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Cost-Effectiveness of a Smoking Cessation Program After Myocardial Infarction

HARLAN M. KRUMHOLZ, MD, BRIAN J. COHEN, MD,* JOEL TSEVAT, MD, MPH,†
RICHARD C. PASTERNAK, MD, FACC,† MILTON C. WEINSTEIN, PHD*

New Haven, Connecticut and Boston, Massachusetts

Objectives. **The purpose of this study was to evaluate the cost-effectiveness of a smoking cessation program initiated after acute myocardial infarction.**

Background. **The value of allocating health care resources to smoking cessation programs after myocardial infarction has not been compared with the value of other currently accepted interventions.**

Methods. **A model was developed to examine the cost-effectiveness of a recently reported smoking cessation program after an acute myocardial infarction. The cost was estimated by considering the resources necessary to implement the program, and the effectiveness was expressed as discounted years of life saved. Years of life saved were estimated by modeling life expectancy using a single declining exponential approximation of life expectancy based on data from published reports.**

Results. **The cost-effectiveness of the nurse-managed smoking cessation program was estimated to be $220/year of life saved. In a one-way sensitivity analysis, the cost-effectiveness of the program remained <$20,000/year of life saved if the program decreased the smoking rate by only 3/1,000 smokers (baseline assumption 26/100 smokers), or if the program cost as much as $8,840/smoker (baseline assumption $100). In a two-way sensitivity analysis, even if the cost of the program were as high as $2,000/participant, the cost-effectiveness of the program would be <$10,000/year of life saved so long as the program helped an additional 12 smokers quit for every 100 enrolled.**

Conclusions. **Over a wide range of estimates of costs and effectiveness, a nurse-managed smoking cessation program after acute myocardial infarction is an extremely cost-effective intervention. This program is more cost-effective than beta-adrenergic antagonist therapy after myocardial infarction.**

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More than 25 years after the publication of the first U.S. Surgeon General's report (1), cigarette smoking remains an important contributor to worldwide morbidity and mortality from coronary heart disease. Cigarette smoking is estimated to be responsible for >100,000 deaths from coronary heart disease each year in the United States alone (2). Smoking after an acute myocardial infarction is particularly hazardous. Smokers who have had an acute myocardial infarction and continue smoking have a much higher mortality rate than do those who stop smoking (3).

Taylor et al. (4) reported a successful smoking cessation program for patients hospitalized with an acute myocardial infarction that included meetings with nurses and a regular, brief telephone follow-up after hospital discharge. However, despite the success of this program, organized smoking cessation programs with telephone follow-up for survivors of acute myocardial infarction are not widely disseminated and are not currently reimbursed by most third-party payers in the United States. One impediment to directing resources toward smoking cessation programs may be the perception that these programs are not worth their costs. The purpose of this analysis was to determine the cost-effectiveness of a reported smoking cessation program for smokers hospitalized with an acute myocardial infarction and to compare it with that of other medical therapies.

Methods

We developed a model to compare a nurse-managed smoking cessation program with usual smoking cessation counseling for survivors of acute myocardial infarction. The model is represented graphically as a decision tree in Figure 1. The benefit was expressed as the number of discounted life-years saved as a result of the expected reduction in mortality among patients who stopped smoking. All calculations were rounded to the nearest $10.

Description of the smoking cessation program. As described by Taylor et al. (4), the program is initiated in the hospital when a smoker becomes clinically stable after an

From the Section of Cardiovascular Medicine, Yale School of Medicine, New Haven, Connecticut; Cardiovascular Division and the Division of Clinical Epidemiology, Departments of Medicine, †Beth Israel Hospital and Brigham and Women's Hospital, *Harvard Medical School and the Department of Health Policy and Management, Harvard School of Public Health, Boston, Massachusetts. This study was supported in part by Training Grant LM7044 from the National Library of Medicine, Bethesda, Maryland and Grant HL07374 from the National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, and by the Institute of Respiratory Diseases Foundation, Sarasota, Florida.

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Address for correspondence: Dr. Harlan M. Krumholz, Section of Cardiovascular Medicine, Yale School of Medicine, 333 Cedar Street, New Haven, Connecticut 06510.

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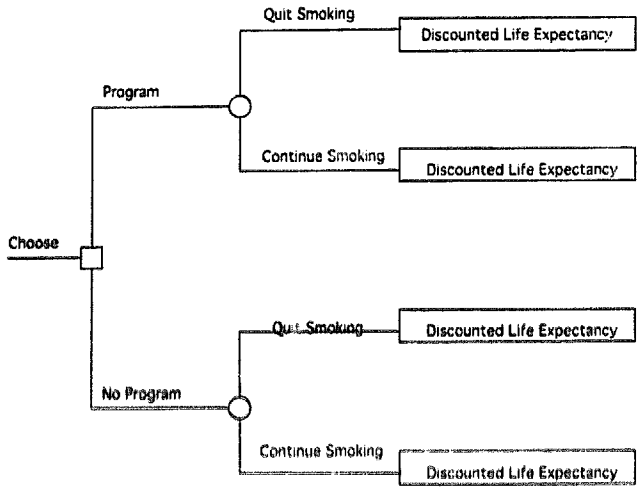

Figure 1. A decision tree of the choice to refer a smoker for a smoking cessation program after an acute myocardial infarction.

acute myocardial infarction. A nurse trained in smoking cessation techniques visits the patient and reviews the risks of continued smoking and the benefits of smoking cessation. The nurse gives the patient a manual that explains how to identify high risk smoking situations and counsels him or her about how to cope with the temptation to smoke. After hospital discharge, nurses call the patients weekly for 3 weeks and then monthly for 4 months to provide support.

Probabilities. Taylor et al. (4) compared their program with usual postmyocardial infarction care for smokers, consisting of a firm, unequivocal message from doctors and nurses to the patients to stop smoking, and reported that 71 of every 100 smokers in the intervention group stopped smoking compared with 45 of every 100 smokers in the usual care group. Subjects in the study were followed up for 1 year, and their smoking status was verified by measurement of expired carbon monoxide and by serum thiocyanate levels. On the basis of that study, we assumed that the new program would be responsible for helping an additional 26 smokers stop smoking for every 100 smokers enrolled in the program (1 person stopping for every 3.8 smokers enrolled in the program).

Several studies (Table 1) have observed the smoking status of large groups of smokers (>100 subjects) after an acute myocardial infarction and then followed them up for >5 years (5–10). In these studies the 5-year mortality rate among smokers ranged from 22% to 47%. All of the large studies have shown a substantial reduction in mortality in patients who quit smoking compared with that of patients who continued smoking. Åberg et al. (5), in the largest study, followed up 983 men <68 years of age (mean 52.6 years) for up to 10.5 years after acute myocardial infarction. In that study, smoking status was ascertained 3 months after infarction. At 5 years, the mortality rate was 16% in the quitters and 22% in the smokers, a 27% relative difference. This difference in mortality rates was among the lowest in the studies reviewed and is the estimate that we used in our baseline analysis.

Life expectancy was modeled for smokers and nonsmokers using a single declining exponential curve (11) with a time constant calculated from the 5-year mortality rates from the study of Åberg et al. (5). These curves fit the reported data well for at least the 1st 8 years of the study (Fig. 2). The modeled survival curve for the ex-smokers slightly underestimates the reported survival figures, whereas the modeled survival curve for the smokers slightly overestimates survival. Discounted life expectancy was calculated for smokers and ex-smokers by taking the integral under each survival curve from year i to year i + 1, multiplying that by $1/(1.05^i)$, and summing for i = 1 to 50. The resultant calculated gain in life expectancy from smoking cessation (life expectancy of ex-smokers minus life expectancy of smokers) is estimated to be 1.7 years.

Costs. The program was assumed to require approximately 3 h of nursing time per patient (4). The cost of nursing time was estimated to be approximately $30/h, based on estimated prevailing salaries in the Boston area. We assumed that each patient would be given a self-help manual and other instructional material at a cost of approximately

Table 1. Summary of Large Observational Studies of the Effect of Smoking Cessation on Mortality After Acute Myocardial Infarction With at Least 5 Years of Follow-Up

Study*	Patients Studied (no.)	5-Year Mortality Rate		Comment
		Quitters	Smokers	
Sparrow (8), 1978	365 (269 men, 96 women)	12%	25%	Framingham Heart Study; quitting defined as not smoking after first MI on the biennial examination after MI
Åberg (5), 1983	983 (men only)	16%	22%	Quitting defined as not smoking 3 months after MI
Daly (10), 1983	498 (men only)	20%	30%	Quitting defined as not smoking 2 years after first MI or unstable angina episode
Johansson (6), 1985	156 (women only)	15%	27%	Quitting defined as not smoking 3 months after MI
Perkins (7), 1985	119 (90 men, 29 women)	21%	47%	Quitting defined as not smoking at 3 months, 6 months and yearly for up to 5 years of follow-up
Hedback (9), 1987	305 (258 men, 47 women)	16%	31%	Quitting not defined (smoking defined as regular smoking in the month before MI)

*First author, reference number, year of publication. MI = myocardial infarction.

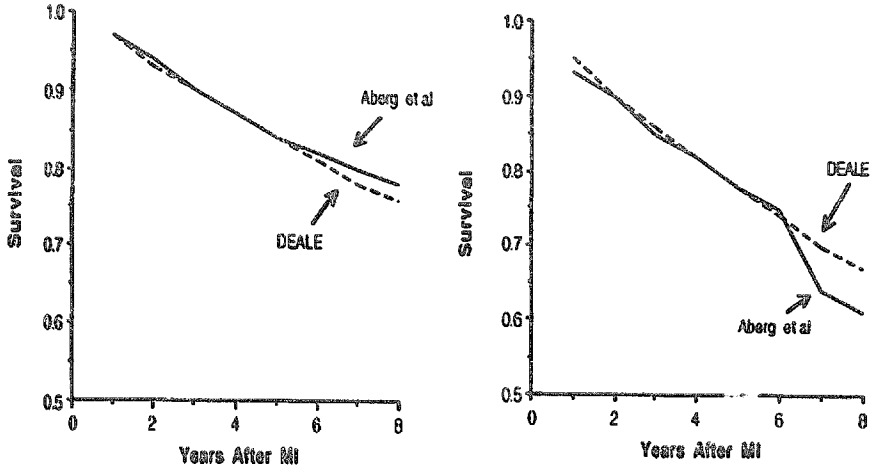

Figure 2. Comparison of survival curves after myocardial infarction (published values from Åberg et al. [5] and values calculated from modeling a declining exponential approximation of life expectancy [DEALE]) for ex-smokers (left) and smokers (right).

$10/patient. Therefore, the estimated cost of the program for each patient was $100. Our analysis did not include the cost of setting up the program and initially training the nurses.

To be consistent with previous cost-effectiveness studies of smoking cessation strategies (12,13), we did not include medical costs incurred by the survivors in subsequent years. It is proper, nevertheless, to consider the additional medical costs incurred for routine care during the years of life gained and, therefore, we included those costs that were incurred subsequently in a sensitivity analysis.

We did not include indirect costs to the patients, such as the time lost from work while participating in the program because the initial contact occurs while the patient is hospitalized, and subsequent contacts are very brief. We also did not consider the effect of smoking cessation itself on decreasing days missed from work as a result of illness averted.

Sensitivity analysis. Each variable was examined over a wide range in sensitivity analyses. The effectiveness of the program, measured as the number of additional quitters/100 smokers enrolled in the program, varied from 0 to 33 quitters/100 smokers (baseline assumption 26/100 smokers). Discounted life-years gained varied from 0.1 to 5 (baseline assumption 1.7). If we assume that there was no survival benefit to the quitters after the 8 years for which Åberg et al. (5) followed up their cohort, then the discounted life-years saved is 0.3 (calculated as before up to $i = 8$), well within the range in the sensitivity analysis. The costs of the program varied from $50 to $2,000/patient (baseline assumption $100). Annual discounted medical costs incurred by survivors varied from $0 to $20,000. This range encompasses a recent estimate of $2,100 for the annual cost of medical therapy for patients after myocardial infarction (14).

Results

Cost-effectiveness. The cost of the recently published smoking cessation program compared with usual care for patients who have had an acute myocardial infarction was estimated to be $380 for each smoker who quits (the product of the cost per participant [$100] and the number of enrollees needed to produce an ex-smoker [3.8]). On the basis of the preceding analysis, each person who stopped smoking after acute myocardial infarction gained approximately 1.7 years compared with patients who continued to smoke. Therefore, the incremental cost-effectiveness is estimated to be approximately $220 for each additional year of life saved (the quotient of the cost of the program for each ex-smoker produced [$380] and the number of years gained by each ex-smoker [1.7]).

Sensitivity analyses. The cost/year of life saved is calculated to be <$6,000 if the program helps at least 1 additional smoker to quit for every 100 smokers enrolled (Table 2). The program has a cost-effectiveness ratio of <$20,000/year of life saved as long as at least three additional smokers of

Table 2. One-Way Sensitivity Analyses

	Cost-Effectiveness ($/year of life saved)
Baseline	220
Effectiveness of program in decreasing smoking (baseline 26/100)	
33/100	180
6/100	980
1/100	5,880
3/1,000	19,610
Discounted life-years gained (baseline 1.7)	
5	80
3	130
1	380
0.10	3,850
Cost of the smoking cessation program (baseline $100)	
$50	110
$1,000	2,260
$2,000	4,520
Medical care costs incurred during years gained (baseline $0)	
$2,100	2,330
$5,000	5,230
$10,000	10,230

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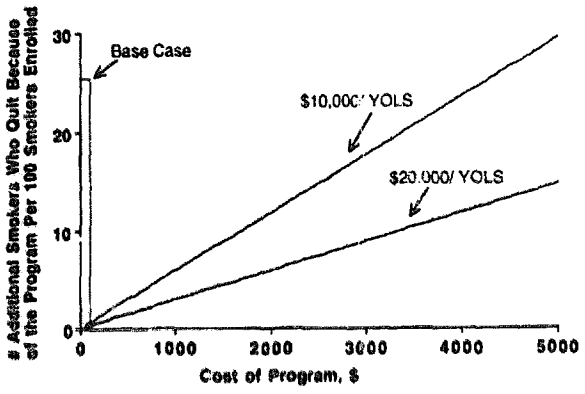

Figure 3. Two-way sensitivity analysis in which the cost and effectiveness of the program are varied. Lines represent coordinates that would result in a cost-effectiveness ratio of $20,000/year of life saved (YOLS) and $10,000/year of life saved. Coordinates that are above and to the left represent more favorable ratios. The baseline result is also indicated.

every 1,000 patients enrolled are able to quit. Even if the effectiveness of the program was estimated to be less than the baseline analysis, the program remained extremely cost-effective. If the discounted years gained from smoking cessation were assumed to be as low as 0.1, the cost-effectiveness of the program still did not exceed $4,000/year of life saved. Furthermore, given the baseline assumptions for effectiveness, the cost of the program could be as much as $8,840/participant and still remain <$20,000/year of life saved.

The cost of the program and its effectiveness in producing ex-smokers varied together in a two-way sensitivity analysis (Fig. 3). The program could cost much more than our baseline estimate and still be relatively cost-effective, even if the program were less effective than assumed. For instance, even if the cost of the program were as high as $2,000/participant, the cost-effectiveness of the program would be <$10,000/year of life saved so long as it could help 12 additional smokers to quit for every 100 enrolled.

Discussion

The principal finding of our analysis is that a smoking cessation program for survivors of an acute myocardial infarction is an extremely cost-effective intervention. Our baseline analysis was modeled on a recently described nurse-managed program that increased smoking cessation rates by 26/100 smokers. We showed that this program is much more cost-effective than the use of either beta-adrenergic antagonists after myocardial infarction in high risk patients ($4,700/year of life saved in 1991 dollars) (15) or coronary artery bypass grafting for left main coronary artery stenosis in patients with severe angina ($7,000/quality-adjusted year of life in 1991 dollars) (16), two interventions that are considered very cost-effective by current standards.

Sensitivity analyses. Although our baseline calculations were based on a successful nurse-managed smoking cessation program, our results suggest that even smoking cessation programs with much lower effectiveness and higher cost would have a cost-effectiveness that is superior to that of many other interventions in cardiovascular medicine (Table 3). If the program were as effective as that described by Taylor et al. (4), yielding a decrease in smoking of 26/100 smokers, then it could cost as much as $2,000 for each participant and still have a cost-effectiveness ratio that is <10% that of the hospital stay in a coronary care unit for a patient with a 20% probability of having a myocardial infarction, a strategy that has been estimated to cost approximately $60,000/year of life saved in 1991 dollars (17). If the program cost only $100/smoker, as in our baseline analysis, then an increase in the quitting rate by only 1 person for each 169 smokers enrolled would result in a cost-effectiveness ratio <$10,000/year of life saved.

Table 3. Comparison of Cost-Effectiveness of Interventions for Patients With Myocardial Infarction

	Cost-Effectiveness Per Year of Life Saved ($)
Postinfarction	
Smoking cessation program	220
Beta-adrenoceptor antagonist therapy (Goldman et al. [15])	
Low risk patient	27,000
Medium risk patient	7,400
High risk patient	4,700
Peri-infarction	
Thrombolytic therapy (Krumholz et al. [14])	
70 years old	21,200
75 years old	22,400
80 years old	21,600
Coronary care unit (Fineberg et al. [17])	
Probability of MI 5%	260,000
Probability of MI 20%	60,000

MI = myocardial infarction.

Assumptions of the study. Throughout the analysis, when information was equivocal, we made assumptions that tended to bias the analysis against the intervention. For instance, despite the likelihood that smoking cessation would result in savings from an expected decrease in the incidence of cancers, strokes and respiratory-related diseases, we did not include this factor in the model. The inclusion of estimates of these savings would have resulted in an even more favorable cost-effectiveness ratio.

Our assumptions about reinfarction after smoking cessation were also conservative. The 1990 U.S. Surgeon General's Report (2) concluded that smoking cessation after acute myocardial infarction decreases the rate of reinfarction. However, because not all studies have found a statistically significant reduction in reinfarction rate, our analysis assumed that smoking cessation had no effect on reinfarction rates. The cost-effectiveness ratio of the program may be even more favorable if it were assumed that smoking cessation prevents reinfarction.

Despite our conservative assumptions, our conclusions emphasize that resources devoted to smoking cessation programs after myocardial infarction are well spent. Furthermore, our analysis extends the observations from the previous reports. Other investigators have analyzed the cost-effectiveness of physician counseling and of nicotine gum as an adjunct to physician counseling against smoking (12,13,18). Those analyses reported that the cost-effectiveness of physician counseling was <$2,000/year of life saved and that nicotine gum as an adjunct to physician counseling was <$10,000/year of life saved. However, neither of those analyses considered secondary prevention after myocardial infarction.

Limitations of the study. There are some important limitations to our analysis. Because no randomized trial of smoking cessation has been published, we based our estimate of the effectiveness of smoking cessation on the large observational studies (5–10). In those studies, the two comparison groups were often very different: The smokers who quit commonly had a worse risk profile (e.g., more severe left ventricular failure, higher peak creatine kinase enzyme levels) than that of the smokers who continued. Therefore, it is more likely that the observed relative reduction in mortality at 5 years was the result of smoking cessation rather than selection (5).

The baseline estimate of the discounted survival benefit was calculated using a single declining exponential as a model of survival in both groups. This approach has been validated previously as an appropriate technique in situations where mortality is dominated by a single disease process (11). Figure 2 shows that this fits the actual data well for at least the 1st 8 years after myocardial infarction. This method may overestimate the survival benefit in the long run because there are no data to show that the survival benefit to quitters persists over a long period and, over time, the mortality rate in both groups is likely to increase rather than remain constant as in the single declining exponential model. Nevertheless, discounting future life-years minimizes any discrepancy because it gives greater weight to the earlier years. Furthermore, the range of the sensitivity analysis for discounted life-years saved included values below that calculated, assuming that there was no survival benefit after 8 years.

We did not model a relapse rate after smoking cessation because smoking status in the published studies was evaluated early after the acute myocardial infarction and not subsequently verified. In the study by Åberg et al. (5), for instance, smoking cessation was assessed only 3 months after acute infarction. Many of those patients may have subsequently had a relapse; thus, the relapse rate is incorporated into the published survival curve.

We did not model costs incurred during years gained in the baseline analysis because previous studies of smoking cessation have not included those costs. Those costs are difficult to estimate because costs incurred by years gained may be offset by savings from the prevention of costly morbidity that is averted as a result of smoking cessation. Large observational studies with careful cost accounting would be necessary to document the effect of smoking cessation on subsequent medical costs. Nevertheless, the sensitivity analysis did include a wide range of costs and showed that the program remained very cost-effective even if annual medical costs were as high as $10,000.

The lack of data about the benefit of smoking cessation after acute myocardial infarction for women and older patients made it difficult to model explicitly the effect of age and gender on the cost-effectiveness of this intervention. Many of our assumptions are based on studies of middle-aged men and women. With a paucity of empiric data it is difficult to model confidently how age would influence many of the assumptions in this model. However, there is evidence that older smokers do benefit from smoking cessation (19). In our analysis we sought to determine whether this intervention would be cost-effective over a wide range of assumptions that would encompass reasonable estimates pertaining to men and women of any age.

Finally, our analysis did not consider the potential benefit of transdermal nicotine patches. Recent studies have demonstrated the value of these patches in smoking cessation programs (20,21). However, there are no published trials of the patch in patients after myocardial infarction. Furthermore, there are theoretic concerns about the hazards of administering nicotine to patients after an acute myocardial infarction. Nevertheless, if the patches are safe and effective in this setting, our results suggest that the benefits of increasing smoking cessation with transdermal nicotine therapy could easily outweigh its costs. Further studies of the role of transdermal nicotine patches in this population are needed.

Conclusions. We believe that our analysis has important implications for the approach to the treatment of smokers with acute myocardial infarction. Taylor et al. (4) demonstrated that this intervention is effective after myocardial infarction, and we showed that it is more cost-effective than commonly accepted treatments, such as beta-adrenergic antagonist therapy. Organized smoking cessation programs with telephone follow-up by trained professionals should be a part of the care for every smoker who suffers a myocardial infarction.

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