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Health Benefits of Transportation Emissions Reductions

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Introduction

The Sustainable Communities Working Group of the Transportation and Climate Initiative identified "health benefits of transportation emissions reductions" as a priority indicator at their metrics workshop in December of 2011. The relationship between transportation emissions reductions and health benefits is multi-tiered. Fundamentally, there is a direct and well-understood relationship between transportation emissions and health impacts; each year, illnesses arising from exposure to these gases and particulate matter cost between $40 and $64 billion nationwide (APAHA, 2009). The Centers for Disease Control (CDC), for example, states that "(a)lthough motor vehicle emissions have decreased significantly over the past three decades, air pollution from mother vehicles continues to contribute to the degradation of our environment and adverse respiratory and cardiovascular health effects." Because of this, CDC recommends the adoption of transportation policies that "(r)educe human exposure to health impacts associated with (transportation-generated) pollutants" (CDC, 2012).

It would be an oversimplification to suggest that the relationship between human health impacts and transportation emissions is limited to the negative effects of pollution on human health. Transportation policies aimed at reducing greenhouse gas emissions have the potential to affect human health in ways beyond reducing emissions. Many greenhouse gas (GHG) emissions reduction policies aim to increase reliance on active transportation for shorter, neighborhood scale trips, which has the potential to provide significant co-benefits in the in the form of improved cardiovascular health and reduced risk of health conditions associated with a sedentary lifestyle. In fact, a number of health benefits are associated with transportation policies that reduce GHG emissions. Integrated transportation and land-use planning policies that reduce reliance on single occupancy vehicles can improve mobility for residents that are unable or unwilling to operate personal vehicles, thus providing a host of additional health benefits associated with improved economic status and social connectivity (Younger et al 2008).

Below is a brief discussion of the health concerns associated with transportation emissions, beginning with the emissions of concern, as well as the maladies they are known to cause or exacerbate. An overview of current scientific knowledge regarding the links between emissions and illness is then provided along with a discussion of the current understanding of the relationship between active transportation and human health followed by recommended actions regarding the use of this indicator.

Health Impacts of Transportation Emissions

Vehicular traffic leads to the generation of a variety of pollutants, both in the form of gases and suspended particulate matter (PM) of various sizes. This can be particularly problematic in urban areas, where short trip lengths[1] mean that catalytic converters may not be fully functional, and traffic volumes and congestion can be significant – for these reasons, fully 30% of fine PM[2] in cities originates from tailpipe emissions.[3]

Transportation emissions are linked to a number of respiratory ailments. Several studies found that lung cancer rates are higher among populations suffering long-term exposure (APHA, 2009; Kyrzyzanowski, et al, 2005). Non-allergic respiratory ailments are aggravated by exposure to emissions; an outcome which has been shown through laboratory studies to be the result of alterations in reactive oxygen species and antioxidant defense, as well as increases in

[1] Many trips are less than 6km (WHO, 2005).
[2] PM that is less than 2.5 μm in aerodynamic diameter
[3] Other air pollutants result from transportation – such as benzene, nitrogen dioxide, and contributors to ambient levels of larger PM (i.e. 2.5-10 μm in aerodynamic diameter) including re-suspended road dust and dust generated from wear on brakes and tires. However, these are not "emissions," and are therefore not treated explicitly in this paper.

inflammation (Kyrzyzanowski, et al, 2005). While just a handful of studies have focused on cardiovascular morbidity, those studies found considerable increases in myocardial infarction, and reductions in autonomic nerve functioning after exposure (Kyrzyzanowski, et al, 2005), thus showing that transportation-related air pollution increases the risk of death.

Controlled experiments have also indicated that these pollutants may elevate the risk of developing allergies (Kyrzyzanowski, et al, 2005). Diesel exhaust is thought to be partially responsible for the allergy pandemic because it acts as an adjuvant to other allergens, thereby enhancing the sensitization response (Sydbom, et al, 2001). It is worth noting, however, that most studies linking exhaust exposure to allergies are laboratory based. Population studies do not consistently support this conclusion (Sydbom, et al, 2001; Kyrzyzanowski, et al, 2005).

A direct link between exposure to transportation emissions and asthma attacks, particularly in children has also been found (Kyrzyzanowski, et al, 2005; Sydbom, et al, 2001). Currently, some 22 million Americans suffer from asthma and residents of the northeastern United States (which comprises much of the Transportation and Climate Initiative (TCI) region) are among those most likely to be affected. Each year about 4,000 individuals die nationwide from asthma-related causes, and the disease is a contributing factor in another 7,000 deaths annually (APHA, 2009).

Finally, pregnancy-related complications, such as low birth weight and premature birth, have been shown to result from exposure to emissions. However, study findings have been inconsistent in this regard (Kyrzyzanowski, et al, 2005).

Diesel exhaust, which accounts for a significant percentage of the PM emitted in urban areas, is particularly noxious. Acute exposure to such emissions is shown to cause irritation of the nose and eyes, changes in lung and respiratory functioning, nausea, fatigue, and headache.

Chronic exposure, in turn, is known to cause long term decreases in lung function, and increases in sputum production and cough; effects which are even more severe among asthmatics (Sydbom, et al, 2001).

Clearly, transportation emissions are known to contribute to multiple illnesses, but central to understanding the impact of emissions on health is knowledge of the relationships that exist between exposure and symptomology. People's exposure to transportation emissions varies considerably based on a number of factors, and their time-activity patterns are of particular importance in this regard (Kyrzyzanowski, et al, 2005).

Individuals who live or work (or both) near busy thoroughfares are at greatest risk, especially if their residences or workplaces are ventilated with air drawn from road canyons.[4] Those who spend long portions of their day in traffic (whether commuting or as part of their jobs) are also in danger, as they can be exposed to up to three times the background levels of PM and primary exhaust gases. Pedestrians and cyclists who travel near (or on) congested roadways face similar risks (Kyrzyzanowski, et al, 2005).

Other Health Impacts of Transportation

In recent years, as transportation and public health models have become more sophisticated, a number of efforts have been made to quantify the health benefits associated with transportation policies that aim to reduce emissions by increasing rates of active transportation. Concerns have been raised that policies that increase active transportation in areas with high levels of transportation-related air pollution could, in fact, be harmful to human health; either by increasing exposure to air pollution or by increasing the likelihood of accidents involving cyclists or pedestrians (Maizlish et al, 2013; Grabow et al. 2011). Several studies suggest that the

[4] A "road canyon" is a heavily trafficked roadway where dispersion of pollutants is hindered by physical impediments (i.e. buildings, natural formations, etc.).

public health benefits of active transportation significantly outweigh the risks (de Hartog et al, 2010; Rabl and de Nazelle, 2011; Maizlish, et al, 2013, Grabow et al. 2011). Overall, studies in both the United States and Europe suggest that increasing rates of active transportation has a net beneficial effect on human health. Moreover, because use of public transportation systems often requires more walking than use of single occupancy vehicles, public transport also has the potential to increase rates of active transportation. As such, to the extent that greenhouse gas emissions policies aim to reduce emissions by shifting mode share to active transportation, it is reasonable to expect such policies to effect an improvement in public health (Rabl and de Nazelle, 2011).

There are several models and tools available that can help assess the public health impacts of various transportation and community planning decisions. The Integrated Transport and Health Impact Modelling Tool (ITHIM) "uses regional data from health surveys, traffic collision databases, vital statistics, and the results of regional models for travel demand, vehicle emissions, and air pollution. ITHIM then relates physical activity, air pollution, and travel behaviors to specific health outcomes based on established cause-effect relationships reported in the scientific literature for heart and respiratory disease; stroke; diabetes; cancers of the breast, colon, and lung; dementia; and depression" (Maizlish et al. 2011). BenMAP, developed by the Environmental Protection Agency, uses Geographic Information System (GIS) to estimate health impacts from a variety of policy decisions that affect air quality.

The Appropriateness of Measuring Health Outcomes Directly

There are many mitigating and confounding causal factors that influence many of the health outcomes that are impacted by transportation emissions. As such, measuring actual health impacts alone is not likely to yield meaningful information as an indicator of sustainable community policy. It has been suggested that disease rates reported by the CDC and/or local health agencies could serve as proxies for this metric, but given the indirect nature of the causal link, it would be impossible to attribute changes -either positive or negative - to TCI-related efforts, making such a metric difficult to defend.

The likelihood of experiencing emissions-induced health impacts is, in large part, a function of people's time-activity patterns. Therefore, it is reasonable to expect that those policy and investment decisions undertaken in conjunction with TCI that lead to lowered exposure will help to decrease the incidence of cardiovascular and respiratory ailments in target areas to the extent that other factors do not simultaneously increase the risk of such ailments. For example, enhancements to public transportation will provide viable alternatives to personal vehicles, thereby reducing congestion and the resulting emissions, and taking people off the roads where their exposure levels are highest. Similarly, the development of compact, mixed-use development will bring homes and jobs closer together, decreasing commute times, traffic, and the resulting emissions while simultaneously providing more opportunities for individuals to rely upon walking or cycling to fulfill their shorter distance travel needs.

However, as noted above, the relationship between health outcomes and transportation policy is multi-faceted and active transportation rates and integrated land-use and transportation planning policies do have a link with health outcomes. While it may not be advisable for the TCI jurisdictions to rely upon health impacts of transportation emissions as a sustainable community indicator, one possible alternative indicator that could demonstrate the health benefits of GHG emissions reduction policies is active transportation rates. Active transportation rates can reasonably be expected to increase in areas that are designed to easily accommodate bicycle and pedestrian traffic and an increase in the rate of active transportation may serve as a proxy indicator of health benefits resulting from transportation policies that aim to reduce GHG emissions via mode shift. At the same time, models such as the ITHIM and BenMAP can help state agencies determine how transportation-related GHG emissions reduction strategies will affect human health while controlling for other mitigating factors.

Recommendations

It is understandable that states will want to measure health impacts associated with greenhouse gas emission reduction strategies. The United States has an aging population and healthcare costs have risen steadily for several decades. Inasmuch as greenhouse gas emissions reductions policies have the potential to reduce healthcare expenses and improve mobility, states that adopt such policies may serve several policy objectives at once, improving public health, facilitating access to employment, lowering healthcare costs and reducing greenhouse gas emissions. However, given the potentially misleading information that a strict measure of health conditions might provide, TCI states would be well-served to use a proxy indicator, such as rate of active transportation, to demonstrate the health benefits of sustainable community transportation policies. Prior to implementation of such policies, TCI states may find it useful to utilize models or tools such as IHTIM or BenMAP to assess how these policies will improve health outcomes.

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