UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

July 27, 2000

OFFICE OF THE ADMINISTRATOR
SCIENCE ADVISORY BOARD

EPA-SAB-EEAC-00-013

The Honorable Carol Browner
Administrator
United States Environmental Protection Agency
401 M Street, SW
Washington, DC 20460

Subject: An SAB Report on EPA's White Paper *Valuing the Benefits of Fatal Cancer Risk Reduction*

Dear Ms. Browner:

This Report on the Environmental Protection Agency's (EPA's) white paper on possible approaches to *Valuing the Benefits of Fatal Cancer Risk Reduction* was developed by the Environmental Economics Advisory Committee (EEAC) of the Science Advisory Board (SAB) in response to a charge received from the Agency during January 2000 (attached). The review was carried out in a meeting held on February 25, 2000.

As is described in detail in the full report, the Committee's general conclusion is that estimates of the value of a statistical life (VSL) derived from wage-risk tradeoff studies should not be taken as precise estimates of the value of reducing the risk of fatal cancers, because of differences in the nature of the risks being valued and in the socio-economic characteristics of the affected populations, and because of various sources of uncertainty. In the judgment of all but one member of the Committee, however, there is not at present a sufficient theoretical and empirical basis for making most of the Agency's suggested quantitative adjustments to the wage-risk-based VSL to account for these differences.

Despite limitations of the VSL estimates, these seem to offer the best available basis at present for considering the value of fatal cancer risk reduction. We therefore recommend that the Agency

continue to use a wage-risk-based VSL as its primary estimate, including appropriate sensitivity analyses to reflect the uncertainty of these estimates.

The Committee wishes to commend EPA for taking the steps necessary to develop systematic and credible approaches to improved valuation of the benefits of fatal cancer risk reduction. The EEAC is aware of no other Agency or Department of the Federal government that has taken such initiative.

We look forward to continuing to work with you and the Agency on the important set of issues that are addressed in EPA's white paper, *Valuing the Benefits of Fatal Cancer Risk Reductions* and to receiving your response to this report.

Sincerely,

Dr. Morton Lippmann,
Interim Chair
Science Advisory Board

Dr. Robert N. Stavins, Chair
Environmental Economics Advisory Committee
Science Advisory Board

NOTICE

This report has been written as part of the activities of the Science Advisory Board, a public advisory group providing extramural scientific information and advice to the Administrator and other officials of the Environmental Protection Agency. The Board is structured to provide balanced, expert assessment of scientific matters related to problems facing the Agency. This report has not been reviewed for approval by the Agency and, hence, the contents of this report do not necessarily represent the views and policies of the Environmental Protection Agency, nor of other agencies in the Executive Branch of the Federal government, nor does mention of trade names or commercial products constitute a recommendation for use.

Distribution and Availability: This Science Advisory Board report is provided to the EPA Administrator, senior Agency management, appropriate program staff, interested members of the public, and is posted on the SAB website (www.epa.gov/sab). Information on its availability is also provided in the SAB's monthly newsletter (*Happenings at the Science Advisory Board*). Additional copies and further information are available from the SAB staff.

U.S. Environmental Protection Agency
Science Advisory Board
Environmental Economics Advisory Committee
Panel for Review of the White Paper: *Valuing the Benefits of Fatal Cancer Risk Reduction*

CHAIRMAN

Dr. Robert N. Stavins, Albert Pratt Professor of Business and Government, John F. Kennedy School of Government, Harvard University, Cambridge, MA

SAB MEMBERS

Dr. Trudy Ann Cameron, Professor, Department of Economics, University of California, Los Angeles, CA

Dr. Maureen L. Cropper, Professor, Department of Economics, University of Maryland,, and Principal Economist, DECRG, World Bank, Washington, DC

Dr. Lawrence H. Goulder, Associate Professor, Department of Economics & Institute for International Studies, Stanford University, Stanford, CA

Dr. Dale W. Jorgenson, Frederic Eaton Abbe Professor of Economics, Department of Economics, and JFK School of Government, Harvard University, Cambridge, MA

Dr. Paul L. Joskow, Elizabeth and James Killian Professor of Economics and Management, Massachusetts Institute of Technology, 50 Memorial Drive, Cambridge, MA

Dr. Catherine Kling, Professor, Department of Economics, Iowa State University, Ames, IA

Dr. Morton Lippmann, Professor, New York University School of Medicine, Nelson Institute of Environmental Medicine, Tuxedo, NY

Dr. Richard L. Revesz, Professor of Law, New York University School of Law, New York, NY

Dr. Jason F. Shogren, Stroock Distinguished Professor of Natural Resource Conservation and Management, Department of Economics and Finance, University of Wyoming, Laramie, WY.

Dr. Hilary A. Sigman, Assistant Professor, Department of Economics, Rutgers University, New Brunswick, NJ.

CONSULTANTS

Dr. A. Myrick Freeman, Professor, Department of Economics, Bowdoin College, Brunswick, ME

Dr. Michael T. Kleinman, Professor, Department of Community & Environmental Med.,College of Medicine, University of California, Irvine, CA

Dr. W. Kip Viscusi, John F. Cogan, Jr. Professor of Law and Economics, Harvard Law School, Cambridge, MA

SCIENCE ADVISORY BOARD STAFF

Mr. Thomas O. Miller, Designated Federal Officer, Science Advisory Board (1400), U.S. Environmental Protection Agency, Washington, DC

Mrs. Dorothy M. Clark, Management Assistant, Science Advisory Board (1400), U.S. Environmental Protection Agency, Washington, DC

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY AND CONCLUSIONS

The Environmental Economics Advisory Committee (EEAC) of the EPA Science Advisory Board (SAB) reviewed the Agency's white paper entitled *Valuing the Benefits of Fatal Cancer Risk Reduction* (EPA, 2000a) during a meeting held on February 25, 2000, in response to a request received from EPA that is contained in its charge (EPA, 2000b). This request follows the SAB's review of EPA's Guidelines for Preparing Economic Analysis, that we reported on in September 1999.

In the EEAC's September 1999 report, we stated: "Economics, like any scholarly discipline, is constantly changing. Environmental economics, a relatively young branch of the discipline, has experienced particularly rapid growth. New areas of the literature continue to emerge, and existing areas change and expand. Hence, despite the Committee's generally positive assessment of the revised Guidelines, we urge EPA to carry out new reviews every two to three years." The current review of EPA's white paper is a natural extension of our previous review, since the topic that is covered in detail in EPA's white paper is one which was treated only very generally in the Agency's draft Guidelines.

Benefit-Cost analysis (BCA), as described in the Agency's Guidelines, is not the only analytical tool nor is efficiency the only appropriate criterion for social decision making. But it is important to carry out such analyses in an unbiased manner, with as much precision as possible, given the typically imprecise nature of the required judgments and the inevitable uncertainties associated with eliciting such judgments. The valuation of the benefits of fatal cancer risk reductions raises a set of difficult analytical issues regarding the potential use of empirically derived estimates of the value of a statistical life (VSL) in lieu of direct measures of the value of a statistical cancer fatality.

The Committee's general conclusion is that estimates of the value of a statistical life (VSL) derived from wage-risk tradeoff studies should not be taken as precise estimates of the value of reducing the risk of fatal cancers, because of differences in the nature of the risks being valued and in the socio-economic characteristics of the affected populations, and because of various sources of uncertainty. It is the judgment of all but one member of the Committee, that, on the basis of the current literature, the only risk characteristic for which adjustments to the VSL can be made is the timing of the risk. Other risk-related adjustments suggested in the white paper are not adequately supported by the literature. With regard to population characteristics, the Committee believes that it can be appropriate to adjust the value of projected statistical lives saved in future years to reflect higher incomes in those years, but not for cross-sectional differences in income. Thus the Committee does not believe that the current literature supports adjustments to the VSL for differences in age, health status, or risk aversion. Any appropriate adjustments that are made for timing and income growth should be part of the Agency's main analysis while any other proposed adjustments should be accounted for in the sensitivity analysis recommended by the Committee.

Despite limitations of the VSL estimates, these seem to offer the best available basis at present for considering the value of fatal cancer risk reduction. We therefore recommend that the Agency continue to use a wage-risk-based VSL as its primary estimate, including appropriate sensitivity analyses to reflect the uncertainty of these estimates.

2. INTRODUCTION

The Environmental Economics Advisory Committee was requested to review EPA's white paper *Valuing the Benefits of Fatal Cancer Risk Reduction*. EPA's concerns are reflected in the charge which requests the Committee to comment on the following:

1. Does the white paper accurately describe the empirical economic literature relevant to the benefit transfer issues that ensue when using the Value of a Statistical Life (VSL) literature to estimate the Value of a Statistical Cancer Fatality (VSCF) in a benefit-cost analysis?

2. Does the white paper present the important risk and demographic factors that can affect benefit transfer approaches that use VSL estimates for VSCF?

3. Does the white paper accurately describe attempts in the economic literature to measure VSCF directly?

4. There are two numeric case studies of environmental cancer risks developed for the white paper. Each presents risk assessment information that forms the basis for quantifying the number of statistical cancer fatalities that will be reduced as a consequence of a hypothetical proposed environmental policy. The case studies are then used to illustrate the outcome of using direct measures of the VSCF and benefit transfer adjustments to VSL estimates in order to calculate the VSCF.

    a. Which of the valuation approaches applied to the case study designated as ALPHA are valid to use? Does this case study omit any credible alternative protocols for valuing reductions in fatal cancer risks for benefit-cost analyses of environmental programs?

    b. Which of the valuation approaches applied to the case study designated as OMEGA are valid to use? Does this case study omit any credible alternative protocols for valuing reductions in fatal cancer risks for benefit-cost analyses of environmental programs?

5. Which economic methods illustrated with the case studies, or additional methods identified by the Committee under charge questions 4.a and 4.b, serve as credible protocols for the Agency to use in representing quantitative data, qualitative information, and sensitivity analyses for the economic value of reduced fatal cancer risks reported in benefit-cost analyses?

During its discussions, the Committee reached the conclusion that it was neither appropriate nor necessary to respond to questions 4a or 4b above, because those questions focus on illustrative examples that were intended to clarify points made by the Agency in its White Paper. All of the points illustrated by the cases were covered by the Committee's discussions and are addressed in response to charge questions 1 through 3. For the same reason, it was decided not to address Question 5, as originally written, since it refers back to questions 4a and 4b. However, the major thrust of the question is important, and so the Committee included a revised version in a larger set of additional questions that it perceived as meriting attention (new numbering below pertains to those questions added to the charge by the Committee):

4. Are current methods of estimating cancer cases avoided by regulations consistent with

   (a) fundamental principles of benefit-cost analysis, and

   (b) existing benefit-cost practice for non-cancer health effects?

5. In valuing the health benefits of environmental regulation should mortality be valued separately from morbidity?

6. Should appropriate (non-cancer) adjustments be applied to all effects (not just cancer) when we value the risk reductions associated with environmental regulation?

7. How does adaptation enter the valuation methods proposed by EPA? Does it? Should it? How is adaptation integrated with risk assessment?

8. What advice can the EEAC provide to EPA of ways to improve, in the short term, the information the Agency develops and uses regarding economic valuation of fatal cancer risk reductions?

Before turning to our specific responses to this set of questions, the EEAC wishes to commend EPA for taking the steps necessary to develop systematic and credible approaches to improved valuation of the benefits of fatal cancer risk reduction. The EEAC is aware of no other Agency or Department of the Federal government that has taken such initiative.

3. SPECIFIC RESPONSES TO CHARGE QUESTIONS

The Committee's specific comments in response to the final Charge are organized into eight sections, one for each of the eight (revised) charge questions.

3.1 Value of Statistical Life Relative to Value of Statistical Cancer Fatality Estimates

EPA Charge Question 1. Does the white paper accurately describe the empirical economic literature relevant to the benefit transfer issues that ensue when using the VSL literature to estimate the VSCF in a benefit-cost analysis?

The white paper discusses four sets of risk characteristics that are relevant to valuing a statistical cancer fatality: (1) timing, (2) morbidity, fear and dread, (3) voluntariness and controllability, and (4) the public nature of the risk reduction. Recommendations are made, based on the literature, to adjust the VSL for each of these characteristics when estimating the VSCF. The white paper also discusses four population characteristics that may be relevant to valuing a statistical cancer fatality—income, risk aversion, age, and health status.

All but one member of the EEAC believe that, on the basis of the current literature, the only risk characteristic for which adjustments to the VSL can be made is the timing of the risk. The adjustments suggested in the white paper for other risk characteristics are not adequately supported by the literature. With regard to population characteristics, the Committee believes that it is appropriate to adjust the value of projected statistical lives saved in future years to reflect higher incomes in those years, but not for cross-sectional differences in income, because of the sensitivity of making such distinctions. More research is needed on the effects of age on WTP to reduce risk of death. The Committee does not believe that the current literature supports adjustments to the VSL for differences in health status or risk aversion.

3.1.1 Adjusting the VSL for Risk Characteristics

3.1.1.1 Timing

The white paper correctly states that there is evidence in the literature that individuals discount future health effects at rates which broadly reflect market interest rates. The paper suggests that when risk reductions are brought about in the future by current policy initiatives (that is, after a latency period), they can appropriately be discounted to the present at the same rate as is used to discount other future benefits and costs. The Committee agrees with this judgment.

3.1.1.2 Morbidity, Fear, and Dread

The Committee supports the principle that the morbidity, fear, or dread associated with cancer is a valid component of the cost that individuals attribute to the incidence of cancer. Thus, in principle, the value of reductions in cancer risks should include both the value of the reduced risk of death and the value of reduced risk of the morbidity, fear, and dread that precedes the death incident. To the extent that cancer victims typically suffer greater morbidity, fear, or dread than the victims of the causes of death involved in VSL studies, it would be appropriate to attach a "cancer premium" to the value of an avoided death from cancer. The Committee finds, however, that existing studies provide little reliable

information as to the magnitude of this premium, and concludes that until better information becomes available, it is best not to assign such a premium.

The white paper cites studies by Savage (1993) and by Jones-Lee, Hammerton, and Philips (1985) as evidence that people are willing to pay a "cancer premium" to avoid fatal cancers relative to other fatal risks. The paper cites a suggestion from Revesz (1999) that the VSL for an immediate fatality be adjusted by "at least a factor of two" to capture the morbidity, fear, and dread associated with cancer.

The Committee disagrees with this suggestion for two reasons. First, the articles by Savage and Jones-Lee et al. do not measure individuals willingness-to-pay (WTP) to avoid fatal cancer; hence they cannot be used to justify the proposed adjustment. Jones-Lee et al. ask respondents if they could reduce deaths from one of three causes — motor accidents, heart disease and cancer — by 100 persons annually, which cause would they select? The respondent is then asked how much he or she would pay for this reduction. This question measures WTP to reduce risks *to others* as well as to oneself, whereas the VSL values private risk reductions. Similarly, the Savage article does not elicit private WTP but asks the respondent to allocate $100 among "commercial airplane accident research," "household fires research," "automobile accident research," and "stomach cancer research." Second, the appropriate way to determine whether a "cancer premium" is required is to value reductions in the risk of a fatal cancer directly. There is only one study (Magat et al. 1996) that has attempted to value reductions in fatal cancer risk directly. For the case of fatal lymphomas it suggests that no cancer premium is warranted. Clearly, further research is called for in this area. The Committee believes that until empirical work clearly establishes the value of this premium, it is best not to attempt to apply one.

3.1.1.3 Voluntariness and Controllability

The white paper cites a study by Cropper and Subramanian (1999) (as interpreted by Revesz (1999)) to justify multiplying the VSL by a factor of two for risks that are involuntary and difficult to control. For reasons explained below, the committee does not believe that any such adjustment in warranted by the Cropper and Subramanian study. Cropper and Subramanian attempted to study the importance of qualitative risk characteristics (such as voluntariness and controllability) in explaining people's choices among life saving programs. One measure of the importance of voluntariness used in the study is how many more lives must be saved by a program that controls a voluntary risk, relative to a program that controls an involuntary risk, to make the median respondent in the survey indifferent between them.

Revesz notes that in Cropper and Subramanian's paper, a program to control radon in one's home (a voluntary risk) must save approximately twice as many lives as a program to control pesticide residues on fruit (an involuntary risk). The reason for this result is not, however, differences in the voluntariness of the risks controlled by the two programs. Voluntariness is not a statistically significant predictor of program choice in Cropper and Subramanian, and controllability is only weakly significant.

Holding all other factors other than voluntariness and controllability constant, the difference in these two variables requires that the radon program save only *1.07* times more lives than the pesticide ban. The example therefore does not support the adjustment proposed in the white paper.

3.1.1.4 Public v. Private Nature of the Risk (Altruism)

The white paper notes that reductions in cancer risks often benefit many people simultaneously. This raises the question "If Smith cares about Jones, should Smith's willingness to pay to reduce Jones's risk of cancer be added to Smith's WTP to reduce his own risk of cancer? The white paper correctly explains that it should not if Smith cares about Jones but respects Jones's preferences. The white paper then goes on to cite empirical estimates of altruistic WTP.

The EEAC believes that the circumstances under which altruistic benefits may legitimately be counted in a benefit-cost analysis are restrictive. Moreover, the issue of adding altruistic benefits to private WTP arises in the case of virtually all environmental programs, not only those that reduce cancer risks. It is an issue that should be addressed separately from the estimation of the VSCF.

3.1.2 Adjusting the VSL for Population Characteristics

3.1.2.1 Income

The white paper correctly notes that the income elasticity of WTP to reduce mortality risks is positive, based on cross-sectional data. It suggests that estimates of VSLs accruing in future years be adjusted to reflect anticipated income growth, using the range of income elasticities (0.08, 0.40 and 1.0) employed in *The Benefits and Costs of the Clean Air Act, 1990-2010*. The EEAC agrees with this recommendation. It does not agree with the suggestion that the VSL be adjusted upward because workers in labor market studies earn less, on average, than median earnings of all U. S. workers (Revesz 1999), because of the sensitivity of making such distinctions, and because of insufficient evidence available at present.

3.1.2.2 Attitudes Toward Risk

The white paper argues that workers in wage-risk studies are more willing to incur health risks than the population affected by cancer risk reduction programs, and that the VSL should be adjusted upward for this reason. The argument is that workers who place a lower value on health self-select into risky jobs and, therefore, require less compensation. The Advisory Committee notes, however, that there are other factors operating in labor markets that may cause compensating wage differentials to *overstate* required compensation. Workers select occupations of different inherent risks based on

both their risk preference *and* their skill at reducing risk. If workers who are more skilled self-select into riskier jobs, this will counteract the effect noted in the white paper. Unless and until this relationship is better understood, the EEAC recommends that no adjustment be made to the VSL for risk aversion.

3.1.2.3 Age

The white paper presents empirical evidence on the impact of age on WTP to reduce mortality risks from studies by Jones-Lee and co-authors (1989 and 1993). The studies show a modest impact of age on WTP, with WTP increasing up to about age 40 and declining gradually thereafter. Mean WTP at advanced ages (75 or 80) may, however, be 45 to 50 percent below peak values. The white paper argues that empirical estimates of the effect of age on WTP are superior to adjusting estimates of the VSL for remaining life expectancy, as was done in *The Benefits and Costs of the Clean Air Act, 1970-1990*. The approach taken in that study was to compute the value of a statistical *life year* (VSLY) and multiply remaining life expectancy by the VSLY. Inferring the value of a statistical life year, however, requires assumptions about the discount rate and about the time path of expected utility of consumption. The Committee agrees with the judgement expressed in the white paper that the theoretically appropriate method is to calculate WTP for individuals whose ages correspond to those of the affected population, and that it is preferable to base these calculations on empirical estimates of WTP by age. The Committee urges that more research also be conducted on this topic.

3.1.2.4 Health Status

The white paper correctly states that there is little evidence to suggest that WTP to reduce risk of death is affected by current health status. That is, there are no published studies that show that persons with physical limitations or chronic illnesses are willing to pay less to increase their longevity than persons without these limitations. People with physical limitations appear to adjust to their conditions, and their WTP to reduce fatal risks is therefore not affected. The EEAC suggests that no adjustments be made to the VSL to reflect the health status of persons whose cancer risks are reduced, unless additional research documents such effects.

3.2 Risk and Demographic Factors

> *EPA Charge Question 2. Does the white paper present the important risk and demographic factors that can affect benefit transfer approaches that use VSL estimates for VSCF?*

The implications of heterogeneity in risk and in socioeconomic status (SES) for the practice of benefit transfer merit considerable attention. If the distribution of risk and demographic factors in a VSL study sample match the distribution of risk and demographic factors in a VSL policy sample, it is unnecessary, of course, to be concerned about systematic variation in VSL according to risk

differences or demographic heterogeneity. In that case, point and interval estimates of the VSL found in the study sample can be transferred directly to the policy sample (which may be the entire US population). But, if attributes of the VSL study sample or of the choice scenario which produces the VSL estimate differ from analogous features of the policy sample, direct transfer may be inadvisable.

As a practical matter, interval estimates for VSL in many contexts are uncomfortably broad. Even the familiar $5.8 million figure is an estimate of the central tendency from a sample of two dozen individual point estimates from a collection of studies. In many cases, the uncertainty in this "baseline" VSL may swamp any efforts at fine-tuning in the process of adapting VSL estimates when policy-sample attributes are distributed differently than study-sample attributes.

On page 3 of the EPA white paper, it is noted that mean income in the constituent VSL study samples (of mostly middle-aged, blue-collar workers observed to be making wage-risk tradeoffs), is similar to mean income in the population. The implication is drawn that since mean incomes are similar in the two samples, so will be mean WTP. This will be true only if WTP (VSL) is a *linear* function of income. If the VSL is a nonlinear function of income, then expected value of WTP in the population will depend upon the *distribution* of income in that population, not simply upon mean income in the population.[1]

3.2.1 Heterogeneous Socioeconomic Status

Incorporating variations in VSL that are related to socioeconomic attributes such as race, income, gender, and educational attainment raises difficult moral, ethical, and political issues about which the Committee is not and cannot be in full agreement.[2] But policy makers make explicit or implicit tradeoffs involving these issues all the time. In theory, policy makers would be better informed if they were aware of the nature and magnitude of the heterogeneity in VSL and the statistical significance of these variations. At present, however, the analyses reported in the economic literature are not sufficiently refined to assess differences in personal valuations across demographic groups. Hence, the Committee believes that EPA should not abandon its approach — described in its *Guidelines for Preparing Economic Analyses* — of using a uniform VSL across populations that vary in the above socioeconomic attributes.

3.2.2 Missing Attributes in Survey Scenarios

---

[1]For linear functions f(X), it is indeed true that E[f(X)] = f(E[X]). For nonlinear functions, however, this is not generally true. As a common example, $E[X^2]$ is not equal to $(E[X])^2$. The difference between these quantities is the variance of X, and will be zero only if X is a constant, rather than a random variable.

[2]One attribute that may be an exception is age, and the relative acceptability of differentiating VSL according to age may be due to the fact that, *ex ante*, everyone will belong to each age group over their lifetime.

Where no actual markets exist that allow researchers to observe revealed choices, stated choices may be used, where survey subjects are presented with hypothetical choice opportunities and asked to select from a set of options that differ in their costs and risks. In stated choice scenarios, it is critically important that all of the logically relevant attributes of each alternative in the choice set be fully specified. If a study does not elicit consumers' assumptions about the levels of unspecified attributes, it is not possible to test whether these implicit assumptions by respondents are consistent with the assumptions of the researcher. An example is the failure to elicit subjects' assumptions about latency periods associated with cancer fatalities. The potential for such omissions to affect willingness to pay estimates of the VSCF should be recognized.

3.2.3 Heterogeneity in "Fear and Dread"

In most stated choice scenarios that might be used to ascertain cancer risk tradeoffs, participants would be given varying degrees of (exogenous) information about the nature of the morbidity and mortality risks involved. However, the degree of fear and dread associated with fatal cancers is inherently subjective. It is not possible for a researcher to convincingly tell someone what level of fear and dread they will experience if exposed to a particular objective level of risk. Likewise, in revealed choice contexts, individuals may possess identical information about the objective risks embodied in each of their possible choices, but their unobserved and heterogeneous levels of fear and dread will influence their observed choices.

If the distribution of fearfulness in the study population is different from the distribution of fearfulness in the desired policy population, then failure to assess fear and dread in the study sample may preclude direct transfer of the estimated VSL from the study to the policy sample. Differing levels of fear and dread will also affect the advisability of transferring VSL estimates across different *types* of cancer. If morbidity patterns and treatment options differ across cancers, so are levels of fear and dread likely to differ.

3.2.4 Omitted Behavioral Responses

Sometimes differences in ambient levels of pollutants are used directly to explain differences in health outcomes across individuals. This is because ambient levels are typically what is being regulated, and policy-makers desire to see how a reduction in ambient levels of a pollutant will translate into improved health outcomes. WTP for this improved health outcome is then considered to be the social benefit of the precipitating reduction in ambient levels. It is tempting to transfer this benefit of reduced ambient levels to a different (policy) sample.

This reduced form relationship ignores intermediate behavioral responses that are possible in many cases. Ambient pollutant levels do not translate directly into exposures because different individual activity patterns will lead some people to have greater exposure and some to have less exposure. It is also possible for people to undertake conscious avoidance measures to reduce their

exposures, and the extent of these avoidance measures often depends upon the ambient levels of the pollutant. In the case of cancers, survival rates are also dependent upon stage at presentation for first treatment, and this may vary across individuals as well. Even if the value of the eventual statistical life is identical for all individuals, the relationship between changes in ambient levels and social benefits may differ.

3.2.5 SES and VSCF: Effects Via "Other Prices," Not Just "Preferences"

Many characteristics of cancer incidence are known to differ by socioeconomic status (SES). WTP to avoid a fatal cancer may also differ systematically by SES. VSCF is the inverse demand for avoidance of one unit of statistical fatal cancer. Inverse demand (WTP) depends upon quantity, income, all other prices, and preferences.

Absent from the white paper is consideration of other prices. Prices faced for other goods (both substitutes and complements) can be expected to influence WTP for an avoided statistical fatal cancer. Some of these other prices differ across socioeconomic groups. For example, the marginal price of doctor visits can be much higher for households without health insurance.

Some goods may be perceived as *substitutes* for avoided statistical fatal cancer, such as avoided malnutrition, illiteracy, or cardiovascular disease. These goods may have higher effective marginal prices for low SES households than for high SES households, often because of geographic accessibility. Access to good-quality education may have a higher marginal price for low SES households.

The epidemiological literature does not attempt to distinguish between socioeconomic variables in their role of contributing to different preferences with respect to avoided fatal cancer, and socioeconomic variables serving as proxies for differences in the effective prices that determine households' opportunity sets. This distinction is inescapable, however, in economics. Even if there were no socio-demographic differences in preferences with respect to fatal cancers, and incomes were identical, socio-demographic differences could still lead to different WTP for avoided statistical fatal cancer cases, if these differences were correlated with prices of other goods in households' consumption bundles.

3.3 VSCF Measurement

EPA Charge Question 3. Does the white paper accurately describe attempts in the economic literature to measure VSCF directly?

The white paper summarizes evidence concerning the value that subjects place on a case of cancer. The first set of results referenced by EPA were developed by Magat, Viscusi, and Huber (1996) in a study in which subjects considered a reference lottery. An interesting question is how

would subjects equate a fatal case of lymphoma with an automobile accident death? The median subject reviewed these outcomes as equivalent. In particular, any given probability of an automobile accident death was equivalent to the same probability of fatal lymphoma.

The EPA white paper asks whether respondents viewed cancer risks as being equivalent to the risk of an automobile accident, taking into account the latency period for cancer. The study's subject were not told whether deaths from lymphoma would be contemporaneous with exposure to harm, or whether instead, they would occur after a period of latency. All but one member of the Committee believes that it cannot be assumed that respondents took the latency period for cancer into account, because the character of the tradeoff considered by respondents was not to compare automobile accident death risks and cancer risk *exposures*, for which one might assume a latency period, but rather to compare areas that differed in terms of their automobile accident deaths and their cancer deaths in *any given year*.

When designing the survey, the authors were conscious of the latency issue, but thought it would be difficult for subjects to confront both the latency issue and the valuation task simultaneously. As a result, subjects were presented with pair-wise comparisons in which they faced different combinations of risks of cancer and fatal automobile accidents. Moreover, when describing the consequences of the cancer, an explicit latency period was not indicated. Thus, when making the comparison, subjects considered combinations of automobile accident deaths and fatal cancer death rates that would be equivalent from their standpoint. The question was not to consider automobile accidents as compared to, for example, risk exposures that would eventually lead to cancer. Hence, it is incorrect to assume that respondents necessarily took into account the existence of a latency period.[3]

In contrast, one member of the Committee questions whether one should attribute to the subjects of the Magat, Viscusi and Huber (1996) study the counterfactual view that carcinogenic deaths would be contemporaneous with exposure to risk as opposed to the factually accurate view that death would follow a period of latency. The study itself suggests that the subjects believed that there was a latency period: "Another way to interpret these results is that out of the 100 percent loss in utility that the median respondent would suffer from contracting terminal lymphoma, 58.3 percent of the loss would be due to the morbidity consequences and 41.7 percent of the loss would be due to death *some time in the future*." (p. 1125, emphasis added). Similarly, the study states: "Consistent with our results, we would expect that for most people curable lymph cancer [with a 90% survival rate] would be a serious disease, but less onerous than certain and immediate death because the probability of dying is well below one and death, if it occurs, *is not immediate*." (p. 1123, emphasis added).

Because of this issue, one member on the Committee does not believe that discounting the cancer valuations obtained in the Magat, Viscusi and Huber (1996) study is appropriate. The majority

[3]One member of the review panel has abstained from participation in either the majority or minority views expressed in this and the previous paragraph.

recognizes that one could certainly hypothesize, as does the EPA white paper, that some respondents might have assumed that there was a latency period. This possibility cannot be ruled out, although the researchers may have attempted to prevent it in their experimental design. To resolve this issue, further exploration of the valuations for different latency periods might be explored.

A second issue from the same study pertains to the value of non-fatal lymphoma. In Magat, Viscusi, and Huber (1996), estimates were made of the value of curable cancers, which have a 10 percent chance of death. Through various manipulations, one can calculate the value of the morbidity component. The authors concluded that the median respondent viewed a non-fatal lymphoma as being equivalent to a 0.417 probability of being healthy and a 0.583 probability of death. This calculation focuses solely on the morbidity component.

Is there a contradiction implied by these results? The value of a car accident equals the value of mortality from cancer, but each of these values includes the morbidity component associated with the ailment as well as the fact that life terminates. It should be noted that EPA is correct in interpreting the results in terms of lotteries, but some readers may be confused. To say that the morbidity component of cancer is equivalent to a 0.583 probability of death in an automobile accident does not imply that, on some utility metric other than that pertaining to lotteries, one could use such scales. One member on the Committee is not persuaded by the above argument because the attention of the subjects was not directed to the morbidity component associated with automobile accidents.

EPA also draws estimates from Hamilton, Viscusi, and Gayer (1999), a study which focuses on housing price effects of Superfund sites.[4] The dollar estimates of the value of a case of cancer based on this housing market study are correct. The assumption made in this study is that the housing price estimates reflect knowledge of the risk based on calculations of the risk posed to houses at different distances from Superfund sites using estimates that in turn are based on EPA remedial investigations and feasibility studies. The results yielded the finding that the values of cases of cancer were comparable to those estimated in the literature for fatalities and for cancer. These estimates did not adjust for any latency period, and it is not clear what households were cognizant of when reacting to risks. Many other studies of Superfund sites have indicated that people tend to overreact to the hazards posed by Superfund sites. The fact that these estimates are in the general range of the estimates for the value of life should not, however, lead to the conclusion that the latency period was irrelevant to people in thinking about risk.

From the standpoint of policy analysis, all but one member of the Committee believes that the soundest approach that would seem to be justified until further evidence becomes available is to value

[4]A question arose at the EEAC meeting as to whether this study was peer-reviewed. MIT Press undertook a formal peer-review process for this book before publishing it, and the article version of this material is forthcoming in the *Review of Economics and Statistics*, which is also peer-reviewed.

cancer risks as being comparable to fatalities of other kinds and to discount these valuations appropriately, taking into account the latency period.

3.4 Consistency Across Assessment Components

> New Charge Question 4. Are current methods of estimating cancer cases avoided by regulations consistent with: (a) fundamental principles of benefit-cost analysis; and (b) existing benefit-cost practice for non-cancer health effects.

Benefit-cost analysis (BCA) has the potential to be a valuable tool in informing policy makers of the efficiency consequences of regulatory actions. However, BCA will encourage efficiency only if it is applied consistently in all circumstances (whether to a regulation affecting fire safety in schools, space travel, cancer risk, or any other regulation). If the benefits of one regulation are assessed based on very conservative estimates (yielding unrealistically high net benefits from a regulation) and those of another are based on realistic and accurate estimates (yielding realistic estimates of the net benefits), incorrect ranking of projects can occur. Thus, consistency in BCA methodology across applications is critical.

Fundamentally, benefit-cost analysis should be based on the most accurate and realistic consequences of a regulation that can be predicted at the time of the analysis. This applies to all BCAs, whether they relate to reduced cancer mortality, improved literacy rates, wildlife habitat, or any other issue. In responding to this charge question, the Committee considered whether the risk assessment information generally available provides the appropriate type of information needed for an accurate and realistic benefit-cost analysis of regulations that alter cancer risk.

To conduct an accurate benefit-cost analysis of a regulation that alters cancer and/or non-cancer health risks requires risk assessment information of the following form: (1) the proposed regulation and associated standard need to be clearly identified; (2) the most accurate and realistic estimates of the expected change in exposure resulting from the standard, including any potential behavioral adjustments (which can increase or decrease exposure) need to be determined; and (3) the most accurate and realistic estimate of the expected cancer-related consequences resulting from the change in exposure need to be provided. Again, the estimates of exposure and resulting cancer cases avoided need to be as realistic as possible, employing neither particularly conservative nor optimistic assumptions.

Steps two and three, above, will likely contain significant uncertainty in the estimates. This information should be characterized and provided by the risk analyst. Any assumptions that are of critical importance, as well as the methods employed in the risk assessment, should be documented and provided to those responsible for performing the benefit-cost assessment. Thus, the process of performing benefit-cost analysis cannot be easily separated from the risk assessment process.

Currently, estimates of cancer cases avoided are generated by EPA's predictive models which require data on, and assumptions about, both unit risk factors and exposure factors. For most of the chemicals listed as carcinogens, there are no human data for all the factors needed to establish a unit risk, and EPA has had to rely on animal-bioassay tests at high dosages to develop its unit risks. It is necessary to extrapolate from (a) the cancer responses in animals (rodents) exposed at or near maximally tolerated dose levels, to (b) humans exposed at much lower levels. In order to do this, EPA has generally made a conservative assumption of no threshold and used a linear extrapolation approach. In order to protect public health with a substantial margin of safety, it has extrapolated the upper 95th% confidence band of the dose-response data rather than its central tendency. While this conservative approach may be required for regulatory purposes, it does not provide realistic, best estimates for the purposes of benefit-cost analysis.

The prediction of cancer cases also requires estimates of exposure, as well as the exposure-response relationship discussed above. Here too, EPA has relied on conservative elements in its exposure models, for example, assuming continuous emissions from known sources at their historic or maximal emission rates, and assuming minimal dissipation and/or degradation while moving downstream. For airborne carcinogens, EPA has assumed that ambient air concentrations are what people breathe, a very conservative assumption. For some carcinogens, there are indoor sources of the same carcinogens (from unvented combustion, consumer products, etc.) that dominate total human inhalation exposure and risk, but these sources are not subject to EPA controls and therefore are not considered. For drinking water, the calculations often assume an unrealistically high (upper bound) ingestion of tap water.

Overall, using both conservative unit risk factors and exposure models likely causes the number of cancer cases predicted in the no-control scenario to be much higher than in reality. Therefore, the number of cases prevented by the imposition of controls will also be exaggerated. Thus, current methods of estimating cancer cases avoided by regulations are not consistent with fundamental principles of benefit-cost analysis, that is, they normally generate upper bound estimates, not central-tendency or "best estimates." This shortcoming has been recognized by the Science Advisory Board's Advisory Council on Clean Air Act Compliance Analysis (ACCAACA or the Council) and its subcommittees. This has led the SAB and EPA to schedule an expert workshop in June 2000 to identify: (1) approaches for hazard assessments for selected pollutants that would facilitate benefit assessments; (2) views on whether it is possible to produce a methodology for developing central tendencies and distributions in hazard assessments for hazardous air pollutants for use in benefit analyses and how this might be done; and (3) how best to identify limitations and uncertainties in both risk assessment methods and economic models, and suggestions and priorities for a research agenda to address identified gaps in available data and methods needed to conduct such benefit analyses.

An important exception to the above has been in the area of criteria air pollutant control (particulate matter, ozone, carbon monoxide, etc.). For most of the six criteria air pollutants, there are relatively rich data bases on human exposure-response (epidemiological and clinical exposure studies)

and on area-wide airborne pollutant concentrations (AIRS monitoring data), which might make it possible for EPA to develop credible (best case) estimates of cases of mortality and morbidity under control and no-additional control scenarios for the 1970-1990, and for the 1990-2010 periods. For the non-criteria air pollutants, however, and for non-cancer causing pollutants in other media, the data bases available for best-case health risk predictions are not adequate for purposes of consistent BCA.

Available risk assessment information on the criteria air pollutants appear to permit benefit-cost analysis in a manner that is consistent with fundamental principles. However, a benefit assessment of regulations that have both cancer and non-cancer health effects will usually be neither internally consistent nor consistent with BCA's fundamental principles. In short, current cancer risk assessment methods do not appear to be consistent with the assessment practices for non-cancer health effects, but the assessment practices for at least some non-cancer health effects do appear to generate estimates that are consistent with (and thus appropriate for) benefit-cost analysis.

3.5 Morbidity Valuation

New *Charge Question 5. In valuing the health benefits of environmental regulation should mortality be valued separately from morbidity?*

Morbidity should be given more serious attention, especially for cancers that are non-fatal, and for other chronic diseases that cause severe disability and/or dysfunction. The Magat, Viscusi, and Huber (1996) study of non-fatal lymphoma demonstrates the relatively high morbidity valuation for this illness. This high valuation may reflect an expectation of diminished longevity and/or quality of life, a common expectation for other, debilitating non-cancer diseases that may be related to environmental exposures, such as Alzheimer's Disease, Multiple Sclerosis, and Parkinson's Disease.

For fatal cancers, research should evaluate willingness to pay for scenarios that include both mortality and related morbidity. Magat et al's study, which offers survey respondents a choice between risk of an automobile accident and a terminal lymphoma, is an example of the kind of information necessary to value a statistical cancer fatality when morbidity is taken into account. The resulting valuation includes all consequences of cancer. Although there may be a value of death independent of morbidity that derives exclusively from lost years of life, estimation approaches that combine mortality and morbidity into a single willingness to pay value can be preferable. Estimating the value jointly does not require that the value of avoiding mortality conditional on becoming ill is the same as its value in the absence of illness.

The lack of studies that value different types of cancer morbidity (and morbidity for other diseases that may be related to environmental exposures) presents a difficulty for practical economic analysis at EPA. A great need exists for estimates of willingness to pay to avoid risks of varying forms of cancer that would be more appropriate for benefits transfer than existing estimates of VSL based on risks of accidental death.

3.6 Cancer Versus Non-cancer Effects

New *Charge Question 6. Should appropriate (non-cancer) adjustments be applied to all effects (not just cancer) when we value the risk reductions associated with environmental regulation?*

As we have explained above, under some circumstances, the valuations of life obtained from studies of risks of instantaneous deaths in workplace accidents will not provide meaningful measures of the benefits of environmental regulation. This is likewise true of some non-carcinogenic environmental harms. The same principles should be utilized for both cases, although additional research on such adjustments is needed. See the recommendations in Section 3.8, below.

3.7 Adaptation

New *Charge Question 7. How does adaptation enter the valuation methods proposed by EPA? Does it? Should it? How is adaptation integrated with risk assessment?*

Environmental risk to human health is defined by two elements — the *likelihood* an unfavorable event will occur and the *severity* of the event if realized. People often protect themselves privately from these risks by investing resources in mitigation and adaptation options. People mitigate risk by taking actions to lower the likelihood that bad states of nature occur, and adapt to risk by changing production and consumption decisions to reduce the severity of a bad state if it does occur. Both mitigation and adaptation jointly determine risks and the values people assign to collective risk reduction strategies proposed by government agencies.

Examples of adaptation include minimizing human environmental exposure, such as minimizing time spent outdoors to reduce the inhalation of air pollutants of outdoor origin; exercising outdoors only in the morning to minimize exposures to the ozone peaks in the afternoon and early evening; venting cooking fumes and combustion effluents outdoors; and drinking bottled spring water to minimize ingestion of contaminants in tap water. People also adapt by minimizing adverse effects of inhaled or ingested chemicals by adding antioxidants to food or ingesting appropriate vitamin supplements. People make changes in diet and lifestyle that can compensate for risks associated with personal risk factors for cancer and other diseases, such as family history, smoking, blood lipids, exposures at work or through hobbies and recreation.

Since private citizens have the liberty to adapt of their own accord, a policymaker must consider these adaptive responses when choosing the optimal degree of public mitigation. Otherwise, policy actions will be more costly than need be, given the risk reductions achieved.

Observed risks are functions of both natural science parameters and economic circumstances that define people's abilities to adapt. Given the relative marginal effectiveness of alternative self-

protection efforts, how people make decisions about risk differs across individuals and situations, even though the natural phenomena that trigger these efforts apply equally to everyone. Therefore, assessing risk levels solely in terms of natural science can be misleading — costly self-protection is endogenous and may vary systematically in the observed risk data. The sources of the systematic variation are relative prices, incomes, and other economic (and social) parameters that influence individuals' self-protection decisions.

By not explicitly addressing adaptation and people's private but unobservable skill at reducing risk privately, VSL estimates based on estimated wage-risk tradeoffs in labor markets could exaggerate the actual value of reduced mortality risk to workers. To see the potential for biased VSL estimates for the population of workers in wage-risk studies, consider the following example. As we discussed previously, workers are heterogeneous in two respects: they have unique risk preferences (i.e., they put different values on life and health) and they have unique skills to protect themselves, so that they encounter different risks even if their occupation and job activities are identical. Workers select occupations of different inherent risks based on both their skill to protect themselves and their risk preferences. One would expect workers in a more risky occupation to be more skilled or more tolerant to risk or both. They need not be equally skilled or equally tolerant to risk due to self-protection, self-insurance, job stickiness, switching costs, irreversibility, imperfect mobility across occupations, life cycle in skills, experience, education, and safety.

The VSL is likely to be systematically biased upward, because of worker heterogeneity in both *skill* and *risk preference*. A worker's unobserved skill to privately reduce his own risk affects the value of risk reduction. The reason for this is that the marginal worker is not randomly selected. Rather he is the person among those in the occupation who demands the highest compensation for *his* risk in the job. Relative to other workers, the marginal person has either higher risk or lower tolerance to risk or both. This implies that when the *marginal worker's* wage differential is divided by the statistical risk in the occupation, which measures the average risk of all the workers in the occupation, the resulting VSL estimate is biased. The VSL estimate is most likely upwardly biased because the *highest* required wage differential among the workers is divided by their *average* risk. Alternatively, it might be the case that such observed tradeoffs could understate the value of life for those people who found these high-risk jobs too hazardous to work in them at all if they have relatively low skill and/or high value of life. In any event, there are currently no empirical estimates available of these effects.

3.8 Valuation Improvements in the Short Run

> New *Charge Question 8. What advice can the EEAC provide to EPA of ways to improve, in the short term, the information the Agency develops and uses regarding economic valuation of fatal cancer risk reductions?*

Estimates of the value of statistical life (VSL) derived from wage-risk tradeoff studies should not be taken as accurate estimates of the value of reducing the risk of fatal cancers because of

differences in both the nature of the risks being valued and in the socio-economic characteristics of the affected populations. However, in the judgment of all but one member of the Committee, there is not at present a sufficient theoretical and empirical basis for making most of the Agency's suggested quantitative adjustments to the wage-risk based VSL to account for these two types of differences. More research is needed, and the Science Advisory Board could conceivably play a valuable role by helping the Agency articulate critical research gaps for the broader research community. In the meantime, we recommend that the Agency continue to use a wage-risk based VSL as its primary estimate. Any appropriate adjustments that are made for timing and income growth (see Section 3.1) should be part of the Agency's main analysis while any other proposed adjustments should be accounted for in sensitivity analyses to show how results would change if the VSL were adjusted for some of the major differences in the characteristics of the risk and of the affected populations.

REFERENCES

Cropper, Maureen L. and Uma Subramanian (1999), "Public Choices Between Lifesaving Programs: How Important Are Lives Saved?" *Valuing Environment Benefits: Selected Essays of Maureen Cropper*. Cheltenham, United Kingdom: Edward Elgar.

Hamilton, James T., W. Kip Viscusi, and Ted Gayer (1999), "Market Reactions to Site Risks" in James T. Hamilton and W. Kip Viscusi (eds.) *Calculating Risks: The Spatial and Political Dimensions of Hazardous Waste Policy*. Cambridge, MA: MIT Press.

Jones-Lee, Michael W., Max Hammerton, and Peter Phillips (1985), "The Value of Safety: Results of a National Sample Survey," *Economic Journal*, 95: 49-72.

Jones-Lee, Michael W. (1989), *The Economics of Safety and Physical Risk*. Oxford: Basil Blackwell.

Jones-Lee, M. W., G. Loomes, D. O'Reilly, and P.R. Philips (1993), "The Value of Preventing Non-Fatal Road Injuries: Findings of a Willingness-to-Pay National Sample Survey," TRL Working Paper, WP SRC2.

Magat, Wesley A., V. Kip Viscusi and Joel Huber (1996), "A Reference Lottery Metric for Valuing Health," *Management Science*, 42(8):1118 - 1130.

Revesz, Richard L.(1999), "Environmental Regulation, Cost-Benefit Analysis, and the Discounting of Human Lives," *Columbia Law Review*, 99(4): 941-1017.

Savage, Ian (1993), "An Empirical Investigation into the Effect of Psychological Perceptions on the Willingness-to-Pay to Reduce Risk," *Journal of Risk and Uncertainty*, 6: 75-90.

APPENDIX A

Draft Charge to Science Advisory Board - Environmental Economics Advisory Committee on Valuation of Fatal Cancer Risks

February 3, 2000

The Science Advisory Board–Environmental Economics Advisory Committee (SAB-EEAC) review of the draft *Guidelines for Preparing Economic Analyses (Guidelines)* helped the Agency to identify valid and sound economic procedures to use when conducting benefit-cost analyses of environmental policies. Both the *Guidelines* and the SAB-EEAC review (EPA-SAB-EEAC-99-020, dated September 1999) recognize that economic theory will evolve and new empirical literature will be forthcoming that may necessitate revisiting the analytic procedures contained in the *Guidelines*. There may also be situations where the *Guidelines* do not provide sufficient detail to respond to analytic questions whose answers have broad implications for the conduct of economic analysis at the EPA. Both circumstances have recently arisen, making it necessary for the Agency to submit for SAB-EEAC review a document that examines the "benefit transfer" issues that arise when using the value of statistical life (VSL) literature that is based on accidental risks to estimate the economic benefits of environmental policies that reduce fatal cancer risks.

The *Guidelines* provide information and guidance on the valuation of reduced mortality risks (Chapter 7, pp. 37-43). The Agency *Guidelines* conclude - and we understand the SAB-EEAC to have concurred in their review on this subject - that one practical and well-supported means to value changes in mortality risks is to use the Value of a Statistical Life (VSL) approach. Further, in response to the SAB-EEAC review, the *Guidelines* describe a number of important factors to consider in applying benefit transfer approaches using VSL estimates from the empirical literature on wage-risk tradeoffs. Recognizing that this is an important benefit category, the Agency *Guidelines* stated that the EPA would "continue to conduct annual reviews of the risk valuation literature" and "reconsider and revise the recommendations in these guidelines accordingly." Furthermore, the EPA would "seek advice from the Science Advisory Board as guidance recommendations are revised."

The Agency needs to return to the SAB-EEAC and obtain additional counsel on this subject. Some economists within the government have suggested some particular approaches to dealing with the benefit-transfer issues. Since the Guidelines were drafted, a few relevant articles have been published that examine benefit transfer issues surrounding the use of VSL estimates when there is a passage of time (or latency period) between the pollution exposure and harm, or when fatal *cancer* risks are involved. The importance of these issues was articulated in a recently proposed regulation to reduce human health risks from radon in drinking water. The proposed rule estimated the number of reduced fatal cancers resulting from different regulatory options. The Agency presented information on the economic values for the reductions in fatal cancer risks, along with other quantified benefits. A brief discussion of some of the benefit transfer issues involved in this estimation was published in the preamble to the proposed rule for setting standards for exposure to radon from drinking water sources (*Federal*

Register, November 2, 1999 volume 64, Number 211, pages 59245-59378). Quoting from the *Federal Register* notice requesting SAB review:

> "Latency is one of a number of adjustments or factors that are related to an evaluation of potential benefits associated with this rule, how those benefits are calculated, and when those economic benefits occur. Other factors which may influence the estimate of economic benefits associated with avoided cancer fatalities include (1) a possible "cancer premium" (i.e., the additional value or sum that people may be willing to pay to avoid the experiences of dread, pain and suffering, and diminished quality of life associated with cancer-related illness and ultimate fatality); (2) the willingness of people to pay more over time to avoid mortality risk as their income rises; (3) a possible premium for accepting involuntary risks as opposed to voluntary assumed risks; (4) the greater risk aversion of the general population compared to the workers in the wage-risk valuation studies; (5) "altruism" or the willingness of people to pay more to reduce risk in other sectors of the population; and (6) a consideration of health status and life years remaining at the time of premature mortality. Use of certain of these factors may significantly increase the present value estimate. EPA therefore believes that adjustments should be considered simultaneously. The Agency also believes that there is currently neither a clear consensus among economists about how to simultaneously analyze each of these adjustments nor is there adequate empirical data to support definitive quantitative estimates for all potentially significant adjustment factors. As a result, the primary estimates of economic benefits presented in the analysis of this rule rely on the unadjusted $5.8 million estimate. However, EPA solicits comment on whether and how to conduct these potential adjustments to economic benefits estimates together with any rationale or supporting data commenters wish to offer. Because of the complexity of these issues, EPA will ask the Science Advisory Board (SAB) to conduct a review of these benefits transfer issues associated with economic valuation of adjustments in mortality risks. In its analysis of the final rule, EPA will attempt to develop and present an analysis and estimate of the latency structure and associated benefits transfer issues outlined previously consistent with the recommendations of the SAB and subject to resolution of any technical limitations of the data and models." (page 59326)

In the process of responding to reviews prepared during deliberations on the proposed radon rule, the Agency found that the *Guidelines* lack sufficient detail on how to fully evaluate and characterize the different risk attributes that are central to a complete understanding of the benefit-cost implications of this rule. For example, time can pass between the point of initial exposure to a carcinogen, the biological manifestation or onset of cancer in the body, the medical diagnosis of cancer, and death caused by the cancer. During development of policies affecting cancer risks, suggestions have been made to discount the VSL estimate (i.e., $5.8 million recommended in the *Guidelines*) to account for latencies, or the delay in time between reduced exposure and when the cancer death would have occurred absent the exposure reduction.

Others argued that a suitable approach for valuing benefits from reduced cancer risks must consider simultaneously *all* of the benefit transfer factors related to valuing cancer risks to ensure a careful and full treatment of benefits. There is evidence in the economics literature regarding many such factors (e.g., potential premiums ascribed to cancer risk reductions due to a higher willingness to pay to avoid the dread, pain and suffering, morbidity effects, and other features of cancer endpoints) that may suggest introducing upward adjustments factors which offset any potential downward adjustments caused by accounting for cancer latency. In addition, proponents argue that adjustments for the age of population at risk, income, altruism and other risk characteristics (e.g., controllability, voluntariness) can all have some potential influence on the value of a statistical cancer fatality (VSCF) and therefore need to be reflected in the quantitative benefit assessment.

While developing the primary benefit estimates for reduced fatal cancer risks in the proposed radon rule, questions arose regarding the implementation of adjustments for some factors, but not others. For example, would it ever be appropriate to adjust only for latency periods, and not other factors, in the valuation of reduced cancer deaths? To help answer this and related questions regarding the valuation of cancer risks, the Agency seeks the SAB-EEAC's counsel. We further ask that your guidance reflect the typical uncertainties facing EPA economists, including those surrounding the underlying risk assessments, the prediction (or lack thereof) of latency periods for cancers, and the risk characteristics associated with the VSL approach.

Therefore, the Agency proposes to seek review of a "white paper" and list of charge questions by the SAB-EEAC on the valuation and benefit transfer practices arising in the calculation of the economic benefits of reduced fatal cancer risks. The Agency seeks SAB-EEAC review of the treatment and presentation of quantitative and qualitative information for these types of benefits. Numeric case studies are included in the white paper, to both identify and present prospective approaches to address these issues. The results of the SAB-EEAC review of this document, and responses to the specific charge questions, will be considered by the Agency during future revisions to the *Guidelines,* consistent with the Agency's commitment to credible and consistent economic analysis in support of the policy making process.

Charge Questions:

As the Committee considers the charge questions, it is asked to keep in mind the differing situations relating to differing degrees of data availability or uncertainty in key parameters.

1. Does the white paper accurately describe the empirical economic literature relevant to the benefit transfer issues that ensue when using the VSL literature to estimate the VSCF in a benefit-cost analysis?

2. Does the white paper present the important risk and demographic factors that can affect benefit transfer approaches that use VSL estimates for VSCF?

3. Does the white paper accurately describe attempts in the economic literature to measure VSCF directly?

4. There are two numeric case studies of environmental cancer risks developed for the white paper. Each presents risk assessment information that forms the basis for quantifying the number of statistical cancer fatalities that will be reduced as a consequence of a hypothetical proposed environmental policy. The case studies are then used to illustrate the outcome of using direct measures of the VSCF and benefit transfer adjustments to VSL estimates in order to calculate the VSCF.

   a. Which of the valuation approaches applied to the case study designated as ALPHA are valid to use? Does this case study omit any credible alternative protocols for valuing reductions in fatal cancer risks for benefit-cost analyses of environmental programs?

   b. Which of the valuation approaches applied to the case study designated as OMEGA are valid to use? Does this case study omit any credible alternative protocols for valuing reductions in fatal cancer risks for benefit-cost analyses of environmental programs?

5. Which economic methods illustrated with the case studies, or additional methods identified by the Committee under charge questions 4.a and 4.b, serve as credible protocols for the Agency to use in representing quantitative data, qualitative information, and sensitivity analyses for the economic value of reduced fatal cancer risks reported in benefit-cost analyses?