AGENDA ITEM #3
September 29, 2009

Introduction

MEMORANDUM

September 23, 2009

TO: County Council

FROM: Amanda Mihill, Legislative Analyst AMihill
GO Glenn Orlin, Deputy Council Staff Director

SUBJECT: **Introduction:** Resolution to adopt Board of Health Regulation requiring a health impact assessment for major road projects

A resolution to adopt a Board of Health Regulation requiring a health impact assessment for major road projects, sponsored by Councilmembers Trachtenberg and Elrich, Council President Andrews, and Councilmembers Navarro and Ervin, is scheduled to be introduced on September 29, 2009. A public hearing is tentatively scheduled for November 3.

This Board of Health regulation would require the Department of Health and Human Services to conduct a health impact assessment on each major road project. In this regulation, major road projects mean any new road or improvement of an existing road that (a) adds vehicle capacity or improves transit service on a road classified arterial or higher; and (b) is within 1,000 feet of a master-planned sensitive land use. The Board of Health regulation would take effect January 1, 2010.

Attached on ©4 is an article promoting the benefits of conducting health impact assessments. Attached on ©7 is an article identifying some of the negative health effects of vehicle emissions. Additional background information on this subject is in the Council staff packet for the March 24, 2009 Council discussion on the health effects of air quality near major highways.[1]

This packet contains:	Circle #
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Health Impact Assessment: A Step Toward Health in All Policies	4
Potential Health Effects Associated with Residential Proximity to Freeways and Primary Roads	7

[1] Agenda item #8.

Resolution No.: _____
Introduced: _____
Adopted: _____

COUNTY COUNCIL
FOR MONTGOMERY COUNTY, MARYLAND
SITTING AS THE MONTGOMERY COUNTY BOARD OF HEALTH

By: Councilmembers Trachtenberg and Elrich, Council President Andrews, and Councilmembers Navarro and Ervin

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Subject: **Board of Health Regulation requiring a health impact assessment for major road projects.**

Background

1. County Code §2-65, as amended effective August 10, 2000, provides that the County Council is, and may act as, the County Board of Health, and in that capacity may adopt any regulation which a local Board of Health is authorized to adopt under state law.

2. Maryland Code Health-General Article §3-202(d) authorizes the County Board of Health to adopt rules and regulations regarding any nuisance or cause of disease in the County.

3. On {*date*} the County Council held a public hearing on this regulation. As required by law, each municipality in the County and the public were properly notified of this hearing.

4. The County Council, sitting as the Board of Health, finds after hearing the testimony and other evidence in the record of the public hearing that requiring a health impact assessment for major road projects is necessary to protect the health of County residents.

Action

The County Council for Montgomery County, Maryland, sitting as the County Board of Health, approves the following regulation:

1 **Health Impact Assessments for Major Road Projects**
2
3 (a) **Definitions.**
4 (1) "***Air pollutant***" means:
5 (1) carbon monoxide;
6 (2) nitrogen dioxide;
7 (3) benzene;
8 (4) 1,3 butadiene;
9 (5) particulates (PM10);
10 (6) fine particulates (PM2.5);
11 (7) ultrafine particulates (PM.1); and
12 (8) any other EPA-regulated air pollutant that the Director finds is known or
13 suspected to be toxic or carcinogenic.
14 (2) "***At-risk population***" includes:
15 (A) individuals under 18 years of age;
16 (B) individuals 65 years of age or older;
17 (C) women aged 18-45; or
18 (D) individuals with respiratory disease, cardiovascular disease, diabetes, or
19 another disease that would make them more susceptible to harm from air
20 pollutants emitted by motor vehicles.
21 (3) "***Design year***" means approximately 20-25 years after a major road project is
22 anticipated to be open to traffic.
23 (4) "***EPA***" means the United States Environmental Protection Agency.
24 (5) "***Health Impact Assessment***" means a combination of procedures, methods, and
25 tools by which a project is judged in terms of its potential effects on the health of
26 the at-risk population and the distribution of those effects in that population.
27 (6) "***Major road project* or *project***" means any new road or improvement of an
28 existing road that:
29 (A) adds vehicle or intersection capacity or improves transit service if that
30 road has a classification of arterial or higher as defined in Chapter 49-31;
31 and
32 (B) is within 1,000 feet of a master-planned sensitive land use.

33 (7) ***"Sensitive land use"*** means any land use with a high proportion of the at risk
34 population, including:
35 (A) parks;
36 (B) schools;
37 (C) daycare centers;
38 (D) senior housing; and
39 (E) hospitals.
40 (b) **Health Impact Assessment required.** The Department of Health and Human Services
41 must conduct a health impact assessment on each major road project. The health impact
42 assessment must be conducted:
43 (1) during Facility Planning – Phase I for a County major road project; and
44 (2) during project planning for a State major road project.
45 For a County major road project, the Council must receive and review the Health Impact
46 Assessment before Facility Planning – Phase II begins.
47 (c) **Contents of Health Impact Assessment.** The Health Impact Assessment must:
48 (1) develop a baseline of background exposures of air pollutants for the design year
49 of the appropriate project;
50 (2) model projected emissions of air pollutants from vehicles using the project for the
51 design year of the appropriate project;
52 (3) model the likely dispersion of air pollutants from vehicles traveling on the project
53 for the design year of the appropriate project;
54 (4) quantify the cumulative public impacts of exposure to air pollutants from motor
55 vehicles on the project for the design year of the appropriate project;
56 (5) quantify the potential risks to at-risk populations in the sensitive land uses within
57 1,000 feet of the project for the design year of the appropriate project; and
58 (6) make recommendations that promote health benefits and minimize health risks.
59 (d) **Applicability.** This regulation applies Countywide.
60 (e) **Severability.** If the application of this regulation or any part of it to any facts or
61 circumstances is held invalid, the rest of the regulation and its application to all other
62 facts and circumstances is intended to remain in effect.
63 (f) **Effective Date.** This regulation takes effect on January 1, 2010.

Health Impact Assessment

A Step Toward Health in All Policies

Janet Collins, PhD
Jeffrey P. Koplan, MD, MPH

FOR THE PAST 4 DECADES, THE ENVIRONMENTAL IMpact statement (EIS) process has been used to assess the environmental effects of major projects and policies that involve federal funds, such as designing highways, altering waterways, extracting resources on federal lands, and setting Corporate Average Fuel Economy standards. Created under the National Environmental Policy Act of 1969, EISs do not determine policy but rather ensure that stakeholders have full information about unintended environmental impacts before reaching a decision.[1] By evaluating alternative proposals and their relative risks and benefits, an EIS helps decision makers choose options that promote favorable outcomes and mitigate adverse environmental consequences.

A natural extension of this work is the use of health impact assessment (HIA) to examine the effects that a policy, program, or project may have on the health of a population. An HIA is defined as "a combination of procedures, methods and tools that systematically judges the potential, and sometimes unintended, effects of a policy, plan, programme or project on the health of a population and the distribution of those effects within the population. HIA identifies appropriate actions to manage those effects."[2] Most health professionals are probably more familiar with EISs and their intent and usage than with HIAs. Yet there has been a movement to adopt HIAs in public policy settings and legislation and in a recently emerging health policy literature that describes and advocates for this process. HIAs offer great potential for promoting health by encouraging decisions that protect and enhance health and health equity.[3,4]

There is increasing recognition that many contemporary health issues are profoundly influenced by factors outside the traditional realm of health and health care. Factors such as literacy, poverty, employment, and racism contribute to disparities in life expectancy as well as to health-related quality of life. Concerns about how to address these factors have led to a focus on "health in all policies," in which policies in social sectors such as transportation, housing, employment, and agriculture ideally would contribute to health and health equity. An HIA offers a vehicle to make these health effects explicit. Unfortunately, the evaluation of health effects in policy making has been slow to take hold.

See also pp 317 and 320.

The United States lags behind many European nations, Canada, and other countries in the use of HIAs.[4,5] This situation is somewhat surprising, given that US environmental policy explicitly requires the examination of health effects as part of the National Environmental Policy Act. Although most EISs in the United States incorporate little about health effects, experience in California and Alaska has demonstrated that a wide range of health effects can be successfully integrated into the EIS process.[3]

Beyond increasing attention to health outcomes within EISs, the potential applications of HIAs are clearly evident. For example, although air pollution and injury prevention are often considered in major transportation projects, the influence of road design on physical activity and obesity is not. An HIA that recommends the addition of pedestrian and bicycle facilities ("complete streets") to a transportation plan would contribute to a built environment that promotes the public's health.

The agriculture sector seeks to maximize productivity, meet consumer demand, and sustain livelihoods. From a health perspective, agricultural policy determines food quantity, quality, and prices that directly affect consumption patterns and therefore affect health.[6] HIAs could be used to examine the health effects of proposed agricultural policies, such as ones that enhance production of energy-dense, nutrient-poor foods that contribute to the increasing obesity epidemic. HIAs of proposed zoning plans, which would contribute to decreased density of fast-food and liquor stores or increased density of restaurants and full-service grocery stores, especially in low-income areas, could result in changes that better promote health.

In education, a timely HIA might have reduced the inadvertent effects of the No Child Left Behind legislation on physical education programs and health curricula by pro-

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viding alternate scenarios for achieving the desired educational outcomes while simultaneously promoting health. A prospective HIA of proposed sites for local schools could recommend locating new schools at sites that have low levels of noise and air pollution and that have features that encourage children to walk or bicycle to school (including the construction of safer street crossings near schools).

In commerce, an HIA of proposed domestic and international trade policies affecting the price and availability of tobacco could recommend policy modifications to reduce tobacco use and its adverse health consequences. HIAs could thus help national policymakers consider the relative costs, benefits, and risks of tobacco as an agricultural product and export crop and as a toxic risk factor for poor health outcomes and increased health care costs.

Although the potential applications are expansive, increasing evidence of the effects of HIAs on decision-making makes this strategy compelling.[3-5] The TABLE highlights selected HIAs in the United States and outcomes associated with those efforts. HIAs can make an important contribution to social equity and the elimination of health disparities, especially when community input is incorporated into the planning, conduct, and communications processes of HIAs.[3]

Several pieces of current federal legislation have important implications for health. The Food, Conservation, and Energy Act of 2008 (Pub L No. 110-224, also known as the 2008 US Farm Bill)[7] was enacted in June 2008 and addresses crop subsidies that influence food prices, nutrition programs such as the Supplemental Nutrition Assistance Program (formerly known as the federal Food Stamp Program), and food accessibility. The transportation bill to be considered for reauthorization in this congressional session addresses support for roads and their design, bicycle paths, and public transportation—all of which are integrally involved with physical activity and injury prevention. The Child Nutrition and WIC Reauthorization Act of 2004, set to expire in September 2009, deals with the school breakfast and national school lunch programs, the summer food service program, the child and adult care food program, and the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC).[8] HIAs are urgently needed to examine these bills for their likely effects on health.

Health is determined not only by genetics and personal choices but also by policies and environmental factors. Public health and medicine need to engage more proactively in policy decisions, and HIAs provide a great vehicle for doing so. In addition, greater awareness and use of HIAs could be achieved if legislators, funders, donors, and foundations would incorporate HIAs in the planning of projects they support. For example, the World Bank requires HIAs as part of their large development efforts,[9] and bills encouraging or requiring the use of HIAs have been introduced at the federal level as well as in a number of states.[10] The challenge ahead is to increase the demand for the routine use of HIAs, both within and outside the EIS process, and to increase the capacity of health professionals and others to conduct HIAs. To promote this goal, the Robert Wood Johnson Foundation, with the Pew Charitable Trusts, will launch a national initiative in fall 2009 to demonstrate the value of HIAs as a tool to provide policymakers with the information they need to make decisions that improve health.

Table. Selected Examples of Health Impact Assessments (HIAs) and Their Subsequent Outcomes in the United States[a]

HIA	Location and Date	Subsequent Outcomes
Living wage ordinance	San Francisco, CA, 1999	HIA contributed to the passage of local living wage and minimum wage ordinances and to funding for the creation of the San Francisco Department of Public Health HIA program
Trinity Plaza housing redevelopment	San Francisco, CA, 2003	HIA findings led city officials to require the developer to include a no-displacement alternative, which prevented the displacement of all existing low-income residents as well as more routine participation of the city health department in the local environmental review process
Northeast National Petroleum Reserve oil and gas leasing program	Alaska, 2007	In part because of an HIA, the Bureau of Land Management subsequently withdrew from leasing some of the land for which oil and gas development would have adversely affected the health of native populations and instituted new pollution monitoring and controls; on a larger scale, multiple federal agencies are now accepting health considerations in the federal environmental impact statement process both within Alaska and in other regions
Lowry Corridor redevelopment	Minneapolis, MN, 2007	HIA recommendations helped the project manager obtain pedestrian and bicycle improvements for this low-income urban corridor
Taylor Energy Center coal-fired power plant	Florida, 2007	The development authority accepted HIA recommendations about hiring minorities and providing health benefits; the project was later cancelled because of climate change concerns
BeltLine transit, trails, and parks project	Atlanta, GA, 2007	The project funding advisory committee approved using HIAs as a factor in selecting proposals for specific components of this $2.8 billion project
City of Decatur Community Transportation Plan	Decatur, GA, 2007	The city accepted the HIA recommendations to make infrastructure improvements and hired a community health planner to work on active living issues across departments

[a] Adapted from Dannenberg et al.[4] A database of HIAs completed in the United States, including periodic updates, is available from the UCLA Health Impact Assessment Clearinghouse Learning and Information Center.[11] A database of HIAs completed in Europe and elsewhere is available from the Association of Public Health Observatories.[12]

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Integrating Clinical Care and Community Health

Delivering Health

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Steven M. Teutsch, MD, MPH

HEALTH CARE AND PUBLIC HEALTH PROFESSIONALS IN the United States can look at their achievements over the last century with pride. Increasing the life span of Americans by almost one-third of a year each year over an entire century is an enormous and unprecedented accomplishment. The virtual elimination of many childhood illnesses, control of cardiovascular disease and stroke, effective treatment of pneumonia, and reductions in infant mortality exemplify the remarkable progress made. Along with changes in the social and physical determinants of health, these improvements are often attributed either to application of better medical knowledge or to public health actions, but have really required both.

Public health professionals generally think about how to improve health at a population level, whereas clinicians generally address the needs of individuals. These streams converge in systems of clinical care and are also embodied in population health principles of measurement, system change, and accountability. For example, safe and effective immunizations require timely delivery. School immunization requirements, outreach programs, up-to-date schedules, reminder systems, financial incentives, and education made it possible for clinicians to ensure those vaccines were delivered. Employers and others took delivery of influenza vaccination to work sites and community locations. Registries were created, immunization rates were tracked, and feedback was provided.

As strategies for controlling tobacco, hypertension, and hyperlipidemia emerged, clinicians collaborated with public health officials on education programs; screening; pharmaceutical management; and tobacco prevention, cessation programs, and policies to reduce use. New initiatives in urban planning and mass transit that encourage walking and biking complement school and employer-based programs to enhance physical activity.

Although much progress has been made, tobacco, physical inactivity, poor diet, alcohol, and substance use remain the highest ranked causes of death today. Microbial agents, toxins, motor vehicle crashes, firearm injuries, and harmful sexual behaviors also continue to take an unnecessary

See also pp 315 and 320.

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Potential Health Effects Associated with Residential Proximity to Freeways and Primary Roads: Review of Scientific Literature, 1999–2006

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Abstract This review presents epidemiologic evidence of adverse health effects associated with residential proximity to traffic. Of the 29 peer-reviewed studies that met the authors' defined criteria, 25 reported statistically significant associations with at least one adverse health effect across a broad range of exposure metrics and diverse geographical locations. Specific pollutants contributing to the associated health effects could not, however, be identified, and uncertainties existed because of the lack of individual exposure assessments that could rule out confounding by other factors. Improved exposure assessments and future studies should be considered for better identification of contributing pollutants and mechanisms of action. In the meantime, additional policies, additional regulations, and improved land use and urban planning can better protect the public and limit exposure, especially for vulnerable populations such as pregnant women, children, and the elderly.

Introduction

During the 1970s and 1980s, environmental regulations substantially reduced emissions from industry and stationary sources. Automobiles and other road traffic (mobile sources) became the most prominent contributors to urban air pollution in many areas of the United States (U.S. Environmental Protection Agency, 1994). Traffic emissions include nitrogen oxides (NO_x), carbon monoxide (CO), volatile organic compounds (VOCs) including benzene and 1,3 butadiene, and particulate matter (PM). In addition, toxic air pollutants including aldehydes, polycyclic aromatic hydrocarbons (PAHs), and metals can adhere to traffic-generated particulate matter (Oberdörster, 2001).

Studies characterizing distributions of fresh vehicular exhaust documented that concentrations were higher near roadways but diminished to near background levels within 150–300 meters (m) (Gilbert, Goldberg, Beckerman, Brook & Jerrett 2005; Zhu, Hinds, Kim, & Sioutas, 2002; Zhu, Kuhn, Mayo, & Hinds, 2006). The steep declines in concentrations were attributed to evaporation of volatile constituents, atmospheric dispersion, and coagulation (Zhu, Hinds, Kim, Shen, & Sioutas, 2002).

Adverse health effects have been associated with residential proximity to traffic. Traffic constituents potentially affecting health include ultrafine ($PM_{0.1}$) and fine ($PM_{2.5}$) particles which can penetrate deep into the lungs (Oberdörster, 2001) and have been associated with respiratory, pulmonary, and cardiovascular morbidity and mortality (Brunekreef & Holgate, 2002; Dockery 2001; Pope, Burnett, Thun, Calle, & Kerwski, 2002). Exposures to traffic-related PM and CO have been associated with adverse birth outcomes (Ritz, Yu, Fruin, Chapa, Shaw, & Harris, 2002; Ritz & Yu, 1999; Ritz, Yu, & Fruin, 2000), which may lead to increased childhood morbidity and mortality and increased risk of hypertension and coronary heart disease in adulthood (Barker, 1995; Osmond & Baker, 2000). Diesel emissions have been associated with effects including lung cancer (Lloyd & Cackette, 2001; Maunderly, 1990; Sydbom, Blomberg, Parnia, Stenfors, Sandstrom, & Dahlen, 2001) and pulmonary/respiratory disorders (Nel, Diaz-Sanchez, & Li 2001). In addition, traffic emissions contain many known and suspected carcinogens. Because of their potency and high concentrations, most of the cancer risk has been attributed to benzene, 1,3 butadiene, and particle-bound PAHs (Rosenbaum, Axelrad, Woodruff, Wei, Ligocki, & Cohen 1999). Chronic benzene exposures have been linked to both structural and chromo-

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TABLE 1a

Research on Traffic Proximity and Parent-Reported Adverse Respiratory Effects—Key Results

Reference	Location	Study Population (N)	Health Effects Assessed	Exposure Metric	Health Effects with Significant Associations	Distance to Traffic	Traffic Density	Adjusted Odds Ratio	95% CI
Venn et al., 2001	Nottingham, England	4–11 year olds (6,147)	Parent-reported wheeze prevalence	Postal code distance and daily traffic vehicles/day	Parent-reported wheeze prevalence	150 m	10,000–100,000 vehicles/day	1.08	1.00–1.16
		11–15 year olds (3,709)	Parent-reported wheeze prevalence	Postal code distance and vehicles/day	Parent-reported wheeze prevalence	150 m	10,000–100,000 vehicles/day	1.16	1.02–1.32
Janssen et al., 2003	20 city districts, Netherlands	7–12 year olds (2,082)	Parent-reported wheeze, nasal symptoms, lung function, conjunctivitis, itchy rash, bronchitis asthma, hay fever, eczema, allergy	Residential distance to truck traffic; trucks/day	Parent-reported conjunctivitis	500 m	5,190–22,326 trucks/day	2.57	1.00–6.58
					Parent-reported itchy rash	500 m	5,190–22,326 trucks/day	2.08	1.20–5.58
					Parent-reported current wheeze	50 m	>99,500 vehicles/day	1.67	1.07–2.58
					Parent-reported cough prevalence	50 m	>99,500 vehicles/day	1.62	1.62–2.27
Nicolai et al., 2003	Munich, Germany	4–6 year olds & 9–11 year olds (7,508)	Cough, current asthma wheeze, lung function, bronchial hyperreactivity	Average daily traffic count & distance to residence	Parent-reported asthma prevalence	50 m	>99,500 vehicles/day	1.79	1.05–3.05
					Parent-reported current wheeze	50 m	>99,500 vehicles/day	1.67	1.07–2.58
					Parent-reported cough prevalence				
Lewis et al., 2004	United Kingdom	4–6 yr olds (11,562)	Self-reported wheeze, asthma prevalence; medication use	Residential distance to main road	None	50 m	>99,500 vehicles/day	1.62	1.62–2.27
						150 m	N/A	No statistically significant results	
Gauderman et al., 2005	10 of 12 Southern California Communities in the Children's Health Study	4th graders (average age =10 years) (208)	Self-reported wheeze, asthma prevalence, asthma medication use	Residential distance to freeway	Parent-reported asthma prevalence	150 m	N/A	1.89	1.19–3.02
					Parent-reported wheeze	150 m	N/A	1.59	1.06–2.36
					Parent-reported wheeze with exercise	150 m			
Ryan et al., 2005	Cincinnati, Ohio	≤1 year old (622)	Parent-reported wheeze	Residential distance to freeway, state route with speed >50 mph; bus or state route with speed <50 mph	None	400 m	N/A	2.57	1.50–4.38
					None	100 m	Freeway	No statistically significant results	
					Parent-reported wheeze	100 m	State route, speed >50 mph	No statistically significant results	
							Bus/state route, speed <50 mph	2.50	1.15–5.42

Notes:
Relative risk (RR) by comparison with low- or no-exposure categories.
N/A = not available (i.e., not reported).

somal anomalies in humans and increased incidence of leukemia in individuals occupationally exposed (Finkelstein, 2000; Paxton, 1996; Rinsky, Smith, et al., 1987; Rinsky, Young, & Smith, 1981).

This paper summarizes available scientific findings published in peer-reviewed journals in English on health effects associated with defined residential proximity to traffic from January 1999 through June 2006.

Methods

An electronic search was performed on PubMed. Search terms included "traffic" and "traffic emissions" in combination with any of the following terms: "asthma," "adverse birth outcomes," "birth weight," "childhood cancer," "mortality," and "health effects." A total of 139 unique records were returned. Twenty-nine epidemiological studies defined residential proximity to traffic met specific inclusion criteria. Fifty-four records were excluded because they were exposure characterizations or assessments and did not address health effects; 26 were based on exposures in settings other than residences, such as workplaces or schools; 16 were based on air pollution monitoring or modeling; eight were risk assessments; three were animal studies; and three were not in English. It should be noted these criteria excluded some important studies conducted since 1999, such

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TABLE 1b

Research on Traffic Proximity and Self-Reported Adverse Respiratory Effects—Key Results

Reference	Location	Study Population (N)	Health Effects Assessed	Exposure Metric	Health Effects with Significant Associations	Distance to Traffic	Traffic Density	Adjusted Odds Ratio	95% CI
Garshick et al., 2003	Southeastern Massachusetts	U.S. veterans 60.6 ± 12.8 years old 2,628	Self-reported persistent wheeze, chronic cough, chronic phlegm	Average daily traffic count & distance to residence	Self-reported persistent wheeze	50m	9,351 vehicles/day median	1.31	1.00–1.71
							>10,000 vehicles/day	1.71	1.22–2.40
Heinrich et al., 2005	East Germany	18–79 year olds (6,896)	Self-reported wheeze, nocturnal coughing, current asthma, hay fever, chronic, bronchitis, allergic sensation	Self-reported residential proximity to traffic intensity	Self-reported chronic bronchitis	Street of residence	Self-reported extremely or considerably busy roads	1.36	1.01–1.83
Schikowski et al., 2005	Dortmund, Duisburg, Essen, Gelsenkirchen, & Herne, Germany	Women 54–55 years old (4,757)	Frequent cough, chronic bronchitis, COPD, forced expiratory volume, forced vital capacity	Average daily traffic count & distance to residence	Self-reported COPD	100 m	>10,000 vehicles/day	1.79	1.06–3.02
					Self-reported frequent cough	100 m	>10,000 vehicles/day	1.24	1.03–1.49
Venn et al., 2005	21 districts of Jimma, Ethiopia	Children and adults	Self-reported wheeze, rhinitis, eczema, dust mite sensitivity	Residential distance to road and density of vehicles/12 hours	Self-reported wheeze	150 m	653 vehicles per 12 hours median	1.17 per 30 m	1.01–1.36
McConnell et al., 2006	13 California communities	5–7 year olds (4,762)	Self-reported asthma prevalence, asthma medication use, wheeze	Residential distance to freeways, highways, & arterial roads	Lifetime asthma	75 m	N/A	1.29	1.01–1.86
					Asthma prevalence	75 m	N/A	1.50	1.16–1.95
						75–150 m	N/A	1.33	1.02–1.72
					Asthma prevalence with no family asthma history	75 m	N/A	2.46	1.48–4.09
					Current wheeze with no family asthma history	75 m	N/A	2.74	1.71–4.39

Notes:
Relative risk (RR) by comparison with low- or no-exposure categories.
N/A = not available (i.e., not reported).

as that by Wilhelm and Ritz (2005), which used residential proximity to central-site ambient-air-monitoring stations to evaluate potential associations between adverse birth outcomes and traffic-related pollutants.

Literature Review Results

Respiratory Effects

Nineteen studies evaluated residential proximity to traffic and respiratory effects. The results for studies of parent-reported respiratory effects are summarized in Table 1a, those for self-reported respiratory effects are summarized in Table 1b, and those for physician-diagnosed respiratory effects are summarized in Table 1c. Of the 19 studies, 10 examined respiratory symptoms such as wheeze, frequent coughs, and chronic phlegm; four examined indicators of asthma severity including hospitalizations and doctor visits; and six investigated the relationship between residential proximity to traffic and prevalence of asthma.

Seven of the 10 studies examining self- or parent-reported respiratory symptoms reported statistically significant associations between proximity to traffic and wheeze (McConnell et al., 2006; Garschick, Laden, Hart, & Caron, 2003; Gauderman et al., 2005; Nicolai et al., 2003; Ryan et al., 2005; Venn, Lewis, Cooper, Hubbard, & Britton, 2001; Venn, Yemaneberhan, Lewis, Parry, & Britton, 2005). Persistent or current wheeze was found to be associated with residential proximity within 50, 75, and 150 m of busy roads (McConnell et al., 2006; Gauderman et al., 2005; Venn et al., 2005; Garschick et al. 2003; Janssen et al. 2003; Venn et al. 2001). McConnell and co-authors (2006) reported statistically significant associations for residential proximity within 75 m and between 75 and 150 m but not for residences at distances of 150–300 m or greater. Heinrich and co-authors (2005) reported only marginal increases in wheeze, nocturnal coughing attacks, and hay fever in a group of East German adults with self-reported residential proximity to traffic. Lewis and co-authors (2004) reported no statistically significant associations between residential proximity to traffic within 150 m and self-reported asthma prevalence, medication usage, or wheeze in children in the United Kingdom.

Results were mixed for five studies examining associations between proximity to traffic and respiratory-related doctor visits and hospitalizations. In a study of San Diego children, English and co-authors (1999) reported that doctor visits for asthma were associated with traffic density at the second quintile (5,500–9,000 cars/day) and 95th percentile (>41,000 cars/day) within

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TABLE 1c

Research on Traffic Proximity and Physician-Diagnosed Respiratory Effects—Key Results

Reference	Location	Study Population (N)	Health Effects Assessed	Exposure Metric	Health Effects with Significant Associations	Distance to Traffic	Traffic Density	Adjusted Odds Ratio	95% CI
English et al., 1999	San Diego, California	≤14 year olds w/ asthma (5,996)	Asthma prevalence and asthma doctor visits	Average daily traffic vehicles/day & distance to residence	Asthma doctor visits	550 ft	5,500–9,000 vehicles/day	2.14	1.10–4.16*
							>41,000 vehicles/day	2.91	1.28–6.91
Wilkinson et al., 1999	North Thames London, England	5–14 year olds w/asthma & respiratory illnesses (9,214)	Asthma and respiratory illness hospitalizations 1992–1994	Postal code centroid distance to road and peak hourly traffic vehicles/hour	None	150 m	>1,000 vehicles/hour	No statistically significant results	
Lin et al., 2002	Erie County, New York	≤14 year olds w/ asthma (417)	Asthma hospital. admissions	Average vehicle miles traveled & distance to residence	Asthma hospital. admissions	200 m	>4,043 vehicle miles traveled	1.93	1.13–3.29
				Residential distance to heavy truck traffic	Asthma hospital admissions	200 m	≥1% heavy trucks	1.43	1.03–1.99
Lwebuga-Mukasa et al., 2004	16 ZIP codes near Peace Bridge on U.S./Canada Border	≥18 yr olds (13,910)	Asthma hospitalizations and outpatient visits 1991–1996	Pre- and post-NAFTA traffic volumes	None	N/A	N/A	No statistically significant results	
Zmirou et al., 2004	France	0–3 year olds (434)	Diagnosed asthma incidence, asthma prevalence	Lifetime average time weighted traffic density (vehicles/meter)	Diagnosed asthma incidence	300 m	>30 vehicles per day per meter	2.28	1.14–4.56
Gordian et al., 2006	Anchorage, Alaska	5–7 year olds (756)	Asthma prevalence	Average daily traffic per meter vehicle within buffer around residence	Asthma prevalence in children with no family asthma history	100 m	40,000–80,000 vehicle meters	2.43	1.23–5.28
							>80,000 vehicle meters	5.43	2.08–13.74
Smargiassi et al., 2006	Montreal, Canada	≥60 year olds (35,309)	Respiratory hospitalizations	Residences along roads and density of vehicles during 3-hour daily peak	Respiratory hospitalizations compared to other diagnostic groups	N/A	>3,160 vehicles/3- hour peak	1.18*	1.06–1.31
Sugiri et al., 2006	East & West Germany	5–7 yr olds (2,574)	Total lung capacity, airway resistance	Average daily traffic density kilometers/day & distance to highway	Total lung capacity	50 m	216–214 km/day mean	1.07	1.06–1.09
					Airway resistance	50 m	216–214 km/day mean	1.02	1.00–1.03

Notes:
Relative risk (RR) by comparison with low- or no-exposure categories.
N/A = not available (i.e., not reported).

550 feet (ft) of residences; this association was strongest for girls. Lin and co-authors (2002) reported increased risk of asthma hospitalization for children living in New York neighborhoods with heavy truck traffic and increased traffic density within 200 m of their homes. Smargiassi and co-authors (2006) reported increased risks of respiratory-related hospitalizations for older adults living in areas of Montreal with high traffic volumes. Wilkinson and co-authors (1999), however, using a postal-code centroid within 150 m of a busy road, reported no association between respiratory-related hospital visits and residential proximity for school children in London. Lwebuga-Mukasa and co-authors (2004) also did not find a statistically significant association for respiratory-related children's hospital visits when they examined the change in traffic patterns before and after implementation of the North American Free Trade Agreement (NAFTA) near the Peace Bridge on the U.S./Canada Border.

Four of six studies examining asthma prevalence reported statistically significant findings with residential proximity within 75, 100, 150, and 300 m of dense traffic across geographically diverse locations including Alaska, California, and France (Gordian, Haneuse, & Wakefield, 2006; McConnell et al., 2006; Gauderman et al., 2005; Zmirou et al., 2004).

Additional respiratory effects were reported to be associated with residential proximity to traffic. Schikowski and co-authors (2005) reported elevated risks of diagnosed chronic obstructive pulmonary disease, frequent cough, and reduced lung function associated

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TABLE 2

Traffic Proximity and Childhood Cancer Research—Key Results

Reference	Location	Study Population (N)	Health Effects Assessed	Exposure Metric	Health Effects with Significant Associations	Distance to Traffic	Traffic Density	Adjusted Odds Ratio	95% CI
Pearson et al., 2000	Denver, CO	≤14-yr-olds with cancer (579)	All cancers, leukemia	Daily distance-weighted traffic density—vehicles/day and distance to residence	All cancers	750 ft	5000–9999 vehicles/day	1.68	1.02–2.80
						750 ft	≥20,000 vehicles/day	5.90	1.69–20.56
					Leukemia	750 ft	5000–9999 vehicles/day	2.04	1.05–3.95
						750 ft	≥20,000 vehicles/day	8.28	2.09–32.80
Reynolds et al., 2002	California	≤15-yr-olds with cancer (6,368)	All cancers, leukemia, gliomas	Vehicles per square mile and miles of road per square mile within block group of residence	All cancers	N/A	6081–8530 vehicles/square mile	1.10*	1.01–1.19
							21.7–24.8 miles/square mile	1.11*	1.02–1.20
					Leukemia	N/A	6081–8530 v/m2	1.18*	1.03–1.35
Crosignani et al., 2003	Varese Province, Italy	≤14-yr-olds with childhood leukemia (120)	Childhood leukemia	Distance to residence plus Caline model to estimate benzene concentration	Childhood leukemia	300 m	Benzene over 10 µg/m3 estimated annual average.	3.91*	1.36–11.27
Steffen et al., 2004	Nancy, Lille, Lyon, & Paris, France	≤14-yr-olds with childhood leukemia (567)	Acute leukemia, acute non-lymphocytic leukemia, acute lymphocytic leukemia	Self-reported exposure to heavy-traffic roads & neighboring business	Acute leukemia	N/A	N/A	No statistically significant results	

Notes:
Relative risk (RR) by comparison with low- or no-exposure categories.
N/A = not available (i.e., not reported).

with residential exposure to traffic within 100 m for women 54–55 years of age in Germany. Sugiri and co-authors (2006) reported that residential proximity to a busy road of within 50 m was associated with reduced lung function in a group of German children.

Childhood Cancers

The studies that we examined augmented scientific evidence on potential associations between residential proximity to traffic and childhood cancers including acute non-lymphocytic leukemia and acute lymphocytic leukemia. Three of four studies (Table 2) reported a statistically significant association between childhood cancer and traffic exposure metrics and residential proximity within 750 ft (229 m), 200 m, and 300 m in Denver, Colorado; California; and Varese Province, Italy (Crosignani et al., 2003; Pearson, Wachtel, & Ebi, 2000; Reynolds et al., 2002). Steffen and co-authors (2004) reported an association for self-reported residential proximity to automobile repair stations and petrol stations but not for exposure to heavy traffic. That study, however, was one of the few relying on the participant's perception of living near heavy traffic rather than more objective traffic and exposure metrics.

Adverse Birth Outcomes

Three studies examined the relationship between adverse birth outcomes and traffic exposure and reported statistically significant associations (Table 3). Maternal residence within 500 m of a major freeway in Taiwan was reported to be a significant risk factor for preterm birth (Yang et al., 2003). Wilhelm and Ritz (2003) reported that California mothers who lived within 750 ft (229 m) of the highest quintile of heavy-traffic roadways during pregnancy were more likely to have a preterm baby. These researchers reported higher risks of preterm and low-birth-weight babies being born in the fall and winter to mothers living nearer the highest-quintile traffic density. An extended analysis of these California births by Ponce and co-authors (2005) further confirmed the association between proximity to dense traffic and low birth weight for births occurring in the winter.

Mortality Risks

Three studies examined the relationship between residential proximity to traffic and mortality. Associations were reported for cardiopulmonary, stroke, and cardiovascular mortality in the Netherlands, the United Kingdom, and Canada (Finkelstein, 2000; Maheswaran & Elliot, 2003; Hoek, Brunekreef, Goldbohm, Fischer, & van den Brandt, 2002). Both Finkelstein (2000) and Hoek and co-authors (2002) reported statistically significant mortality risks for residences within 100 m of a highway (freeway) and 50 m of an urban road. Maheswaran and Elliot (2003) reported elevated mortality risks at a distance of up to 1000 m from the centroid of the residential enumeration district. These findings were consistent with those of previous studies establishing PM as a well-defined risk factor for premature mortality; more than 50 percent of total PM emissions in urban

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TABLE 3

Traffic Proximity and Adverse Birth Outcomes Research—Key Results

Reference	Location	Study Population (N)	Health Effects Assessed	Exposure Metric	Health Effects with Significant Associations	Distance to Traffic	Traffic Density	Adjusted Odds Ratio	95% CI
Wilhelm & Ritz, 2003	Los Angeles County, CA	1994–1996 live births (50,933)	Low birth weight, preterm births, low birth weight and preterm births	Distance-weighted traffic density (DWTD), and one or more freeways and distance to residence	Preterm births	750 ft	Highest-quintile DWTD	1.08*	1.01–1.15
					Preterm births during fall/winter	750 ft	Highest-quintile DWTD	1.15*	1.05–1.26
					Low birth weight and preterm during fall/winter	750 ft	Highest-quintile DWTD	1.24*	1.03–1.48
					Low birth weight	750 ft	40th to 59th percentile DWTD	1.16*	1.03–1.30
							60th to 79th percentile DWTD	1.15*	1.02–1.29
					Low birth weight during fall/winter	750 ft	Highest-quintile DWTD	1.33*	1.11–1.58
Yang et al., 2003	East Kaohsiung, Taiwan	1992–1997 live births (6,251)	Preterm delivery	Residential distance to a major freeway with average daily traffic count—vehicles/day	Preterm delivery	500 m	93,000 vehicles/day	1.30	1.03–1.65
Ponce et al., 2005	112 ZIP codes in Los Angeles County	1994-1996 live births (37,347)	Low birth Weight	Residential ZIP codes distance intersected by freeways and major arterials, and DWTD	Low birth weight during winter	3.2-km buffer	DWTD 80th percentile	1.30	1.07–1.58

Notes:
Relative risk (RR) by comparison with low- or no-exposure categories.
N/A = not available (i.e., not reported).

areas of industrialized countries have been estimated to come from traffic (Wróbel, Rokita, & Maenhaut, 2000; Briggs et al., 1997).

Discussion and Policy Implications

Of the 29 studies reviewed, 25 reported statistically significant associations between residential proximity to traffic and at least one of the following adverse health effects: increased prevalence and severity of symptoms of asthma and other respiratory diseases; diminished lung function; adverse birth outcomes; childhood cancer; and increased mortality risks. These associations were reported across a broad range of exposure metrics ranging from self-report to sophisticated mobile-source models, a wide variety of analytical designs controlling for diverse confounders, and diverse geographical locations. The results were particularly consistent for 9 of 10 non-respiratory studies reporting statistically significant associations between residential proximity to traffic and childhood cancer; adverse birth outcomes; and cardiopulmonary, cardiovascular, cerebrovascular, and stroke mortality.

Mixed findings from studies of respiratory outcomes and residential proximity to traffic may be partly explained by issues related to case identification and definitions used for asthma diagnosis. First, asthma prevalence and respiratory symptoms in many of the studies were self-reported through surveys and were subject to recall bias (Garshick et al., 2003; Gauderman et al., 2005; Heinrich et al., 2005; Janssen et al., 2003; Lewis et al., 2004; McConnell et al., 2006; Schikowski et al., 2005; Venn et al., 2001; Venn et al., 2005). Obtaining accurate reporting of symptoms by young children is especially challenging because they may not be aware of or capable of verbalizing symptoms, or may not be able to recall symptoms as well as older children or adults (Kuehni & Frey, 2002). Second, studies have demonstrated that parental conceptual understanding of wheeze varies across ethnic groups (Cane, Pao, & McKenzie, 2001) and differs from definitions used by epidemiologists (Cane, Ranganathan, & McKenzie, 2000). Third, even a physician's diagnosis of asthma can be unreliable because of changes in diagnostic practices and definitions over time (Hill, Williams, Tattersfield, & Britton 1989).

Residential distance to and density of traffic were reported to be important factors in the assessment of the relationship between traffic exposure and adverse health outcomes. The majority of studies using varying distances to residences as exposure metrics reported associations with adverse health effects for distances up to 200 m but not for greater distances (Garshick et al., 2003; Gordian et al., 2006; Lin et al., 2002; McConnell et al., 2006; Nicolai et al., 2003; Schikowski et al., 2005; Sugiri et al., 2006; Venn et al., 2001; Wilkinson et al., 1999). Only three studies reported health effects associated with residential proximity greater than 300 m (Ponce et al., 2005; Yang et al., 2003; Maheswaran & Elliot, 2003).

Four of five studies evaluating residential proximity to major highways (freeways) reported statistically significant associations with adverse health effects (Finkelstein et al., 2004; Ponce et al., 2005; Hoek et al., 2002; Yang et al., 2003). Adverse effects were reported

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for traffic counts as low as 5,500–9,000 vehicles/day (English et al., 1999), 10,000 vehicles/day (Garshick et al., 2003; Schikowski et al., 2005), and approximately 24,000 vehicles/day (Smargiassi, Berrada, Fortier, & Kosatsky 2006; Wilkinson et al., 1999), as well as for busy-highway (freeway) averages of up to 93,000 vehicles/day (Yang et al., 2003).

Vehicle mix was also suggested as an important factor. Lin and co-authors (2002) reported an association between asthma hospitalizations and residential proximity within 200 m of heavy truck traffic. Ryan and co-authors (2005) reported a statistically significant association between residential proximity within 100 m of stop-and-go bus and truck traffic and parent-reported wheeze in infants less than 12 months-old. Janssen and co-authors (2003) assessed health impacts of residential proximity to car and truck traffic and reported elevated risks of conjunctivitis and an itchy rash only for truck traffic.

Several challenges existed to the assessment of relationships between exposure to traffic and health effects. First, personal monitoring that documents duration of exposure and air concentrations of traffic emissions that people actually breathe is typically cost-prohibitive and not practical for most epidemiological studies to date. Therefore, researchers used surrogate exposure metrics to estimate exposure. The precision of exposure metrics used by studies covered in this review ranged from self-report (Heinrich et al., 2005; Steffan et al., 2004; Sugiri et al., 2006) to outputs of sophisticated mobile-source models and geographic information system mapping of residential addresses (Gauderman et al., 2005; Smargiassi et al., 2006). Second, most studies did not account for the relative amount of time people spend in microenvironments other than residences such as work, school, or commuting, where levels of exposure to traffic emissions can vary. Third, estimates of exposure typically do not take into account indoor sources of air pollutants or the variability in residential penetration of pollutants such as benzene and PM (Sioutas, Delfino, & Singh, 2005). Fourth, physical and chemical properties, composition, and toxicity of fuel mixtures for natural gas, gasoline, and diesel vary in different parts of the world and even within countries (Verma & Tombe; 2002). Finally, constituents, concentrations, and duration of traffic-related residential exposures are affected by many factors, including varied fleet characteristics such as average ages and types of vehicles; designs, grades, and distributions of roads; traffic congestion and driving habits; and different inspection and maintenance programs, as well as variations in national and local regulations (Gwilliam, 2003).

The consistency of reported results across the studies we reviewed provided a "weight-of-evidence" finding suggesting that residential proximity to traffic can be associated with adverse health effects and poses a public health threat. A number of steps can be taken to decrease exposure to traffic-related pollutants and to protect the public. Exposures, especially diesel, can be minimized for children, the elderly, and other vulnerable populations by improved land use and community planning that ensures that schools, daycare centers, and nursing homes are not located within 300 m of a busy road. Also, prohibiting prolonged idling of school buses outside schools and widespread conversion of diesel buses to cleaner alternatives, including buses that use low-sulfur fuels and particulate traps, can reduce exposures of school-aged children (Behrentz et al., 2005; Sabin et al., 2005). Furthermore, federal, state, and local governments can reduce emissions by adopting and enforcing regulations on tailpipe emissions and higher fuel economy standards; promoting use of alternative fuels and low-sulfur diesel; promoting carpooling through use of subsidies and high-occupancy vehicle lanes; implementing smart-growth strategies to reduce urban sprawl; and providing convenient, affordable mass transit options. Employers can reduce traffic-related emissions by providing car- and van-pooling incentives and allowing employees to telecommute. Individuals can purchase low-polluting vehicles, combine trips, and use alternative means of transportation such as bicycling or walking.

Conclusions

Studies we reviewed consistently reported statistically significant associations between residential proximity to traffic and at least one of the following adverse health effects: increased prevalence and severity of symptoms of asthma and other respiratory diseases; diminished lung function; adverse birth outcomes; childhood cancer; and increased mortality risks. At present, however, epidemiological studies cannot determine causality, and uncertainties exist because of a lack of individual exposure assessments that could rule out confounding by other, unmeasured factors. Also, the studies reviewed did not elucidate which traffic-related pollutant or mixtures of pollutants may have contributed most to the observed adverse health effects. Improved exposure assessments and mechanistic or toxicological studies are needed to identify contributing pollutants and mechanisms of action. Meanwhile, public health can be better protected through enhanced, precautionary land use; smart growth; and transportation policies, as well as through government and private-sector incentive programs and individual actions.

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