Children's Exposure to Diesel Exhaust on School Buses

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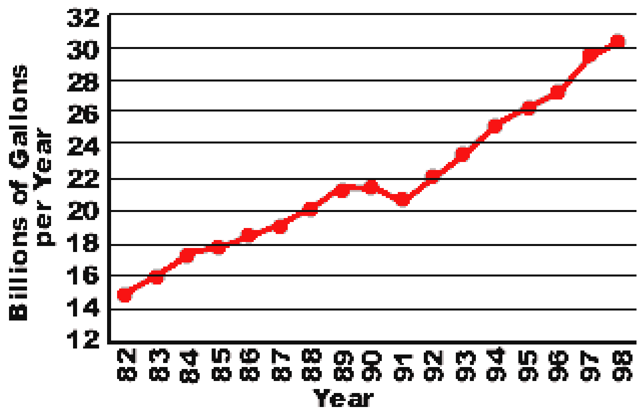
U.S. Trends in Diesel Fuel Consumption 30 Billion Gallons Per Year

This figure demonstrates a 45% increase in diesel fuel consumption in the U.S. over the past decade. As newer diesel engines emit less pollution, total pollution may still increase in response to increasing numbers of vehicles on the highway, and increasing miles driven by diesel vehicles.



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Abstract

In the United States nearly 600,000 school buses transport 24 million students to school daily. Each year buses travel 4.3 billion miles as children take nearly 10 billion

school bus rides. In Connecticut, 387,000 students ride to school each day on 6,100 buses. If rides average 30 minutes in each direction, students will spend 180 hours on buses each year. Collectively, U.S. children spend 3 billion hours on school buses each year. Connecticut children annually spend more than 50 million hours on school buses.1

More than 99% of U.S. school buses are powered by diesel fuel. Diesel exhaust is comprised of very fine particles of carbon and a mixture of toxic gases. Federal agencies have classified diesel exhaust as a probable human carcinogen. Benzene, an important component of the fuel and exhaust, is designated to be a known human carcinogen. Components of diesel exhaust are genotoxic, mutagenic, and can produce symptoms of allergy, including inflammation and irritation of airways. There is no known safe level of exposure to diesel exhaust for children, especially those with respiratory illness.

The Centers for Disease Control and Prevention (CDC) estimates that 4.5 million U.S. children have asthma. This figure includes nearly 44,500 school-aged children in Connecticut diagnosed with the illness. Diesel exhaust can adversely affect children with underlying respiratory illnesses such as asthma, bronchitis, and infections. Diesel emissions may enhance the effects of some allergens among sensitive individuals. Children’s airways are not yet fully developed and have a smaller diameter than those of adults. If airways are inflamed or constricted by asthma, allergies or infections, diesel exhaust may make breathing more difficult.

Fine particulate concentrations ($PM_{2.5}$) measured on buses in this study were often 5-10 times higher than average levels measured at the 13 fixed-site $PM_{2.5}$ monitoring stations in Connecticut. Levels of fine particles we re often higher under certain circumstances: when buses we re idling with windows opened, when buses ran through their routes with windows closed, when buses moved through intense traffic, and especially when buses we re queued to load or unload students while idling.

This study concludes that the laws intended to control air pollution in the U.S. and Connecticut must be strengthened to protect the health of children in several important respects. First, fixed monitoring facilities do not capture the variability in air pollution experienced by children. Second, air quality indoors and within vehicles is not regulated by EPA or the State of Connecticut, while Americans spend on ave rage between 80-90% of their time indoors. Third, tougher diesel regulations adopted by

EPA last year are insufficient to protect health. Under the new provisions, they will be phased in between 2006-2010. This delay means that children may be exposed to increasing levels of diesel exhaust for nearly a decade, as truck and bus traffic are likely to continue their steady rate of increase. Fourth, Connecticut is already beyond compliance with federal air quality standards for ozone, which may exacerbate respiratory illnesses. Given the limited monitoring facilities and extended averaging periods allowed by current law, state “compliance” with federal standards offers little assurance of sufficient health protection . Fifth, routine emissions testing for school buses is not re q u i red by federal law, and school buses are specifically exempted from testing in Connecticut. Sixth, Connecticut adopted idling regulations, limiting idling time to 3 minutes, however, few know of the restriction, and it is neither monitored nor enforced.

It is possible to reduce children’s exposure to diesel emissions immediately. We suggest prohibition of bus idling, especially while loading and unloading students. Exposures could also be reduced by limiting the amount of time students spend on buses. The dirtiest buses should be identified by testing emissions and air quality within passenger compartments . The cleanest buses could then be assigned to the longest routes.

These interventions would provide some relief, but additional steps are needed to protect the respiratory health of children, and provide the “adequate margin of safety” required by the Clean Air Act. The current fleet of diesel-powered buses should soon be retrofitted with interior air filters, particle traps, catalytic converters, and be powered by ultra low sulfur fuels. These strategies, if adopted together, would substantially reduce pollution levels in the air students breathe on their way to and from school.

Diesel Buses: Each day, nearly 600,000 school buses transport 24 million students to schools in the U.S. Within Connecticut, nearly 387,000 children ride 6,100 school buses, and 99% are powered by diesel fuel.

Children’s Time on Buses: The time spent on buses by individual students varies between 20 minutes and several hours per day. For one child, a half-hour ride to school, and a half-hour ride home each day amounts to 180 hours per school year—90 full 24-hour-days over 12 years of school. Annually, U.S. children spend 3 billion hours on school buses. Connecticut children spend 50 million hours on buses each year.

Background Particulates: Connecticut background fine particulate matter levels (PM2.5) are near or above national standards, when averaged over 24 hours. Children’s exposure to diesel exhaust from school buses constitutes an additional exposure beyond background levels of particulates reported from current monitoring efforts.

Background Ozone: Connecticut is not in compliance with current federal ozone standards. In 2001, portions of the state exceeded the 8-hour limit on 26 days, and the 1-hour limit was exceeded on 9 days. Ozone is known to exacerbate asthma, and is normally highest in the afternoon, when children’s exposure to diesel particulates from school bus rides is also likely to be high. NO_x precursors to ozone have increased over the past 10 years. In 2001, nearly 109 million people lived in 272 counties where federal ozone limits were exceeded.

Carcinogenicity of Diesel Exhaust: Diesel exhaust is classified as a probable human carcinogen by many governmental authorities, including the International Agency for Research on Cancer (WHO), the U.S. National Toxicology Program, the U.S. Environmental Protection Agency, and as a known carcinogen by the State of California. The California South Coast Air Quality Management District recently estimated that nearly 71% of the cancer risk from air pollutants in the area is associated with diesel emissions. Diesel exhaust includes benzene, 1,3-butadiene, and soot, all classified as known human carcinogens. Nearly 33 studies have explored the association between diesel exhaust exposure and bladder cancer. A recent meta analysis of this literature found increased risk between 18-76%. These findings are based primarily upon studies of truck drivers, railroad workers, bus drivers and shipyard workers.

Diesel Exhaust Contains 40 Hazardous Air Pollutants: In addition, diesel exhaust contains both carbon particulates and 40 chemicals that are classified as "hazardous air pollutants" under the Clean Air Act.

Particulates and Respiratory Diseases: Exposure to particulates has been associated with: increased mortality among those with cardiopulmonary diseases; exacerbation of symptoms for asthma, bronchitis, and pneumonia; decreased lung function; and retarded lung development. It has also been correlated with increased hospital admissions and emergency room visits for respiratory illnesses.

Children's Susceptibility: Children may be especially susceptible to adverse respiratory effects following exposure to fine-diameter particulate matter ($PM_{2.5}$) emitted from diesel engines. Nearly 94% of diesel particulates have diameters less than 2.5 micrometers (um).4 The average diameter of diesel particulates is 0.2 micrometers. Smaller particles are able to penetrate children's narrower airways reaching deeply within the lung, where they are more likely to be retained. Higher rates of respiration among child ren may lead to their higher exposure, when measured per unit of their body weight.

No Known Safe Exposure to Diesel Exhaust: There is no known safe exposure to diesel exhaust for children, especially those with asthma or other chronic respiratory disease. There is no single standard for acceptable cancer risk from diesel exhaust in the U.S.

Asthma Prevalence: Nationally, 4.8 million children have asthma. More than 44,500 Connecticut school children have the disease.

Asthma Costs: Asthma costs an average of $500 per child per year for medications, physician care, and hospital treatment. Annual direct medical costs are estimated to be nearly $22 million for Connecticut school students alone. This estimate does not account for other costs that often include school absenteeism, lost parental work while caring for ill children, psychological effects, and abnormal social development.

Children's Exposure to Particulates on Buses: Children were exposed to airborne particulate concentrations in tested buses that we re sometimes 5-15 times higher than background levels of PM_2

Variability Within Buses: Particulate and black carbon levels vary within individual buses over time. The most important influences on variability include: bus idling behavior, queuing practices, bus ventilation via windows, and outdoor concentrations on bus routes. Particulate and carbon concentrations did not vary by sampling location within diesel buses, e.g., front vs. rear. Engine model, age of engine, number of miles since last overhaul, maintenance cycles, location of bus engine (front, next to driver, or rear), elevation change, passenger load, and climate may all influence levels of interior pollutants and children’s exposure.

Exhaust From Other Traffic: The intensity and type of traffic along bus routes significantly affects air quality on buses. Buses following diesel-powered vehicles, including other buses, have increased levels of carbon and particulate concentrations within passenger compartments. Particulate levels rose rapidly within the passenger cabin when buses pulled behind other diesel vehicles in traffic. No buses tested had air filtration equipment capable of removing the fine particles detected in the buses.

Idling Buses: Idling buses tested had higher concentrations of particulates and carbon than moving buses. Higher concentrations occurred when idling buses had open windows when compared with buses with closed windows. There is a current Connecticut Department of Environmental Protection (DEP) regulation, DEP 22a-174-18 (a)(5), that limits idling time to 3 minutes, yet it is neither monitored nor enforced.

Queued Idling Buses: Queued idling buses had the highest levels of particulates and black carbon measured. Idling buses tend to accumulate diesel exhaust which may be retained during the ride, depending upon bus ventilation rates. Particulate and carbon concentrations rise rapidly once idling begins.

Length of Bus Route: The length of bus routes affects the magnitude of children's exposure to air pollutants in the interior compartment. Time in transit between home and school spent by Connecticut students varied between 20-180 minutes per day in the towns sampled. The longest routes may occur in the rural parts of the state, especially in large regional school districts.

Lower Emissions From Natural Gas Buses: Natural gas buses studied emitted 60-98% less carbon than diesel-powered buses.

Findings Are Likely to Underestimate Exposure: Exposures to carbon and particulates found in this study were measured in environments with exceptionally low traffic and few other sources of pollution. Most children are exposed to additional pollution from traffic and other residential, commercial and industrial activities. These findings therefore are likely to underestimate levels of fine particulates and carbon found in more urban areas and routes with higher traffic intensity.

Additional Sources of Particulate Exposure Threaten Children: Residential use of tobacco products, wood stoves, candles, kerosene heaters, and poorly ventilated cooking stoves are for many children additional sources of exposure to carbon-based particulates and organic gases that result from combustion. Federal and state monitoring efforts fail to account for these exposures despite the fact that most people spend more than 80% of their time indoors. Most epidemiological studies that associate PM_{10} levels with adverse respiratory health effects consider particles measured by outdoor stationary monitoring facilities, neglecting indoor air exposures.

School Buses Are Exempt From Emissions Testing: School buses are currently exempt from routine emissions testing in Connecticut.5 There is no federal requirement that all state governments monitor school bus emissions, although some states require testing.

Federal Particulate Standards Exceeded: EPA estimates that in 2000, 11 million U.S. children lived in areas that exceeded one or more federal air quality standard. Nearly 3.5 million children lived in areas where the particulate standards were exceeded in 1998. Within Connecticut, bus exposures when combined with background outdoor particulate levels may elevate children's average daily exposure beyond the current federal 24-hour $PM_{2.5}$ standard.

Absence of Passenger Cabin Air Quality Standards: Current law does not regulate air quality within buses.

Federal Monitoring vs. Personal Monitoring: Federal law and regulation permit the testing of air quality by means of fixed monitors. In Connecticut, 13 fixed monitors measure PM2.5. This sampling design fails to capture the local variability and severity of air pollution in the state. National standards permit averaging particulates over 24- hour periods. These practices ensure that shorter episodes of intense pollution—such as those experienced in bus rides—are neither recognized nor regulated by the state or federal government.

Tougher Federal Diesel Standards Delayed Until 2006: Tougher new diesel emissions standards will not be phased in until 2006. This delay poses respiratory health threats to

Connecticut citizens, who now experience air pollution at levels above acceptable federal standards for ozone. Compliance with current standards does not ensure health protection. EPA estimated that the new standards would result in 8,300 fewer premature deaths, 17,600 fewer cases of childhood acute bronchitis, and 360,000 fewer asthma attacks. These estimates demonstrate the scale of respiratory health threat EPA believes exist under current conditions.

Federal Particulate Standards: The exposures identified in this study will not be affected by the tougher federal PM standards adopted in 1997 (which are different from the diesel standards described in 26 above), since monitoring to determine compliance with the PM standards is done outdoors.

Bus Parking Yards: Bus parking and maintenance facilities have the potential to create localized particulate air pollution that far exceeds ambient outdoor levels reported from State monitoring efforts. Pollution may routinely migrate to adjacent properties, as buses are left idling, or during periods of peak use—early mornings and afternoons. If vehicles are parked near schools, both outdoor and indoor school air quality may be diminished.

Bus Drivers: Bus drivers' exposure to motor vehicle and diesel exhaust is significantly higher than children's, due to longer periods of time spent on buses.