NIH-PA Author Manuscript
NIH-PA Author Manuscript

NIH Public Access
Author Manuscript
Arch Environ Occup Health. Author manuscript; available in PMC 2009 July 23.

Published in final edited form as:
Arch Environ Occup Health. 2005 ; 60(2): 70–76.

Report of Workshop on Traffic, Health, and Infrastructure Planning

Ronald H. White, MST, **John D. Spengler, PhD**, **Kumkum M. Dilwali, MS**, **Brenda E. Barry, PhD**, and **Jonathan M. Samet, MD, MS**
and **Jonathan M. Samet** are with the Department of Epidemiology at Johns Hopkins Bloomberg School of Public Health in Baltimore, MD. **John D. Spengler** is with the Department of Environmental Health at the School of Public Health at Harvard University in Boston, MA. **Kumkum M. Dilwali** is with Environmental Health and Engineering, Inc, in Newton, MA. **Brenda E. Barry** was with Environmental Health and Engineering, Inc, at the time of the workshop and is currently with the Cadmus Group, Inc, in Watertown, MA

Abstract

Recent air pollutant measurement data document unique aspects of the air pollution mixture near roadways, and an expanding body of epidemiological data suggests increased risks for exacerbation of asthma and other respiratory diseases, premature mortality, and certain cancers and birth outcomes from air pollution exposures in populations residing in relatively close proximity to roadways. The Workshop on Traffic, Health, and Infrastructure Planning, held in February 2004, was convened to provide a forum for interdisciplinary discussion of motor vehicle emissions, exposures and potential health effects related to proximity to motor vehicle traffic. This report summarizes the workshop discussions and findings regarding the current science on this issue, identifies planning and policy issues related to localized motor vehicle emissions and health concerns, and provides recommendations for future research and policy directions.

Keywords

air pollution; exposure assessment; health effects; motor vehicle emissions; traffic proximity

The identification of adverse heath effects associated with elevated exposures to motor vehicle emissions (MVE) near busy roadways has emerged as a significant public health concern. This concern is based on recent air-pollutant measurement data documenting the unique aspects of the air-pollution mixture near roadways and an expanding body of epidemiological data suggesting increased risks for exacerbation of asthma and other respiratory diseases, premature mortality, and certain cancers and birth outcomes from air-pollution exposures in populations residing in relatively close proximity to roadways. Measurements indicate that pollutant concentrations can be substantially elevated near major highways and other roadways with large traffic volumes and that this pollutant mixture has specific characteristics reflecting its recent formation and dispersion behavior. Current transportation-planning policies primarily consider the potential impact of increased MVE on population health and on potential exceedances of National Ambient Air Quality Standards (NAAQS) at the metropolitan and regional levels. However, if future studies of health risks from traffic proximity continue to demonstrate increased health risks for populations located near major roadways and

Requests for reprints should be sent to Ronald H. White, MST, Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health, 615 N Wolfe Street, Room W6035, Baltimore, MD 21205. E-mail: E-mail: rwhite@jhsph.edu.

transportation infrastructures, particularly in densely populated urban areas, the implications would be significant, not only for transportation and air-quality planning, but also for urban development.

The Workshop on Traffic, Health, and Infrastructure Planning, held in February 2004, was convened to provide a forum for interdisciplinary discussion of proximity to MVE and related health effects. The 43 workshop participants (a list of workshop participants is available at http://www.jhsph.edu/RiskSciences/Research) comprised an interdisciplinary group from the scientific and public-health communities in 4 specific fields that covered mobile-source air-pollution emissions and exposures, their associated health effects, and transportation-infrastructure planning and policy. The objectives of the workshop were to (1) promote dialogue among environmental-health scientists, transportation and urban planners, environmental and transportation advocates and policy-makers, and the motor-vehicle industry regarding the implications of traffic-related health effects for motor-vehicle technology, transportation planning, and urban design; (2) evaluate the scientific evidence regarding the relationship of roadway proximity to MVE exposures and adverse health outcomes and identify research needs; (3) present approaches to assessing pollutant-based health risks from roadways; and (4) consider approaches for integrating planning and design strategies that mitigate potential health risks associated with traffic into transportation-infrastructure design and policy, reflecting the emerging knowledge of exposure and health consequences of MVE.

Although the discussion of policy and planning issues at the workshop focused on the US experience, the scientific information that provided the technical basis for discussion was international in scope, and the findings and recommendations from the workshop have broad implications. The workshop agenda focused on the following 6 key questions developed by the planning committee:

1. What is the current state-of-the-science for on-road mobile-source emissions, localized exposures and health effects?
2. Is this information sufficient to warrant further action to protect public health?
3. What are the current strategies in place to address traffic-exposure and health issues? Have these current strategies been effective?
4. If there is a public-health basis for decreasing exposure to motor-vehicle emissions, then what information is needed to guide strategies to reduce exposures?
5. If further action is needed, is there sufficient information on the impact of various mobile-source types and the scale of exposure to influence decisions on mitigation strategies and policies?
6. Prospectively examine current trends in urbanization and changing motor vehicle and fuel technologies. With regard to these trends (eg, urban sprawl, metropolitan-area in-fill, tighter emission standards, hybrid engines, cleaner fuels), what is the net impact of these trends on exposure?

WORKSHOP FINDINGS AND RECOMMENDATIONS

This document summarizes findings regarding the current science, identifies the planning and policy issues related to localized MVE and health concerns, and provides recommendations for future directions. It also introduces new information and initiatives that have emerged since February 2004. It is not intended to serve as a comprehensive review of the scientific literature on proximity to traffic and health, and the citations listed are for illustrative purposes only. Documents summarizing information on motor-vehicle pollution emissions, near-roadway air-pollution exposures and health effects, and transportation-planning and policy issues are available at http://www.jhsph.edu/RiskSciences/Research.

Motor-Vehicle Emissions and Resulting Air Pollution

Motor-vehicle traffic is a mixture of vehicles that vary in age, type, and fuels and that travel under different operating conditions at variable speeds and densities across different roadway configurations and geographical settings. This dynamic source produces a highly variable, complex mixture of air pollutants, and the set of factors determining its characteristics is likely to be important in understanding air pollution from traffic and potential human-health effects.

The mixture of traffic-related air pollution comprises components derived from diverse species, the primary and secondary formations of which are driven by physical and chemical processes. Primary emissions include particulate matter (PM), nitrogen oxides (NO_X), carbon monoxide (CO), and hydrocarbons (HC). Exhaust particles are emitted primarily as submicrometer aerosols (< 1 μm) from operating engines.[1,2] The concentrations of emitted pollutants decrease as they are transported and dispersed by wind and the turbulence induced by vehicle movement. Particle concentrations undergo shifts in their size distributions through agglomeration, condensation, and evaporation, with increasing domination of larger particles at greater distances from roadways. This dynamic process occurs rapidly within tens of meters of the roadway.[3-5] Ambient temperature and local meteorology can influence this process. In addition, the emitting mix of vehicles (passenger cars and trucks), driving behavior (acceleration, cruise, idle, braking), and speed all determine the local characteristics of near-field pollution.[6]

Traffic produces other potentially hazardous combustion products, including volatile organic compounds, carbonyls, and semivolatile organic compounds (polycyclic aromatic hydrocarbons [PAHs] and nitro-PAHs).[7] Other traffic-related factors (eg, noise, stress) may also contribute to adverse health responses.

Abrasion of surfaces and friction-induced mechanical disruption resuspends “road dust,” itself a complex mixture comprised predominantly of coarse particles (> 2.5 μm in aerodynamic diameter).[8] Sandy, salty, dirty, and unpaved roadways can result in elevated concentrations of coarse particulate matter.[9] The coarse fraction might contain earthcrustal material, along with asphalt, metals, latex tire fragments, pollens, and oil-coated particles. The wearing of vehicle parts, including tires and brake pads and discs, generates latex, metal, and ceramic debris.[10] Motor oils evaporate off engine parts or drip onto road surfaces to become part of the complex mixture of contaminants.

Although they typically represent a relatively small percentage of the vehicle fleet, high-emitting vehicles (which often emit visible tailpipe smoke) have been found to contribute a substantial portion of in-use emissions.[11] These vehicles are typically poorly maintained and/or have emissions control systems that have been tampered with, and emissions levels in excess of 200 g/mi CO and 20 g/mi HC are possible without properly functioning emission-control systems. Older vehicles also generally contribute disproportionately more pollution than newer vehicles because of previously less stringent emission standards and equipment deterioration over time.

Air-Pollution Exposures

Motor-vehicle traffic leads to pollutant exposures for vehicle occupants, pedestrians, and occupants of nearby homes, schools, and other buildings. Collective emissions from mobile sources typically give rise to higher concentrations of pollutants, such as CO and NO_X, within urban centers than in surrounding suburban and rural areas.

Several key components of the complex mixture of traffic-derived pollutants, such as CO, NO_x, ultrafine particles, and black carbon, have been found to follow a declining concentration gradient with distance from roadways.[4,12] In addition, studies have found concentrations of benzene and other air toxics to be significantly higher near busy roads.[13]

Exposures to traffic-related pollutants reflect long-term trends in MVE emissions from changes in the fleet mix and engine design, control technology, and fuel formulation, as well as seasonal, daily, and hourly variations in emissions related to road-surface conditions, congestion, vehicle speed, and weather conditions.[5,14,15] Current tools for understanding the composition of air pollution near roadways include traffic-demand models, traffic-flow models, source-receptor dispersion models, and transportation-tracking systems. Population exposures to air pollution are further affected by variation in the indoor contribution as it is modified by natural and mechanical ventilation of roadway-adjacent structures and their occupant-activity patterns.[16]

The workshop identified substantial limitations in the current understanding of characterization of near-roadway-population exposures to motor-vehicle pollution. In particular, the roles of population characteristics such as other pollutant exposures and social factors, including those related to environmental-justice concerns, are not well studied.

Exposure to elevated levels of pollution along and near roadways presents a special concern and poses challenges both for research and for contaminant control. Exposure-related issues discussed at the workshop included the definition of these areas in the context of near-roadway exposures; the detection of these areas, given the current and likely future limitations of available monitoring networks; and the identification of the extent and causes of these elevated pollutant levels and potential mechanisms to mitigate them.

Near-Roadway Traffic and Health

A rapidly expanding body of epidemiologic studies has documented associations of proximity to roadways or traffic exposure with a wide array of health effects, ranging from diminished quality of life to increased risk of cardiopulmonary mortality. Associations of adverse health outcomes with measures of traffic volume or distance of residential location from roadways have been found in Japan, Europe, Scandinavia, the United States, Canada, and elsewhere. Positive associations have been found for a broad spectrum of adverse health effects with various surrogate indicators of traffic-related pollution exposure, and these findings are also generally consistent with the broader literature on the health effects of air pollution.

Most frequently reported health effects are associations of increased risk of respiratory symptoms, including exacerbation of asthma, with proximity to or measures of traffic pollution; studies from throughout the world have reported similar, generally positive, findings.[17-28] Other studies have identified an increased risk of cardiopulmonary and stroke mortality related to close proximity to traffic.[29,30] However, studies of other health outcomes, such as asthma hospitalizations and medication use and risk for various cancers, have provided less consistent evidence.[31-48] Evidence also suggests that traffic density[49] and traffic proximity[50] may be linked to adverse preterm birth outcomes.

The specific components of the mixture contributing to the health effects are uncertain. Although no health researchers to date have quantified subject exposure to the full range of components of the complex traffic-related mixture of pollutants, surrogates, such as NO_2, CO, benzene, and carbon soot (reflectance), have been used for this purpose. Researchers have measured or modeled a few of these pollutants in the community and associated them with adverse health outcomes for children and adults.[42,43,51] Furthermore, variations in these air-pollutant measures are reasonably predicted by geographic variations in traffic density or distance from high-volume roadways.[52] A majority of the epidemiologic studies using distance from roadway as a measure of exposure have defined near-roadway proximity as radial distances up to 200 to 300 meters from the road, whereas studies using traffic volume as the exposure measure have found adverse effects associated with traffic volumes as low as 10,000 vehicles per day.[20]

Health studies suggest near-roadway air pollution health effects are of concern for populations considered generally susceptible to the effects of air pollution (eg, persons with respiratory and cardiovascular disease, children). However, data on the scope of susceptible populations and the magnitude and distribution of the health risks are still lacking.

Policy- and Infrastructure-Planning Issues

Current federally mandated mobile source-control programs are generally insufficient to address and mitigate spatial disparities in traffic-related exposures. The Clean Air Act (CAA) “conformity” provision (Section 176[c]), which requires that planned development of additions to metropolitan transportation systems contribute to the emissions reductions needed for attainment of the NAAQS, requires assessment of the air-quality impact of these projects, primarily at the metropolitan level. However, localized, project-level analyses are required for CO and PM_{10} nonattainment areas. Localized $PM_{2.5}$ requirements have been proposed as an option for implementation of the $PM_{2.5}$ NAAQS[53]. The National Environmental Policy Act (NEPA) has played a limited role in reducing emissions by requiring consideration of less-polluting alternatives in the development of major highways. However, this obligation has been limited to a consideration of alternatives that can be implemented at the scale of the corridor to be served by a particular highway.

Federal and state air-monitoring networks for NAAQS compliance and for hazardous air pollutants range from neighborhood-scale to a mesoscale of tens of kilometers. Near-roadway traffic-related impacts are detected at the microscale of meters, highlighting the challenges associated with identifying potential areas and exposures of concern and implementing mechanisms to monitor air-quality improvements. Given the potential number of locations of concern and the costs of air-quality monitoring, microscale air quality and human-exposure models will likely be used extensively. Additional data will be needed to further develop and evaluate these models. This modeling is also typically reliant upon integrated measures, although continuous data collections may be needed to fully understand the impact of a given source.

High levels of traffic-related air pollution can result from localized traffic congestion as well as from large vehicle volumes. Regulatory policy that crosses the domains of environmental protection and city planning has not been adequately formulated to address this broader problem. Although some “hot spots” of traffic are predictable (eg, toll plazas, truck stops), other situations are sporadic (eg, accidents, construction, poor weather, special events). Even where road conditions on freeways and commercial streets are static, traffic volume varies over time, and this temporal variability provides an additional challenge to transportation-management systems.

As another consideration in policy formulation, patterns of land use change with respect to transportation infrastructure. New transportation infrastructures attract users and often stimulate related development, which can lead to congestion and increased exposure to traffic emissions. This phenomenon is often referred to as “induced demand.” The divergent trends of expanding urban sprawl, which increases traffic volumes and results in roadway expansions, and urban revitalization efforts, which encourage urban in-fill to populate urban centers, both have the potential to worsen population exposures to near-roadway motor-vehicle pollution.

Considering a health-assessment paradigm that extends from emissions to exposures to health effects, there are several potential strategies to mitigate health impacts of traffic. These include technical and regulatory control-program approaches, as well as traffic-oriented capital projects. In addition, local zoning and ordinances, procedures, and codes affecting development could mitigate traffic through land-use decisions.

Pollution-Exposure Reduction Options

Reducing population exposures to high levels of traffic-related air pollutants can be accomplished using the following 2 major approaches: (1) reduction of direct vehicle emissions and (2) increasing the separation of populations from emissions.

Reduction of MVE can be accomplished through a variety of approaches, including vehicle-based emission controls, fuel-based emission controls, travel-demand reduction (eg, increased walkability), mode shifting (eg, car to transit or bike), congestion mitigation (eg, traffic-signal coordination), and inspection and maintenance of emission controls on in-use vehicles. Mass emissions can be reduced through any of these measures, although consequences for population exposures may be different.

Reducing emissions at the source is accomplished by limiting emissions from vehicles based on emission-control technologies, modifications to engine design and the combustion characteristics of traditional fuels to reduce pollutant formation, and/or the conversion from gasoline- and diesel-fueled vehicles to vehicles that use less-polluting or nonpolluting energy sources.

Although emissions standards for passenger vehicles will tighten somewhat over the next several years, only very modest gains in emission reductions are expected from the increased Corporate Average Fuel Economy (CAFE) standards and closing of some “light-duty truck” emissions standards loopholes for sport utility vehicles (SUVs). In contrast, wide-spread use of low-sulfur diesel fuels and particle traps, along with selective catalytic reduction technology, are expected to result in a substantial reduction of new heavy-duty truck emissions. Because existing truck engines are designed to power vehicles for hundreds of thousands of miles, thus extending the time required for fleet turnover, near-term gains for local air quality from these sources will necessarily depend on improved vehicle maintenance and retrofitted controls.

As part of State Implementation Plans (SIPs) containing the air-pollution control measures required to demonstrate attainment of the NAAQS under the CAA, states have adopted strategies to reduce vehicle emissions by means other than reducing direct emissions from vehicles. These strategies include reductions in vehicle miles traveled through the development of public transportation alternatives to single-occupant vehicle travel and reductions of aggregate emissions by decreasing total-vehicle travel. Additional strategies include the implementation of transportation-control and/or land-use strategies that encourage personal travel by multiple-occupant vehicle modes and walking or bicycling rather than single-occupant vehicles; reducing trip lengths by land-use planning that facilitates closer proximity of trip origins and destinations; consolidating freight shipments onto larger platforms (eg, truck to rail or barge), encouraging freight transport by less-emitting modes of shipment; and reducing travel demand.

The public-health consequences of close-proximity exposures to MVE can also be reduced by separating populations from areas with large traffic volumes and/or high levels of traffic congestion where vehicle emissions are highly concentrated. This could be achieved by the isolation of truck and bus depots from residential neighborhoods, the relocation of rail switch yards to unpopulated areas, and the creation of open-space buffer zones along major freeway rights-of-way and near large airports. Exposures could also be reduced by setbacks, berms, plantings, placement of building air intakes, or installing air-cleaning equipment in mechanical ventilation systems. The comparative quantitative consequences of these strategies to reduce exposures have not been well studied.

Research Needs

A broad range of research is needed to improve our understanding of the health consequences of exposures to MVE near roadways. Refinement of our knowledge and improvements to the analysis of the health, ecological, and economic consequences of congestion and air pollution from traffic will lead to more effective mitigation policies. Key research needs, identified based on the workshop discussions, are as follows:

- More information on the composition and spatial variation of MVE is needed, especially on those components that have received less attention, such as metals, PAHs, and air toxins. Standardized methods to collect and chemically speciate air samples are needed to improve the understanding of the range and variability of potential population exposures.
- Exposure studies to date are limited to 2 types: case studies of specific road configurations and studies to establish relationships among easily measured parameters and traffic- and land-use variables. Case studies of different configurations, effects of buffers, pollution penetration into structures, and personal exposure to traffic-related air pollution are needed.
- Quantification of the variation in traffic-related exposures across age, gender, ethnic, and economic variables that differentiate residential location, commuting patterns, and type of employment in the United States is needed. The application of existing air-quality models to near-roadway issues has been limited because of model uncertainty. Additional data on the above variables, as well as identification of traffic operating characteristics leading to elevated exposures and adverse effects, are needed to further develop and evaluate the utility of these models in understanding exposures to traffic-related air pollution.
- Health evidence relating exposure effects to key cofactors such as noise, socioeconomic status, and related social stressors is needed. Researchers must conduct studies to determine whether the impact of outdoor and indoor allergens is enhanced by coexposure to diesel particles. Additional studies on health outcomes such as cancer, cardiovascular disease, and developmental and immunologic effects are also needed. These should include both real-world as well as scripted studies so the full range of potential scenarios can be examined. Studies of other potentially susceptible populations are needed to address the lack of information on the role of health conditions other than asthma on potential adverse health effects from exposure to fresh automotive emissions.
- Controlled exposure and toxicological studies are needed to begin to evaluate the health impacts of the near-roadway air-pollution mixture (including MVE, road dust, and emissions related to brakes and tire wear), to identify the pollution components most responsible for health effects, to investigate questions of causality and biological susceptibility, and to identify potential biological mechanisms of adverse health effects from the near-roadway air-pollution mixture.
- Demonstration projects linking traffic-relief strategies to corresponding improvement in health effects or their associated biological markers are needed. Performed as a community collaborative effort, such demonstration projects offer opportunities to educate politicians, planners, developers, and citizens.

- Social experiments are needed to understand factors that would lead to behavior modification. Stemming the everincreasing vehicle miles traveled will be critical to reducing congestion in the long run. The market forces that are the precursors to traffic are poorly understood. Understanding the financial and other incentives needed to trade passenger miles among modes of transit is critical.

FUTURE DIRECTIONS

Specific and certain quantification of the health consequences of traffic is not possible at the present time, but the emerging evidence from exposure and health studies provides a warning. Living close to heavy traffic has been associated with increases in risk for several adverse health effects. Further research is needed, but the evidence is sufficient to warrant its consideration in many planning decisions and policies. In addition, the relationship between exposure to near-roadway traffic emissions and health impacts, which have primarily been expressed based on residential and, to a more limited extent, school locations, may extend to other locations, such as offices and elder care facilities in close proximity to high-traffic roadways with expected extended-duration exposures. The emerging literature on the relatively high levels of personal exposures to motor-vehicle-related air pollution encountered in-vehicle while traveling, including children's exposure to diesel emissions in school buses, also raises concerns regarding the impact of coexposures on public health.

Despite remaining uncertainties in the specific nature and magnitude of the health problems associated with near-roadway traffic-pollution exposures, workshop participants discussed a range of "no regret" strategies that are directionally correct both in terms of reducing local exposures and lowering the overall impact of mobile source emissions, including greenhouse gases. These strategies, which have national, regional, and local air-quality benefits accruing from reduced emissions and fuel reformulation, included increasing the CAFE standards; retrofitting trucks and buses with additional emission-control technology; promoting cleaner vehicles (including hybrids), electrified truck stops, and other idling-reduction measures. In addition, promotion of telecommuting, densification of housing stock, and expanding public transit, car sharing, and bicycling may lower emissions and congestion levels. Strategic implementation of these improvements can potentially contribute to relieving or averting local areas of high traffic-related pollution.

In addition to the approaches discussed above that reduce exposures through reductions in vehicle emissions, other strategies that reduce pollution exposures are also available. These include revising building codes, zoning, and traffic-avoiding ordinances to minimize the potential for exposure to traffic-related pollution.

Municipal governments might consider the relationships between traffic and health when planning public investments. Examples of such strategies include siting schools with a buffer setback from heavily traveled roads; equipping diesel school buses with enhanced pollution controls, such as particle traps and positive crankcase ventilation; or converting current fuels to lower-polluting fuels (eg, biodiesel or liquid natural gas). Buildings with mechanical ventilation systems might orient air intakes to minimize vehicle-exhaust intrusion and use higher-efficiency filters and air cleaners.

The multi-disciplinary nature of the issue of air pollution from motor vehicles requires an integrated approach to problem recognition and response from the scientific, engineering, planning, and regulatory communities, which are typically in the domains of separate professional groups. Professionals and citizens alike find it difficult to be broadly informed in sufficient depth across multiple disciplines to comprehensively address traffic-related health concerns. Emerging scientific and engineering knowledge regarding near-roadway traffic air pollution and its impact on public health is typically in the domain of specialized scientific and technical organizations with seemingly little communication between those groups and city planners, architects, developers, or transportation policy makers or regulators. Enhanced communication between all these disciplines would be mutually beneficial to understanding and addressing this issue. It was with this perspective in mind that the workshop included representatives from many of the various disciplines and stakeholders described above.

Enhanced public awareness of the range of health and other societal impacts associated with high levels of motor-vehicle traffic is also needed. With more transparent and comprehensive accounting of these impacts, evaluation of alternative strategies to mitigate unwanted impacts and public support for control measures will improve.

Finally, it is important to note that, since completion of the Traffic, Health and Infrastructure Planning Workshop in February 2004, interest and concern regarding near-roadway-pollution exposures and health effects has continued to grow and is receiving increasing attention from the scientific, regulatory, and public-health communities. The US Environmental Protection Agency (EPA) and the Mickey Leland National Urban Air Toxics Research Center are supporting research on this issue, and the Health Effects Institute has identified this issue as a priority area for research in its 2005-2010 strategic plan.

CONCLUDING COMMENTS

In planning this workshop, there was strong recognition of the topic’s immediacy and of the need for convening a multidisciplinary group. The multidisciplinary, multisector approach of this workshop offers a model for future efforts on this subject. In reviewing findings since the workshop, we are impressed by the continued surge of evidence on near-roadway-traffic-related impacts on health. Although the foundation of evidence for decision making still has many gaps, an array of policy options for control needs to be developed now. For some “no regrets” options, immediate implementation may be warranted; for others, specifying alternatives may sharpen planning research.

Acknowledgments

Funding for this workshop was provided by California Air Resources Board, Engine Manufacturers Association, Harvard University Particulate Matter Research Center, Mickey Leland National Urban Air Toxics Research Center, National Institute of Environmental Health Sciences, Southern California Environmental Health Sciences Center & Children’s Environmental Health Center, US Environmental Protection Agency, and US Federal Highway Administration.

The authors of this report wish to acknowledge the work and contributions of all the workshop participants. They particularly acknowledge the efforts of N. Kunzli, F. Gilliland, C. Sioutas, R.Yuhnke, F. Salvucci, H. Nitta, S. Cadle, and M. Brauer for their work in preparing and presenting supporting materials for the workshop. They also thank Rebecca Nachman for her invaluable assistance in planning and executing the workshop logistics, as well as for her editorial assistance with this manuscript.

This report provides the proceedings of the workshop. There was no attempt to achieve group consensus on all issues; consequently, the report should not be necessarily construed as reflecting the views of all participants or their organizational affiliations, nor those of the sponsoring organizations. Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official agency policy.

References

1. Morawska L, Bofinger ND, Kocis L, Nwankwoala A. Submicrometer and super micrometer particles from diesel vehicle emissions. Environ Sci Technol 1998;32:2033–2042.
2. Ristovski ZD, Morawska L, Bofinger ND, Hitchins J. Submicrometer and supermicrometer particles from spark ignition vehicles. Environ Sci Technol 1998;32:3845–3852.
3. Hitchins J, Morawska L, Wolff R, Gilbert D. Concentrations of submicrometre particles from vehicle emissions near a major road. Atmos Environ 2000;34:51–59.

4. Zhu Y, Hinds WC, Kim S, Sioutas C. Concentration and size distribution of ultrafine particles near a major highway. J Air Waste Manag Assoc 2002;52:1032–1042. [PubMed: 12269664]
5. Zhang KM, Wexler AS, Zhu YF, Hinds WC, Sioutas C. Evolution of particle number distribution near roadways. Part II: the “road-to-ambient” process. Atmos Environ 2004;38:6655–6665.
6. National Research Council. Modeling Mobile Source Emissions. National Academy Press; Washington, DC: 2000.
7. US Environmental Protection Agency. Health assessment document for diesel engine exhaust. US Environmental Protection Agency; Washington, DC: 2002. EPA/600/8-90/057F
8. Rogge WF, Hildemann LM, Mazurek MA, Cass GR, Simoneit BR. Sources of fine organic aerosol. 3. Road dust, tire debris, and organometallic brake lining dust: roads as sources and sinks. Environ Sci Technol 1993;27:1892–1904.
9. Abu-Allaban M, Gillies JA, Gertler AW, Clayton R, Proffitt D. Tailpipe, resuspended road dust, and brake-wear emission factors from on-road vehicles. Atmos Environ 2003;37:5283–5293.
10. Riediker M, Devlin RB, Griggs TR, et al. Cardiovascular effects in patrol officers are associated with fine particulate matter from brake wear and engine emissions. Part Fibre Toxicol 2004;1:2. [PubMed: 15813985]
11. Pokharel SS, Bishop GA, Stedman DH, Slott R. Emissions reductions as a result of automobile improvement. Environ Sci Technol 2003;37:5097–5101. [PubMed: 14655694]
12. Zhu Y, Hinds WC, Kim S, Shen S, Sioutas C. Study on ultrafine particles and other vehicular pollutants near a busy highway. Atmos Environ 2002;36:4375–4383.
13. Sapkota A, Buckley TJ. The mobile source effect on curbside 1,3-butadiene, benzene, and particle-bound polycyclic aromatic hydrocarbons assessed at a tollbooth. J Air Waste Manag Assoc 2003;53:740–748. [PubMed: 12828334]
14. Charron A, Harrison RM. Primary particle formation from vehicle emissions during exhaust dilution in the roadside atmosphere. Atmos Environ 2003;29:4109–4119.
15. Zhu Y, Hinds WC, Ki S, Shen S, Sioutas C. Seasonal trends of concentration and size distributions of ultrafine particles near major freeways in Los Angeles. Aerosol Sci Technol 2004;38:5–13.
16. Ozkaynak, H.; Xue, J.; Weker, R., et al. The particle TEAM (PTEAM) study: analysis of the data. Vol. 3. US Environmental Protection Agency; Washington, DC: 1996. Final reportEPA/600/R-95/098
17. Brauer M, Hoek G, Van Vliet P, et al. Air pollution from traffic and the development of respiratory infections and asthmatic and allergic symptoms in children. Am J Respir Crit Care Med 2002;166:1092–1098. [PubMed: 12379553]
18. Braun-Fahrlander C, Ackermann-Liebrich U, Schwartz J, Gnehm HP, Rutishauser M, Wanner HU. Air pollution and respiratory symptoms in preschool children. Am Rev Respir Dis 1992;145:42–47. [PubMed: 1731597]
19. Ciccone G, Forastiere F, Agabiti N, et al. SIDRIA collaborative group. Road traffic and adverse respiratory effects in children. Occup Environ Med 1998;55:771–778. [PubMed: 9924455]
20. Garshick E, Laden F, Hart JE, Caron A. Residence near a major road and respiratory symptoms in U.S. veterans. Epidemiology 2003;14:728–736. [PubMed: 14569190]
21. Gehring U, Cyrys J, Sedlmeir G, et al. Traffic-related air pollution and respiratory health during the first 2 yrs of life. Eur Respir J 2002;19:690–698. [PubMed: 11998999]
22. Kramer U, Koch T, Ranft U, Ring J, Behrendt H. Traffic-related air pollution is associated with atopy in children living in urban areas. Epidemiology 2000;11:64–70. [PubMed: 10615846]
23. Murakami M, Ono M, Tamura K. Health problems of residents along heavy-traffic roads. J Hum Ergol (Tokyo) 1990;19:101–106. [PubMed: 1717546]
24. Nicolai T, Carr D, Weiland SK, et al. Urban traffic and pollutant exposure related to respiratory outcomes and atopy in a large sample of children. Eur Respir J 2003;21:956–963. [PubMed: 12797488]
25. Nitta H, Sato T, Nakai S, et al. Respiratory health associated with exposure to automobile exhaust. Results of cross-sectional studies in 1979, 1982, and 1983. Arch Environ Health 1993;48:53–58. [PubMed: 7680850]

26. Oosterlee A, Drijver M, Lebret E, Brunekreef B. Chronic respiratory symptoms in children and adults living along streets with high traffic density. Occup Environ Med 1996;53:241–247. [PubMed: 8664961]
27. van Vliet P, Knape M, de Hartog J, et al. Motor vehicle exhaust and chronic respiratory symptoms in children living near freeways. Environ Res 1997;74:122–132. [PubMed: 9339225]
28. Venn A, Lewis S, Cooper M, et al. Local road traffic activity and the prevalence, severity, and persistence of wheeze in school children: combined cross sectional and longitudinal study. Occup Environ Med 2000;57:152–158. [PubMed: 10810096]
29. Hoek G, Brunekreef B, Goldbohm S, Fischer P, van den Brandt PA. Association between mortality and indicators of traffic-related air pollution in the Netherlands: a cohort study. Lancet 2002;360:1203–1209. [PubMed: 12401246]
30. Maheswaran R, Elliott P. Stroke mortality associated with living near main roads in England and Wales: a geographical study. Stroke 2003;34:2776–2780. [PubMed: 14615623]
31. Buckeridge DL, Glazier R, Harvey BJ, et al. Effect of motor vehicle emissions on respiratory health in an urban area. Environ Health Perspect 2002;110:293–300. [PubMed: 11882481]
32. Duhme H, Weiland SK, Keil U, et al. The association between self-reported symptoms of asthma and allergic rhinitis and self-reported traffic density on street of residence in adolescents. Epidemiology 1996;7:578–582. [PubMed: 8899382]
33. Edwards J, Walters S, Griffiths RK. Hospital admissions for asthma in preschool children: relationship to major roads in Birmingham, United Kingdom. Arch Environ Health 1994;49:223–227. [PubMed: 7518223]
34. English P, Neutra R, Scalf R, et al. Examining associations between childhood asthma and traffic flow using a geographic information system. Environ Health Perspect 1999;107:761–767. [PubMed: 10464078]
35. Feychting M, Svensson D, Ahlbom A. Exposure to motor vehicle exhaust and childhood cancer. Scand J Work Environ Health 1998;24:8–11. [PubMed: 9562395]
36. Gordian ME, Haneuse S, Wakefield J. An investigation of the association between traffic exposure and the diagnosis of asthma in children. J Expo Sci Environ Epidemiol 2006;16:49–55. [PubMed: 16007113]
37. Harrison RM, Leung PL, Somervaille L, Smith R, Gilman E. Analysis of incidence of childhood cancer in the West Midlands of the United Kingdom in relation to proximity to main roads and petrol stations. Occup Environ Med 1999;56:774–780. [PubMed: 10658564]
38. Lin S, Munsie JP, Hwang SA, Fitzgerald E, Cayo MR. Childhood asthma hospitalization and residential exposure to state route traffic. Environ Res 2002;88:73–81. [PubMed: 11908931]
39. Livingstone AE, Shaddick G, Grundy C, Elliott P. Do people living near inner city main roads have more asthma needing treatment? Case control study. BMJ 1996;312:676–677. [PubMed: 8597735]
40. McConnell R, Berhane K, Lurmann F, et al. Traffic and asthma prevalence in children. Am J Respir Crit Care Med 2002;165:A492.
41. Morris SE, Sale RC, Wakefield JC, et al. Hospital admissions for asthma and chronic obstructive airways disease in East London hospitals and proximity of residence to main roads. J Epidemiol Community Health 2000;54:75–76. [PubMed: 10692969]
42. Nafstad P, Haheim LL, Oftedal B, et al. Lung cancer and air pollution: A 27-year follow up of 16,209 Norwegian men. Thorax 2003;58:1071–1076. [PubMed: 14645978]
43. Nyberg F, Gustavsson P, Jarup L, et al. Urban air pollution and lung cancer in Stockholm. Epidemiology 2000;11:487–495. [PubMed: 10955399]
44. Pearson RL, Wachtel H, Ebi KL. Distance-weighted traffic density in proximity to a home is a risk factor for leukemia and other childhood cancers. J Air Waste Manag Assoc 2000;50:175–180. [PubMed: 10680346]
45. Reynolds P, Von Behren J, Gunier RB, Goldberg DE, Hertz A. Residential exposure to traffic in California and childhood cancer. Epidemiology 2004;15:6–12. [PubMed: 14712141]
46. Shima M, Nitta Y, Adachi M. Traffic-related air pollution and respiratory symptoms in children living along trunk roads in Chiba prefecture, Japan. J Epidemiol 2003;13:108–119. [PubMed: 12675120]

NIH-PA Author Manuscript
NIH-PA Author Manuscript

47. Wilkinson P, Elliott P, Grundy C, et al. Case-control study of hospital admission with asthma in children aged 5-14 years: relation with road traffic in North West London. Thorax 1999;54:1070–1074. [PubMed: 10567625]
48. Zmirou D, Gauvin S, Pin I, et al. Traffic related air pollution and incidence of childhood asthma: results of the Vesta case-control study. J Epidemiol Community Health 2004;58:18–23. [PubMed: 14684722]
49. Wilhelm M, Ritz B. Residential proximity to traffic and adverse birth outcomes in Los Angeles County, California, 1994-1996. Environ Health Perspect 2003;111:207–216. [PubMed: 12573907]
50. Yang CY, Chang CC, Chuang HY, et al. Evidence for increased risks of preterm delivery in a population residing near a freeway in Taiwan. Arch Environ Health 2003;58:649–654. [PubMed: 15562637]
51. Raaschou-Nielsen O, Hertel O, Thomsen BL, Olsen JH. Air pollution from traffic at the residence of children with cancer. Am J Epidemiol 2001;153:433–443. [PubMed: 11226975]
52. Brauer M, Hoek G, van Vliet P, et al. Estimating long-term average particulate air pollution concentrations: application of traffic indicators and geographic information systems. Epidemiology 2003;14:228–239. [PubMed: 12606891]
53. U.S. Environmental Protection Agency. Options for PM2.5 and PM10 hot-spot analyses in the transportation conformity rule amendments for the new PM2.5 and existing PM10 national ambient air quality standards, Supplemental notice of proposed rule. December 13;2004 69 Fed. Reg. 72140-72156