

WORKSHOP ON TRAFFIC, HEALTH, AND INFRASTRUCTURE PLANNING
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BACKGROUND INFORMATION SUMMARY DOCUMENT

**TRAFFIC PROXIMITY AND DENSITY-RELATED HEALTH EFFECTS:
SUMMARY OF RECENT RESEARCH**

INTRODUCTION

Motor vehicle traffic is responsible for the emission of high concentrations of toxic particles and gases, as well as the atmospheric resuspension of roadway dust in close proximity to roadways. This complex, freshly emitted aerosol evolves rapidly over time and space as it disperses away from the roadway, ages, and interacts with the regional ambient pollutants (Figure 1). The population is exposed to this traffic-related pollution through time spent near roadways and through the contribution of traffic emissions to the complex mixtures of air pollutants found in urban areas. Understanding transportation-related exposures is an area of active research. The pollutant dose delivered to the lung produces local pulmonary responses and ultrafine particles are distributed systemically to the cardiovascular systems and other target tissues. Researchers postulate that the subsequent oxidative stress and inflammation cascade activation contributes to a wide spectrum of acute and chronic adverse health outcomes. Susceptible groups such as neonates and young children, the elderly and those with preexisting cardiopulmonary disease may be at greatest risk for adverse health effects associated with exposure to traffic-related pollutants.

A growing number of studies have examined the relationship between traffic-related exposures and health. There are basically two (interrelated) approaches to classify proximity to roadways (within the 0-200 meter buffer) as a surrogate of residential exposure to “fresh traffic exhaust.” The first approach is based on distance from roads as an index of exposure, with the assumption that the closer one lives to the curbside, the higher are the levels of respective pollutants at the home. The second concept uses traffic density measures among subjects living within the relevant proximity buffer as an index of relative exposure.

While studies of the respiratory health impacts of residing in close proximity to high density traffic date back almost three decades to work in Tokyo, Japan, there has been a dramatic increase in both the number of studies and the health outcomes examined over the past decade. A broad spectrum of traffic density and proximity-related health outcomes have been investigated in North America, Europe, Scandinavia, and Japan using diverse study designs and exposure assessment methods in several populations and subgroups, including children, adults from the general population, and occupationally-exposed workers. These include: respiratory symptoms, function, and infections; asthma incidence, prevalence, and exacerbations; atopy and allergic sensitization; childhood cancers including leukemia, central nervous system cancers, brain cancer, lymphomas, as well as adult lung cancer and total cancers; total, cardiopulmonary, and stroke mortality; and birth outcomes. This report presents key investigative findings for various outcomes and identifies knowledge gaps.

KEY FINDINGS

Respiratory Effects

Respiratory Symptoms

The largest body of evidence relates to increased risk of respiratory symptoms, especially for children residing in close proximity to roads with high traffic densities. Studies in Germany (Nicolai et al. 2003; Krämer et al. 2000; Gehring et al. 2002), the Netherlands (Oosterlee et al. 1996; van Vliet et al. 1997; Brauer et al. 2002), Switzerland (Braun et al. 1992), Italy (Ciccone et al. 1998), the United Kingdom (Venn et al. 2000), Japan (Murakami et al. 1990; Nitta et al. 1993), and the United States (Garshick et al. 2003) have found increased risk of respiratory symptoms such as wheeze, cough, chronic phlegm production, and dyspnea (shortness of breath) in children and adults based on measures of either proximity to roadways and/or local traffic density, comparing those classified as more exposed to those classified as less exposed. The weight of this evidence is also the most consistent in terms of positive findings.

Asthma-Related Outcomes

A number of studies have also examined a variety of asthma-related health endpoints, including asthma symptoms, prevalence and incidence, medication use, as well as hospitalization. In general, the studies find a consistently increased risk for some asthma-related health outcomes (e.g. asthma symptoms, asthma prevalence and incidence) in relation to roadway proximity or traffic density. However, the evidence for other outcomes (e.g., asthma hospitalizations, asthma medication use) is much less consistent. The lack of consistency in studies of these health outcomes may reflect differences in the number of studies for the specific health outcome, as well as variations in the analytic methodologies applied in the studies. Additional studies examining asthma-related outcomes not previously referenced above with those examining other respiratory symptoms include studies in Germany (Duhme et al. 1996), France (Zmirou et al. 2004), Japan (Shima et al. 2003), the United States (Lin et al. 2002; English et al. 1999; Gordian 2003; McConnell et al. 2002), the United Kingdom (Edwards et al. 1994; Wilkinson et al. 1999; Livingstone et al. 1996; Morris et al. 2000), and Canada (Buckeridge et al. 2002).

Respiratory Function

Studies in Germany (Wjst et al. 1993), the Netherlands (Brunekreef et al. 1997), and Switzerland (Schindler et al. 1998) have all found positive associations between higher traffic density and reduced lung function, with some indication that exposure to heavy-duty (diesel) vehicles is particularly important. No studies on respiratory function in relation to traffic density or roadway proximity have yet been conducted in North America, though in Southern California the Children's Health Study (Gauderman et al. 2002) showed that traffic-related pollutants (NO₂, PM_{2.5}) were associated with clinically meaningful deficits in lung function growth.

Atopy

There is limited evidence from studies in Europe that there is an increase in sensitization to allergens, rhinitis, and other indicators of atopy with proximity to roadways, although these findings are not consistent across studies. The study in Düsseldorf, Germany by Krämer et al. referenced above in the discussion of respiratory symptoms also found increases in hay fever, rhinitis, and sensitization with exposure to higher emission levels using NO₂ concentrations as a surrogate for traffic-related pollution. The study of children age 12-15 years in Munster, Germany by Duhme et al., referenced above regarding asthma symptoms, also found an association between self-reported exposure to high density truck traffic and symptoms of allergic rhinitis. A study in Basel, Switzerland found a statistically significant association at the two highest quartile exposure levels between sensitization to outdoor allergens (pollen)

and traffic volume, though an association was not found with hay fever (Wyller et al. 2000). However, a study of children exposed to traffic-related air pollutants (benzene, NO₂, CO) in inner-city Dresden, Germany (Hirsh et al. 1999) did not find an increase in atopic sensitization, symptoms of atopic disease, and bronchial hyperresponsiveness associated with these pollutants, though an association was observed between increases of these pollutants and prevalence of morning cough and bronchitis.

Cardiovascular Effects

A growing number of epidemiologic studies have examined the effects of ambient air pollution on cardiovascular endpoints and disease outcomes including changes in heart rhythm and ischemic heart disease. However, no studies have directly assessed the role of proximity to roadways and traffic density on these endpoints.

Cancers

Vehicle emissions contain various respiratory carcinogens as well as benzene, a leukemogen. Studies in several countries have examined the relationship of various cancers in children and adults in relation to traffic density or roadway proximity. The primary cancers associated in these studies with traffic density or roadway proximity have been leukemia in children and lung cancer in adults. Associations with other cancers (as well as total cancers) have also been examined, with inconsistent results.

Childhood Cancers

A Danish study that modeled NO₂ and benzene exposures to characterize in-home exposure to traffic-related carcinogens found an association between traffic exposure and Hodgkin's disease (Raaschou-Nielsen et al. 2001). However, leukemia, central nervous system (CNS), and total cancers were not associated with traffic exposure. Conversely, a Swedish study originally designed to examine the relationship of exposure to electromagnetic fields with childhood cancer cases found a relationship between traffic exposure estimated using traffic-based NO₂ models and leukemia, CNS cancers, and total cancers, though results were not statistically significant for dose-response across quartiles (Feychting et al. 1998). A study in the United Kingdom examining childhood cancers and proximity to roadways (less than 100 meters) found a positive but not statistically significant association based on a relatively small number of childhood leukemia cases (Harrison et al. 1999). In the United States, several studies in California and a study in Denver, Colorado have examined this issue, with mixed results. Although the Denver study (Pearson et al. 2000) did report an association between proximity to high traffic roadways and all childhood cancers and childhood leukemias, the results of the best designed and most current of the California studies (Reynolds et al. 2004) are consistent with other recent findings from that region generally not finding an association between traffic density and childhood leukemia or brain tumors.

Adult Cancers

Population-based case control studies in Sweden (Nyberg et al. 2000) and Norway (Nafstad et al. 2003) have examined the association between lung cancer cases and exposure to traffic pollution using modeled residential NO₂ levels as the indicator of traffic pollution exposure. Both studies found an association between increased incidence of lung cancer and increased NO₂ exposure, which presumably represents exposure to higher traffic density emissions.

Mortality

Recent studies in the Netherlands (Hoek et al. 2001) and the United Kingdom (Maheswaran and Elliott 2003) have found statistically significant positive associations between cardiopulmonary and stroke mortality, respectively, with proximity to roadways. The Dutch study considered a number of potential

personal and socioeconomic confounding variables and used NO₂ and Black Smoke levels as indicators of exposure to traffic pollution. Living near a highway or main road (with “near” defined as within 100 meters and 50 meters respectively) was significantly associated with almost a doubling of the risk of cardiopulmonary-related mortality, and an increased risk for total mortality was also observed.

Stroke mortality was studied in England and Wales with an ecological design that considered potentially confounding socioeconomic variables at the census district rather than individual level. A comparison of the residents at locations less than 200 meters away from a main road with those living greater than or equal to 1000 meters away resulted in a small (5%) but statistically significant increased risk of stroke mortality.

Another study in Amsterdam (Roemer and van Wijnen 2001) observed stronger time-series associations for mortality with ambient background PM for those living along busy roads compared to background pollution levels. However, this finding cannot be solely interpreted as an effect of traffic proximity but may be due to different susceptibility patterns among people living very close to high traffic or to interactions between pollutants in those areas.

Birth and Development

A recent study of birth outcomes in Los Angeles County in relation to traffic density found a small (8%) but statistically significant increased risk of pre-term birth for the quartile with the highest traffic density compared to the lowest traffic density quartile (Wilhelm and Ritz 2003). The effects of traffic were largest during the fall/winter months when stagnant air conditions are likely to produce higher exposures. The effects of traffic density on pre-term birth appeared to be larger among women residing in low socioeconomic status (SES) areas. Associations of traffic density with low birth weight were less consistent.

This finding is supported by a number of other published studies finding an association of traffic-related pollutants with adverse birth outcomes. These studies have associated regional traffic indicators including CO and particulate polycyclic aromatic hydrocarbons (PAHs) with low birth weight, pre-term birth and reduced head circumference (Liu et al 2003; Maisonet et al 2001; Perera et al 2003). However, while these studies provide support for a link between traffic-related pollutants and adverse birth outcomes, they did not directly assess the role of proximity to roadways or local traffic density to these health results. In one recent study in Taiwan that used roadway proximity as an indicator of exposure to traffic air pollution, the risk of preterm birth in mothers living within 500 meters of a major freeway was 30 percent higher compared with mothers living in the 500-1500 meter range (Yang et al. 2003).

DISCUSSION AND CONCLUSIONS

Interpretation of epidemiologic studies of traffic-related exposures and health outcomes requires consideration of key sources of bias. The major threats to validity for these studies are exposure measurement error and confounding, including SES, genetic variation, other environmental exposures associated with roadways or poverty. Exposure considerations are particularly prominent, as the epidemiological studies have largely used measures of proximity to the source, i.e., the roadway. Substantial random misclassification would be anticipated to result from these exposure assessment approaches, tending to reduce associations with health outcomes. Reporting bias is also a concern for those studies that do not utilize objective measures of health outcomes.

In conclusion, a substantial and growing body of evidence from epidemiologic studies indicates that residence in close proximity to roadways with high traffic density is associated with increased risk of a

broad spectrum of health outcomes in adults and children. The scientific evidence is stronger for the health outcomes of mortality, lung function, and lung cancer in adults, and for respiratory symptoms including asthma/wheezing and lung function in children. The interpretation of study results for asthma medication or health care use, cancer in children, and atopy are less consistent.

The epidemiologic evidence from these traffic-related studies is supported by generally consistent results using two distinct approaches, both of which study the same traffic-related pollutants and health outcomes, but at different scales. The first is from a large body of scientific evidence from studies that examine populations on a larger geographic scale, such as neighborhoods or cities. The second is a set of clinical studies of health effects from exposure to individual traffic-related pollutants such as carbon monoxide and diesel exhaust particles.

Finally, additional research is needed to better understand the health consequences of the additional air pollution exposure specifically associated with spending significant amounts of time in very close proximity to high traffic density roadways. This is especially important for the health outcomes for which results from studies to date have been inconsistent, or for those outcomes for which there is quite limited data. Disentangling the role of the various components of traffic pollution in the health findings, especially the role of diesel versus gasoline engine emissions, will be particularly informative in terms of future regulatory policy to address motor vehicle air pollution.

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Figure 1. Biological Impact Pathway for Traffic-Related Pollutants

