

## FINAL MEMORANDUM | November 30, 2016

**TO** Elaine Shen, South Coast Air Quality Management District  
**FROM** Amelia Geggel, Lindsay Ludwig, and Henry Roman, Industrial Economics, Incorporated  
**SUBJECT** Final Study Evaluation Criteria for Epidemiological and Economic Studies

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In its role as air pollution control agency for the South Coast Air Basin, the South Coast Air Quality Management District (SCAQMD) develops air pollution control plans to help this portion of California achieve compliance with Federal and State air quality standards. Development of the regional Air Quality Management Plan (AQMP) includes considerations of the socioeconomic impacts of that plan, including its expected benefits and costs. SCAQMD's Socioeconomic Analysis of the AQMP includes a detailed assessment of the benefits of reducing air pollutant concentrations. Regulatory benefit analyses such as this typically require large datasets covering a wide array of information including, but not limited to, baseline rates of disease, demographic data, concentration-response data, and valuation data. A review of the Socioeconomic Analysis for the 2012 AQMP by Abt Associates identified the following ways in which the benefits analysis could be strengthened<sup>1</sup>:

- Instituting a more transparent and systematic process for conducting literature reviews relevant to the Socioeconomic Assessment;
- Clarification of benefits transfer approaches that may be used to adjust concentration response functions or benefit valuation inputs; and
- Provide greater information about uncertainty in benefits analysis, both qualitative and quantitative.

As it prepares for the 2016 AQMP Socioeconomic Analysis, SCAQMD needs to ensure that it is applying the most up to date, scientifically defensible methods and inputs for calculating the benefits to society resulting from air pollution strategies. As the first step in this process, IEc has developed evaluation criteria that will be used to select and recommend studies for use in SCAQMD's 2016 AQMP Socioeconomic Assessment.<sup>2</sup> In this memorandum, we outline our proposed criteria related to the review of both epidemiological and economic studies.

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<sup>1</sup> Abt Associates, Inc. 2014. Review of the SCAQMD SOCIOECONOMIC ASSESSMENTS. Prepared for South Coast Air Quality Management District. Available at <http://www.aqmd.gov/home/library/clean-air-plans/air-quality-mgt-plan/socioeconomic-analysis>.

<sup>2</sup> We would like to acknowledge and thank Lisa Robinson and Dr. George Thurston for their advisory roles on this project.

## CRITERIA FOR EPIDEMIOLOGICAL STUDIES

Population-based epidemiological studies provide key evidence on the magnitude of the relationship between ambient environmental exposures and health outcomes. Data reported in these studies inform the concentration-response functions used in EPA's BenMAP model that predict the change in a given health outcome for each unit change in pollutant exposure. These population-based studies will therefore be the focus of our health effects literature review.

IEc will critically evaluate studies against the criteria in Exhibit 1. We start with a set of general criteria that focus on making sure the documents are of high quality (e.g., peer-reviewed), accessible (published in English), and focused to provide maximum information about the advances in the air pollution health benefits literature since the previous Socioeconomic Assessment was conducted in 2012. IEC's literature review will focus on ambient exposures to ozone (O<sub>3</sub>), fine and coarse particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>), nitrogen oxides (NO<sub>x</sub>), and sulfur dioxide (SO<sub>2</sub>) for the years indicated in Exhibit 1. This review will not include exposure to volatile organic chemicals (VOCs), due to the potentially large variance in the composition of VOCs between studies and geographic areas, and the difficulty in assessing local hotspots. The years specified for each pollutant will ensure that this review builds on, and does not repeat, previous literature reviews conducted by SCAQMD or other agencies. The years shown in Exhibit 1 were chosen based on the end dates of past SCAQMD reviews of those pollutants. To the extent that other agencies have conducted comprehensive reviews that cover some portion of these time periods (e.g., EPA Integrated Science Assessment documents), IEC will consider their findings as part of its overall review. The review will ensure that the 2016 AQMP Socioeconomic Assessment includes the latest science on human health effects of these key criteria air pollutants and will emphasize both advances in our understanding of air pollution-related health outcomes previously quantified by the SCAQMD in its Air Quality Management Plans as well as new outcomes for which prior evidence did not support quantification. The goal of the review is to identify studies or groups of studies that contribute to the existing body of evidence regarding the likelihood or magnitude of a causal or likely causal relationship between air pollutant exposures and health outcomes.

The next set of criteria address the study area and study population. When comparing studies of similar quality, IEC will give preference to studies where the exposures and populations assessed are more similar to those found in the South Coast Air Basin. Because the chemical composition of particulate matter differs based on pollution sources and geography, our criteria emphasize studies conducted within California or in the western United States, when available, as well as studies whose range of pollutant exposures includes levels found in the study area. We believe that the potential for differences in pollution levels, particle and pollutant mix, health care systems, and activity patterns in countries outside of the U.S. or Canada make results observed in those countries less applicable to the SCAQMD study area. We will also give preference to studies that assess populations similar to those living in the Basin, if available. Additionally, IEC will evaluate whether studies report relative risks stratified by population attribute, such as socioeconomic status or baseline health status. These

population-specific functions would allow SCAQMD to assess the impact of air quality changes on subpopulations in the Basin.

The remaining criteria address study quality. IEc will focus this review on population-based epidemiological studies and will exclude studies using animal or in vitro models, because of significant uncertainties extrapolating from these types of studies to human exposures. (We may identify as part of the review controlled human exposure studies that augment epidemiological evidence for morbidity outcomes not previously included in prior Socioeconomic Assessments, though these studies would not for the sole basis for a concentration-response function.) IEc will assess the quality of each study by evaluating how the authors' controlled for factors that may introduce error or bias into the reported exposure-response relationship, such as those listed in Exhibit 1. High quality studies should clearly acknowledge and discuss potential residual sources of uncertainty and their implications for the study results, and they should provide quantitative estimates of uncertainty in the results that could be incorporated in the BenMAP benefits analysis. Information on the potential lag time between exposure and outcome and whether study results identified a threshold exposure level will also be considered, as both can be important elements of quantifying and monetizing air quality benefits. Finally, we will prioritize studies that report changes in morbidity or mortality incidence, rather than changes in the exacerbation of symptoms of existing cases, because economic valuation estimates for the former are much more likely to be found in the literature.

**EXHIBIT 1. SELECTION CRITERIA FOR EPIDEMIOLOGICAL STUDIES**

CRITERIA
<b>GENERAL:</b>
<ol style="list-style-type: none"> <li>1. Study is peer-reviewed.</li> <li>2. Study is written in English.</li> <li>3. Study measures exposure to at least one of the following pollutants: O<sub>3</sub>, PM<sub>2.5</sub>, PM<sub>10</sub>, NO<sub>x</sub>, SO<sub>2</sub>,</li> <li>4. Preference given to studies or groups of studies that significantly advance our understanding of the relationship between air pollution exposures and mortality and morbidity endpoints, including those endpoints previously quantified by the SCAQMD in its Air Quality Management Plans as well as new endpoints.</li> <li>5. Study was published within the following timeframes:               <ol style="list-style-type: none"> <li>a. PM<sub>2.5</sub>/PM<sub>10</sub>: 2012 - present</li> <li>b. NO<sub>2</sub>: 2012 - present</li> <li>c. O<sub>3</sub>: 2007 - present</li> <li>d. SO<sub>2</sub>: 2003 - present</li> </ol> </li> </ol>
<b>GEOGRAPHY AND STUDY POPULATION:</b>
<ol style="list-style-type: none"> <li>6. Study measures exposures at or near ambient levels found in the South Coast Air Basin. Order of preference of study location:               <ol style="list-style-type: none"> <li>a. South Coast Air Basin (Los Angeles, Orange, Riverside, and San Bernardino Counties)</li> <li>b. Within State of California</li> <li>c. Within Western United States</li> <li>d. Within United States or Canada</li> </ol> </li> <li>7. Study uses study population with similar characteristics as found in Los Angeles, Orange, Riverside, and San Bernardino counties.</li> </ol>
<b>STUDY DESIGN:</b>
<ol style="list-style-type: none"> <li>8. Study is population-based, preferably using cohort and case-control epidemiological study designs. Controlled human exposure studies may be evaluated for supporting evidence. Animal and in-vitro studies excluded.</li> <li>9. Study controls for factors that may obscure the true concentration-response relationship, including selection bias, misclassification, recall bias, confounding (including by other pollutants), effect modification, mortality displacement, loss to follow-up, etc.</li> <li>10. Study appropriately assesses any potential lag between exposure and outcomes.</li> <li>11. Study appropriately assesses any potential exposure thresholds for health outcomes.</li> <li>12. Study clearly presents information about uncertainty in results to facilitate evaluation and comparison with other studies.</li> <li>13. Prefer studies that assess changes in the risk of incidence of disease, rather than exacerbation of existing cases or changes in symptoms.</li> </ol>

### CRITERIA FOR ECONOMIC STUDIES<sup>3</sup>

The economics literature provides a variety of ways to quantify the dollar value of changes in the risk of air pollution-related health impacts. For mortality risk reductions, benefits are quantified using willingness-to-pay (WTP) estimates for small risk reductions that are scaled to a value per statistical life (VSL). The WTP estimates from which the VSL is derived are estimated via: (1) revealed-preference wage-risk studies; (2) stated-preference surveys; and (3) meta-analysis of (primarily) wage-risk studies. For morbidity risk reductions, benefits are quantified using either WTP estimates to avoid an adverse health outcome or cost-of-illness (COI) estimates associated with that outcome. WTP estimates are usually preferred because they tend to capture a wider array of health related costs, including pain and suffering, while COI estimates are often limited to direct medical expenditures and are thus viewed as lower bounds on the value of an adverse health outcome. This memorandum describes potential evaluation criteria for both the mortality and morbidity literature.

#### Mortality Literature

In 2010, the U.S. Environmental Protection Agency (EPA) assembled two databases summarizing the two primary literatures used to assess WTP for mortality risk reductions: revealed-preference wage-risk studies and stated-preference studies.<sup>4</sup> EPA also outlined the selection criteria employed in creating these two databases. The objective of the selection criteria is to exclude low-quality studies and ensure applicability in the United States. The Science Advisory Board-Environmental Economics Advisory Committee (SAB-EEAC) subsequently reviewed these selection criteria and added to them.<sup>5</sup>

SAB-EEAC has also provided guidance on the use of meta-analysis to combine VSL estimates. SAB argues that the appropriate statistical approach to be used in a meta-analysis varies and depends upon factors such as the total number of observations available in the meta-analysis and the number of VSL estimates to be drawn from each study.<sup>6</sup> Our interpretation of SAB's guidance is that the criteria for stated preference and revealed preference studies should also be applied to meta-analyses that draw on these bodies of literature.

Since EPA and SAB-EEAC's review, two relevant reviews have occurred – one for the U.S. Department of Transportation (DOT) and one for the U.S. Department of Health and

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<sup>3</sup> The discussion of the criteria for the willingness-to-pay studies used to value mortality and morbidity risk reductions is an edited version of the discussion in: Robinson, L.A. and J.K. Hammitt. 2015(a). "Valuing Reductions in Fatal Illness Risks: Implications of Recent Research." *Health Economics*. Early View, and Robinson, L.A. and J.K. Hammitt. 2015(b). "The Effect of Income on the Value of Mortality and Morbidity Risk Reductions." Prepared for the U.S. Environmental Protection Agency under subcontract to Industrial Economics, Incorporated.

<sup>4</sup> U.S. Environmental Protection Agency (EPA). 2010b. "Valuing Mortality Risk Reductions for Environmental Policy: A White Paper." SAB Review Draft. National Center for Environmental Economics, U.S. Environmental Protection Agency.

<sup>5</sup> Kling, C.L. et al. 2011. "Review of 'Valuing Mortality Risk Reductions for Environmental Policy: A White Paper' (December 10, 2010)." Memorandum to Lisa P. Jackson, EPA Administrator, from the EPA Science Advisory Board and Environmental Economics Advisory Committee. EPA-SAB-11-011.

<sup>6</sup> *Ibid.*

Human Services (HHS).<sup>7,8</sup> These reviews used selection criteria that are somewhat modified from those suggested by SAB-EEAC, in order to reflect the evolution of the literature. IEC proposes to use criteria for the SCAQMD review that are based on those used for the HHS review because these criteria were developed recently and take into account current best methodological practices.<sup>9</sup> These criteria are presented in Exhibit 2.

**EXHIBIT 2. CRITERIA FOR MORTALITY VALUATION STUDIES**

CRITERIA
<b>GENERAL:</b>
<ol style="list-style-type: none"> <li>1. Study is written in English.</li> <li>2. Study is publicly available.</li> <li>3. Study is based on a sample of the general U.S. population.</li> </ol>
<b>FOR REVEALED-PREFERENCE STUDIES:</b>
<ol style="list-style-type: none"> <li>4. Study uses hedonic methods that address the trade-off between wages and job-related risks.</li> <li>5. Study relies on high-quality risk data, equal or superior to the Census of Fatal and Occupational Injuries (limits studies to those published from 2003 - present).</li> <li>6. Study controls for potentially confounding factors, such as nonfatal injury risk as well as both industry and occupation.</li> </ol>
<b>FOR STATED-PREFERENCE STUDIES:</b>
<ol style="list-style-type: none"> <li>7. Study elicits values for private risk reductions that accrue to the respondent.</li> <li>8. Study expresses the risk change as a probability, not as a life extension.</li> <li>9. Study estimates willingness-to-pay, not willingness-to-accept compensation.</li> <li>10. Study provides evidence of validity, including sensitivity of willingness to pay to changes in risk magnitude (more likely to be met by studies published from 1994 - present).</li> </ol>

*General Criteria:* These criteria relate to the context in which the valuation estimates are likely to be applied. Because SCAQMD’s analyses are intended to inform decision-makers and the general public, those reviewing the analyses must be able to access and read the underlying data sources. Criterion 1, “be written in English,” directly relates to this accessibility and is consistent with the SAB-EEAC recommendations (Kling et al. 2011, p. 15).

Criterion 2, “be publicly available,” is somewhat broader than the criteria used for epidemiological studies and that suggested by the SAB-EEAC, who suggest limiting the

<sup>7</sup> U.S. Department of Transportation. 2014. *Guidance on Treatment of the Economic Value of a Statistical Life (VSL) in Departmental Analyses - 2014 Adjustment*. Memorandum to Secretarial Officers and Modal Administrators from P. Rogoff, Acting Under Secretary for Policy, and K. Thomson, General Counsel.

<sup>8</sup> Robinson, L.A. and J.K. Hammitt. 2015(a). “Valuing Reductions in Fatal Illness Risks: Implications of Recent Research.” *Health Economics*. Early View.

<sup>9</sup> These criteria are also applied in Robinson, L.A. and J.K. Hammitt. 2015(b). “The Effect of Income on the Value of Mortality and Morbidity Risk Reductions.” Prepared for the U.S. Environmental Protection Agency under subcontract to Industrial Economics, Incorporated.

search to the peer-reviewed literature.<sup>10</sup> However, the SAB-EEAC also notes that unpublished studies may have some advantages, particularly because they provide more recent results and may incorporate methodological improvements (Kling et al. 2011, p. 20). Thus we include publicly-accessible working papers and reports as well as peer-reviewed articles because they include the most up-to-date research and because the factors considered by referees for peer reviewed journals, such as novelty and innovation, may differ from the factors of interest for policy analysis. We will evaluate unpublished studies using the same criteria as published studies (detailed below), with additional emphasis placed on the most recent unpublished literature, which would indicate cutting-edge research. A more critical evaluation of older unpublished literature may be necessary to determine the reasons why the study was not published in a peer-reviewed journal and whether these reasons would limit the study's usefulness to SCAQMD.

Criterion 3, "based on a representative sample of the general U.S. population," ensures that we select studies that rely on probability samples of the adult U.S. population, rather than convenience samples or samples of small local areas. This criterion reflects SCAQMD's interest in developing estimates for application in the Socioeconomic Analysis of their AQMP, which affects the population of the South Coast Air Basin.<sup>11</sup> Ideally we would rely on studies that were based on a representative sample of the South Coast Air Basin population or of areas with populations very similar to that of the Basin. We expect, however, that most economic valuation studies are likely to include a sample representative of the U.S. population as a whole. To the extent that we can find quality studies with study populations that are similar (e.g., urban populations in California or in the western U.S.) we will give them preference.

*Criteria for revealed-preference studies:* For studies that rely on market behavior to estimate the VSL, under Criterion 4 we limit the scope to those that consider the trade-off between compensation and job-related risks, controlling for influencing factors. Some revealed-preference studies instead evaluate averting behaviors; i.e., defensive measures or consumer products used to protect against perceived risks. These studies are applied infrequently in policy analysis due to concerns about their limitations and were not addressed by the SAB-EEAC review.

Under Criterion 5, we limit the studies to those that rely on risk data at least as good as the Census of Fatal Occupational Injuries (CFOI). The CFOI was implemented in 1992 by the Bureau of Labor Statistics (BLS), and is based on review of a comprehensive set

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<sup>10</sup> We are able to apply this broader criterion to the economic literature because it is a smaller field than the epidemiological literature. Therefore, it is possible to search for and evaluate studies that are not peer-reviewed. On the other hand, peer-reviewed status represents a clear, defensible criterion upon which the larger body of epidemiological literature can be assessed.

<sup>11</sup> As discussed earlier, the SAB-EEAC (Kling et al. 2011, pp. 14-18) notes that ideally the studies would address the specific population affected by each policy; however, the VSL literature is not yet well-enough developed to support such differentiation. This criterion excludes wage-risk studies based on extremely dangerous jobs or specific causes of death, as the SAB-EEAC recommends. In discussing sampling issues, the SAB-EEAC also suggests developing a criterion that reflects the precision of the estimate. Rather than express this as a selection criterion, we provide information on standard errors when summarizing the results from the selected studies.

of records supplemented by additional confirmation of the data.<sup>12</sup> Thus it represents a substantial improvement over the data sources previously available. This criterion is consistent with the SAB-EEAC recommendations (Kling et al. 2011, p. 19).<sup>13</sup>

Criterion 6, related to controls for potentially confounding factors, requires some judgment. Consistent with the SAB-EEAC (Kling et al. p. 18) we consider whether the study addresses nonfatal injury risks and controls for industry and occupation, as well as other potentially important confounding factors. Given the number of factors that can influence the relationship between wages and risks, there is no clear dividing line between studies that do, and do not, provide sufficient controls. Our literature review will describe the characteristics of the models used in presenting the results for the wage-risk studies. We will then evaluate the quality of the study based on our determination of whether sufficient controls were applied.

In evaluating the available meta-analyses, we will consider whether they address the study characteristics discussed above, either by using them as selection criteria or by controlling for them in the modelling.

*Criteria for stated-preference studies:* For studies that rely on surveys, under Criterion 7 we select those that elicit individual WTP for reductions in the respondent's own risks.<sup>14</sup> We exclude studies that instruct the respondent to consider risk reductions that accrue to the community of which he or she is a part, or that elicit the respondent's WTP for risk reductions that accrue to others. This criterion is narrower than the criteria suggested by the SAB-EEAC, which indicate that EPA should include studies of both public and private risk reductions when estimating the VSL (Kling et al. 2011, pp. 2, 12-13). However, we believe that this narrower criterion is more appropriate for SCAQMD's application because benefit-cost analyses generally assume that each individual is the best judge of his or her own welfare. In addition, the available research on public risk reductions is limited and, in some cases, provides counter-intuitive results. More research is needed to resolve these issues and address concerns about the validity of the results.

Under Criterion 8, we also limit our selection of stated-preference studies to those that express the risk change as a probability (or frequency) rather than as life extension. We are aware of only one U.S. study that directly elicits values for life extension.<sup>15,16</sup> While it suggests that the life extension approach is promising, more work is needed, in particular to ensure that respondents understand that the risk reduction affects each year of life rather than adding time at the end of the life when one's quality of life is likely to have

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<sup>12</sup> Although both our criterion and the criterion recommended by the SAB-EEAC allow for use of other data sources that are equivalent to or better than the CFOI, we are not aware of another national U.S. data source that currently meets this standard.

<sup>13</sup> This criterion excludes studies based on Society of Actuaries data as recommended by the SAB-EEAC (Kling et al. 2011, p. 17).

<sup>14</sup> This criterion is implicit in the criteria for revealed preference studies, because the focus on wage-risk studies means that all of the selected studies address an individual's willingness to trade-off changes in earnings for changes in his or her own risks.

<sup>15</sup> Morris, J. and J.K. Hammitt. 2001. "Using Life Expectancy to Communicate Benefits of Health Care Programs in Contingent Valuation Studies." *Medical Decision Making*. 21: 468-478.

<sup>16</sup> We focus here on primary research, not on the common practice of deriving a value per statistical life year (VSLY) from a VSL estimate using simple assumptions about the relationship between the VSL and life expectancy.

declined. While not explicitly discussed in the 2011 SAB-EEAC report, this criterion is consistent with the recommendations of an earlier SAB report as well as a National Academies study commissioned by EPA, which each address the limitations of the available value per statistical life-year (VSLY) research.<sup>17,18</sup>

Criterion 9 requires that stated-preference studies elicit WTP rather than WTA, consistent with the SAB-EEAC recommendations (Kling et al. 2011, p. 16).<sup>19</sup> Because government policies and regulations typically involve expenditures for improvements from the status quo rather than compensation for damages, WTP is conceptually the more appropriate measure. WTP is also more frequently studied and the estimates are generally considered more reliable; the large and variable differences between estimated WTP and WTA are poorly understood.<sup>20</sup>

Finally, under Criterion 10, we require that stated-preference studies provide evidence of validity, consistent with the discussion in the SAB-EEAC report (Kling et al. 2011, pp. 5-6, 16). A major concern is that respondents may not report their true WTP because the payment is hypothetical. In addition, research suggests that survey respondents often do not understand small probabilities. Thus we focus in particular on scope tests that indicate whether estimated WTP is sensitive to the magnitude of the risk reduction. We select only those studies that (1) include an internal or external scope test, and (2) find that WTP is at least somewhat sensitive to the change in risk, highlighting those that find that the change in WTP is close-to-proportionate to the risk change as demonstrating particularly strong evidence of validity.<sup>21</sup>

As is the case for the revealed preference studies, we apply the same criteria to the available stated preference meta-analyses as to the individual studies, considering whether the meta-analyses use these characteristics as selection criteria or control for them in the modelling. Where meta-analyses include both revealed and stated preference studies, we consider the criteria that apply to both types of studies.

While these criteria do not explicitly address the date when the studies were completed, they do so implicitly. The first wage-risk study that relied on CFOI data was published in 2003; thus Criterion 6 (data at least equal in quality to the CFOI) effectively limits our selection of revealed-preference studies to those published in 2003 or later. The starting

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<sup>17</sup> Cropper, M. et al. 2007. "SAB Advisory on EPA's Issues in Valuing Mortality Risk Reduction." Memorandum from the Chair, Science Advisory Board, and the Chair, Environmental Economics Advisory Committee, to EPA Administrator Stephen L. Johnson. EPA-SAB-08-001.

<sup>18</sup> National Academies. 2008. *Estimating Mortality Risk Reduction and Economic Benefits from Controlling Ozone Air Pollution*. Committee on Estimating Mortality Risk Reduction Benefits from Decreasing Tropospheric Ozone Exposure. Washington D.C.: National Academies Press.

<sup>19</sup> This criterion primarily affects the selection of stated-preference studies because revealed preference studies typically address a market equilibrium rather than a change that can be characterized as WTP or WTA. However, Kniesner, Viscusi, and Ziliak (2014) find that there is not a significant divergence between WTP and WTA when estimated using revealed preferences for job-related risks.

<sup>20</sup> While standard economic theory suggests that WTP and WTA will be similar in many cases, prospect theory suggests that the endowment effect and loss aversion may lead to substantial differences.

<sup>21</sup> External scope tests compare WTP between subsamples of respondents presented with different risk changes, while internal scope tests compare WTP for different risk changes from the same respondents. External tests are preferred because internal tests can be influenced by a respondent's effort to provide internally consistent responses.

point is not as clearly defined for the stated-preference studies. However, we exclude studies published in 1993 or earlier for several reasons. First, they were conducted before the issuance of an expert panel report that significantly influenced the conduct of stated-preference studies.<sup>22</sup> Studies completed after that time are more likely to meet Criterion 10, related to evidence of validity. Second, most of the older studies use small, specialized samples that are not representative of the overall U.S. population. Third, preferences elicited over 20 years ago may not accurately reflect preferences at the present time.

#### Morbidity Literature

The value of morbidity risk reductions has received less attention than the value of mortality risk reductions. Therefore, fewer studies are available and the available research is not likely to meet the stringent criteria IEC is proposing for the mortality literature. The most recent review of the morbidity literature that we are aware of is the Organization for Economic Cooperation and Development's (OECD's) 2010 "Review of recent policy-relevant finding from the environmental health literature."<sup>23</sup> This review provides a broad overview of the monetary valuation of environmental health risks, with a focus on non-fatal health impacts. The OECD review provides some general guidance on how to evaluate the quality of morbidity studies. In particular, the review provides the following criteria for WTP studies:

- Low quality – Clear serious methodological weakness and/or low sample size less than 200
- Medium quality – Some methodological weakness and/or sample size between 200 and 500
- High quality – State-of-art method and sample size greater than 500

The OECD review also suggests the following guidelines for evaluation of the COI evidence base for a given health endpoint:

- Low quality – Less than two studies worldwide; no European Union (EU) studies in the past five years
- Medium quality – Two to three studies worldwide; one to two EU studies in the past five years
- High quality – Greater than three studies worldwide; greater than two EU studies in the past five years

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<sup>22</sup> National Oceanic and Atmospheric Administration. 1993. "Report of the NOAA Panel on Contingent Valuation." (Arrow, K., R. Solow; P.R. Portney, E.E. Leamer, R. Radner, and H. Shuman.) *Federal Register*. 58: 4601-4614.

<sup>23</sup> Hunt, A. and J. Ferguson. 2010. "Review of recent policy-relevant finding from the environmental health literature." Prepared for the Organization for Economic Cooperation and Development. ENV/EPOC/WPNEP(2009)9/FINAL.

These criteria are general and subjective. SCAQMD requires more concrete criteria that can be objectively applied to the literature. Exhibit 3 presents the evaluation criteria for morbidity valuation studies proposed by IEC for SCAQMD.<sup>24</sup>

**EXHIBIT 3. CRITERIA FOR MORBIDITY VALUATION STUDIES**

CRITERIA
<b>GENERAL:</b>
<ol style="list-style-type: none"> <li>1. Study is publicly available.</li> <li>2. Study is written in English.</li> <li>3. Study is conducted in the U.S.</li> </ol>
<b>FOR STATED-PREFERENCE STUDIES:</b>
<ol style="list-style-type: none"> <li>4. Study elicits values for private risk reductions that accrue to the respondent.</li> <li>5. Study estimates WTP, not WTA compensation.</li> </ol>
<b>FOR COI STUDIES:</b>
<ol style="list-style-type: none"> <li>6. Study includes clear description of the elements that make up the COI estimate.</li> <li>7. Study includes clear description of health endpoint and estimates incidence-based or prevalence-based cost as appropriate for the health endpoint evaluated.</li> <li>8. Prefer studies that estimate costs specific to affected groups (especially, affected age groups).</li> </ol>

*General criteria:* Our general criteria are similar to those applied to the VSL studies. Studies must be written in English and publicly available. Publicly available studies include peer-reviewed articles as well as publicly-accessible working papers and reports (e.g., COI report published by CARB). For morbidity studies, rather than focusing on those that address the national population, we also include U.S. studies that are limited to particular localities.<sup>25</sup> For COI studies, health care costs in the U.S. may differ from those abroad and may differ based on location within the U.S. We will only select COI studies that use U.S. data with a preference for studies that provide regional estimates.

*Criteria for stated-preference studies:* We focus on stated preference studies because of the concerns about averting behavior studies noted in the previous chapter, and because the wage-risk studies generally focus on fatal rather than nonfatal injuries.<sup>26</sup> We again select only studies that address WTP rather than WTA. Because very few studies are available, we select all that meet these criteria, without further screening for evidence of

<sup>24</sup> General criteria and those for stated-preference studies were developed for and applied in Robinson, L.A. and J.K. Hammitt. 2015(b). "The Effect of Income on the Value of Mortality and Morbidity Risk Reductions." Prepared for the U.S. Environmental Protection Agency under subcontract to Industrial Economics, Incorporated.

<sup>25</sup> Many of the quantified morbidity risk reductions in air pollution and other analyses affect children rather than adults; however, in our selection criteria we again focus on values for adults. Because children generally lack the independent financial means as well as cognitive ability needed to respond to WTP questions, related research generally elicits parental WTP. We describe the limitations associated with studies that elicit the respondent's WTP for risk reductions that accrue to others above.

<sup>26</sup> Wage-risk studies often control for nonfatal injury rates, and may provide values for nonfatal injuries expressed as the overall injury rate, the rate for injuries severe enough to result in a lost workday, or the rate of lost workdays, rather than as values for injuries of particular types.

validity. However, we again exclude studies published in 1993 or earlier, given the likely methodological improvements and changes in preferences over time as discussed above.

*Criteria for COI studies:* For COI studies, our criteria ensure that the COI estimates will be derived using the highest quality data and will be appropriate for the study region and health endpoints of interest. In particular, the study should include a clear description of the elements that make up the COI estimate (e.g., inpatient costs, outpatient follow-up, and home care). In general, our preference is for COI estimates that include the broadest set of costs. The study should also estimate either an incidence- or prevalence-based cost as appropriate for the health endpoint. Incidence-based costs generally reflect lifetime costs per case of an illness while prevalence-based costs reflect the average cost per case in a given year. Morbidity rates are reported as either incidence or prevalence of an illness and the appropriate cost should be applied. Costs often differ depending on the characteristics of those affected. Many of these characteristics may not be observable to the researcher; however, we often know the age of those affected. Therefore, it is desirable to have age-specific cost estimates.