

to put into broader perspective other O₃-related health effects that could not be included in the risk assessment (summarized below).

The computer model used in these analyses, the probabilistic NAAQS exposure model for O₃ (pNEM/O₃), combines information on O₃ air quality with information on patterns of human activity to produce estimates of O₃ inhalation exposures. This model has been developed to take into account the most significant factors contributing to total O₃ inhalation exposure including: The temporal and spatial patterns of ground-level O₃ concentrations throughout an urban area; the variations of O₃ levels within a comprehensive set of "microenvironments;"³³ the temporal and spatial patterns of the movement of people throughout an urban area; and the effects of variable exertion levels (represented by ventilation rates), associated with a range of activities that people regularly engage in, on O₃ uptake in exposed individuals. The analysis of these key factors incorporated extensive data bases, including, for example, data from ground-level O₃ monitoring networks in these areas, data from numerous research studies that characterized the activity patterns of the general population and at-risk groups as they go about their daily activities (*e.g.*, from indoors to outdoors, moving from place to place, and engaging in activities at different exertion levels),³⁴ and census data on relevant factors such as age, work status, home location and type of air conditioning system present, and work place location.

The regulatory scenarios examined in the exposure analyses include both 1-hour O₃ standards, at levels of 0.12 ppm (the 1979 NAAQS) and 0.10 ppm, and 8-hour standards, at levels of 0.07, 0.08, and 0.09 ppm, with 1- and 5-expected exceedance forms, *i.e.*, the range of alternative 8-hour standards recommended in the Staff Paper and supported by CASAC as the appropriate range for consideration in this review. These estimates were also used to roughly bound exposure estimates for

concentration-based forms of the standards under consideration (*e.g.*, the second- and fifth-highest daily maximum 8-hour average O₃ concentration, averaged over a 3-year period).³⁵ The estimated exposures are based on a single year of air quality data and reflect what would be expected in a typical or average year in an area just attaining a given standard over a 3-year compliance period; additional analyses were done to estimate exposures that would be expected in the worst year of a 3-year compliance period.

Based on the results of the exposure analyses, children who are active outdoors (representing approximately 7 percent of the population in the study areas) appear to be the at-risk population group examined with the highest percentage and number of individuals likely to experience exposures of concern. Estimated exposures of concern varied significantly across the urban areas examined in this analysis, with far greater variability associated with the 1-hour NAAQS in contrast to the more consistent results associated with alternative 8-hour standards.³⁶ Despite this variability across areas, general patterns can be seen in comparing alternative standards. For example, for aggregate estimates of the mean percent of outdoor children likely to experience exposures of concern within the seven nonattainment areas: The range of estimates associated with the 1-hour NAAQS is approximately 0.3–24 percent, whereas for alternative 8-hour standards (of the same 1-expected-exceedance form as the 1-hour NAAQS), the ranges are approximately 3–7 percent for a 0.09 ppm standard, 0–1 percent for a 0.08 ppm standard, and essentially zero for a 0.07 ppm standard. Within any given urban area, these differences in estimated exposures of concern between alternative standards are statistically significant.

In looking more specifically at a comparison between 8-hour standards at the 0.09 ppm and 0.08 ppm levels, aggregate estimates of the mean percentage of outdoor children likely to experience exposures of concern are

estimated to be approximately 3 percent at the 0.08 ppm level (ranging from 2–10 percent in the nine areas), increasing to approximately 11 percent at the 0.09 ppm level (ranging from 7–29 percent in the nine areas).³⁷ Thus, based on these analyses, a standard set at 0.09 ppm would allow more than three times as many children to experience exposures of concern as would a 0.08 ppm standard, with the number of children likely to experience such exposures increasing from approximately 100,000 to more than 300,000 in these nine areas alone. These exposures of concern are judged by EPA to be an important indicator of the public health impacts of those O₃-related effects for which information is too limited to develop quantitative estimates of risk, but which have been observed in humans at a level of 0.08 ppm for 6- to 8-hour exposures. Such effects include increased nonspecific bronchial responsiveness (related, for example, to aggravation of asthma), decreased pulmonary defense mechanisms (suggestive of increased susceptibility to respiratory infection), and indicators of pulmonary inflammation (related to potential aggravation of chronic bronchitis or long-term damage to the lungs).

In taking these observations into account, the Administrator and CASAC recognized the uncertainties and limitations associated with such analyses, including the considerable, but unquantifiable, degree of uncertainty associated with a number of important inputs to the exposure model. A key uncertainty in model inputs results from limitations in the human activity data base that may not adequately account for day-to-day repetition of activities common to children, such that the number of people who experience multiple occurrences of high exposure levels may be underestimated. Small sample size also limits the extent to which ventilation rates associated with various activities may be representative of the population group to which they are applied in the model. In addition, the air quality adjustment procedure used to simulate air quality distributions associated with attaining alternative standards, while based on generalized models intended to reflect patterns of air quality changes that have historically been observed, contains significant uncertainty, especially when applied to areas requiring very large reductions in air quality to attain alternative standards

quantitative risk assessment. Exposures at and above 0.12 ppm, 1-hour average, at heavy exertion, are also of concern; however, the focus here is on 8-hour average exposures since exposure estimates are higher for the 8-hour average effects level of 0.08 ppm at moderate exertion than for the 1-hour average effects level of 0.12 ppm at heavy exertion.

³³ The five indoor and two outdoor microenvironments included in this exposure model account for the highly localized variations in O₃ concentrations to which people are exposed that are not directly reflected in the concentrations measured at ambient ground-level O₃ monitoring sites.

³⁴ See, for example, Tables V–8 and V–9 in the Staff Paper, pp. 83–84.

³⁵ As discussed in section IV and appendix A of the Staff Paper.

³⁶ The observed area-to-area variability reflects differences in the shape of air quality distributions and differences in the relationships between 1-hour and 8-hour peak concentrations across urban areas, as well as differences in the percentage of homes with air conditioning (which impacts exposure estimates when individuals are indoors) and the frequency of warm versus cool days (which impacts exposure estimates because different sets of human activity patterns are used for warm versus cool days in the exposure model) across the nine urban areas (Richmond, 1997).

³⁷ Based on the supplemental analyses that used the third-highest concentration-based form of the standards (Richmond, 1997).