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Original Research

Do school-based tobacco prevention programmes pay off? The cost-effectiveness of the 'Smoke-free Class Competition'

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Summary *Objective:* The objective of this study was to determine the cost-effectiveness of a school-based tobacco prevention programme.
Study design: Using data from a previous effectiveness study of the 'Smoke-free Class Competition' (SFC), an economic analysis was conducted to determine the cost-effectiveness of the SFC. Cost data were collected from financial statements of the operating agency, surveys of regional co-ordinators and participating classes (direct and productivity costs). The benefit was the product of the number of students prevented from becoming established smokers, based on a stochastic progression model extending the programme's outcome evaluation, and the (direct and indirect) value per prevented smoker.
Intervention: To take part in the SFC, classes make the decision to be a non-smoking class for 6 months (from autumn to spring). The pupils themselves and their teachers monitor the smoking status of the pupils and report on it regularly. Classes that refrain from smoking can win a number of attractive prizes. In the school year 2001/2002, 150,566 German students participated in the SFC, representing approximately 4% of the total target population of 11–14-year-old German students. The effectiveness evaluation is based on 2,142 students who participated in the programme in the school year 1998/1999.
Results: In the school year 2001/2002, it is estimated that the SFC prevented 3,076 students from becoming established smokers, with net benefits of 5.59 Mio. Euro (direct net benefits) and 15.00 Mio. Euro (total net benefits). The direct benefit/cost ratio was 8.2 and the total benefit/cost ratio was 3.6.
Conclusions: Data suggest that the SFC is a cost-effective school-based intervention.

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Introduction

Smoking is a risk factor for mortality from several medical causes.[1] It is estimated that in 2000, 4.83 million premature deaths in the world were attributable to smoking,[2] and current global patterns of youth smoking suggest little abatement of cigarette use.[3] The prevalence of smoking in Germany is approximately 37% for adult men and 28% for adult women.[4] Of particular concern is the high prevalence of smoking in German children and adolescents.[5]

There is a strong positive correlation between starting to experiment with smoking at an early age and the probability of becoming a regular smoker.[6] Therefore, great hope is placed on primary prevention. In the past decades, numerous school-based primary prevention programmes aiming to reduce tobacco use among young people have been developed and implemented. These programmes can be an effective means of preventing tobacco use among adolescents, especially programmes that aim to counteract the social influences that may facilitate tobacco use by adolescents.[7]

As resources to fund school-based smoking prevention programmes are limited, determining that a programme is effective may not be sufficient to justify its implementation. To date, few studies have examined the cost-effectiveness of school-based smoking prevention programmes.[8–10] The objective of this study is to determine the cost-effectiveness of the 'Smoke-free Class Competition' (SFC). The SFC is a school-based smoking prevention programme, currently implemented in 20 European countries, with a participation rate of approximately 750,000 students in the school year 2006/2007.

The aim of the SFC is to re-inforce non-smoking behaviour. Non-smokers are rewarded if they stay smoke-free.[11] In this way, non-smoking becomes a popular and worthwhile behaviour, and social norms within the peer groups are influenced in a way that non-smoking remains more common in classes than smoking. The general rules are as follows: (a) classes make the decision to be a non-smoking class for 6 months (from autumn to spring); (b) the pupils themselves and their teachers monitor the smoking status of the pupils and report on it regularly; and (c) regular smoking is not accepted. Classes that refrain from smoking can win a number of attractive prizes, with the main prize being a trip to another European country. A detailed description of the intervention is published elsewhere.[12]

Two controlled and two randomized controlled studies with a total number of 12,812 adolescents have been performed to evaluate the intervention. These studies were carried out in Finland, Germany and the Netherlands.[13–17] An overall analysis of these four studies showed that from baseline to follow-up 12–24 months later, smoking increased by 21.78% in the control group compared with an increase of 16.02% in the intervention group. At follow-up, 27.57% of the pupils from the intervention group and 35.91% of the pupils from the control group were smokers [odds ratio (OR) 1.61; 95% confidence interval (CI) 1.43–1.81; $P<0.001$].[18]

The effectiveness study carried out in Germany,[17] which was reviewed by an expert in the field,[19] was of particular interest for the present study. In order to evaluate the effectiveness of the SFC, a sample of 131 participating and non-participating classes ($n = 2{,}142$ pupils, mean age 12.9 years, standard deviation 0.98) was compared with regard to their smoking behaviour. Smoking status (4-week prevalence) was assessed on three occasions: (a) before the competition; (b) 1 month after the competition; and (c) 1 year after the start of the competition. From pre-test to post-test, smoking increased by 7.5% in the comparison group and decreased by 0.2% in the intervention group (OR 2.19; 95% CI 1.69–2.85; $P<0.001$). At follow-up, a clear increase in smoking prevalence was seen in both groups; however, the increase in smoking was significantly lower for pupils in the intervention group (OR 1.45; 95% CI 1.15–1.82; $P<0.01$).

The following limitations of this study should be noted: (a) classes in the experimental group were pre-selected in two German cities (Hamburg and Berlin), while the classes in the control group were chosen at random from a different city (Hanover); (b) at 1 year follow-up, there was 53% attrition in the intervention group and 45% attrition in the control group (total n at baseline = 4372); and (c) 16.2% of the retention sample and 21.5% of the attrition sample were 4-week smokers (OR 1.42; 95% CI 1.21–1.67; $P<0.001$). However, no significant interaction could be found for smoking status and group condition (OR 0.93; 95% CI 0.78–1.10; P = n.s.).

The present study adds to the literature on the cost-effectiveness of school-based smoking prevention programmes using actual, rather than modelled, cost data from an established (real-world) large-scale prevention programme.

Methods

The cost/benefit analysis was performed in three basic steps adapted from an earlier cost-effectiveness study.[10] Based on the outcome evaluation

data,[17] (a) a smoking progression model was used to estimate the number of students who were prevented from becoming established smokers; (b) the average societal cost saved per smoker avoided was applied to the number of smokers prevented to obtain the benefit valuation; and (c) the cost data of the programme were collected and compared against the benefit.

The study was designed in accordance with a set of generally accepted recommendations for health economic evaluations in Germany[20] and was conducted from a societal perspective.[21] The hypothesis that the benefits of the programme are exceeded by its costs was tested against a reference alternative of foregoing the programme.

The baseline year was 2001/2002. In total, 5,791 classes and approximately 150,566 students took part in the SFC in 2001/2002 in Germany, representing approximately 4% of the total target population of 11–14-year-old German students.[22] An annual discount rate of 5% was used and alternative discount rates of 0%, 3% and 10% were tested in the sensitivity analysis. The indirect costs were relatively large in comparison with the direct costs. Significant opportunity costs existed in terms of the programme cost (foregone classroom time) and the benefit (foregone labour productivity of smokers), so cost/benefit analyses are reported separately for direct and total (direct and indirect) data. Univariate and multivariate sensitivity analyses were conducted to determine the stability of the results and to identify the relative importance of the parameters.

Number of smokers prevented

Firstly, the number of students who were prevented from becoming established smokers by follow-up was modelled. Next, a progression model was applied to estimate how many students had been prevented from becoming lifetime established smokers. The concept of a hypothetical control group (equal in size and initial smoker proportions to the experimental group, but not undergoing the intervention) was utilized in the first step. Sample size ($n = 1{,}495$) and pre-intervention proportions of 4-weekly and daily smokers were taken from the experimental group in the outcome evaluation.[17] The higher smoker proportions in the control group at follow-up, reduced by the difference in smoker proportions before the test, were applied to the hypothetical control group. The number of students who were prevented from becoming established smokers at follow-up was the difference between the number of smokers in the experimental and hypothetical control groups. As such, 43.6 daily smokers and 63.5 monthly smokers were prevented at the time of follow-up.

With regard to the prevention of lifetime established smokers, two alternative approaches were taken. First, the progression model of Wang et al.[10] was applied, which provides estimates of the smoking propensity of 26 year olds based on their status (established smoker, experimenter and non-smoker) in the ninth grade. The prevalences of Wiborg and Hanewinkel[17] were translated into those of Wang et al.[10] Applying the progressions to the three student groups at follow-up, 38.9 (2.6%) students would have been prevented from becoming established smokers by 26 years of age. A second, more conservative set of assumptions was used as a benchmark. Paavola et al.[23] reported the respective progression rates of weekly smokers and non-smokers at 15 years of age to smokers or non-smokers at 28 years of age. The application of these progression data led to an estimate that 27.3 (1.8%) students were prevented from becoming weekly smokers.

Since most smoking-related health risks decrease after cessation, a further assumption was introduced. Based on a German survey,[24] current smoker cessation rates for 10-year age intervals could be estimated. The reduction of the relative risk for lung cancer by age of cessation[25] was used as a proxy for the post-cessation reduction in smoking-related health risk. By multiplying the cessation rates with the respective discounted risk reductions for each age group, the number of prevented smokers was estimated to be reduced by 7.9%. The average of the two progression models, reduced by the cessation effect, was used as the base for the proportion of programme participants who would be prevented from becoming established smokers.

Cost per prevented smoker

The benefit of a prevented smoker equals the lifetime excess cost (relative to a non-smoker) that could be avoided through prevention. Two prevalence studies of tobacco-related costs were available, and both estimated the total annual cost of cigarette smoking in Germany. The respective values were 17.28 bn Euro for 1993[26] and 16.6 bn Euro for 1996.[27] Both figures account for direct health-related costs as well as the indirect costs of foregone labour productivity based on the human capital method.

To obtain the lifetime incidence cost per smoker, the prevalence values were transformed into incidence values and foreign cost data were used

as comparables. The estimated direct and indirect costs from the two German studies were averaged. The direct costs were divided by the number of smokers and the indirect costs were divided by the number of smokers in the working population. Assumptions regarding onset (age 30 years) and cessation (direct costs: age 81 years; indirect costs: age 65 years) and an exponential annual cost increase were applied.[28] Finally, the annual costs were discounted and totalled.

Programme cost

Cost information was collected for the 2001/2002 competition from the operating agency of the SFC in Germany (IFT-Nord, Kiel, Germany). Three separate areas of analysis corresponded to the levels of programme activity: the central agency managing the SFC; regional or local health-, education- or drug-related government offices serving as co-ordinators for states or regions; and the schools and students participating in the SFC.

The cost information from the operating agency was based on detailed reporting extracted from the agency's accounting system and verified through in-depth discussions with employees. The main expense categories were personnel, travel, programme materials and overhead expenses. Personnel expenses consisted of salaries, payroll taxes, insurance and other related expenses, attributed on a *per diem* basis based on the employees' time sheets. Travel and subsistence as well as material expenses, such as printing and postage, were accounted on a per invoice basis. Overhead expenses included office, facilities and depreciation expenses and were estimated based on the share of overall expenses.

Questionnaires were sent to all contact people in order to collect the cost information from the regional partners. Thirteen questionnaires were returned, representing nine out of 16 participating regions and 57.9% of participating classes. The respondents were asked to identify the number of days that they and other people had invested in the programme over the period, the travel- and event-related expenses, and the value of the prizes as well as other expenses. The reported days were multiplied by the standard civil service daily rate.[29] The median cost per class was applied to the classes that were not represented by responses.

At class level, direct costs and productivity costs of classroom time were measured. Both were estimated based on a 2003 survey of all teachers ($n = 219$) in the German state of Saxony who participated in the SFC. One hundred and sixty-one teachers responded to a questionnaire covering various aspects of the programme. Direct costs were monthly reporting to the organizing agency and materials used for side projects. Based on the survey responses, costs were estimated for materials, postage and communication expenses, and a lump sum of various other expenses.

A matrix of duration estimates for three types of class activities (discussion of decision to participate, weekly class discussions, ancillary activities) and three types of classes (completed competition successfully, dropped out during the competition, considered but decided against participation) was generated. While the estimated duration of the weekly class discussions was taken directly from the above survey, additional base case, minimum and maximum estimates were made. The resulting time investment ranged from 0.8 h for classes who decided against participation to 7.8 h for classes who completed the competition. As a proxy for the productivity costs of classroom time, the cost of the teacher as well as the school administration and infrastructure was applied.[30] Total productivity costs were the product of the number of class hours and the cost per class hour. To obtain the total cost per class hour, an estimate of the cost per class and year[29] was divided by the average number of school hours per year.[31]

Results

Smokers prevented

It was calculated that 2.04% of programme participants would be prevented from becoming established smokers. When applied to the 150,566 participants in the 2001/2002 school year, this indicated that 3,076 students were prevented from becoming established smokers.

Sensitivity analyses were performed on a number of parameters: a 95% CI around the proportions; a 10% variance of the cessation rate; the alternative progressions from Wang et al.[10] and Paavola et al.[23] rather than the average; and the percentages of the most extreme variances in the number of smokers prevented in Wang et al.[10] With a variance of 17.4% of smokers prevented, the selection of the progression model displayed the strongest sensitivity. The variances in Wang et al.[10] indicated sensitivity of 4.0%, while sensitivities of the other parameters remained below 2%.

Benefit per prevented smoker

The benefit per prevented smoker equals the sums of the discounted annual costs over the period. The

direct benefit was 2,068 Euro, the indirect benefit was 4,718 Euro, and the total benefit was 6,786 Euro. The sensitivity of the results to all assumptions that were introduced was tested. Alternative ages for cost initiation (25 and 35 years) and indirect cost termination (60 and 70 years) as well as alternative distributions (first year values of 50 and 150) were tested. This resulted in cost variances ranging from −9.7% (steeper increase of costs towards end of lifetime) to +9.8% (cost initiation at 25 years of age) of benefit per prevented smoker. Not surprisingly, the model displayed the greatest sensitivity to alternative discount rates, with total cost range of 871% (0% discount rate) and −85.3% (10% discount rate).

Programme cost

The total cost for the programme agency was 276,102 Euro. Materials and personnel were the largest expense categories, with respective shares of 57% and 34%. The lack of detailed 'real-life' cost data in other studies justifies a listing of expenses by category in Table 1.

Table 1 Costs for the programme agency for the 2001/2002 competition (in Euro).

Personnel expenses		
Management and programme development	22,716	
Programme operations	54,446	
Information technology/ website	10,905	
Financial and staff administration	7,179	
Total		95,246
Travel expenses		
Transportation	3,827	
Per diems	4,676	
Total		8,503
Materials		
Print products	86,710	
Packaging	4,086	
Postage	49,244	
Prizes/give-aways	17,451	
Total		157,491
Programme administration		
Facilities	6,451	
Attributable overheads	4,080	
Depreciation	3,000	
Other	1,332	
Total		14,863
Total costs		276,103

The total cost for the regional partners was 451,098 Euro, with personnel (265,445 Euro), prizes (68,772 Euro) and events (52,060 Euro) representing the largest expense categories. At school level, direct costs totalled 44,855 Euro. At 5.10 Mio. Euro, the productivity costs were the single largest cost. The resulting total costs were 0.77 Mio. Euro excluding productivity costs and 5.87 Mio. Euro including productivity costs (Table 2).

In the sensitivity analysis, inclusion of the programme agency's marginal activities was tested. At regional partner level, sensitivity analyses for the following assumptions were conducted: that agencies who did not respond had not produced any costs; that the responding agencies underestimated costs at local level by 10%; and a CI around the median applied to the non-responding classes. Since the 99% CI only produced the base variable, a confidence band of an increase/decrease of 10% was used. At school level, a 95% CI around the cost of materials was tested. Alternative duration estimates were based on minimum and maximum estimates for the class's decision to participate, as well as the 99% CI for class discussions and activities. The most significant variances of total cost were 8.3% (duration of the weekly class discussions) and 3.6% (duration of decision to participate). All other variances remained below 2.5%.

Overall results

The net benefit of the programme was 5.59 Mio. Euro for the direct cost and benefit calculation and 15.00 Mio. Euro for the total sum. The direct benefit/cost ratio was 8.2 and the total benefit/cost ratio was 3.6 (Table 3).

In addition to the above sensitivity analyses, overall univariate and multivariate sensitivity analyses were performed. In the univariate sensitivity analysis, the values at which costs would exceed benefits for the three main variables were determined. The benefits would have to be reduced

Table 2 Total programme cost for 2001/2002 competition (in Euro).

Programme agency	276,103	
Regional partners	451,098	
Schools (direct costs)	44,855	
Total direct costs		772,056
Schools (productivity costs)	5,099,638	
Total costs (direct and indirect)		5,871,694

Table 3 Costs and benefits of the programme.

		Unit	Direct costs and benefits	Total costs and benefits
(a)	Benefit per prevented smoker	Euro	2,068	6,786
(b)	Number of prevented smokers	*n*	3,076	3,076
(c)	Total benefit = (*a*)*(*b*)	Euro	6,361,181	20,872,001
(d)	Programme cost	Euro	772,055	5,871,694
(e)	Net benefit = (*c*)−(*d*)	Euro	5,589,126	15,000,308
(f)	Benefit/cost ratio = (*c*)/(*d*)	*f*	8.2	3.6

by 88% and 72% or costs increased by 724% and 255%, respectively, to change the overall result. All of the above singular sensitivity analysis values were applied to the overall result one by one. Only one scenario (a discount rate of 10%) changed the overall assessment that benefits exceed costs.

For multivariate analysis, a Monte Carlo analysis in 10,000 cycles was performed on the model using Crystal Ball 2000 (Decisioneering Inc.). Each variable addressed in the univariate sensitivity analysis was replaced with an appropriate triangular or normal distribution. The resulting net benefits averaged 5,769,124 Euro, with a standard deviation of 545,083 Euro. The upper and lower bounds of the 95% CI were 5,758,438 Euro and 5,779,808 Euro, respectively.

Discussion

The present study adds to the published literature regarding the cost-effectiveness of school-based smoking prevention programmes. It applied actual, rather than modelled, cost data from an established (real-world) large-scale prevention programme. It was calculated that 2.04% of programme participants would be prevented from becoming established smokers. When applied to the 150,566 SFC participants in the 2001/2002 school year, this led to an estimate that 3,076 students were prevented from becoming established smokers, providing net benefits of 5.59 Mio. Euro (direct values) and 15.00 Mio. Euro (total values). The direct benefit/cost ratio was 8.2 and the total benefit/cost ratio was 3.6.

Comparisons with similar studies support the overall conclusion that the results are plausible, as the benefits are relatively low and the costs are relatively high. There may be multiple causes for this difference, which may be related to the programme itself or the methods and assumptions applied here. The point, from the perspective of plausibility, is that the valuations do not appear grossly out of bounds.

The estimated smoking preventative effect size of 2.04% is relatively conservative. Other estimates range around 4%,[8] and the progression model of Wang et al.[10] shows an effect of 4.5%. The excess cost per smoker varies considerably in published studies,[8,28,32–35] ranging from −15,708[34] to +84,477 Euro.[33] Although the figure in the present study is a gross figure that does not account for the smoker's shorter average life, it is lower than the four cost point estimates with positive values. The best-established comparable figure was reported by Hodgson, where the average excess medical costs of a smoker compared with a non-smoker were US$ 9,379 in 1990.[32]

The costs of the programme are 5.13 Euro (direct costs) and 39.00 Euro (total costs) per student. This compares against a range of 13.74[10] to 138.51 Euro[30] in five comparable studies. A benchmark is possible of the overall result with two studies.[8,10] These studies show net benefits per programme participant of 260 and 328 Euro, while the present study shows 37 Euro and 100 Euro for direct and total benefits, respectively. These studies show benefit/cost ratios of 19.9 and 15.4, both of which are larger than that found in the present study.

Limitations of the study

This economic evaluation has a number of clear limitations. First, it was based on an outcome evaluation that only extended for 6 months after completion of the programme. Second, smoking progression was modelled, rather than measured, using an average of two different progression assumptions. Third, the state-of-the-art methods and estimates for smoker costs are still rather crude. Fourth, the transfer from prevalence to incidence costs introduced additional unverifiable assumptions. Fifth, gross, rather than net, smoking cost was applied. Sixth, different time periods for programme cost and outcome evaluation were combined.

A further limitation of the study was that the cost-effectiveness analysis was based on an

intervention in a single school year. Due to the young age of the participants, repeated participation in older grades is possible as well as participation in other school-based smoking prevention interventions. This would have an impact on cost-effectiveness.

Conclusion

A number of factors justify the overall conclusion that the SFC is cost-effective. There was a wide margin of difference between the cost and benefit figures, care was taken to use empirical data wherever available, valuations were made as conservatively as possible, the result remained stable throughout the sensitivity analysis, and the results appear modest in comparison with other studies.

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Competing interests
None.

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