

children active outdoors, outdoor workers, and individuals with pre-existing respiratory disease, such as asthma.

There has been new research that suggests additional serious health effects beyond those that had been known when the 8-hour ozone health standard was set. Since 1997, over 1,700 new health and welfare studies relating to ozone have been published in peer-reviewed journals.<sup>29</sup> Many of these studies have investigated the impact of ozone exposure on such health effects as changes in lung structure and biochemistry, inflammation of the lungs, exacerbation and causation of asthma, respiratory illness-related school absence, hospital and emergency room visits for asthma and other respiratory causes, and premature mortality. EPA is currently in the process of evaluating these and other studies as part of the ongoing review of the air quality criteria and NAAQS for ozone. A revised Air Quality Criteria Document for Ozone and Other Photochemical Oxidants will be prepared in consultation with EPA's Clean Air Science Advisory Committee (CASAC). Key new health information falls into four general areas: development of new-onset asthma, hospital admissions for young children, school absence rate, and premature mortality.

Aggravation of existing asthma resulting from short-term ambient ozone exposure was reported prior to the 1997 decision and has been observed in studies published subsequently.<sup>30,31</sup> In particular, a relationship between long-term ambient ozone concentrations and the incidence of new-onset asthma in adult males (but not in females) was reported by McDonnell *et al.* (1999).<sup>32</sup> Subsequently, an additional study suggests that incidence of new diagnoses of asthma in children is associated with heavy exercise in

communities with high concentrations (*i.e.*, mean 8-hour concentration of 59.6 ppb) of ozone.<sup>33</sup> This relationship was documented in children who played 3 or more sports and thus had higher exposures and was not documented in those children who played one or two sports. The larger effect of high activity sports than low activity sports and an independent effect of time spent outdoors also in the higher ozone communities strengthened the inference that exposure to ozone may modify the effect of sports on the development of asthma in some children.

Previous studies have shown relationships between ozone and hospital admissions in the general population. A study in Toronto reported a significant relationship between 1-hour maximum ozone concentrations and respiratory hospital admissions in children under the age of two.<sup>34</sup> Given the relative vulnerability of children in this age category, we are particularly concerned about the findings.

Increased respiratory diseases that are serious enough to cause school absences have been associated with 1-hour daily maximum and 8-hour average ozone concentrations in studies conducted in Nevada<sup>35</sup> in kindergarten to 6th grade and in Southern California in grades 4 through 6.<sup>36</sup> These studies suggest that higher ambient ozone levels may result in increased school absenteeism.

The air pollutant most clearly associated with premature mortality is PM, with dozens of studies reporting such an association. However, repeated ozone exposure is a possible contributing factor for premature mortality, causing an inflammatory response in the lungs which may predispose elderly and other sensitive individuals to become more susceptible to other stressors, such as PM.<sup>37,38,39</sup>

<sup>33</sup> McDonnell, R.; Berhane, K.; Gilliland, F.; London, S. J.; Islam, T.; Gauderman, W. J.; Avol, E.; Margolis, H. G.; Peters, J. M. (2002) Asthma in exercising children exposed to ozone: a cohort study. *Lancet* 359: 386–391.

<sup>34</sup> Burnett, R. T.; Smith, Doiron, M.; Stieb, D.; Raizenne, M. E.; Brook, J. R.; Dales, R. E.; Leech, J. A.; Cakmak, S.; Krewski, D. (2001) Association between ozone and hospitalization for acute respiratory diseases in children less than 2 years of age. *Am. J. Epidemiol.* 153: 444–452.

<sup>35</sup> Chen, L.; Jennison, B. L.; Yang, W.; Omaye, S. T. (2000) Elementary school absenteeism and air pollution. *Inhalation Toxicol.* 12:997–1016.

<sup>36</sup> Gilliland, F.D., K. Berhane, E.B. Rappaport, D.C. Thomas, E. Avol, W.J. Gauderman, S.J. London, H.G. Margolis, R. McConnell, K.T. Islam, J.M. Peters (2001) The effects of ambient air pollution on school absenteeism due to respiratory illnesses. *Epidemiology* 12:43–54.

<sup>37</sup> Samet JM, Zeger SL, Dominici F, Currier F, Coursac I, Dockery DW, Schwartz J, Zanobetti A. 2000. The National Morbidity, Mortality and Air Pollution Study: Part II: Morbidity, Mortality and Air Pollution in the United States. Research Report

Although the findings have been mixed, the findings of three recent analyses suggest that ozone exposure is associated with increased mortality. Although the National Morbidity, Mortality, and Air Pollution Study (NMMAPS) did not report an effect of ozone on total mortality across the full year, the investigators who conducted the NMMAPS study did observe an effect after limiting the analysis to summer when ozone levels are highest.<sup>40,41</sup> Similarly, other studies have shown associations between ozone and mortality.<sup>42,43</sup> Specifically, Toulomi *et al.* (1997) found that 1-hour maximum ozone levels were associated with daily numbers of deaths in 4 cities (London, Athens, Barcelona, and Paris), and a quantitatively similar effect was found in a group of four additional cities (Amsterdam, Basel, Geneva, and Zurich).

In all, the new studies that have become available since the 8-hour ozone standard was adopted in 1997 continue to demonstrate the harmful effects of ozone on public health, and the need to attain and maintain the NAAQS.

b. *Current and projected 8-hour ozone levels.* The current primary and secondary ozone NAAQS is 0.12 ppm daily maximum 1-hour concentration, not to be exceeded more than once per year on average. EPA is replacing the previous 1-hour ozone standard with a new 8-hour standard. The new standard

No. 94, Part II. Health Effects Institute, Cambridge, MA, June 2000. (Docket Number A–2000–01, Document Nos. IV–A–208 and 209).

<sup>38</sup> Devlin, R. B.; Folinsbee, L. J.; Biscardi, F.; Hatch, G.; Becker, S.; Madden, M. C.; Robbins, M.; Koren, H. S. (1997) Inflammation and cell damage induced by repeated exposure of humans to ozone. *Inhalation Toxicol.* 9: 211–235.

<sup>39</sup> Koren HS, Devlin RB, Graham DE, Mann R, McGee MP, Horstman DH, Kozumbo WJ, Becker S, House DE, McDonnell SF, Bromberg, PA. 1989. Ozone-induced inflammation in the lower airways of human subjects. *Am. Rev. Respir. Dis.* 139:407–415.

<sup>40</sup> Samet JM, Zeger SL, Dominici F, Currier F, Coursac I, Dockery DW, Schwartz J, Zanobetti A. 2000. The National Morbidity, Mortality and Air Pollution Study: Part II: Morbidity, Mortality and Air Pollution in the United States. Research Report No. 94, Part II. Health Effects Institute, Cambridge MA, June 2000. (Docket Number A–2000–01, Documents No. IV–A–208 and 209)

<sup>41</sup> Samet JM, Zeger SL, Dominici F, Currier F, Coursac I, Zeger, S. Fine Particulate Air Pollution and Mortality in 20 U.S. Cities, 1987–1994. *The New England Journal of Medicine.* Vol. 343, No. 24, December 14, 2000. P. 1742–1749.

<sup>42</sup> Thurston, G. D.; Ito, K. (2001) Epidemiological studies of acute ozone exposures and mortality. *J. Exposure Anal. Environ. Epidemiol.* 11: 286–294.

<sup>43</sup> Touloumi, G.; Katsouyanni, K.; Zmirou, D.; Schwartz, J.; Spix, C.; Ponce de Leon, A.; Tobias, A.; Quenel, P.; Rabaczko, D.; Bacharova, L.; Bisanti, L.; Vonk, J. M.; Ponka, A. (1997) Short-term effects of ambient oxidant exposure on mortality: a combined analysis within the APHEA project. *Am. J. Epidemiol.* 146: 177–185.

<sup>29</sup> New Ozone Health and Environmental Effects References, Published Since Completion of the Previous Ozone AQCD, National Center for Environmental Assessment, Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711 (7/2002). A copy of this document is available in Docket No. OAR 2002–0030.

<sup>30</sup> Thurston, G.D., M.L. Lippman, M.B. Scott, and J.M. Fine. 1997. Summertime Haze Air Pollution and Children with Asthma. *American Journal of Respiratory Critical Care Medicine*, 155: 654–660.

<sup>31</sup> Ostro, B., M. Lipsett, J. Mann, H. Braxton-Owens, and M. White (2001) Air pollution and exacerbation of asthma in African-American children in Los Angeles. *Epidemiology* 12(2): 200–208.

<sup>32</sup> McDonnell, W.F., D.E. Abbey, N. Nishino and M.D. Lebowitz. 1999. "Long-term ambient ozone concentration and the incidence of asthma in nonsmoking adults: the ahsog study." *Environmental Research*. 80(2 Pt 1): 110–121.