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Review

Meeting the Challenges of an Aging Workforce

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Background *Demographic, labor market and economic forces are combining to produce increases in the number and percentage of U.S. workers 55 and older. In some ways these workers will be our most skilled and productive employees but in others the most vulnerable.*

Methods *The literature on aging and work was reviewed, including demographic trends, physical and cognitive changes, safety and performance, work ability, and retirement patterns.*

Results and Conclusions *Older workers have more serious, but less frequent, workplace injuries and illnesses than younger ones. There is evidence that many of these problems can be prevented and their consequences reduced by anticipating the physical and cognitive changes of age. Many employers are aware that such efforts are necessary, but most have not yet addressed them. There is a need for implementation and evaluative research of programs and policies with four dimensions: the work environment, work arrangements and work-life balance, health promotion and disease prevention, and social support. Employers who establish age-friendly workplaces that promote and support the work ability of employees as they age may gain in safety, productivity, competitiveness, and sustainable business practices.* Am. J. Ind. Med. 51:269–280, 2008. *© 2008 Wiley-Liss, Inc.*

KEY WORDS: aging workforce; work ability; prevention; human factors; older workers

INTRODUCTION

Two simultaneous demographic changes have begun to produce a marked growth in the number and percent of older workers (those 55 and older) in American workplaces. First, the enormous birth cohort born between 1946 and 1964 has started to crest past the age of sixty. Second, the twentieth century trend toward earlier retirement has reversed and growing numbers of employees are planning longer working careers. As a result, the median age of the civilian labor force (those working or looking for work), which had dropped to 35 in 1984, rose to 40.3 in 2004 and is expected to reach 41.6 by 2014. The number of those in the workforce who are 55 and older will increase by 49% from 2004 to 2014. Their proportion is also growing, from 11.9% in 1994 to 15.6% in 2004 to 21.2% expected in 2014 [Toossi, 2005].

OUR AGING WORKFORCE

Prior to the passage of the Social Security Act in 1935 work did not typically end with a planned retirement. Average retirement (meaning the age at which 1/2 of workers from an initial age cohort remain in the workplace) was age 70 or more for men. After World War II there was a need to open the workplace to growing numbers of unemployed younger workers, particularly veterans. Also retirement leisure was becoming a symbol of success. Social security and private pension policies were designed to encourage earlier departures from work. In 1961, for example, Congress lowered the age men were eligible for unreduced Social Security benefits from 65 to 62. Average retirement dropped

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from age 70 in 1950 to age 65 in 1970 with age 62 becoming the norm by 1985 [Quinn, 2002; Cahill et al., 2005].

Despite this long trend toward earlier retirement since the 1940s, the 78 million baby boomers born between 1946 and 1964 comprise such a large group that there are more workers in their fifties and sixties on the job than ever before. As they leave the workforce, whether at age 55, 62, 65 or later, there will also be more retirees than ever before. To complete the picture, as these baby boomers age at work and then leave for retirement, they are followed by a substantially smaller younger generation, the baby bust of 1965–1976 (Fig. 1).

The enormous economic and labor market consequences of this demographic transformation are becoming clear. In the State of Washington, for example, 29% of employed workers were 45 or older in 1995. This had grown to 39% by 2005 [Kaglic, 2005]. This growth is not being matched by younger workers. By 2015 there will be 115,000 more 60- to 64-year olds and 30,000 fewer 40- to 44-year olds in the Washington State labor force (those who are either employed or seeking employment) than there were in 2005 [Bailey, 2006]. Nationally, from 2004 to 2014, "the labor force will continue to age, with the annual growth rate of the 55-and-older group projected to be 4.1%, four times the rate of growth of the overall labor force. By contrast, the annual growth rate of the 25- to 54-year age group will be 0.3%, and that of the young age group consisting of 16- to 24-year olds will be essentially flat" [Toossi, 2005].

As these older workers move into retirement the direct impact will be a tighter labor market and a shortage of various skills. According to the International Brotherhood of Electrical Workers by 2010 as many as 60% of today's experienced utility workers will retire [IBEW, 2005]. Similarly, the average age of hospital caregivers today is about 45, with 70% of the hospital workforce eligible to retire over the next 20–25 years [Briley and Hutson, 2002].

The indirect, but equally profound, impact of the demographic changes will be economic. The integrity of our federal social security system has depended upon the labor and income of large numbers of young workers supporting the retirement needs of smaller numbers of disabled and retired workers and their dependents. In 2005 for every person 65 and older there were five people aged 20–64 (i.e., an old age dependency ratio of 20%). The Social Security Administration estimates that by 2080 this ratio will more than double, to more than 40%, with only 2.5 younger people for every older one (Fig. 2). Not only will the number of retirees grow, but their life expectancy and associated duration of retirement is increasing as well. While private pension systems are theoretically fully funded at the time the commitment is made to provide the future benefit, in fact this is often not fully realized. Underfunded pension programs in both the private and public sectors are now common, the federal assurance program for these pensions is not robust, and these pensions may also be jeopardized by these changing demographics. Although the impact of the growing dependent older population will be somewhat mitigated by lower fertility rates which reduce the numbers of the very young who are also dependent on the working age population [Burtless, 2005], this will not offset the profound economic consequences of the demographic trends.

STAYING ON THE JOB LONGER

As these trends progress—more older workers moving toward retirement with fewer younger replacements—substantial pressure on our social security and pension funds will accompany the anticipated shortages of labor and skills. Public and private employment policies will almost certainly evolve to encourage workers to stay on the job longer. Other factors creating incentives to stay at work longer include the need for private health insurance until at least the age of 65 in the face of relentlessly rising health care costs and the increasing uncertainty about pension benefits that comes with the trend from defined benefit private pension plans shift toward defined contribution programs.

Some of the expected policy changes are already evident, including the 1978 and 1986 amendments to the

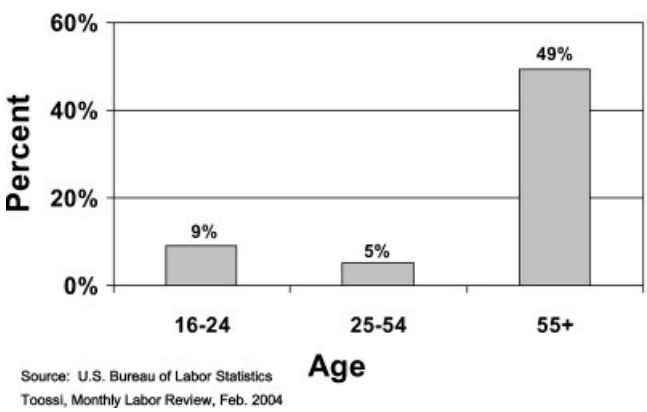

FIGURE 1. Growth of U.S. Workforce 2002–2012.

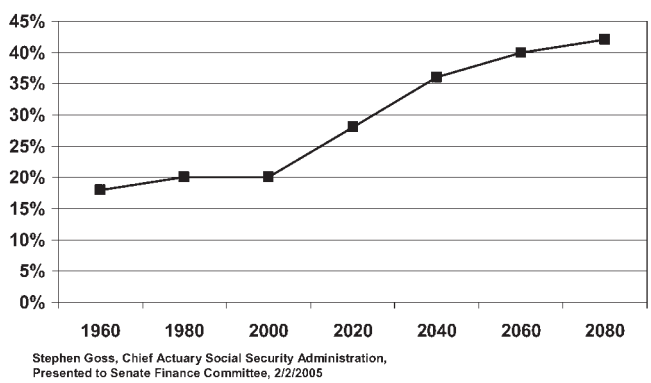

FIGURE 2. Old age dependency ratio (age 65+/age 20–64).

Age Discrimination in Employment Act of 1967 [ADEA, 1967] which have largely eliminated mandatory retirement ages, the gradual increase in the age for full social security benefits from 65 to 67, and a relaxation of the social security retirement earnings test so that workers can stay on the job longer without a loss of benefits. The Pension Protection Act of 2006 has made it easier for senior employees to phase their retirement plans by starting to draw pension income without penalty while they continue to work full or part time past age 62 [PPA, 2006].

These changes are probably not enough. Business Week magazine, for example, predicts that social security's normal retirement age will incrementally rise to 70 [Coy and Brady, 2005]. This, however, is not certain since along with predictable political opposition many actuaries assume that raising the retirement age would result in an increasing number of older people applying for Social Security disability benefits, thus offsetting the possible savings from the raised retirement age.

The impact of these developments is already apparent. While the labor force participation rate among 65-year-old men dropped from 70% in 1940 to only 32% in 1985 [National Research Council, 2004] this trend shows signs of reversing as the incentives for early retirement are beginning to soften. From 1985 to 2004 the labor force participation rate of 25- to 54-year olds stayed essentially stable (fluctuating between 82% and 84%) while the rate among 55- to 64-year olds increased consistently from 54% to 62% [Toossi, 2005]. This trend is likely to continue, as signaled by a May, 2005 Gallup survey showing that the percent of people planning to put off retirement until after age 62 had risen from 35% in 1998 to 55% in 2004. The Bureau of Labor Statistics projects that the percent of older workers staying on the job will continue to rise at least through 2014, even without major changes in social policy such as further increases in full social security retirement age.

PHYSICAL AND COGNITIVE CHANGES OF AGING

In some ways older workers are the most skilled and productive employees but in others they are the most vulnerable. Employers who do not anticipate the physical and cognitive capacities of older workers and who fail to provide the programs and policies needed to support their productive capacities and minimize their vulnerabilities will experience adverse impacts on quality, productivity, workplace safety, and workers' compensation.

Older workers differ from their younger counterparts in several important ways that might have an impact on their safety and health at work. Whether these are normative effects of aging (e.g., loss of visual acuity) or age dependent increases in various ''abnormal'' conditions (e.g., coronary artery disease), aging brings changes to all parts of the body, from decline in brain cell connections to decrease in muscle mass. Maximum physical strength is at age 20–30, gradually declining until 40–50 and more quickly thereafter [Millanvoye, 1998]. Bone density, pulmonary oxygen uptake, exercise capacity, visual acuity, resistance to heat and cold stress, and many other physiologic functions decline predictably with age. The prevalence of work-limiting disabilities increases with age, from 3.4% of workers aged 18–28 to 13.6% of those greater than 60, according to the 1994 National Health Survey [National Research Council, 2004].

The impacts of age on cognitive function are more complicated. Some mental processes such as those requiring spatial abilities, problem solving, and processing of complex stimuli are especially age sensitive. Cross sectional data sets suggest declines in these domains beginning as early as 20–30 years old, while the onset is a bit later for longitudinal studies. Performing multiple simultaneous tasks or holding multiple items in working memory are examples of these age dependent processes. Psychologists distinguish these ''fluid'' functions which involve processing input at the time of performance from other ''crystallized'' cognitive functions which are the cumulative results of earlier processing and are better preserved with age. The ''crystallized'' knowledge of word meaning or the ability to retrieve familiar information, for example, is relatively age stable. In addition to these crystallized semantic skills, memory for procedural skills such as typing, which relies on early learning, is also relatively well maintained with age [National Research Council, 2004].

While age-related changes in mental and physical function are inevitable, they do not invariably lead to incapacity or reduced performance and productivity at work. While many older workers with illnesses or limitations leave the workforce a considerable number remain on the job. Seitsamo and Klockars [1997] followed a group of 4,534 Finnish municipal workers over an 11-year period. 37% had a self-reported musculoskeletal disorder and 17% had a self-reported cardiovascular disease at baseline (with mean age of 50). Prevalence of self-reported musculoskeletal disorders rose to 51% and cardiovascular diseases to 31% at 11 years (with mean age of 61.6). Twenty percent of the cohort remained in the same occupation throughout the study period and workers in this subgroup had a prevalence of 45% for self-reported musculoskeletal disorders and 23% for self-reported cardiovascular diseases after 11 years. Forty-five percent of the cohort had retired due to old age and their prevalence of musculoskeletal and cardiovascular diseases was no different from their counterparts who remained at work. Disease prevalence was higher, however, among those who had retired due to disability. The fact that many workers with chronic diseases remain at work is probably because the health conditions are not severe, the need to work outweighs

other incentives, they have strong social support and coping skills, or their job duties or work environment are modified.

There are other important reasons that workers, even with diminished physical or cognitive function, may continue to work effectively as they age. First, most jobs do not require performance at full capacity even for older workers, although in general older people work closer to their physical limits than younger workers. Second, while various physical and cognitive capabilities decline with age, there is great inter-individual variation in these normative trends, it being ''axiomatic in gerontology that most general physiological and biological functions in older persons tend to have greater variation than in younger persons'' [National Research Council, 2004]. Third, older individuals can often compensate for age-related losses with relatively age stable strategies and skills related to their experience and expertise, although the relationships are complex and the literature is mixed [Morrow et al., 1994; Meinz and Salthouse, 1998; Charness et al., 2001].

Salthouse [1987] notes a ''discrepancy between the rather pessimistic results of the laboratory and the more encouraging observations of daily life'' and offers several possible explanations. First, people sometimes are able to select into work or other activities as they age that match their competence. Second, the artificial nature of laboratory tests of physical and cognitive capacity may result in low motivation and high anxiety that result in diminished performance. Third, laboratory tests of cognition may measure age-sensitive fluid capacities while daily activities are more likely to utilize age-preserved crystallized cognition. Fourth, experience is more of a factor in daily activities than in most laboratory settings.

The ability to work successfully with increasing age is thus the integrated result of many factors. For example, older typists have been shown to have slower tapping rates and reaction times, but are able to compensate for declining motor speed by using experience to scan characters further in advance than younger, less experienced typists [Salthouse, 1984; Bosman, 1993, 1994]. Similarly, despite significant age-related declines in the cognitive ability to recall short musical melodies, at every age those with musical experience and skills tend to maintain their advantage in musical memory over those with less experience and skill [Meinz and Salthouse, 1998; Meinz, 2000]. Based on a comprehensive review Salthouse [2006] has concluded that while many types of cognitive and physical performance are improved at all ages with training and practice, this does not appear to change the rate at which capability declines with age. In other words training, practice and experience can enhance performance at older ages and can often result in older workers outperforming younger ones, despite the fact that age-related declines continue at the same rate as they do in workers with less experience and practice. Laflamme and Menckel [1995] have summarized these complex relationships in a study of work injuries by noting that skills and experience can compensate for age-related physical and cognitive declines only when the job demands remain lower than overall work capacity and that this compensation is not feasible when work organization and working methods are rigid.

SAFETY AND PERFORMANCE AMONG OLDER WORKERS

Since aging is associated with reduced physical capacity and brain function, we might predict aging to be associated with poor performance, particularly because many of the functions that decline with age—like the ability to solve abstract problems—are strong predictors of initial job performance. But, with the exception of certain jobs with exceptionally high cognitive demands like air traffic controllers, most studies have not found an age trend in measures of job performance [Waldman and Avolio, 1986; McEvoy and Cascio, 1989; Avolio et al., 1990]. Duration tends to be a better predictor of performance than age and variations within age groups tend to exceed the average differences between age groups. McEvoy and Cascio [1989] point out that those who continue to work after normal retirement age are probably not average workers and that selective retention may partially explain why performance does not tend to decline with age. Not surprisingly, findings vary depending on the nature of the work. Warr [1994] proposes four types of jobs, depending on whether their physical and cognitive requirements exceed capacities as workers age and whether performance on the job is enhanced with experience. Performance is expected to diminish with age in only those jobs where capacities decrease with age and experience provides little advantage (e.g., unskilled manual labor or fast paced data processing). In many others where capacities are maintained with age and experience enhances performance, the relationship between performance and age is expected to be positive. Warr [1994] provides several examples of such ''age enhanced'' jobs, including mail sorters, shoe leather cutters and sales workers.

In addition to their generally satisfactory performance, older workers experience lower overall rates of non-fatal work-related injury and illness compared with younger workers. In the 1988 National Health Interview Survey Supplement on Occupational Health and Safety, men greater than 50 averaged half the lost workday injury rate of men aged 30–49 [Landen and Hendricks, 1992]. In a review of 13 studies Laflamme and Menckel [1995] report ''the most common finding is that accident frequency tends to decrease as age increases.'' The reasons for this positive experience are not fully understood. While experience, skill and maturity of older workers may play a role, Rix [2001] notes another plausible explanation to be systematic differences in the exposures to hazards of different age groups. While overall

injury rates are low, there is evidence that some subgroups of older workers with pre-existing problems may be vulnerable to higher workplace injury rates and a variety of adverse outcomes. Zwerling et al. [1998a,b] report that poor eyesight and hearing is associated with occupational injuries among older workers.

Although injury rates are generally low, the impact of workplace injury among older workers has been found disproportionately high in most studies [Mitchell, 1988; Layne and Landen, 1997; Layne and Pollack, 2004]. Laflamme and Menckel [1995] note the most common finding in nine studies reviewed to be that "age-related accident severity tends to increase with age." According to the Bureau of Labor Statistics, the median duration of absence from work due to a work injury increases consistently with age, from 5 days among those less than 25–12 days for those aged 55 and older [Rogers and Wiatrowski, 2005] (Fig. 3). Laflamme et al. [1996] found lower injury rates but greater case severity among older male Swedish iron-ore miners. The literature has not been completely consistent, with exceptions including reduced self-reported adverse outcomes among older workers in the National Health Interview Survey Supplement cited above. Also, in a survey of injured New Hampshire workers Pranksy et al. [2005] found that despite more severe injuries the workers 55 and older did not have more lost work time or other adverse outcomes than the younger workers. In this population older workers reported greater satisfaction and fewer residual symptoms than younger workers, possibly related to longer and stronger attachment to their jobs as well as a healthy worker effect.

While the rates for non-fatal injuries are lower for older workers, fatality rates have been higher [Goldberg et al., 1989; Bell et al., 1990]. Kisner and Pratt [1999] found that workers over 65 had a workplace fatality rate nearly three times that of those aged 16–64, despite the fact that the older workers averaged substantially fewer hours of work each week. The difference persisted after stratifying by type of injury and industry. The rate of machinery-related deaths among males in retail trade was nearly seven times greater among older workers and for machinery-related deaths among males in transportation was nearly nine times greater. Agnew and Suruda [1993] also found an increased rate of fatal falls among workers after the age of 45. This was particularly noted among falls from lower heights with lower energy of impact, suggesting that "once a fall has occurred older workers are more vulnerable to serious injury than younger counterparts."

There are two likely reasons for the increasing impact of injury with age. First, the types of injuries sustained by older workers tend to be more severe; fractures accounting for a substantially greater percentage of non-fatal injuries among older workers compared with younger ones, while the percentage of strains and sprains decreases with age. For example, 20% of injuries to older truck drivers are from fractures, compared with only 9.3% of injuries to all truck drivers [Rogers and Wiatrowski, 2005]. Second, for the same condition older workers experience more severe outcomes, including longer recuperation and lost work time. Fractures from falling to the floor result in a median 35 days for recovery among older workers and 25 days among younger workers [Bureau of Labor Statistics, 1996]. In a study of fall injuries among union carpenters Lipscomb et al. [2003] found age was not associated with the risk of falls from elevations but the mean cost per fall increased fourfold with age. Whether this is a function of injury severity or medical care delivery and personnel practices is not clear.

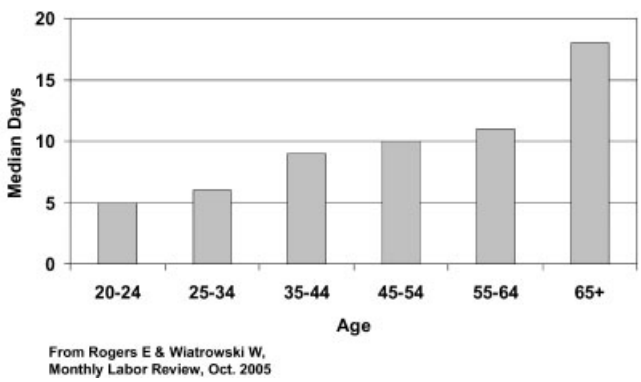

FIGURE 3. Median days away from work for non-fatal workplace injuries and illnesses, 2003.

MAINTAINING WORK ABILITY, SAFETY AND HIGH PERFORMANCE IN AN AGING WORKFORCE

Since we can reasonably predict growing numbers and percentages of older workers for the next 25 years, we collectively have a strong interest in ensuring that our workplaces are hospitable to their needs and capacities so they may contribute their labor with maximum safety and productivity. Under current conditions the rate of workplace injury and illness among these older workers will be lower than that of their younger counterparts, but the number of cases will increase substantially and their average severity, disability, cost and risk of fatality will be high. These adverse outcomes are likely to outweigh the advantages of relatively low rates unless we adopt workplace strategies that build upon the strengths and protect against the vulnerabilities of workers as they age [Ilmarinen and Rantanen, 1999; Rix, 2001; National Research Council, 2004].

AARP [2002a] has articulated this need as a challenge to employers to develop programs which match the workplace environment with the needs and capabilities of older workers: "If employers are to reap the benefits of the work

ethic and experience of older workers, they must design the workplace of the future to meet their needs.'' The concept of designing work to match the physical and cognitive capacities of workers applies equally well at all ages and there is some evidence, mostly from the Nordic countries and the European Union, suggesting that carefully designed employer programs can provide age friendly working environments that preserve the capacity of employees to function safely and effectively as they age.

Ilmarinen [2001] and colleagues at the Finnish Institute of Occupational Health have developed a conceptual model of work ability in which an individual's capacity to perform job functions successfully is the integrated product of a number of self-reported individual and workplace environmental factors. The critical work ability factors include health status and physical impairment, the physical and cognitive demands of work, the psychosocial work environment, and the individual's general well being and supportive resources. Since 1981, a quantitative Work Ability Index (WAI), derived from a standardized, self-administered employee questionnaire, has been used widely by researchers in the Nordic countries and the European Union [Tuomi et al., 1998, 2001; Nielsen, 1999; Kiss et al., 2002; de Zwart et al., 2002; Camerino et al., 2003]. Using the WAI a cohort of 6257 Finnish municipal employees ranging in age from 44 to 58 was first evaluated in 1981 [Ilmarinen et al., 1991a]. Five thousand five hundred fifty-six were re-evaluated in 1985 and 4,534 in 1992, with four principal sets of findings [Nygard et al., 1991; Tuomi et al., 1991; Ilmarinen et al., 1991b, 1997; Ilmarinen and Tuomi, 1992; Seitsamo and Ilmarinen, 1997; Ilmarinen and Rantanen, 1999; Ilmarinen, 2001; Savinainen et al., 2004].

First, the WAI at baseline has been found to be associated with disability pensions and mortality at 4 and 11 years of follow-up [Ilmarinen et al., 1991b; Tuomi et al., 1997a]. For example, among a group of municipal workers with poor work ability scores in 1981 62.2% had retired on disability pensions and 11.6% had died in 1992, while the corresponding outcomes for those with good work ability were 21% disability pension and 3% deceased. Similarly, in a group of construction workers the WAI predicted disability pensions at 4 years of follow-up [Liira et al., 2000]. Scores on the WAI also predicted self-reported good health and physical condition after 5 years of follow-up and were positively associated in cross sectional analysis with self-reported quality and productivity of work [Tuomi et al., 2001]. Ilmarinen [2003] has also reported an association between WAI scores and per person disability and sickness absence costs.

Second, there is an overall decrease in WAI with age but with substantial inter-individual variability. Municipal workers (818) remaining in the same occupation were followed from 1981 to 1992 [Ilmarinen et al., 1997]. WAI in 1981 was not associated with age but declined significantly for each age cohort for both men and women over the period of the study. The prevalence of poor work ability increased with age, from 1.7% at age 47, 3.3% at age 51, and 18% at age 58.

Third, several potentially modifiable variables are shown to be associated with WAI. Among the group of 818 workers noted above, variables associated with improved WAI over the 11-year study period included decreased repetitive movements, increased satisfaction with supervisor attitude and increased leisure physical exercise [Tuomi et al., 1997b]. Variables associated with decline in WAI were increased standing at work, decreased satisfaction with restless and noisy workrooms, decreased recognition and esteem at work and decreased leisure time physical exercise.

Fourth, four sets of variables have been associated with the preservation or enhancement of WAI over time and suggest strategies for intervention: (a) adjustments in physical work environment (physical workload, rest/work schedule, repetitive motion, and regulation of one's own work and breaks); (b) adjustments in the psychosocial work environment (flexible work schedules, teamwork, age-management skills for supervisors); (c) health and lifestyle promotion (physical exercise, risk factor reduction, occupational health services); and (d) worker skills and competency building [Ilmarinen et al., 1997; Ilmarinen and Rantanen, 1999].

Although these issues have not been explored as actively in the U.S. literature, Burkhauser, using data from the 1978 Survey of Disability and Work and the 1992 Health and Retirement Study, found that provision of a workplace accommodation for an employee with a health impairment slowed withdrawal from the workforce and delayed the time to beginning social security disability payments [Burkhauser et al., 1995, 1999].

PROGRAMS AND POLICIES TO MEET THE NEEDS OF AN AGING WORKFORCE

Several recommendations have been made for the implementation of practical programs consistent with the evidence summarized above. Four strategic dimensions have been suggested, including interventions that focus on the work environment, the way work and retirement are arranged and organized, the health and fitness of the individual worker, and the social context of work [Ilmarinen, 2001; Moyers and Coleman, 2004; National Research Council, 2004] (Fig. 4).

The Work Environment

Injuries and poor job performance are more likely to occur when work requirements exceed individual capabilities, a mismatch potentially more frequent among older workers. The tools of workplace ergonomics and human factors engineering, applied to workers of all ages in an aging

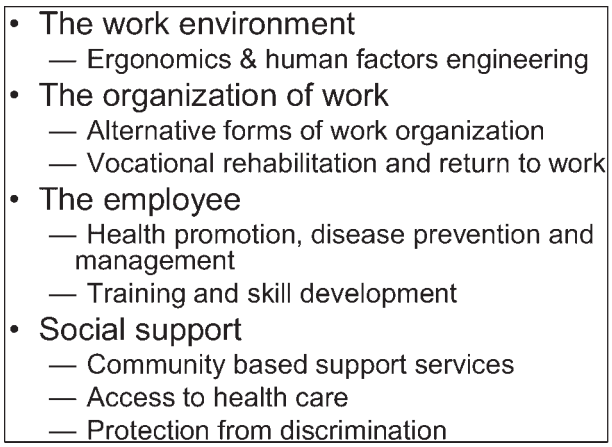

FIGURE 4. Four strategic dimensions for programs that meet the needs of an aging workforce.

workforce, can be used to eliminate or modify exposure to hazards so that young workers can reach older ages without injury or that impaired or limited workers can continue to work without further harm [Garg, 1991]. The principles of ''universal design,'' aimed at products and environments that can be used safely and effectively by people of widely ranging differences in age, size and other characteristics, are especially useful for creating age-friendly workplaces. These principles (including equitable use, flexible use, simple and intuitive design, perceptible information, tolerance for error, low physical effort, and size and space provided for approach and use) are more fully described at http://www.design.ncsu.edu/cud/about_ud/udprincipleshtmlformat.html#top.

The opportunities for safe design are particularly applicable to the prevention of work-related musculoskeletal disorders, an Institute of Medicine panel having concluded ''that primary and secondary prevention interventions to reduce the incidence, severity and consequences of musculoskeletal injuries in the workplace are effective when properly implemented. . .'' [National Research Council, 2001]. For example, in a randomized, population based clinical trial Loisel et al. [1997] found that workers with subacute work-related back pain returned to work 2.5 times faster when modified work was added to the usual regimen of clinical care. Krause et al. [1998, 2001] concludes that modified work programs consistently increase return to work rates twofold and reduce disability days in half.

The principles of ergonomics, human factors and universal design can be applied to challenges in the areas of balance, vision, hearing, strength and endurance faced by workers as they age.

Balance

Many workers above the age of 50 begin to have problems with balance, risking injuries from trips and falls [Whipple et al., 1993; Konrad et al., 1999; Rogers and Mille, 2003]. Measures to compensate for postural instability include handrails along travel routes, housekeeping to reduce clutter, slip resistant walking surfaces, repair of uneven or wet floors, and the use of color contrast between stairway risers and treads.

Vision

Vision deteriorates with age in several ways, including normative changes such as the loss of ability to focus on near objects (presbyopia) as well as age-related pathology including macular degeneration, glaucoma, and cataracts [Das, 1999; Quillen, 1999]. As a result older people experience reduced acuity, loss of accommodation to objects at varying distances, diminished color discrimination and depth perception. Five general rules for supporting the vision of older workers have been suggested, although without a great deal of scientific validation [Figueiro, 2001]. These include general lighting at intensities 50% greater than for younger workers, task lighting levels three times greater than general levels to help with fine detailed low contrast objects, placement of task lights to the side and in front of the worker to reduce shadows, increased contrast for stair edges and curbs, and high illuminance fluorescent fixtures to enhance color discrimination.

Hearing

Even without noise induced hearing loss, workers after age 50 typically begin to lose higher frequency hearing [Irwin, 2000; Seidman et al., 2002; Rosenhall, 2003]. They may have difficulty in understanding conversations or localizing sounds in space. This is especially important where audible signals are important for safety or performance. In addition to noise reduction, helpful steps include redundant warning signals such as flashing warning lights or cell phones with vibration, reduced speech rate and elimination of speech compression on automated systems such as voice mail, and provision of telephone amplifying devices.

Strength and endurance

The general methods of workplace ergonomics to reduce physical stresses on the body, particularly the musculoskeletal system, are well understood [Hagberg et al., 1995; Cohen et al., 1997; National Research Council, 2001]. Strategies for fitting the workplace to the worker (rather than the reverse) include substituting mechanical for manual strength, reducing highly repetitive tasks, allowing adequate recovery time, reducing static and stressful postures, and job rotation. As a last choice it may be necessary to provide alternate job assignments and appropriate retraining for

workers whose physical capacities are so reduced that even modest strength or endurance is impossible and adjustments on the usual job are not feasible.

Work Arrangements and Work-Life Balance

The way relationships at work are designed can have a major impact on the ability of employees to perform safely and productively. Important factors include work schedules, supervisory relationships, decision control, information transfer, and avenues for conflict resolution. Factors associated with lower injury rates include empowerment of the workforce, autonomy, delegation of control, good relations between management and workers, low stress, low grievance rates and encouragement of long-term commitment of the workforce [Shannon et al., 1997; Hale and Hoyden, 1998]. A stressful work organization can increase the risk of chronic diseases, such as cardiovascular disease [Belkic et al., 2004]. A 1999 Swedish study found increases in self-reported stress and systolic blood pressure over a work shift on a traditional auto assembly line but not with a more flexible assembly operation in small groups with opportunities to alter pace and content of work [Melin et al., 1999]. Two studies suggest that the impact of job stressors on blood pressure levels may be greater among older employees [Schnall et al., 1992; Iwasaki et al., 1998].

In addition to concerns about the design of work itself, many employers and employees are searching for alternatives to the traditional abrupt transition from full time work to full time retirement. There is a growing need for career path and retirement options that take into account issues related to increased longevity, elder care, and the increased prevalence of chronic illnesses. For example, the Health and Retirement Study, conducted every 2 years by the National Institute on Aging and the University of Michigan, ''has consistently shown that three out of every four older workers have said they would prefer to reduce hours gradually rather than retire abruptly'' and that older adults are ''increasingly interested in part-time opportunities and other activities to stay busy and productive with age'' [National Institute on Aging, 2007]. A variety of alternative job designs such as flexible hours, job sharing, telecommuting or phased retirement may provide more supportive working environments that reduce job stressors and enable safe and productive performance [Landsbergis, 2003].

Individual Measures

Individual measures are also needed to protect workers, promote their health and build their competencies. Five chronic diseases (heart disease, cancer, stroke, chronic obstructive lung disease, and diabetes) cause almost 70% of the deaths in the USA every year [Centers For Disease Control, 2003]. These diseases become more common as people age and they cause significant disability and dysfunction long before people die from them. In addition, other chronic problems that increase in frequency with age but do not typically lead to death, such as arthritis, hearing loss and obesity, are responsible for enormous medical costs and disability. Medical care costs are nearly two times more for employees with cancer, heart disease, or diabetes than for those without disease and these costs for 65-year olds are four times those of 40-year olds [Centers For Disease Control, 2003]. Indirect costs can be even greater than the cost of health care—including absenteeism and productivity, employee turnover and replacement, workers' compensation, and life insurance benefit costs. Expenditures for employees just at risk for chronic disease—measured by blood pressure, body weight, and cholesterol—averaged over 50% more than for those at low risk [Lichiello et al., 2005]. A number of key clinical services, such as influenza immunization, colorectal cancer screening, mammography, cholesterol and blood pressure screening and maintaining three healthy habits—not smoking, eating a healthy diet, and moderate physical fitness—can prevent or delay disability from chronic conditions by as much as 10 years [Centers for Disease Control, 2003; Moyers and Coleman, 2004; U.S. Preventive Services Task Force, 2006]. Yet most employers and employees are not taking advantage of most of these cost effective measures [Lichiello et al., 2005; Bondi et al., 2006].

The cognitive changes of aging also deserve individual attention at the workplace. For example, older workers process information more slowly than when they were younger and training methods need to take these changes into account [National Research Council, 2004]. Fisk et al. [2004] have suggested practical guidelines: provide one and a half to two times the training time provided for young adults; allow for self-paced learning; minimize distractions such as background noise; present ''how to'' information in a step-by-step format; teach spatial tasks using a visual medium; provide immediate feedback about how to correct mistakes; make sure learners are actively involved, for example by problem solving exercises or hands-on practice; and minimize demands on working memory using visual cues and aids such as drop down menus on computer screens.

Social Measures

A broad range of daily living tasks become more complex and challenging with aging and these non-work factors can interfere with successful performance on the job. For example, older workers may not be able to drive to work as easily as when they were younger and therefore have greater needs for public transportation, car pools or telecommuting. As workers age, evolving family needs may become a significant distraction at work. For example, an employee may not be able to function adequately at work

without knowing that the home health care needs of an older spouse are under control. While some of these steps may be within the reach of individual employers (e.g., work based car pools or elder care benefits), some must be addressed as broader social services such as improved access to health care, public transportation, and laws to protect against discrimination.

CONCLUSION

We are beginning to experience profound workplace changes related to the demographic changes of an aging population. Those employers who do not encourage employees to stay on the job as they age may experience escalating pension costs as well as a host of expenses associated with tighter labor markets and shortages of various skills. Those who do encourage older employees to remain at work but fail to take steps to support their productive capacities and minimize their vulnerabilities may experience adverse impacts on quality, productivity, workers' compensation and other insurance costs. On the other hand employers who promote and support the work ability of employees as they age may gain in safety, productivity, competitiveness, and sustainable business practices.

A 1998 survey of 400 employers by AARP found that while 55–68% of employers recognized the value of various programs to address the needs of older workers, only 18–44% were actually implementing them [AARP, 2002b]. There are several possible reasons why employers have been slow to anticipate and meet the needs of an aging workforce. *First*, some of the actions that that have been suggested—such as phased retirement programs—might require complex changes in pension law, benefits agreements and personnel policies. *Second*, many employers still harbor false beliefs that older workers are less reliable, less productive, less safe and more expensive than younger ones [Wegman, 1999]. *Third*, some employers are insufficiently informed about laws governing workplace bias and equal opportunity and are fearful that measures perceived to favor older workers might open them to charges of discrimination. Two recent U.S. Supreme Court decisions should mitigate these fears, but knowledge of them is not widespread [General Dynamics, 2004; Smith, 2005]. In combination these decisions make it clear that while age sometimes does affect an individual's capacity to do certain types of work, employers may attend to the special needs of older workers without providing equivalent assistance to relatively younger workers. Thus, it is permissible to treat older workers preferentially in comparison to younger workers, but it is not permissible to deny them advantages or privileges extended to younger workers. It is important to note, however, that programs and policies which most effectively meet the needs of an aging workforce are not just programs for older workers but are those starting when workers are young in order to prevent or slow the effects of aging at work. *Fourth*, while there is strong evidence to support the implementation of some of the interventions discussed in this paper (e.g., ergonomic measures to prevent musculoskeletal disorders and clinical preventive services to reduce disability from cancer and cardiovascular disease), the evidentiary base for comprehensive programs and policies (Fig. 4) is sparse and unknown to most employers. Evaluative research is needed to determine the effectiveness of various program designs together with a substantial effort to disseminate results and recommendations to employer and employee organizations.

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