

2. Background

Several of the most prevalent and costly adverse health conditions among older Americans—including chronic respiratory disease, heart disease, cerebrovascular disease, cancer, pneumonia/influenza, and gastrointestinal illness—are known to be associated, at least in part, with environmental exposures. To improve understanding of the magnitude of the cost burden imposed by these types of environmentally related health effects among older Americans, we selected specific health conditions for economic analysis. In this section, we define the selected conditions and discuss why they were chosen for this analysis. We also provide a general description of the COI method, and we review the existing evidence from the COI literature regarding the direct and indirect costs associated with the selected conditions. We then discuss the limitations of using results from the existing literature for assessing the direct and indirect costs of conditions related to environmental exposures in older adults.

2.1 Selection of Health Effects

Some of the key considerations in selecting conditions for analysis were:

- prevalence among the older population,
- expected average costs associated with illness,
- evidence of linkages to environmental exposures, and
- data availability.

We targeted conditions that were expected to impose a relatively high burden (through high prevalence and/or high cost) among the elderly and conditions for which environmental exposures are expected to be important risk factors. Using the commonly applied International Classification of Disease (ICD-9) system for coding illnesses, we also defined conditions in a way that could be easily identified and matched from multiple data sources.

Table 2-1 lists the selected health conditions according to their ICD-9 codes and groups the conditions into six general categories of illness. The first category—chronic respiratory illness—is common among older Americans and strongly associated with indoor and outdoor air-quality conditions. Based on data for the Centers for Disease Control and Prevention (Lucas et al., 2004), in 2001, 6.7 percent of the 65 and older population suffered from chronic bronchitis and 5.1 percent suffered from emphysema, compared to 5.3 and 0.8 percent respectively for those under 65. Prevalence of asthma among the elderly (8.7 percent) is lower than in children and young adults; however, the illness is typically more severe in older age groups. Exposures to common air pollutants, such as particulate matter (PM) and ozone, have been found in several studies to cause and/or exacerbate these conditions.¹

Coronary heart disease, including heart attacks and angina pectoris, is among the most common conditions among the 65 and older population in the U.S., affecting roughly 21 percent of this population in 2001. Several studies have also shown that exposures to common pollutants such as PM can increase risks associated with heart disease, and exposures to less common toxic pollutants such as lead have also been found to increase these risks. Because of the chronic nature of both heart disease and chronic respiratory disease, both diseases are expected to be associated with frequent and costly health-care utilization.

The prevalence of stroke is also very high among seniors, affecting 9 percent of the 65 and older population in 2001. In that same year, more than 404,000 Medicare fee-for-service beneficiaries were admitted to the hospital with a primary diagnosis of stroke (Trisolini et al., 2002). The Medicare hospital payments associated with those admissions were quite high—approximately \$2 billion in 2001. Because

¹ For a summary of the epidemiological evidence regarding links between common air pollutants and respiratory and cardiovascular illness, see for example EPA (1999).

stroke victims often require a great deal of therapy and care beyond the initial hospital admission, the full cost of stroke among older Americans is likely to be much higher than \$2 billion. Regarding the environmental etiology of stroke, studies have shown that exposures to pollutants such as PM, ozone, and lead may increase risks of stroke-related deaths (ATSDR, 1999).

Lung cancers, which according to CDC estimates (Lucas et al., 2004) affect less than one percent of the 65 and older population, are less prevalent in the elderly population than other conditions and certain other cancers. Nevertheless, lung cancers have the 2nd highest prevalence of cancers among those 65 and older, and it is known to impose significant costs on a per case basis. Furthermore, links between environmental exposures and lung cancers are well established. Known or suspected environmental causes of lung cancer include, among others, exposures to PM (Pope et al., 2002), asbestos (ATSDR, 2001), and radon (ATSDR, 1990).

Pneumonia is a relatively high-prevalence condition among older individuals, but more importantly, when older individuals are afflicted with this condition, they generally require more costly medical care than younger individuals. Among Medicare fee-for-service beneficiaries, the rate of hospital admission for pneumonia (and/or influenza) was 20 per 1,000 in 2001.² The annual cost of hospitalizations related to pneumonia is also typically very high, and pneumonia infections are also more likely to result in death when elderly persons become infected. As with chronic lung disease, exposures to common air pollutants, such as PM and ozone, have been found in several studies to cause and/or exacerbate pneumonia.

Table 2-1. Selected Health Conditions (by ICD-9 Code)

ICD-9 Code	Health Condition
Chronic Lung Disease	
491	Chronic bronchitis
492	Emphysema
493	Asthma
494	Bronchiectasis
496	Chronic airway obstruction, not elsewhere classified
Ischemic Heart Disease	
410	Acute myocardial infarction
411	Other acute and subacute forms of ischemic heart disease
412	Old myocardial infarction
413	Angina pectoris
414	Other forms of chronic ischemic heart disease
Stroke	
430	Subarachnoid hemorrhage
431	Intracerebral hemorrhage
432	Other and unspecified intracranial hemorrhage
433	Occlusion and stenosis of precerebral arteries
434	Occlusion of cerebral arteries
436	Acute, but ill-defined, cerebrovascular disease
Lung Cancer	
162.2–162.9	Malignant neoplasm of bronchus and lung
197	Secondary malignant neoplasm of respiratory and digestive systems
231	Carcinoma in situ of respiratory system
Pneumonia	
480	Viral pneumonia
481	Pneumococcal pneumonia
482	Other bacterial pneumonia
483	Pneumonia due to other specified organism
485	Bronchopneumonia, organism unspecified
486	Pneumonia, organism unspecified
487	Influenza with pneumonia
Gastrointestinal Illness	
001–009*	Intestinal Infectious Diseases
558.9	Other and unspecified noninfectious gastroenteritis and colitis

*Excluding 008.45 (Clostridium difficile colitis)

² Age- and gender-adjusted; based on RTI analysis of the Medicare Quality Monitoring System special analytical files (Trisolini et al., 2002).

Gastrointestinal illness (GI) is common in all age groups in the U.S.; however, the elderly face particularly high risks of hospitalization and death due to GI. According to discharge statistics for 1979–1995, hospitalization rates for GI were more than twice as high for those older than 65, and over 75 percent of hospital deaths from diarrheal disease were among this age group (Mounts et al., 1999). Exposures to waterborne pathogens are suspected to be significant contributors to overall rates of GI (Morris and Levin, 1995; Payment et al., 1991; and Bennett et al., 1987), although the attributable fraction is highly uncertain.

2.2 Overview of the COI Approach

The COI approach may be used to assess both direct and indirect costs of illness. Direct costs represent the dollar value of goods and services consumed as a result of illness and for which payment is made. They include payments for treatment, diagnosis, continuing care, rehabilitation, and terminal care and are typically measured as costs related to hospital stays, physician services, nursing homes, prescription drugs, and in-home health care services. Indirect costs represent costs for which no payment changes hands but for which an economic effect is still observed. They include primarily productivity losses associated with illness and premature death, and are typically measured as the value of lost productivity (labor and household) due to illness.

Most COI studies use a prevalence-based approach for estimating costs. Prevalence-based cost estimates include all costs related to a condition for the prevalent population over a given time period, usually a year. This approach includes costs for newly diagnosed cases as well as for those in the advanced stage of disease. Prevalence-based COI estimates are useful primarily for quantifying and highlighting the burden of a particular disease or condition. Incidence-based COI estimates represent the lifetime cost of disease, from onset to death. Incidence-based estimates require a great deal of data on disease progression in addition to costs at each stage of disease, and provide a useful measure of the cost savings of preventing or delaying onset of a disease for use in economic evaluations of preventive interventions. Because EPA is currently interested in understanding and quantifying the burden of diseases associated with environmental exposures in older Americans, a prevalence-based approach is most appropriate.

In this study, we used a prevalence-based approach to develop COI estimates that focus on the direct costs and labor, as well as household productivity losses, associated with each of the six conditions of interest. Our methods and data sources for the COI analysis are described in Section 3, and results are shown and described in Section 4.

2.3 COI Literature Review

Prior to generating our own estimates of the costs associated with heart disease, stroke, chronic lung disease, lung cancer, pneumonia, and gastrointestinal illness in individuals older than 65 years, we reviewed the literature on the costs of these conditions. We initially searched MEDLINE and PubMed to identify articles on the cost, cost-of-illness, expenditure, or economic impact or burden of each of the health conditions in a U.S. population 65 years and older. We limited our review to articles that were published in peer-reviewed journals from 1990 to the present. Following the decision to focus on the specific conditions and associated ICD-9 codes listed in Table 2-1 for COI analysis, we refined our literature search to include only those conditions. However, we also eliminated the requirement that studies provide cost estimates specifically for the 65 and older population. Our final review of articles on the six conditions consisted of 24 articles on the direct or indirect costs of chronic lung disease, 7 on heart disease, 9 on stroke, 7 on lung cancer, 9 on pneumonia, and 6 on GI illness. Brief summaries of methods, data sources, and findings from each study reviewed are provided in Tables A-1 to A-6 in Appendix A.

The methods, data sources, disease classifications, age groups considered, and specific cost categories estimated in each study varied widely. For chronic lung disease, specific studies focused on a

range of different cost outcomes, including hospitalization costs only, expenditures for all health care services, work-loss costs only, employer costs for absenteeism and employees' health care services, and informal caregiving costs. Data sources for estimating chronic lung disease costs also varied, and included survey data sources, such as the National Hospital Discharge Survey and Medical Expenditure Panel Survey, Medicare or private insurance claims data, and hospital-specific data on costs. Consequently, cost estimates also varied widely. In 2000 dollars, estimated annual costs for all health care services associated with chronic lung disease were approximately \$1,000 to \$7,800 per person (See Table A-1).

Estimated costs for heart disease also varied widely. Estimated direct medical costs associated with heart disease varied from about \$5,900 to \$7,400 per person. Total estimated medical costs associated with heart disease ranged from \$67 billion for females over 45 years of age to \$90.3 billion for all circulatory diseases in those 65 years and older. Large differences in estimated costs arise primarily because of differences in the cost categories analyzed or in the age groups considered.

For stroke, many of the studies reviewed focused on hospital charges, but one of these estimated costs only for those with diagnoses of both stroke and myocardial infarction. One study estimated hospital charges of approximately \$13,000 per person for stroke alone. The estimated total direct and indirect cost of stroke was approximately \$46 billion per year.

The estimated costs of lung cancer in the literature range from \$5.6 billion (females over 45 years only) to \$8.2 billion per year. One study estimated average Medicare payments per year for several cancers, including lung cancer, of about \$28,000 per affected beneficiary (Riley et al., 1995).

Pneumonia cost studies primarily focused on hospitalization costs. Mean or median costs associated with pneumonia ranged from about \$5,900 to \$10,000 per person. Variations in these estimates reflect differences in the definitions used for pneumonia and the methods used (i.e., primary diagnosis costs versus attributable costs). Total direct medical cost estimates associated with pneumonia ranged from \$5.7 to \$19.4 billion per year.

Only one of the GI studies used the same disease classifications used in our COI analysis (Sandler et al., 2002). We selected the condition codes shown in Table 2-1 because they reflect the GI most closely associated with environmental exposures. Sandler et al. (2002) estimated direct medical costs associated with GI of \$1.7 million per year for all age groups, and additional indirect costs of \$540 million per year. Just over half of those costs were estimated to result from foodborne illnesses.

2.4 Discussion

Our review of the COI literature on the six conditions revealed large differences across studies in the methods used, the specific condition codes considered, the data sources analyzed, the age groups included, and the categories for which costs were estimated. Such differences make it difficult to compare cost estimates from different studies without first attempting to adjust them. We therefore recommended original COI analyses for the six conditions, using a consistent set of methods and data sources and focusing on the same cost categories across conditions for those 65 years and older.

In this subsection, we discuss features of COI studies in the literature that make it difficult to compare cost estimates across conditions or across studies on the same condition. We then describe how our COI approach produces comparable estimates across the six conditions.

First, the methods used to estimate disease costs vary across studies in the literature. Some analyses estimate costs for a primary diagnosis of a condition, while others provide cost estimates for any diagnosis of a condition. Still other studies generate cost estimates at the person level, as opposed to the condition level, by calculating the costs attributable to a condition (i.e., those costs that could presumably be saved if the condition were prevented) or by calculating incremental costs for people with the condition as compared to costs for people without the condition. No one approach is better than the others. In most cases, the available data dictate which methods may be used to assess costs. For

example, if condition codes are assigned to individuals with the condition as opposed to being assigned to specific health care services, it is generally preferred to estimate the incremental, or excess, cost of care for people with the condition.

COI studies in the literature rarely defined the conditions using the same set of ICD-9 codes as we selected for focus, making it difficult to compare cost estimates across studies and to our COI estimates. Our selection of ICD-9 codes for each condition was in part based on identifying health effects that are more likely to be associated with environmental exposures in older adults.

The data available for COI analysis ranged from private health insurance or Medicare claims data to national household-based survey data. Data from insurance claims are likely to provide the best source of information for identifying costs for each of the ICD-9 codes of interest. In contrast, survey data generally contain ICD-9 codes that are assigned to individuals based on self-reports of a health condition. However, because claims data provide cost and utilization information only for direct medical costs and exclude nonreimbursable medical care costs and nonmedical and indirect costs, survey data are often needed to estimate costs in these categories.

Finally, in reviewing COI analyses in the literature, we discovered that many studies focus on narrow categories of costs, such as hospitalization or employer-based costs, which makes it difficult to compare estimates across studies without accounting for the differences in the cost categories included. In our COI analyses, we attempted to estimate costs for the same set of cost categories for all six of the conditions. For some categories of costs, however, there were not enough observations with a specific condition to be able to generate reliable condition-specific cost estimates.

Differences in the information available from each data source used meant that data-specific methods were applied to estimate each category of costs. These methods were consistently applied across the six conditions. For example, because claims data contain information about the costs to diagnose or treat a specific condition, we estimated inpatient, physician, outpatient, home health, and durable medical equipment costs from Medicare claims by estimating the costs of a primary or any diagnosis of the health condition of interest (see Section 3 for details). In contrast, survey data generally contain costs for individuals but not for specific diagnoses. We therefore used survey data to estimate the incremental prescription drug and nursing home costs for people with each condition and to estimate the work loss and bed days attributable to each condition.

Because consistent COI methods, data sources, and disease classifications were used in our COI analyses for the six conditions, EPA can use the resulting COI estimates to make comparisons across the conditions. Such comparisons should help in assessing the relative burden of each condition among older adults and in making decisions about where to direct resources for the prevention or treatment of disease associated with environmental health exposures in the elderly.