

Economics of Interventions to Increase Active Travel to School: A Community Guide Systematic Review



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Context: The number of children who bicycle or walk to school has steadily declined in the U.S. and other high-income countries. In response, several countries responded in recent years by funding infrastructure and noninfrastructure programs that improve the safety, convenience, and attractiveness of active travel to school. The objective of this study is to synthesize the economic evidence for the cost and benefit of these programs.

Evidence acquisition: Literature from the inception of databases to July 2018 were searched, yielding 9 economic evaluation studies. All analyses were done in September 2018–May 2019.

Evidence synthesis: All the studies reported cost, 6 studies reported cost benefit, and 2 studies reported cost effectiveness. The cost-effectiveness estimates were excluded on the basis of quality assessment. Cost of interventions ranged widely, with higher cost reported for the infrastructure-heavy projects from the U.S. (\$91,000–\$179,000 per school) and United Kingdom (\$227,000–\$665,000 per project). Estimates of benefits differed in the inclusion of improved safety for bicyclists and pedestrians, improved health from increased physical activity, and reduced environmental impacts due to less automobile use. The evaluations in the U.S. focused primarily on safety. The overall median benefit–cost ratio was 4.4:1.0 (IQR=2.2:1–6.0:1, 6 studies). The 2-year benefit–cost ratios for U.S. projects in California and New York City were 1.46:1 and 1.79:1, respectively.

Conclusions: The evidence indicates that interventions that improve infrastructure and enhance the safety and ease of active travel to schools generate societal economic benefits that exceed the societal cost.

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CONTEXT

Research has shown that motorized transport that displaces walking and bicycling contributes to reduced physical activity¹ and pollution^{2,3} that lead to poor health outcomes,^{4,5} other economic costs,⁶ and reduced quality of life.⁷ In the case of transport of children to and from schools, motorized modes have proliferated, even for short distances that were previously walked or bicycled. In 1969, in the U.S., 41% of children in kindergarten through eighth grade (approximately age of 5–14 years) lived within 1 mile of school, and of these, 89% usually walked or bicycled to school.⁸

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In 2009, the percentage of children in kindergarten through eighth grade who lived within 1 mile of school declined to 31%, and only 35% of them usually walked or bicycled to school.⁹ A recent survey finds that of the 15 million children who lived within 1 mile of their school, 31% walked or bicycled to school, 20% took the school bus, 0.8% took public transport, and the remaining 48% traveled by private vehicle.¹⁰

One of the many factors contributing to the decline in active travel to school (ATS) is the greater distance from homes to schools due to school-siting practices that locate larger schools on the outskirts of communities.^{11,12} Among the barriers identified from surveys of the U.S. parents in 2005, the distance between home and school was the most prominent, followed by concerns about the dangers of traffic, inclement weather, and crime,¹³ with more recent studies finding similar results.^{14,15}

ATS interventions aim for children who live within 1–2 miles of schools to walk or bicycle to school by making routes to school safer and easier to use and promoting their use. In the U.S., the largest and most prominent of these interventions were those funded and promoted under the Safe Routes to School (SRTS) program of the Department of Transportation. In 2018, the Community Preventive Services Task Force (CPSTF), an independent, nonfederal panel of population health experts, recommended interventions to increase ATS. The recommendation was based on a systematic review of evidence that showed that ATS interventions increased walking among students and reduced the risks for traffic-related injury.¹⁶ This study is a systematic review of the economic evidence for the cost and economic benefit of ATS interventions implemented in the

U.S. and other high-income countries as defined by the World Bank.¹⁷

EVIDENCE ACQUISITION

Concepts and Methods

The ATS interventions make it easier and safer for children to walk and bike to school by targeting the physical or social safety of common routes to school or by promoting safe travel behaviors. Interventions must include ≥ 1 of the following components on the basis of the SRTS model¹⁸:

1. engineering—improvements to the built environment infrastructure;
2. education—materials and activities to teach the importance of active travel;
3. encouragement—events and activities to promote active travel; and
4. enforcement—partnerships with law enforcement and others to ensure that traffic laws are obeyed in school neighborhoods.

This study was conducted using established methods for systematic economic reviews approved by the CPSTF.¹⁹ The team included subject matter experts on physical activity and active travel from various agencies, organizations, and academic institutions in addition to members of the CPSTF and experts in systematic economic reviews from the Community Guide Office at the Centers for Disease Control and Prevention. A total of 2 reviewers independently screened the search yield, abstracted information from the included studies, computed economic estimates, and quality scored each estimate. Disagreements were resolved through discussions.

This study asks what it costs to implement ATS interventions and what the economic benefits are that result from the intervention. Do the economic benefits due to intervention exceed the cost to implement?

The economic review framework in Figure 1 depicts how the intervention is expected to work and the pathways to economic

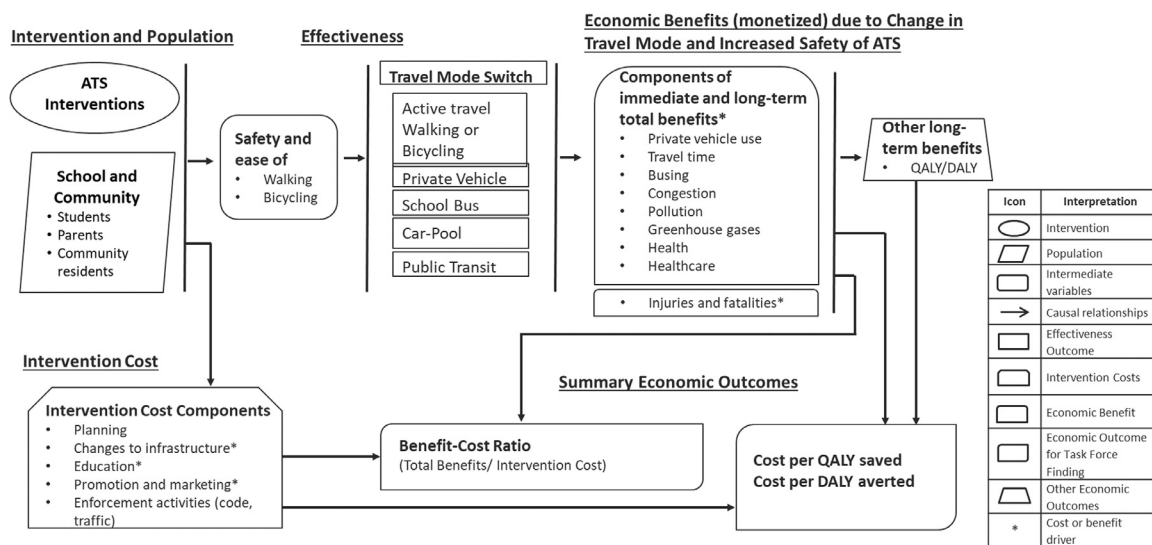


Figure 1. Pathways to economic costs and benefits of ATS interventions.

ATS, active travel to school; DALY, disability-adjusted life year; QALY, quality-adjusted life year.

costs and benefits. Moving from top left to the right, the targeted population includes students and their parents for whom walking or bicycling to school is feasible, plus other community residents who may use the routes for other purposes. All the students and parents have multiple mode choices available to them to travel between home and school, including private automobiles, school buses, walking, bicycling, and public transit. The effective intervention leads to an increase in the proportion of students who choose the ATS mode (i.e., walking or bicycling) and a reduction in the proportions using other modes of travel, as was shown in the review of effectiveness.¹⁶ Health improves from the increased physical activity of active travel and averted longer-term diseases associated with inactivity and excess weight. Each travel mode choice has particular private and societal costs that derive from monetization of effects on resource use, travel time, health, traffic-related injuries, and impacts on the environment. Where these costs are reduced because of the intervention are the economic benefits owing to intervention. ATS interventions also improve the social environment (e.g., a Walking School Bus program; safety in numbers) and the built environment's physical safety, thereby reducing injuries for both current and new users of the routes.

The economic costs and consequences of the interventions are shown at the bottom of [Figure 1](#). At the bottom left, economic evaluations of these interventions capture the cost to implement the intervention, which includes planning, infrastructure changes, education, promotion, and enforcement activities. The components marked with asterisks are expected to be the drivers of the magnitude of estimates. At the bottom right are the monetized and other benefits owing to intervention. The total societal monetized benefit of the intervention is therefore the sum of the following elements of costs associated with all individuals and their travel mode choices after intervention minus the costs at baseline: physical resources and travel time, environmental impacts, near- and longer-term healthcare costs, and injuries and fatalities. All the components of benefits are expected to be the drivers of the magnitude of the estimate and are therefore marked with asterisks. The framework in [Figure 1](#) postulates that ATS interventions cause a shift toward cheaper, safer, environmentally friendlier, and healthier ATS modes and away from the use of private automobiles and busing.

Quality of Estimates

Quality assessment of the economic evidence follows the methods developed by the Community Guide for systematic economic reviews.¹⁹ In general terms, individual estimates from the studies are assigned a quality score of good, fair, or limited on the basis of assessments within each of the 2 domains. First, quality is assessed on the basis of the domain of capture; that is, how well an economic estimate captures the drivers from among its components. A driver of an estimate is a component that contributes substantially to its magnitude. Second, quality is assessed on the basis of the domain of measurement, which is the appropriateness of methods used by the study to measure and value the estimates. The final quality assignment is the lower of the 2 assigned quality scores. The quality of a composite estimate such as cost benefit is the lower of the quality assigned to its individual cost and benefit parts. Limited quality estimates are excluded from the body of evidence.

The quality assessment process just described in general terms was adapted within a quality assessment tool developed for the specifics of this review and is available in the [Appendix \(available online\)](#). Within the domain of capture, engineering and education or encouragement were considered the drivers of intervention cost. The drivers of benefits were costs of private automobile use, injuries and fatalities, travel time, healthcare cost related to physical inactivity and body weight, and the health and other impacts of congestion, pollution, and greenhouse gases. Note that these were the drivers also identified in [Figure 1](#). Within the domain of measurement, the quality of benefit estimates and cost estimates were additionally assessed in the following listed areas along with what are deemed appropriate for the present intervention and review. Limitation points were assigned for departures from what is appropriate.

1. Perspective: societal is appropriate.
2. Population: Students and their parents that are targeted must live within a distance from their school that is walkable or bikeable. A sample size of ≥ 100 in school enrollment.
3. Source of benefits: economic benefits must be derived from observed changes in travel mode or improved safety.
4. Time horizon for benefits: a 10-year horizon is appropriate for infrastructure-heavy projects.
5. Model inputs, parameters, and valuation: the methods used for cost or benefit estimation are transparent or peer reviewed. Appropriate valuation of resources and effects are based on local conditions.

Opportunity is provided in the assessment process to assign a fatal flaw that automatically scores an estimate as limited quality. A fatal flaw is some feature of the estimate that almost certainly causes it to severely misrepresent the true cost or benefit of the ATS intervention.

All monetary values are in 2019 U.S. dollars, adjusted for inflation using the Consumer Price Index²⁰ and converted from foreign currency denominations using purchasing power parities.²¹ All analyses were conducted in September 2018–May 2019.

Search Strategy

Peer-reviewed and gray literature were searched for economic evaluations. Criteria for inclusion were as follows: met the definition of the intervention, conducted in a high-income country,¹⁷ written in English, and included ≥ 1 economic outcomes described in the research questions.

A formal search was conducted within PubMed, Scopus, Cochrane, National Transportation Library, National Technical Information Service, and EconLit for papers published through July 2018. Informal searches were also conducted for reports from governments and nongovernmental organizations using Google and Google Scholar search engines. Finally, citations from another review²² and reference lists in included studies were screened, and subject matter experts were consulted for additional studies. The detailed search strategy is available on the Community Guide website.²³

EVIDENCE SYNTHESIS

Results

A total of 1,745 papers were screened, yielding 9 studies^{24–32} for inclusion ([Appendix Figure 1, available](#)

online). A total of 3 papers were consulted for additional information on the included studies: 2 studies^{33,34} related to 1 primary study²⁸ and 1 study³⁵ related to another primary study.²⁵

Table 1 provides an overview of the studies. A total of 3 studies were from the U.S.,^{28,29,31} and all the 3 evaluated projects within the SRTS program. Of the 6 studies outside the U.S., 2 were from the United Kingdom (UK),^{24,32} 3 from Australia,^{25–27} and 1 from Canada.³⁰ A total of 2 studies^{26,27} were purely education and promotion interventions with no infrastructure, and the remaining ranged across infrastructure heavy,^{24,29,32} a mix of infrastructure and promotion or education,^{28,31} and mostly, promotion or education with small infrastructure.^{25,30}

Table 1 provides additional details regarding the projects, schools, and students who were targeted. The number of projects and schools included in the U.S. studies of SRTS interventions were 48 projects involving 53 schools in the national study,²⁸ 125 projects involving 350 schools in the California study,³¹ and 124 schools in the New York City study.²⁹ The Canadian study³⁰ involved 13 schools, and the 2 UK studies^{24,32} evaluated a total of 12 different projects but did not report the number of impacted schools. Most of the interventions were for elementary or primary school populations. Hence, the number of interventions evaluated, from an evidence perspective, constitutes a much larger number than a simple count of the included studies. The U.S. national study of the SRTS program²⁸ reported a median student body of 675 per participating school, and the study of SRTS in California³¹ reported that 53% of the projects undertaken were associated with student populations in excess of 1,000. Table 1 shows that the majority of studies reported the change in travel modes due to intervention, in particular, the increase in travel by walking or bicycling after the intervention. The cost of the intervention was reported by all the 9 studies. A total of 2 studies in the U.S.^{29,31} and 4 studies outside the U.S.^{24,25,30,32} estimated benefit–cost ratios, and 2 studies from Australia^{26,27} estimated cost per disability-adjusted life year averted.

Intervention Cost

The cost of the intervention from the 9 studies is provided in Table 2 along with the components included in the estimate and the quality of the estimate. Cost per school or cost per project is shown wherever possible. A total of 2^{27,30} of the estimates for intervention cost were of good quality, and 7 studies^{24–26,28,29,31,32} were of fair quality. The most frequent reasons for the assignment of quality limitations were reporting funded amount without details by components or matched funding from

local sources, failure to include the cost of volunteer and in-kind contributions, and failure to include infrastructure component in some studies and noninfrastructure in other studies.

The grand mean of cost per school from the 3 U.S. SRTS studies was \$152,243. The mean cost per school was similar for the 48 projects (53 schools) in California³¹ and the 125 projects (350 schools) in multiple states²⁸ at \$186,576 and \$179,012, respectively. By contrast, the SRTS program in New York City²⁹ cost \$91,140 per school. The difference in cost may be due to the relatively less infrastructure-heavy components in the New York City projects, which primarily improved sidewalks and crossing areas.²⁹ By contrast, the multi-state study²⁸ and the California study³¹ evaluated projects that included some or all the following in intervention cost: sidewalk construction or improvement, crosswalks, traffic calming measures, and bicycle paths and facilities. Projects in the UK had even greater infrastructure components than the U.S. SRTS projects, which may account for their higher cost of \$226,753²⁴ and \$664,864³² per project.

Benefits of Intervention

Table 3 provides the quality assessment of the estimates for the benefits reported by 8 studies.^{24–27,29–32} The estimates are not presented in Table 3 because the basis of the estimates differed widely in both time horizon and geographic scope; instead, the estimates and methods behind them are described in the Cost–Benefit section and in Table 4. There were 4 good quality estimates for benefits^{24,25,30,32} and 2 that were of fair quality.^{29,31} The most frequent reasons for the assignment of quality limitations were benefits based only on 1 impact such as injuries or fatalities, long time horizon of 30 or 50 years, short time horizon of 1 year, ATS change based on self-report or counts of users observed on routes, and ATS change that included adults. A total of 2 estimates of cost per disability-adjusted life years averted from 2 studies^{26,27} were assigned limited quality because they accounted for benefits from averted obesity only, and this was considered a fatal flaw for this review. These 2 limited quality estimates were excluded from further consideration.

Cost Benefit

Estimates along with assessed quality for cost benefit and its component parts are shown in Table 4 from 2 U.S. studies^{29,31} and 4 non-U.S.^{24,25,30,32} studies. A total of 1 estimate³⁰ is rated as good for cost–benefit, and the remaining estimates are all of fair quality. Table 4 also shows the sources and methods used to estimate the intervention cost and economic benefit, along with the

Table 1. Characteristics of Study, Intervention, and Target Population, Intervention Effect, and Type of Economic Analysis

Study author (type)	Country (area)	Primary intervention component and focus	Program name (level of school)	Projects (schools), n	School enrollment	Effect of intervention in travel mode	Type of economic analysis
Moudon (2012) ^{28,33,34} (Gov)	U.S. (WA, WI, MS, FL)	Infrastructure (25%) and mixed infrastructure and noninfrastructure (75%) projects. No outcomes beyond ATS.	SRTS (elementary ^a and middle ^b)	48 (53)	Median 675 (IQR =319–962)	Pre- and post-project reports of walking or bicycling to school. Stewart (2014) ³⁴ reports that overall ATS increased by 36% (from 12.9% to 17.6%) at 53 schools representing 48 projects with complete data.	Cost
Muennig (2014) ²⁹ (journal)	U.S. (NYC)	Improved infrastructure for safety. Focused on pedestrian and bicyclist safety.	SRTS (NR)	NR (124)	NR	+11% ATS 33%–44% injury reduction. ⁴⁶	Cost–benefit
Orenstein (2007) ³¹ (Gov)	U.S. (CA)	A mixture of infrastructure and noninfrastructure. Focused on pedestrian and bicyclist safety.	SRTS (elementary ^a and middle ^b)	125 (350)	By project: ≥1,000 52.8%	Scenario 1: +25% ATS. Scenario 2: +50% ATS. Increase in ATS in SRTS locations based on evaluations of the California SRTS program ^{47,48} and reports from individual schools or projects.	Cost–benefit
Davis (2014) ²⁴ (Gov)	UK (Selected projects)	Infrastructure projects including new bikeways and pedestrian pathways. Health outcomes from physical activity and environmental impacts.	Links to schools. Tackling the school run. (NR)	9 (NR)	NR	Median of new users reported from multiple projects: Bicyclists 70, Pedestrians 268. Median change in trips for children: Bicycle +98%, walking +5%.	Cost–benefit
Ker (2011), ²⁵ Ker (2011) ³⁵ (NGO)	Australia (Queensland)	School- and street-level infrastructure ATS projects. Health outcomes from mode shift away from private automobiles and environmental impacts.	Active school travel (primary ^c)	NA (470)	Mean 400	Car use reduced by 10%, and the switch to active travel distributed as 25% to increased bicycling and 75% to increased walking. Effect estimate informed by experience in the City of Brisbane. ³⁵	Cost–benefit
Moodie 2009 (journal) ²⁶	Australia (all)	Noninfrastructure. Walking School. Bus program. Focused on averted obesity.	Walking school bus (primary ^c)	350 (1,400)	11.2 participants per school	Baseline to post-participation rates based on data from VicHealth, Victoria, Australia. ⁴⁹ Wide range assumed for an increase in the number of students walking to school owing to a lack of data to identify new participants.	Cost per DALY

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Table 1. Characteristics of Study, Intervention, and Target Population, Intervention Effect, and Type of Economic Analysis (*continued*)

Study author (type)	Country (area)	Primary intervention component and focus	Program name (level of school)	Projects (schools), n	School enrollment	Effect of intervention in travel mode	Type of economic analysis
Moodie (2011) ²⁷ (journal)	Australia (all)	Noninfrastructure educational and promotional. Focused on averted obesity.	Travel SMART (primary ^c)	NR (3,870)	The whole of school mean 247; Curricular mean 1,620	Pre and post parent survey indicated the following percentage point increases: Walking increased by 2.4 and Bicycling increased by 12.1	Cost per DALY
Sustrans (2014) ³² (Gov)	UK (Selected projects)	Infrastructure ATS projects including new bikeways and pedestrian pathways. Health outcomes from physical activity and environmental impacts.	Linking communities (NR)	3 (NR)	NR	Increase from almost no child users to 2009 and 8,318 for 2 projects.	Cost–benefit
University of Toronto (2016) ³⁰ (Gov)	Canada (Toronto)	Incentives, promotion, and education with small infrastructure. Health outcomes from physical activity and the impact of reduced private automobile use.	School travel planning (elementary ^a)	NA (13)	Mean 534	Changes in mode of travel to school collected from 13 participating schools using hands-up surveys of students. car use –3.5%, walking +1%, bicycling +1.5%, public transit +3.5%.	Cost–benefit

^aElementary, grades 1–5 in the U.S.

^bMiddle, grades 6–8 in the U.S.

^cPrimary, grades 1–5 or 6 in UK and grades 1–6 or 7 in Australia.

ATS, active travel to school; CA, California; DALY, disability-adjusted life year; FL, Florida; Gov, government; MS, Mississippi; NA, not applicable; NGO, nongovernment organization; NR, not reported; NYC, New York City; SRTS, Safe Routes to School; UK, United Kingdom; WA, Washington; WI, Wisconsin.

Table 2. Intervention Cost: Estimates, Components, and Quality of Estimates

Study	Cost per school, \$	Quality of estimate	Components of intervention cost				
			Education	Enforcement	Promotion	Other	Infrastructure
Muodon (2012) ^{28,33,34}	Median 154,959 and Mean 179,012	Fair	Education activities	Patrol	Walk/ride days	WSB	Sidewalk, crosswalk, signage
Muennig (2014) ^{28,33,34}	91,140	Fair	Education programs	No	No	No	Sidewalk improvement and construction, safety improvements at dangerous intersections
Orenstein (2007) ³¹	186,576	Fair	No	No	No	No	Sidewalk, traffic calming, signals, crosswalk, bicycle paths
Davis (2014) ²⁴	226,753 per project	Fair	No	No	No	No	Modified or new roadways, bikeways, walkways, sidewalks, crossings, signals
Ker (2011), ²⁵ Ker (2011) ³⁵	12,253	Fair	Safety education and skills	Police presence	Walk/ride day	WSB, maps, transition to high school	School bike cages. The study does not include the cost of street-level infrastructure changes in intervention cost, with the argument that such changes fall within the purview of public works and not school systems.
Moodie (2009) ²⁶	12,464	Fair	Volunteer training, kits	No	Walk/ride days, newsletter	WSB, Government coordinators, school liaisons, volunteer time	No
Moodie (2011) ²⁷	2,529	Good	Teacher training, Teacher time	No	Special events	National and local government coordinators, school liaisons	No
Sustrans (2014) ³²	664,864 per project	Fair	No	No	No	No	New biking/walking path and bridges, modify/expand green corridor paths to enhance connectivity
University of Toronto (2016) ³⁰	8,840 per project	Good	Bicycle training	No	Walk/ride days, Incentives	No	School bike racks, signage, pavement marking

Note: No indicates that a component was not included in the estimate.
 NA, not applicable; WSB, Walking School Bus.

Table 3. Intervention Benefits: Components and Quality of Estimates

Study	Quality of benefits estimates		Components of benefits						
	Quality of capture Quality of measurement	Overall quality	Private vehicle use	Travel time	Injuries or fatalities	Busing	Congestion	Pollution or greenhouse	Health-related
Moudon (2012) ^{28,33,34}	NA NA	NA	NA	NA	NA	NA	NA	NA	NA
Muennig (2014) ²⁹	Fair Good	Fair	No	No	Yes	Yes	No	No	No
Orenstein (2007) ³¹	Fair Good	Fair	No	No	Yes	No	No	No	No
Davis (2014) ²⁴	Good Good	Good	No	Yes	Yes	No	Yes	Yes	Yes
Ker (2011), ²⁵ Ker (2011) ³⁵	Good Good	Good	Yes	Yes	Yes	No	Yes	Yes	Yes
Moodie (2009) ²⁶	Fair Limited	Limited	No	No	No	No	No	No	Yes
Moodie (2011) ²⁷	Fair Limited	Limited	No	No	No	No	No	No	Yes
Sustrans (2014) ³²	Good Good	Good	No	Yes	Yes	No	Yes	Yes	Yes
University of Toronto (2016) ³⁰	Good Good	Good	Yes	Yes	No	No	Yes	Yes	Yes

Note: No indicates that a component was not included in the estimate. Yes indicates that a component was included in the estimate. NA, not applicable.

Table 4. Benefit–Cost Ratio Estimates

Study area, country (n of schools)	Source for intervention cost	Source and method for benefits estimation	Time horizon for benefits	Cost, \$	Benefit, \$	B–C ratio	Quality of estimate
Muennig (2014) ²⁹ New York City, U.S. (124)	Funded amount for New York City. No details provided.	Focus on safety as stipulated in the federal statute. ³⁶ Averted medical costs of student pedestrian injury reductions plus funeral costs in the rare case of death. Injuries were classed by severity ⁵⁰ and associated costs drawn from CDC ⁵¹ and other sources	Scenario 1: 50 years. Scenario 2: 2 years ^a	11.30 mil	242 mil ^b	22.1:1	Fair
				11.3 mil	20.03 mil ^b	1.79:1	Fair
Orenstein (2007) ³¹ California, U.S. (214)	Funded amount from national SRTS project tracking database with information collected from state coordinators. Unclear if the amount includes state and local matching funds.	Focus on safety as stipulated in the federal statute. ³⁶ Modeled 1-year economic benefit of reduced pedestrian traffic injuries and fatalities rates in 125 SRTS locations compared with non-SRTS locations after an increase in ATS in SRTS locations owing to intervention.	Scenario 1: 1 year Scenario 2: 2 years ^a	36.6 mil	27.2 mil	0.74:1	Fair
				36.6 mil	53.5 mil	1.46:1	Fair
Davis (2014) ²⁴ Select projects, UK (9 projects)	No details. Likely, the funded amount including any matching funds.	Averted healthcare cost from favorable long-term health outcomes owing to increased walking and bicycling. Monetized value of reduced impacts on the environment owing to reduced automobile use. Healthcare costs dominate most of the evaluations. Methods consistent with guidance provided by the UK Department for Transport, ⁵² and the health benefits of walking and bicycling as modeled with WHO's HEAT. ⁴³	10 years	Mean 226,753	Mean 909,533	Mean 5.2:1 (All>1.0:1)	Fair
Ker (2011), ²⁵ Ker (2011) ³⁵ Queensland, Australia (470)	Brisbane City Council pilot program data ³⁵ and allowance for the development of program resources and materials.	Reduced automobile use averts private cost and time and reduces the negative impacts of pollution, congestion, and climate change. Increased walking and bicycling improve health and fitness and have a large favorable impact on health outcomes, which reduces future healthcare costs. Extensive technical section with the references provided for methods.	10 years	8.0 mil	27.9 mil	3.5:1	Fair

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Table 4. Benefit–Cost Ratio Estimates (continued)

Study area, country (n of schools)	Source for intervention cost	Source and method for benefits estimation	Time horizon for benefits	Cost, \$	Benefit, \$	B–C ratio	Quality of estimate
Sustrans (2014) ^{32a} Select projects, UK (3 projects)	No details. Likely, the funded amount including any matching funds.	Averted healthcare cost from favorable long-term health outcomes owing to increased walking and bicycling. Monetized value of reduced impacts on the environment owing to reduced automobile use. Healthcare costs dominate the majority of the evaluations. Methods are consistent with guidance provided by the UK Department for Transport, ⁵² and the health benefits of walking and bicycling as modeled with WHO's HEAT. ⁴³	30 years	Mean 664,865	Mean 5.21 mil	Mean 10.0:1 (All>1.0:1)	Fair
University of Toronto (2016) ³⁰ Toronto area, Canada (13)	Collected by facilitators from each school.	Benefits from reduced vehicle kilometers that reduce environmental and parent time impacts. Healthcare costs averted from health benefits of walking or bicycling. Based on methods from the Victoria Transport Policy Institute. ⁶	5 years	115,008	724,017	6.3:1	Good

^aComputed by present reviewers.

^bBenefits for adults only.

ATS, active travel to school; B–C ratio, benefit–cost ratio; CDC, Centers for Disease Control and Prevention; HEAT, Health Economic Assessment Tool; mil, million; SRTS, Safe Routes to School; UK, United Kingdom.

geographic area and time horizon. The median benefit to cost ratio reported by the 6 studies was 5.8:1 (IQR=3.9:1–9.1:1). The study of the SRTS program in California³¹ reported a benefit–cost ratio of 0.74 over a very short 1-year time horizon, and the study of the SRTS program in New York City²⁹ reported a benefit–cost ratio of 22.1:1 over a very long 50-year time horizon. Available information allowed the present reviewers to recompute the benefit–cost ratios on the basis of a 2-year time horizon for these 2 studies. For the recomputed estimates, the median benefit–cost ratio from the 6 studies was 4.4:1 (IQR=2.2:1–6.0:1). The median benefit–cost ratio for the infrastructure-heavy projects from the U.S.^{29,31} and those from the UK^{24,32} was 3.5:1 (IQR=1.7:1–6.4).

DISCUSSION

This study reviewed the evidence for the cost and the economic benefits from ATS interventions. The cost to implement ATS interventions varied widely, with higher costs observed for projects that included new or improved infrastructure. Estimates of societal benefits owing to ATS interventions also varied. The benefits estimated in the U.S. studies^{29,31} were derived from improved safety that reduced traffic-related injuries and fatalities. The focus of the U.S. SRTS programs on safety fits with the prominent placement of safety as an objective of the federal legislations that funded SRTS programs nationwide.³⁶ Studies from outside the U.S.^{24,25,30,32} included benefits of reduced injuries and a range of additional environmental and health impacts of reduced motorized transport and increased walking and bicycling. For the aforementioned reason, the benefit–cost ratios from studies outside the U.S. tended to be larger than those for U.S. ATS interventions. These variations aside, the evidence showed that the economic benefits of ATS interventions exceed the cost both in the U.S. and in the other high-income countries.

The issues revealed in this review regarding the appropriateness of conceptual framework, measurement, modeling, and risks of bias in the estimation of cost and benefit are not confined to ATS interventions. They have been recognized in other systematic and critical reviews of the ATS³⁷ and larger literature on built environments, active travel, and physical activity.^{38–42} The issues and criticisms fall into 2 broad areas: first, the framework of what is included in the estimates and the causal pathways between them; second, with regard to methods and measurement. The results from this review are examined in light of the key issues raised in the aforementioned critical reviews.

The expert review and commentary by McDonald et al.³⁷ identified the plausible benefits from ATS

interventions in the U.S. All elements of benefits identified in the expert review are captured in ≥ 1 studies included in this review except for the benefits from averted hazard busing due to improved safety. Hazard busing, estimated to cost between \$100 and \$500 million annually, is bus service provided in the U.S. for children who may live close to schools but where it is physically or socially unsafe to walk or bicycle to school. Doorley et al.³⁹ and Mueller et al.⁴⁰ noted that evaluations differed in the inclusion of health effects, whether from physical activity, ambient pollution inhalation, or risk of collision, and whether they included the costs of morbidity or mortality or both. They concluded in their syntheses that the health benefits were greatest from increased physical activity followed by injuries prevented by improved infrastructure and possibly safety in numbers. Furthermore, Mueller et al.⁴⁰ found that the health benefits from physical activity far outweighed any harms from inhaled pollutants or injuries from increased active travel. The substantial part of the benefits estimated for ATS interventions in this review was derived from averted healthcare costs. The U.S. SRTS studies that were focused on the injuries and averted fatalities monetized those benefits on the basis of the associated healthcare costs for averted morbidity and funeral costs²⁹ or value of statistical life³¹ for the rare fatality. On the basis of the observations made in the critical reviews, the U.S. SRTS evaluations in this review may have underestimated the benefits by not accounting for increased physical activity's impact on disease and healthcare costs averted. By contrast, all the studies in this review that were from outside the U.S. included the monetized benefits from increased physical activity owing to ATS, albeit using the different methods and calculations, as shown in Table 4. The UK studies in this review followed the methods similar to the WHO Health Economic Assessment Tool,⁴³ which derives the health benefits of physical activity from averted disease-related mortality. A monetary value is assigned to each kilometer of active travel by the Australian study,⁴⁴ based in turn on estimates from the New Zealand Department of Transport and also by the Canadian study³⁰ on the basis of the estimates drawn from a transport research institute.⁶ These differences in methodologies may explain the variations in reported cost–benefit estimates.

The 2 recent methodologic reviews of active travel evaluations^{38,41} describe far knottier problems faced by researchers who work with nonexperimental observational study designs, namely, the difficulties in correctly estimating the magnitude of travel mode shift and change in physical activity, and even identifying the target population of interest. The reviews note that the evaluations of extensive infrastructure interventions are

more likely to correctly estimate the change in total physical activity by measuring the range of daily travel modes and behaviors over a greater area, whereas smaller projects may conflate the true change in physical activity with activity displaced from elsewhere. The possibility of conflation is especially problematic where active travel change is measured from simply observed counts of users along a single route or pathway.³⁸ The evaluations of ATS interventions in this review may not be as susceptible to these pitfalls, but they are not immune. The target population of school students in ATS is quite well defined, and there are clear destination and purpose for school travel. Students have to get to and from school by some travel mode or other, and any reduction in one mode must show up as an increase in some other mode. Therefore, a show of hands in class or self-report from a student or parents survey, as done in many of the studies included in this review, should be an acceptable measure of mode shift for ATS interventions. Furthermore, the U.S. SRTS evaluations that were included in this review assessed the monetized benefits from observed²⁹ or estimated³¹ reductions in injuries and fatalities and not directly from a change in active travel. By contrast, the issue of physical activity possibly displaced from elsewhere is certainly a limitation of the ATS evaluations from the UK,^{24,32} which estimated physical activity from the observed pre–post counts of walkers and bicyclists on improved or new paths and included both children and adults.

The critical reviews^{40,42} also called for more attention to equity considerations in the evaluation and comparison of active travel interventions. In this regard, the SRTS programs in the U.S. urban areas, with their focus on both physical and social safety, are likely to have substantial equity impacts. Densely populated urban districts in the U.S., with a large representation of minority race/ethnicity and low-income populations, are more likely to walk or bicycle to school. These children have been seen to take longer than the shortest routes to avoid hazardous streets, sidewalks, graffiti, and crime.⁴⁵ The SRTS programs can benefit these children who may very well have no choice but to walk or bicycle to school.

The quality assessment tool used in this review scored each cost and benefit estimate on the basis of what conceptually important components were captured and how the estimates were measured. Limitation points were assigned to each estimate for each shortfall within a number of areas including target population and size, price used to monetize the value of resources, accuracy of observed outcomes (active travel or mode shift) from which benefits are modeled, time horizon, and others. The elements enumerated

from the quality assessment tool cover most but not all of the issues raised in the recent critical reviews of the literature. The large number of estimates that received a fair rather than good rating indicates that it is rare that every one of the difficulties and issues raised by the critical reviews is successfully addressed by an ATS economic evaluation.

Limitations

The number of people who can reasonably choose an active mode of travel to school and the proportion that actually did so at baseline and after intervention are needed to evaluate the effectiveness of ATS interventions. The omission by U.S. studies of other health and environmental benefits from ATS interventions substantially understates the plausible total economic benefits. Separate estimates for the components of economic benefits from ATS interventions should be reported. It would be useful from the perspective of policymakers from different government agencies to know what the contribution to total benefits was from traffic injuries/fatalities, pollution, traffic gridlock, public safety and crime, physical activity, overweight and obesity, and academics and learning. Some components may have greater significance to their mission and objectives than others.

CONCLUSIONS

Evidence indicates that interventions that improve infrastructure and enhance the safety and ease of ATS generate societal economic benefits that exceed the cost to implement these interventions.

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SUPPLEMENTAL MATERIAL

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