TLV ADJUSTMENTS FOR AGE

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ABSTRACT

Occupational hygienists are facing an aging workforce. Most exposure limits or exposure scenarios are based on a "normal" workforce consisting of young healthy workers. The workforce is slowly changing, and adjustments in our thinking have to be made in order to handle this new reality. Insufficient research has been carried out on the effects of workplace exposures on older workers. However, there is evidence that reduced pulmonary function, visual acuity, hearing, rates of metabolism, and response to heat can alter an older worker's response to workplace hazards. To compound the problem, there is an increased incidence of chronic illnesses such as heart and kidney diseases, diabetes, and arthritis. This includes the medications required to manage these illnesses which can affect the worker's reaction to workplace risks. Occupational hygiene is not a clerical comparison of exposure levels to occupational exposure limits, or comparing an actual workplace to model workplace scenarios, but the protection of workers through the understanding of workers and workplaces.

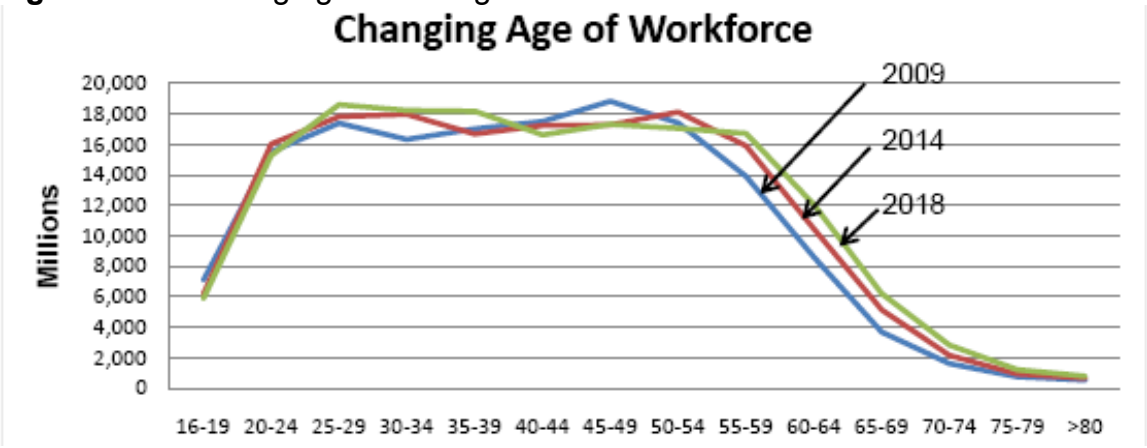
INTRODUCTION

Over the coming years, the aging "baby boomers" will alter the demographics of the workforce. The number of youths in the workforce will shrink due to the aging baby boomers, and it is predicted there will be a growing pool of older workers emerging from retirement to return to work. This will result in a future workforce that is older than today's. Even today's workforce may not represent the "normal" workforce that the exposure guidelines assume. For example, in the 70's the median age for Canada's workforce was about 34, and by the 90's it was about 39, and 41 by 2001. By 2006, 15.3% of Canada's workforce was 55 years old or older [(1)]. It has been predicted that soon there will be workplaces in Australia with the average worker's age over 45 years[(2)]. Similar changes are expected in the United States the United Kingdom and other countries[(3, 4)].

Figure 1 shows the United States Department of Labor's predicted ages of the workforce as of December 2009. As can be seen, the increasing age of workers as seen in the past is predicted to continue into the future. This increase in the number of older workers in the workforce will continue through the aging of the generation of Echo Boomers when they start reaching the age of 45 in 2030[(5, 6)]. Thus, age may have to be

taken into account in assessing “acceptable” exposures for groups and individuals in the current workforce, and workforces of the future.

Figure 1: The changing median age of the workforce from 2009 to 2018.



These predictions of an aging workforce are not new and have implications for the occupational hygienist. We soon (if not already) have to identify, assess, and control hazards in the context of a changing workforce profile.

At present, there is a lack of concrete evidence that industrial hygienists can use in their daily practice to adjust for age. Mechanisms for potential problems can be shown, and a few examples exist (see Figure 2).

PULMONARY FUNCTION

Figure 2 shows the reduction in maximum oxygen uptake (VO_{2max}) with age. This is the ability of the lungs to deliver O_2 to tissues and is a measure of work capacity. It is a combination of pulmonary and cardiovascular conditions and muscle mass. Similar decreases are shown for other pulmonary functions in Table 1[8].

A reduced lung function may result in the older worker being more susceptible to airborne particulates, because of the decreased ability to clear the lungs. This could result in a reduced capacity to work in high dust environments and increased dust-related diseases. Also, as the diffusing capacity (DL_{CO} the ability of oxygen to transfer from the lungs to the blood) is reduced, the ability of chemicals to permeate the air-blood barrier is also reduced. This can affect both the absorption and elimination of workplace chemicals [8].

It should be noted that workers with COPD, asthma, and rhinitis, have stopped working significantly earlier than those without chronic conditions, but the health impact was especially pronounced among persons with COPD and the health effect was particularly strong late in their work life [10].

Figure 2: Changes in oxygen uptake (VO_{2max}), hearing, and vision with increasing age shown as a percentage [7, 8, 9].

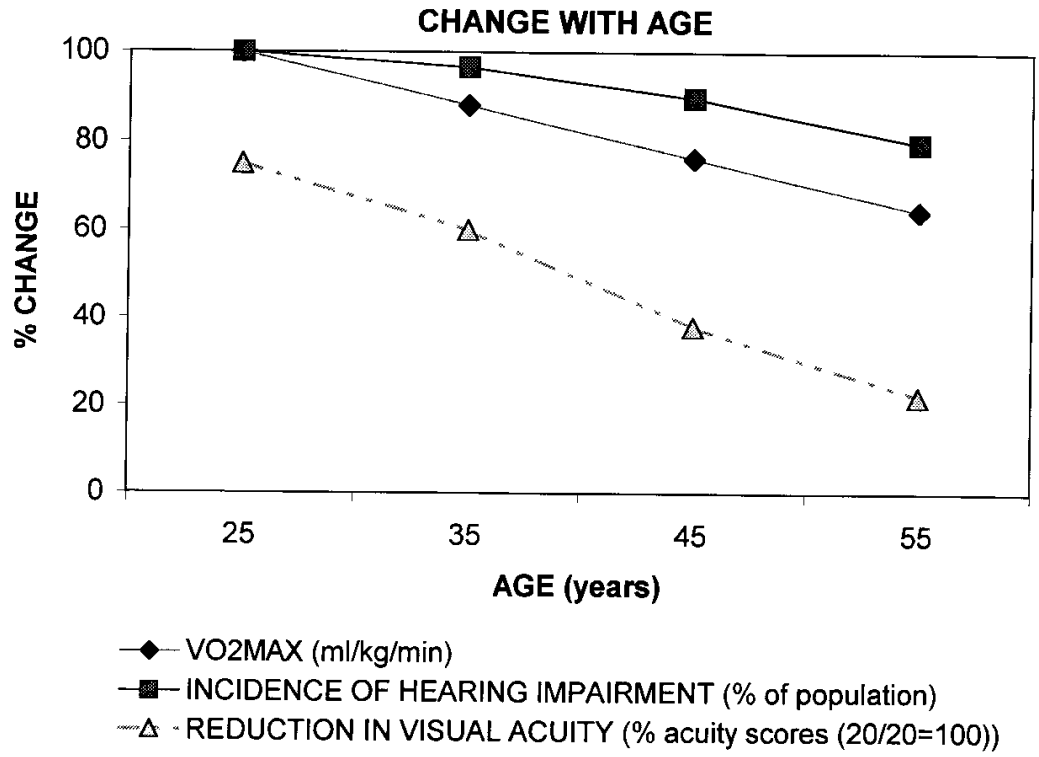


Table 1: Loss of Lung Function with Age [8].

	LOSS OF FUNCTION/YEAR	
	MEN	**WOMEN**
FEV_1	32 ml/year	24 ml/year
FVC	25 ml/year	25 ml/year
VO_{2MAX}	0.55 ml/kg/year	0.37 ml/kg/year
DL_{CO}	0.5%/year	0.5%/year

HEARING

People exposed to low noise levels (well below 80dBA) show an increasing incidence of hearing impairment with age as defined by the medical profession. It has been estimated that there will be 22 cases of hearing impairment out of 100 unexposed people from the general population by the age of 60[7].

The typical complaint of older adults demonstrating "classic presbycusis", is that they can hear people talking, but they cannot make out the words. Age-related hearing loss first affects the ability to hear the highest pitches and only later affects lower pitches. The loss of the ability to hear high-pitched sounds such as "s" and "th" often makes it

difficult to tell them apart. Understanding the consonant sounds in speech is dependent upon our ability to hear high pitches.

Presbycusis may be caused by changes due to aging such as decreased blood supply to the ear because of heart disease, high blood pressure, blood vessel conditions caused by diabetes, or other circulatory problems. Family history or genetics can be a contributing factor. It appears that age-related hearing loss tends to run in the family. This is thought to be related to a common variant in the GRM7 gene, which is believed to be associated with susceptibility to glutamate excitotoxicity and hearing loss. The over expression of glutamate is thought to cause damage to the inner and outer hair cells in the inner ear leading to age-related hearing loss.

Other causes of presbycusis are noise exposure, vascular disease and certain medications that affect hearing (ototoxicity). The following are some factors that can increase the potential for ototoxicity. Items that have special effects on older workers are shown in bold.

- Dose and duration of therapy
- Infusion rate and cumulative lifetime dose
- **Impaired kidney function, which can lead to rapid accumulation of the ototoxic drugs**
- **Concurrent administration of another ototoxic drug (e.g. aminoglycosides and loop diuretics)**
- **Age**
- **Pre-existing hearing loss or sensorineural hearing loss**
- Exposure during pregnancy
- **Previous exposure to head and neck radiation (for chemotherapeutic agents)**
- Genetic susceptibility
- Family history of ototoxicity

The following are examples of some drugs that have an ototoxic effect. If a worker uses any of these, there is a risk of hearing damage. This effect can be increased if the worker is exposed to loud noises while taking the medication. Older workers are at greater risk due to an increased likelihood of using medications, the possibility of previous hearing loss due to previous noise exposure, and the possibility of impaired circulatory or renal functions.

Salicylates:

Asprin

Diuretics:

Furosemide (Lasiz)
Ethacrynic acid

Antibiotics:

Gentamicin
Kanamycin
Neomycin
Streptomycin
Tobramycin
Amikacin
Erythromycin
Chloroquin
Quinine
Vancomycin

Antineoplastic medications:

Cisplatinum
Bleomycin
Nitrogen mustard

The result of taking the above medications will be a workforce with hearing loss due to presbycuses plus a lifetime of occupational noise exposure. This could result in a workforce with a poorer hearing profile. There is also a concern about accelerated hearing loss among these workers due to prescribed medications.

VISION

Many aspects of vision change with age and can affect performance in visually guided activities. Many older workers wear corrective lenses. When vision is not given proper consideration in workplace design it can affect safety. For example, where critical viewing is necessary, make changes within the workstation so that bifocal and trifocal viewing is comfortable. Remove awkward head and eye positions that are fatiguing.

In addition to the aging process itself, there are age related diseases such as cataract, macular degeneration, glaucoma, as well as other retinal diseases that decrease vision. There are also systemic diseases such as arteriosclerosis, hypertension, diabetes as well as interactions from the medications used to combat these diseases that can decrease vision.

Aging factors can have the following effects [9, 11]:

- Reduced ability to see small objects
- Increased depth of field
- Decreased color perception (blue and violet light absorbed resulting in greater difficulty distinguishing between blue and green)
- Reduced ability to see movement in peripheral vision
- Decreased adaptation to changing light levels
- Reduced ability to see in the presence of glare
- Increased need for more illumination due to a smaller pupil

SKIN

Sun exposure and smoking are the major external factors influencing the premature aging of the skin. Sun exposed (photo-aged) skin, has a thinner epidermis, has increased permeability, and is a potentially poorer barrier to chemicals [12]. At the same time, there is reduced blood flow to the skin with age, this will decrease the amount of chemicals delivered to other parts of the body [13].

There is an apparent increased vulnerability in younger workers which may, at least in part, be attributed to the types of jobs they often get and perhaps to a greater disregard for safe work procedures [9, 14].

Although there is information regarding the effects of medications and agricultural chemicals on the skin, there is little data regarding the many industrial chemicals in use. Although there may be little that industrial hygienists can do to interpret specific exposures, they should be aware of potential problems.

CHEMICAL HAZARDS

There is little information about the effects of age on the toxicity of chemicals in humans, however it has been demonstrated in laboratory animals. Newborn or infant animals show greater or less sensitivity than adult animals depending on whether it is the material itself or the metabolite that produces the toxic effect. Because the liver microsomal enzyme systems and the kidneys are undeveloped in immature animals, materials that depend on these systems for clearance will be retained longer. The difference in toxicity ratio between neonates and adults ranges from 0.002 to 16. For example, DDT is less toxic to newborn rats than to adult rats, while the opposite is true for organophosphates. Accidental poisonings to parathion show this to be true for humans as well [15].

It has been shown that there is a decline in metabolic-dependent drug clearance in the elderly. This has been attributed to a reduced hepatic blood flow and a reduction in the enzymes required for metabolism, which is the primary route of elimination for many materials.

The liver has two phases for detoxifying the body, Phase I and Phase II. Phase I decreases with age. In Phase I, the liver secretes a group of enzymes (P450) that converts toxins through hydroxylation, dealkylation, and hydrolysis into a form that can be easily excreted. Phase II, also called conjugation, completes the detoxification process by producing compounds that have much greater water solubility leading the metabolites to be excreted in the urine. Phase II has very little or no change with age.

Phase I and Phase II enzymes work in concert: Phase I enzymes will “functionalize” the drug (e.g. place a metabolic handle hydroxyl group) then the Phase II enzymes will carry out further reactions. When Phase I and Phase II enzymes are not efficient, toxins

can accumulate in the fatty tissues, brain, and other areas of the body which eventually leads to a variety of health problems.

Renal function decreases with age; efficiency is proportional to blood flow. Renal blood flow decreases from 1200 mL/min in young adults to 600 mL/min by age 80. The clearance of creatinine from the body drops after age forty at the rate of 8 mL/min/1.73 m^2 body surface/decade. Materials that are eliminated by the same route as creatinine will be similarly slowed down [8].

Since there is a decrease in metabolism and excretion of solvents and metals by older workers due to the reduced liver and renal functions, it would suggest that exposure standards should be reviewed when older workers are involved. Biological monitoring, particularly for metals may be important to assessing the risk.

The retention of solvents which affect the central nervous system may have an exaggerated effect on older workers who may already have mild cognitive impairment.

HEAT STRESS

If allowed to work at their own pace, and if they do not over exert themselves (by exceeding V_{O2max}) older workers perform well on hot jobs. However, due to a reduced oxygen uptake in older workers (Figure 2), there is a delay in the onset of sweating and a lower sweat rate for older workers, this group is at a disadvantage when compared to younger men.

GENERAL

There is a lack of scientific evidence on the effects of age when comparing the extreme age groups (children and elderly) and those that make up the workforce. There is even less evidence within the working age group [15, 16]. However, the potential effects of age cannot be ignored.

Despite the lack of useful information for the industrial hygienist regarding a direct relationship between exposure and effects, it is important to remember the effect of age may well be significant because of the degenerative diseases that accompany the aging process. While age itself may not be a factor requiring modifications of the guidelines, the chronic diseases of aging must be considered. For example, the transport of oxygen from the lungs to the tissues and of carbon dioxide from the tissues to the lungs is not affected by aging in the absence of anemia. Anemia is not found in the healthy elderly but is frequently found in those suffering from age-associated diseases.

It is also important to take into account diseases that may have arisen out of past workplace exposures. As the workforce ages, these cumulative health effects must be taken into account. Table 2 shows some of the conditions that can affect an aging population.

Table 2: Health Conditions (2009) Shown as a Percent of the Age Group [17]

	AGE		
	18-44	45-64	65-74
Heart disease (all types)	4.6	12.3	26.7
Any cancer	2.3	8.9	19.2
Diabetes	2.3	12.1	20.4
Kidney disease	0.7	1.8	3
Arthritis diagnosis	7.5	30.9	48.3
Hearing trouble	6.9	18.4	27.8
Vision Trouble	7.2	13.8	14.3

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