Potential Approaches for Characterizing Benefits at Low $PM_{2.5}$ Concentrations: Synopsis

The U.S. EPA uses evidence from long-term exposure cohort studies to estimate the number of $PM_{2.5}$-related premature deaths in its air pollution benefits analyses. Often the U.S. EPA quantifies effects for the full distribution of ambient $PM_{2.5}$ concentrations, including at concentrations below the lowest measured levels (LML) of these studies; this reflects the current scientific evidence, which does not find a threshold in the concentration-response parameter. However, because of the absence of data at such low concentrations, there is greater uncertainty about the likelihood of health effects, including premature death. The degree of uncertainty associated with premature deaths estimated at these lower levels has over time taken on greater prominence, due in part to decreasing ambient $PM_{2.5}$ concentrations, the public health importance of $PM_{2.5}$-associated mortality, and the magnitude of the economic value of the effect.[1] As a means of improving its methods for quantifying and characterizing effects estimated at these lower $PM_{2.5}$ levels, the Agency is developing and evaluating potential alternative approaches for estimating these effects. Potential approaches will be described in a U.S. EPA report. This report will: detail new techniques for deriving information regarding uncertainty at low $PM_{2.5}$ concentrations using data available from the peer-reviewed published epidemiology literature; demonstrate the application of these techniques in an example $PM_{2.5}$ air pollution benefits assessment; discuss the strengths and weaknesses of each technique; and, compare these techniques against meta-analyses published in the peer-reviewed literature also designed to characterize the magnitude of the PM mortality effect at lower concentrations, as well as approaches EPA has previously employed including the use of lowest measured level cutpoints. This report will be subject to an independent, contractor-led peer review.

The report will outline two potential approaches for characterizing uncertainty at low $PM_{2.5}$ concentrations. Each option (A & B) infers the uncertainty at concentrations below the mean concentration and LML of the long-term exposure epidemiology studies by employing statistical techniques; these draw upon data that are available in peer-reviewed published epidemiology studies. The report will demonstrate the techniques using data available in studies that examined long-term $PM_{2.5}$ exposure and mortality within the American Cancer Society (ACS) cohort.[2,3] Option A uses an assumed relationship between the mean and variance of a $PM_{2.5}$ concentration distribution from the ACS cohort to calculate adjusted standard errors and corresponding confidence intervals for hypothetical $PM_{2.5}$ concentration distributions with defined means that deviate incrementally from the observed mean. This approach yields wider confidence intervals (i.e., greater uncertainty) at lower concentrations due to smaller variance in the $PM_{2.5}$ concentration distribution. This technique can be used to quantitatively estimate uncertainty at a given concentration or identify the $PM_{2.5}$ concentration at which the adjusted confidence intervals cross the null. Option B also uses the assumed relationship between the mean and variance to estimate the variance for a series of hypothetical $PM_{2.5}$ distributions with defined means at stepwise increments above and below the observed mean. The estimated variances along with other known information from the ACS cohort are used to perform a power calculation for each of the hypothetical $PM_{2.5}$ distributions, which estimates the probability that a statistically significant effect (i.e., Hazard Ratio) would be observed at each concentration. This approach can be used to determine at what concentration there would be insufficient power remaining to detect a statistically significant effect.

In the final section, the report will apply the above techniques to an example air quality benefits assessment using the environmental Benefits Mapping and Analysis Program—Community Edition

(BenMAP-CE). Using several previously published air quality modeling simulations for sectors including Electricity Generating Units, mobile sources and industrial point sources (cement, refineries pulp and paper facilities), the report will quantify a mean and distribution of estimated avoided $PM_{2.5}$-related premature deaths using both techniques noted above.[4–6] Finally, the report will appraise the strengths and weaknesses of each technique; explore the extent to which the Agency may use these techniques to judge how the size of the $PM_{2.5}$ mortality effect changes at relatively low ambient $PM_{2.5}$ concentrations; and compare these techniques against alternatives including the use of lowest measured level cutpoints or the use of meta-analytic approaches designed to characterize the magnitude of the PM mortality effect across a broader array of concentrations. The draft and final versions of the report will be posted to https://www.epa.gov/economic-and-cost-analysis-air-pollution-regulations/PM_Uncertainty.

References

(1) U.S. EPA. *National Ambient Air Quality Standards for Particulate Matter; Final Rule*; USA, 2012.

(2) Krewski, D.; Jerrett, M.; Burnett, R. T.; Ma, R.; Hughes, E.; Shi, Y.; Turner, M. C.; Pope, C. A.; Thurston, G.; Calle, E. E.; et al. Extended Follow-up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality. *Res. Rep. Health. Eff. Inst.* **2009**, No. 140, 5–114; discussion 115-36.

(3) Turner, M. C.; Jerrett, M.; Pope, I. I. I.; Krewski, D.; Gapstur, S. M.; Diver, W. R.; Beckerman, B. S.; JD, M.; Su, J.; Crouse, D. L.; et al. Long-Term Ozone Exposure and Mortality in a Large Prospective Study. *American Journal of Respiratory and Critical Care Medicine*. 2015. https://doi.org/10.1164/rccm.201508-1633OC.

(4) U.S. EPA. *Regulatory Impact Analysis for the Proposed Federal Plan Requirements for Greenhouse Gas Emissions from Electric Utility Generating Units Constructed on or Before January 8, 2014; Model Trading Rules; Amendments to Framework Regulations*; Research Triangle Park, NC, 2015.

(5) US EPA. *Control of Air Pollution from Motor Vehicles: Tier 3 Motor Vehicle Emission and Fuel Standards Final Rule*; Washington DC, 2014.

(6) U.S. EPA. Technical Support Document Estimating the Benefit per Ton of Reducing PM 2 . 5 Precursors from 17 Sectors. **2013**, No. January, 1–107.