DESIGN FOR HEALTH

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Key Questions:

Air Quality

Metropolitan Design Center

Version 2.0

DESIGN FOR HEALTH is a collaboration between the University of Minnesota and Blue Cross and Blue Shield of Minnesota that serves to bridge the gap between the emerging research base on community design and healthy living with the every-day realities of local government planning. This Air Quality Key Question is part of a series with a focus on identifying and interpreting evidence-based research linking public health with planning.

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Overview

Tackling the issue of air quality and its relationship with public health is particularly challenging because of the variety of geographic scales to consider and the variety of sources of pollutants. The main categories of air pollution are area sources (dry cleaners, lawn mowers, etc.), mobile sources (cars, trucks, off-road equipment), and stationary sources (factories, power plants, etc.). These different sources produce different types of pollutants. For example, transportation-related air pollutants (mainly carbon monoxide, ozone, particulate matter and nitrogen dioxide) differ from those emitted by manufacturing or other uses. Also, some pollutants tend to have a greater effect over an entire metropolitan area versus those stemming from direct point sources.

The most significant policy governing air quality is the Clean Air Act of 1970. The Clean Air Act required the federal government, through the Environmental Protection Agency (EPA) to establish national ambient air quality standards for key air pollutants (NAAQS) (Barr 2004; Reitze 2001). Primary standards established limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly, while secondary standards were set to protect public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings (US EPA 1993). Under the Clean Air Act, states are required to prepare State Implementation Plans (SIPs) only if they have violated NAAQS, which establish emissions limits, air pollution monitoring systems, permitting, incentives, and other programs to achieve the NAAQS (Barr 2004; Reitze 2001).

There is evidence that supports the causal link between roadside air quality and public health. The primary health consequences associated with air quality are mortality and respiratory health, though cardiovascular health, cancer, and others are also implicated (Frumkin et al. 2004; Gehring et al. 2002; Grahame and Schlesinger 2007). Though mobile sources of air pollution, such as cars and trucks, often receive the most attention in the planning literature, area sources, such as dry cleaners, and stationary sources, such as factories, are also associated with negative health outcomes and can be regulated.

Even with stricter federal and state standards, air quality is a growing problem and many communities are finding it harder to reach emissions targets due to expanding metropolitan regions, increased highway travel, longer trips, and congestion. In addition, any air quality improvements due to vehicle technology need to be tempered against overall rates of driving that are increasing because of more people and longer travel distances. Further, the relationship between air quality and driving is complicated as a good percentage of the grams of carbon monoxide and nitrogen oxide that are emitted from cars is in the first minutes of driving, particularly if the car's engine is not warm; thus, many short trips can be more detrimental than fewer, longer trips (US EPA, 2004)). Congested roads create more localized pollution than uncongested ones. A study conducted during the 1996 Atlanta Olympic Games found that ozone decreased with a decrease in peak traffic and that asthma-related hospital visits decreased, although only one of four measures of such reductions in visits was statistically significant (Friedman et al. 2001).

Still, planners have many opportunities to influence air quality through decisions made in relation to the built environment and design. While air pollution is in many ways a regional issue, it is possible for local planners to influence matters at the local level. This sheet focuses on that scale of intervention. Reducing vehicle use through changes in land use is a very challenging and long-term project although comprehensive plans work at that scale.

Things for certain (or semi-certain)

- Motor vehicle emissions are the primary source of most fine and ultrafine particles, according to a literature review (Hitchins et al. 2000, 52). These pollutants produced by vehicles are also those that produce most harm, compared with coal-fired electrical plants for example (Grahame and Schlesinger 2007, 476).

- The concentration of pollutants such as black smoke, NO2, and ultrafine particles (PM0.1) decreases with distance from roadways. While this relationship is confirmed, specific distances are still debated in the literature and are discussed later in this document. As can be seen in the next section, this relationship between air pollution and distance from roadway has implications for disease:

  Example: A study of outdoor air quality near major roadways in Australia found that as distance from the road increased the concentration of ultrafine particles decreased, though direction and speed of wind were also factors (Hitchins et al. 2000).

  Example: In a study of traffic-related air pollution in Holland, Roorda-Knape et al. (1998, 1923) found "black smoke and NO2 concentrations strongly declined with distance from the roadside."

- Vehicle-related air pollution is associated with higher levels of mortality and the incidence of certain diseases. In particular, health problems are significant within 200 m (656 ft) of major roads but decline after that so they are negligible within 500 m (1640 ft):

  Example: In a cohort-mortality study of 5228 people in Ontario, Canada, Finkelstein et al. (2005) found that people living within 50 m (164 ft) of a major urban road or within 100 m (328 ft) of a highway had circulatory disease mortality rates "associated with indices of ambient air pollution at the subjects' residence and with residential proximity to traffic" (481).

  Example: Lin et al. (2002, 73) found that children hospitalized for asthma "were more likely to live on roads with the highest tertile of vehicle miles traveled (VMT) within 200 m (656 ft) and were more likely to have trucks and trailers passing by within 200 m (656 ft) of their residence." These same variables were not significant at the 500 m (1640 ft) level.

  Example: Using "distance-weighted traffic density" to measure proximity to roadways, Wilhelm and Ritz (2003, 211) "observed an approximately 10-20 percent increase in risk of term Low Birth Weight and preterm birth in infants born to women living close to heavy-traffic roadways and therefore potentially exposed to higher levels of motor vehicle exhaust".

  Example: A cross-sectional study of 1068 children in the Netherlands found that "cough, weeze, runny nose, and doctor-diagnosed asthma were significantly more often reported for children living within 100 m (328 ft)" of a major freeway (Van Vliet et al. 1997, 122)

- Living above dry cleaners exposes people to greater concentrations of perchloroethylene (a dry-cleaning solvent and hazardous air pollutant) than does living in buildings without dry cleaners.

  Example: In a study of 14 buildings in Hudson County, New Jersey, Garetano and Gochfeld (2000, 59) "found that concentrations of perchloroethylene were elevated significantly in residences located in buildings that also housed dry-cleaning establishments… relative to their concentrations in controlled residences."

  Example: A study in New York City of 14 people living in buildings also housing dry cleaners found increased levels of perchloroethylene in the apartments, compared to background levels (Schreiber et al. 2002).

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- Air exposure to the dry cleaning solvent perchloroethylene has been found to be damaging to human health, though the extent of these negative outcomes differs depending on the degree of exposure and the type of health outcome.

  Example: In a study of 14 people living next to dry cleaners for at least one year, Altmann et al. (1995, 88) found "vigilance, reaction time, as well as visual memory" were reduced when compared to control cases.

  Example: Using visual contrast sensitivity analysis (VCS) to measure the effects of perc exposure, Schreiber et al. (2002) found deficits in visual detection ability in subjects exposed to perchloroethylene. The authors note that while these deficits "are not known to indicate a progressive disease process, they do represent a long-lasting, adverse alteration in neurobehavioral function" (Schreiber et al. 2002, 662).

- Living near industry can cause increased risk of preterm birth and respiratory and other diseases (excluding cancer, which is discussed later in this document).

  Example: In a multi-stage cross-sectional study of 486 children in Lebanon, Kobrossi et al. (2002, 216) found "that children living closer to the cement or fertilizer factories (within a radius of 4 km (2.5 miles) were in general at a higher risk of respiratory problems than those living farther."

  Example: In a study of self-reported health in the Texas cities of Beaumont and Port Arthur, cities with major chemical-industrial complexes, Morris et al. (2004, 160) "found all categories of self-reported health effects were elevated, with an odds ratio > 3.0, when they compared these two communities with the reference community."

  Example: In a study of 64,215 singleton births in Taiwan, Tsai et al. (2003, 987) found "the prevalence of delivery of preterm-birth infants was significantly higher in mothers living in the industrial area compared to control regions of Taiwan."

Things up in the air

- It unclear whether the concentrations of pollutants such as fine and course particulate matter (PM2.5 and PM10) and benzene decrease with distance from roadways. Studies have found conflicting results, though they have consistently found that particulate matter concentrations decline more slowly (if at all) with distance from the road than concentrations of NO2 or black smoke.

  Example: A study of traffic-related air pollution in the Netherlands found no decrease in PM2.5, PM10 or benzene with distance from the road (Roorad-Knape et al. 1998). This means these particles are distributed throughout urban air.

  Example: In a study of roadside air quality Janssen et al. (1997) found concentrations of PM2.5 and PM10 were only 1.3 times higher near the road (0.5 m) than they were in background conditions.

  Example: In a study of outdoor air quality, Hitchins et al. (2000) found that concentrations of PM2.5 and PM10 decreased 65 to 75 percent from roadside levels at a distance of 375 m (1230 ft) from the road.

- Establishing a recommended buffer distance from roadways for air quality purposes is difficult, as results from the literature are mixed.

—The varying methods used in these studies contribute to the lack of established standards. For example, studies differ on distances measured, size of road, type of pollutants, and contributing factors (such as wind). Despite this uncertainty, the popular literature on air quality often identifies 150 meters (492 feet) as a working buffer width. A more conservative level is 200-500 m (656-1640 ft).

—The 150 m (492 ft) buffer is partially supported by the claims of Hitchins et al. (2000, 51), who state, "where the wind is blowing directly from the road, the concentrations of fine and ultrafine particles decays to around half of the maximum…at a distance of approximately 100-150 m (328-492 ft) from the road." They go on to write, "From the findings of this study it is clear that exposure to submicrometre particles is significantly increased within the investigated distance from 15-150 m (49-492 ft) from a major road" (Hitchins et al. 2000, 58; British Columbia Ministry of Environment 2004). Other authors using similar research design have not gone as far and merely report their results, which vary.

Example: Nitta et al. (1993) examined pollutant levels near roadways and found that at 150 m (492 ft) from the road, NO2 concentrations decreased to about 74 percent of the level found at the roadside. Roorda-Knape et al. (1998) found NO2 concentrations declined by 60 percent after 250 m (820 ft).

Example: For particulate matter (PM2.5 and PM10), Nitta et al. (1993) found that concentrations decreased to 80 percent of the roadside level after 150 m (492 ft), while Hitchins et al. (2000) found that concentrations decreased 50 percent from roadside levels 100-150 m (328-492 ft) from the road (as stated above) and decreased 65 to 75 percent from roadside levels at a distance of 375 m (1230 ft) from the road.

Example: Zhu et al. (2002) found that within 300 m (984 ft) of the 710 freeway near Los Angeles, ultrafine particle concentrations were indistinguishable from background concentrations.

- The extent to which barrier walls or landscape buffers can mitigate the spread of air pollution from major roadways is unclear.

  —It is clear that vegetation is capable of absorbing air pollutants, though their ability to do so depends on plant species, pollutants, wind, climatic factors, etc. (Kahn and Abbasi 2000).

  —However, the effects of these measures have not been studied rigorously so numbers are not available on the relative effect on pollution concentration that a vegetative buffer may have.

- Technological changes such as new diesel engine components can reduce pollution at the source. The exact effects often take time to understand and can be counteracted by increased use (Grahame and Schlesinger 2007).

Working thresholds for HIA

Overall, air quality in relation to human health focuses on three issues. First, studies show decreasing particulates, respiratory diseases and premature births with distance from major roads. Residential areas, schools and playgrounds are key environments for vulnerable groups. We recommend residential areas, schools, and day care facilities should be more than at least 200 m from a major road. Second, certain businesses contribute disproportionately to air-quality problems. We recommend that non-residential uses need to be non-polluting or have adequate air pollution reduction technologies. Third, there is some evidence that well designed plantings can reduce air pollutants, e.g., help remove particulates. The ability of plants to improve air quality, however, depends on plant species, pollutants, wind, climatic factors, etc., and the topic needs more research. We recommend that tree canopy should be provided.

Glossary

Perchloroethylene - A dry cleaning solvent. Also called tetrachloroethylene, perc, PCE, and tetrachloroethene.
PM0.1 – particulate matter with an aerodynamic diameter of up to 0,1 micrometers (μm). PM0.1 consists of ultrafine particles.
PM2.5 – particulate matter with an aerodynamic diameter of up to 2.5 micrometers (μm). PM2.5 consists of fine, as well as ultrafine, particles.
PM10 – particulate matter with an aerodynamic diameter of up to 10 micrometers (μm). PM10 consists of coarse, as well as fine, particles

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