cost of lost productivity. There is very good evidence that several classes of medications are associated with the ability to reduce the productivity losses associated with medical conditions. Examples include drugs to treat respiratory illnesses, including asthma, allergic disorders, bronchitis and upper respiratory infections such as influenza, diabetes, depression, dysmenorrhea and migraine headache (108).

As noted by former U.S. Surgeon General C. Everett Koop, "Drugs don't work in patients who don't take them" (109). Non-adherence with medication is a global problem and has been estimated to cost $177 billion annually in avoidable direct and indirect costs, annually contributing to 125,000 deaths in the U.S. alone (110). WHO estimated that only about 50% of patients take their medications as prescribed by their healthcare provider. Studies indicate that 20% or more of new prescriptions are never filled and perhaps half of medications for chronic diseases are discontinued within one year of the initial prescription. Non-medication adherence leads to avoidable disease progression, medical complications and reduced on-the-job productivity and, in some instances, increases in mortality. For example, absenteeism was found to be lower among workers who were adherent to their antidepressant therapy (111). Therefore, initiatives to improve medication compliance need to be an important part of productivity enhancement efforts in the future.

The Role of the Occupational Physician in Managing Worker Productivity

The occupational/environmental medicine physician, and in particular the Corporate Medical Director, can play a key role in the health and productivity of the entire workforce and in the direct and indirect success factors of the organization. Clearly, health and safety are important areas of responsibility for occupational health professionals. It is now clear that similar factors that drive success in maintaining the health and safety of the workforce are influential in determining the productivity of the workforce (112).

The Corporate Medical Department can maximize its role by integrating its data management system and including data related to productivity, such as scattered absences, short-term and long-term disability, worker's compensation claims, and other available data sets indicating where worker health might be adversely impacted or where worker health might be enhanced (113). In the 1980s, corporations implemented a number of disability management programs. Several such programs have been described in the literature. The goals of such programs were both to insure that employees with job limitations were placed in appropriate jobs and to assist in the control of disability costs. A major automotive manufacturing corporation implemented a variation on this theme. As a result, over the subsequent 3 years total disability leave rates fell approximately 50% (114). Similarly, a major financial services corporation that instituted an in-house disability management program reported that overall short-term disability average duration declined 20%.

The Corporate Medical Department can play an important role in managing the indirect costs of worker health. Worksite health promotion or "wellness programs" can be critical in avoiding unnecessary or prolonged disability absences. Similarly the quality of health care may play a role in disability absences. For example, such an absence may be prolonged by delays in a worker receiving appropriate medical care and or testing (115). Thus, the role of the Corporate Medical Department has truly expanded to include the impact of worker health on corporate productivity and profitability, in addition to its more traditional role of enhancing worker health in terms of disease and safety.

Translating the Health-Productivity Paradigm to Sustainable Development

Health and productivity research in the workplace still has many challenging issues to address. However, perhaps an even bigger challenge for the future of the health-productivity paradigm is scaling up the approach to the national and global level. Can we extrapolate from occupational health to environmental health – from the corporation to the country – from the workplace to the world? In this regard, the World Health Organization has implemented a Comparative Risk Assessment (CRA) to estimate the global burden of disease and injury due to 26 selected occupational health risk factors based on published research studies (116). Information is available for 14 country groups and updated annually by WHO. However, this report is limited by several factors including the absence of data for developing countries, exclusion of occupational risks for reproductive disorders, dermatitis, infectious disease, coronary heart disease, intentional injuries, musculoskeletal disorders of the upper extremities, most cancers, and risks associated with child labor (under 15 years of age), due to the lack of acceptable data. Nevertheless, the health of a population can be associated with a higher productivity in a country (117). There is a positive relationship between the health of a country's population and its per capita income. Average life expectancy for a country is directly correlated with the per capita income. As the average income increases in a country, this gives rise to the ability of the population to purchase goods and services that can improve health. Healthier populations will have less absenteeism from work for their own illness and for the need to care for ill family members. Investments in international development that lead to healthier populations should thus lead to greater economic development.

It is likely that this is the scale of the health-productivity paradigm that Adam Smith had in mind as he considered the development of England at the dawn of the Industrial Revolution. It is also likely that this is the relationship that the economist Jeffrey Sachs has in mind as he considers the eradication of poverty and the achievement of sustainable development for all the countries of the world, including the extreme poor. Sachs notes:

> The greatest tragedy of our time is that one sixth of humanity is not even on the development ladder. A large number of the extreme poor are caught in a poverty trap... They are trapped by disease, physical isolation, climate stress, environmental degradation, and by extreme poverty itself... Poor health causes poverty and poverty contributes to poor health (118).

In other words, for much of the world's population, health problems are diminishing productivity and preventing them from developing, keeping them poor and unhealthy. And, as Sachs notes, at least part of the problem is due to poor environment. So, in many ways, occupational physicians are well-suited to help solve this problem. Their knowledge of the interaction of the occupational environment and workers' health can be extrapolated to the general environment and the population's health, and their knowledge of the interaction of workplace health and productivity can be extrapolated to nationwide health and economic development.

The Global Burden of Disease Study (GBD) used DALYs to compare death and disability metrics for 107 disorders in 1990 for developing and developed countries (119). This report served to highlight the significant chasm between health expenditures in developed and developing countries and the impact of that difference. For example, while developed countries accounted for 11.6% of the worldwide DALY burden, they accounted for 90.2% of global healthcare expenditures. These same authors published updated global burden of disease and risk factor data for 2001 in which they examined trends from 1990 to 2001. Although there was a 20% reduction in the global burden, more than 50% of child deaths were still attributable to preventable causes such as acute respiratory infections, measles, diarrhea, malaria and HIV/AIDS (120). Table I emphasizes the relationship of household income in countries to the different patterns of disease in those countries.

Risk factors found among the poor in low- and middle-income countries included unsafe water, poor sanitation and hygiene, indoor smoke from household use of solid fuels, and unsafe sex, as well as high blood pressure, smoking, and alcohol use, whereas the most common risk factors in high-income countries included smoking, high

Table I. ***Ten Leading Cause of DALYs by Country Income Group, 2001****

Diseases	Percent of Total DALYs
Low- and Middle-Income	
Perinatal conditions	6.4%
Lower respiratory infections	6.0%
Ischemic heart disease	5.2%
HIV/AIDS	5.1%
Cerebrovascular disease	4.5%
Diarrheal diseases	4.2%
Unipolar depressive disorders	3.1%
Malaria	2.9%
Tuberculosis	2.6%
Chronic obstructive pulmonary disease	2.4%
High-Income Countries	
Ischemic heart disease	8.3%
Cerebrovascular disease	6.3%
Unipolar depressive disorders	5.6%
Alzheimer's disease and other dementias	5.0%
Tracheal, bronchial and lung cancers	3.6%
Hearing loss, adult onset	3.6%
Chronic obstructive pulmonary disease	3.5%
Diabetes mellitus	2.8%
Alcohol use disorders	2.8%
Osteoarthritis	2.5%

* Adapted from: Lopez et al. (120)

blood pressure, overweight and obesity, high cholesterol and alcohol use. The leading cause of global health loss in both 2001 and 1990 was under-nutrition. It seems reasonable to conclude that gains in the productivity of workers in poor and developing countries could be achieved in a relatively short period of time by further investments in relatively low cost public health measures to improve the health status of the population (121).

Consider, for example, the case of Bangladesh (122). Chronically plagued by diarrheal diseases caused by microbial contamination of surface drinking water sources, an international program was established in the 1970's to install millions of tube wells around the country to provide non-microbially contaminated ground water as the primary source of drinking water. However, much of the groundwater in Bangladesh turns out to be naturally contaminated with high levels of arsenic. Reliance on this contaminated groundwater source for drinking water over the past several decades has resulted in an enormous epidemic of arsenicosis with an estimated 25-40 million people in Bangladesh exposed – what has been described as the worst environmental poisoning in history. Thus, while acute diarrheal diseases have abated, they have been replaced by the chronic health problems of arsenicosis, including skin lesions followed by skin cancers as well as other internal malignancies, lung disease, cardiovascular disease, and stunted neuro-cognitive development of children.

Now consider the potential impact of arsenical skin lesions, with their preference for the soles of the feet and the palms of the hand, on the productivity of this principally manual labor economy. The burden of DALYs due to skin lesions in Bangladesh have been estimated at over 140 per thousand population exposed to arsenic in drinking water >50 ug/L, the Bangladesh standard. This could translate into as much as a $1.7 billion loss of discounted future earnings per year. Add in estimated DALYs for the cancers and other chronic health effects as well as the loss of intellectual capacity from depressed neuro-cognitive development and the loss could be more than $2 billion of discounted future earnings per year, out of an overall economy with a GDP of approximately $67 billion. In other words, the arsenicosis epidemic may be costing Bangladesh as much as 3% of its economy, obviously a significant drag on its development potential. And, of course, Bangladesh faces many other similar environmental health hindrances from lung disease due to the local effects of outdoor air pollution from vehicles and indoor air pollution from biomass burning to the infectious and other disease increases projected from the global effects of climate change, all of which could further suppress the productivity of the population and the economic development of the country.

If the developed world is serious about achieving global sustainable development, the occupational/environmental health physician can make a significant contribution by translating the corporate health-productivity paradigm and rigorously demonstrating the links between such health risks and national productivity. It has been conservatively estimated that the 330 million DALYs saved by investing $30-40 per person in developing countries could result in $186 billion in annual direct economic benefit, not including the savings in higher worker productivity (123) As with the case of the employer and the employee, it is not only the right thing to do but the mutually beneficial thing to do, since in a globalized economy the health and wealth of the nation will ultimately depend on the health and wealth of all nations.

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