Estimation of the Break-Even Point for Smoking Cessation Programs in Pregnancy

ABSTRACT

Background. Successful programs to help pregnant women quit smoking have been developed and evaluated, but formal smoking cessation programs are not a part of care at most prenatal sites. The cost of such programs may be an issue. Considering the costs of adverse maternal and infant outcomes resulting from smoking, we estimated there would be an amount of money a prenatal program could invest in smoking cessation and still "break even" economically.

Methods. A model was developed and published data, along with 1989 hospital charge data, were used to arrive at a break-even point for smoking cessation programs in pregnancy.

Results. Using overall United States data, we arrived at a break-even cost of $32 per pregnant woman. When these data were varied to fit specific US populations, the break-even costs varied from $10 to $237, with the incidence of preterm low birth weight having the most impact on the cost.

Conclusions. It may be advisable to invest greater amounts of money in a prenatal smoking cessation program for some populations. However, for every population there is an amount that can be invested while still breaking even. (*Am J Public Health.* 1992;82:383–390)

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Introduction

Cigarette smoking has been linked with adverse pregnancy outcome since at least the 1940s[1,2] and is the most important cause of low birth weight (LBW) in developed countries.[3] However, smoking cessation during the first trimester leads to infant outcomes similar to those for nonsmokers,[4] suggesting that smoking cessation programs during early pregnancy can alter pregnancy outcomes.

Although successful programs to help pregnant women quit smoking have been developed and evaluated,[5–8] formal antismoking programs are not a part of most prenatal care. The reasons why smoking cessation programs have apparently not been implemented are not known with certainty, but the cost of such programs is probably a major issue.

A recent analysis[9] of the cost-effectiveness of smoking cessation programs in pregnancy, however, showed that over $3 was saved for every dollar spent on smoking cessation. Their cost-effectiveness was also demonstrated in a study that examined such a program in a health maintenance organization (HMO) population.[10]

These two studies looked at cost-effectiveness by assuming a fixed program cost and comparing this cost with that of the adverse medical outcomes. An alternative approach to cost-effectiveness analysis is to examine the cost of adverse medical outcomes with an intervention and compare it with the cost without such an intervention. The difference in these two costs is the amount that the program could invest in the intervention and still "break even" economically.

Our analysis takes such a perspective. We calculated the aggregate costs of medical outcomes for a hypothetical prenatal program that included a formal smoking cessation intervention and compared them with a hypothetical prenatal program that did not have such an intervention. Assuming that any program must decide how to allocate fixed resources for a group of pregnant women, who comprise both smokers and nonsmokers, we therefore arrived at an estimation of cost per pregnant woman rather than of cost per pregnant smoker in our final result. Then, after arriving at this break-even point, we examined the extent to which this amount might vary from program to program, depending on the prevalence of smoking, the success of the cessation program, the incidence of adverse pregnancy outcomes in the population in question, and the cost of medical care.

Methods

Decision Analysis Models

We constructed two decision trees—one for infant outcome (Figure 1) and one maternal outcome (Figure 2)—to compare two strategies: (1) providing a

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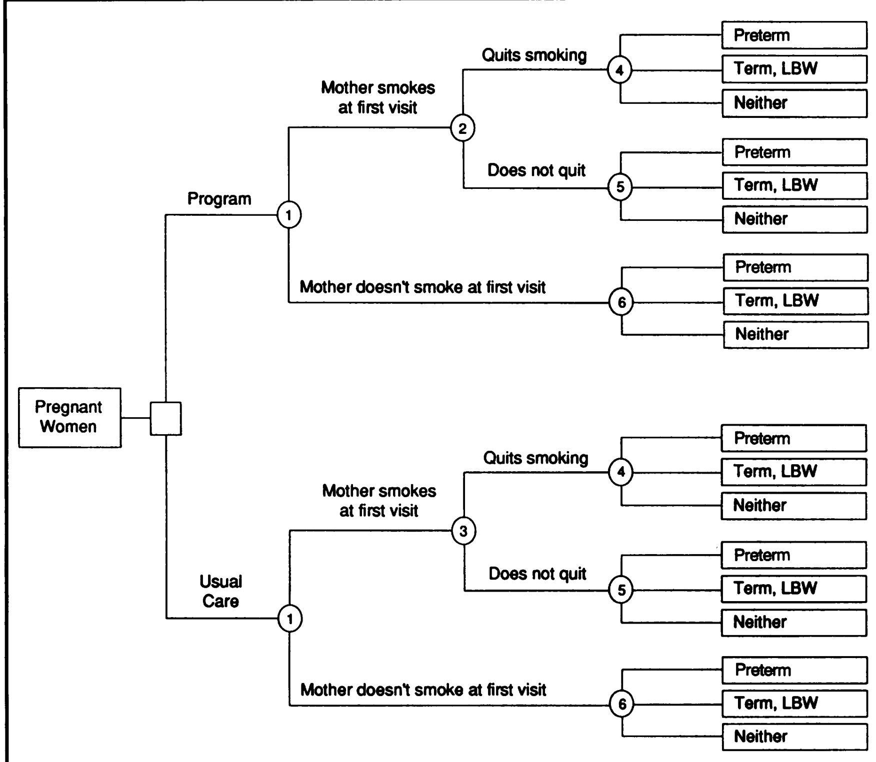

FIGURE 1—Decision tree depicting infant outcome for pregnant women provided or not provided with a formal smoking cessation program. Circles are chance nodes and square is a decision node.

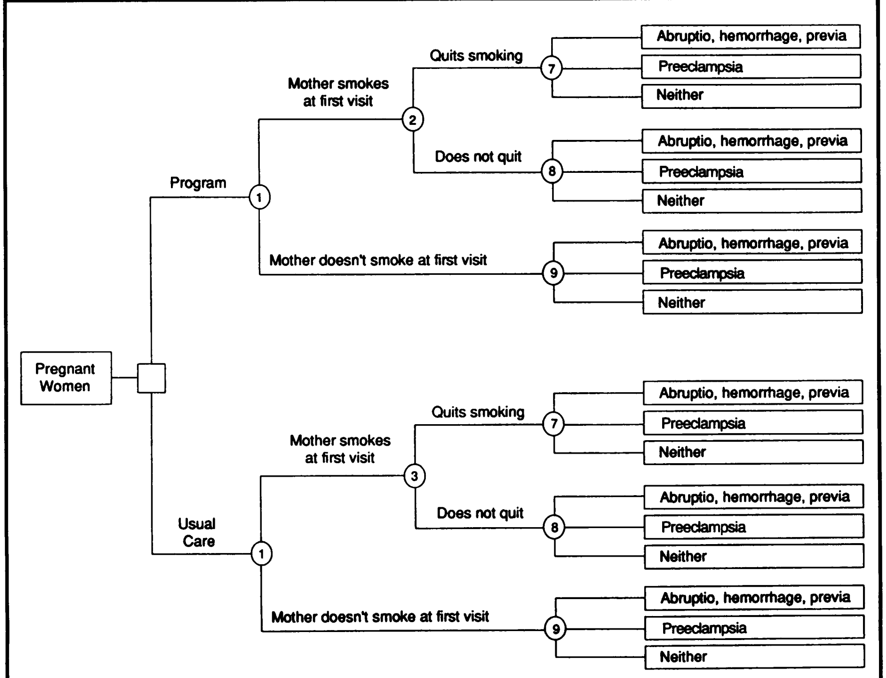

FIGURE 2—Decision tree depicting maternal outcome for pregnant women provided or not provided with a formal smoking cessation program.

formal smoking cessation program for pregnant women who smoke, or (2) not providing a formal smoking cessation program. Probabilities used in the decision model were estimated based on published data (Table 1).

Data and Assumptions

Prevalence of Smoking at First Prenatal Visit (Node 1). Population-based data on smoking prevalence were obtained from the 1985 National Health Interview Survey (published in 1988).[11] Among survey respondents, 31.8% of the women between the ages of 18 and 44 who had given birth to a child within the past 5 years smoked cigarettes during the 12 months preceding pregnancy. Because 21.2% of the women quit smoking upon learning they were pregnant, we estimated a baseline probability of 25% for women still smoking at the time of their first prenatal visit (.318–(.318) (.212) = .25). This prevalence of .25 is the figure used for all the baseline analyses. The greatest variability in smoking prevalence was for women with different education levels. Therefore, probability estimates for the sensitivity analysis were based on a comparison of women with fewer than 12 years of education (probability .39) and women with 16 or more years of education (probability .08). These estimates take into account the before-pregnancy smoking rates and the chances of women quitting upon learning of pregnancy.

Quit Rate after First Prenatal Visit in Pregnant Smokers Who Are Provided with a Formal Program (Node 2). Randomized clinical trials of smoking cessation programs allow us to estimate quit rates attributable to formal smoking cessation programs. An optimal intervention program for pregnant women was implemented and evaluated by Sexton and Hebel,[7] who achieved the highest quit rate among pregnant smokers published to date (43%). Subtracting the quit rate in the control group (20%) in that study from the quit rate in the intervention group, we estimated a quit rate attributable to the program of 23%; this figure was used for the baseline analysis. In a study of a different smoking cessation program by Windsor et al.,[6] the quit rate attributable to the program was 12% (14% intervention, 2% control), which provided the lower probability estimate for our sensitivity analysis. We obtained the upper probability estimate of 29% by taking the difference in the smoking cessation rates between the intervention (43%) and control (14%) groups for men who participated in the Multiple Risk Factor Intervention Trial (MRFIT)[12] study. Although the MRFIT study evaluated men rather than pregnant women, we used it as the high estimate of the effectiveness of a smoking cessation program because MRFIT's smoking intervention

TABLE 1—Probabilities Used in Decision Analysis

	Baseline Probability	Range of Probability	Node	Source
Prevalence of smoking at first prenatal visit	.25	.08–.39	1	NCHS, 1988[11]
Quit rate in pregnant smokers[a] who are provided with a formal program	.23	.12–.29	2	Sexton and Hebel, 1984[7] Windsor et al., 1985[6] MRFIT 1982
Spontaneous quit rate in pregnant smokers[a]	.02	.00–.06	3	Windsor et al., 1985[6] MacArthur et al., 1987[13]
Probability of LBW (<2500 g) at term (≥37 wks)				
nonsmokers	.017	.015–.031	6	NCHS 1988[11]
quit smoking after 1st visit	.017	.015–.031	4	Puffer and Serrano, 1987[14] Ounsted et al., 1985[15]
continue smoking after 1st visit	.060	.053–.109	5	McIntosh, 1984[16]
Probability of LBW (<2500 g) and preterm (<37 wks)				
nonsmokers	.035	.029–.066	6	NCHS, 1988[11]
quit smoking after 1st visit	.035	.029–.066	4	Puffer and Serrano, 1987[14] Kramer, 1987[3]
continue smoking after 1st visit	.049	.041–.092	5	McIntosh, 1984[16]
Probability of normal birth weight (≥2500 g) at term (≥37 wks)				
nonsmokers	.948	.903–.956	6	NCHS 1988[11]
quit smoking after 1st visit	.948	.903–.956	4	Puffer and Serrano, 1987[14] Ounsted et al., 1985[15]
continue smoking after 1st visit	.891	.799–.906	5	Kramer, 1987[3]
Probability of abruptio placenta, placenta previa, or antepartum hemorrhage				
nonsmokers	.009	.007–.021	9	Meyer et al., 1976[23]
quit smoking after 1st visit	.009	.007–.021	7	Reid et al., 1972[25] Cunningham et al., 1989[24]
continue smoking after 1st visit	.013	.010–.029	8	McIntosh, 1984[16]
Probability of preeclampsia of pregnancy				
nonsmokers	.058	.058–.117	9	Marcoux et al., 1989[27]
quit smoking after 1st visit	.058	.058–.117	7	Cunningham et al., 1989[24] Goplerud, 1982[26]
continue smoking after 1st visit	.024	.024–.049	8	
Probability of none of the above complications				
nonsmokers	.933	.862–.935	9	Marcoux et al., 1989[27]
quit smoking after 1st visit	.933	.862–.935	7	Cunningham et al., 1989[24] Goplerud, 1982[26]
continue smoking after 1st visit	.963	.922–.966	8	Reid et al., 1972[25] Meyer et al., 1976[23]

[a]women who smoke at the first prenatal visit.

was highly effective and may represent the maximum achievable for a formal cessation program. There is no assurance, however, that the same results could be achieved in pregnancy.

Spontaneous Quit Rate after First Prenatal Visit in Pregnant Smokers (Node 3). Spontaneous quit rates were assumed to be the same as quit rates in women in the control groups of randomized clinical trials. The baseline probability (.02) was derived from the 2% quit rate found among control group women participating in the study by Windsor et al.[6] The upper probability range (.06) was derived from a study by MacArthur et al.,[13] and the probability range of zero was chosen as an alternative, assuming that all women who are going to quit smoking do so prior to their first prenatal visit.*

Infant Outcomes

Probability of LBW (< 2500 g) at Term (≥ 37 weeks) for Nonsmokers and Quitters (Nodes 4 and 6). Only incidence rates and relative risks were available in the literature. Thus, we used the following formula to calculate the probability of LBW at term for nonsmokers and quitters:

$$P_{NS} = \frac{I_{LBW}}{(RR_s)(Pv_s) + (Pv_{NS})},$$

*Regarding the estimates for nodes 2 and 3, we used data from randomized trials of smoking cessation programs to determine the net effect attributable to the smoking cessation program, which was estimated as the difference between the quit rates in the intervention group and the control group. This was the estimate used for the program arm of the decision tree. In the nonprogram arm of the decision tree, we also used this data on quit rates from the control groups to estimate the community spontaneous quit rate because these studies are among the few reliable sources of data on quit rates among pregnant women.

where

P_{NS} = the probability of the outcome among nonsmokers and quitters,

I_{LBW} = the incidence of LBW at term for the population,

RR_S = the relative risk of LBW at term for continuing smokers,

Pv_S = the prevalence of smoking for the population, and

$Pv_{NS} = 1-Pv_S$.

The incidence rate of LBW at term (2.8%) was derived from US population-based data,[14] and the relative risk of term LBW for smokers (3.5) was obtained from a study by Ounsted et al.[15] The value used for the prevalence of smoking at the first prenatal visit was .25, and was derived as explained earlier.

Probability of LBW (< 2500 g) and Preterm (< 37 weeks) for Nonsmokers and Quitters (Nodes 4 and 6). The same formula was used to calculate the probability of LBW and preterm for nonsmokers and quitters, substituting a baseline overall incidence of preterm LBW of 3.8% and a baseline relative risk of preterm LBW of 1.4.[3,14]

Probability of LBW (< 2500 g) at Term (≥ 37 weeks) and Preterm (< 37 weeks) for Continuing Smokers (Node 5). The probability of each outcome among continuing smokers was derived from the probability of the outcome among nonsmokers and quitters and the relative risk of the outcome for continuing smokers:

$$P_S = (P_{NS})(RR_S),$$

where

P_S = the probability of the outcome among continuing smokers,

P_{NS} = the probability of the outcome among nonsmokers and quitters, and

RR_S = the relative risk of LBW for continuing smokers.

The range of relative risk estimates for continuing smokers was obtained from the Alameda County Low Birth Weight Study.[4] These were 4.5 to 5.1 for term LBW and 2.2 to 3.3 for preterm LBW.

Probability of Normal Birth Weight (> 2500 g) at Term (≥ 37 weeks) for Continuing Smokers (Nodes 4,5,6). The probability of normal birth weight at term for each smoking category was derived by subtraction:

$$P_{Norm} = 1-P_{Preterm}-P_{Term},$$

where

P_{Norm} = the probability of normal birth weight at term,

$P_{Preterm}$ = the probability of LBW and preterm, and

P_{Term} = the probability of LBW at term.

Sensitivity Analysis for Infant Outcome. Table 1 presents the range of probability estimates used in the sensitivity analysis. The first sensitivity analysis varied the prevalence of smoking at the first prenatal visit, using the lower (.08) and upper (.39) probability range values to determine the individual effect of smoking prevalence on the break-even point. Additional analyses were then conducted using the probability range estimates for each additional variable, varying only one estimate at a time. The analysis for the variable preterm LBW had values ranging from a low incidence of 3.2% to a high incidence of 7.3%, and the values for LBW at term were 2.4% and 5.0%, respectively.[14]

Because exact probabilities of infant outcomes could not be obtained from the literature and because the model appeared to be particularly sensitive to the relative risk of preterm LBW, a second sensitivity analysis examined the independent effects of varying the incidence rate for each outcome and relative risk estimate for preterm LBW. A final sensitivity analysis examined the independent effects of varying the incidence rate for each outcome and relative risk estimate for term LBW.

Maternal Outcomes

Probability of Antepartum Hemorrhage, Abruptio Placenta, and Placenta Previa for Smokers, Nonsmokers, and Quitters (Nodes 7, 8, 9). Studies[16–23] report elevated relative risks among smokers for placental abnormalities or bleeding during pregnancy. We converted these relative risks to probabilities using the formula cited earlier. An incidence of .01 for hemorrhage[24–26] and a relative risk of 1.43 for hemorrhage in smokers[23] were used in the baseline formula, and we obtained the probability of hemorrhage in continuing smokers (node 8) by the same method we used for infant outcomes.

Probability of Preeclampsia in Smokers, Nonsmokers, and Quitters (Nodes 7, 8, 9). The formula cited earlier was used to calculate the probability of preeclampsia in nonsmokers and quitters. The incidence rate of preeclampsia for pregnant women in the United States (.05) was obtained from studies cited in general obstetrics texts.[24,25] The baseline relative risk of preeclampsia for smokers (.42) was obtained from a recent case-control study,[27] which obtained a relative risk value similar to that obtained in older studies.[19] The reason for the lower relative risk of preeclampsia in smokers is uncertain, but it has been theorized that nicotine might inhibit the potent vasoconstrictor thromboxane, a substance found to be increased in studies in preeclamptic women.[28,29]

For the probability of preeclampsia in continuing smokers (node 8), we multiplied the relative risk in smokers (.42) by the probability of preeclampsia in nonsmokers and quitters (P_{NS}).

Probability of Births Not Complicated by Placenta Previa, Placenta Abruptio, Hemorrhage, or Preeclampsia (Nodes 7, 8, 9). The probability of a pregnancy not complicated by any of the above diagnoses was derived by subtraction.

Sensitivity Analysis for Maternal Outcomes. For the range of probabilities cited in Table 1, we varied the incidence rates of hemorrhage and preeclampsia through the ranges cited in the literature (.008 to .023 for hemorrhage and .05 to .10 for preeclampsia) while maintaining the relative risks for continuing smokers.

Additional sensitivity analyses varied, one at a time, the prevalence of smoking at the first prenatal visit, the probability of quitting smoking with a smoking program in place, and the probability of quitting smoking without a program in place.

Costs

Because true cost data cannot be obtained and results of this analysis are of most interest to third-party payors, charges were used as a proxy for costs. We included in our analysis only the direct medical charges for maternal care at delivery and for hospital care for newborns. With no national data available at the level of detail needed for this analysis, we approximated charges based on 1989 hospital and physician charges from two San Francisco Bay Area hospitals with perinatal databases. Because exact obstetric and newborn charge data are unavailable to compare San Francisco hospital charges with national averages, we varied the ranges of charges in our sensitivity analysis from 50% to 200% of the San Francisco charges, a range that includes most hospital charges in the United States.[30] The cost assumptions used in the model are summarized in Table 2 and were derived as described below.

Maternal Charges. We identified all patients discharged from the two study hospitals with antepartum hemorrhage or preeclampsia (ICD-9 codes 641.11, 641.21, 642.41, and 642.51)[31] between July 1 to December 30, 1989. We took a systematic random sample of women who delivered during the same period without hemorrhage or preeclampsia.

We did not include maternal hospitalization prior to delivery for any of the diagnoses, given that reliable data were not available on this parameter. However, predelivery charges are unlikely to make a major contribution to total charges. We obtained hospitalization bills for 94% of the women identified (124 of 132), and to each bill we added a standard obstetrician charge for the delivery of an infant.

For our mean baseline value for both infant and maternal charges, we eliminated the highest and lowest values, presuming them to be outliers.

Infant Charges. All infants diagnosed as term LBW born in the study period were identified using the obstetrical database of each hospital (n = 31). For infants who were preterm LBW and term not LBW, we took a systematic random sample of discharges from the same period (n = 30 for each diagnosis). For all these infants, we obtained hospitalization bills for 96% (87 of 91).

We approximated physician charges for preterm and term LBW infants by taking 20% of hospital charges for each infant, a number found in an earlier study,[32] to be the average physician charge for one of the same Bay Area hospitals used in our study. For the infants who were not LBW, we used a standard charge billed by the pediatric group of each institution for care of a normal newborn.

Sensitivity Analysis for Costs. Because hospital and physician charges for the same diagnosis may vary widely due to regional and institutional characteristics, we performed a sensitivity analysis by varying the amount charged for each diagnosis from 50% to 200%.

TABLE 2—Hospital and Physician Mean Charges for Selected Diagnoses Associated with Smoking in Pregnancy: San Francisco, 1989

	Number of Patients	Mean Charges ($)
Maternal		
Hemorrhage	35	11 056
Preeclampsia	51	8891
No hemorrhage or preeclamp	38	6794
Infant		
<37 wks, <2500 g	28	43 755
≥37 wks, <2500 g	29	4978
≥37 wks, ≥2500 g	30	2738

TABLE 3—Estimated Break-Even Cost[a] per Pregnant Woman of a Program for Smoking Cessation in Pregnancy, by Outcomes Considered and Risk Characteristics of Population in Terms of LBW

	Outcomes Considered ($)	
Risk of LBW	Infant Only	Infant and Maternal
Baseline	35	32
Low incidence preterm LBW[b]	28	25
High incidence preterm LBW[c]	67	64
Low incidence Term LBW[d]	30	27
High incidence Term LBW[e]	64	61

[a]number of dollars per pregnant woman that could be invested in smoking cessation program with a net expenditure of zero after taking into account costs due to changes in cost of medical care for other pregnancy outcomes.
[b]Using the lower probability estimate of preterm LBW for nonsmokers and quitters (.029).
[c]Using the upper probability estimate of preterm LBW for nonsmokers and quitters (.066).
[d]Using the lower probability estimate of term LBW for nonsmokers and quitters (.015).
[e]Using the upper probability estimate of term LBW for nonsmokers and quitters (.031).

Results

Table 3 summarizes the estimated break-even cost per pregnant woman of a program for smoking cessation in pregnancy, based on various outcomes and population characteristics. Using our baseline assumptions and considering only infant outcomes, we estimate that $35 per pregnant woman is the largest amount the program could cost without exceeding the cost of care for LBW infants later on. This amount is the estimated break-even cost. Using our baseline assumptions and considering both maternal and infant outcomes, the break-even cost of a program for smoking cessation during pregnancy is estimated to be $32 per pregnant woman. This is $3 less than the cost considering only infant outcomes because the higher risk of preeclampsia in nonsmokers results in an increase in expenditures.

Considering only infant outcomes, estimates of the break-even cost of such a program range from $28 to $67, depending on the assumed background incidence of preterm LBW in a population, and from $30 to $64, depending on the assumed incidence of term LBW (Table 3). When both maternal and infant outcomes are considered, the estimates of break-even cost are not much different.

Using the baseline assumptions, estimates of the break-even cost vary, depending on the percentage of women who smoke at the first prenatal visit. These estimates range from $12 per woman in a population with 10% smokers to $45 per woman in a population with 35% smokers (Figure 3).

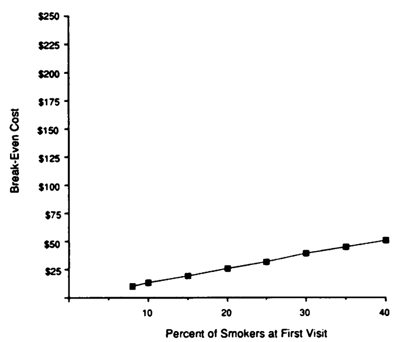

FIGURE 3—Estimated break-even cost of a program for smoking cessation during pregnancy, by prevalence of smoking at the first prenatal visit, considering both infant and maternal outcomes and using baseline assumptions for all other variables.

The estimated break-even cost strongly depends on assumptions about

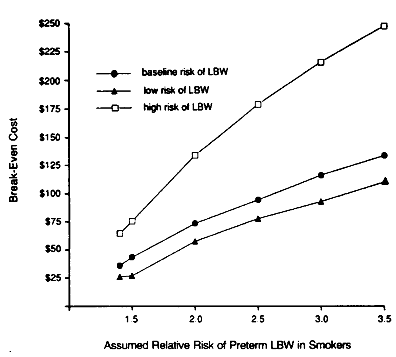

FIGURE 4—Estimated break-even cost of a program for smoking cessation during pregnancy for different assumptions about the relative risk of preterm LBW and several estimates of the background incidence of preterm LBW, considering both infant and maternal outcomes and using baseline assumptions for all other variables.

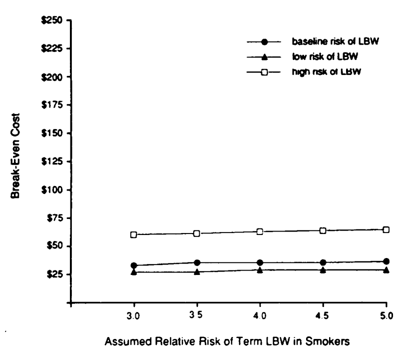

FIGURE 5—Estimated break-even cost of a program for smoking cessation during pregnancy for different assumptions about the relative risk of term LBW and several estimates of the background incidence of preterm LBW, considering both infant and maternal outcomes and using baseline assumptions for all other variables.

the relative risk of preterm LBW in continuing smokers (Figure 4). If the relative risk of preterm LBW in smokers is 3.0, as has been reported in one study of an urban Black population with a high background incidence of preterm LBW,[4] the break-even cost is $215 per woman. The estimated break-even cost does not depend on assumptions about the relative risk of term LBW in smokers (Figure 5).

TABLE 4—Estimated Break-Even Cost for Several Assumptions about the Cost of Various Outcomes, under Baseline Assumptions, Considering Both Maternal and Infant Outcomes

	Infant	Maternal	Net Cost ($)
Baseline	35	(−3)	32
Preterm LBW 50%	19	(−3)	16
Preterm LBW 200%	67	(−3)	64
Term LBW 50%	30	(−3)	27
Term LBW 200%	46	(−3)	43
Preeclampsia 50%	35	(+5)	40
Preeclampsia 200%	35	(−19)	16
Hemorrhage 50%	35	(−4)	31
Hemorrhage 200%	35	(−1)	34

As might be anticipated, assumptions about the effectiveness of the smoking cessation program influence estimates of the break-even cost. If the rate of smoking cessation were as low as 10% as a result of the program, the break-even cost drops to $12 per woman; however, if the program results in a net rate of smoking cessation as high as 29%, the break-even cost is $41.

Assumptions about the cost of care for a preterm LBW infant affect the estimate of the break-even cost more than assumptions about the cost of medical care for term LBW infants or for either of the maternal complications whose risk is increased in smokers (Table 4). No reasonable estimate of the cost of medical care for preeclampsia results in a net increase in expenditures when both infant and maternal outcomes are considered.

Discussion

Our analysis shows that, even when considering only direct medical charges related to hospitalization at delivery, a smoking cessation program that invests $32 for every pregnant woman seen in the facility would still break even economically in the short term. The number of dollars that could be invested in a smoking cessation program and still allow the program to break even is greater for populations with higher incidences of LBW, greater relative risks of LBW in smokers, and higher prevalence of smoking than the national average. However, at every level of LBW and of smoking prevalence found in the literature, money could be invested in a smoking cessation program and the program would still break even.

It should be noted that, consistent with the program perspective of our analysis described earlier, our "per patient" cost estimates apply to a cost for all patients, combining smokers and nonsmokers. To obtain the amount that could be invested per smoker, the "per patient" cost is divided by the prevalence of smoking in the population (e.g., in a baseline population with a smoking prevalence of 25%, $32/.25, or $128.00, could be spent for each smoker).

The largest cost associated with medical care of pregnant smokers and their infants is for infant care and not for care of maternal complications. There are three reasons for this. First, adverse infant outcomes are more common in smokers than are adverse maternal outcomes. Second, charges for adverse infant outcomes are much higher than those for maternal complications. Third, preeclampsia is less common in smokers than in nonsmokers.

The estimate of a break-even cost was most sensitive to assumptions about the incidence of preterm LBW and the relative risk for preterm LBW for smokers. For instance, in a population studied recently with a high incidence of and high relative risk for preterm LBW, the break-even cost was $237.[4] Although the prevalence of smoking at the first prenatal visit and the success rate of the formal smoking cessation program also affected the cost analysis, within the range of probabilities in the literature they did not produce as much variability in the break-even cost.

The break-even cost is moderately influenced by the quit rate for smokers attributable to the program, a rate that has varied considerably for programs studied.[6–8,12] Our baseline analysis is derived from a fairly optimistic quit rate of 23% obtained from an intensive intervention program for pregnant women that included one home visit, one telephone call per month, and twice-per-month mailings of smoking cessation literature.[7] More modest quit rates of 12% to 13.6% were obtained by programs that included only short health education sessions and printed materials.[6,8] These more modest programs cost only $7.13 to $11 per pregnant smoker,[8,33] an amount below our calculated break-even cost when we substituted these quit rates into our analysis.

There are several important limitations to our study. First, we included only medical charges for the hospital admission for delivery and in-hospital charges for the neonate after delivery; therefore, our estimates are conservative. Second, we used local charge data because they are precise for LBW diagnoses. However, in our sensitivity analysis, we varied charges for each diagnosis from 50% to 200% of the mean charge, figures that include the charges for services at most US hospitals.[30] Last, we included only direct medical costs in our analysis. Cost analyses of other conditions often include indirect costs to society associated with years of potential life lost per premature death[34,35] and days of work lost due to illness.[34,36] Moreover, some studies have shown increased infant mortality in babies of smokers.[37,38] Still others suggest that children of smokers may have deficiencies in growth, intellectual development, and behavior[39–41] or an increased risk of otitis media.[42,43] Again, not considering these other adverse effects of smoking in pregnancy makes our analysis conservative.

A recent cost-effectiveness analysis was done by Marks et al.,[9] who hypothesized that $30 per pregnant smoker could be spent for a model smoking cessation program; with a 15% cessation rate, this would cost $23 505 300 nationally per year, or $4000 per LBW baby averted. The study compared this figure with NICU costs for LBW babies of smokers and surmised that the program would save $3.31 for every $1 invested. This ratio would increase to over $6 saved for every $1 spent if the costs of long-term care for infants with disabilities secondary to LBW were included. Although this study differed from the present analysis in several ways, the major difference was one of perspective: their analysis calculated the costs for a smoking cessation program nationally and compared them with the costs of care for LBW infants; our study takes a program perspective.

Importantly, our analysis includes a way of determining which variables the analysis is most sensitive to, and it provides a way for planners to input their own values for these population variables. Both our study and the Marks et al. study, as well as the HMO study mentioned earlier,[10] conclude that smoking cessation programs in pregnancy are cost-effective, whether from a national or a program perspective. Our analysis adds a dimension that allows program planners to determine how much to spend on these programs.

Program planners and administrators can use our analytic framework along with their own data to help decide how much to invest in a smoking cessation program. However, planners may want to consider factors other than the immediate break-even cost in their decision to include a smoking cessation program in their prenatal care. Considering the other long-range adverse medical, psychological, and societal outcomes of smoking, planners and society should be willing to invest in smoking cessation programs for pregnant women, regardless of their direct benefit of saving money. □

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Finding Fault before Drilling: A Solution for Avoiding Radon

Dr. Irina Cech calls it a $2 solution. It's a solution, however, that could add up to a great deal of financial and health savings, not to mention saving headaches, particularly for those concerned with developing public water supplies.

Cech, professor of environmental health sciences and hydrology at the School of Public Health of The University of Texas Health Science Center at Houston, has some simple advice: to avoid a radon-contaminated well, don't drill within 4 miles from a salt dome, fault, or areas known or suspected to have uranium deposits.

Radon is a radioactive byproduct of uranium decay. Because it is odorless and colorless, there is nothing to alert well drillers or household residents unless testing occurs, Cech said.

"It is very costly to drill a well only to find out that the radon concentration is too high. By examining the area for fault lines before drilling, the problem can be avoided," she said.

Cech said uranium deposits appear primarily along the coastline of Texas, but dot other areas of the state as well. Radon deposits also collect along the flanks of salt domes, also common to the coastal areas. She said faults in the domes allow radon to "leak" upward. If an aquifer, or underground layer of earth saturated with water, happens to lie above or near a salt dome, radon may enter the water supply through the faults.

To date, Cech and her students have gathered almost 1000 water samples in Texas from public and individually owned domestic water wells and surface sources, along with wells used for livestock watering, industrial purposes, and oil production. Although radon can escape through the soil and seep through foundation cracks, in Texas it is primarily found in the water supply, Cech explained.

"Concentrations of radon were particularly high in public water wells along the Gulf Coast and in parts of west-central Texas," she said, explaining that the same area has one of the highest rates for respiratory cancer mortality in the nation.

"What we found was very interesting. When wells are developed around faults, a greater likelihood exists for encountering radon," she said.

The maximum acceptable limit of radon concentration in public drinking water that the Environmental Protection Agency has proposed is 300 pCi/L. According to the EPA, the lifetime risk of developing lung cancer from household water that contains 10 000 pCi/L of radon is roughly 3 to 13 in 1000.

"About 50% of the public water supplies measured by our group exceed the recommended standards. The highest concentration, 22 000 pCi/L, was found in southwest Texas near Refugio. In Houston, the highest observed was 6000 pCi/L," she said.

"This is of concern but should not be cause for alarm since radon levels are correctable," she said, explaining that public utilities will have until 1996 to meet the EPA requirements. Aerating the water supply would allow radon to escape before the water is piped to homes and businesses.

Radon in water is a problem only when the chemical is released from the water and enters household air. As one breathes, the radon breaks down further, causing small bursts of energy that can damage lung tissue. The chemical is released, for example, when people wash dishes and clothes, take showers, and flush toilets.

"Radon is more likely to be present in homes that are heavily insulated and airtight, which is extremely common in Texas. Drinking the water is not considered as much of a hazard as breathing the radon," she said. Economical ways to reduce risk from radon are to increase air flow in and out of the house and to refrain from smoking (scientific evidence indicates that smoking may increase the risk of exposure to radon).

Because radon appears primarily along the coastal borders, it is believed that similar situations exist in other parts of the world.