Repeated Tobacco-Use Screening and Intervention in Clinical Practice

Health Impact and Cost Effectiveness

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Background: This report updates 2001 estimates of disease burden prevented and cost effectiveness of tobacco-use screening and brief intervention relative to that of other clinical preventive services. It also addresses repeated counseling because the literature has focused on single episodes of treatment, while in reality that is neither desirable nor likely.

Methods: Literature searches led to four models for calculating the clinically preventable burden of deaths and morbidity from smoking as well as the cost effectiveness of providing the service annually over time. The same methods were used in similar calculations for other preventive services to facilitate comparison.

Results: Using methods consistent with existing literature for this service, an estimated 190,000 undiscounted quality-adjusted life years (QALYs) are saved at a cost of $1100 per QALY saved (discounted). These estimates exclude financial savings from smoking-attributable disease prevented and use the average 12-month quit rate in clinical practice for tobacco screening and brief cessation counseling with cessation medications (5.0%) and without (2.4%). Including the savings of prevented smoking-attributable disease and using the effectiveness of repeated interventions over the lifetime of smokers (23.1%), 2.47 million QALYs are saved at a cost savings of $500 per smoker who receives the service.

Conclusions: This analysis makes repeated clinical tobacco-cessation counseling one of the three most important and cost-effective preventive services that can be provided in medical practice. Greater efforts are needed to achieve more of this potential value by increasing current low levels of performance.

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Introduction

Tobacco use is the most important and frequent cause of death, morbidity, and healthcare costs, causing 435,000 deaths in the United States, or 18.1% of the total in 2000.[1] Published evidence and the 2000 Public Health Service (PHS) guideline confirm that identifying smokers and providing them with brief advice and cessation assistance in clinical practice are both very effective and cost effective.[2] The *Guide to Community Preventive Services* has strongly recommended multicomponent efforts to improve the delivery of brief primary care clinical cessation support, based on its review of the evidence.[3]

Most importantly for this analysis, the U.S. Preventive Services Task Force (USPSTF)[4] in 2003 said that it "strongly recommends that clinicians screen all adults for tobacco use and provide tobacco-cessation interventions for those who use tobacco products (A Recommendation)." The Task Force "found good evidence that brief smoking cessation interventions, including screening, brief behavioral counseling (less than 3 minutes), and pharmacotherapy delivered in primary care settings, are effective in increasing the proportion of smokers who successfully quit smoking and remain abstinent after 1 year." This is the only USPSTF counseling recommendation with an A rating.

The problem is that despite an increase in the delivery of smoking-cessation services, the level of service in medical practice is still well below the optimum level. The specific behaviors recommended in the PHS guideline are known as the 5A's for: ask about tobacco use at every visit, advise to quit, assess willingness to make a quit attempt, assist with counseling and pharmacotherapy, and arrange follow-up.[2] National benchmark rates are those provided by nonprofit staff-model health plans—and they show considerably higher rates of cessation advice than assistance. In a recent study, while 71% of 4207 smokers enrolled in such plans

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reported that they had been advised to quit at least once over the past year, 56% were assessed, 49% received some form of assistance, only 38% were offered pharmacotherapy, and only 9% received a recommendation for follow-up.[5] Since most members make at least three to four office visits per year, the actual rates of these actions at each visit are clearly much less. It is also helpful to know that 68% of these smokers reported intending to quit in the next 6 months, 27% had asked for help with quitting, and 82% wanted their physicians to discuss smoking cessation often or at every visit. National data from Health Plan Employer Data and Information Set (HEDIS) or the National Health Interview Survey show much lower rates.[6,7] More typical of rates in most practices are those reported by smokers in the Community Intervention Trial for Smoking Cessation (COMMIT) community trial, with 75% reporting being asked, 49% advised, and 25% offered pharmacotherapy in the past year.[8] Thus, there is ample room and need for improvement.

Although there are many published studies of the effectiveness of various smoking-cessation interventions in the literature and almost as many studies of their cost effectiveness, these two issues have not been addressed simultaneously, and none has studied the long-term effects of the repeated counseling interventions recommended by the USPSTF and the PHS. Moreover, these studies have not been performed in a way that would permit direct comparison of their results with the other preventive services recommended by the USPSTF. With the exception of a single study of providing insurance coverage for bupropion,[9] the literature assesses the cost effectiveness of one-time interventions,[10–37] although in practice, cessation counseling should be delivered repeatedly over multiple years for continuing smokers. Other services, such as cancer screening and childhood immunizations, are evaluated on the basis of repeated interventions at recommended intervals, not on the basis of a one-time intervention. In addition, the vast majority of cost-effectiveness estimates in U.S. populations exclude the cost savings from prevented tobacco-attributable illness,[9–18,20–22,25] although that is rarely the case for other preventive services. Although data on the effectiveness of repeated counseling are limited, providing the best possible analysis of the health benefits and cost-effectiveness of repeated tobacco-use screening and intervention is necessary to provide decision makers with information that is comparable to that available for other recommended preventive services. This update with improved methods to Partnership for Prevention's 2001 ranking of 30 clinical preventive services is important for its potential to better understand the comparative value of tobacco-cessation interventions and thereby to stimulate greater efforts to improve delivery rates.[38] Using new data and a more detailed model than was used for the 2001 ranking, this article presents the details of new estimates of the clinically preventable burden (CPB) and cost effectiveness of tobacco-use screening and brief interventions for the companion article that ranks USPSTF clinical preventive services.[39]

Methods

A detailed description of the generic study methods is also available in a companion article and a more detailed technical report is available online.[38,40,41] These methods were designed to ensure consistency in calculating the two components of the estimate used in the ranking: (1) CPB as a measure of health impact and (2) cost effectiveness of delivering each service. This section focuses on the specific methodologic issues for each calculation that are unique to repeated tobacco-use screening and brief intervention.

The literature review and model were limited to counseling interventions that could be conducted and were tested in primary care practices on most of their smoking patients. However, the literature review did not strictly follow the USPSTF guideline of a 3-minute intervention because the time needed for each intervention studied is not clearly described in the trials. Therefore, all brief interventions that were clearly feasible because they were tested in busy practices under real-life conditions were included. Studies of more intensive counseling or of interventions involving many counseling or reinforcement contacts as a part of follow-up after the original intervention were excluded from the literature review and are not represented in this model. All included studies assessed interventions initiated by primary care clinicians during office visits for any reason by their regular adult patients. Therefore, studies focusing on quit lines or mailed interventions were excluded, but studies referring for external services or with a brief follow-up were included.

To facilitate comparisons of these results with existing estimates, four alternative models were estimated. Model 1 analyzes one-time counseling and excludes savings from illness prevented; this model is most comparable to the existing literature. Model 2 incorporates savings from prevented smoking-attributable illness into Model 1 in order to evaluate how the results of current models may differ if savings were included. Model 3 estimates repeated annual counseling without savings. Finally, Model 4, the base-case model for the ranking of preventive services, analyzes annual counseling and incorporates savings from prevented tobacco-associated illness. All results are presented as the increment to quits seen in the usual-care control arms of the studies. Following these study methods, cost effectiveness results are reported in year-2000 dollars and all costs and benefits are discounted at 3% annually.

Evidence Gathering

The effectiveness literature search began with the extensive meta-analyses and references conducted as part of the PHS guideline, *Treating Tobacco Use and Dependence*.[2] The 163 articles in their 23 meta-analyses included studies published through 1998. Another 595 reports of clinical trials from Level 1 and two searches[40,41] of PubMed between January 1999 and April 2004 and 505 reports of observational studies were added. Only 255 of these articles met the criteria of

practice relevance. (References are available in the technical report online at prevent.org/ncpp.) These were further reduced to 23 studies for abstraction based on the requirements that a study must have a control group, include ≥50 smokers in each study arm, analyze smoking cessation as an outcome, and provide follow-up of ≥9 months. During the adjudication process, three of these 23 articles were found to have important deficiencies that made them unusable for these purposes.[42–44] The other 20 were used in the effectiveness analysis.[45–64]

The search for cost-effectiveness articles involved Level 1 and 2 searches[40,41] from January 1992 through March 2005. The 1252 articles that were found plus others identified in their references were reduced to 68 articles on the costs of smoking or the cost effectiveness of cessation interventions for the general population (references available online in technical report) and then to 17 that compared smoking-cessation intervention costs to benefits in U.S. settings.[9–25] No articles were abstracted because none provided estimates of the cost effectiveness of counseling delivered repeatedly over multiple years.

Model Population

Clinically preventable burden is the population burden addressed by the service multiplied by the effectiveness of the service if all smokers received the service annually over their lifetimes. It is measured as quality-adjusted life years (QALYs) saved in order to measure the combined impact of morbidity and premature death.[65] Although based on the delivery of the service to a 1-year U.S. birth cohort of 4 million individuals over their adult years, the number of ever smokers had to be estimated from available cross-sectional data in which smoking prevalence differs among the birth cohorts represented in the cross-section. In the base case, the CPB and cost effectiveness were estimated for the ever smokers among current 35- to 44-year-olds, while ever smokers among 24- to 35-year-olds and 45- to 55-year-olds were used in sensitivity analyses.[66]

Model Variables

The variables used in the model are shown in Table 1. The base-case column shows either the point estimate for the variable or the result of a calculation based on other data in the table. The source column in Table 1 shows the literature sources or the calculation formula for data points that are calculated within the table. The letters in the formula refer to the row labels in the leftmost column for the data points on which the calculation is made. The derivations of these formulas are explained in the online technical report (prevent.org/ncpp). The range column shows the range over which the point estimates were varied in the sensitivity analysis.

Benefits of quitting. Average gains in life expectancy from quitting smoking were estimated from the National Health Interview Survey and National Mortality Feedback Survey data used for never, current, and former smokers by Rogers and Powell-Griner,[67] and from the 14-year prospective study of 1.2 million U.S. residents by Taylor et al.[68] The age distribution of people who reported in the 2003 Behavioral Risk Factor Surveillance Survey (BRFSS) that they had stopped smoking for ≥1 day was used to calculate a weighted average from the age-stratified results from these two surveys. The average of these two studies was used in the base case.

The gains in quality of life from reduced morbidity for current smokers (row b in Table 1) were estimated as the difference in quality of life between current and former smokers. Given the available data, the first step in this calculation was to determine quality-of-life decrements (QALYs lost) among all ever smokers (current and former) due to smoking-attributable (SA) morbidity (row c). This was calculated following study methods as outlined in Appendix A (see appendix online).

Next, the QALYs lost among current smokers (row d) were calculated from the data points in the next two rows, using the formula shown in the source column for row d.

The relative risk of all smoking-attributable diseases for current smokers compared to former smokers (row e) is not directly known. However, if smokers have the same costs per case as former smokers, the relative risk of diseases should be similar to their relative expenditures on smoking-attributable disease. Similarly, if smokers have the same case-fatality rates as former smokers, the relative risk for disease should be similar to the relative risk of mortality. It is not clear which of these better approximates the relative risk of disease, and therefore the average of the two measures was used. The relative risk of smoking-attributable expenditures was calculated from a single study that reported total charges for current, former, and never smokers according to smoking status.[69] In comparing current smokers to former smokers who had quit for ≥5 years, the relative cost of smoking-attributable charges was estimated to be 0.535. Estimates for those who had quit for ≥5 years were used in order to exclude former smokers who had quit following illness. Similarly, the relative risk of mortality from three studies that used different data sources and reported the mortality risk for current, former, and never smokers were used: the American Cancer Society CPS II study,[68] National Center for Health Statistics surveys,[70] and a prospective observational study of British doctors.[71] The average relative mortality risk calculated from these three studies is 0.249 (range 0.20 to 0.30). The average of the relative smoking-attributable expenditures (0.535) and the relative risk of smoking-attributable mortality (0.249) is 0.392 (row e). In sensitivity analyses, this estimate was varied from the lowest estimate from the mortality studies (0.20) to a high estimate of relative smoking-attributable expenditures (0.56) that was calculated from the average of relative expenditures of three studies that were not used for the base-case estimate.[72–74]

Effectiveness of counseling. The long-term effectiveness of one-time counseling (row g) is derived from four variables: the 12-month quit rate of counseling alone (row h), the 12-month quit rate with use of pharmacologic cessation aid (row i), the portion of those counseled who reported using a cessation medication (row k), and the relapse rate among 12-month abstainers (row l). The 12-month quit rates are the mean results of included counseling studies with[48,50,54,55,58,64] and without[45,46,51–53,56–62] smoking-cessation medications. For the portion of those counseled who also used a smoking-cessation medication, the result from a submodel was used (16.3%) because published data were not found on the use of cessation medications among individuals who were advised to quit that could be generalized to all

Table 1. Model variables

	Data points 1 (all but morbidity calculations)	Base case	Source	Range
a	Average LYs gained per additional long-term quit	5.65	CDC (2005)[66], Rogers (1991)[67], Taylor (2002)[68]	±25%
b	Average QALYs gained from avoided morbidity per additional long-term quit	0.353	= d − d*e	
c	QALYs lost to SA illness per ever smoker	0.398	Appendix A	±50%
d	QALYs lost to morbidity per current smoker	0.581	= c / (e*f + (1 − f))	
e	Relative risk of SA disease, former compared to current smokers	0.392	Musich (2003)[69], Rosenbaum (1998)[70], Doll (2004)[71], Kiiskinen (2002)[72], Pronk (1999)[73], Terry (1998)[74]	0.20 to 0.56
f	Portion of ever smokers who are former smokers	51.9%	CDC (2005)[66]	±5%-points
g	Long-term effectiveness of one-time counseling	1.8%	= (h*(1 − j) + i*j) * (1 − k)	
h	12-month quit rate with counseling alone	2.4%	Hollis (1993)[45], Segnan (1991)[46], Curry (2003)[51], Burton (1995)[52], Russell (1987)[53], Slama (1990)[56], Jamrozik (1984)[57], Russell (1983)[58], Russell (1979)[59], Demers (1990)[60], Stewart (1982)[61], Tonnesen (1996)[62]	1% to 4%
i	12-month marginal quit rate with counseling plus cessation medication	5.0%	Killen (1997)[48], Pieterse (2001)[50], ICRF (1994)[54], Daughton (1998)[55], Russell (1983)[58], Grandes (2000)[64]	2% to 8%
j	Portion counseled who use a cessation medication	16.3%	Submodel	10% to 30%
k	Relapse rate for 12-month quitters	37%	OSH (1990)[77]	25% to 50%
l	Long-term effectiveness of annual counseling in inducing additional quits among ever smokers	23.1%	Submodel, Appendix B	2.8% to 46.2%
m	Cost of 10-minute office visit	$ 44	Ingenix (2004)[78]	±33%
n	Cost of patient time and travel for office visit	$ 42	BLS (2002)[79]	±50%
o	Portion of office visit used for counseling	25%	Assumed	10% to 50%
p	Total cost of counseling per occasion	$ 22	= (m + n)*o	
q	Average cost of smoking-cessation aids per quit attempt	$ 170	See text	±25%
r	Annual cost savings per additional year as former smoker	$ 912	= t − v	
s	PHE 19+ in 2000	$6957	Keehan (2004)[85], Hoffman (2001)[86]	±20%
t	Average annual PHE of current smokers	$8291	= u / ((1 − y)*w + aa*x + z)	
u	Average annual PHE of never smokers	$6329	= w*t	
v	Average annual PHE of former smokers	$7379	= u/x	
w	Ratio of average PHE, never compared to current smokers	0.76	Musich (2003)[69]	0.65 to 0.85
x	Ratio of average PHE, never compared to former smokers	0.86	Musich (2003)[69]	0.75 to 0.95
y	Ever smokers as % population	0.466	CDC (2005)[66]	0.40 to 0.55
z	Current smokers as % population	0.224	CDC (2005)[66]	0.20 to 0.27
aa	Former smokers as % population	0.242	= y − zz	

BLS, Bureau of Labor Statistics; CDC, Centers for Disease Control and Prevention; ICRF, Imperial Cancer Research Fund; OSH, Office on Smoking and Health; LY, life year; PHE, per capita health expenditures; QALY, quality-adjusted life year; SA, smoking-attributable.

smokers in primary care settings. This estimate was measured among all counseled smokers, including those who do not make a quit attempt, and reflects nonadherence with clinician recommendations to use a smoking-cessation aid. The most important data underlying the submodel result are estimates of the use of smoking-cessation aids among smokers who made a quit attempt in 1996[75] and 2001.[76] The relapse rate for 12-month abstainers was obtained from a review.[77]

Unfortunately, there is no evidence on the effectiveness of repeated counseling. It is not known whether counseling in subsequent years has equal, lesser, or greater effect than initial counseling. Therefore, a reasonable extrapolation was needed of the 12-month rate to what would result from repeated delivery over the lifetime of smokers. Lacking any individual-level data for this task, national data were used to estimate a submodel. The submodel answers the question: "What long-term quit rate for repeated counseling is consistent with (1) trends in counseling delivery rates, (2) trends in total quits among smokers, (3) trends in spontaneous quits, and (4) the 12-month effectiveness of one-time counseling with and without cessation aids?" The structure of the submodel is described in Appendix B (see appendix online). The data used in the submodel, its sensitivity, and its limitations are described in the technical report for this service.[41] It is

Table 2. CPB and CE of one-time and annual tobacco-use screening and intervention

	Model 1	Model 2	Model 3	Model 4
Counseling frequency	One-time	One-time	Annual	Annual
Cost savings from prevented SA illness	Excluded	Included	Excluded	Included
Additional quits among ever smokers (% of ever smokers)	1.8%	1.8%	23.1%	23.1%
Average gain in QALYs per smoker counseled, undiscounted	0.11	0.11	1.39	1.39
Average lifetime costs of counseling and cessation medication per ever smoker counseled, undiscounted	$ 49	$ 49	$1,308	$ 1,308
Average lifetime savings per additional long-term quit, undiscounted	$ 0	$22,434	$ 0	$22,434
Average lifetime savings per ever smoker counseled, undiscounted	$ 0	$ 399	$ 0	$ 5,188
Average gain in QALYs per smoker counseled, discounted	0.021	0.021	0.268	0.268
Average lifetime costs of counseling and cessation medication per ever smoker counseled, discounted	$ 23	$ 23	$ 607	$ 607
Average savings per ever smoker counseled, discounted	$ 0	$ 88	$ 0	$ 1,149
CPB (undiscounted QALYs saved)	190,262	190,262	2,473,996	2,473,996
Net cost per ever smoker counseled, discounted	$ 23	$ −65	$ 607	$ −542
CE $/QALY saved	1,110	n.d.	2,266	n.d.

CE, cost effectiveness; CPB, clinically preventable burden; n.d., CE ratio is not defined because discounted net costs are negative; QALY, quality-adjusted life year; SA, smoking-attributable.

important to know that the submodel proved to be very sensitive to key data points. Therefore, the base-case result of the submodel (23.1% quit rate, row l) was calculated using conservative assumptions for those data points.

Costs of counseling. The costs of counseling include clinician time for counseling, smoking-cessation medication use, and patient time and travel for clinician visits. It was assumed that, on average, 25% of a 10-minute office visit would be used to counsel patients according to the 5A's, with some patients not receiving more than initial cessation advice and others receiving recommended brief counseling and medication along with follow-up contacts. The cost of an office visit was calculated as the average of Medicare reimbursement and 75% of the median of private-sector charges.[78] The costs of patient time and travel for a visit were estimated as 2 hours of time valued at the average hourly earnings and benefits.[79]

The average costs of all prescription fills over a 6-month period were estimated from the initial prescription for a cessation medication (nicotine replacement therapy or bupropion) in a sample of 650 health plan members with a pharmacy benefit who filled at least one prescription. An average cost of $170 is based on 80% of the year 2000 average wholesale price for prescriptions plus a $7 fill fee.

Savings from quitting. Although healthcare costs of current smokers are higher than those of former smokers during the 3 to 5 years after cessation, former smokers often have higher costs than current smokers[73,80] shortly after cessation.[69,74,81,82] This has been attributed to smokers who quit due to illness.[83,84] The goal of repeated counseling is to induce and assist quits before the onset of smoking-attributable illness. Therefore, the best comparison for estimating the cost savings attributable to counseling is between healthy quitters and continuing smokers.

Musich et al.[69] reported total healthcare charges at various times since quitting in a national sample of General Motors employees. Healthcare charges in this population may provide a poor estimate of the absolute costs of care of current and former smokers in the general U.S. population. Therefore, these charges were used to estimate the ratio of personal health expenditures (PHE) of never smokers relative to those of 5-year quitters and current smokers for persons aged ≥19 years.[85,86] Therefore, it is assumed that most smokers who quit as a result of counseling do so before symptoms of smoking-attributable disease. Smoking status was obtained from the BRFSS[66] for rows z to bb. To check the calculated costs of current and former smokers, the estimates were used to calculate the implied percentage of PHE that is attributable to smoking. That percentage was then compared to four published estimates that were derived from different models.[80,87–89] The result from this calculation (9.9%) was very similar to the mean of the four published estimates (9.7%, range 6.5% to 14.0%).

Results

Table 2 shows results for the four models. The results of Models 1 and 2, with effectiveness of one-time counseling, produced a CPB of 190,000 QALYs—a large enough health impact to be among the top half for evidence-based preventive services. Models 3 and 4,

based on the effectiveness of repeated counseling, produced a CPB of 2.47 million QALYs—a large enough health impact to be among the top three evidence-based preventive services.

Model 1 most closely resembles existing estimates of the cost effectiveness of tobacco-cessation counseling in the United States. Using it, brief one-time tobacco-cessation counseling appears extremely cost effective at $1100/QALY saved. When the financial savings from prevented illnesses are added (Model 2), one-time counseling proves to save $65 per smoker counseled despite an effectiveness of only 1.8%.

Repeated counseling is also very cost effective ($2000/QALY saved) when the cost offsets of financial savings from prevented illness are excluded (Model 3), and is estimated to save >$500 per smoker counseled when these savings are included (Model 4).

As modeled following the current literature, tobacco-cessation counseling is one of the ten most cost-effective services. As modeled to provide estimates comparable to other preventive services, tobacco-cessation counseling is cost saving, and is among the three highest-priority services.

Sensitivity Analysis

The total of 0.398 QALYs lost per ever smoker is entered in Table 1 as the key measure in adding morbidity to the calculation of CPB. However, because years of life gained with counseling far exceed health years of life equivalents from reduced illness, any variables that are specific to estimating quality-of-life gains have little influence on the estimate of CPB. In contrast, CPB is moderately sensitive to changes in the life years saved by cessation and highly sensitive to changes in the long-term effectiveness of repeated advice. In multivariate sensitivity analyses conducted according to study methods,[41,65] an extremely wide CPB range of 231,000 to 9.17 million QALYs saved was obtained. This wide range is not as problematic to the ranking as it may first appear, because even the lower-bound estimate places tobacco-cessation counseling among the services with the highest CPB.

Cost effectiveness is highly sensitive to the effectiveness of repeated advice and the ratio of personal health expenditures of former smokers compared to current smokers. Cost effectiveness is moderately sensitive to the cost of smoking-cessation medications, the portion of those screened and counseled who use a medication, and average personal healthcare expenditures for all individuals. Multivariate sensitivity analysis thus found lifetime savings as great as $9800 per smoker counseled, and cost-effectiveness ratios up to $28,000 per QALY saved.

The most important and least certain data point in these calculations is the effectiveness of repeated intervention. The threshold value of effectiveness for repeated screening and intervention to produce cost savings is 12.2%. Although this is half of the base-case estimate (23.1%), and the base-case estimate was generated using conservative parameter estimates in the submodel, the instability of the submodel makes it impossible to definitively say that repeated primary care tobacco-use screening and intervention is cost saving. These estimates of the effectiveness of one-time counseling with and without smoking-cessation medications are comparable to similar reviews.[2,90,91] Unfortunately, there are no estimates in the literature with which to compare this modeled estimate of the effectiveness of repeated intervention.

Discussion

Applying these standardized methods for calculating CPB and cost effectiveness results in such high estimates that smoking-cessation counseling with offers of medication prescription is clearly one of the most important clinical preventive services, even at the seemingly low rate of effectiveness at 12 months of 2.4% to 5.0%. Measured as percent of burden of disease prevented, the cumulative effectiveness of repeated annual tobacco-use screening and intervention may be similar to that of annual fecal occult blood test screening, annual influenza immunizations, biennial mammography screening, and cholesterol measurement every 5 years. Thus, physicians who feel discouraged about their low absolute one-time success rate should take heart from these findings and take steps to ensure the maximum consistent intervention with all of their patients who smoke.

As noted earlier, it is clear that the current delivery rates of this service are well below what is desirable and would be effective, especially for the assist and arrange portions of the 5A's in the PHS tobacco guideline. Over the last 15 years, it has become increasingly clear that the way to accomplish that task is for medical practices to establish a system[92–97] with the following integrated components:

1. Include smoking status as a vital sign for collection by the nurse interviewing each patient who does not already have a marker or other information of being a long-term nonsmoker.[98]
2. Use a chart marker or computer prompt to remind the clinician of the need to discuss smoking.[99]
3. Provide clinicians with a clear but time-limited role to assess interest in quitting, encourage quitting for those not currently interested, and encourage use of cessation medications and follow-up.[95]
4. If the quitter needs more information about particular problems with quitting or how to use the medications effectively, provide alternative systematic ways to obtain it without requiring clinician time, such as having an office nurse or educator

provide this information, or referral to a telephone quit line or other counseling resource.[95]
5. Automatically provide follow-up phone calls by a nurse or educator for those on medications or who have set a quit date.
6. Ideally, have a flow sheet in the chart or computer record so that the clinician can see a summary of past smoking discussions and quit attempts.

Such a system also fulfills each of the components of the chronic care model by Glasgow et al.,[100] which reinforces the emerging view of smoking as another chronic condition. The importance of building it as an integrated system has been reinforced by studies showing that having only one of the components noted above (e.g., smoking as a vital sign) fails to increase all recommended counseling actions.[98,101] Studies have also demonstrated the infrequency of even those individual components in typical practice settings.[102,103] With a system like this, one clinic found that 25% of its smokers had quit at 1 year, a rate equal to the calculated lifetime quit rate and twice the average found in the intervention arm of randomized trials.[104]

Despite the high ranking for this service that warrants establishing such practice systems, there are certainly limitations in the estimates. For example, CPB and cost-effectiveness estimates are limited by uncertain data points. The most troublesome problem is the lack of controlled trials and observational studies of the effectiveness of repeated, long-term counseling in prompting smokers to quit. The submodel built to address this piece of missing data produces a wide range of estimates. Although a base-case estimate for repeated counseling derived from conservative parameters in the submodel was used, high instability of the submodel around key data points prevents us from being certain that the base-case estimate itself is conservative. Therefore, caution must be used in interpreting and applying these results. The important point to understand is that these effectiveness, CPB, and cost-effectiveness estimates are not based on short-term counseling as typically evaluated in the literature.

The literature and data used to derive the effectiveness of both one-time and repeated counseling include some smokers who may have been more highly motivated to quit due to symptoms of smoking-attributable illness. In estimating the health and financial benefits of quitting, it was implicitly assumed that the majority of quits attributable to counseling were among healthy smokers. The use of these estimates with the estimated effectiveness data may cause the benefits of quitting to be overstated. However, the effectiveness estimates were estimated as the incremental effect relative to spontaneous quits. It is expected that the impact of ill quitters on incremental quits will be smaller than the impact on total quits.

Several offsetting factors were not included in the model, and have been excluded from virtually all cost-effectiveness models of cessation: the cost of cigarettes, the time costs of smoking and efforts to quit, and changes to daily quality of life due to initial withdrawal and reduction in smoking. The willingness to purchase cigarettes and commit time to smoking may be an indicator of the enjoyment of smoking. If this is the case, it would be inappropriate to include savings from reduced cigarette expenditures without the associated loss of enjoyment in terms of a small daily quality-of-life reduction. On the other hand, smoking is addictive, and therefore any enjoyment of smoking may not fully explain the willingness to expend personal resources on it. We chose to exclude these factors rather than quantifying assumptions about the enjoyment of smoking and the pain of withdrawal in a QALY measure. This does make it less likely to conclude that screening and brief intervention are cost saving. Cigarette purchases may exceed $500 annually even after excluding taxes when performing an analysis from the societal perspective.

The estimates from Model 1 are consistent with the existing literature. This literature search identified 17 economic evaluations with settings in the United States that compare the costs and effects of counseling, cessation aids, changes to insurance benefits, and mailed, phone, or Internet interventions.[9–25] Thirteen of the studies excluded cost offsets from reduced expenditures on smoking-related illness,[10–18,20–22,25] and all but one[9] analyzed an intervention provided only once to individuals. In that study, the effectiveness of each quit attempt appears to have been based on the literature from one-time interventions and was assumed to be independent of previous attempts. Despite a wide variety of interventions and methods, results of the studies that exclude cost-offsets are remarkably similar. Among studies that report discounted costs per quit, the results range from $1000 to $4000 per quit, and among studies that report discounted costs per life year saved (with or without quality adjustment), the results are $1000 to $8000 per year saved. This latter range is reduced to $1000 to $2500 when more-intensive interventions and analyses of the incremental benefit of cessation aids relative to counseling are excluded.

Of the four studies that include a cost offset for tobacco-cessation counseling, only one study[23] reports results in terms of net dollars per quit or per year of life saved. In this study, Warner et al.[23] found a net cost of $4700 per life year saved of insurance coverage for smoking-cessation treatment from the perspective of a managed care organization. It appears that the study did not find coverage to be cost saving because general medical costs during the additional years of life lived attributable to providing insurance coverage were included.

Whether general medical costs not related to the intervention should be included in economic analysis is debatable. Including medical costs from increased life expectancy in some estimates of the costs of smoking[105] has sparked debate on whether smoking cessation reduces healthcare costs.[88,106,107] Most economic evaluations of tobacco interventions that provide a rationale for excluding savings from prevented smoking-attributable illness cite the conflicting evidence for lifetime savings.[12,14,27,108] The methods established to maintain consistency across services in the prevention prioritization project[40,41] exclude unrelated medical costs from cost-effectiveness analyses. While the Panel on Cost-Effectiveness in Health and Medicine (PCEHM) was ambiguous about this point of methodology,[109] unrelated medical costs were excluded here for three reasons: First, most published cost-effectiveness studies exclude costs that are unrelated to the preventive service. Therefore, with the exception of tobacco-cessation counseling, these estimates maintain comparability with existing literature. Second, from the societal perspective, there is no reason to include medical expenditures attributed to increased life expectancy, but to exclude food, housing, transportation, entertainment, or any other resource use attributable to increased life expectancy. Third, including costs associated with increased life expectancy could produce counterintuitive results such as high cost-effectiveness ratios for low-cost, effective childhood vaccinations against disease with high fatality rates.

Even if there is need for caution in taking these estimates literally, or if there is disagreement on the appropriateness of including cost savings from prevented smoking-attributable illness, there is no conceivable scenario in which smoking-cessation assistance that is consistently delivered in clinical practice settings would not be one of the most important preventive services. The challenge for this service is different—it is to find ways to ensure that it is delivered at rates and in ways that achieve the extraordinary potential benefits.

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APPENDIX A

Quality-Adjusted Life Years Lost Due to Smoking-Attributable Morbidity

Table A provides the detail for this calculation, and the total is entered in row c of Table 1. For most smoking-attributable (SA) conditions, the lifetime number of SA cases was calculated as the number of years of life lived by a birth cohort of 4 million after the age of 35 years multiplied by the SA fraction of the annual incidence of disease. For example, among adults aged 35 years and older, the annual incidence of oral cancer is 21.0 per 100,000. From life tables,[1] it was estimated that there would be 164,596,352 years of life lived after the age of 35 in a birth cohort of 4 million. An estimated 64.6% of oral cancers are attributable to smoking.[2] Thus, approximately $164{,}596{,}352 \times 0.00021 \times 0.646 = 22{,}325$ cases of SA oral cancers are predicted to occur over the lifetime of a birth cohort of 4 million. These calculations are made by age groups whenever age-specific data are available, and the weighted averages are shown in Table A. Cases for pediatric diseases and fire injuries were calculated using the number of years of life lived from birth rather than age 35.

Table A. QALYs lost to smoking-attributable morbidity

Condition	Incidence rate	SAF	SA disease	Type of incidence data	Duration (years)	QALY weight	SA QALYs lost
Cancers							
Oral cavity, pharynx	0.000210	0.646	22,325	New cases	4.3	0.2	19,200
Esophagus	0.0000949	0.681	10,644	New cases	1.8	0.3	5,748
Stomach	0.000151	0.207	5,152	New cases	3	0.2	3,091
Pancreas	0.000216	0.222	7,913	New cases	1.24	0.3	2,944
Larynx	0.0000727	0.805	9,637	New cases	2	0.3	5,782
Lung, bronchus	0.00124	0.803	163,299	New cases	2	0.3	97,979
Urinary bladder	0.000424	0.404	28,193	New cases	4.7	0.2	26,501
Kidney, renal pelvis	0.000242	0.259	10,311	New cases	4.7	0.2	9,692
Acute myeloid leukemia	0.0000788	0.170	2,204	New cases	4.6	0.2	2,028
Cervix uteri	0.000151	0.120	1,555	New cases	4	0.2	1,244
Circulatory diseases							
Ischemic heart disease	0.0147	0.164	396,975	Hospital stays	0.058	0.3	6,871
Other heart disease	0.00797	0.125	164,364	Hospital stays	0.058	0.3	2,845
Congestive heart failure	0.00387	0.125	79,859	New cases	2.3	0.2	36,735
Strokes	0.00352	0.102	58,783	First strokes	7.8	0.4	183,403
Transient ischemic attack	0.00147	0.102	24,571	Hospital stays	0.058	0.3	425
Atherosclerosis	0.000774	0.143	18,256	Hospital stays	0.058	0.3	316
Aortic aneurysm	0.000443	0.575	41,926	Hospital stays	0.058	0.3	726
Other arterial disease	0.000711	0.134	15,620	Hospital stays	0.058	0.3	270
Respiratory diseases							
Pneumonia, influenza	0.0429	0.169	1,192,136	Self-reported	0.038	0.3	13,755
Bronchitis, emphysema, chronic airways obstruction	0.00169	0.785	218,910	New cases	6.6	0.2	288,961
Injuries							
Fire injuries	0.0000485	0.25	3,596	Injuries	0.077	0.3	83
Childhood diseases							
Short gestation/low birth weight	0.0150	0.0907	5,434	Hospital stays	0.25	0.3	408
Respiratory distress syndrome	0.00815	0.0346	1,128	Hospital stays	0.167	0.3	57
Other respiratory—newborn	0.0244	0.0472	4,618	Hospital stays	0.167	0.3	231
Total							709,063
Total per ever smoker							0.398

QALY, quality-adjusted life year; SA, smoking-attributable; SAF, smoking-attributable fraction.

Smoking-attributable QALYs lost to morbidity are the product of the lifetime incidence of SA disease, the duration of disease, and the associated quality-of-life reduction (QALY weight). Continuing the example using the data in Table A for oral cancers, $4.3 \times 0.2 = 0.86$ QALYs are lost to morbidity for each case, and a total of $22{,}325 \times 0.44 = 19{,}200$ QALYs are lost to SA oral cancers over the lifetime of the birth cohort.

The annual incidence rates for the morbidity calculations in Table A come from several sources. Cancer cases are based on 2001 incidence rates, age adjusted to the 2000 population (unadjusted rates were not reported).[3] For most other conditions, 2001 hospital stays with the ICD-9 of interest listed as the primary diagnosis were used when available.[4] The exceptions follow:

- Congestive heart failure—lifetime incidence[5]
- Strokes—incidence of first strokes[6]
- Pneumonia and influenza—self-reported medically attended episodes[7]
- Bronchitis, emphysema, and chronic obstructive pulmonary disease (COPD)—incidence of COPD from the Global Burden of Disease study[8]
- Fire injuries—cases of injuries from home fires[9]

With the exception of fire injuries, the disease categories listed in Table A are those for which SA mortality is reported in the CDC's (Centers for Disease Control and Prevention) Smoking-Attributable Mortality, Morbidity, and Economic Costs (SAMMEC).[2] Mortality SA fractions (SAFs) from SAMMEC were applied to morbidity because SAFs are not available for most SA diseases.

The duration of illness for many conditions (all cancers, stroke, congestive heart failure, chronic airways obstruction) are from closely corresponding (i.e., not always identical) disease categories of the global burden of disease estimates for established market economies.[8] Incidence data on many chronic conditions were not available. When necessary, the incidence of hospital stays was used, and the morbidity calculations were treated as estimates of the quality of life lost due to acute episodes of chronic disease. For each hospital stay, a 3-week duration of illness was assigned to reflect both the hospital stay itself and subsequent recovery time. Longer durations were assigned for hospital episodes of childhood disease cases, and shorter durations were assigned to medically treated cases of influenza and pneumonia.

Estimates of the QALYs lost per year lived with an illness ("QALY weight" in Table A) are the standard ranges used in this study of 0.3 for acute conditions and 0.2 for chronic conditions.[10,11] Cancers of less than 2-year duration are treated as acute illnesses because of their low survival rates. The QALY lost per year for stroke of 0.40 (range 0.25 to 0.55) is based on published estimates from utility scales rather than the standard QALY weight for chronic conditions, because the utility scales indicate that strokes have substantially higher quality of life losses per year than most other chronic conditions.[12-18]

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APPENDIX B

Long-Term Quit Rate Submodel

A submodel was developed to answer the question, "What long-term quit rate for repeated counseling is consistent with the following?"

(a) Trends in counseling delivery rates
(b) Trends in total quits among smokers
(c) Trends in spontaneous quits
(d) The 12-month counseling effectiveness of brief to medium counseling obtained from the literature review described in the text.

Equations (1) and (2) show how the submodel determines the long-term effect of repeated counseling:

$$\text{LTMQRC} = \sum_{t=1}^{\infty} MQRC_t = MQRC_{t-1} \times e^{-\alpha t} \quad (1)$$

$$\text{LTMQRC}_{\text{RX}} = \sum_{t=1}^{\infty} MQRCRX_t = MQRCRX_{t-1} \times e^{-\alpha t} \quad (2)$$

These equations define the long-term effectiveness of repeated counseling as an exponential function of the 1-year quit rates. $LTMQRC$ and $LTMQRC_{RX}$ are the marginal long-term quit rates of brief to medium counseling with and without smoking cessation aids (respectively), and $MQRC_t$ and $MQRCRX_t$ are the marginal quit rates of brief to medium counseling with and without smoking cessation aids in the t^{th} year following the initial year of counseling. For these variables, the margin is defined as the quit rate in a population receiving repeated interventions group less the expected quit rate from self-initiated quit attempts. Self-initiated quit attempts are all quit attempts, with or without the use of smoking cessation aids that are initiated by the smoker.

In year 1, $MQRC_t$ and $MQRCRX_t$ are equal to the 12-month marginal quit rates found in our evidence review (2.4% and

5.0%, respectively). The constant e is 2.71828 (the base of the natural logarithm), and alpha is an unknown constant that is determined by the other data points in the submodel.

The long-term quit rate submodel is summarized in Equation (3). It defines the cumulative quits in a cohort of smokers starting in year t and ending in year u.

$$LTQR = \sum_{t=1}^{u} PS_{t-1} \times (SQR_t + C_t \times MQRC_t + CRX_t \times MQRCRX_t) \quad (3)$$

$LTQR$ is the observed long-term total quit rate of a cohort of smokers, including quits attributable to clinician counseling and quits not attributable to clinician counseling. PS_{t-1} is the portion of the cohort still smoking at the end of the previous year; and SQR_t is the self-initiated quit rate in year t less relapse over subsequent years (the "permanent" self-initiated quit rate). C_t is the portion of smokers who receive counseling in year t and do not use a pharmacologic smoking aid; and CRX_t is the portion of smokers receiving counseling and who do use a quit aid.

With algebraic substitutions from Equations (1) and (2), Equation (3) becomes.

$$LTQR = \sum_{t=1}^{u} PS_{t-1} \times (SQR_t + C_t \times MQRC_{t-1} \times e^{-\alpha t} + CRX_t \times MQRCRX_{t-1} \times e^{-\alpha t}) \quad (4)$$

In year 0, PS is equal to 1 (e.g., 100% of smokers are smoking at end of the year), and in subsequent years PS is determined within the model by the number of self-initiated quits and counseling-attributable quits in previous years, less relapse among counseling-attributable quits from previous years. All variables other than PS and alpha can be estimated from available data as described in the online technical report (www.prevent.org). Therefore, α in Equation (4) was solved by iteration and then inserted into Equations (1) and (2) to estimate the long-term quit rates with annual counseling. New quits and relapses among those previously counseled were not separately modeled. Instead the constant α was allowed to reflect the quits in subsequent periods, net of relapse of individuals who had previously quit for 1 year as a result of counseling.

The model was populated with a cohort of smokers older than 39 years ($u = 39$) from 1965 through 2003. However, the constant α was determined using observed long-term quits over the period 1985 to 2003. This allowed the model to be estimated over the period for which better data are available that at the same time reflect the effect of counseling that occurred before 1985.