Appendix E

Health Benefits Analysis

Date of Release: June 23, 2020
Date of Hearing: August 27, 2020

LIST OF ACRONYMS AND ABBREVIATIONS USED IN APPENDIX E

Acronym or Abbreviation	Description
ADAM	Aerodynamic Data Analysis and Management system
CARB	California Air Resources Board
DPM	Diesel Particulate Matter
ER	Emergency Room
IMPROVE	Interagency Monitoring of Protected Visual Environments
IPT	Incidence-Per-Ton
NOx	Oxides of Nitrogen
PM2.5	Fine Particulate Matter
U.S. EPA	United States Environmental Protection Agency

Methodology for Estimating Health Benefits of the Heavy-Duty Omnibus Regulation

This appendix provides further details on the methodology for estimating the health benefits for the Proposed Amendments. The calculations conducted for these analyses are contained in the Heavy-Duty Omnibus Regulation Health Benefit Spreadsheets (CARB, 2020c).

Summary

The Heavy-Duty Omnibus Regulation is expected to provide health benefits through the reduction of oxides of nitrogen (NOx) emissions. Inhaling nitrogen dioxide, a component of NOx, can cause lung irritation and aggravate lung diseases such as asthma (U.S. EPA, 2016). However, the most serious quantifiable impacts of NOx emissions occur through conversion of NOx to fine particles of nitrate aerosol through chemical processes in the atmosphere. Pollutants such as nitrate aerosol particulate which are formed from precursor compounds by chemical processes are termed secondary pollutants, as distinct from primary pollutants which are emitted directly from sources such as vehicles.

Exposure to fine particulate matter (PM2.5) increases the risk of lung and heart diseases and premature death (U.S. EPA, 2009). California Air Resources Board (CARB) quantifies five health endpoints related to PM2.5 exposure: cardiopulmonary mortality, hospitalizations for cardiovascular illness, hospitalizations for respiratory illness, emergency room (ER) visits for respiratory illness, and ER visits for asthma. CARB chose these endpoints because the United States Environmental Protection Agency (U.S. EPA) has identified them as having a causal or likely causal relationship with exposure to PM2.5 (U.S. EPA, 2010). The U.S. EPA examined other health endpoints such as cancer, reproductive and developmental effects, but determined there was only suggestive evidence for a relationship between these outcomes and PM exposure, and insufficient data to include these endpoints in the national health assessment analyses routinely performed by U.S. EPA.

The U.S. EPA has determined that both long-term and short-term exposure to PM2.5 plays a causal role in premature mortality, meaning that a substantial body of scientific evidence shows a relationship between PM2.5 exposure and increased risk of death. This relationship persists when other risk factors such as smoking rates, poverty and other factors are taken into account (U.S. EPA, 2009). While other mortality endpoints could be analyzed, the strongest evidence exists for cardiopulmonary mortality (U.S. EPA, 2009). The greater scientific certainty for this effect, along with the greater specificity of the endpoint, leads to an effect estimate for cardiopulmonary deaths that is both higher and more precise than that for all-cause mortality (U.S. EPA, 2009).

CARB staff used incidence-per-ton (IPT) methodology to estimate the health benefits of the regulation (CARB, 2010; CARB 2020b). The IPT methodology is based on an approach developed by the U.S. EPA (Fann et al., 2009; Fann et al., 2012; Fann et al., 2018). It is used to estimate benefits of reductions in primary PM2.5 emitted directly from sources, and secondary PM2.5 formed from NOx, when modeled concentrations are not available. The basis of the IPT methodology is that changes in emissions are approximately proportional to changes in health outcomes. IPT factors are derived by calculating the number of health outcomes associated with exposure to measured PM2.5 concentrations for a 2014-2016 baseline period using the direct approach described above. The resulting estimates are aggregated by air basin and divided by the emissions of PM2.5 or a precursor. The calculation is performed separately for each air basin:

$$IPT = \frac{\text{number of health outcomes in air basin}}{annual\ emissions\ in\ air\ basin}$$

Multiplying the emission reductions from a regulation in an air basin by the IPT factor then yields an estimate of the reduction in health outcomes achieved by the regulation. For future years, the number of outcomes is adjusted to account for population growth.

CARB currently uses IPT factors for two types of PM2.5: diesel particulate matter (DPM) and secondary ammonium nitrate formed from oxides of nitrogen (NOx). Air quality data are taken from CARB's Aerometric Data Analysis and Management system (ADAM) air quality database (CARB, 2020a) and the Interagency Monitoring of Protected Visual Environments (IMPROVE) visibility network (IMPROVE, 2020). Data at monitoring sites is spatially interpolated to each census tract using inverse distance-squared interpolation. A more detailed description of the IPT methodology is available at the CARB web site (CARB, 2020b).

Uncertainty in health outcome estimates

Uncertainty in estimates of health outcomes arises from a variety of sources. The uncertainty ranges given in this report only take into account the uncertainty of the relative risk, a parameter which determines how changes in air quality translate into changes in health outcomes. Other factors, such as the uncertainty arising from spatial interpolation, and presence of effect modifiers such as socioeconomic variables and smoking rates that are not included in the health model, also contribute to the variability in the estimates. The reported uncertainty ranges in the health impacts therefore understate the true uncertainty.

Estimated health benefits

Table 1 shows the estimated statewide reduction in cardiopulmonary mortality, hospitalizations for cardiovascular illness, hospitalizations for respiratory illness and emergency room visits for asthma, summed over the 2022-2050 time period, associated with the regulatory proposal and alternatives. Numbers in parentheses are 95% confidence intervals. The values for the health incidents in Table 1 are reported to two significant figures; however, when estimating the monetized health benefits, CARB staff used the unrounded numbers to minimize calculation rounding errors.

Table 1. Estimated Statewide Reduction in Health Endpoints summed over the 2022-2050 time period

Health endpoint	Proposed	Alternative 1	Alternative 2
Cardiopulmonary mortality	3,900 (3,000 - 4,800)	4,300 (3,300 - 5,200)	3,600 (2,800 - 4,400)
Hospitalizations for cardiovascular illness	620 (0 - 1,200)	670 (0 - 1,300)	570 (0 - 1,100)
Hospitalizations for respiratory illness	740 (170 – 1,300)	800 (190 – 1,400)	680 (160 – 1,200)
Emergency room visits	1,800 (1,100 – 2,500)	1,980 (1,300 – 2,700)	1,700 (1,100 – 2,300)