Cost-effectiveness analyses of health promotion programs: a case study of smoking prevention and cessation among Dutch students

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Abstract

Little research has been done to connect health promotion programs to outcomes in terms of life expectancy, health care costs and cost-effectiveness. For a policy maker, economic evaluation may be an important tool to support decisions on how to allocate the health care budget. The aim of this paper was to determine the cost-effectiveness of a Dutch school-based smoking education program. The incremental cost-effectiveness ratio of the school program was estimated at €19,900 per quality adjusted life year gained. For a complete analysis, not only intervention costs but also savings for smoking-related diseases and differences in total health care costs should be taken into account. As several assumptions had to be made in order to estimate cost-effectiveness, the study outcomes should be interpreted with caution. Main problem in estimating the cost-effectiveness was the lack of proper effectiveness data on daily smokers among adolescents. Absence of specific effectiveness data often is an obstacle in the economic evaluation of public health interventions. While some problems may be the result of insufficient sample size or follow-up, another possible explanation might be the different basic principles of analysis of health promoters and economists.

Introduction

The World Health Organization defines health promotion as the process of enabling people to increase control over the determinants of health and thereby improve their health [1]. In the United States, health promotion is commonly referred to as health education. The aim of both health promotion and health education is to have people adopt healthier lifestyles resulting in longer and healthier lives. As smoking is a leading cause of preventable morbidity and mortality, educating adolescents about the risks of smoking is a classic example of health education [2].

Interventions targeted at preventing smoking have a great potential impact in improving public health for three reasons. First, the majority of smokers started smoking under the age of 20. Among the adult (ex-) smokers, 89% report that they tried their first cigarette before the age of 18 [3]. Second, among those who try to quit smoking, 70–75% will start again [4]. As it is so difficult to quit smoking, targeting at prevention of smoking initiation in young people may be a wise approach. Third, the risk of mortality among 45- to 54-year-old smokers is almost twice as high in persons who started smoking before the age of 15, compared with persons who started after the age of 25 [5].

Although this is all common knowledge, little research has been done to connect health promotion programs targeted at smoking to outcomes in terms
of life expectancy, health care costs and cost-effectiveness. For policy makers, the economic evaluation of interventions may be an important tool in the decision-making process of allocating health care budgets. Unfortunately, there is a lack of information on the economic aspects of health-promoting programs in general and of smoking prevention in particular. The aim of a project described by Rush et al. [6] was to compile a census of the evidence on the economic efficiency of health-promoting interventions. The census provided a simple count and classification of the available evidence on the economic efficiency of population health interventions published between 1990 and 2001. The authors concluded that the economic evidence was concentrated in a few established areas of health promotion practice such as lifestyle interventions and vaccinations. Little was known about the cost-effectiveness of social interventions in schools, despite the influence of school climate on child and adolescent health [7]. Rush et al. [6] recommended researchers to perform primary economic evaluations of health-promoting interventions, especially those based in schools.

In order to fill this gap, the aim of this study was to determine the cost-effectiveness of a health education program in schools to prevent or stop smoking in adolescents.

In the next section, we first describe the methods used. In the following sections, after a short description of the specific study results, we will discuss the results and the problems that may occur.

Methods

Description of the health promotion program

Dijkstra et al. [8] studied the effectiveness of implementing a school program based on a social influence approach and boosters. Fifty-one classes of 32 schools were offered the social influence approach (SI program) and 67 classes of 20 schools served as control (control group). Approximately half of the SI group received in addition boosters in the form of special magazines [8]. The SI+ booster program consisted of five weekly peer-led lessons of 45 min each in small groups of four or five eighth grade students. The peer-leader was a non-smoking student from the same class [8]. The costs of the SI+ booster program were estimated at €75, per participant as calculated in Table I. For calculating the intervention costs, resource use (volumes) and unit prices of these resources were determined. Details about the resource use and the content of the intervention were retrieved from the article. When the information was not available, assumptions were made. Subsequently, resource use was multiplied by unit costs as recommended by Oostenbrink et al. [9]. Unit costs were estimated when not available.

Effectiveness of the health promotion program

The effectiveness of the health promotion program was evaluated on the basis of the outcome measure ‘experimental’ (not regular) smoking, as assessed by the question ‘Have you smoked during the last month?’. After 12 months, the number of smokers had increased with 5.6% in the intervention group versus 12.6% in the control group. So the intervention resulted in 7% fewer experimental smokers after 1 year. After 18 months, the number of smokers in the intervention group had increased with 9.7 versus 14.9% in the control group [8]. However, a problem emerges if we try to estimate long-run health gains of the intervention since reductions in daily smoking result in most health gain. Especially, since not all experimental smokers are or become ‘daily’ smokers. Moreover, prevalences of smoking differ depending on the type of smoking status that is measured, i.e. daily smoking or experimental smoking. In 2004, 22% of Dutch adolescents aged 14 indicated that they had smoked during the last month while 10% indicated to smoke daily. Thus, it was estimated that ~45% of all experimental smokers aged 14 are daily smokers. To what extent the intervention affected daily smoking is not known as it was not assessed. However, reductions in daily smoking result in most health gains. It cannot be excluded that the intervention
only reduced the proportion of experimental smokers (who, maybe, would never become daily smokers) without any effect on daily smokers. But it could also be the case that, on the contrary, it were especially the daily smokers among the experimental smokers who were most affected.

To estimate the effects of the school intervention, we used computer simulation to model the life courses of a hypothetical cohort for different scenarios. The cohort consisted of 500 boys and 500 girls aged 14. To extrapolate the effectiveness of the school interventions, we made different assumptions regarding the effect of the intervention. In our base case estimate of cost-effectiveness, we assumed that the intervention is equally effective in discouraging daily smoking as in discouraging experimental smoking. We estimated that in a cohort of 1000 adolescents aged 14, only some 100 would smoke daily.

Cost-effectiveness analysis

Once the effectiveness of a health-promoting intervention has been shown, its costs and how these costs relate to the effectiveness can be analyzed using methods of economic evaluation. A choice can be made between a cost-minimization analysis, a cost-effectiveness analysis, a cost-utility analysis or a cost-benefit analysis [10]. In economic evaluation studies, health gains due to an intervention are related to its costs. Results of such studies are expressed in cost-effectiveness ratios. The ratios can be computed by dividing the additional costs resulting from the intervention by health gains due to the intervention. The intervention with the lowest cost-effectiveness ratio is, by definition, the most cost-effective intervention, and offers the most value for money.

To estimate cost-effectiveness of tobacco control policies, first, effects on the number of smokers have to be determined. In turn, these need to be translated into long-term effects on health and health care costs. In our study, we have included all related and unrelated future health care costs and effects. It has been argued convincingly that such a comprehensive approach is the most appropriate from the point of view of rational decision making [11]. This means that effects and costs of diseases due to longer life [life years gained (LYG)] were included as well. The cost-effectiveness analysis was performed from a health care perspective. It concentrated on effects of interventions on health and health care costs and compared these with intervention costs.

Table I. Resource use and costs of SI+ booster program (2004 €)

<table>
<thead>
<tr>
<th>Resource use</th>
<th>Unit costs</th>
<th>Costs per participant</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>225 min time teacher</td>
<td>€1.02 per minute</td>
<td>€230/4, 5 = €51</td>
<td>Five lessons times 45 min (groups of 4, 5 participants)</td>
</tr>
<tr>
<td>60 min time teacher</td>
<td>€1.02 per minute</td>
<td>€60/60 = €1</td>
<td>60 min training teachers (groups of 2 times 30 persons)</td>
</tr>
<tr>
<td>60 min time health educator</td>
<td>€1.07 per minute</td>
<td>€64/60 = €1</td>
<td>To train teachers (groups of 2 × 30 persons)</td>
</tr>
<tr>
<td>One manual per student</td>
<td>€12.65 per manual</td>
<td>€12.65</td>
<td>Assumed that the costs of one contract equals the costs of two flyers</td>
</tr>
<tr>
<td>One manual per teacher</td>
<td>€12.65 per manual</td>
<td>€12.65/60 = €0.20</td>
<td></td>
</tr>
<tr>
<td>One non-smoking contract</td>
<td>€2.02 per contract</td>
<td>€2.02</td>
<td></td>
</tr>
<tr>
<td>One brochure</td>
<td>€1.07 per brochure</td>
<td>€1.07</td>
<td></td>
</tr>
<tr>
<td>Video</td>
<td>€11.13 per video</td>
<td>€11.13/60 = €0.20</td>
<td></td>
</tr>
<tr>
<td>Three magazines per student</td>
<td>€1.50 per magazine</td>
<td>€4.50</td>
<td>Assumed that costs of one magazine equals the costs of one flyer a €1.01 plus €0.50</td>
</tr>
</tbody>
</table>

€75, The total costs of the program.
From smoking to health gains and health care costs: the simulation model

To extrapolate from reductions in the numbers of smokers (due to the school intervention) to LYG and quality adjusted life years (QALYs) gained and to effects on health care costs, the RIVM Chronic Disease Model (CDM) was used [12]. The CDM simulates the long-term effects of differences in smoking prevalence on the incidence, prevalence, mortality and costs of 14 smoking-related diseases, i.e. coronary heart disease (myocardial infarction and other coronary heart disease), chronic heart failure, stroke, chronic obstructive pulmonary disease, diabetes, lung cancer, stomach cancer, larynx cancer, oral cavity cancer, esophagus cancer, pancreas cancer, bladder cancer and kidney cancer, as well as on total mortality, morbidity and health care costs. The CDM has been applied in other analyses of smoking policy [13–20] and more details on the model can be found in several background reports and papers [21–25].

At a given age, a current smoker has a higher probability to die or get a smoking-related disease than a former or a never smoker. The disease risks of former smokers decrease gradually with time since cessation. To evaluate the long-term effects of tobacco control policies, intervention scenarios in which cessation rates and/or initiation rates are temporarily altered are compared with the current practice scenario with default values for transition rates. Individuals prevented from smoking due to the intervention remain at risk of starting smoking at a later age in the model. In the intervention scenarios, it was assumed that starting from the base year (2005), an intervention was implemented for the period of 1 year.

Sensitivity analyses

Sensitivity analyses were performed on key parameters in the evaluation. Besides testing the assumption that the program was equally effective in daily and experimental smokers, effects of variations in intervention costs, discount rate and time horizon were computed.

Results

When assuming that the intervention is equally effective in daily smoking as in experimental smoking, there will be 32 fewer daily smokers after 1 year. The lower number of smokers causes a decrease in the incidence, and thus the prevalence of smoking-related diseases. This causes a gain in (healthy) life expectancy and cost savings for smoking-related diseases. Gains in life expectancy, in turn, cause a future increase in health care costs of diseases unrelated to smoking. In Table II, a summary of the results is shown. Future costs and effects were discounted at the annual percentage of 4% which is recommended in the official Dutch guideline. The time horizon was 100 years. All cost data are presented in euros, at a 2004 price level. In order to compare the cost-effectiveness with the outcomes of other studies, the cost-effectiveness ratios are presented in four different ways (Table II):

Table II. Summary of the results (for a cohort of 1000 adolescents) assuming 32 quit

<table>
<thead>
<tr>
<th>Effect measure</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference in number of smokers after 1 year</td>
<td>32</td>
</tr>
<tr>
<td>Cumulative intervention costs</td>
<td>€75,000</td>
</tr>
<tr>
<td>Intervention costs per averted smoker</td>
<td>€2,300</td>
</tr>
<tr>
<td>Cumulative LY[a]</td>
<td>58</td>
</tr>
<tr>
<td>Cumulative QALYs gained[a]</td>
<td>41</td>
</tr>
<tr>
<td>Intervention costs per LY gained[a,b]</td>
<td>€14,100</td>
</tr>
<tr>
<td>Intervention costs per QALY gained[a,b]</td>
<td>€15,400</td>
</tr>
<tr>
<td>Cumulative difference in health care costs of smoking-related diseases between intervention cohort and control cohort[b]</td>
<td>−€15,800</td>
</tr>
<tr>
<td>€ per LY gained[a,b,c]</td>
<td>€11,200</td>
</tr>
<tr>
<td>€ per QALY gained[a,b,c]</td>
<td>€12,200</td>
</tr>
<tr>
<td>Cumulative difference in total health care costs (including smoking-related diseases)[b]</td>
<td>€21,600</td>
</tr>
<tr>
<td>€ per LY gained[a,b,d]</td>
<td>€18,200</td>
</tr>
<tr>
<td>€ per QALY gained[a,b,d]</td>
<td>€19,900</td>
</tr>
</tbody>
</table>

LY = life year.
\[a\] Effects discounted at 4%.
\[b\] Costs discounted at 4%.
\[c\] Intervention costs and future savings in smoking-related diseases taken into account.
\[d\] Intervention costs and difference in total future health care costs taken into account.

LY = life year.
\[a\] Effects discounted at 4%.
\[b\] Costs discounted at 4%.
\[c\] Intervention costs and future savings in smoking-related diseases taken into account.
\[d\] Intervention costs and difference in total future health care costs taken into account.

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(i) Intervention costs per averted smoker: representing the short-term cost-effectiveness of the different interventions; €2300. Intervention costs per life year/QALY gained; €14 100/€15 400.

(ii) Intervention costs plus savings in the future costs of smoking-related diseases per life year/QALY gained; €11 200/€12 200.

(iii) Intervention costs plus the total difference in future health care costs per life year/QALY gained; €18 200/€19 900.

It should be mentioned that, in our opinion, the last ratio is the most important and that this is the only one that can be compared with health care interventions not aimed at smoking cessation, provided that those interventions have also been evaluated in a comprehensive manner [11, 26, 27].

When only future costs of smoking-related diseases were taken into account [method (ii) mentioned above], the costs were 12 200 per QALY gained. When the aggregate lifetime difference in health care costs was taken as measure [method (iii)], the cost-effectiveness ratio increased to 19 900. This increase was due to the extra health care costs incurred in LYG [28].

Figure 1 displays the costs per QALY as a function of effectiveness in terms of numbers of averted daily smokers. A threshold analysis showed that costs per QALY were <20 000 as long as the number of averted smokers was >30. If the intervention only reduces the number of smokers by 10, the cost per QALY increases to 60 000. From this figure, it can be seen that the cost-effectiveness is sensitive to variations in effectiveness. A drop in effectiveness means that the fixed intervention costs are divided by a lower amount of QALYs, overall resulting in an increase of the cost-effectiveness ratio.

Table III displays the results of the univariate sensitivity analyses for intervention costs, discount rate and time horizon. The cost-effectiveness ratios were most sensitive to variations in time horizon. The sensitivity analyses show that cumulative health effects and especially cumulative differences in health care costs are sensitive to variations in time horizon and effectiveness since the LYG occur only after 60–100 years. That is, with a short-time horizon, the cost-effectiveness ratios are relatively unfavorable, because the greatest health gains lie beyond the horizon. Estimates were robust to variations in intervention costs.

**Discussion**

In this study, we described the cost-effectiveness analysis of a health promotion program in schools to prevent smoking among adolescents. In the Netherlands, a preventive intervention is assumed to be cost-effective when it costs <€20 000 per QALY [29, 30]. The incremental cost-effectiveness ratio of the school program was estimated to be
€19,900 per QALY gained, including intervention costs, savings for smoking-related diseases and differences in total health care costs. The school program seems to be cost-effective. However, due to the assumptions made necessary for estimating cost-effectiveness, the study outcomes should be interpreted with caution.

Firstly, there is the issue of effect measures. In the school program, which was the basis of our model, the outcome was prevention of experimental smoking. To estimate cost-effectiveness by using the CDM, data on daily smoking were needed. Therefore, the assumption was made that the effects of the school intervention on daily smoking were the same as those on experimental smoking. This assumption is important for the results as presented above. If the school interventions only influence smoking behavior of experimental smokers and not that of daily smokers, health gains would vanish and cost-effectiveness ratios would, of course, be infinitely high. The lack of information on daily smoking might be due to the fact that the intervention evaluated was targeted at adolescents aged 14. Most adolescents start daily smoking at a later age, with a peak at age 19 [31].

Another limitation of our study is the absence of evidence on the effectiveness of school-based smoking cessation programs in meta-analyses. A recent Cochrane review of school-based programs for preventing smoking concludes that ‘there is a lack of high-quality evidence about the effectiveness of combinations of social influences and social competence interventions, and of multi-modal programs that include community interventions’ [32]. High-quality evidence is only provided by randomized clinical trials. In most health promotion programs, it is not possible to use such trials. The effectiveness estimates used in our analysis were based on a single trial and not on the more solid evidence produced by a well-performed meta-analysis. However, the single study was based on a Dutch trial. This results in better comparison to the Dutch situation than the outcomes of a meta-analysis of foreign studies.

A third problem is that health promotion programs are usually evaluated in a specific setting, like the school setting in our analysis. Circumstances in other settings always differ from that of the trial setting. The program will probably be implemented in a different school setting. This means that proven cost-effectiveness of the program in the trial setting not automatically results in cost-effectiveness in other school settings.

It is known that health promoters and economists use different principles of analysis [33, 34]. Differences in evaluation methodology lead to a lack of fit between the data provided and the requirements of economic evaluation (Fig. 2). Health promoters want to tailor programs to local needs and are mainly interested in process evaluation. Economists want standardized programs and are more interested in outcome evaluation. Health promoters generally identify three different levels of outcome: health and social outcomes, intermediate health outcomes and health promotion outcomes [35]. Much of the economic literature in this area has concentrated on health outcomes [36]. In order to be able to compare costs and effects of different interventions, it is necessary to have quantitative generalized effect measures such as extended life or more quality of life. Most health promotion studies use intermediate effect measures such as a reduction in the number of smokers, while for cost-effectiveness analysis, integrative outcome measures such as LYG or (for quality adjusted) life years gained are needed. But the use of such measures in evaluation of health promotion activities is rarely seen, partly because QALYs will not capture the full range of benefits of health promotion, which can be broader than those from treatment programs. Besides benefits to individuals, other consequences can be social diffusion, effects on diseases other than the one being targeted, changes in anxiety and changes in self-esteem [36].

In economic evaluation, modeling is needed to measure long-term effects and costs [37]. By using the RIVM CDM, it was possible to estimate the proper outcome measures to evaluate costs and effects of the school program in general terms. However, it was necessary to make additional assumptions on the effectiveness in daily smokers and future smoke transition rates.
In the literature, we found two other studies concerning the cost-effectiveness of school programs to prevent smoking. Tengs et al. [38] evaluated the cost-effectiveness of enhanced nationwide school-based anti-tobacco education in the United States. The authors concluded that >50 years, cost-effectiveness was between $4900 and $340 000 per QALY. Wang et al. [39] determined the cost-effectiveness of a school-based tobacco-use prevention program. Their results showed the program to be cost saving over a reasonable range of model parameter estimates. Both studies used similar assumptions as we did to transform effects on experimental smokers to daily smokers and carried out a series of sensitivity analyses. But neither of the studies investigated the sensitivity of their obtained results to the assumption regarding the relation between experimental smoking and daily smoking.

The potential gain in life expectancy due to smoking prevention is ~7 years [21]. However, since it is taken into account that smokers prevented due to the intervention may start smoking at a later age, total LYG are not simply the product of the smokers prevented times this potential gain in life expectancy. Important difference with the earlier cost-effectiveness studies as mentioned above [38, 39] is the simulation model used to estimate long-term effects of smoking. Our model describes the life course of individuals stratified by smoking status (never, current and former smokers). It distinguishes the most important smoking-related chronic diseases, and the incidence risks of former smokers depend on time since cessation. Moreover, it explicitly describes morbidity from these diseases by modeling the change of the disease prevalence rates over time. Morbidity, in turn, determines mortality in the model. By modeling diseases, effects of smoking cessation on quality of life and health care costs can simply be estimated by coupling health care costs and quality of life figures to diseases instead of coupling them directly to smoking status as has been done in the earlier studies.

**Conclusion**

In summary, the analyses presented in this study show that the school program to prevent smoking in adolescents is cost-effective. However, the results should be viewed with caution. In general, lack of specific information that is needed for this type of evaluation is a major problem in analyzing the cost-effectiveness of health promotion programs. This is partly due to the fact that health promoters are more interested in evaluating the process of program implementation than in analyzing its cost-effectiveness, which is the main concern of the health economist. This might be one of the reasons why so far not much research has been done on the economic evaluation of health promotion initiatives. For policy makers, cost-effectiveness is very important information, because investing in the promotion of public health now results in large future health gains and savings in the costs of care.
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Conflict of interest statement

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References


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