Journal of Physical Activity and Health, 2011, 8, 503-515

Assessing Cost-Effectiveness in Obesity: Active Transport Program for Primary School Children—TravelSMART Schools Curriculum Program

Marj Moodie, Michelle M. Haby, Boyd Swinburn, and Robert Carter

Background: To assess from a societal perspective the cost-effectiveness of a school program to increase active transport in 10- to 11-year-old Australian children as an obesity prevention measure. ***Methods:*** The TravelSMART Schools Curriculum program was modeled nationally for 2001 in terms of its impact on Body Mass Index (BMI) and Disability-Adjusted Life Years (DALYs) measured against current practice. Cost offsets and DALY benefits were modeled until the eligible cohort reached age 100 or died. The intervention was qualitatively assessed against second stage filter criteria ('equity,' 'strength of evidence,' 'acceptability to stakeholders,' 'feasibility of implementation,' 'sustainability,' and 'side-effects') given their potential impact on funding decisions. ***Results:*** The modeled intervention reached 267,700 children and cost $AUD13.3M (95% uncertainty interval [UI] $6.9M; $22.8M) per year. It resulted in an incremental saving of 890 (95%UI –540; 2,900) BMI units, which translated to 95 (95% UI –40; 230) DALYs and a net cost per DALY saved of $AUD117,000 (95% UI dominated; $1.06M). ***Conclusions:*** The intervention was not cost-effective as an obesity prevention measure under base-run modeling assumptions. The attribution of some costs to nonobesity objectives would be justified given the program's multiple benefits. Cost-effectiveness would be further improved by considering the wider school community impacts.

Keywords: walking, children, weight gain

Concerns about the growing levels of childhood obesity and the increased levels of traffic congestion and vehicle pollution coincide to produce an interest in active transport to and from school. The majority of children in urban environments in Australia live within walking and cycling distance to school;[1] 70% of primary school children attend government schools (as distinct from Catholic or Independent schools)[2] which in urban areas are likely to be in relatively close proximity for the majority of children. Nevertheless, travel to school across the Melbourne metropolitan area accounts for 17% of morning peak hour traffic, with 39% of those vehicles taking a trip from home to school to home.[3] It is logical for a number of reasons that programs should be developed to promote active transport among school students. Active transport to and from school provides a potential opportunity for Australian school aged children to increase their levels of daily physical activity,[4] with both potential health[5,6] and other benefits.[7]

Moodie and Carter are with Deakin Health Economics, Population Health Strategic Research Centre, Deakin University, Burwood, Victoria, Australia. Haby is with the Public Health Branch of the Dept of Human Services, Melbourne, Australia. Swinburn is with the WHO Collaborating Centre for Obesity Prevention, Deakin University, Burwood, Australia.

Over short distances, walking and cycling is an ideal form of transport; however analysis of rates of participation reveal a steady and dramatic decline in the last 2 decades.[8] There are a number of parent and child perceived barriers which contribute to the continued decline in active transport rates, including a perceived physical danger to children from strangers, inadequate safe crossing points and the presence of heavy traffic,[9] and the increasing participation of women in the workforce adds time pressure to family living.[3]

The TravelSMART Schools (TSS) curriculum program, a school-based program designed to achieve travel behavior change, is an example of such a program. While it encompassed other strategies, the promotion of active transport to school was a key plank of the program.[10] The program, through its endeavors to promote travel alternatives to the car, offered multiple potential benefits such as community building, reduced pollution, less traffic congestion, and fewer accidents around schools.

This paper takes data from a pilot survey, and models the costs, benefits, and cost-effectiveness of the program if applied throughout Australia. The primary purpose of this paper is to measure the capacity of the intervention as an obesity prevention measure, which accords with one of the program's stated objectives of "addressing the health concerns of the low levels of physical activity for children."[10] Nevertheless, while the other program benefits were not quantified, this paper acknowledges them and recognizes attribution of costs as a key issue.

Methods

Overview

The intervention was modeled as part of the Assessing Cost-Effectiveness in Obesity (ACE-Obesity) project[11] and the full economic evaluation methods are detailed in a separate paper.[12] A cost-effectiveness evaluation was conducted and the incremental cost-effectiveness ratio (ICER) was calculated as the cost ($AUD) per Disability-Adjusted Life Year (DALY) saved, as well as the cost per Body Mass Index (BMI) unit saved. Pathway analysis was used to identify all resources associated with intervention delivery. The intervention was modeled for 1 year in steady-state operation from a societal perspective, and the time horizon for estimating all the associated cost-offsets and DALY benefits was rest-of-life or 100 years. All costs and benefits were discounted at 3%,[13] and the reference year was 2001, the latest year for which all datasets were available.

The intervention was also assessed against a series of second stage filter criteria ('strength of evidence,' 'equity,' 'acceptability to stakeholders,' 'sustainability,' 'feasibility of implementation,' and 'potential for positive and negative side effects'), to capture broader less quantifiable issues which are of prime concern to policy-makers and therefore impinge on resource allocation decision-making. The second stage filters were assessed by a Working Group of stakeholders (government, service providers, academics, etc.), which is a key component of the ACE approach.[11]

The Intervention

The modeled intervention was based on the TSS program, a curriculum-based program specifically targeted at children in years 5 and 6 (age 10 and 11 years), and which was piloted in 6 Victorian schools in 2002–03. The program was intended to raise awareness about the impact on local environments of car use including health and safety and promoted the use of walking, cycling, and public transport to travel to and from school. It aimed to decrease traffic congestion around schools, increase physical activity levels and increase the community capacity to work together by planning more active ways for children to travel to school.[10]

The program involved a number of key components designed to engage the whole school community (school councils, administrators, teachers, students, parents, and families). It included meetings and information sessions about the program; a professional development program for teachers; classroom activities for year 5 and 6 students (approximately 20 hours over 4 weeks); whole-of-school activities and events, and promotion of the program within the local community. However, the whole-of-school activities are relatively small and few in number and are secondary to the key component of the intervention which is the classroom lesson.

Since the initial pilot, the TSS program has been expanded and altered in accordance with the United Kingdom approach, which entails a more whole-of-school, whole-of-problem centered approach rather than a curriculum-based one, and centers heavily on the development and implementation of a school travel plan.

Current Practice

The comparator for this intervention was current practice as very few school travel-based interventions exist in Australia. In other words, active transport levels were as they were in the absence of the TSS program. Measures of active transport in the participating schools were taken before the program's introduction.

Assessment of Benefit

The first stage of benefit assessment involved the estimation of the health gain that could be attributed to the intervention using the DALY. This required conversion of the effect in terms of a change in behavior to a change in BMI as children to DALYs saved over their lifetime. DALYs were chosen as the main measure of health gain as they cover both mortality and morbidity gains and offer a common metric which can be used across disease areas.

The results from a parent pre and post survey about the change in their child's travel behavior to school as a result of the program were used in the modeling. The survey response rate was low (30%), and hence these reported changes were included in the uncertainty analysis. A modest increase in walking (from 41.3% preintervention to 43.7% post), a modest fall in public transport use (from 3.4% to 2.9%), and a significant increase in cycling (from 13.1% to 25.2%) were reported for the journey home from school, with similar changes for the forward journey.[10]

We then used a range of other available data to model the likely change in the BMI of individual participants who took up walking, cycling, or using public transport to and from school as a result of the intervention (Table 1). The increased energy expenditure for a child who changed from car transport to walking (cycling or taking public transport) to school was calculated by subtracting the energy costs of walking (3.5 metabolic units [METs]) from the energy costs of sitting in a car (1.0 MET).[14] The net 2.5 METs was then multiplied by the assumed average weight of the target age children (kg) and the assumed time to walk to and from school to derive the increased energy expenditure (kJ/d). Given the absence of definitive evidence, we assumed that there was no effect of active transport on other energy expenditure (ie, walking to school neither increased or decreased physical activity at other times) or energy intake levels.[8,15–17] The validated method of Swinburn et al 2006 was used to convert changes in energy balance to changes in weight.[18] The resultant change in BMI was then converted to DALYs saved over the lifetime of the child using the methodology reported elsewhere.[11]

The second stage of benefit assessment (the second stage filter analysis) involved the assessment of issues

Table 1 Modeling of Reduction in BMI for a Single 'Average' Child New to Active Transport (Effects Are Averaged Over 1 Calendar Year Period)

	Walking		Cycling		Public transport		
	Boys	Girls	Boys	Girls	Boys	Girls	Comments
Height (m)	1.44	1.46	1.44	1.46	1.44	1.46	Mean height for age group 10–11 years (1995 National Nutrition Survey[22])
Weight (kg)	37.66	40.49	37.66	40.49	37.66	40.49	Mean weight for age group 10–11 years (1995 National Nutrition Survey[22])
Body Mass Index, BMI (kg/m^2)	18.06	18.87	18.06	18.87	18.06	18.87	Mean BMI for age group 10–11 years (1995 National Nutrition Survey[22])
Estimated total energy expenditure (MJ/day)	8.77	9.43	8.77	9.43	8.77	9.43	Total energy expenditure (MJ/day) = [.107 × weight (kg)] + [2.91 × height (meters)] + .417[23]
Estimated total energy expenditure (kJ/day)	8775	9432	8775	9432	8775	9432	Conversion to kilojoules—multiply by 1000.
Increased METS—walking or cycling or public transport (versus sitting)	2.5	2.5	3.0	3.0	1.5	1.5	Metabolic equivalents for sitting = 1.0, walking 3.5, cycling 4.0, public transport 2.5. Therefore, additional energy expenditure of walking to school = 2.5 METS, cycling 3.0, using public transport 1.5[14,24]
Extra time spent on walking or cycling or public transport (mins)	28.30	28.30	10.00	10.00	6.00	6.00	Mean travel time for Victorian children participating both in morning and afternoon Walking School Bus program.[25] Time for other modes estimated from walking time.
Energy expenditure increase from active transport participation (kJ/day)	187	201	79	85	24	26	Increase in individual energy expenditure from active transport (kj per school day) = weight (kg) × increased METs × time (hrs) × factor for converting kcal to kJ (4.2).
Average number of days of active transport participation to and from school per week	3	3	3	3	3	3	Estimate
Number of potential weeks of active transport participation per year	40	40	40	40	40	40	Number of weeks in the school year

(continued)

Table 1 *(continued)*

	Walking		Cycling		Public transport		
	Boys	Girls	Boys	Girls	Boys	Girls	Comments
Total number of days of active transport participation per year	120	120	120	120	120	120	Number of active transport days per week × number of school weeks
Energy expenditure increase from active transport (kJ/day)	61	66	26	28	8	9	Total increase in individual energy expenditure from active transport × number of days of active transport per year divided by 365
Relative increase in energy expenditure with TSS intervention (%)	0.70	0.70	0.30	0.30	0.09	0.09	Average individual energy expenditure from active transport as % of estimated total energy expenditure per day
Conversion factor	0.45	0.45	0.45	0.45	0.45	0.45	Factor for conversion of relative change in energy balance to relative change in body weight[18,26]
Relative lower weight with TSS intervention	0.33	0.33	0.14	0.14	0.04	0.04	$[1-(\text{energy expenditure}_1/\text{energy expenditure}_2)^{0.45}] \times 100$
Absolute lower weight with TSS intervention (kg)	0.12	0.17	0.05	0.06	0.02	0.02	% of original weight
New weight (kg)	37.54	40.32	37.61	40.43	37.65	40.4	Original mean weight minus decrease in weight as a result of TSS intervention
New BMI	18.00	18.79	18.04	18.85	18.05	18.87	New weight divided by square of height
Reduction in BMI[a]	0.06	0.08	0.03	0.03	0.01	0.01	Original mean BMI minus new BMI.

[a] These figures are point estimates, which do not take into account uncertainty around any of the input parameters. As a result, they are different to the BMI changes quoted in the results section.

Abbreviations: m, meters; kg, kilograms; m^2, meters squared; MJ/day, megajoules per day; kJ/day, kilojoules per day; METS, metabolic equivalent units; mins, minutes; hrs, hours; kcal, kilocalories; TSS, TravelSMART Schools; BMI, body mass index.

that either influenced the degree of confidence that could be placed in the cost-effectiveness ratio (such as the 'strength of evidence'), or broader issues that need to be taken into account in decision-making about resource allocation (such as 'equity,' 'acceptability to stakeholders,' 'feasibility of implementation,' 'sustainability,' and 'potential for side-effects').[11]

Simulation of the Intervention

Delivery Model. The Victorian Department of Transport recruited schools to the pilot via an expression of interest process using specified selection criteria. It then negotiated the curriculum component with the individual schools. Essentially the TSS program did not entail alteration of the current curriculum content, but rather the introduction of the theme of health promoting travel behavior into existing classroom subjects, which were taught by the normal classroom teacher.

It was assumed that the intervention would be implemented in schools throughout Australia within a 1-year timeframe, given the knowledge and expertise now available to the program and an adequate allocation of resources to it.

Participation of Schools. In the application of the TSS program on a national basis, its uptake by individual schools was assumed to be voluntary. Evidence drawn from the take-up of other voluntary programs (Asthma Friendly Schools, Life Education) within Victorian schools suggested that a 50% take-up was realistic, which equated to a total of 3870 primary schools throughout Australia in 2001.[19] Assuming these schools accounted for an equivalent proportion of students, this translated to a total of 956,206 students (5–11 year olds) potentially being reached by any whole-of-school activities. Based on the proportion of Victorian primary school children in years 5 and 6, 267,738 children nationally would receive the curriculum components of the intervention.[20]

Assessment of Costs

Pathway analysis was used to identify the component activities of the intervention to ascertain the associated resource utilization (Figure 1). The costs included, unit costs and their sources, and the assumptions employed are specified in Table 2. All costs were adjusted to real prices in the 2001 reference year using the relevant Consumer Price Index.[21]

Given the societal perspective, all costs to the health sector, patients, and families, and other sectors involved in the delivery of the intervention, were included (Figure 1). Since the intervention was assumed to be operating in 'steady state' (that is, fully implemented without workforce or learning-curve problems), costs associated with initial research, design, and set-up of the intervention were excluded.

Uncertainty Analysis

Uncertainty analysis was conducted because of the need to make assumptions due to the lack of definitive evidence surrounding some parameters. Simulation-modeling techniques (using the @RISK software and Monte Carlo simulations based on 3000 iterations) facilitated the calculation of a 95% uncertainty range around the median health benefits, costs, and ICERs. The parameters included in the uncertainty analysis are listed in Table 3.

Sensitivity Analysis

Sensitivity analysis was undertaken around key design issues associated with the intervention. The following scenarios were modeled as univariate sensitivity tests: Scenario 1—joint cost attribution across multiple objectives, whereby 30%, 50%, 70%, and 80% of total costs were apportioned to transport (nonobesity-related) objectives; Scenario 2—broadening of the benefit to include other children in the school who were assumed to take up active transport at half the rate of children in grades 5 and 6, and conservatively receive only half of the benefit; Scenario 3—exclusion of selected cost items (training venue hire, teacher travel time, and vehicle operating costs).

Results

Incremental Cost-Effectiveness

The incremental effect of the TSS intervention ranged from a reduction of 0.01 BMI units (children taking up public transport to/from school) to 0.07 (girls taking up walking).

Based on the modeled cost-effectiveness evaluation, the intervention cost resulted in modest savings of 890 BMI units which translated to 95 DALYs saved (Table 4). Following the inclusion of cost-offsets, this equated to a net ICER of $AUD117,000 per DALY saved under base-run current assumptions. The uncertainty intervals were wide, reflecting the limited evidence of effectiveness. The key sources of uncertainty around the costs were the costs of backfilling the TSS school coordinator's position ($r = .772$) and the number of schools recruited ($r = .607$), while the key source of uncertainty around the benefits was the proportion of children walking to/from school after the intervention ($r = .501$). Figure 2 shows that for the majority of iterations of the model, the intervention was not cost-effective. There was only a 6.6% chance that the intervention would cost less than $AUD50,000 per DALY (the commonly accepted Australian benchmark for cost-effectiveness) saved; there was also a 7.8% chance that the intervention would entail higher costs for negative benefits (ie, is dominated) (Figure 2). The potential for negative benefits arose because the underpinning pilot data indicated a small decline in the proportion of children taking public transport to school as a result of the intervention.

No comparative ICERs were available to place these results in a broader cost-effectiveness analysis context. The results assumed full maintenance of the BMI benefit into adulthood. If any of the benefit is lost, as is likely to be the case, the ICERs reported here would increase.

The majority of the intervention costs varied in relation to the number of schools and teachers recruited to the program. Fixed costs constituted only $AUD1.2M or 9% of total costs, and comprised project coordination at the national and state level. The largest component of costs related to the back-filling of the TSS coordinator's position.

Sensitivity Test Results

The intervention became cost-effective as an obesity prevention measure (against the $AUD50,000 per DALY

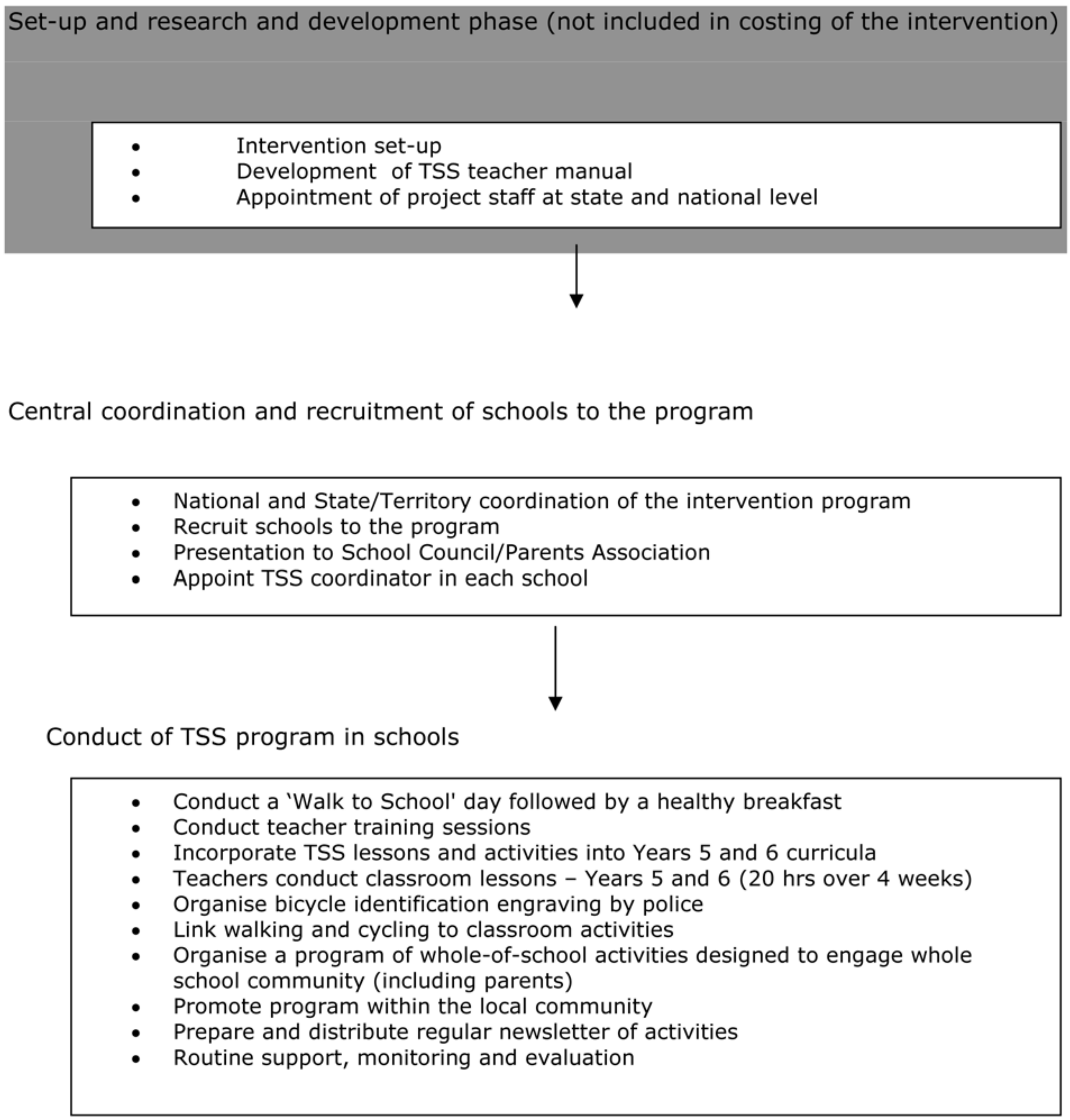

Figure 1 — Intervention pathway. Source: ACE-Obesity project.

saved benchmark) when around 55% or more of the costs were apportioned to nonobesity-related objectives (Scenario 1, Table 4).

Besides the curriculum components which targeted grades 5 and 6 children, the TSS intervention also incorporated whole-of-school community measures. If the benefit was broadened (Scenario 2), the ICER was more than halved, and approached cost-effectiveness.

The exclusion of some costs such as teacher travel time to training, teacher vehicle operating costs, and the hire of a training venue (Scenario 3) had a negligible impact on the ICERs, given their small-scale.

Second Stage Filter Analysis

A consideration of second stage filters for the intervention is summarized in Table 5. The key decision points related to strength of evidence, feasibility of implementation, and sustainability.

Table 2 Unit Costs, Data Sources, and Assumptions

Element costed	Unit cost (real prices 2001 $AUD)	Source	Assumptions
Central coordination			
Project Officer time per annum (+ 60% on-costs)	$84,152	Middle of Australian Public Service Level 6 salary range ($57,113) as at July 04. www.apsc.gov.au	Program coordination by 15 full-time project officers (2 national, 13 states and territories)
School recruitment			
TSS coordinator per day	$180.69	Maximum daily rate for a 3 or 4 year trained teacher. Salaries for Casual Relief Teachers in Victorian Government Schools, April 2003 Victorian Dept. of Education and Training.	In each school, a teacher appointed as TSS coordinator for 1 hour per week. Their position backfilled by casual relief teachers.
Teacher training			
Teacher time at training	$0.00		One day training program. Assuming an average class size of 25.2 students, provision made for 11,609 teachers to be trained (3 teachers per school plus a small allowance for staff turnover).Training provided to groups of around 40, so 290 repetitions of training. Training occurs in school term time and within normal school hours, so no additional reimbursement over normal salary.
Backfill teachers during training per day	$180.69	Maximum daily rate for a 3 or 4 year trained teacher. Salaries for Casual Relief Teachers in Victorian Government Schools, April 2003 Victorian Dept. of Education and Training.	Casual relief teachers cover for each teacher attending training
Conduct of teacher training by experienced teachers (per day)	$236.62	Subdivision A-3 of Accomplished Classroom Teacher range. Victorian Dept of Education and Training, Salaries for Teacher Class Structure, August 2004	Training conducted by 2 experienced seconded teachers. Allow 2 days per 1 day training session (to cover preparation, delivery, and travel time). Includes 30% salary on costs.

(continued)

Table 2 ***(continued)***

Element costed	Unit cost (real prices 2001 $AUD)	Source	Assumptions
Teacher travel time to training (per hour)	$15.47	Gender specific average ordinary time earnings adjusted to labor force statistics and population gender ratio.[27]	Half an hour travel time both to and from the training costed for each attending teachers. As employees in Australia are not paid for travel to/from work, only the additional travel time involved in attending training was costed. Urban teachers 50%; rural teachers 90% travel time assumed additional travel time and valued at the leisure time rate (ie, 25% of the Australian average weekly earnings rate.
Vehicle costs to training (per km)	$0.55	2003 Vehicle Operating Costs—private vehicle reimbursement rate for medium 2–3 liter vehicles. Royal Automobile Club of Victoria	A 10 kilometer vehicle allowance each way to and from training included for all attending teachers.
Training venue hire	$110.00	Live Eat and Play [LEAP] study[28]	
Catering at training session (per head)	$27.63	Estimate	
Conduct of intervention in schools			
Teacher time in delivering lessons	$0.00		Classroom time of teachers delivering the lesson components not costed as no additional classroom time involved.
Curriculum manuals	$40.00	Department of Transport, Victoria	Each teacher completing training provided with a curriculum manual. Value annuitized over 5 years.
Whole-of-school events	$500.00	Estimate	Allocation per school to cover resources expended on whole-of-school activities both at launch stage and during routine operation.

Note. Source: ACE Obesity project.

Table 3 Uncertainty Analysis

Parameters	Values	Uncertainty distribution	Sources and assumptions
Height, weight of participants	Mean, SE	Normal[a]	National Nutrition Survey 1995[22]
% of primary schools recruited	25%, 50%, 75%[b]	Triangular[c]	Asthma Friendly Schools, Life Education
No. of project officers per state	1, 2, 3[b]	Triangular[c]	Estimate
No. of project officers (TAS, ACT, NT)	0.5, 1.0, 1.5[b]	Triangular[c]	Estimate
Loading on national and state project officer salaries	50%, 60%, 70%[b]	Triangular[c]	Estimate. Includes salary on-costs (superannuation, holiday leave, long service etc.), office overheads, consumables, administrative support, routine monitoring, support, and evaluation
Loading on teachers' salaries	20%, 30%, 40%[b]	Triangular[c]	Estimate. Includes as above
Teachers requiring training per school	2, 3, 4[b]	Triangular[c]	Estimate
Number of teachers per training workshop	20, 40, 60[b]	Triangular[c]	Estimate
No. of days of active transport per week	1, 3, 5[b]	Triangular[c]	Estimate
Extra minutes spent on walking per day	6, 28.3, 84[b]	Triangular[c]	VicHealth[25]
Increase in METS from walking	1.5, 2.5, 3[b]	Triangular[c]	Ainsworth et al[14]
Factor for conversion of % change in energy balance to % change in body weight	0.38, 0.45, 0.51[b]	Triangular[c]	Swinburn et al[18]
% increase in grades 5 & 6 children walking	Mean ± 20%[b]	Triangular[c]	DiPietro and Hughes[10]
% increase in grades 5 & 6 children cycling	Mean ± 20%[b]	Triangular[c]	DiPietro and Hughes[10]
% increase in grades 5 & 6 children using public transport	Mean ± 20%[b]	Triangular[c]	DiPietro and Hughes[10]
TSS Coordinator time (hours per week)	1, 4[d]	Uniform[e]	Department of Transport
Curriculum manual	$40± 20%[b]	Triangular[c]	Estimate
Special events, theme days etc.	$250, $500, $1,000[b]	Triangular[c]	Estimate
Expected life of manual (years)	4, 5, 6[b]	Triangular[c]	Estimate
DALYs per child—males			
Walking	0.005 (0.002; 0.015)[b]	Triangular[c]	Haby et al[11]
Cycling	0.002 (0.001; 0.003)[b]	Triangular[c]	Haby et al[11]
Public transport	0.0007 (0.0005; 0.001)[b]	Triangular[c]	Haby et al[11]
DALYs per child—females			
Walking	0.005 (0.003; 0.013)[b]	Triangular[c]	Haby et al[11]
Cycling	0.003 (0.001; 0.004)[b]	Triangular[c]	Haby et al[11]
Public transport	0.0009 (0.0003; 0.001)[b]	Triangular[c]	Haby et al[11]

[a] Values are distributed in a normal bell-shaped curve.

[b] Values are minimum, most likely and maximum.

[c] In a triangular distribution, the greatest probability of being chosen is the value representing the top of the triangle (i.e. the most likely value), while the probability of other values being chosen tapers off toward the extremes of the base of the triangle (i.e. the minimum and maximum values).

[d] Values are minimum and maximum.

[e] In a uniform distribution, every value in the specified range has an equal probability of being chosen in each iteration of the simulation.

Abbreviations: SE, standard error; TAS, Tasmania; ACT, Australian Capital Territory; NT, Northern Territory; METs, metabolic equivalent units; TSS, TravelSMART Schools; DALYs, disability-adjusted life years.

Note. Source: ACE-Obesity project.

Table 4 Cost-Effectiveness Results ($AUD)

Total BMI units saved	890 (–500; 2,900)
Median BMI reduction per child	
Walking—boys; girls	0.07 (0.02; 0.17); 0.07 (0.02; 0.18)
Cycling—boys; girls	0.02 (0.01; 0.04); 0.03 (0.01; 0.04)
Public transport—boys; girls	0.007 (0.004; 0.011); 0.008 (0.004; 0.012)
Total DALYs saved	95 (–40; 230)
Total intervention cost	$13.3M ($6.9M; $22.8M)
National & state coordination	$1.2M
Backfill school coordinator	$9.3M
Special events	$2.2M
Other	$0.6M
Total intervention cost by sector	
'C1': health sector	$0 (0% of total cost)
'C2': client/family	$0 (0% of total cost)
'C3': other sectors	$13.3M (100% of total cost) (Key sector: Education)
Gross cost per BMI unit saved	$13,000 (dominated; $120,000)
Gross cost per DALY saved	$125,000 (dominated; $1.07M)
Total cost-offsets	$750,000 (–$300,000; $1.9M)
Net cost per DALY saved (with cost-offsets)	$117,000 (dominated; $1.06M)
Scenarios (net cost per DALY saved)	
Attribute % total costs to nonobesity objectives	
30%	$79,000 (dominated; $845,000)
50%	$53,000 (dominated; $600,000)
70%	$30,000 (dominated; $340,000)
80%	$17,000 (dominated; $210,000)
Broadening benefit to include other children in the school	$54,000 ($15,000; $277,000)
Exclude costs of teacher travel time, teacher vehicle costs to training, venue hire	$113,000 (dominated; $1.22M)

Note. Values are medians; figures in brackets show the 95% uncertainty interval. Source: ACE-Obesity Project.

Abbreviations: BMI, Body Mass Index; DALYs, disability-adjusted life years; M, million.

Discussion

While obesity prevention was the not the primary purpose of the TSS program, it has an acknowledged role in improving the physical activity levels of primary school children (physical inactivity is a known risk factor for obesity). There is evidence at least in adults to suggest that active commuting is more likely to be adopted and sustained than exercise programs.[29] However, the TSS intervention was not cost-effective in terms of its effect on obesity in children on the basis of the base-run assumptions, where all costs were attributed to this single objective. Even when cost offsets arising from future reduction in obesity-related diseases were taken into account, the ICER did not come close to the usually acceptable threshold level in Australia of $AUD50,000 per DALY saved. The uncertainty intervals around the ICER were wide, and there was a small chance of the intervention being "dominated" (ie, combination of negative benefits and net costs).

There is a lack of other economic evaluations of active transport to school programs to provide some context in which to consider this result. The only known study is our own evaluation of the Walking School Bus program,[30] which was also evaluated as part of the ACE-Obesity study. It was more cost-ineffective given the very high cost of its delivery structure coupled with low participation rates.

So while the intervention was not cost-effective when a narrow view of benefit was adopted and all of the costs were attributed to obesity, a case for cautious optimism arose when a broader view of benefit was assumed. As stated at the outset, the intervention was not designed as a dedicated initiative to curb weight gain, but rather as a program to produce change in the travel behavior of students and their parents and families. If the program's other potential positive side-effects (such as reduced traffic congestion, accidents, and pollution around schools) are recognized, it can be quite validly argued that the intervention costs should not be wholly attributed to the

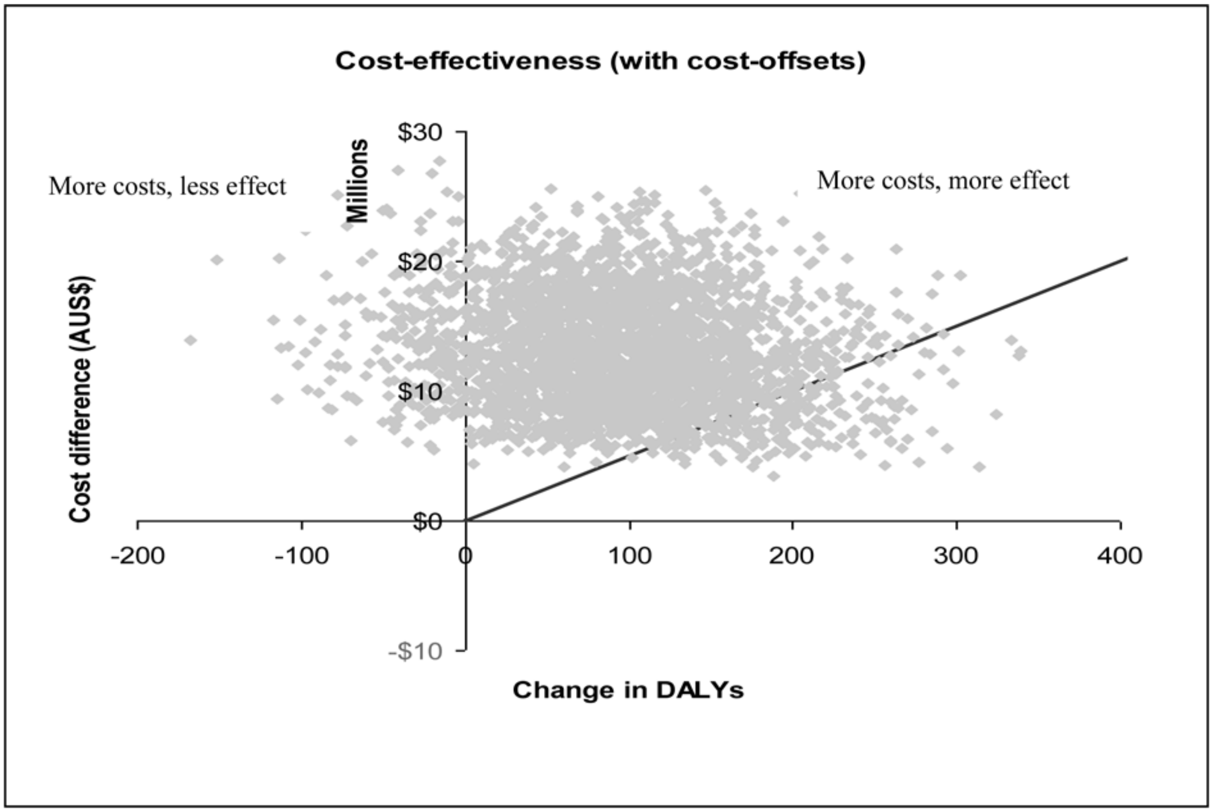

Figure 2 — Cost-effectiveness plane—Net cost per DALY saved. Note: The diagonal line represents a cost-effectiveness ratio of $AUD50,000 per DALY saved.

BMI outcomes, but rather be apportioned across the full range of program objectives. Sensitivity testing showed that if around 55% of the intervention's total costs were apportioned to its primary transport and environmental objectives, the intervention would become cost-effective as an obesity-reduction measure. The widening of the benefits included and apportionment of costs accordingly makes for a more optimistic case for inclusion of the program in an obesity prevention strategy.

While it is debatable as to what proportion of intervention costs should be apportioned to other objectives, it cannot be denied that the intervention's capacity to increase the physical activity levels of children were among its listed potential positive benefits. The paper by DiPietro and Hughes (2003)[10] highlights the health benefits, and the program's School Teachers Guide and Student Workbook both include units on the importance of physical exercise to health, and the role of active transport in promoting such activity.A key limitation of the modeling is the assumption of 100% maintenance of benefit over time. This is very unlikely in reality especially given the brevity of the intervention and the modest size of the effect at the level of the individual.

A further issue was the limited evidence of effectiveness, based on 1 small pilot study. The survey from which pre and post active transport activity data were drawn was completed by only 30% of parents of students in grades 5 and 6 in 4 of the pilot schools. The low response rate may have under-estimated the real take-up of the intervention. On the other hand, the reverse may have been true if there was any selection bias in the sample, whereby the families supporting the intervention were most likely to respond. No data were available about resultant changes in the active transport behavior of other students in the school (despite a focus of the program being whole-of-school activities) or of parents or other family members.

A larger study with longer-term follow-up data is required to facilitate a more definitive assessment of the intervention's effectiveness in reducing BMI. It is unlikely, however, that a larger study will be repeated as the TSS program in Victoria has now changed direction and has moved toward a more whole-of-school, whole-of-problem centered approach rather than a curriculum based one, and centers heavily around the development and implementation of a school travel plan. While this new program could potentially be modeled if data were available on its uptake and effectiveness, this current evaluation was confined to the curriculum program given the availability of data from the pilot program. Other issues likely to affect the take-up of the program by schools are its long-term sustainability given the need for ongoing funding and support, and the number of other initiatives competing for time in the school curriculum.

Table 5 Second Stage Filter Analysis

Strength of evidence	Equity	Acceptability	Feasibility	Sustainability	Side-effects
Weak evidence of effectiveness • Based on 1 small pilot study (level III study design) • Very low response rate (30%) • Only measured change in % of students using active transport • BMI not measured as obesity prevention not the primary focus • Since the program has since changed, the analysis needs to be redone. The program as tested in the pilot study requires further research.	Depends on implementation strategies (eg, targeting of schools by socioeconomic status, location)	Issues of acceptability to schools, teachers (added burden), parents. Rising petrol prices likely to make active transport more acceptable.	Issues that may arise: • Level of ongoing funding & support required. • Long lead time to achieve curriculum change • Take-up rate by schools	Issues likely to arise: • Program requires substantial ongoing funding and support, which may impact on sustainability	Positive: • Less traffic & pollution, safer traffic environment. • Enhances pedestrian skills • Improves sense of personal security • Positive impacts on family travel • Raised awareness of environmental & health issues Negative:
Decision point					
Weak evidence of effectiveness. Further research needed before implementation	Not a key issue	Possible concerns need attention	Some significant concerns	Needs to be entrenched in curriculum	Significant wider positive benefits
Policy considerations	The TSS intervention is not cost-effective in terms of its effect on obesity in children. However, the intervention was not designed as an initiative to promote weight loss but as a program to produce change in the travel behavior of students and their parents and families. There are several potential positive side-effects not incorporated in the cost-effectiveness results. A larger study and longer term effectiveness is required to make a more definitive assessment of the intervention's effectiveness in reducing BMI. Key decision points are: cost-effectiveness, strength of evidence, feasibility and sustainability.				

Acknowledgments

The Assessing Cost-Effectiveness in Obesity (ACE-Obesity) project was funded by the Victorian Government Department of Human Services, Australia. We thank members of the ACE-Obesity Working Group for their input into the project: Michael Ackland (Deputy Chair), Bill Bellew, John Catford, Elizabeth Develin, Helen Egan, Bonnie Field, Tim Gill, John Goss, Robert Hall (Chair), Brian Harrison, Kellie-Ann Jolly, Mark Lawrence, Amanda Lee, Tony McBride, Karen McIntyre, Jan Norton, Anna Peeters, Theo Vos, Melissa Wake, Rowland Watson. Acknowledgment is made of the input of Mr Brian Peddie, TravelSMART program, Victorian Department of Transport, Mr Ian Hughes and Ms Leah Galvin. At the time of this research, this department was known as the Department of Infrastructure. The opinions, analysis, and conclusions in this article are those of the author/s and are not necessarily endorsed by the Victorian Government Department of Human Services, the Victorian Minister for Health or the Government of Victoria.

References

1. Australian Bureau of Statistics. *Travel to work, school and shops*. Canberra, Australia: Australian Bureau of Statistics; 1994.
2. Australian Bureau of Statistics. Schools. Catalogue 4221.0. Canberra, Australia: Australian Bureau of Statistics; 2008.
3. Morris J, Wang F, Lilja L. *School children's travel patterns—A look back and a way forward.* Hobart: 24th Australasian Transport Research Forum; 2001.
4. Cooper AR, Anderson LB, Wedderkopp N, Page AS, Froberg K. Physical activity levels of children who walk, cycle, or are driven to school. *Amer J Prev Med.* 2005;29(3):179–184.
5. Cooper AR, Wedderkopp N, Wang H, Andersen LB, Froberg K, Page AS. Active transport to school and cardiovascular fitness in Danish children and adolescents. *Med Sci Sports Exerc*. 2006;38(10):1724–1731.
6. Dollman J, Lewis NR. Active transport to school as part of a broader habit of walking and cycling among South Australian youth. *Pediatr Exerc Sci.* 2007;19(4):436–443.

7. Rissel CE. Active travel: a climate change mitigation strategy with co-benefits for health. *NSW Public Health Bull.* 2009;20(2):10–13.
8. Harten N, Olds T. Patterns of active transport in 11-12 year old Australian children. *Aust N Z J Public Health*. 2004;28(2):167–172.
9. Timperio A, Crawford D, Telford A, Salmon J. Perceptions about the local neighbourhood and walking and cycling among children. *Prev Med.* 2004;38:39–47.
10. DiPietro G, Hughes I. *TravelSMART Schools—there really is a better way to go.* 26th Australasian Transport Research Forum, Wellington, New Zealand; 2003.
11. Haby M, Vos T, Carter R, et al. A new approach to assessing the health benefit from obesity interventions in children and adolescents: the Assessing Cost-effectiveness in Obesity (ACE-Obesity) project. *Int J Obes*. 2006;30:1463–1475.
12. Carter R, Moodie M, Markwick A, Magnus A, Vos T, Swinburn B, Haby M. Assessing Cost-Effectiveness in Obesity (ACE-Obesity): an overview of the ACE approach, economic methods and cost results. *BMC Public Health*. 2009;9:419.
13. Gold MR, Siegel JE, Russell LB, Weinstein MC. *Cost-effectiveness in health and medicine*. New York: Oxford University Press; 1996.
14. Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, et al. Compendium of physical activities: an update of activity codes and MET intensities. *Med Sci Sport Exer.* 2000;32(9, Suppl.):S498–S516.
15. Dale DC, Dale K. Restricting opportunities to be active during school times: do children compensate by increasing physical activity levels after school? *Res Q Exerc Sport*. 2000;71(3):240–248.
16. Michaud-Tomson L, Davidson M. Walk to school—does it make a difference in children's physical activity levels? *ACHPER Healthy Lifestyles J* 2003;50(3.4): 16-24.
17. Cooper A, Page AS, Foster LJ, Qahwaji D. Commuting to school—are children who walk more physically active? *Am J Prev Med*. 2003;25(4):273–276.
18. Swinburn B, Jolley D, Kremer PJ, Salbe A, Ravussin E. Estimating the effects of energy imbalance on changes in body weight in children. *Am J Clin Nutr*. 2006;83:859–863.
19. Australian Bureau of Statistics. *Schools Australia 2001, Cat. No. 4221.0*. Melbourne, Australia: Australian Bureau of Statistics; 2001a.
20. Department of Education, Victoria. *Annual Report 2000-2001*. Melbourne, Australia: Victorian Government; 2002.
21. Australian Bureau of Statistics. *Consumer Price Index, Australia, Cat. No. 6401.0*. Melbourne: Australian Bureau of Statistics; 2004.
22. McLennan W. *Australian Bureau of Statistics, Information Paper. National Nutrition Survey, confidentialised unit record file, 1995*. Canberra: Australian Bureau of Statistics; 1998.
23. Goran MI, Nagy TR, Gower BA, et al. Influence of sex, seasonality, ethnicity and geographic location on the components of total energy expenditure in young children: implications for energy requirements. *Am J Clin Nutr*. 1998;68:675–682.
24. Health Promotion Strategy Unit. *Active for life. Physical activity patterns & health impacts in Victoria*. Melbourne: Public Health & Development Division, Victorian Government Department of Human Services; 1999.
25. VicHealth. *Walking School Bus Snapshot, 8-12 November 2004.* Melbourne: VicHealth; 2004.
26. McMahon T. Size and shape in biology. *Science*. 1973;179(4079):1201–1204.
27. Australian Bureau of Statistics. *Average weekly earnings, Australia Cat. 6302.0, 2001*. Melbourne: Australian Bureau of Statistics; 2001b.
28. McCallum Z, Wake M, Gerner B, et al. Can Australian general practitioners tackle childhood overweight/obesity?—methods and processes from the LEAP randomised controlled trial. *J Paediatr Child Health*. 2005;41:488–494.
29. Tin Tin S, Woodward A, Thornley S, Ameratunga S. Cycling and walking to work in New Zealand 1991-2006: regional and individual differences and pointers to effective interventions. *Int J Behav Nutr Phys Act.* 2009;6(1):4.
30. Moodie M, Haby M, Galvin L, Swinburn B, Carter R. Cost-effectiveness of active transport for primary school children—Walking School Bus program. *Int J Behav Nutr Phys Act.* 2009;6:63.