Methods for Estimating the Environmental Health Impacts of SRTS Programs

SafeRoutes
National Center for Safe Routes to School

Prepared by the National Center for Safe Routes to School ■ www.saferoutesinfo.org

Introduction

Lake Sybelia Elementary, Maitland, Florida

Imagine walking along a main road in your community. Four lanes of traffic speed past, making it difficult to hear much but the sound of engines. The air blends the smell and taste of vehicle exhaust. The empty sidewalk, cracked and incomplete, offers little separation between pedestrians and the street.

Now imagine a well-kept sidewalk with a grassy buffer between it and traffic. Trees line the route, providing shade and a pleasant atmosphere. Students walk excitedly along the sidewalk, kicking at the fallen leaves and talking with their parents and friends about the day. Each family represents one less vehicle along the route to school.

Everyday elements of a walking and bicycling route — the quality of the air, the sights and sounds along the way, and even the very physical condition of sidewalks and streets—can affect the health of students who walk and bicycle to school and influence the choice to walk or bicycle for many students and parents. These elements also describe environmental health, or physical environmental qualities which directly or indirectly influence health behaviors and outcomes.

One of the most significant air quality issues in the United States is air pollution from motor vehicles. As with all motor vehicle trips, driving a child to school is powered by a combustion process that burns fuel in vehicle engines and emits air pollutants through each stage of the journey. In fact, the start of a vehicle's engine and the first few minutes of driving generate the trip's highest emissions, as the vehicle's emissions-control equipment has yet to reach its optimal operating temperature.[1]

According to the 2009 National Household Travel Survey, the average trip length for elementary school students driven to school was 3.3 miles and the national average vehicle trip length was 9.7 miles.[2,3] Because the drive from home to school is relatively short compared to all trips, emissions from vehicles over these trips concentrate air pollutants near schools. In addition, idling in student drop-off and pick-up lines further diminishes air quality around schools.[4] In response, many schools and communities across the nation see increasing the number of walking and bicycling trips to school, and reducing the number of personal vehicle trips, as ways to reduce air pollution and improve local environmental health.

Safe Routes to School (SRTS) programs aim to encourage and enable children to walk and

bicycle to school, which can increase physical activity and decrease traffic congestion. Increasing the number of children who regularly walk and bicycle may also reduce fuel consumption and vehicle emissions, which can help improve air quality in and around schools and reduce carbon dioxide contributions. This report explores environmental health and Safe Routes to School through a review of the relationship between environmental health and school travel, a discussion on measuring the environmental health impacts of school travel, and five examples of methods used by SRTS programs to estimate the impact of their activities on local air quality and carbon dioxide emissions.

Vehicle Emissions and Environmental Health

Vehicle emissions include air pollutants that affect the short-term and long-term health of individuals and communities. Motor vehicles emit air pollutants like ozone, nitrogen oxides, carbon monoxide, particulate matter and volatile organic compounds. Exposure to these air pollutants can cause short-term health problems, like headaches; nausea; skin and eye irritation; and nose, throat, and lung inflammation. These pollutants can also aggravate and intensify long-term respiratory and cardiovascular health problems, such as asthma and heart disease.[5]

Children are particularly vulnerable to the effects of air quality because they breathe 50 percent more air per pound of body weight than adults.[6] In fact, childhood asthma rates are one of the most common pollution-related health problems in America,[7] with more than 7 million children currently living with asthma. Annually, more than 14 million school days in the United States are lost due to childhood asthma.[8]

In addition to affecting local air quality, emissions from motor vehicles also contribute to greenhouse gases, namely carbon dioxide levels. Overall, motorized transportation accounts for roughly one-third of the United States' total greenhouse gas emissions.[9] By encouraging and enabling children to walk and bicycle to school, SRTS programs have a unique opportunity to lower individual and school-level contributions to greenhouse gases and to reduce impacts on local air quality.

School Travel and Vehicle Emissions

In 2009, the personal vehicle was the most common travel mode used to get K-8th grade students to school and the second most common way for them to return home.* In that same year, personal vehicles taking all grades of students to school accounted for five to seven percent of vehicle miles traveled (VMT) and 10 to 14 percent of all personal vehicle trips made during the morning peak travel period (7:00 a.m. to 9:00 a.m.).[10]

Furthermore, among parents who drove their children to school, approximately 40 percent returned home immediately after dropping their children at school.[11] While these trips are only a portion of overall VMT, walking and bicycling present an opportunity to avoid some personal vehicle trips and reduce corresponding environmental health impacts.

* In 2009, 45 percent of K-8 students usually traveled to school by personal vehicle and 39 percent usually returned home from school by personal vehicle. The most common transportation mode for the return trip home from school was the school bus, used by 42 percent of students.

Measuring the Environmental Health Impacts of School Travel

Many SRTS program participants want to know if their activities reduce vehicle emissions and contribute to a healthier local and global environment. However, direct measurement using air quality impact analysis can be complex and expensive, making it an unrealistic option for many SRTS programs. To discuss the factors involved in measuring SRTS program impacts on air quality and carbon dioxide levels, the National Center for Safe Routes to School convened a panel of environmental health and air quality experts. Panel members represented the Centers for Disease Control and Prevention's National Center for Environmental Health and the U.S. Environmental Protection Agency's Office of Air and Radiation and Office of Smart Growth.

The panel supported efforts to understand local air quality and carbon dioxide impacts that could be associated with SRTS activities and identified several considerations for evaluating the environmental health benefits of SRTS programs:

- Factors beyond vehicle emissions contribute to local air quality, such as seasonal weather, temperature, and proximity to concentrated sources of air pollution, like smoke stacks and freeways. These outside factors can influence the overall air quality benefits attributable to a reduction in personal vehicle traffic.
- Relative to other trips, the distance from home to school is often short. However, the vehicle emissions associated with driving a child to school are significant because the emissions from a motor vehicle are concentrated while the engine warms up.[12]
- Roughly 60 percent of vehicle trips to school are integrated with a parent's work commute.[13] Eliminating these trips to school may not significantly reduce overall driver vehicle emissions, but may reduce emissions concentrated near schools.

– The remaining 40 percent of motor vehicle trips, in which drivers return directly home after student drop-off, present an opportunity to reduce emissions by eliminating these trips entirely.

With these measurement considerations in mind, the panel suggested that SRTS programs track student travel modes to estimate environmental health impacts. While not every student walking and bicycling to school will be a vehicle trip avoided, it is assumed that increases in the number of children walking and bicycling to school are associated with reductions in the number of children driven to school. In turn, decreases in personal vehicle trips can have assumed air quality benefits due to trip and idling vehicle emissions avoided.

The general formula recommended for estimating vehicle emission reductions associated with walking and bicycling to school is:

Motor Vehicle Trips Avoided x Distance to School x # of School Days x Average Emissions of Passenger Vehicles per Mile = Vehicle Emissions Reduction

Measurement	How the measurement is obtained
Motor Vehicle Trips Avoided	Calculate the number of students that walk or bicycle to school using the National Center for Safe Routes to School's Parent Survey or Student Travel Tally, direct observation during school arrival and dismissal times, or other means. Note: This number assumes each pedestrian or bicycle trip replaces a personal motor vehicle trip.
Distance to School	Calculate the distance from home to school using parent responses from the National Center for Safe Routes to School's Parent Survey or information obtained from the school district. An average distance can be calculated for the entire school population, or each student's distance from home to school can be calculated separately and summed.
Number of School Days	The total number of days that students walked or bicycled to school.
EPA Emission Average – Passenger Vehicle	US EPA's passenger vehicle emissions chart. See Appendix A.

Programs That Estimated Environmental Health Impacts

Over three years, the National Center for Safe Routes to School conducted periodic interviews with local SRTS leaders who estimated the environmental health benefits of their SRTS activities. Program organizers used a variety of methods and sources to try to quantify impacts. Some chose measurements that mirror the panel's formula, and others chose measurements unique to their program. As a result, the following examples reflect a selection of different program methods for estimating local air quality and carbon dioxide impacts.

To figure car trips avoided, programs generally used student travel mode information collected with the National Center for Safe Routes to School's Student Travel Tally or Parent Survey or by direct observation. To obtain trip distance, programs calculated an average distance using Parent Survey results, estimated the average distance based on school enrollment statistics, or used other means. These measurements were then entered into vehicle emission calculators (summarized in Appendix B) to determine environmental health impacts. The final example features a program that directly measured ozone levels around a school using mobile ozone testing units. Collectively, these examples demonstrate a variety of approaches to measuring environmental health impacts of school travel.

Lake Sybelia Elementary, Maitland, Florida

Lake Sybelia Elementary School in Maitland, FL

Information Collected: Walk/Bike Numbers, Average Distance to School

Calculation Tools: Student Travel Tally, Parent Survey, Missouri Bicycle Federation Pedestrian Savings Calculator

What They Learned: Air Pollution Reduction, Gallons of Fuel Saved, Pounds of Carbon Dioxide Emissions Avoided, Miles Walked/Biked

In order to understand the environmental health impact of Lake Sybelia Elementary's SRTS activities, the program enlisted the help of teachers and older students, who used the National Center's Student Travel Tally to count the number of students who walked and bicycled to school. Teachers also sent home the National Center's Parent Survey in order to gather parents' perceptions of walking and bicycling to school and to estimate an average distance from home to school for Lake Sybelia families.

Mount Vernon Elementary, Alexandria, Virginia

Student travel results were entered into the Missouri Bicycle Federation's Pedestrian Savings Calculator. The program was able to estimate the number of walking trips made per year from the Student Travel Tally, and calculated average distance per trip and walking speed from the Parent Survey results. With these numbers, the Pedestrian Savings Calculator provided an estimate of 90 pounds of air pollutants avoided, 700 miles walked, 69 gallons of fuel saved, and 1,355 pounds of carbon dioxide emissions avoided. The school used these values to help students understand the impact of their school travel choices.

Mount Vernon Community School in Alexandria, VA

Information Collected: Walk/Bike Numbers, Average Distance to School, Student Drop-off Numbers and Vehicle Size

Calculation Tools: Student Travel Tally, Parent Survey, Observation, Nature Conservancy Carbon Footprint Calculator

What They Learned: Pounds of Carbon Dioxide Emissions Avoided

With an interest in estimating the carbon dioxide emissions avoided due to SRTS activities and participation in the SRTS National Partnership's Local School Project, the Mount Vernon Community School's SRTS program distributed the National Center's Student Travel Tally to measure the number of students walking and bicycling to school. Program leaders also administered the National Center's Parent Survey in order to determine the approximate distances from students' homes to school and understand parental perceptions of barriers to walking and bicycling. In addition, the school conducted vehicle drop-off counts at the main campus entrance in the fall and spring semesters and recorded the number and size of vehicles driving students to school.

Using UC Berkeley's SafeTREC model, the program refined its results in order to use the Nature Conservancy's Carbon Footprint Calculator. First, vehicle type percentages were determined based on vehicle drop-off observation, with vehicles categorized as small, mid-size, or large. These categories helped the program account for variations in carbon dioxide emissions due to vehicle size. Parent Survey data was then used to determine the percentage of students living within each of the five distance categories available on the Parent Survey: less than ¼ mile, ¼ mile to ½ mile, ½ mile to 1 mile, 1 mile to 2 miles, and more than 2 miles. These measurements were entered into the Carbon Footprint Calculator to obtain an estimate of the carbon dioxide contribution for each of the 15 categorical combinations of vehicle type and distance from home to school. Due to Mount Vernon's participation in a larger research project, the environmental health benefits estimated by the program are unavailable.[14] However, the methods used to estimate effects offer another valuable option for SRTS program organizers to consider.

St. Thomas Aquinas in Indianapolis, IN, and Foothills Elementary in Boulder, CO

Information Collected: Walk/Bike Numbers, Distance to School

Calculation Tools: Boltage and Active4.me Barcode Systems – Scanner, Database, and Website

What They Learned: Air Pollution Reduction, Gallons of Fuel Saved, Pounds of Carbon Dioxide Emissions Avoided, Miles Walked/Biked, Calories Burned

St. Thomas Aquinas School in Indianapolis, IN, and Foothill Elementary School in Boulder, CO, used electronic tracking systems to calculate student travel modes and estimate corresponding

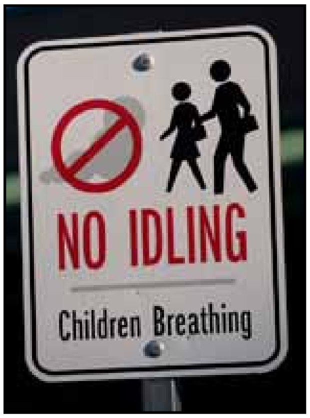
St. Thomas Aquinas, Indianapolis, Indiana

environmental health impacts. Using Active4.me and Boltage software programs, students at each school received personalized barcodes to attach to their backpacks and bicycle helmets. Each student's barcode was electronically embedded with the student's name, address and parent's email address. Students who walked or bicycled to school had their personalized barcode scanned by a school representative as they arrived at school in order to be a part of the daily student travel count.

Once student barcodes were scanned, school travel information was sent to a school-specific online database. Students were then able to view their progress through the school's website, allowing them to track the number of trips made, miles traveled, gasoline saved, calories burned, and pounds of carbon dioxide emissions avoided. The software programs used addresses of the school and students' homes, average gasoline mileage for personal vehicles, daily weather, and carbon dioxide emission averages for passenger vehicles to generate the detailed estimates. For example, St. Thomas Aquinas reported estimates of 1,913 miles walked, 1,702 pounds of carbon dioxide avoided, 89 gallons of gas saved, and more than 76,000 calories burned.

Fountain Inn Elementary School in Greenville, SC

Information Collected: Student Drop-off Numbers, Personal Vehicle Idling Numbers



Fountain Inn Elementary, Greenville, South Carolina

Calculation Tools: Observation

What They Learned: Air Pollution Reduction, Gallons of Fuel Saved, Pounds of Carbon Dioxide Emissions Avoided

Fountain Inn Elementary School participated in South Carolina's statewide Breathe Better (B^2) program, which aimed to reduce idling cars and buses through educational messaging, encouragement, monitoring, and evaluation. Specifically, student volunteers on the "Clean Air Patrol" collected data and encouraged parents to turn off their engines during drop-off and pick-up times.

In order to determine the effect of the program's activities on local air quality, the Clean Air Patrol counted the number of vehicles arriving at the school and whether they idled upon arrival. They counted for one week in the fall and then again in the spring and compared the numbers. With this information, the program estimated 6,503 pounds of air pollutants avoided, 30 gallons of fuel saved, and 333,660 pounds of carbon dioxide emissions avoided.

Fisher Middle School, Los Gatos, California

Fisher Middle School in Los Gatos, CA

Information Collected: Air Quality, Weather Conditions, Walk/Bike Numbers

Calculation Tools: Handheld Ozone Counter, Observation, Student Travel Tally

What They Learned: Impact of SRTS activities on Local Ozone Levels

Students at Fisher Middle School directly measured local ozone levels around their schools to look for patterns corresponding with their SRTS activities. Students were assigned different tasks to perform on measurement days, including measuring air quality with handheld ozone counters before peak drop-off times and recording weather data. Overall, measurements were taken twice– once during a morning with scheduled SRTS activities and again during a morning without scheduled SRTS activities. In addition to measuring ozone levels, the schools used the National Center's Student Travel Tally to understand how students were arriving at school on a regular basis.

Using readings from the ozone counters and results from the school's Travel Tally, students found differences in air quality during regular school days and SRTS activity days. In fact, Fisher students reported ozone levels three to four times lower during SRTS activity days, and drew associations between school traffic and local air quality.

Conclusion

Motor vehicles emit air pollutants that impact the quality of air. In so doing, vehicle emissions directly affect the short-term and long-term health of individuals and communities, and may even influence the choice of whether to walk or bicycle to school. As a result, decreasing the emissions associated with students being driven to school is central to the efforts of many Safe Routes to School programs.

SRTS programs have a number of methods with which to estimate the air quality and environmental health impacts of their activities, whether through measuring the number of trips avoided and inputting results in vehicle emission calculators, or directly measuring air quality changes around schools.

Increases in walking and bicycling to school can reduce total vehicle miles traveled and associated emissions. In addition, increases in walking and bicycling to school can reduce school traffic and congestion near schools, further reducing fuel consumption and vehicle emissions. And finally, the walking and bicycling skills and habits learned by students in SRTS programs can foster a lifelong view of walking and bicycling as good ways to get around their communities.

For more information on program evaluation, see the National Center's *Evaluation Guide for Community Safe Routes to School Programs* at: http://guide.saferoutesinfo.org/evaluation/index.cfm.

For more information on the National Center's *Student Travel Tally and Parent Survey*, visit: http://www.saferoutesinfo.org/data-central/data-collection-forms.

For additional SRTS program success stories on a variety of topics, visit: http://www.saferoutesinfo.org/data-central/success-stories.

Appendices

Appendix A: Passenger Vehicle Emissions

Component	Emission Rate and Fuel Consumption (per mile)
Hydrocarbons	2.80 grams (g)
Carbon Monoxide	20.9 grams
Oxides of Nitrogen	1.39 grams
Carbon Dioxide	0.916 pound (lb)
Gasoline	0.0465 gallon

Source: http://www.epa.gov/oms/consumer/f00013.pdf

Appendix B: Vehicle Emission Calculators

Model	How It's Used	Inputs	Limitations
Missouri Bicycle Federation's Bicycle/ Pedestrian Savings Calculator	Uses trips avoided from observation and/or the National Center's Student Travel Tally; uses average distance to school and vehicle emissions from EPA.	1. Bicycle/walking trips in a school year (arrive/depart=2 trips) 2. Average miles per trip from home to school 3. Average speed (miles per hour)	Uses EPA average for miles per gallon and vehicle emission estimates rather than exact measurements.
Nature Conservancy's Carbon Footprint Calculator	Uses trips avoided from observation and/or the National Center's Parent Survey; uses survey for distance-to-school percentages and vehicle size categories for vehicle emissions.	1. Vehicle category (mpg) - hybrid: > 40 mpg - small: 30-40 mpg - mid-size: 20-30 mpg - large: < 20 mpg 2. Number of miles driven per unit of time 3. Unit of time (month, week, day)	Uses EPA average for CO_2, but accounts for different vehicle emissions and distance from home to school.

Sources: http://mobikefed.org/savingscalculator, http://www.nature.org/greenliving/carboncalculator/index.htm

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