UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C. 20460

OFFICE OF THE ADMINISTRATOR
SCIENCE ADVISORY BOARD

July 29, 2011

EPA-SAB-11-011

Honorable Lisa P. Jackson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Subject: Review of *Valuing Mortality Risk Reductions for Environmental Policy: A White Paper (December 10, 2010)*

Dear Administrator Jackson:

The EPA's National Center for Environmental Economics (NCEE) requested the Science Advisory Board's (SAB) advice on how the Agency should value mortality risk reductions in its benefit-cost analyses of environmental policy. The NCEE asked the SAB to review its White Paper entitled "Valuing Mortality Risk Reductions for Environmental Policy" (December 2010). To respond to this advisory request, the SAB's Environmental Economics Advisory Committee (EEAC) was augmented with additional experts with expertise in valuing mortality risk reductions.

The White Paper recognizes a longstanding problem with the term "value of statistical life" (VSL). A "statistical life" has traditionally referred to the aggregation of small risk reductions across many individuals until that aggregate reflects a total of one statistical life. For example, a one year decrease in average risk of mortality in the U.S. of 1 in a million would result in 310 "statistical lives" saved (given a population of 310 million). The VSL has been a shorthand way of referring to the monetary value or tradeoff between income and mortality risk reduction, i.e. the willingness to pay for small risk reductions across large numbers of people, but it has led to confusion because many have interpreted it as referring to the loss of identified lives. In recognition of the confusion and controversy caused by the VSL term, the White Paper proposed replacing the VSL term with "value of mortality risk." The SAB enthusiastically endorses a terminology change, but in our view, a term like "value of risk reduction" (VRR) would better communicate the notion that value is derived from reducing risks rather than the risks themselves. While the SAB recommends this terminology, we recognize that we are not experts in risk communication and suggest that EPA consider focus groups or some other mechanism to explore the language that best communicates this concept to the public. Public engagement is needed to dispel common misconceptions around this issue.

When valuing risk reduction, it is important to communicate exactly what kind of risk is being reduced since the public may value reducing risk of one kind of mortality (e.g., cancer mortality) differently from reducing risk of another kind (e.g., traumatic injury). The White Paper notes that research suggests that people are willing to pay more for mortality risk reductions that involve cancer than for risk reductions from accidental injury, and proposes a placeholder value that could be used for this cancer differential while the Agency pursues long-term research to differentially value other types of risks. The SAB agrees that values for risk reductions are not "one size fits all" and endorses the Agency's proposal to apply different values to different type of risk contexts. The SAB encourages the Agency to explore alternative methods identified in this report for estimating these context-specific values from the available research base.

The White Paper correctly notes that the amount of money people would be willing to pay for "public" risk reductions (that affect everyone) can differ from willingness to pay for "private" risk reductions (that affect only the individual or household). While this is conceptually true, the empirical literature is not yet sufficiently developed to be able to adapt values for altruistic concerns in benefit-cost analysis. Thus, at present, the SAB recommends that EPA include estimates of willingness to pay for both public and private risk reductions without distinguishing between the two.

The SAB was asked a number of technical questions about EPA's database of mortality risk reduction values and the most appropriate statistical approach for deriving a value for mortality risk reduction from existing studies. In this report, the SAB offers specific recommendations on criteria that should be used to select studies for inclusion in the database. The report also discusses how these studies could be used in meta-analysis or other approaches to estimate appropriate values of risk reduction. The SAB supports the Agency's plan to update its estimates for valuing risk reduction on a regular basis. The estimates that the Agency currently uses are based on studies that are at least 20 years old and do not take into consideration the wealth of newer studies that make use of better techniques, better data, and that better reflect current conditions. To avoid using estimates based on outdated research in the future, the Agency should establish a protocol for updating regularly the estimates of the value of risk reduction that it uses in its work.

Lastly, this SAB report does not address the complex social and political context for benefit-cost analysis in environmental policy. The White Paper described the valuation challenge facing the Agency and the different contexts underlying existing mortality risk reduction values. Thus, the SAB EEAC applied its expertise toward the analytic and empirical challenges described in EPA's eight charge questions and thus limited its scope to these topics. It should be noted that the Agency's White Paper only addressed valuing mortality risk reductions for adults. Accordingly, the SAB did not address the challenges associated with valuing children's risk reductions except to encourage the Agency to devote resources to research on this deserving topic.

Thank you for the opportunity to provide advice on this White Paper. The SAB looks forward to receiving the Agency's response.

Sincerely,

/signed/

Dr. Deborah L. Swackhamer
Chair
Science Advisory Board

/signed/

Dr. Catherine L. Kling
Chair
Environmental Economics Advisory Committee

Enclosures

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1. EXECUTIVE SUMMARY

This report was prepared by the Science Advisory Board (SAB) Environmental Economics Advisory Committee Augmented for Valuing Mortality Risk Reduction (the "Committee") in response to a request by EPA's National Center for Environmental Economics (NCEE) to review its draft White Paper "Valuing Mortality Risk Reductions for Environmental Policy" (December 10, 2010). The Committee, augmented with additional experts, deliberated on the charge questions during a January 20 – 21, 2011 a face-to-face public meeting and a subsequent public conference call on March 14, 2011 was approved by the Chartered SAB at a public teleconference call on June 7, 2011. Three topics were highlighted in the charge questions: EPA's proposed terminology change, willingness to pay for cancer risk reductions, and the treatment of altruism. Other charge questions covered the selection criteria for inclusion in EPA's database of studies, the income elasticity of mortality risk reduction values, EPA's statistical approach for deriving an estimate, more timely updates to the Agency's guidance, and other methods for valuing health risk reduction. This Executive Summary highlights the SAB's major findings and recommendations.

EPA's Proposed Terminology Change (Charge Question 1). The White Paper discusses problems associated with the popular misunderstanding of the "value of statistical life" (VSL) metric that has traditionally been used in benefit-cost analysis. The VSL concept arose in benefit-cost analysis to express society's willingness to pay (WTP) for health risk reductions. Since environmental policies that reduce mortality risks also impose costs, information about the resulting benefits is necessary to determine whether the benefits of the improvements outweigh the costs. One category of benefits is captured by society's willingness to pay for health risk reductions. Much indignation has been expressed in public and political settings over the VSL term because it is often perceived as the value of life itself or the value of an individual's life when, in fact, the term is meant to refer to society's willingness to pay for small changes in risk. In the jargon of economics, VSL describes individuals' marginal rate of substitution between health risks and income or wealth. To better communicate this concept, SAB agrees with EPA that the Agency should move away from the traditional VSL term in favor of a new term that conveys the tradeoff between income and small reductions in health risk. While the SAB favors (and use in our advisory) a term like "value of risk reduction" (VRR) or "value of mortality risk reduction", we encourage the Agency to undertake some research, possibly including focus groups, on how best to communicate this tradeoff to the public. EPA needs a term that captures the value of small risk reductions that can be aggregated over large numbers of people, not a term that is easily confused with the value of life itself. In addition to finding ways to communicate the tradeoff between income and health risk reductions, the SAB encourages the Agency to explain the type of risk to be reduced while seeking ways to differentiate willingness to pay for one kind of health risk reduction versus another. Since these values express demands for different goods by different groups of people, a single "one size fits all" metric used to express the marginal rate of substitution between health risks and income oversimplifies the many complex policy contexts in which EPA operates.

Willingness to Pay for Cancer Risk Reductions (Charge Question 2). Reducing environmental cancer risk is an important part of EPA's mission to protect human health. Thus a key question is how to account for individuals' preferences for reducing cancer risks relative to other types of health risks. In addition to cancer, many other health threats addressed by environmental policies also consist of illness profiles with long latencies and substantial periods of morbidity prior to death. EPA has correctly noted that some research finds a "cancer premium," i.e. a higher willingness to pay for cancer risk reductions than for other kinds of mortality risk reductions, though other good studies find no evidence of a differential. EPA asked the SAB to comment on a placeholder value that could be used for this cancer

premium while the Agency pursues long-term research to differentially value different types of risks. The SAB believes that the "first-cut" estimate of a 50 percent differential for cancer should be refined before application. This refinement should take into account the different comparators used in current studies (e.g., fatal accident, chronic disease) and recognize that several good studies find small differences between cancer and other risks while others find large differences.

Building from the recognition that WTP to reduce cancer risks may differ from WTP to reduce other fatal health risks, the SAB recommends that EPA work toward developing a set of estimates of VRR corresponding to policy-relevant contexts defined by the type or characteristics of the risk (e.g., associated morbidity, latency) and of the affected population (e.g., age, health, income). Economic theory and empirical evidence suggest that WTP can vary with these characteristics and that a single value of mortality risk reduction is not appropriate for all contexts. Developing this set of estimates will be challenging because the available empirical estimates do not cover all relevant contexts and there is substantial, poorly understood variation among estimates from different studies. The SAB describes several methods for developing this set of estimates and encourages EPA to evaluate the validity and relevance of these methods for informing policy analysis. Proposed approaches include: (1) using only primary estimates obtained for the specific context; (2) developing adjustment factors to transfer estimates from other contexts; (3) developing meta-regression equations and (4) structural benefit-transfer methods to characterize appropriate values across multiple contexts.

Altruism (Charge Question 3) EPA asked us to comment on how altruism should be treated in valuing risk reductions for environmental policy. The White Paper correctly notes that the amount of money people would be willing to pay for "public" risk reductions (that affect everyone) can differ from willingness to pay for "private" risk reductions (that affect only the individual). Differences may be a result of altruism, either paternalistic or pure (also called non-paternalistic). Pure altruism occurs when altruists respect the preferences of the beneficiary and care about the net welfare effect on the beneficiary. Paternalistic altruism occurs when benefactors substitute their own preferences for that of the beneficiary, e.g., care about the risk reduction but not about any costs imposed on the beneficiary. The literature is clear that values driven by paternalistic altruism should be counted while values driven by pure altruism need not be counted as they do not affect the sign of net benefits. (Preferences concerning the distribution of benefits or costs in the population affect the evaluation and should be counted.)

Although the theory is clear, economic analysis has not evolved to the point of being able to separately measure portions of total value attributable to paternalistic and non-paternalistic altruism. In addition, there is little empirical evidence that altruistic concerns are significant drivers of values for risk reduction. Thus, at present, the SAB recommends that EPA include estimates of willingness to pay for both public and private risk reductions without distinguishing between the two.

Database Development (Charge Question 4). EPA asked the SAB about inclusion criteria for its database of stated preference and hedonic wage studies. Specific recommendations are offered in response to EPA's questions about selection criteria and weaknesses in data sets in the attached report. With regard to concerns about whether and how to combine results from stated preference and revealed preference studies, the SAB judges that the distinction between study type is less important than accounting for differences in risk and individual characteristics.

Income Elasticities (Charge Question 5). The Agency asks for advice concerning procedures for updating its values to account for income growth. The SAB notes that the decision on how to adjust values of risk reduction (VRR) for income growth over time is related to the approach used to estimate

the VRR (or range of VRRs) for a particular application. The SAB recommends developing estimates of income-elasticity as part of the process used to estimate appropriate VRRs for different contexts described above.

Updating Values of Risk Reduction (Charge Questions 6 and 7). The Agency requested guidance on whether it was sensible to use a simplified approach for updating the values of risk reduction using a set of available studies to fit a parametric distribution. The SAB strongly endorses EPA's proposal to update VRR estimates routinely as improved information becomes available and urges the Agency to establish a protocol for regular updates. The current estimates depend upon studies that are 20 – 35 years old and it is time to take advantage of a wealth of new studies and better data. In principle, any of the methods described above for estimating VRRs in different contexts could be updated to include new literature.

Long-Term Research (Charge Question 8). To support improved value estimates in the longer term, the SAB encourages EPA to work toward using structural preference functions, although the SAB believes that it will be some time before such an approach will be ready for implementation. The Agency also should encourage research to obtain revealed and stated preference estimates for the types of risk and types of affected populations that are most relevant to environmental policy contexts.

2. BACKGROUND

Reductions in mortality risk constitute the largest quantifiable benefits category of many of EPA's rules and regulations. As such, mortality risk valuation estimates are an important input to EPA's benefit cost analyses. EPA has historically used a value of statistical life (VSL) to express the benefits of mortality risk reductions in monetary terms for use in benefit cost analyses of its rules and regulations. EPA has used the same central default value (adjusted for inflation) in its primary analyses since 1999 when the Agency updated its *Guidelines for Preparing Economic Analyses* (2000). EPA's *Guidelines* advise analysts to use a central VSL estimate of $4.8 million in 1990 dollars which converts to $6.2 million in 2002 dollars.

Prior to the release of the *Guidelines*, EPA sought advice from the Science Advisory Board (SAB) on the appropriateness of this estimate and its derivation. In 2000, EPA also consulted with SAB on the appropriateness of making adjustments to VSL estimates to capture risk and population characteristics associated with fatal cancer risks (USEPA 2000). The SAB responded with the report, ''An SAB Report on EPA's White Paper Valuing the Benefits of Fatal Cancer Risk Reduction'' (EPA–SAB–EEAC–00–010). In 2004, EPA consulted with the SAB on questions related to appropriate methodologies for valuing life extensions of different lengths and the use of meta-analysis to combine estimates from the literature. In 2006, the SAB reviewed an EPA paper on the application of meta-analysis techniques to deriving estimates for the value of mortality risk reduction as well as a paper on appropriate and available methods for valuing mortality risk reductions when affected populations have relatively short remaining life expectancy. In 2007, the SAB responded with ''SAB Advisory on EPA's Issues in Valuing Mortality Risk Reduction''(EPA–SAB–08–001).

In 2010, EPA's National Center for Environmental Economics issued its draft White Paper "Valuing Mortality Risk Reductions for Environmental Policy: A White Paper (December 2010) and requested an SAB review. Augmented with additional experts, the SAB's Environmental Economics Advisory Committee met on January 20 – 21, 2011 to deliberate on NCEE's questions (found in Appendix A) and teleconferenced on March 14, 2011 to finalize its draft report. This report was approved by the chartered SAB on June 7, 2011.

3. GENERAL COMMENTS

To frame the responses to the charge questions, this report provides some perspective on the concept of valuing mortality risk reduction and its use in estimating the benefits of environmental policies. This perspective is followed by responses to the specific charge questions.

The economic theory concerning valuation of reductions in mortality risk is well developed but application to evaluation of environmental policies is challenging. First, there is a limited set of empirical studies available for reliably determining values of mortality-risk reduction and how these values depend on characteristics of the risk and affected population. Second, the conventional term used to describe the value of risk reduction (the "value of a statistical life," or VSL) is easily misinterpreted, leading to confusion about key concepts. As discussed below, the SAB applauds EPA's proposal to adopt an alternative to the conventional term and use the term "value of risk reduction" (VRR) in our discussion.

From an economic perspective, VRR is an individual- and risk-specific value defined as the individual's marginal rate of substitution between money and mortality risk. It has units of dollars per change in probability of death in a specified time period (e.g., the current year). This marginal rate of substitution can be used to estimate the money value of a small change in risk (by multiplying the change in probability by the rate); analogously, the rate is often estimated from information about the monetary value that an individual judges to be equivalent to a small change in risk.

VRR is often characterized using the maximum amount an individual could pay for a risk reduction without making himself worse off. In other words, an individual's willingness to pay (WTP) for a risk reduction Δp is defined as the amount of money such that the individual is indifferent between his initial position (with initial risk and wealth) and a position in which his mortality risk (in the specified period) is reduced by Δp and his wealth is reduced by WTP. Alternatively, one can define VRR using the amount of money the individual would require as compensation to forgo a risk reduction; i.e., he is indifferent between having his initial wealth with the risk reduction Δp, and forgoing the risk reduction but having his wealth increased by his willingness to accept compensation (WTA). For the small risk changes that are usually relevant to environmental policy, these two estimates of VRR ($WTP/\Delta p$ and $WTA/\Delta p$) should be nearly equal.[1]

Economic theory implies that VRR is likely to depend on characteristics of the individual and the risk. Five key implications of standard theory for valuing mortality risk are highlighted below.

First, the amount of money an individual judges as equivalent to a change in risk (both WTP and WTA) should be larger for a larger risk change. Moreover, for small changes in risk (for which WTP or WTA is a small share of wealth or income), the money value should be nearly proportional to the risk change, which is equivalent to saying the rate of substitution between money and the change in risk is nearly

[1] In this example, WTP is the compensating variation and WTA is the equivalent variation for the risk reduction. One can also define VRR using WTA compensation for a risk increase (i.e., compensating variation for a risk increase) and WTP to prevent a risk increase (i.e., equivalent variation for a risk increase). Under conventional economic theory, these two values of VRR should be identical to the two defined in the text for infinitesimally small risk changes. Empirically, estimates of WTA are often much larger than estimates of WTP, as discussed in response to charge question 4.a.i (Stated Preferences Studies).

constant (e.g., if a risk reduction of one in one million is worth $10, then an otherwise similar risk reduction of two in one million is worth $20).[2]

Second, VRR depends on the individual's wealth or income, i.e., on his ability to pay. It seems intuitive and is consistent with economic theory and empirical evidence that a richer person will generally be willing to pay more for (and demand greater compensation to forgo) a risk reduction.

Third, VRR is likely to depend on other individual characteristics, such as age, life expectancy, future health prospects, responsibility to care for dependents, and other factors. Intuitively, the benefit of surviving the current period depends on the future conditions one is likely to face, and the opportunity cost of spending money to improve survival (or of accepting compensation to forgo an improvement) depends on other demands on an individual's wealth. For these factors, however, economic theory does not provide clear implications and empirical estimates are limited in coverage and quality.

Fourth, VRR is likely to depend on other characteristics of the risk, including both objective and subjective characteristics. Objective characteristics include latency (time between exposure and subsequent illness or death) and the duration and severity of associated morbidity (these attributes can be described as an "illness profile"). Subjective characteristics include the extent to which the hazard which presents the risk is perceived as under the individual's control, voluntarily accepted, familiar, well-understood, and dreaded. Again, theory and empirical evidence provide only limited information on how these factors affect VRR.

Fifth, the monetary value to an individual of any given program to reduce mortality risk may also depend on program characteristics in addition to the individual's personal risk reduction. For example, individuals may have different values for risk reductions provided through public goods that affect other people (such as cleaner ambient air) and risk reductions provided through private goods that affect only themselves or their households (cleaner indoor air at their residence). Their values may also depend on the distribution of risk reductions within the population (e.g., whether disadvantaged populations are disproportionately affected) and the mechanism through which costs are paid (e.g., income taxes, electricity prices).

Recognizing that VRR is a metric that can vary with both individual and risk characteristics, the conceptually appropriate method to estimate the benefits to the U.S. population of a change in mortality risk that results from environmental policy is to estimate the risk changes faced by each individual over time, value these changes using the appropriate individual VRRs, and sum the results over the population. In contrast, an alternative "short-cut" approach is conventionally applied. The short-cut approach is to multiply the number of people in the population by the population-mean risk reduction (yielding the number of "lives saved") and multiply that by the population-mean VRR. The short-cut

[2] Many stated-preference studies estimate that the rate of substitution between money and risk change varies substantially with the magnitude of otherwise similar small risk changes. If this finding accurately represents individuals' preferences, it implies that individuals' indifference curves between wealth and the probability of surviving the specified time period are sharply curved or kinked within the range of survival probabilities in question. It seems implausible that different individuals, facing different initial mortality risks, will have sharp curves or kinks in their indifference curves in precisely the small regions needed to account for this empirical finding and more plausible that the finding reflects a limitation of stated-preference methods. Sharply diminishing marginal WTP with the size of the risk reduction implies that an individual would value a second risk reduction of Δp much less than an initial risk reduction of Δp. This seems unreasonable, from the perspectives of economic theory and common sense, except when payment for the initial risk reduction substantially reduces ability to pay for the second increment. If it were accepted as a valid description of individual preferences, then valuation of environmental policies would need to account for it by using sharply different VRRs for individuals obtaining larger and smaller risk reductions (Hammitt and Treich 2007).

approach yields an approximation to the conceptually appropriate method. It requires information on only the average VRR and risk reduction, not on how VRR and risk reduction vary across individuals. The approximation is exact when any of three conditions hold: (a) all individuals face the same risk reduction; (b) all individuals have the same VRR; or (c) individual risk reductions and VRRs are uncorrelated in the population. If none of these conditions holds, the short-cut approach introduces bias as a result of "premature aggregation" (Cameron 2010, Hammitt and Treich 2007).

Because appropriate valuation of reductions in mortality risk generally requires information on how VRR varies among individuals and with risk characteristics, the SAB recommends that EPA orient its approach toward (a) recognizing the conceptually appropriate method to estimate population benefits and (b) developing a set of estimates of VRR for policy-relevant cases characterized by risk and individual characteristics (or a function relating VRR to risk and individual characteristics). This orientation would be a departure from the older notion of identifying "the value of a statistical life" that is appropriate for policy evaluation. (EPA has already moved away from this older notion, e.g., by recognizing that cancer risks may be valued differently than fatal injury risks.) The SAB recognizes that developing a set of context-specific VRRs will be challenging, due to limitations of the empirical literature. This implies that, for the near term, place-holder values will be needed for many contexts, perhaps obtained using VRRs estimated for other contexts with or without adjustment. Nevertheless, the SAB recommends that economic evaluation of environmental policies specify the conceptually appropriate approach and explicitly acknowledge the necessity to apply pragmatic proxies for that ideal given data limitations.

Conceptually appropriate, context-specific estimates of VRR should account for uncertainty about the VRR for each case, ideally as a probability distribution. Developing this set of estimates is challenging because of limited theoretical guidance and empirical evidence concerning how VRR varies with risk and individual characteristics. Moreover, estimates of VRR are highly variable, both within and between studies. This variability makes it difficult to distinguish differences in VRR associated with risk and individual characteristics from random variation and from differences in study design. Many effects of study characteristics on VRR estimates are not well understood. In estimating the VRR for each case, one confronts a tradeoff between using only studies that are specifically relevant to that case and using estimates for other cases, whether neighboring or more distant, perhaps by estimating a functional relationship of values to risk and individual characteristics. The former choice will tend to minimize bias at the cost of higher variance, especially variance of the difference in valuation between cases. It may even lead to illogical differences in VRR between cases. The latter choice will tend to increase bias but reduce variance and provide a smoother relationship between values and characteristics.

While it is clear from economic theory that individual WTP may vary with individual and risk characteristics, the SAB acknowledges that the objectives, methods, and principles underlying benefit-cost analysis and particularly the values of mortality risk reductions and other non-market goods are often misunderstood or rejected as inappropriate by many participants and commentators on the policy-making process. In the past, for example, the Agency was criticized for considering VRRs that differ by individuals' age. However, as acknowledged in the White Paper, values for health risk reductions are not "one size fits all." Applying a willingness to pay value to a targeted population (such as low income or elderly) that exceeds that group's willingness to pay for reduced risk could result in decisions that ultimately reduce the well-being of the targeted group. The proposed change of terminology and application of VRRs that differ with individual and risk characteristics provide an opportunity for constructive engagement with the public and other interested parties concerning these topics.

Finally, the SAB notes that the White Paper and most of the charge questions concern technical issues concerning methods for valuing reductions in mortality risk to adults for use in benefit-cost analysis. The SAB did not engage in a broader evaluation of the appropriateness of benefit-cost analysis for evaluating environmental regulations, methods for valuing mortality risk reductions to children, or other topics that were outside the scope of the White Paper and charge questions. While the White Paper focuses on values for risk reductions for adults, values of reducing children's risk are not as well understood, thus this is a topic deserving of EPA's attention and resources for research.

4. RESPONSES TO CHARGE QUESTIONS

4.1. Question 1 - Terminology

Current EPA guidelines and standard practice use "Value of Statistical Life" (VSL) as the metric for valuing mortality risks. Section 3.1 of the White Paper discusses the VSL terminology commonly used in mortality risk valuation exercises in greater detail. The White Paper suggests that the Agency move away from using the traditional VSL terminology in favor of a new term for estimates of the marginal rate of substitution between health risks and income (see section 3.1). Specifically, the White Paper suggests that the Agency refer to these estimates as the "value of mortality risk," and report the associated units using standard metric prefixes to indicate the size of the risk change, e.g., $/mr/person/yr (dollars per milli[10-3]-risk per person per year), or $/μr/person/yr (dollars per micro[10-6]-risk per person per year), etc. Does the Committee agree that the Agency should pursue such a change? Does the Committee believe that making these changes would ease or exacerbate the misunderstandings documented by Cameron (2010)? Would some other terminology or approach be preferable? Please explain.

The SAB strongly supports replacing the "value of statistical life" (VSL) with a term that more accurately reflects what is being measured. The SAB encourages EPA to consider replacing VSL with "value of risk reduction" (VRR) and using VRR to delineate different types of risk. For example, there might be a VRR for sudden workplace death, a VRR for cancer death, a VRR for heart disease, and so forth. VRRs might also vary demographically (e.g., a VRR for cancer death for men 40 to 50 years old). The SAB chose not to recommend standard units but did discuss micro-risk, milli-risk and nano-risk as obvious possibilities. The best units to use will depend on the policy context, the level of aggregation, and the way in which VRR will be used.

The EPA's White Paper proposed the terminology "value of mortality risk" (VMR) to replace VSL. The SAB believes that the new term should include "reduction" since the value is typically derived from a reduction in risks rather than from the risks themselves and used to value risk reductions. Also, VMR gives the impression that people have a positive value for risk. Using risk reduction avoids this confusion. The SAB also believes that using "mortality" does not always provide a complete description of the risks involved. Different types of risks are often intertwined in valuation studies and policies often lead to changes in mortality as well as morbidity risks. For example, the morbidity (and other factors such as dread) associated with cancer is difficult to separate from the mortality risk of cancer. Excluding "mortality" allows for VRRs that encompass a broader array of health risks. As noted above, the SAB suggests that VRRs for morbidity or mortality risks be accompanied by a policy-specific classification of the type of probabilistic outcome, the target population, etc.

While the SAB recommends the terminology VRR, we recognize that we are not experts in communication. For this reason, the SAB suggest that EPA consider testing the VRR terminology and explore alternative terminologies in focus groups, discussions, and presentations with relevant user groups. Along these lines and in response to the public misconceptions of VSL documented in Cameron (2010), the SAB recommends EPA consider conducting or sponsoring research into effective communication of VRR and its role in benefit-cost analysis to the general public. Numerous public comments in response to an article about the VSL in the popular press suggest that many people also

have difficulty with the use of the word "value."[3] Many non-economists seem to believe that the word value means "intrinsic worth," rather than the economists' notion of willingness to pay, and they bridle at the idea that their government would presume to put a dollar value on their lives. In any event, the change from VSL to something like VRR as well as the other suggested changes (e.g., from a single value of VRR to values for specific policy-related risk changes) provide a prime opportunity to engage in effective public communication. There have been calls in the past for EPA to start research programs on public communication and recent developments in climate change communication further highlight the importance of public communication in the effectiveness of policy making and implementation.

Regardless of the exact language chosen, the SAB believes that making such a change will contribute to easing the public misunderstanding of VSL. The SAB applauds EPA's leadership in this suggestion.

4.2. Question 2 – Cancer Differential

> *Experts generally agree that value function transfers can outperform point value transfers in cases where the characteristics of the risks and/or the exposed populations differ between the source studies and the policy context in measurable ways. That is, the more commodity- and individual-specific attributes that can be included in the benefit transfer exercise, the better the estimate of willingness to pay. Charge questions 2 and 3 inquire about whether applications of benefits transfer methods to value mortality risk reductions from environmental pollutants can be improved by controlling for more of the attributes that distinguish the source studies from the policy scenario.*
>
> *The White Paper concludes that research since the 2000 EPA Guidelines suggests that people are willing to pay more for mortality risk reductions that involve cancer than for risk reductions from accidental injury (see section 3.3). Our preliminary review suggests that a "cancer differential" of up to 50% over immediate accidental or "generic" risk valuation estimates may be reasonable. Conceptually, would the weight of evidence (both theoretical and empirical) suggest there is a cancer differential? If so, does the Committee believe that our estimate of the differential is appropriate If not, how does the Committee recommend the Agency incorporate cancer differentials in benefits analysis involving reduced cancer risks?*

The SAB commends EPA for its effort to develop appropriate values for mortality risk reductions rather than applying a "one size fits all" value to all cases. As discussed in the introductory section, theory suggests that VRR depends on characteristics of the risk and the individual.

As noted, charge questions 2 and 3 inquire about the use of benefit-transfer methods. Charge questions 4 – 7 are also concerned with issues of inferring the appropriate VRR for a specific application from available studies. As explained in the introductory section, SAB recommends that EPA work toward developing a set of estimates of VRR for policy-relevant cases characterized by risk and individual characteristics. There are strong precedents for applying benefit-transfer methods to analyze non-health benefits of EPA policies. In that context, as with VRR, analysts confront choices between how much to rely on estimates that are specific to the application and how much to "borrow information" or extrapolate from estimates that are less similar to the application (in the present context, how much to adjust for differences in attributes between the risk valued in source studies and the policy-relevant risk). There is no general answer to this problem. The best approach will be sensitive to the quality and number of available studies that estimate relevant values. In the case of death from traumatic injury, the

[3] See Binyamin Appelbaum, "As U.S. Agencies Put More Value on a Life, Businesses Fret," New York Times, February 16, 2011 and the inventory of public comments available at http://pages.uoregon.edu/cameron/vita/Stakeholder_misconceptions.pdf.

set of empirical estimates is rich, including revealed-preference studies of wage differentials and consumer products (e.g., motor vehicles) and stated-preference studies of transportation hazards. For other applications, the empirical literature is much more limited and often includes only stated-preference studies.

Given this background, SAB recommends that EPA explore alternative methods to estimate a distribution of appropriate VRRs for relevant cases (e.g., deaths associated with exposure to airborne fine particulate matter, fatal cancers associated with exposure to environmental carcinogens). Below, the SAB suggests four possible methods. It may be appropriate to use different methods for different policy-relevant cases to reflect differences in the number and quality of relevant studies and differences in the characteristics of the risk reductions they value.

One approach would be to develop independent estimates for relevant cases, using only studies that are closely matched on risk and individual characteristics. This approach may be useful for some cases but not others, due to the limited coverage of the empirical literature.

A second approach would be to develop a baseline distribution of estimates (perhaps for fatal injury) and a set of adjustment factors for risk and individual characteristics as warranted. Such adjustment factors might be developed for hazard characteristics (e.g., one or more cancer differentials appropriate for different types of cancer), individual characteristics (e.g., adjustment factors for age and income), and program characteristics (e.g., public programs versus private risk reductions). This approach could incorporate both direct estimates of VRR for different risks and risk-tradeoff studies that estimate only differentials in VRR between risks. This approach and the first approach could be informed using formal expert elicitation to identify the studies that are sufficiently closely matched to the policy context of interest and/or to estimate distributions of baseline estimates and adjustment factors.

A third approach would be to develop a meta-regression model to estimate VRR as a function of risk and individual characteristics. The historical EPA approach, using the mean of 26 studies, is an example of a meta-regression including only one term (an intercept). This approach could be extended to include a small number of categorical or indicator variables (e.g., for cancer type, age or income categories) and/or a small number of continuous variables (e.g., income or its logarithm). It may be appropriate to include variables describing study type (notably stated or revealed preference) to avoid confounding estimates of risk and individual characteristics with (poorly understood) effects of study type (at minimum, one should test for sensitivity to study type). Such a meta-regression can be viewed as a reduced-form or first-order approximation of a more complicated function relating VRR to risk and individual characteristics.

A fourth approach would be to develop and estimate a structural preference function. An advantage of this approach is that its structure is consistent with economic theory, and so extrapolation from existing estimates can be performed with greater confidence (e.g., it may be possible to develop improved estimates of how VRR depends on the magnitude of the risk reduction). Moreover, it provides a method for incorporating other types of information, in addition to estimates of VRR, that are informative about individual preferences regarding mortality risk reduction. (As described in response to charge question 8, SAB judges that the structural-preference-function approach requires further development and testing before it should be relied on as a primary source of VRR estimates.)

In evaluating the different approaches, one criterion is the degree of fit between the resulting estimated distribution for VRR in each specific context and the results from high-quality studies that estimate

VRR for that context directly. A second criterion is the intuitive plausibility of the pattern of VRR distributions across contexts.

In estimating VRRs and how they vary with risk and individual characteristics, the SAB suggests caution in using results from non-US populations. The effects of individual and population characteristics on VRRs may be sensitive to health-care and social-welfare programs and other factors that differ significantly between countries.

In response to charge question 2, SAB recognizes that cancer is (after fatal injury) the risk for which the empirical literature provides the most information. In addition, there are some estimates of VRR for respiratory and other chronic disease. The SAB concurs with EPA's judgment that only the studies that compare values for cancer and other risk reductions are useful for evaluating possible differentials. These include valuation studies of two or more types of fatal risk and risk-tradeoff studies. Stated- and revealed-preference studies of only one type of risk, without internal comparison, are not useful because there is too much unexplained variation between studies to determine how much of the differential is associated solely with risk characteristics.

The SAB believes that the "first-cut" estimate of a 50 percent differential for cancer should be refined before application. This estimate is justified in the White Paper as approximating the average differential found in nine studies (reported in footnote 14, page 25). However, no control is made for the fact that different studies evaluate different types of cancer and compare it against different risks (e.g., injury, other disease) and the differential associated with the Van Houtven et al. (2008) study is misreported (the proportional WTP is 3 times higher but the differential is 2). Any quantitative estimate of a cancer differential will be sensitive to the weight given to the Van Houtven et al. study, which estimates a much larger effect than any of the other studies. (Note that six of the nine reported studies yield estimates between -0.15 and +0.30).

Finally, in evaluating hazard-specific differentials it is important to distinguish between differentials that are conditional on characteristics of the illness profile (e.g., duration and severity of morbidity, latency) and differentials that do not control for these characteristics. In evaluating values of faster vs. slower deaths (e.g., from injuries vs. cancers), it seems important to control for whether the period of morbidity extends life or shortens the period of healthy life (i.e., is the comparison between instantaneous death and manifestation of a fatal disease at the same time or between instantaneous death and death from chronic disease at the same time?). In addition, some studies provide information on valuation of different types of cancer, suggesting that there is no single differential that is appropriate for all cancers.

In sum, the SAB suggests that the magnitudes of cancer and other hazard-specific differentials should be evaluated as part of an integrated process used to estimate the value of mortality risk reduction and how it varies with risk and individual characteristics, using some of the methods described above.

4.3. Question 3 – Public and Private Risk Reduction

> *Environmental policies generally provide public risk reductions. However, research, particularly stated preference research, provides willingness to pay estimates for both public risk reductions as well as private risk reductions. And, some research indicates that individuals' willingness to pay for public risk reductions may be different than that for private risk reductions. One factor that may contribute to these differences is altruism, which, all else equal, should make values for public risk reductions larger than those for private risk reductions.*

a. Should EPA rely on studies that estimate willingness to pay for both public and private risk reductions? If so, is it sufficient to control for this key characteristic in the modeling framework? Or, should EPA limit the analysis to studies according to the type of risk reduction in the study? If using only one type of study is recommended, should EPA use studies that estimate public or private risk reductions? If we are to limit the studies used to one type, is there a role for the excluded group?

As described above, VRR may vary with program characteristics such as public or private risk reduction. The SAB does not recommend categorically restricting inference to studies that are only private or only public but exploring the estimated magnitude of the effect. If the effect is of sufficient magnitude to warrant accounting for it in economic evaluation of a program, it can be accounted for by using only studies that are closely matched to the required application or by adjusting results from other studies.

b. Studies that estimate willingness to pay for public risk reductions may allow EPA to better capture altruistic preferences in benefit-cost analysis. Did the White Paper adequately capture the theory on how to incorporate altruism into the value of mortality risk reduction? How should altruistic preferences be treated in benefit-cost analysis? Should the Agency incorporate altruism into the value of mortality risk reductions, even if we are unable to distinguish the specific form of altruism involved (i.e., paternalistic or non-paternalistic)? More generally, what alternatives should the Agency pursue in the short-term to appropriately account for altruistic preferences when evaluating public programs, if any?

The White Paper adequately summarizes the literature on altruism in benefit-cost analysis. Values driven by paternalistic altruism are considered legitimate in benefit-cost analysis. The literature is clear that pure (non-paternalistic) altruism, in which the benefactor respects the preferences of the beneficiary, can result in over-counting benefits (e.g. Flores 2002, Bergstrom 2006). This is because welfare gains that accrue to beneficiaries, and that are valued by altruists, depend on the net value to beneficiaries. If beneficiaries were to pay exactly their value for a larger quantity of a public good, then altruists would receive no altruistic welfare gain. However if beneficiaries paid less (more) than their value, altruists would receive an altruistic welfare gain (loss). In short, pure altruists care about both the benefits received and costs paid by beneficiaries; counting only the altruistic benefits is incorrect.

While the economic literature is clear on how values driven by paternalistic and non-paternalistic concerns should be treated in economic analysis, the state of the art in economic analysis has not evolved to the point of being able to separately measure portions of total value attributable to paternalistic and non-paternalistic altruism. There is little empirical evidence that altruistic concerns are significant drivers of values for risk reduction. At present, the SAB recommends that EPA include estimates of willingness to pay for both public and private risk reductions without distinguishing between the two.

4.4. Question 4 – Stated Preference and Hedonic Wage Studies

The two primary literatures used to assess willingness to pay for mortality risk reductions are stated preference studies and hedonic wage studies. The White Paper assembles two databases summarizing studies in both literatures, capturing much of the information outlined in number 3 of

the SAB-EEAC's recommendations dated October 2007 (see section 4).[4] *These studies, or a subset thereof, would form the basis of revised guidance in the near term as well as possible future meta-analyses.*

a. The selection criteria employed in creating the two data sets are carefully outlined in the paper (see sections 4.1.2 and 4.2.4). Please consider these criteria in answering the following questions:

i. Should additional criteria be added to screen studies for inclusion in the datasets? If so, please specify those criteria. Should any criteria be eliminated or modified?

The EPA assembled two databases summarizing stated preference and hedonic wage studies following the SAB-EEAC's recommendations dated October 2007 (see especially Section 4). As noted in the charge question, these criteria are intended to be used to identify appropriate studies for estimating VRR, whether as part of a meta-analysis or using some other approach, such as those identified in response to charge question 2. A set of eight criteria was used to select studies to include in each database. The objective of the selection criteria -- to exclude low-quality studies and to ensure applicability to the US -- should be stated explicitly to ensure transparency and the selection of appropriate criteria. An additional criterion that should be added is that estimates should be restricted to those obtained for appropriate risk and population characteristics when that restriction is appropriate for the approach used to estimate VRR in a particular context (see the discussion of methods described in response to charge question 2). Below are answers for each of the specific charge questions for each database separately (where appropriate). Note also that the criteria apply to studies valuing of both morbidity and mortality since both types of endpoints are relevant to measuring VRRs in different contexts.

Stated Preferences Studies

With respect to stated preference studies, the SAB provides its response to the White Paper's eight selection criteria.

(1) Minimum sample size of 100.

The SAB believes that setting a minimum acceptable sample size is not a very useful criterion. Small samples are of concern for two reasons: the precision of the estimates is likely to be low and the sample is unlikely to adequately represent a population of interest. With regard to the first point, the relationship between sample size and precision of the estimated VRR depends on the study design, e.g., for a fixed sample size, one single-bounded binary-choice valuation question provides less precision than a double-bounded binary-choice question, which provides less precision than an open-ended question. (Note that the approaches that provide more precision may induce more bias and are not necessarily better.) Similarly, choice experiments in which respondents make many choices may provide more precision than contingent-valuation studies in which respondents value only a single good. These considerations suggest that different minimum sample sizes should be developed for different types of stated preference (SP) studies, thereby compromising the simplicity of a sample-size criterion. A conceptually cleaner approach would be to develop a criterion based on precision of the estimate. The SAB understands that some SP studies do not report the precision or standard error of their estimates or information from which this can be

[4] The recommendations included specific features of hedonic wage and stated preference studies that should be identified in the studies.

approximated. Studies that do not report quantitative information about the uncertainty in their estimates do not follow established best research practices and thus are not of adequate methodological quality for use in determining VRR. Moreover, such studies seem unlikely to meet other criteria for methodological adequacy, such as providing evidence that the results can be interpreted as valid estimates of VRR (discussed below).

With regard to the second point, studies with small samples often use convenience samples or other groups that are not representative of the general population. These studies are likely to be excluded by the second criterion, discussed below. If a study with small sample size uses a sample that is representative of the population of concern and provides adequate precision, it should be included in the analysis.

(2) Sample frame based on general population.
The SAB suggests that the sample frame be the "appropriate population" rather than the general population, to the extent practicable. The EPA should be clear in its determination of what the appropriate sample frame is and seek studies that use that sample frame or can be used to understand how to adjust results that use other sample frames. For example, if the EPA is seeking to value reductions of risks that are specific to a particular segment of the population, the study should focus on obtaining values that are relevant for members of that segment of the population. Older studies will eventually fail to adequately represent the current population so the age of the study should be evaluated to determine whether it is reasonable to consider it representative of current preferences.

(3) Conducted in a high-income country.
The SAB believes that surveys should ideally be limited to those conducted in the United States. To the extent that preferences, cultural norms, institutions, and demographic profiles can affect valuation of risk reductions, studies based on non-U.S. populations may provide biased estimates of U.S. values. Indeed, work using similar stated-preference instruments suggests there are significant differences in patterns of WTP even between countries as similar as the U.S. and Canada (Alberini et al. 2004, Cameron et al. 2010).

(4) Results based on exclusive dataset.
The SAB disagrees with this criterion. In economic research, multiple estimates for an outcome of interest (in this case, a point estimate of the VSL) are often reported which are based partially or wholly on overlapping samples. Model uncertainty, covariate-measurement uncertainty, and interest in heterogeneity of impacts across subpopulations all lead to varying outcome estimates. Rather than apply a zero weight to the information contained in all but one of the estimates arising from a single database, or from overlapping databases, the SAB recommends that the EPA include estimates based on its set of other criteria and take all estimates that meet those criteria. If possible, EPA should control statistically for within-study correlations.

(5) Written in English.
The SAB agrees with this criterion.

(6) Provides enough information to calculate a WTP estimate if one is not reported in the paper.
The SAB agrees with this criterion.

(7) Provides estimates for willingness to pay (willingness to accept estimates were not included).
The SAB agrees that contingent valuation studies of WTA often yield results that differ substantially from estimates of WTP (Horowitz and McConnell 2002). The presence of income effects can justify some of the difference between these value constructs, as could limited substitutability of market goods (Hanemann 1991), but the reasons for occasionally very large divergences are not clear. Thus the SAB recommends that contingent valuation estimates of WTA should not be used. A second rationale for this advice is that most environmental policies and regulations do not involve compensating individuals for environmental damages but rather individual willingness to pay the costs of policies or regulations that reduce mortality risk.

(8) Provides estimates for willingness to pay for risk reductions to adults (estimates for risk reductions to children are not included).
The SAB agrees that estimates of VRR for adults should be based on estimates of WTP for risk reductions to adults. Of course, the Agency also needs values for mortality-risk changes for children. VRR estimates for adults should not be automatically applied for children, so this criterion is not applicable in the case of children's risks. The SAB recognizes that there is a paucity of studies focused on estimating the value of risk reduction for children. This is clearly a research need that the Agency may wish to invest in.

The SAB recommends an additional criterion: that the stated preference study should provide evidence that it yields valid estimates of VRR. There are many factors that can influence responses to a stated-preference survey in ways that cannot be interpreted as consistent with estimating the theoretical concept of interest. For example, respondents may give answers consistent with extraordinarily high or low values (e.g., "protest zeros" in open-ended questions). One form of evidence of validity is showing that the study passes a scope test, i.e., that estimated WTP increases with the size of the risk reduction that is valued. A weak scope test demands only that WTP increase in a statistically significant way with the size of the risk reduction; a strong test demands that WTP be proportional to risk reduction (for changes in mortality risk, economic theory implies that WTP is nearly proportional to the risk change with deviations occurring primarily through the income effect (Hammitt and Graham 1999, Corso et al. 2001). External scope tests (that compare WTP between subsamples of respondents) are generally viewed as superior to internal scope tests (that compare WTP within a sample) because respondents could provide mutually consistent estimates of WTP for different risk reductions even if their response to the first valuation question is random.

Hedonic Wage Studies

With respect to hedonic-wage studies, the White Paper describes eight selection criteria, of which four are based on a recently published meta-analysis by Bellavance et al. (2009). The four based on Bellavance et al. are listed below as criteria (5) through (8). The criteria, and the SAB's recommendation regarding each criterion, are described in turn below.

(1) Use a sample size of greater than 100.
Sample size is not a significant concern for most wage-differential studies, which rely on large data sets of workers and actuarial risk estimates based on comprehensive fatality data. As noted in the discussion of stated-preference studies, sample size per se is not relevant to study quality or utility. Hedonic wage studies that are based on other sources (e.g., an original survey of workers) should be evaluated on a case-by-case basis for precision of estimates and representativeness of the sample.

(2) Limit selected studies to those conducted in high income countries as defined by the World Bank.
The SAB recommends that the EPA base its analysis only on studies conducted on U.S. populations. Because hedonic wage equations estimate an equilibrium outcome based on preferences, demographic distributions and technologies, they will be unique to each country. Even if incomes are similar across countries, similarity in other conditions that affect the revealed marginal rates of substitution between risk and wages are not assured.

(3) Omit studies based on the Society of Actuaries risk data.
The SAB agrees with this criterion. Charge Question 4a.ii. relates to this criterion and further comments are given in response to that charge question.

(4) Omit studies that focused on extremely dangerous jobs (e.g., police).
The SAB agrees this is a reasonable criterion because the population included in these studies is not representative of the population affected by EPA regulations. Should there be a case where the EPA is evaluating extreme risks to a well-defined population, research concerning the risk preferences of that population would be relevant.

(5) Retain only studies which employ a model specification "similar to that given" ($\ln(w_i) = X_i\beta + \varphi\rho_i + \mu_i$).
The SAB disagrees with this criterion if it is applied exactly as the White Paper suggests (that only cross-section OLS regressions are included in the database). For example, the criterion would imply that estimates based on panel data, instrumental variable, or quasi-experimental methods would be excluded. The SAB recommends that all estimates arising from conceptually sound methods be included.

(6) Exclude studies based on specific cause of death.
This criterion is appropriate when the goal is to provide an estimate of the value of reducing risks of workplace accidental deaths. The SAB notes, however, that the EPA should recognize that even within the context of accidental deaths, there is a great deal of heterogeneity (e.g., falls versus electrocution). The literature often aggregates these into a single measure of fatality risk but some new studies attempt to distinguish values by these risk characteristics (e.g., Scotton and Taylor 2011).

(7) Exclude studies which use the same underlying sample of workers as other studies. In other words, if multiple VSL estimates are reported based on the same underlying survey sample for stated preference studies or the same worker sample for hedonic wage studies, prior recommendations suggest that only one VSL estimate from a given sample be incorporated into the meta-analysis.
The SAB agrees that this approach is desirable when conducting meta-analyses of clinical trials to describe efficacy of a treatment on a health endpoint, but it is not a desirable approach for meta-analyses applied to economic research. As noted above for stated preference studies, in economic research, multiple estimates for an outcome of interest (in this case, an estimate of VRR) are often reported which are based partially or wholly on overlapping samples. Model uncertainty, covariate-measurement uncertainty, and interest in heterogeneity of impacts across subpopulations all lead to varying outcome estimates. Rather than apply a zero weight to the information contained in all but one of the multiple estimates, the SAB recommends that the EPA select observations for inclusion in the meta-data set or other applications based on its set of other criteria and include all estimates that

meet those criteria. Including multiple estimates from the same or overlapping data raises issues of how to account for statistical dependence among estimates and whether a study that reports more estimates should contribute more to the summary measure. There are several methods for addressing these issues described in the meta-analysis literature (e.g., Mrozek and Taylor 2002, Viscusi and Aldy 2003, Bellavance et al. 2009).

(8) Exclude studies failing to report enough information to calculate the value of mortality risk reductions and/or the average probability of death.
The SAB agrees with this criterion.

Additional comments:

The EPA should consider adding the following criteria:

(a) Hedonic-wage regressions should include a measure for nonfatal-injury risk, or at least provide evidence concerning the sensitivity of the estimated value of mortality risk to inclusion/exclusion of nonfatal risks.

(b) Hedonic-wage regressions should include an appropriate level of industry and occupational control variables to address the problem of unobserved job characteristics that often exists in these studies. Panel models that control for unobserved worker characteristics do little to alleviate this problem when the risk variable is constructed in such a way that it varies only by occupation and industry of the worker. Estimates from models that convincingly address unobserved job and worker characteristics using the best methods available and appropriate for the data are preferred.

(c) Eliminate any study that relies on risk measures constructed at the industry level only (not by occupation within an industry), even if the source of the risk data is the Census of Fatal Occupational Injuries (CFOI). For example, Smith, et al. (2004) use risks that vary only by industry of the worker. While there has not been direct evidence of the degree to which this practice introduces measurement error of the type discussed by Black and Kneisner (2003) and Black, Galdo and Liu (2003), it would seem likely to introduce important measurement error.

(d) Include only estimates that are based on an appropriate sample frame or can be used to adjust the sample frame for the policy context. This criterion follows the suggestion for criterion (2) for stated preference surveys.

ii. Section 4.2.2 of the White Paper discusses problems of measurement error associated with some common sources of occupational risk information among other concerns with the hedonic wage approach. Should EPA limit its selection of hedonic wage studies by the source of occupational risk information? For instance, studies relying on data from the Society of Actuaries (SOA) have been omitted from the described data set. Should the SOA studies be excluded? Should other sources be excluded as well?

EPA should exclude hedonic-wage studies that do not use adequate risk data. The quality of the risk estimates is critical to wage-differential estimates of VRR and there have been substantial improvements in risk data over time. The SOA data are not conceptually appropriate because they include deaths from non-occupational risks, for which no wage differential would be expected. Prior to 1992, Bureau of

Labor Statistics (BLS) workplace fatalities were survey estimates, which the National Academy of Sciences had questioned due to the high rate of sampling errors.[5]

Several sources provide additional details on the difficulties with past risk estimates. Drudi (1997) describes problems in constructing valid risk estimates. Black, Galdo and Liu (2003) and Black and Kneisner (2003) provide a critique of the previous risk measures and illustrate the unreliability of study estimates using these measures. Leigh (1995) highlights the issue of measurement error when using risk data that vary only by industry or by occupation of the worker. Viscusi (2004) finds that estimates of the value of mortality risk using estimates of risk by industry and occupation are roughly half as large as estimates using estimates of risk by industry.

Lastly, there has been a steady decline in overall numbers of workplace deaths since 1970. The labor force has shifted from manufacturing to service-oriented industries and exposures in the workplace have changed over time. Currently up to 15% of workplace deaths are homicides. The reliance on flawed data that are not representative of current conditions is not defensible.

In summary, all studies that rely on data of lower quality than the CFOI should be excluded.

b. Should any of the studies included in the datasets be eliminated? If so, please specify those studies and the reasons for eliminating them.

Stated Preference Studies
The SAB prefers not to endorse or exclude specific studies. The appropriate strategy will be to consider the (revised) criteria recommended above and to revisit the database of studies with these criteria in mind.

The SAB emphasizes that the studies used should adhere to best practices. The quantities being estimated should correspond to a theoretically sound microeconomic construct (i.e., based on the theory of consumer choice) that measures an appropriate concept of value. In general, these measures will involve marginal rates of substitution. Ideally, this marginal rate of substitution is between a specified risk reduction and money, which yields an estimate of willingness to pay for that risk reduction. However, risk-risk tradeoffs can also be expressed as marginal rates of substitution between risks. In combination with appropriate studies that produce marginal rates of substitution between one of the risks in such a pair and money, it may be possible to use risk-tradeoff information to calculate willingness to pay for the other risk.

Hedonic Wage Studies
All studies not based on the U.S. workforce, not based on risk data of comparable or superior quality to the CFOI data, and not adhering to the other criteria discussed above should be excluded. The first two criteria eliminate all studies prior to Viscusi (2004). Additional criteria as discussed in response to charge questions 4.a. should be developed and studies after 2003 should be evaluated on these terms.

c. Is the committee aware of relevant empirical studies in the stated preference and hedonic wage literatures that are not adequately captured in this review? If so, please provide citations.

[5] For example, the BLS estimated there to be 2,900 workplace fatalities in 1990 while the National Safety Council estimated 10,500 and the National Institute of Occupational Safety and Health estimated 5,500 (not including Connecticut and New York and using only death certificates, which Drudi (1997) reports identify as few as 35% of workplace deaths).

There are a number of new studies that could be used to update VRR estimates using meta-analysis or other approaches. However, many of these are not published and therefore not peer reviewed. The benefits of including results from these studies are that they are likely to represent current population characteristics and preferences, use the most up-to-date methods in stated and revealed preference work, and are generally designed to elicit the values that are most policy relevant for EPA. However, these benefits must be weighed against the fact that the use of peer-reviewed literature has long been held as the gold standard of scientific credibility. Given the importance of this latter point, EPA should not rely on the "grey literature" (unpublished manuscripts, reports, dissertations, and other non-refereed materials).

The SAB wishes to emphasize that the important aspect of peer-review that needs to be adhered to is peer-review of the methods, data used to fit the models, and general approach of the study. It is not necessary that every VRR estimate or detail of a model to be transferred in a benefits-transfer context appear in the peer-reviewed publication. Thus, it would be reasonable to admit VRR estimates that are based on methods and data that have been peer-reviewed, even if those estimates are reported only in supplemental, unpublished reports (including working papers or dissertations). Similarly, if a study that estimates a WTP function has satisfied peer review, but researchers need to use parameters not reported in the peer-reviewed publication (e.g., the variance-covariance matrix for the parameters) in order to generate values for a policy-relevant context, this should also be considered to have meet the peer-review mandate.

The SAB suggests the following published studies as additional relevant empirical studies for EPA's consideration.

Other studies to consider:

Stated Preference Studies

Cameron, DeShazo, and Stiffler (2010).
Cameron, DeShazo, and Johnson (2010).

Hedonic Wage Studies

Evans and Schaur (2010).
Evans and Smith (2006).

4.5. Question 5 – Income Elasticities

Income elasticities are discussed briefly in section 5 of the White Paper. In keeping with Agency practice, we created the two databases by adjusting all estimates for income growth over time using an income elasticity value of 0.5 based on prior Agency reviews of the literature and results Viscusi and Aldy, 2003. In addition, we adjusted all estimates for inflation as well as for purchasing power parity where necessary, as recommended by the EEAC's October 2007 report. Does the Committee agree with this approach to accounting for income growth over time?

The question of how to adjust estimates of VRR before combining them in a meta-analysis is distinct from the question of how to adjust for use in policy analysis (discussed below). For meta-analysis, the SAB suggests that EPA not adjust VRR estimates for income growth but explore how VRR varies with (a) the time period to which the data pertain and (b) the average sample income as part of the meta-analysis.

Does the Committee believe the Agency should adjust its value of income elasticity for use in policy analysis in light of recent findings in the literature?

Intuition, economic theory, and empirical estimates all suggest that VRR should increase with income, and so EPA should adjust for changes in income in evaluating benefits of risk reduction. The income elasticity of VRR, like VRR itself, may vary with risk and individual characteristics.

The literature on VSL income elasticity has employed several approaches and produced a wide range of results (Hammitt and Robinson 2011), including cross-section analysis of within-sample variation in stated-preference data (e.g., Alberini et al. 2004), meta-analysis of hedonic-wage studies (e.g., Viscusi and Aldy 2003), longitudinal analysis of hedonic-wage data for a particular population (e.g., Costa and Kahn 2004), and quantile analysis of hedonic-wage data (Evans and Schaur 2010, Kniesner et al. 2010). Estimates obtained from cross-section analysis of stated-preference data range between 0.1 and 1.0 while longitudinal-study estimates range between 1.3 and 3.0. Quantile analysis yields elasticity estimates of 2.2 for the lowest decile of income and 1.2 for the highest decile of income.

Consistent with its recommendations on VRR, the SAB recommends that EPA attempt to characterize the distribution of income elasticity and how it varies with risk and individual characteristics using one or more of the approaches described for characterizing VRR.

If so, what value or range of values does the Committee believe should be used?

See previous response.

4.6. Question 6 – Statistical Approach

The White Paper describes a simplified approach for updating the Agency's recommended mortality risk value estimate(s) (see section 5.1.1). This approach involves fitting a parametric distribution to the set of estimates from selected studies. This is similar to the approach used for EPA's current default VSL estimate.

a. Should EPA pursue this approach for updating its mortality risk valuation guidance in the near term (until a more detailed analysis can be conducted)?

The SAB recommends that EPA explore some of the methods proposed above (in response to charge question 2) for estimating a distribution of VRR for relevant cases. Whichever method is used for a particular application can be updated over time. If it is not possible to develop an appropriate VRR for a particular case within the allowable time, placeholder estimates and sensitivity analysis may have to be used, but if this is done, it should be made clear how the policy context differs from the contexts within which the available WTP estimates have been measured and what assumptions are required to transfer benefit estimates to the policy context.

b. If so, should the databases on which values are based be created using only one estimate drawn from each study or multiple estimates from each study?

In general, it will be appropriate to include multiple estimates from each study (see response to charge question 4).

c. If only one estimate per study should be used, what criteria should the Agency apply in selecting the appropriate estimate? How would these criteria vary from one segment of the literature to the other? The paper describes the methods used to select independent estimates from each study. Does the Committee agree with the methods used?

Not relevant (see charge question 6b).

d. How important is it that estimates be drawn from non-overlapping subsamples? If multiple estimates per study are recommended in the construction of the meta-datasets, should the estimates be selected to avoid overlapping sub-samples?

It may be appropriate to include multiple estimates from the same subsample. As discussed in response to charge question 4, studies of VRR often explore the effects of using alternative model specifications on the estimated value. When (as is often the case) it is often not clear which specification (and resulting estimate) is most appropriate, it is preferable to include all estimates from the same (or overlapping) subsets that meet other acceptance criteria.

In other literatures, meta-analysis is sometimes used to estimate the "true" value of some physical parameter (e.g., Bell et al. 2005, Ito et al. 2005, Levy et al. 2005). Willingness to pay for a risk reduction, however, is not some fixed and immutable constant of nature; it may vary systematically with risk attributes such as the type of illness or injury, the latency of the illness, and the duration of morbidity, as well as the number of lost life-years that can be anticipated. The value of a risk reduction may also vary systematically with the characteristics of the individual, including age, gender, and income, as well as with subjective risks and other co-morbidities. Thus one sample and one model, if sufficiently general, can provide estimates of the values of different types of risk reductions to different types of people. Indeed, using one data set and a sufficiently general model to capture this heterogeneity can produce better estimates of how VRR varies with these characteristics by eliminating between-study effects.

It is also possible that the same sample can be used with different, but equally plausible, specifications to yield different estimates of the value of the same risk reduction. In cases where the best functional form is unknown and multiple alternatives yield similar measures of fit, it is appropriate to preserve information about both the variation across specifications in the different point estimates of the VRR as well as the precision (standard error) for each individual point estimate. As noted above (in response to charge question 4.a.i), when using multiple estimates from a single study or dataset, it is important to consider how to weight individual estimates and to adjust for statistical dependence among them.

e. Does the Committee still favor analyzing the stated preference and hedonic wage estimates separately? If so, how should the separate results of these analyses be used in evaluating new policies? If not, how should they be combined in a single analysis?

The effects of risk and individual characteristics on VRR may be more important than the distinction between stated preference (SP) and revealed preference (RP) studies. However, wage-differential studies and SP studies seem to yield systematically different estimates, even for reasonably similar risks (e.g., traffic fatalities). The reasons for this difference are not well understood.

In evaluating how VRR varies with context, it may be necessary to distinguish SP and hedonic wage estimates to avoid confounding effects of risk or individual characteristics with study type. This does not imply that the two literatures must be treated independently. Indeed, to the extent that each literature

provides useful information about the VRR in a particular context, or the variation of VRR between contexts, it is important to combine their results. Results from risk-tradeoff studies can also provide useful information and should be considered for inclusion. Although risk-tradeoffstudies do not provide WTP estimates, they can be used to translate estimates of WTP to reduce one type of risk into WTP to reduce other types of risks. Of course, estimation errors would have to be compounded across these two stages.

Results from hedonic-wage and SP literatures can be combined using some of the methods described in response to charge question 2. In addition, even though wage-risk studies may not address the types of illness profiles that are relevant to EPA policy contexts, these studies are vitally important for validation of SP studies. Hedonic-wage estimates can serve as a benchmark for evaluating stated-preference estimates of the value of the "sudden death in the current period" illness profile. Consistency between SP and best-practices RP studies, for comparable types of risks and populations, will remain an important criterion for cross-validation of the estimates from SP studies. (Validation is more difficult for domains of SP studies which are not overlapped by available RP studies.)

f. Would the Committee support the development and application of separate means or ranges generated from the two segments of the literature? Given separate means and/or ranges from each segment, should the results be weighted and combined to produce a single point estimate or range? If so, how? Are other presentations of the results preferable? More generally, how should uncertainty in the estimated value(s) of mortality risk reductions be handled in benefits analyses?

The use of weighted averages of individual point estimates is only appropriate if these point estimates measure the same thing. Recent research highlights heterogeneity in WTP for risk reductions as a function of both the type of risk to be reduced and the characteristics of the affected population. If multiple estimates are available for the same context, then these can be averaged, and it is appropriate to consider some sort of weighting scheme that reflects the relative precision of the different point estimates. Weights that reflect relative precision are sometimes quantified as an inverse-standard-error weighting scheme, so that more precisely estimated (i.e. more certain) values are given greater weight than less precisely estimated values. As always, it will be important to recognize the uncertainty related to the choice of a statistical model as well as the uncertainty related to the standard error of the VRR estimate from any given statistical model.

4.7. Question 7 – Standardized Protocol

We are interested in developing a standardized protocol for updating the Agency's recommended mortality risk value estimates on a regular basis—for example, every 5 years or so—to incorporate new estimates from relevant economic valuation studies as they appear in the literature. Such a protocol might be based on the approach outlined in Section 5.1.1 or something similar. This approach, combined with a set of rigorous criteria for determining which new studies and value estimates are suitable for inclusion in the pool for meta-analysis, would allow the Agency to update its guidance in a more timely and transparent manner. (After a working protocol was put in place, it then could be modified over time to match changes in the Agency's general mortality risk valuation approach and meta-analysis methods, as necessary. See charge question 8.) Does the committee believe that developing such a protocol is feasible and desirable? Please explain.

The SAB believes that the Agency should establish a regular schedule for updating its value of risk reduction (VRR) estimates. The central-tendency estimate that the Agency currently uses is based on studies that are at least 20 and in some cases over 35 years old. Many of the studies included in the current pool may not satisfy the criteria for qualifying studies recommended by the Agency in the White Paper and further criteria recommended by the SAB in response to charge question 4. Moreover, the current estimate does not take into consideration the wealth of new studies published over the last 20 years that make use of better techniques, better data, and that better reflect current conditions. To avoid using VRR estimates based on decades-old and possibly obsolete research in the future, the Agency should establish a protocol for updating regularly the estimates of the value of risk reduction that it uses in its work.

The protocol should include a procedure for updating all of the information needed to construct the value of risk reduction. This should include the following:

- Identification of recent additions to the literature on valuing risk reductions, particularly related to mortality risk, as well as studies that provide new estimates of the income elasticity of the value of risk reduction.
- Assessment of the quality of those studies and the estimates contained therein according to criteria established by the agency, as discussed above. Studies that do not meet these criteria should be excluded from consideration.
- The estimates of risk reduction gleaned from the set of qualified studies should be put into comparable real dollar terms using appropriate income elasticity and inflation adjustments.
- The procedure for combining estimates should be in line with the recommendations in response to charge questions 2, 6 and 8.
- All of these procedures should be adaptable to take account of new information and the results of new research that might enable the Agency to employ a new methodology for updating its VRR estimates, such as through developing and parameterizing a structural benefit transfer model.

Updates of the Agency's estimates should be performed on a regular schedule in order to take advantage of new research as it becomes available. The exact timing of these updates will depend on the supply of new studies, the availability of Agency resources to devote to the task, and the nature of the review process for new estimates that the agency develops. The supply of research on valuing risk reductions has been growing in recent years as has the pace with which new studies are appearing and the Agency can have some influence on that supply through its research funding activities. While the supply of new research on this topic may be growing sufficiently fast to warrant annual updates of the VRR estimate, the requirements for review of new estimates produced by the Agency by the Scientific Advisory Board

may make it desirable from the Agency's perspective to update on a less frequent basis, say every 2 or 3 years, or even 5 years at the outside. All of these update schedules are a vast improvement over prior practice.

Regular updates of the value of risk reduction will require an education process to make legislators, administration officials, and the general public aware that estimates of the values of risk reductions are not static. They can be expected to evolve over time as data are improved and methods are refined. Change in the terminology used should assist in this regard, but in conjunction with its efforts to educate the public about the change in terminology, EPA should also take care to inform people about its plans for updating these values and provide information on why this is necessary and important.

4.8. Question 8 – Benefit Function Transfer Approach

In addition to the short-term issues that underlie charge questions 1-7, we are interested in supporting and conducting additional research to further develop EPA's health risk valuation methods over the longer-term. In particular, we would like to begin the transition from the point value transfer approach to a benefit function transfer approach. With this longer-term research and guidance development objective in mind, please answer the following questions:

a. Should EPA continue to use its current approach—that is, a point value or range of values, possibly with an adjustment for cancer risks—or is there now a sufficient body of empirical research to support the development of a more detailed form of functional benefit transfer?

As described above, the SAB recommends that EPA work toward developing a set of estimates of VRR for policy-relevant contexts (defined by risk and population characteristics), together with appropriate characterization of uncertainty about these estimates. The body of empirical research is clearly sufficient to estimate values for occupational accidents and may allow estimation of VRR for some other contexts (e.g., certain types of cancer and of respiratory or heart disease). VRR can also be distinguished by income and perhaps some other individual characteristics. Given the need for VRRs that differ by context, EPA's Science to Achieve Results (STAR) program could be used to fill this research gap.

b. If a functional transfer approach is feasible given the existing body of empirical results, should this be based on a meta-analysis or a calibrated structural preference function or perhaps some hybrid of these?

Alternative methods for characterizing the distribution of VRR and how it varies with risk and individual characteristics are discussed above (in response to charge question 2). The SAB recommends that EPA attempt to apply some of these approaches and evaluate the quality of the results for consistency with VRR estimates in particular contexts and for the plausibility of the pattern of results across contexts.

Moving toward a structural preference function appears to be desirable. It would provide an integrated, consistent framework for understanding how individuals trade off risks against consumption and income. By doing so, it would provide a stronger theoretical foundation for the benefit transfer task commonly faced by EPA: using data on relatively well-studied risks, such as sudden accidental death, to infer willingness to pay for reductions in other risks. Moreover, as noted by Smith et al. (2006), a structural approach may allow additional data on other aspects of individual choice to be brought to bear

on the problem. It may also provide a rigorous means for incorporating the results of risk-tradeoff studies which provide valuable information but are difficult to include in traditional calculations of willingness to pay for risk abatement.

Although a structural approach would provide many benefits, additional research is needed. For example, the existing literature has used a small number of restrictive functional forms. Before the structural approach will be ready for routine use, the effect of these restrictions must be investigated and the restrictions relaxed where possible. EPA should regard the structural approach as a high priority for research and an important long-term goal, but not yet as a replacement for traditional methods.

c. If the body of empirical literature is sufficient to estimate or calibrate some form of structural preference function, what are the key variables that should be included in such a function? That is, based on a priori theoretical considerations and previous empirical findings, which attributes of the affected individuals and the policy scenario should be included? What specifications are feasible given data availability?

As noted above, the theoretical and empirical literature on the structural approach is promising, but still at an early stage of development. The literature is not yet sufficient to estimate an authoritative model. As a research matter, a key initial consideration will be whether to formulate the model in terms of the attributes of risk (latency, morbidity, dread, etc.) or in terms of specific risks (cancer, heart disease). The former approach would be more versatile but the latter approach is likely to be more tractable in the short run. In research currently under review, for example, Cameron, DeShazo and Johnson (2010b) use both types of controls. Their stated preference conjoint choice study includes both the nature of the illness profile corresponding to a particular named health risk and the respondent's assessment of their personal subjective risk of the illness in question as well as their subjective impressions of the controllability of that type of risk.

d. Have the econometric issues we identified (unobserved heterogeneity, heteroskedasticity, and small sample size) been adequately addressed by the recent meta-analyses reviewed in Sections 4.1.1 and 4.2.3? Would the classical approaches that we suggest for overcoming these data limitations improve upon previous work? If a new meta-analysis is conducted, what statistical approach(es) would be preferred?

The econometric techniques that should be used in a meta-analysis will depend on the number of VRR estimates to be drawn from each study and the total number of observations available in the meta-analysis. For example, to be feasible, fixed effects estimators require a sufficient number of observations from each study. Random effects estimators assume that covariates in the model are uncorrelated with the error term, which may be reasonable under some circumstances but not others.

e. What role, if any, does the Committee believe that the life-cycle consumption and mortality risk framework could play in evaluating health risk reductions? In particular, does the Committee believe that this framework could be used as a foundation for some form of structural benefit transfer function?

A life-cycle consumption model can be particularly useful for helping to understand how individuals value risk reductions at different stages of the life-cycle, which is applicable to valuing risks that are

most prevalent for different ages and for evaluating effects of latency. Results of life-cycle models can be highly sensitive to parameters such as discount rates. Using data from stated preference and hedonic wage studies to parameterize a life-cycle model is an ambitious task. It faces all of the difficulties noted above for structural preference approach but in an even more complex form. Allowing utility functions to be age-dependent and to depend on risk characteristics in a manner that varies with age will be difficult. It is also true that the standard life-cycle model assumes people are expected utility maximizers, which may not be a valid assumption. Before pursuing this approach EPA should evaluate the literature that has estimated life cycle models for the purpose of understanding savings and retirement decisions. An important question is how well these models have worked in that context.

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APPENDIX A: EPA'S CHARGE TO THE SAB

MEMORANDUM

To: Holly Stallworth, DFO
Science Advisory Board Staff Office

From: Nathalie B. Simon, Associate Director
National Center for Environmental Economics

Date: December 16, 2010

Subject: Charge Questions for SAB-EEAC January 2011 meeting

The purpose of this memorandum is to transmit charge questions for consideration by the Science Advisory Board's Environmental Economics Advisory Committee (SAB-EEAC) during our upcoming consultation scheduled on January 20 and 21, 2011.

EPA and other agencies use a variety of tools, including benefit-cost analysis, to help inform regulatory and other public policy decisions that affect human health. When considering new regulations to reduce people's exposure to pollutants, EPA first estimates how much the various options would reduce mortality risks. EPA then calculates the benefits associated with those options by using published estimates of how much people are willing to pay for small reductions in their annual risks of dying. This estimate is commonly known as the "Value of Statistical Life" (VSL), but it is important to understand that this quantity does not measure the value of an individual life. Rather, the VSL is the total willingness to pay for small risk reductions summed over a large number of people. This estimate, together with other benefits of the regulation, are then compared to the costs.

EPA is now in the process of updating its guidance for conducting benefit-cost analysis, and has identified a number of important issues that should be considered. These are detailed in a white paper on "Valuing Mortality Risk Reductions in Environmental Policy," which will be submitted to the EPA's independent Science Advisory Board shortly for review and advice. The charge questions follow from a white paper submitted to the SAB-EEAC for review entitled "Mortality Risk Valuation for Environmental Policy." The paper addresses the following key issues:

- Terminology: Replacing the term "Value of Statistical Life," which has often been misunderstood as a measure of the value of individual lives, with the term "Value of Mortality Risk Reductions" (VMR). This change in terminology should help to avoid some of the confusion surrounding the interpretation of the VSL. It would not affect the results of the analysis itself, but rather how the benefits of reduced risks are reported and described.

- Cancer Differential: Taking into account potential differences in how much people would pay for reductions in their chances of dying from cancer relative to other causes when estimating the benefits of policies that reduce exposure to cancer-causing pollutants.

- Altruistic Effects: Taking into account that the amount of money people would pay for "public" risk reductions that affect everyone (like reductions in water pollution) may differ from what they would be willing to pay for "private" risk reductions that only affect the individual (say, choosing to install a water filter in your home). Many of the published estimates of willingness to pay are for private risk reductions, but since EPA regulations generally result in "public" risk reductions, accounting for these differences when estimating benefits could be important.

As indicated in the accompanying materials, advice on these issues will not only be important ultimately to the revision of our *Guidelines for Preparing Economic Analyses,* it will be of immediate relevance to the Agency in its pursuit of improved guidance on mortality risk valuation in particular. We look forward to the SAB-EEAC's review.

Please contact me if you have any questions about the attached charge.

Attachment
Cc: Al McGartland

Valuing Mortality Risk Reductions for Environmental Policy

1. Current EPA guidelines and standard practice use "Value of Statistical Life" (VSL) as the metric for valuing mortality risks. Section 3.1 of the white paper discusses the VSL terminology commonly used in mortality risk valuation exercises in greater detail. The white paper suggests that the Agency move away from using the traditional VSL terminology in favor of a new term of art for estimates of the marginal rate of substitution between health risks and income (see section 3.1). Specifically, the white paper suggests that the Agency refer to these estimates as the "value of mortality risk," and report the associated units using standard metric prefixes to indicate the size of the risk change, e.g., \$/mr/person/yr (dollars per milli[10^{-3}]-risk per person per year), or \$/μr/person/yr (dollars per micro[10^{-6}]-risk per person per year), etc. Does the Committee agree that the Agency should pursue such a change? Does the Committee believe that making these changes would ease or exacerbate the misunderstandings documented by Cameron (2010)? Would some other terminology or approach be preferable? Please explain.

   Experts generally agree that *value function transfers* can outperform *point value transfers* in cases where the characteristics of the risks and/or the exposed populations differ between the source studies and the policy context in measurable ways. That is, the more commodity- and individual-specific attributes that can be included in the benefit transfer exercise, the better the estimate of willingness to pay. Charge questions 2 and 3 inquire about whether applications of benefits transfer methods to value mortality risk reductions from environmental pollutants can be improved by controlling for more of the attributes that distinguish the source studies from the policy scenario.

2. The white paper concludes that research since the 2000 EPA Guidelines suggests that people are willing to pay more for mortality risk reductions that involve cancer than for risk reductions from accidental injury (see section 3.3). Our preliminary review suggests that a "cancer differential" of up to 50% over immediate accidental or "generic" risk valuation estimates may be reasonable. Conceptually, would the weight of evidence (both theoretical and empirical) suggest there is a cancer differential? If so, does the Committee believe that our estimate of the differential is appropriate. If not, how does the Committee recommend the Agency incorporate cancer differentials in benefits analysis involving reduced cancer risks?

3. Environmental policies generally provide public risk reductions. However, research, particularly stated preference research, provides willingness to pay estimates for both public risk reductions as well as private risk reductions. And, some research indicates that individuals' willingness to pay for public risk reductions may be different than that for private risk reductions. One factor that may contribute to these differences is altruism, which, all else equal, should make values for public risk reductions larger than those for private risk reductions.

   a. Should EPA rely on studies that estimate willingness to pay for both public and private risk reductions? If so, is it sufficient to control for this key characteristic in the modeling framework? Or, should EPA limit the analysis to studies according to the type of risk reduction in the study? If using only one type of study is recommended, should EPA use studies that estimate public or private risk reductions? If we are to limit the studies used to one type, is there a role for the excluded group?

   b. Studies that estimate willingness to pay for public risk reductions may allow EPA to better capture altruistic preferences in benefit-cost analysis. Did the white paper adequately capture

the theory on how to incorporate altruism into the value of mortality risk reduction? How should altruistic preferences be treated in benefit-cost analysis? Should the Agency incorporate altruism into the value of mortality risk reductions, even if we are unable to distinguish the specific form of altruism involved (i.e., paternalistic or non-paternalistic)? More generally, what alternatives should the Agency pursue in the short-term to appropriately account for altruistic preferences when evaluating public programs, if any?

4. The two primary literatures used to assess willingness to pay for mortality risk reductions are stated preference studies and hedonic wage studies. The white paper assembles two databases summarizing studies in both literatures, capturing much of the information outlined in number 3 of the SAB-EEAC's recommendations dated October 2007 (see section 4).[6] These studies, or a subset thereof, would form the basis of revised guidance in the near term as well as possible future meta-analyses.

   a. The selection criteria employed in creating the two data sets are carefully outlined in the paper (see sections 4.1.2 and 4.2.4). Please consider these criteria in answering the following questions:
      i. Should additional criteria be added to screen studies for inclusion in the datasets? If so, please specify those criteria. Should any criteria be eliminated or modified?
      ii. Section 4.2.2 of the white paper discusses problems of measurement error associated with some common sources of occupational risk information among other concerns with the hedonic wage approach. Should EPA limit its selection of hedonic wage studies by the source of occupational risk information? For instance, studies relying on data from the Society of Actuaries (SOA) have been omitted from the described data set. Should the SOA studies be excluded? Should other sources be excluded as well?

   b. Should any of the studies included in the datasets be eliminated? If so, please specify those studies and the reasons for eliminating them.

   c. Is the committee aware of relevant empirical studies in the stated preference and hedonic wage literatures that are not adequately captured in this review? If so, please provide citations.

5. Income elasticities are discussed briefly in section 5 of the white paper. In keeping with Agency practice, we created the two databases by adjusting all estimates for income growth over time using an income elasticity value of 0.5 based on prior Agency reviews of the literature and results Viscusi and Aldy, 2003. In addition, we adjusted all estimates for inflation as well as for purchasing power parity where necessary, as recommended by the EEAC's October 2007 report. Does the Committee agree with this approach to accounting for income growth over time? Does the Committee believe the Agency should adjust its value of income elasticity for use in policy analysis in light of recent findings in the literature? If so, what value or range of values does the Committee believe should be used?

6. The white paper describes a simplified approach for updating the Agency's recommended mortality risk value estimate(s) (see section 5.1.1). This approach involves fitting a parametric distribution to the set of estimates from selected studies. This is similar to the approach used for EPA's current default VSL estimate.

[6] The recommendations included specific features of hedonic wage and stated preference studies that should be identified in the studies.

a. Should EPA pursue this approach for updating its mortality risk valuation guidance in the near term (until a more detailed analysis can be conducted)?
b. If so, should the databases on which values are based be created using only one estimate drawn from each study or multiple estimates from each study?

c. If only one estimate per study should be used, what criteria should the Agency apply in selecting the appropriate estimate? How would these criteria vary from one segment of the literature to the other? The paper describes the methods used to select independent estimates from each study. Does the Committee agree with the methods used?

d. How important is it that estimates be drawn from non-overlapping subsamples? If multiple estimates per study are recommended in the construction of the meta-datasets, should the estimates be selected to avoid overlapping sub-samples?

e. Does the Committee still favor analyzing the stated preference and hedonic wage estimates separately? If so, how should the separate results of these analyses be used in evaluating new policies? If not, how should they be combined in a single analysis?

f. Would the Committee support the development and application of separate means or ranges generated from the two segments of the literature? Given separate means and/or ranges from each segment, should the results be weighted and combined to produce a single point estimate or range? If so, how? Are other presentations of the results preferable? More generally, how should uncertainty in the estimated value(s) of mortality risk reductions be handled in benefits analyses?

7. We are interested in developing a standardized protocol for updating the Agency's recommended mortality risk value estimates on a regular basis—for example, every 5 years or so—to incorporate new estimates from relevant economic valuation studies as they appear in the literature. Such a protocol might be based on the approach outlined in Section 5.1.1 or something similar. This approach, combined with a set of rigorous criteria for determining which new studies and value estimates are suitable for inclusion in the pool for meta-analysis, would allow the Agency to update its guidance in a more timely and transparent manner. (After a working protocol was put in place, it then could be modified over time to match changes in the Agency's general mortality risk valuation approach and meta-analysis methods, as necessary. See charge question 8.) Does the committee believe that developing such a protocol is feasible and desirable? Please explain.

8. In addition to the short-term issues that underlie charge questions 1-7, we are interested in supporting and conducting additional research to further develop EPA's health risk valuation methods over the longer-term. In particular, we would like to begin the transition from the point value transfer approach to a benefit function transfer approach. With this longer-term research and guidance development objective in mind, please answer the following questions:

   a. Should EPA continue to use its current approach—that is, a point value or range of values, possibly with an adjustment for cancer risks—or is there now a sufficient body of empirical research to support the development of a more detailed form of functional benefit transfer?

b. If a functional transfer approach is feasible given the existing body of empirical results, should this be based on a meta-analysis or a calibrated structural preference function or perhaps some hybrid of these?

c. If the body of empirical literature is sufficient to estimate or calibrate some form of structural preference function, what are the key variables that should be included in such a function? That is, based on a priori theoretical considerations and previous empirical findings, which attributes of the affected individuals and the policy scenario should be included? What specifications are feasible given data availability?

d. Have the econometric issues we identified (unobserved heterogeneity, heteroskedasticity, and small sample size) been adequately addressed by the recent meta-analyses reviewed in Sections 4.1.1 and 4.2.3? Would the classical approaches that we suggest for overcoming these data limitations improve upon previous work? If a new meta-analysis is conducted, what statistical approach(es) would be preferred?

e. What role, if any, does the Committee believe that the life-cycle consumption and mortality risk framework could play in evaluating health risk reductions? In particular, does the Committee believe that this framework could be used as a foundation for some form of structural benefit transfer function?