ARTICLE

Cost-effectiveness of a School-Based Tobacco-Use Prevention Program

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Objective: To determine the cost-effectiveness of a school-based tobacco-use prevention program.

Design: Using data from the previously reported 2-year efficacy study of the Project Toward No Tobacco Use (TNT), we conducted a decision analysis to determine the cost-effectiveness of TNT. The benefits measured were life years (LYs) saved, quality-adjusted life years (QALYs) saved, and medical care costs saved, discounted at 3%. The costs measured were program costs. We quantified TNT's cost-effectiveness as cost per LY saved and cost per QALY saved.

Intervention: A 10-lesson curriculum designed to counteract social influences and misconceptions that lead to tobacco use was delivered by trained health educators to a cohort of 1234 seventh-grade students in 8 junior high schools. A 2-lesson booster session was delivered to the eighth-grade students in the second year. The efficacy evaluation was based on 770 ninth-grade students who participated in the program in the seventh and eighth grades and in both the baseline and the 2-year follow-up survey.

Results: Under base case assumptions, at an intervention cost of $16 403, TNT prevented an estimated 34.9 students from becoming established smokers. As a result, we could expect a saving of $13 316 per LY saved and a saving of $8482 per QALY saved. Results showed TNT to be cost saving over a reasonable range of model parameter estimates.

Conclusions: The TNT is highly cost-effective compared with other widely accepted prevention interventions. School-based prevention programs of this type warrant careful consideration by policy makers and program planners.

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TOBACCO USE is widely acknowledged to be the leading cause of preventable death in the United States.[1] Approximately 434 000 Americans die each year as a result of smoking; these deaths have been associated with more than 5 million years of potential life lost.[2] Direct medical costs attributable to smoking total at least $50 billion per year.[3] Because most daily smokers (82%) begin smoking before age 18 years and more than 3000 young people become regular smokers each day,[4] school programs designed to prevent tobacco use have been identified as one of the most effective strategies available to reduce tobacco use in the United States.[5,6] In the past decade, numerous school-based primary prevention programs to reduce tobacco use among youth have been developed and implemented across the United States. These programs can be an effective means of preventing tobacco use among youth, especially those programs that focus on counteracting the social influences that may facilitate adolescent tobacco use.[7-11]

While the behavior-change effectiveness of selected school-based tobacco-use prevention programs has been established,[12-14] no studies, to our knowledge, have examined their cost-effectiveness. Because resources to fund school-based tobacco-use prevention programs are limited, determining that a program is effective may not be adequate to justify its implementation. Issues of practical concern to policy makers and program planners are cost (ie, whether they can afford a particular prevention program) and cost-effectiveness (ie, whether the effects of a program justify the cost of its implementation).

The objective of this study is to use economic evaluation techniques to determine the cost-effectiveness of the Project Toward No Tobacco Use (TNT), a school-based education program designed to prevent tobacco use among junior and se-

SUBJECTS AND METHODS

Because program selection decisions often are made in the interest of society as a whole, we conducted this study from a societal perspective, which considers everyone affected by the intervention and counts the most significant health outcomes and costs that are attributable to the intervention. We used standard methods of cost-effectiveness analysis and measured benefits in terms of life years (LYs) saved, quality-adjusted life years (QALYs) saved, and lifetime medical costs saved, discounted at a 3% annual rate as recommended by the Panel on Cost-effectiveness in Health and Medicine.[16] Program costs incurred during the 2-year implementation were included as intervention costs. All costs were in 1990 dollars to correspond with the timing of the intervention. The cost-effectiveness of TNT was compared with the control scenario and was assessed in terms of cost per LY saved and cost per QALY saved.

Although nonsmokers generally have longer life expectancies than smokers, no study to our knowledge has examined the impact of primary smoking prevention on life expectancy. To overcome the gaps in existing research, we used an intermediate outcome measure—number of established smokers prevented. We first translated the relative reduction in trial cigarette use and weekly cigarette use into the number of established smokers prevented and then translated the number of established smokers prevented into LYs saved and QALYs saved. To our knowledge, our study is the first that used such translations.

The base-case analysis was conducted in 5 steps: (1) a retrospective estimation of the intervention cost, (2) an estimation of the number of students prevented from becoming established smokers by age 26 years, (3) an estimation of the number of LYs saved and QALYs saved by the intervention, (4) an estimation of the lifetime medical care costs saved by the intervention, and (5) a calculation of the cost-effectiveness of the intervention. We conducted multivariate and univariate sensitivity analyses to determine the robustness of the base-case analysis and identify the parameters that had the most influence on the results.

INTERVENTION COST

We estimated the direct costs of program delivery (**Table 1**) incurred in the combined intervention, including the cost of training of health educators, the cost of teaching students, and the cost of materials used. In the trial study, 8 schools were assigned to each of the 4 curricula. Nine health educators received 3 weeks of training (120 hours) at an hourly rate of $10 before delivering the curriculum. A master trainer charged $500 per day for conducting the training, or $56 per health educator trained. On the basis of the total number of students who received 1 of the 4 interventions (5263) and the number of students who received the combined intervention (1234), we estimated that 2 health educators would actually be needed for the combined intervention only. During the first year of implementation, the 10-lesson combined curriculum was delivered to 45 classes of seventh-grade students with an average of 5.6 classes per school. Each health educator taught in 4 schools during an 8-week period, 2 weeks for each school. During the second year, 2-lesson booster sessions were delivered to the eighth-grade students at each school. The health educators worked 8 hours a day (5-6 hours of teaching and 2-3 hours of preparation) at an hourly rate of $10. Each health educator received a copy of the teacher manual, which cost $45, and each student received a copy of a student guide book, which cost $3.69.

ESTABLISHED SMOKERS PREVENTED

As shown in the **Figure**, we developed a smoking progression model to estimate the number of students (of the 770 total participants) who would become established smokers by age 26 years in the intervention scenario and in the control scenario. At the 2-year follow-up, the 770 students were divided into nonsmokers (ever smoked <1 cigarette), experimenters (ever smoked ≥ 1 but <100 cigarettes), and established smokers (ever smoked ≥ 100 cigarettes).

Because the students were young adolescents (average age, 14 years), we considered the likelihood that some current nonsmokers or experimenters would become established smokers in the future by using the natural history information reported by Pierce et al[17] on smoking behavior in a national sample of 4500 adolescents aged 12 to 18 years who at baseline reported never having taken a puff from a cigarette. Pierce et al[17] reported the probabilities of smoking progression over a 4-year time period by smoking behavior (experimentation with smoking and established smoking) and by baseline age. To use their estimates in our study, we modeled the smoking progression of nonsmokers and experimenters over three 4-year age periods: ages 14 to 18, 18 to 22, and 22 to 26 years. We assumed that initiation of established smoking ends after age 26 years, since most established smokers started smoking before age 18 years.

Using this model, we first calculated the probability of a 14-year-old experimenter becoming an established smoker by age 26 years (X_e) and the probability of a 14-year-old nonsmoker becoming an established smoker by age 26 years (X_n). We then estimated the total number of established smokers to be expected in the intervention scenario (Y_i), the total number of established smokers to be expected in the control scenario (Y_c), and the total number of students who will be prevented from becoming established smokers by the intervention (Y):

$$(1)\quad X_e = C_1 + (1 - C_1)C_2 + (1 - C_1)(1 - C_2)C_3$$

$$(2)\quad X_n = B_1 + (A_1 - B_1)C_2 + (A_1 - B_1)(1 - C_2)C_3 + (1 - A_1)[B_2 + (A_2 - B_2)C_3 + (1 - A_2)B_3]$$

$$(3)\quad Y_i = N[Q_i + (P_i - Q_i)X_e + (1 - P_i)X_n]$$

$$(4)\quad Y_c = N[Q_c + 2\% + (P_c - Q_c)X_e + (1 - P_c - 2\%)X_n]$$

$$(5)\quad Y = Y_c - Y_i$$

where C_1, C_2, and C_3 are the probabilities of an experimenter becoming an established smoker during each of the three 4-year periods. A_1 and A_2 are the probabilities of a nonsmoker initiating smoking during each of the first two 4-year periods. B_1, B_2, and B_3 are the probabilities of a nonsmoker becoming an established smoker during each of the three 4-year periods. P is the percentage of students who had initiated smoking by the 2-year follow-up; P_i, the percentage in the intervention scenario; P_c, the percentage in the control scenario; and $P_c + 2\%$, the adjusted percentage in the control scenario (2% representing

the adjustment for the baseline difference between the intervention and control group). Q is the percentage of students who had become established smokers by the 2-year follow-up; Q_i, the percentage in the intervention scenario; Q_c, the percentage in the control scenario; and Q_c + 2%, the adjusted percentage in the control scenario (2% representing the adjustment for the baseline difference between the intervention and control group). The values and sources of each of these parameters are listed in **Table 2**.

Because no published study is available on the probability of experimenters becoming established smokers, we made assumptions for each 4-year period. Because experimenters already had shown interest in smoking, we assumed that the probability of an experimenter becoming an established smoker during each age interval was 2 times the probability of a nonsmoker becoming an established smoker.

LYs AND QALYs SAVED

To translate the number of established smokers prevented into the number of LYs saved, we used estimates of life expectancies derived by Rogers and Powell-Griner[18] based on data from the National Health Interview Survey and the National Mortality Followback Survey. These estimates were reported by age and sex for those who had never smoked ("never smokers"), former smokers, and current smokers in the United States in 1986. Never smokers included nonsmokers and experimenters, and current smokers were further divided into light smokers (smoked $<$25 cigarettes per day) and heavy smokers (smoked $\geq$25 cigarettes per day). On the basis of their life table values for smoking status for the 25- to 29-year-old age group, we estimated the distribution of each type of smoker. As given in **Table 3**, of all smokers in the 25- to 29-year-old age group, 31.7% were former smokers, 52.3% were light smokers, and 16% were heavy smokers.

We also estimated the LYs saved by preventing a never smoker from becoming a smoker by comparing the life expectancy of each type of smoker with that of a never smoker. The life expectancy of a never smoker is 2 years longer than that of a former smoker, 3.5 years longer than that of a light smoker, and 14.2 years longer than that of a heavy smoker. When we discounted those LYs at an annual rate of 3%, we estimated an average gain of 0.26 discounted LYs for a former smoker prevented, 0.47 discounted LYs for a light smoker prevented, and 2.13 discounted LYs for a heavy smoker prevented. Thus, for each established smoker prevented, the weighted average of discounted LYs saved is 0.67 ($31.7\% \times 0.26 + 52.3\% \times 0.47 + 16\% \times 2.13$). We calculated the total number of discounted LYs saved by the intervention by multiplying the number of discounted LYs saved per established smoker prevented by the number of established smokers prevented.

To further convert discounted LYs saved into discounted QALYs saved, we used published estimates from the study by Cromwell et al.[19] In their study, 1.31 LYs saved per quitter was estimated as 2.34 QALYs saved for men aged 25 to 29 years, and 1.43 LYs saved was estimated as 1.94 QALYs saved for women aged 25 to 29 years. Using these estimates, we calculated that a weighted average of 1.57 QALYs saved was equivalent to 1 LY saved.

MEDICAL COSTS SAVED BY THE INTERVENTION

To estimate the medical costs saved by the intervention, we needed to know the lifetime medical expenditure associated with becoming a smoker vs not becoming a smoker. Hodgson's study[20] of the lifetime cost of smoking-related illness had the most suitable estimates for this study. Hodgson used data on the use and costs of medical care and on mortality during each age interval in cross sections of the US population to generate profiles of lifetime health care costs beginning at age 17 years. The profiles, estimated for men and women by age and amount smoked, included the costs of inpatient hospital care, physician services, and nursing home care. Over a lifetime an average male smoker spent $8638 more than a never smoker for medical care and an average female smoker spent $10 119 more (1990 US $ discounted at 3%).

Based on Hodgson's estimates, the average expected lifetime medical care costs associated with becoming a smoker were $9379 more than those of not becoming a smoker. We calculated the total medical costs averted by the intervention as the number of established smokers prevented multiplied by the expected lifetime excess medical care costs per smoker.

COST-EFFECTIVENESS OF THE INTERVENTION

We calculated the cost-effectiveness ratio as the net cost per LY saved and the net cost per QALY saved. We calculated the net cost by subtracting medical care costs from intervention costs. Most published cost-effectiveness studies of smoking cessation programs for adults do not include medical care cost savings resulting from smoking cessation. Thus, to make our results comparable with these published results, we recalculated the cost-effectiveness of TNT by excluding the medical care costs savings resulting from the intervention.

SENSITIVITY ANALYSES

Because the model parameters depended largely on estimates from single studies, we examined the cost-effectiveness ratios for both high and low values of each key parameter in the analysis. Using multivariate and univariate sensitivity analyses to test the robustness of our base-case results and identify parameters that had the most influence on results, we examined 12 key parameters: the hourly pay per health educator, the medical care costs, and the 10 parameters (P_c, Q_c, A_1, A_2, B_1, B_2, B_3, C_1, C_2, C_3) that were used to estimate the number of established smokers prevented as presented in Table 2.

We conducted multivariate sensitivity analyses through 2 steps. First, we performed a computer simulation using SAS (SAS Institute, Cary, NC) to estimate the most and the fewest number of established smokers prevented by varying the values of each of the 10 key parameters over a reasonable range. Parameter values for each simulation trial were selected randomly from the 2 bound values of each parameter. As given in Table 2, for 6 of those parameters (P_c, Q_c, A_1, A_2, B_1, B_2), we assumed that the estimates were normally distributed and used a 95% confidence interval to determine a plausible range for variation. Because no data were available for the other 4 parameters (B_3, C_1, C_2, C_3), we based the lower- and upper-bound estimates on assumptions.

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Then we estimated the best- and worse-case cost-effectiveness scenarios by varying the estimates of 3 parameters: the number of established smokers prevented, intervention costs, and medical care costs. Because the hourly pay per health educator in a real-world scenario could be very different from the actual trial scenario, we altered the intervention costs from $16 403 to $36 563 by increasing the hourly pay per health educator from $10 to $30. Although Hodgson's study[20] assessed the medical cost impact of becoming a smoker vs not becoming a smoker, it did not control for other differences between smokers and never smokers besides smoking that affect medical costs. According to a research reported by Manning et al,[21] when other lifestyle choices are controlled, excess lifetime medical costs of smokers compared with nonsmoking smokers (people who are like smokers in age, sex, education, drinking habits, and several other ways, except that they have never smoked) is 87% of the excess lifetime costs of smokers compared with never smokers. For sensitivity analyses, we used Hodgson's estimate of $9379 as our upper-bound estimate and used an estimate of $8160 (87% of $9379) as our lower-bound estimate. To test the sensitivity of the results to the uncertainty in individual parameters, we conducted univariate sensitivity analysis on 1 parameter at a time.

nior high school students. The TNT is a comprehensive social skills program comprising activities that counteract normative and informational social influences to use tobacco and misconceptions about the physical consequences of tobacco use. The program teaches refusal skills, awareness of social misperceptions about tobacco use, and misconceptions about physical consequences.

An efficacy evaluation of TNT[11] was implemented during the 1989-1990 and 1990-1991 school years. Although this efficacy study seems somewhat dated, we chose to use TNT in our cost-effectiveness study for 3 main reasons: (1) economic evaluations of behavioral interventions usually are conducted on the basis of results from efficacy or effectiveness studies, and most of the rigorously evaluated school-based tobacco-use prevention programs, including TNT, were implemented during the late 1980s and early 1990s[12]; (2) the Centers for Disease Control and Prevention, Atlanta, Ga, has identified TNT as a Program That Works on the basis of credible evidence of its efficacy in reducing tobacco use among youth; and (3) TNT has been chosen as a model program by the Center for Substance Abuse Prevention.

The efficacy evaluation was designed to test the effectiveness of 3 separate social influence curricula (a physical consequences curriculum, an informational social influence curriculum, and a normative social influence curriculum) and a fourth combined-strategy curriculum. Forty-eight junior high schools in southern California were assigned randomly to 1 of the 4 curricula or to a "usual care" curriculum. (A detailed description of the efficacy study design, including the randomization process, is provided elsewhere.[15])

Table 1. Intervention Costs*

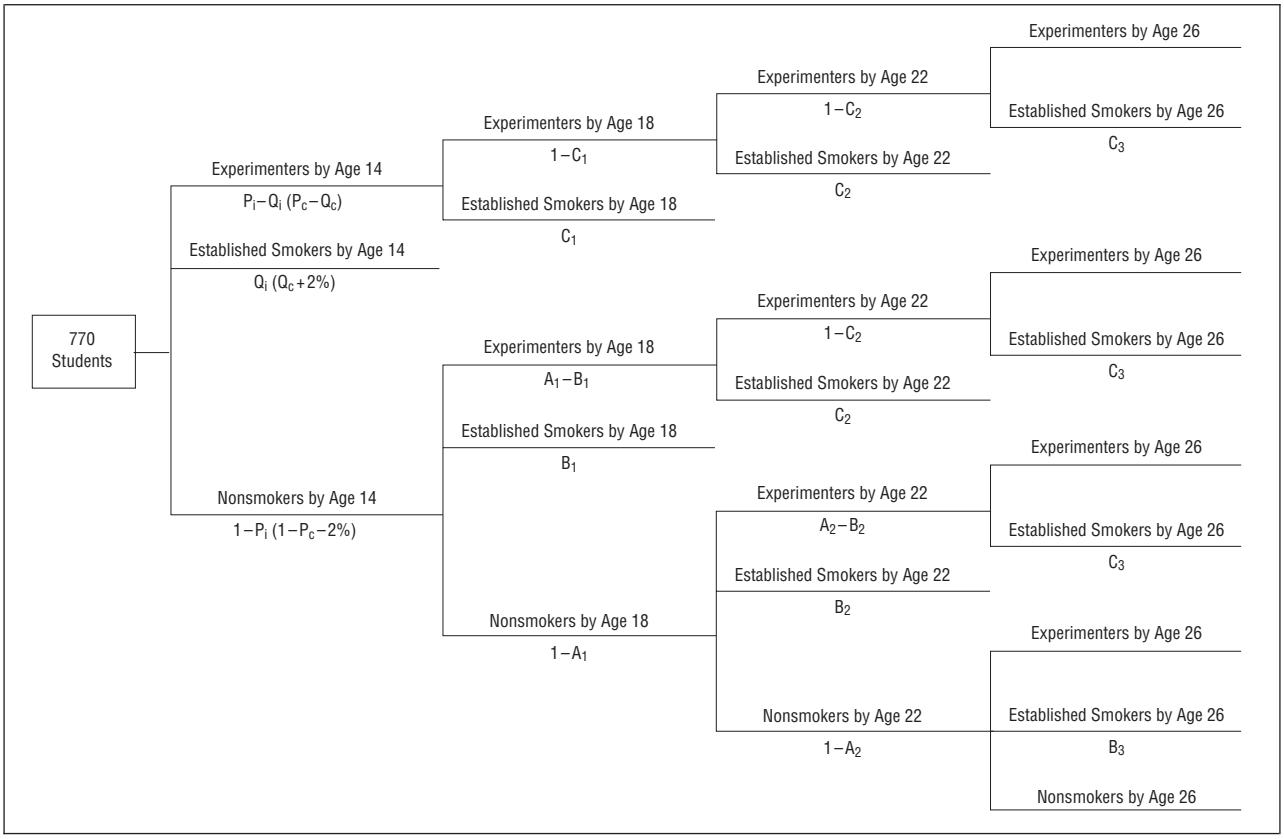
Intervention	Cost, $
Training of health educators	
2 Health educators received $10/h for 15 d (120 h) of training	2 × $10/h × 120 h = 2400
2 Health educators received the training at a fee of $56/d for 15 d (120 h) of training	2 × $56/d × 15 d = 1680
Subtotal	4080
Teaching	
2 Health educators taught at 4 schools each for 10 d (80 h) for $10/h	2 × 4 × 80 h × $10/h = 6400
2 Health educators taught 2-d (16-h) booster sessions at 4 schools each for $10/h	2 × 4 × 16 h × $10/h = 1280
Subtotal	7680
Materials	
2 Teacher manuals at $45 per manual	90
1234 Student manuals at $3.69 per manual	4553
Subtotal	4643
Total	**16 403**

*Values provided by the Project Toward No Tobacco Use evaluation study group.

The 10-lesson curricula were first delivered to a cohort of seventh-grade students in 1989, and a 2-lesson booster session was given to the eighth-grade cohort the following year. The baseline data were collected from 6716 seventh-grade students; 50% of the students were boys; 60%, white; 27%, Hispanic; 7%, black; and 6%, Asian or "other." Two-year follow-up data were collected from 7219 ninth-grade students, 65% of whom reported attending a junior high school at which TNT curricula were offered 2 years earlier. The outcome variables tested were changes in trial and weekly cigarette and smokeless tobacco use 2 years after the intervention.

Results of the 2-year follow-up study showed that each single-strategy curriculum was effective only on trial tobacco use but that the combined-strategy curriculum was effective on both trial and weekly tobacco use. On the basis of these findings, the combined intervention program has since been disseminated. Thus, we used the combined intervention for our economic analyses. The efficacy study showed that TNT was effective in preventing both cigarette use and smokeless tobacco use. We focused our study on the prevention of cigarette smoking because there are more detailed descriptions of mortality directly associated with cigarette smoking than with smokeless tobacco use.

Of a cohort of 1234 seventh-grade students who participated in the combined intervention, 770 participated in the 2-year follow-up survey as ninth-graders. Of 1956 students recruited as a control group, 1565 were surveyed at the 2-year follow-up. During the 2 years, trial cigarette use among students participating in the combined intervention increased from 37% to 53%, and weekly use increased from 6% to 10%. Among students in the control group, trial cigarette use increased



Smoking progression model. Parameters in parentheses indicate control scenario. All ages are given in years.

from 35% to 58%, and weekly cigarette use increased from 4% to 13%. There was no difference in effectiveness by gender.

RESULTS

Table 4 displays the results from both the base-case analysis and the multivariate sensitivity analyses. Under base-case assumptions, at an intervention cost of $16 403 ($13.29 per student), we estimated that the combined intervention would prevent 34.9 students from becoming established smokers. As a result, society could expect to save $327 140 in medical care costs and a total of 23.3 discounted LYs and a total of 36.6 discounted QALYs. This translated to a cost-saving of $13 316 per LY saved and a cost-saving of $8482 per QALY saved. When we excluded the medical care costs from the analyses, we estimated that the intervention would cost $703 per LY saved and $448 per QALY saved.

On the basis of 1024 simulation trials in the first step of the multivariate sensitivity analyses, we estimated that the number of established smokers prevented would range from 19.7 to 51.0. From the second step of the multivariate sensitivity analyses, we estimated that the cost-savings would range from $9427 to $13 539 per LY saved and from $6004 to $8623 per QALY saved. When medical care costs were excluded from the cost-effectiveness calculation, the estimated cost-effectiveness of the intervention ranged from $481 to $2770 per LY saved and $306 to$1764 per QALY saved. These results demonstrated that the cost-effectiveness ratios were robust over a reasonable range of 12 parameter estimates. The intervention can thus be expected to yield net benefits to society under all scenarios considered.

Table 5 presents the results of the univariate analysis for each of the 12 key parameters. The estimate of the cost-effectiveness ratios was relatively insensitive to the uncertainty in individual parameters. The one exception was the effect of the estimate of the percentage of weekly cigarette users in the control group. For that parameter, the cost-effectiveness ratios varied from a cost-savings of $18 729 to $10 326 per LY saved. Such results indicate that the prevalence rate of established smoking has the most influence on the cost-effectiveness results, which warrants careful examination by researchers in future evaluation studies.

COMMENT

This study had some clear limitations. First, the study was retrospective, so costs were estimated rather than prospectively measured. Second, the number of established smokers prevented was modeled rather than directly measured. Third, only one source of data was available for the probabilities of smoking progression by nonsmokers; therefore, we had to use 95% confidence interval estimates for sensitivity analyses. Fourth, no data were available in the literature to describe the probabilities of experimenters becoming established smokers, so we had to make assumptions for each age interval. Fifth, because there are no data to suggest that never smokers in the intervention condition are either less or more likely

Table 2. Data Used to Estimate the Number of Established Smokers Prevented

Parameter Definition	Symbol	Base Case	Range, %	Sources
Intervention students, No.	N	770	. . .*	Rundall and Bruvold[7]
Students who had initiated smoking by age 14 y, intervention group, %	P_i	53.0	. . .	Rundall and Bruvold[7]
Students who had initiated smoking by age 14 y, control group, %	P_c	58.0	55.5-60.5†	Rundall and Bruvold[7]
Students who had become weekly smokers by age 14 y, intervention group, %	Q_i	10.0	. . .	Rundall and Bruvold[7]
Students who had become weekly smokers by age 14 y, control group, %	Q_c	13.0	11.3-14.7†	Rundall and Bruvold[7]
Nonsmokers at age 14 y who initiate smoking by age 18 y, %	A_1	41.4	37.9-45.1†	Bruvold[8]
Nonsmokers at age 18 y who initiate smoking by age 22 y, %	A_2	35.5	30.7-40.4†	Bruvold[8]
Nonsmokers at age 14 y who become established smokers by age 18 y, %	B_1	8.1	6.2-10.3†	Bruvold[8]
Nonsmokers at age 18 y who become established smokers by age 22 y, %	B_2	3.0	1.6-5.2*	Bruvold[8]
Nonsmokers at age 22 y who become established smokers by age 26 y, %	B_3	1.0	0.5-1.5	Assumption
Experimenters at age 14 y who become established smokers by age 18 y, %	C_1	16.2	8.1-24.3	Assumption
Experimenters at age 18 y who become established smokers by age 22 y, %	C_2	6.0	3.0-9.0	Assumption
Experimenters at age 22 y who become established smokers by age 26 y, %	C_3	2.0	1.0-3.0	Assumption

*Ellipses indicate not applicable.
†95% Confidence interval of the base-case value.

Table 3. Data Used to Estimate LYs* Saved (Discounted at 3%)

Parameters	Former Smokers Prevented	Light Smokers Prevented	Heavy Smokers Prevented	Sources
Distribution of smokers, %	31.70	52.30	16.00	Rooney[9]
LYs saved per smoker prevented	2.01	3.55	14.17	Rooney[9]
Discounted (3%) LYs saved per smoker prevented	0.26	0.47	2.13	Authors' calculation

*LYs indicates life years.

Table 4. Results From Base-Case and Multivariate Sensitivity Analyses*

Parameters	Base Case	Worst Case	Best Case
Intervention cost, $	16 403.00	36 563.00	16 403.00
Established smokers prevented, No.	34.9	19.7	51.0
Medical care cost saved, $	327 139.50	160 991.50	478 329.00
Discounted LYs saved	23.3	13.2	34.1
Discounted QALYs saved	36.6	20.7	53.6
Cost per LY saved, $	−13 316.50	−9426.80	−13 538.70
Cost per QALY saved, $	−8481.80	−6004.40	−8623.40
Cost per LY saved (excluding medical care costs saved), $	702.90	2770.10	480.80
Cost per QALY saved (excluding medical care costs saved), $	447.70	1764.40	306.20

*LY indicates life year; and QALY, quality-adjusted life year.

to initiate smoking than never smokers in the control condition, we used an average transition probability for the population as a whole for the behavior of those who have been in the trial. Sixth, we did not consider the continued effectiveness of TNT past the 2-year intervention, nor the effectiveness of TNT on reducing smokeless tobacco use. However, exclusion of those effectiveness measures should yield conservative estimates of the cost-effectiveness of TNT. Seventh, we did not fully account for all the costs of smoking to society, such as passive smoking, smoking-related fires, and maternal smoking on the health, birth outcomes, and long-term growth of infants. However, inclusion of the other costs in our study could only improve the cost-effectiveness of the TNT program and will not affect the general conclusions of this study.

Even with these limitations, we have been cautious in our approach and have carefully examined the robustness of our results. The sensitivity analyses indicated that the results are generally robust with respect to most of the key sources of uncertainty in the analysis. It is justifiable to conclude that TNT is both cost-effective and cost saving under all scenarios considered.

The cost-effectiveness of this primary prevention intervention are even more impressive when compared with results of studies of some widely accepted secondary prevention interventions such as breast cancer screening or cervical cancer screening. For example, routine screening for cervical cancer with Papanicolaou testing for all women aged 15 to 74 years was estimated to cost $22 000 (in 1996 dollars) for every year of life saved, and annual breast cancer screening for women age 50 to 69 years was estimated to cost $46 000 (in 1996 dollars) for every year of life saved.[22] When compared with smoking cessation programs for adults, the cost-effectiveness of TNT is still attractive. The cost-effectiveness ratios of $481 to $2770 per LY saved (excluding medical costs) are generally consistent with those of most smoking cessation programs and, in some cases, more cost-effective. For example, the cost-effectiveness ratio of physicians' smoking cessation counseling was found to range from $705 to $2058 (in 1984 dollars, or $1074-$3136 in 1990 dollars) per LY saved[23]; the cost-effectiveness ratio of nicotine gum as an adjunct to physician's advice was found to range

Table 5. Univariate Sensitivity Analysis

Parameter, %	Symbol	Base Case	Estimated Range*	No. of Established Smokers Prevented		Cost-effectiveness Ratios	
				Lower	Upper	Lower	Upper
Students who had initiated smoking by age 14 y; control group	P_c	58	55.5-60.5*	33.0	36.7	–14 062.3	–12 649.2
Students who had become weekly smokers by age 14 y; control group	Q_c	13	11.3-14.7*	24.8	45.0	–18 729.0	–10 326.3
Nonsmokers at age 14 y who initiate smoking by age 18 y	A_1	41	37.9-45.1*	34.8	34.9	–13 347.1	–13 293.6
Nonsmokers at age 18 y who initiate smoking by age 22 y	A_2	36	30.7-40.4*	34.9	34.9	–13 324.1	–13 312.6
Nonsmokers at age 14 y who become established smokers by age 18 y	B_1	8	6.2-10.3*	33.8	35.8	–13 750.1	–12 970.6
Nonsmokers at age 18 y who become established smokers by age 22 y	B_2	3	1.6-5.2*	34.2	35.3	–13 585.2	–13 154.3
Nonsmokers at age 22 y who become established smokers by age 26 y	B_3	1	0.5-1.5	34.8	35.0	–13 358.6	–13 278.4
Experimenters at age 14 y who become established smokers by age 18 y	C_1	16	8.1-24.3	33.7	36.0	–13 770.5	–12 895.0
Experimenters at age 18 y who become established smokers by age 22 y	C_2	6	3.0-9.0	34.7	35.0	–13 374.0	–13 263.2
Experimenters at age 22 y who become established smokers by age 26 y	C_3	2	1.0-3.0	34.7	35.0	–13 374.0	–13 259.4
Hourly pay per health educator, $	H	10.00	10.00-30.00	34.9	34.9	–13 316.5	–12 452.5
Excess medical care cost per smoker, $	M	9379.00	8160.00-9379.00	34.9	34.9	–13 316.5	–11 494.4

*95% Confidence interval of the base-case value.

from $4113 to $9473 (in 1984 dollars, or $6268-$14436 in 1990 dollars) per LY saved[24]; and the cost-effectiveness ratio of the nicotine patch with brief physician counseling was found to range from $965 to $2360 (in 1995 dollars, or $712-$1742 in 1990 dollars) per LY saved.[25]

The results of this study suggest that school-based tobacco-use prevention programs can be delivered at a reasonable cost and can be highly cost-effective and cost-saving. Primary prevention programs of this type warrant careful consideration by policy makers and program planners when resource allocation and curriculum decisions are made. The findings of this study also suggest that a school-based primary prevention intervention can be as cost-effective as secondary prevention interventions, such as tobacco-use cessation programs for adults. To reduce overall tobacco use, we recommend increasing investment in primary prevention programs for youth. With increased funding for tobacco-use prevention as a result of state settlements with tobacco companies, policy makers should expand school-based primary prevention programs as part of comprehensive tobacco control programs to significantly reduce the adverse health outcomes of smoking in our society.

Over the past decades, economic evaluation research has focused on smoking cessation programs for adult smokers. As more school-based smoking prevention programs demonstrate effectiveness in preventing tobacco use, it will be increasingly important to study their cost-effectiveness so that policy makers and school health administrators can look beyond program effectiveness in making decisions. To improve future analyses and to help these leaders make more informed choices about the prevention of tobacco use among adolescents, we recommend additional research into the stages of smoking establishment from adolescence to adulthood, the medical costs of treating smoking-related diseases, and the life expectancy of smokers and nonsmokers. Researchers should routinely include program cost data in their program evaluations so that more economic evaluations of school-based tobacco-use prevention programs can be conducted.

What This Study Adds

In the past decade, numerous school-based primary prevention programs to reduce tobacco use among youth have been developed and implemented across the United States. Research studies have shown that school-based social influences curricula are effective in preventing tobacco use among youth. While the behavior-change effectiveness of selected school-based tobacco-use prevention programs has been established, no studies have examined their cost-effectiveness.

School-based tobacco-use prevention programs can be delivered at a reasonable cost and can be highly cost-effective and cost saving. Primary prevention programs of this type warrant careful consideration by policy makers and program planners when resource allocation and curriculum decisions are made. With increased funding for tobacco-use prevention as a result of state settlements with tobacco companies, policy makers should expand school-based primary prevention programs as part of comprehensive tobacco control programs to considerably reduce the adverse health outcomes of smoking in our society.

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