The Cost Effectiveness of Three Programs to Increase Use of Bicycle Helmets Among Children

EVI J. HATZIANDREU, MD, MPH, DrPH
JEFFREY J. SACKS, MD, MPH
RUTH BROWN, MS, MHSA
WILLIAM R. TAYLOR, MD, MPH
MARK L. ROSENBERG, MD, MPP
JOHN D. GRAHAM, PhD

Dr. Hatziandreu and Ms. Brown are with the Battelle Medical Technology Assessment and Policy Research Center, Arlington, VA. Dr. Hatziandreu is a Senior Policy Analyst and Ms. Brown is a Research Associate. Dr. Sacks, Dr. Taylor, and Dr. Rosenberg are with the Centers for Disease Control and Prevention, Atlanta, GA. Dr. Sacks is a Medical Epidemiologist, Division of Unintentional Injury Prevention and Control, National Center for Injury Prevention and Control (NCIPC), Dr. Rosenberg is Director, NCIPC. Dr. Taylor is a Medical Epidemiologist, Epidemiology Program Office. Dr. Graham is Professor, Department of Health Policy and Management, Harvard University School of Public Health, Boston, MA.

Battelle conducted this study with funds provided by the Centers for Disease Control and Prevention under contract No. 200-88-0644, task 15.

Tearsheet requests to Jeffrey J. Sacks, MD, MPH, National Center for Injury Prevention and Control, Centers for Disease Control and Prevention (K-63), 4770 Buford Highway, NE, Atlanta, GA 30341; tel. 404-488-4652; FAX 404-488-4338.

Synopsis ....

Each year in the United States, 280 children die from bicycle crashes and 144,000 are treated for head injuries from bicycling. Although bicycle helmets reduce the risk of head injury by 85 percent, few children wear them.

To help guide the choice of strategy to promote helmet use among children ages 5 to 16 years, the cost effectiveness of legislative, communitywide, and school-based approaches was assessed. A societal perspective was used, only direct costs were included, and a 4-year period after program startup was examined. National age-specific injury rates and an attributable risk model were used to estimate the expected number of bicycle-related head injuries and deaths in localities with and without a program.

The percentage of children who wore helmets increased from 4 to 47 in the legislative program, from 5 to 33 in the community program, and from 2 to 8 in the school program. Two programs had similar cost effectiveness ratios per head injury avoided. The legislative program had a $36,643 cost and the community-based one, $37,732, while the school-based program had a cost of $144,498 per head injury avoided. The community program obtained its 33 percent usage gradually over the 4 years, while the legislative program resulted in an immediate increase in usage, thus, considering program characteristics and overall results, the legislative program appears to be the most cost-effective. The cost of helmets was the most influential factor on the cost-effectiveness ratio.

The year 2000 health objectives call for use of helmets by 50 percent of bicyclists. Since helmet use in all these programs is less than 50 percent, new or combinations of approaches may be required to achieve the objective.

Bicycle-related head injuries are a serious public health problem in the United States. Each year, more than 280 cyclists younger than age 17 years are fatally injured, and more than 144,000 are treated at emergency departments for bicycle-related head injuries (*1*). Indeed, head injuries are involved in more than two-thirds of all bicycle-related fatalities and one-third of all nonfatal bicycling injuries (*1*). Even survivors of mild and moderate head injuries can have profound, disabling, and long-lasting sequelae (*2,3*).

Bicycle helmets have been shown to reduce the risk of head injury by 85 percent (*4*). Yet, only 1–2 percent of child cyclists use helmets (*5,6*). Increasing the use of helmets is an important step in reducing childhood head injuries and deaths from bicycling. Different strategies have been used to increase helmet use among children, including legislation, communitywide programs, and school-based programs. Although each of these strategies has been tried in different locations, there have been no cost-effectiveness studies comparing them. The objective

Table 1. Population sizes, bicycle helmet use, and expected and prevented bicycle-related head injuries and deaths in three programs

Characteristics	Legislative	Community	School[1]
Children ages 5–16	30,904	219,364	175,160
Preprogram helmet use (percent)	4	5	1.9
Postprogram helmet use (percent).........	47	33.1	7.5
Increase in helmet use (percent)	43	28.1	5.6
Preprogram expected number of cases over 4 years (undiscounted):			
Head injuries	73.71	523.81	408.97
Deaths	0.16	1.15	0.92
Postprogram prevented number of cases over 4 years (undiscounted):			
Head injuries	27.89	130.68	19.79
Deaths	0.06	0.29	0.04

[1]Pilot-study high-intensity intervention adjusted to total county population.

of this study is to provide this comparison for programs targeting children ages 5 to 16 years.

Methods

Through literature searches and interviews with injury researchers, we identified three prototypical programs that had sufficient descriptive detail of program implementation, information to compute program costs, and a measure of helmet use before and after the programs. It should be noted that although we identified many community- and school-based programs, very few had been rigorously evaluated. A brief description of each program follows.

The three programs.

Legislative approach—Howard County, MD. Following the death of two children in bicycling crashes in 1989, parents, teachers, and school children met with county council members to promote mandatory use of helmets. In 1990, a law was passed requiring that bicyclists younger than age 16 wear helmets on all county roads. Police officers visiting the schools for antidrug programs discussed the importance of the new law and encouraged the use of helmets. Some schools held activities promoting bicycle safety and the use of helmets. Thus, this approach was actually a combination of legislation, with waivable fines ranging from $25–100, and some school-based educational activities (*7*). An observational survey conducted before the law took effect found that 4 percent of Howard County child bicyclists were wearing bike helmets; 7 months after the law was enacted, 47 percent were observed wearing helmets (*8*).

Community approach—Seattle, WA. Realizing that very few children wore bicycle helmets, Harborview Hospital staff members formed a coalition that used a multipronged approach to increase helmet use by children between the ages of 5 and 14 (*9–11*). Parental awareness was increased through public service announcements, articles in the local newspapers, and pamphlets available at physicians' offices, hospitals, and public health clinics. Retail stores promoted helmet-wearing, and parent-teacher associations, youth groups, and volunteers from a bicycle club sponsored community events to encourage children to wear helmets. Helmet prices were lowered through coupons, special offers, and contributions by coalition members. A preprogram observational survey in 1987 showed that 5 percent of child cyclists ages 5 to 12 were wearing helmets; in 1988, helmet use had increased to 16 percent; subsequent surveys found 23 percent of children in the same age groups wearing helmets in 1989 and 33 percent in 1990 (*9*).

School-based approach—Oakland County, MI. Six schools in Oakland County participated in a program that targeted children between the ages of 10 and 14. The program, which is no longer operational, included separate brochures aimed at parents and students, posters, public service announcements, discount coupons for helmets, and classroom activities. Three schools conducted high-intensity interventions, with a special assembly on helmet use featuring sports figures and helmet giveaways. The other three schools conducted low-intensity interventions without special assemblies or helmet giveaways. Rather than directly observing helmet use, this program used pre- and postintervention telephone surveys of parents, who reported helmet ownership and use among their children (*12*). One week before the program, 2 percent of bicycle-riding students from the schools with high-intensity interventions reportedly wore bicycle helmets 75 percent or more of the time; 4 weeks after the intervention, this figure was 8 percent. For the schools with low-intensity interventions, the figures were 2 percent before and 3 percent afterwards.

Cost-effectiveness analysis. We focused our cost-effectiveness analysis on 5- to 16-year-olds and considered the cost to society over a 4-year period. Thus, programs were considered fully initiated at startup, with maintenance costs and health benefits accruing over the following 4 years. The cost-effectiveness ratio for each strategy was calculated as follows:

$$C \div E = (C_H + C_P - C_{HC}) \div (E_P - E_{NP})$$

where C = net costs of the program; C_H = cost of bicycle helmets; C_P = other programmatic costs; C_{HC} = the savings in health care expenditures due to prevention of bicycle-related head injury; E = net health effectiveness measure; E_P = health outcome with the program; E_{NP} = health outcome without the program.

Three different health outcomes were examined—head injuries prevented, deaths averted, and years of life saved. Only discounted estimates were used in calculating cost-effectiveness ratios.

Health outcomes. We calculated the expected number of head injuries and deaths from bicycle-related crashes before the intervention by applying U.S. age-specific rates (*1*) to the actual 5- to 16-year-old population distribution for each intervention area (table 1). We calculated the number of injuries and deaths prevented by using the following formula (*13,14*):

$$AC = C \times [P_b \times (RR - 1)] \div [P_b \times (RR - 1 + 1)] \times [1 - (P_f \div P_b)]$$

where AC = avoided cases; C = expected cases, based on U.S. rates; RR = 6.67 increased risk of bicycle-related head injury from not wearing a bicycle helmet during a crash (*4*); P_b = preintervention prevalence of not wearing bicycle helmets (baseline); P_f = post-intervention prevalence of not wearing bicycle helmets (followup).

We assumed a steady rate of effectiveness during the 4-year maintenance period, that is, P_f was constant over the 4 years. To calculate years of life saved, we assumed the average age at death to be 10 years; thus, 65.9 years of life would be saved for each death prevented (*15*). These 65.9 years of additional life were discounted to the present value at a 5-percent discount rate (*16*) for an additional 19.2 years of discounted life expectancy.

Program costs. Program personnel were contacted for information on component activities. Personnel resources included time for staff, volunteers, and others, such as police officers, teachers, and assembly speakers. Materials included printing and mailing costs, public service announcement costs, in-kind contributions, and other relevant items. Costs for evaluation and expanding the program elsewhere were excluded from resource costs.

We valued resources consumed in dollars for the year of expenditure. When available, actual reported costs for materials and staff were used. Printing costs were estimated by a Washington, DC, printer and deflated to the year in which they were incurred. Volunteer time was valued at one-half of the average hourly wage reported by the Bureau of Labor Statistics in unpublished tabulations from the current population survey. If the occupation of the volunteer was known, one-half the average wage of the most closely identified occupation was used. Time for parents and others volunteering for activities like health fairs and rodeos was valued at half the average

Table 2. Cost-effectiveness ratios for the three bicycle helmet programs, with 4 years maintenance[1]

Characteristics	*Legislative*	*Community*	*School*[2]
Startup	$12,744	$79,821	$125,042
Total 4-year maintenance	$28,850	$285,804	$1,772,185
Startup plus 4-year maintenance	$41,594	$365,625	$1,897,227
Helmet purchase (2 buy:1 wear)	$933,100	$4,327,400	$686,000
Total program cost	$974,694	$4,693,025	$2,583,227
Head injuries			
Health care costs avoided	$68,726	$322,012	$48,411
Injuries avoided, discounted over 4 years	24.72	115.84	17.54
Cost per injury avoided[3]	$36,643	$37,732	$144,498
Deaths avoided			
Health care costs avoided for deaths	$805	$3,769	$584
Deaths avoided, discounted over 4 years	0.05	0.25	0.04
Cost per death avoided[4]	$17,935,341	$18,468,909	$65,549,315
Years of life saved			
Not discounted	1.17	5.50	0.85
Discounted over 4 years	1.04	4.87	0.76
Cost per year of life saved, discounted[5]	$934,904	$961,958	$3,417,551

[1]1992 dollars, discounted to present value with 5-percent discount rate.
[2]Pilot program adjusted to total community.
[3]Total program cost minus cost avoided for head injuries divided by total head injuries avoided.
[4]Total program cost minus cost avoided for deaths divided by total deaths avoided.
[5]Total program cost minus cost avoided for deaths divided by years of life saved.

'Through literature searches and interviews with injury researchers, we identified three prototypical programs that had sufficient descriptive detail of program implementation, information to compute program costs, and a measure of helmet use before and after the programs.'

annual wage multiplied by the amount of time. For those instances where helmet use was part of a more general bicycle safety curriculum, we assumed that half of program costs were attributed to helmet promotion.

Costs were classified as fixed and variable and as startup and maintenance. The variable costs, including such expenses as printing and mailing, increase or decrease depending on the size of the target population. Fixed costs, such as production and design of a public service announcement, for example, occur regardless of the target population size. Startup costs occur during program design and early implementation. Maintenance costs are annual expenditures necessary to keep the program running (for example, staff, additional printing, airing public service announcements). Once program expenditures were calculated, they were inflated to 1992 dollars using the general Consumer Price Index (table 2). All costs occurring after startup were discounted to the startup of the program at a rate of 5 percent.

To compare the school-based program with the other two programs, we expanded the coverage to children ages 5 to 16 years and extrapolated variable costs to the whole community of 175,160 children in that age group. Staff and volunteer time were increased twofold, brochure costs were estimated at $1 per child, and assembly costs were scaled to cover 260 schools in the county.

Direct medical costs. The average estimated costs for outpatient treatment of a head injury in 1987 dollars for a 10- to 14-year-old was $249 (*17*). We assumed that 1 out of 10 children treated for head injury on an outpatient basis was hospitalized (*18–20*). Lifetime direct medical care costs in 1985, including expenditures for hospital and nursing home care, physician services, drugs, and other goods and services, were $14,186 for patients hospitalized with head injuries and $9,816 for those who died (*21*). Inflating all these direct medical costs to 1992 dollars resulted in $371 for outpatient treatment of a head injury, $24,458 for treatment in the hospital, and $16,785 for a death from a head injury.

Helmet purchase costs. We assumed that bicycle helmets were purchased at the startup of a program, have a 4-year life, and cost $35. Because not everyone buying a helmet wears it, we further assumed that approximately half of those purchasing helmets wear them frequently enough to be observed (*22,23*). Thus, to achieve an observed 20-percent increase in helmet wearing, there would have to be a 40-percent increase in the purchase of helmets for use by the population in the age group. (For discount coupons for bicycle helmets, only the cost for printing were included in the analysis.)

Sensitivity analysis. Sensitivity analyses were conducted to assess the effects of varying assumptions about (*a*) the costs of helmets purchased and the ratio of wearers to buyers, (*b*) program and health care costs, (*c*) the risk of head injury during a crash for a cyclist not wearing a helmet and the rate of hospitalization after a bicycle-related head injury, (*d*) program effectiveness and steady state assumptions, (*e*) extrapolation of the Oakland program to the county, and (*f*) the discount rate.

Results

The cost of administering the legislative program from startup through 4 years was approximately $1.35 per child; including helmet purchases, total program costs were $31.54 per child (table 2). The corresponding figures for the community program were $1.67 and $21.39 per child. The estimated administrative costs of the pilot school-based program were $164,788 for startup and 4 years of maintenance; as extrapolated to the entire county, the costs were estimated at $10.83 per child for startup and $14.75 per child for total program costs.

The expected number of bicycle-related head injuries among 5- to 16-year-olds in each community during the 4 years was approximately 2,385 per million; the expected number of deaths from bicycle-related head injuries was approximately 5.2 per million (table 1). In Howard County, 902 bicycle-related head injuries per million and 1.9 deaths from bicycle-related head injuries per million were prevented; in King County, 596 injuries per million and 1.3 deaths per million were prevented; and in Oakland County, 113 injuries per million and 0.2 deaths per million were prevented (table 1).

The costs over 4 years of avoiding a bicycle-related head injury range from $36,643 in the legislative program to $144,498 in the school-based program (table 2). The costs of avoiding a death range from $17,935,341 in the legislative program to $65,549,315 in the school-based program. Costs per year of life saved range from $934,904 for the legislative program to $3,417,551 for the school-based program.

Sensitivity analyses. Sensitivity analyses indicate that the cost-effectiveness ratios are fairly stable (table 3). Overall, the legislative program is always more cost effective, although to a varying degree. The cost of avoiding a head injury varied from $17,773 to $76,065 for the legislative program; for the community-based program, it ranged from $19,054 to $77,956. Finally, for the school-based program, the cost of avoiding a head injury varied from $124,945 to $236,430. For each of these programs, the lower bound estimates are achieved, under the observed effectiveness rates, when everybody who buys a helmet wears it, or when helmet costs are reduced by 50 percent to $17.50. In contrast, the cost to avoid a head injury is highest if program effectiveness is reduced by 50 percent for the legislative and community programs, and the low-intensity school-based program is considered.

The base case analysis assumed a steady rate of effectiveness for the 4 years. For the community program, we had data on helmet wearing for each year. We redid the analysis using these data, 16 percent for year one, 22 percent for year two, and 33.1 percent for years three and four (*9*). The cost of avoiding a head injury increased from $37,732 to $51,760.

For the legislative program, we examined two scenarios—rates for wearing helmets (*a*) gradually fell off and (*b*) gradually increased. These scenarios are shown in table 3 under the headings *a* and *b*. First, the 47-percent observed rate of helmet wearing was gradually decreased by arbitrarily chosen rates, and stabilized at 40 percent (year one, 47 percent; year two, 42 percent; year three, 40 percent, year four, 40 percent). Next we assumed a gradual increase to the 47-percent wearing rate (year one, 37 percent; year two, 42 percent; year three, 45 percent; year four, 47 percent). The results for each scenario were almost identical, $41,375 for the first and $41,196 for the second.

In the school-based program, the low-intensity version had the highest increase in the cost-effectiveness ratio per head injury avoided (from $144,489 to $236,430). The remaining sensitivity analyses for the discount rate, health care costs, assumptions regarding program cost estimation, and the risk of head injury, produced cost-effectiveness ratios that fall between these ranges.

Finally, we calculated the total savings in medical care required to offset the cost of implementing each program, including helmet purchase. For the legislative program, the costs avoided would have to be $974,694. For the community program, the respective figure is $4,693,025, and for the school-based program, it is $2,583,227.

Discussion

The overriding cost factor is not the expense of administering a program, but the cost of helmets. Helmets account for more than 90 percent of the total costs of the legislative and community-based programs and for 27 percent of the school-based program costs. In contrast to the legislative and community programs where helmets were purchased by users, the Michigan school-based program purchased a substantial number of helmets. In addition, because the school-based program was less effective, the number of helmets given away (at a heavily discounted price) was nearly sufficient to cover the small increase in helmet wearing, and, therefore, there were fewer helmets purchased at market price than in the other programs. It should be noted that the societal costs of helmets are identical, regardless of whether they are purchased or given away free. In either case, society foregoes labor and materials that could be used in other fruitful endeavors. However, who pays for the helmets may be a critical issue for programs and decision makers.

There are limitations to the analysis that should be considered when interpreting the results. First of all, the specific programs differed methodologically. Baseline helmet use and the targeted age group varied among the communities, as did the time at which postintervention helmet use was evaluated (6 months for the legislative, 3 years for the community, and 3–4 weeks for the school program). Moreover, the types of evaluation were not comparable. Overall, the data for the legislative and community-based programs were more comparable than that for the school-based program, which necessitated extrapolating a small program to an entire county and dramatically expanding the age groups covered.

The analysis also assumed that the observed effectiveness (that is, proportion of children wearing helmets) remained stable for the 4-year period. We know this was not the case in King County, and recent data suggest that helmet use may be decreasing

Table 3. Sensitivity analyses results of three bicycle helmet programs, in 1992 dollars, discounted to present value using 5-percent discount rate

Condition and type of cost	*Legislative*		*Community*	*School*
	Base case			
Cost avoided per head injury prevented	$ 36,643		$ 37,732	$ 144,498
Cost avoided per death prevented	17,935,341		18,468,909	65,549,315
Cost per year of life saved	934,904		961,958	3,417,551
	Helmet purchase and wearing			
33 percent of purchasers wearing:				
Cost avoided per head injury prevented	$ 55,513		$ 56,410	$ 164,051
Cost avoided per death prevented	26,527,416		26,990,769	74,254,892
Cost per year of life saved	1,382,777		1,405,821	3,871,434
100 percent purchasers wearing or $17.50 helmet cost:				
Cost avoided per head injury prevented	17,773		19,054	124,945
Cost avoided per death prevented	9,343,254		9,947,051	56,843,725
Cost per year of life saved	487,030		518,095	2,963,666
$25 helmet cost:				
Cost avoided per head injury prevented	25,860		27,059	133,325
Cost avoided per death prevented	13,025,574		13,599,277	60,574,689
Cost per year of life saved	678,975		708,322	3,158,188
	Health care and program costs			
Including fatal and nonfatal head injury costs:				
Cost per year of life saved	$ 868,929		$ 895,900	$ 3,353,489
Bicycle safety message costs included:				
Cost avoided per head injury prevented	38,325		40,555	0
Cost avoided per death prevented	18,701,338		19,756,827	0
Cost per year of life saved	974,832		1,029,039	0
	Risk of head injury while not wearing a helmet and hospitalization rate			
3.85 increased risk of head injury:				
Cost avoided per head injury prevented	$ 42,697		$ 44,008	$ 166,702
Cost avoided per death prevented	20,811,949		21,336,495	75,078,966
Cost per year of life saved	1,083,787		1,111,028	3,910,837
25-percent hospitalization rate:				
Cost avoided per head injury prevented	33,030		34,119	140,915
Cost avoided per death prevented	17,935,341		18,468,909	65,549,315
Cost per year of life saved	934,904		961,958	3,417,551
	Helmet use rates (program effectiveness)			
Incremental changes:	*a*[1]	*b*[2]		
Cost avoided per head injury prevented	$ 41,375	$ 41,196	$ 51,760	0
Cost avoided per death prevented	$20,123,403	$20,040,675	$4,868,922	0
Cost per year of life saved	$1,047,959	$1,044,031	$1,295,228	0
Decreasing helmet use by 50 percent:				
Cost avoided per head injury prevented	$ 76,065		$ 77,956	0
Cost avoided per death prevented	$36,219,107		$36,851,024	0
Cost per year of life saved	$1,883,058		$1,919,293	0
	School-based program in Oakland County			
Low intensity:				
Cost avoided per head injury prevented	...		...	$ 236,430
Cost avoided per death prevented	...		...	105,043,712
Cost per year of life saved	...		...	5,485,759
Increased helmet giveaway:				
Cost avoided per head injury prevented	...		...	148,529

Condition and type of cost	Legislative	Community	School
	School-based program in Oakland County (continued)		
Increased helmet giveaway (continued):			
Cost avoided per death prevented	...	...	67,343,801
Cost per year of life saved	...	...	3,511,110
50 percent reported helmet wearing as an outcome measure:			
Cost avoided per head injury prevented	...	...	121,132
Cost avoided per death prevented	...	...	55,079,697
Cost per year of life saved	...	...	2,868,734
	Discount rate		
3 percent:			
Cost avoided per head injury prevented	$ 34,751	$ 35,867	$ 137,718
Cost avoided per death prevented	17,115,733	17,622,097	62,533,662
Cost per year of life saved	891,918	917,660	3,260,086
7 percent:			
Cost avoided per head injury prevented	$ 38,491	$ 38,047	$ 151,399
Cost avoided per death prevented	18,801,006	18,468,974	68,687,374
Cost per year of life saved	978,786	1,007,038	3,577,566

[1]First scenario in which helmet use rate gradually fell off. [2]Second scenario in which helmet use rate gradually increased.

in Howard County (*24*). Further, this analysis is based on data from only a single example of each type of intervention, and data for certain aspects of each intervention were lacking. Clearly, the evaluation of effectiveness for each approach could be improved.

We assumed that the risks of bicycle-related head injury are evenly distributed among all bicyclists. However, it is possible that helmet wearing is subject to ''selective recruitment'' (*25*), meaning that it is safer, or more careful, children who adopt the practice. If so, then fewer deaths from bicycle-related head injury may have been prevented than expected, and our study would have overestimated cost effectiveness. If risks are, indeed, greater among children who engage in high-risk behaviors (such as riding against traffic) and if these children are more resistant to wearing helmets, then a program that gets all children to wear helmets may result in more than twice the reduction in deaths from bicycle-related head injuries as a program that achieves a 50-percent use rate. This variability had occurred in motor-vehicle seatbelt programs, which have found that the part of the population most resistant to wearing seatbelts engages in a wide range of high-risk behaviors and has the highest rate of motor vehicle-related injuries (*25–27*). The effect of selective recruitment on bicycle helmet wearing needs further investigation.

Our estimates of the direct costs of fatal and nonfatal head injuries were from a study that used 1985 data and represent the average cost of head injuries from all causes. We therefore did not use costs pertaining specifically to children 5 to 16 years old or to head injuries from bicycle crashes. Indirect costs, reflecting lost productivity due to premature mortality, were not included in our analysis. This type of cost, however, represents the major proportion of the total costs to society. In 1985, total societal costs for head injury were estimated at $37.8 billion ($49.89 billion in 1992 dollars), with indirect costs representing 88 percent of the total (*21*).

It is known that head injuries can result in significant short- and long-term disabilities that include both physical and cognitive handicaps among children. A survivor of a severe brain injury typically faces 5 to 10 years of intensive services (including rehabilitation) at an estimated cost of more than $4 million (*28*). Our analysis indicates that, for a program to become cost saving, the savings in medical care created by reducing head injuries would have to exceed the total costs of the program. Thus, total medical costs averted would have to exceed $974,694 in Howard County, $4,693,025 in Seattle, and $2,583,227 in Oakland County for the programs to be cost saving. A cost-utility analysis may have been more appropriate, since head injuries result in a variety of outcomes—morbidity, mortality, and disability. However, we lacked the necessary data to conduct such an analysis. Therefore, our estimates are probably conservative in that long-term morbidity and disability are not accounted for.

The results of the sensitivity analyses show significant decreases in the cost-effectiveness ratios

'Overall, the legislative program appears to be the most cost-effective, the community-based intervention slightly less cost effective, and the school-based intervention considerably less cost-effective.'

However, a recently reported study of a school-based promotion in Montgomery County, MD, found that importance of activities to increase the proportion of helmet purchasers who actually wear their helmets and to lower helmet costs.

Overall, the legislative program appears to be the most cost-effective, the community-based intervention slightly less cost effective, and the school-based intervention considerably less cost effective. Moreover, the effect occurs most quickly with the legislative approach. One type of "cost," however, that is part of the legislative but not of the other approaches and was not captured in our analysis is the intangible cost of the legal liability placed on parents. We also did not consider the cost of enforcement; unenforced laws may, indeed, be cheap and decrease effectiveness. The Howard County law was proposed and ultimately was effective because of the community's response to the tragic deaths of two children, and its success may not be realized as easily elsewhere. On the other hand, the demonstrated effectiveness of this approach may encourage passage of legislation elsewhere.

Although the community-based intervention initially appears marginally less cost effective than the legislative program, it becomes clearly less cost effective when the observed gradual increase in effectiveness (over the first 3 years) is considered. It is also likely that the program cost may be higher, since some of the volunteered time may not have been accounted for. Further, a communitywide program is much more labor intensive than a legislative program.

The apparent cost ineffectiveness of the school program is mostly a function of the small increase in helmet use; extrapolating this program to the entire county magnified this relationship. Despite our findings, the school-based approach may not be as cost-ineffective as it appears. In a recent Canadian study (*29*), preintervention observations for a school-based program showed a 3-percent usage rate, and postintervention use was 16 percent; in high-income areas, helmet use went from 3 percent to 36 percent. when helmet costs decrease or when everybody who buys a helmet wears it. This finding underscores the use went from 8 percent to 13 percent, while a nearby control county saw use go from 7 percent to 11 percent (*24*).

It is important to place these cost-effectiveness ratios into perspective. Childhood use of bicycle helmets is less cost effective than the use of motorcycle helmets ($3,675 per year of life saved) yet more cost effective than rear-seat shoulder belts in passenger cars ($4.4 million per year of life saved) (*30*).

Currently, at the national level, the proportion of children wearing bicycle helmets is minimal (*5,6*). The year 2000 health objectives for the nation call for an increase in these rates to 50 percent (*31*). Since helmet use from all the programs we evaluated fall short of 50 percent, new approaches or combinations of approaches may be required to achieve the year 2000 objectives.

In Victoria, Australia, after 10 years of a multipronged communitywide program, a law requiring all bicyclists to wear helmets went into effect in July 1990. Observed helmet use went from 15 percent in 1985 to 31 percent just before the law was enacted and then climbed to 75 percent after enactment (*32*). Similar combined approaches may hold great promise for increasing bicycle helmet use in the United States. Ultimately, the most effective approach may well include a combination of school-based, community, and legislative components (*33*).

References

1. Sacks, J. J., Holmgreen, P., Smith, S. M., and Sosin, D. M.: Bicycle-associated head injuries and deaths in the United States from 1984 through 1988. JAMA 266: 3016–3018, Dec. 4, 1991.
2. Rimel, R. W., et al.: Disability caused by minor head injury. Neurosurgery 9: 221–228 (1981).
3. Rimel, R. W., et al.: Moderate head injury: completing the clinical spectrum of brain trauma. Neurosurgery 11: 344–351 (1982).
4. Thompson, R. S., Rivara, F. P., and Thompson, D. C.: A case-control study of the effectiveness of bicycle safety helmets. N Engl J Med 320: 1361–1367, May 25, 1989.
5. Weiss, B. D.: Trends in bicycle helmet use by children: 1985-1990. Pediatrics 89: 78–80 (1992).
6. Behaviors related to unintentional and intentional injuries among high school students—United States, 1991. MMWR Morbid Mortal Wkly Rep 41: 760–772, Oct. 16, 1992.
7. Scheidt, P. C.: Bicycle helmet law for children: a case study of activism in injury control. Pediatrics 89: 1248–1250 (1992).
8. Coté, T. R, et al.: The effect of legislation and education on bicycle helmet use among Maryland children. Pediatrics 89: 1216–1220 (1992).

9. Rogers, L. W., Bergman, A. B., and Rivara, F. P.: Promoting bicycle helmets to children: a campaign that worked. J Musculoskeletal Med 8: 64–77 (1991).
10. DiGuiseppi, C. G., Rivara, F. P., Koepsell, T. D., and Polissar, L.: Bicycle helmet use by children—evaluation of a community-wide helmet campaign. JAMA 262: 2256–2261, Oct. 27, 1989.
11. Bergman, A. B., Rivara, F. P., Richards, D. D., and Rogers, L. W.: The Seattle children's bicycle helmet campaign. Am J Dis Child 144: 727–731 (1990).
12. Smith, P. R.: Increasing bicycle helmet use in Michigan—a school-based intervention pilot program evaluation report. Michigan Bicycle Helmet Advisory Committee, March 1991.
13. Rothman, K.: Modern epidemiology. Little Brown & Co., Boston, 1986, pp. 38–39.
14. A framework for assessing the effectiveness of disease and injury prevention. MMWR Morbid Mortal Wkly Rep 41 (supp): 1–12, Mar. 27, 1992.
15. Vital statistics of U.S. expectations of life and expected deaths. National Center for Health Statistics, Hyattsville, MD, 1991.
16. Weinstein, M. C., and Fineberg, H. V.: Clinical decision analysis. W. B. Saunders Co., Philadelphia, 1980.
17. Malek, M., Chang, B-H., Gallagher, S. S., and Guyer, B.: The cost of medical care for injuries to children. Ann Emerg Med 20: 997–1005 (1991).
18. Gallagher, S. S., Finison, K., Guyer, B., and Goodenough, S.: The incidence of injuries among 87,000 Massachusetts children and adolescents: results of the 1980-81 statewide childhood injury prevention program surveillance system. Am J Public Health 74: 1340–1347 (1984).
19. Bjoinstig, U., and Vaslund, K.: Pedal cycling accidents—mechanisms and consequences. Acta Chir Scand 150: 353–359 (1984).
20. Bicycle-related injuries: data from the national electronic surveillance system. MMWR Morbid Mortal Wkly Rep 36: 269–271, May 8, 1987.
21. Max, W., MacKenzie, E. J., and Rice, D. P.: Head injuries: costs and consequences. J Head Trauma Rehabil 6: 76–91 (1991).
22. DiGuiseppi, C. G., Rivara, F. P., and Koepsell, T. D.: Attitudes toward bicycle helmet ownership and use by school-age children. Am J Dis Child 144: 83–86 (1990).
23. Towner, P., and Marvel, K.: A school-based intervention to increase the use of bicycle helmets. Fam Med 24: 156–158 (1992).
24. Dannenberg, A. L., et al.: Bicycle helmet laws and educational campaigns: an evaluation of strategies to increase helmet use. Am J Public Health 83: 667–674 (1993).
25. Evans, L.: Restraint-use laws, use rates, and field effectiveness. *In* Traffic, safety and the driver. Van Nostrand-Reinhold, New York, 1991, pp. 251–281.
26. Chorba, T. L.: Assessing technologies for preventing injuries in motor vehicle crashes. Int J Technol Assess Health Care 7: 296–314 (1991).
27. Hunter, W. W., Stewart, J. R., Stutts, J. C., and Rodgman, E. A.: Observed and self-reported seat belt wearing as related to prior traffic accidents and convictions. Accid Anal Prev 25: 545–554 (1993).
28. National Institute of Neurological Disorders and Stroke: Report of the Interagency Head Injury Task Force. National Institutes of Health, Bethesda, MD, 1989.
29. Parkin, P. C., et al.: Evaluation of a promotional strategy to increase bicycle helmet use by children. Pediatrics 91: 772–776 (1993).
30. Tengs, T. O., et al.: Five hundred life-saving interventions and their cost-effectiveness. Risk Anal. In press.
31. Public Health Service: Healthy people 2000: national health promotion and disease prevention objectives. DHHS Publication No. (PHS) 91-50212. U.S. Government Printing Office, Washington, DC, 1991.
32. Vulcan, A. P., Cameron, M. H., and Heiman, L.: Mandatory bicycle helmet use—Victoria, Australia. MMWR Morbid Mortal Wkly Rep 42: 359–363, May 14, 1993.
33. Bader, M.: Helmets for child bicyclists. JAMA 263: 1914–1915, Apr. 11, 1990.