ENVIRONMENTAL STRESSOR AND EXPOSURE INFORMATION FOR OLDER ADULTS

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INTRODUCTION

By the year 2030, it is estimated that more than 70 million Americans (and 960 million people worldwide) will be age 65 or older. This aging population is expected to constitute approximately 20 percent of the U.S. population at that time. Despite these projected figures, little is known about many of the potential environmental exposures and linked adverse health effects facing this population. Aging-related changes in behaviors can alter exposure patterns. Older adults may be at increased risk for some of the environmental hazards to which they are exposed. Certain subpopulations of the elderly may be more susceptible to environmental exposures due to differences in health status, physiological changes, medications, diet, physical activity, and genetics. Additional susceptibilities may be incurred due to accumulated lifetime exposures to contaminants or from the effects of previous exposures. A better understanding of exposures to environmental stressors for older adults is needed to address these concerns. Goals of this work were to:

- review recent literature to identify potentially important chemical and biological stressors for older adults,
- compile and summarize existing exposure information and data for important chemical and biological stressors in older populations, and
- identify data gaps and research needed to improve the exposure component of risk assessment for older populations and subpopulations.

METHODS

Environmental Stressor Literature Review

A literature search based on health outcomes for environmental stressors in older adults was performed.

The focus of this search was for effects of acute stressors on older adults – not effects resulting from earlier or lifetime exposures.

Because the definitions of "older" vary widely, research results reported for people at ages 55 and above were considered. English language literature published from 1990 to 2005 in nine or more literature databases was searched for selected chemical and biological stressors.

Initial results yielded 162 articles of potential interest of which 100 were selected for review and summary compilation.

Environmental Measurement Information Literature Review

A second search was performed for personal and environmental measurement or biomarker information for older adults and stressors identified in the first search.

Initial results yielded 218 articles of potential interest of which 130 were selected for review and summary compilation.

Many articles overlapped with articles selected from the stressor review.

Extant Databases

Biomarker and environmental measurement data for older ($\geq$ 55 years) and younger (18 – 54) age groups from the National Health and Nutrition Examination Survey (NHANES, 1999 – 2002) and National Human Exposure Assessment Survey (NHEXAS, 1995 – 1998) in the United States were examined.

Descriptive statistics were generated from the public access data sets using weighted NHANES data and unweighted NHEXAS data.

Tests for significant differences (t-test, $p < 0.05$) between the older and younger age groups were conducted on ln-transformed values.

RESULTS

Stressors with reported health outcome assessments in older populations or subpopulations are summarized in *Table 1.*

For organophosphorus pesticides, pyrethroid pesticides, and persistent organohalogens, nothing of specific relevance to the exposures and health within the aging population was found. (The focus of this work was on exposures/outcomes for older adults and not on effects from early or chronic lifetime exposures).

Selected results of literature searches for exposure information for key stressors are summarized in *Table 2.*

Overall, environmental and personal exposure measurement results are sparse in older populations for many environmental stressors.

Studies of exposures to environmental contaminants in populations that include older adults often do not report separate results for younger and older segments of the population.

Selected results from comparisons of NHANES and NHEXAS measurements in older and younger age groups are shown in *Figures 1 – 6.* Geometric means are shown in each figure. The p-values for tests of the significance of differences between age groups are also reported.

Biologically persistent pollutant biomarkers were often found at higher levels in older adults, for example lead and DDE in Figures 1 and 2. It is not clear if this is a result of longer lifetime accumulations, exposures occurring when environmental levels were higher, or a combination.

Biomarker concentrations for some non-persistent pollutants were lower in older adults, for example metabolites of pyrene and diethylhexyl phthalate in Figures 3 and 4. This may be related to reduced occupational exposure and/or lower activity or product use levels.

More research is needed to understand whether differences in biomarker levels are the result of differences in exposure or are related to changes in physiology, metabolism, or excretion in older adults.

Two examples of age-group differences in indoor air levels of particulate matter and 1,1,1-trichloroethane in a NHEXAS study are shown in Figures 5 and 6. These may be related to differences in activity and product use, but further investigation is needed.

Some research needs to fill data gaps for health and exposure information in older populations and subpopulations are discussed in *Table 3.*

Table 1. Selected Environmental Stressor and Health Information for Older Adults

Stressor and Number of Articles Reviewed	Reported Outcome	Subpopulations
Particulate Matter ($PM_{2.5}$, PM_{10}, aerosol) *N = 23*	Pulmonary inflammation	Mobile aged, no cardiovascular (CV) disease
	Chronic obstructive pulmonary disease (COPD)	No information (–)
	CV disease	–
	Asthma	–
	Mortality	–
Criteria Pollutants (O_3, NO_2, SO_2, CO) *N = 22*	Reduced pulmonary function	COPD patients
	Heart rate variability	Hypersensitive to ozone
	Eye, airway irritation	Not Available
	Mortality	COPD, CV disease
Environmental Tobacco Smoke *N = 6*	Chronic respiratory symptoms	–
	Respiratory infection	–
	CV disease	–
	Stroke	Nonsmokers
	Asthma exacerbation	Asthmatics
Volatile Organic Compounds (VOCs) *N = 3*		
Trichloroethylene	Kidney disease	Women
Benzene, toluene, formaldehyde	Acute respiratory disease	Sensitive to respiratory disease
	Neurobehavioral effects	Occupational
Metals *N = 23*		
Lead	Decline in cognitive function	–
	Impaired renal function	Diabetics and hypertensives
	Increased blood pressure/increased risk of hypertension	Postmenopausal women (weak association)
	Hyperuricemia and gout	–
Cadmium	Decreased bone density	Women 50+, men and women
	Renal tube damage	Occupational
Mercury	Peripheral nerve damage (no association with dementia or other measures of cognitive function)	Occupational 30 years earlier
Water and Foodborne Pathogens *N = 13*		
Viral (Norwalk-like, hepatitis A, rotavirus, caliciviruses)	Vomiting with fever and diarrhea	Elderly, immuno-compromised
Bacterial/Parasitic: E. Coli O157:H7; Vibrio spp, Cryptosporidium	Noninflammatory and inflammatory diarrhea with and without fever and bloody stool	Elderly, immuno-compromised
Bioaerosols and Bioallergens *N = 9*		
Allergens	Allergy, asthma, and other respiratory problems	Elderly, immuno-compromised
Endotoxins	Potentiates asthma, and other respiratory problems such as emphysema, COPD	Elderly, immuno-compromised
Fungi	Endemic mycoses	Regional presence (associated with outdoor exposure)
	Infection (filamentous fungi)	Elderly, immuno-compromised

Table 2. Selected Exposure Information for Older Adults

Stressor and Number of Articles Reviewed	Highlighted Information
Particulate Matter *N = 20*	The most extensive elderly-specific data related to environmental exposures have been accumulated for particulate matter, especially $PM_{2.5}$
	Exposure data spanning regional monitors to personal exposure measurements have been collected
	Exposure measurement data have been collected for some potentially sensitive subpopulations of older adults
	Objectives of studies for older adults included: • determination of relationships between personal/indoor/outdoor concentrations; • the influence of seasonality, housing characteristics, and personal activities; • composition of particles of ambient origin comprising personal exposure; • collection of data for modeling personal exposures; • identification of surrogates for $PM_{2.5}$
Criteria Pollutants *N = 15*	The number of studies using ambient air data derived from outdoor monitoring stations is comparable to that for particulate matter; few personal exposure data for the elderly are available
	Fewer personal exposure data for the elderly are available and compared to PM
	The data that do exist suggest personal exposures are lower among the elderly
	Although potentially available, data have not been compiled to examine regional differences
ETS *N = 6*	A U.S. urinary cotinine study indicated exposures were highest in the 20s and declined with age
VOCs *N = 5*	Studies suggest that for older adults, VOCs correlate with: • environmental tobacco smoke; • automobile-related activities; • microenvironmental and activity diary information
	At-home contributions to benzene were 41% for the elderly, compared to 17% for students and VOCs and may vary seasonally
Metals *N = 46*	Urinary and blood levels of cadmium increased age up to around age 50
	The concentration of mercury in hair increased with age; blood Hg was not significantly related to smoking for the elderly
	For lead, • measurements show decreases in the blood Pb for older people over time, which parallels decreases for the general US population; • bone Pb levels in the elderly are generally higher in smokers and in those with lower income or lower education; • bone Pb levels increase with increased age; • blood Pb has been found to be significantly correlated with age in some studies but not in others
	For arsenic, • few data on arsenic exposures are available for elderly U.S. populations; • total urinary As above 10 μg/L was found to be inversely related to age in a US study; • a higher ratio of methylated to inorganic As was excreted by older persons in a study of contaminated well water

Table 3. Research Needs To Reduce Uncertainties for Older Adults

Research Need	Rationale	Other Considerations
Health outcome and exposure data needed for many stressors	Few data are available for some stressors for exposure and risk assessment	Potentially susceptible subpopulations of older persons may need to be identified
Population-based studies that include older adults	Permit extrapolation to larger regions or groups; allow comparisons between groups	Oversampling of potentially susceptible subpopulations
Pollutant measurements for older populations' micro-environments	Better understanding of potential exposures and to improve exposure models	Acquire time/activity/location information for a range of subpopulations
Assess changes in activities and physical activity as individuals age	Assess activity-related changes in exposure and dose; improve models	Longitudinal studies required and information needed for subpopulations
Impact of changes in physiology, nutrition, polypharma, on dose/effect	Identify how these factors can impact susceptibility	Models (PBPK) can be used initially but will need to be verified
Feasibility for assessing biological age as distinct from chronological age	Will help clarify the impact of biological factors to reduce variance in the results	No accepted definition or measure of biological age currently available

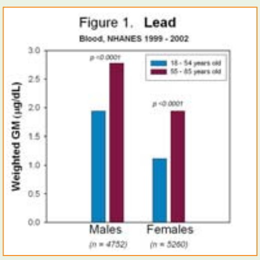

Figure 1. Lead

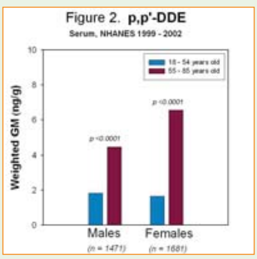

Figure 2. p,p'-DDE

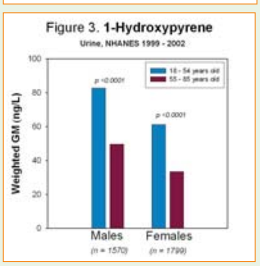

Figure 3. 1-Hydroxypyrene

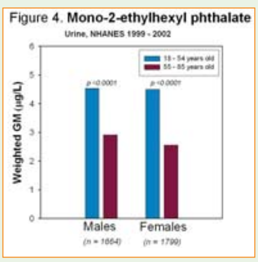

Figure 4. Mono-2-ethylhexyl phthalate

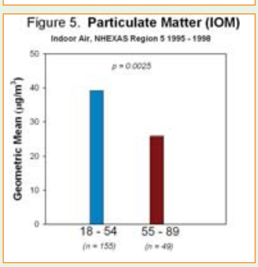

Figure 5. Particulate Matter (IOM)

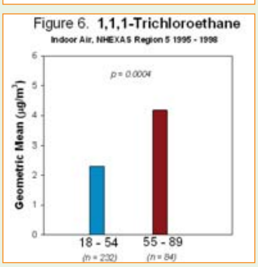

Figure 6. 1,1,1-Trichloroethane

CONCLUSIONS

In general, exposure and health outcome information for older adults is limited for many environmental stressors, particularly with regard to potentially sensitive segments of the aging population.

Little research has been done on elderly populations' exposures from multiple environmental media, to assess the aggregate and cumulative contributions from the various media, and to evaluate the relative importance of the routes of exposure – inhalation, ingestion, and dermal absorption – and how their relative importance may change as individuals age.

Studies that take into account the altered activity and lifestyle factors, altered physiology, and different exposure potential of aging populations and sensitive subpopulations are needed to reduce uncertainties in exposure and risk assessments.

DISCLAIMER