Published in final edited form as:
Addiction. 2014 February ; 109(2): 314–322. doi:10.1111/add.12404.

Cost-effectiveness of Extended Cessation Treatment for Older Smokers

Paul G. Barnett, PhD[1,2], **Wynnie Wong, MS**[1], **Abra Jeffers, MPhil**[2], **Ricardo Munoz**[1,3], **Gary Humfleet, PhD**[1], and **Sharon Hall, PhD**[1]

[1]Department of Psychiatry, University of California, San Francisco

[2]Veterans Affairs Health Economics Resource Center and Stanford University

[3]Palo Alto University

Abstract

Aims—To examine the cost-effectiveness of extended smoking cessation treatment in older smokers.

Design—Participants who completed a 12 week smoking cessation program were factorial randomized to extended cognitive behavioral treatment and extended nicotine replacement therapy.

Setting—A free-standing smoking cessation clinic in the United States.

Participants—402 smokers aged 50 years and older were recruited from the community.

Measurements—The trial measured biochemically-verified abstinence from cigarettes after 24 months and the quantity of smoking cessation services used. Trial findings were combined with literature on changes in smoking status and the age and gender adjusted effect of smoking on health care cost, mortality, and qualify of life over the long-term in a Markov model of cost-effectiveness over a lifetime horizon.

Findings—The addition of extended cognitive behavioral therapy added $83 in smoking cessation services cost (p =.012, CI $21-$212). At the end of follow-up, cigarette abstinence rates were 50.0% with extended cognitive behavioral therapy and 37.2% without this therapy (p <.05, odds ratio 1.69, CI 1.18-2.54). The model-based incremental cost-effectiveness ratio was $6,324 per Quality Adjusted Life Year (QALY). Probabilistic sensitivity analysis found that the additional $947 in lifetime cost of the intervention had a 95% confidence interval of –$331 – $2,081; the 0.150 additional QALYs had a confidence interval of 0.035- 0.280, and that the intervention was cost-effective against a $50,000/QALY acceptance criterion in 99.6% of the replicates. Extended nicotine replacement therapy was not cost-effective.

Conclusions—Adding extended cognitive behavior therapy to standard smoking cessation treatment can be cost-effective.

Corresponding author: Paul G. Barnett, 795 Willow Rd. (152 MPD) VA Palo Alto Health Care System, Menlo Park, CA 94025, Phone: (650) 493-5000 ext 22475, Fax: (650) 617-2639, paul.barnett@va.gov.

Declarations of interest: None

Clinical trials registration: NCT00086385, http://www.clinicaltrials.gov

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Introduction

Smoking cessation has an incremental cost-effectiveness ratio well below the $50,000 per Quality Adjusted Life Year (QALY) threshold often used to define cost-effective health care in the United States. Ratios of less than $10,000/QALY have been reported for brief physician advice to stop smoking (1), treatment consistent with U.S. guidelines for smoking cessation (2), and the addition of pharmacotherapies to counseling (3, 4). Systematic reviews have found that smoking cessation programs that are effective are also highly cost-effective (4-7).

Nicotine dependence is a chronic condition and relapse after treatment is common. A critical policy question is whether more intensive treatment, sustained over the longer term with specific interventions for relapse prevention, are also cost-effective. This paper addresses this question.

Earlier meta-analyses concluded that there was not sufficient evidence to consider relapse prevention interventions effective (8, 9). A more recent meta-analysis found pharmacologic interventions and self-help materials can be effective in preventing relapse (5, 10).

There are few economic evaluations of relapse prevention interventions. Mailing booklets to recent quitters was highly cost-effective (11). A review found that many relapse prevention trials have not examine resource use, but among those that have studied cost, supplementing cognitive behavioral relapse prevention with pharmacotherapy, either bupropion, varenicline, or nicotine replacement therapy (NRT), was cost-effective (12).

We report resource data from a relapse prevention trial. A previous paper reported cognitive behavioral treatment was effective in preventing relapse in older smokers (13). There was no significant sustained benefit from nicotine replacement therapy. We now report on the resource use, cost, outcomes, and cost-effectiveness findings from this trial.

Methods

Participants

Smokers who were at least 50 years of age and smoked at least 10 cigarettes a day were recruited from the general public. The trial excluded individuals with life-threatening conditions, severe medical problems (cardiovascular disease, severe allergies, history of seizure), or psychiatric problems (life-time bipolar disorder, recent psychiatric hospitalization or substance abuse treatment, current major depressive disorder, use of psychiatric medication, suicidal or psychotic symptoms). We focused on older smokers as they are highly dependent on nicotine (14), are often motivated to quit (15), but have been neglected by recent treatment studies (13).

Trial design

All participants entered an initial 12 week long smoking cessation program of group counseling, NRT (nicotine replacement therapy), and bupropion (13). Counseling included five group sessions with content based on self-help materials developed for older smokers. Nicotine gum was provided at a dose of 2 or 4 mg/day, with the higher dose provided to those who had used at least 25 cigarettes/day. Sustained release bupropion was prescribed at 150 mg/day for the first week, and in the absence of adverse effects, 300 mg/day thereafter.

After 8 weeks, participants were randomly assigned in a factorial trial of extended NRT (E-NRT) and extended cognitive behavioral therapy (E-CBT). The four treatment groups included: no further smoking cessation services, E-NRT, E-CBT, or both interventions. Randomization was stratified on gender, positive history of major depressive disorder, and current smoking status. Randomization took place at week 8, before the end of the initial 12 weeks of treatment, in order to provide for the gradual reduction of NRT among those who were not randomized to receive extended NRT.

Participants randomized to E-NRT were given access to up to 40 additional weeks of nicotine gum and told to use it when they felt the urge to smoke. Those who were not randomized to E-NRT were instructed to taper the use of gum at week 8 and to discontinue its use at week 12.

Participants randomized to E-CBT were offered eleven individual in-person counseling sessions addressing motivation, social support, dysphoria, dependence/withdrawal, and weight gain. Sessions were scheduled every two weeks between weeks 10 through 16; every four weeks during weeks 20 through 36; and every eight weeks during weeks 44 and 52. Among those who were randomized to both E-NRT and E-CBT, the counselor reinforced the use of nicotine gum.

Informed consent was obtained under a protocol approved by the University of California, San Francisco (UCSF) Institutional Review Board. Assessments were conducted regardless of treatment status. Participants were paid $25 per completed assessment. Data were collected at baseline and weeks 12, 24, 52, 64, and 104.

This paper is based on self-reported seven-day abstinence from cigarettes verified by carbon monoxide testing. These abstinence rates are slightly higher than the anatabine/anabasine verified abstinence in the previous report (13).

Cost assignment

We determined the cost of smoking cessation services and pharmacotherapy received by study participants from randomization (at week 8) until the end of follow-up. These included services provided by the study and any additional smoking cessation services received outside of the study reported by participants. We estimated the cost of NRT based on retail price. We estimated the cost of bupropion and varenicline as 85% of the average wholesale price plus a $5 per prescription dispensing fee. We added to the cost of these prescriptions the Medicare reimbursement for a visit for the prescription of a psychiatric medication in office-based practice (CPT code 90862).

We estimated the cost of counseling sessions based on the labor cost of counselors, including a pro-rata share of time spent on activities other than direct patient care, and the cost of clinic space and overhead, resulting in a cost of $70/hour of patient contact. We added an additional cost for the time involved in scheduling sessions, reminding patients of visits, and recording sessions in medical records.

Individual counseling sessions provided to those randomized to E-CBT lasted from 20 to 40 minutes, and were assigned a cost of $23 to $46 per session.

Statistical methods

We conducted statistical tests for our main analyses, which simultaneously compared E-CBT to without E-CBT, E-NRT to without E-NRT, and the effect of treatment interaction. We followed the recommended practice to also contrast the four groups created by the factorial design (16). Generalized Linear Model (GLM) regressions were used to evaluate the effect of treatment group assignment on utilization and cost. Utilization of smoking cessation services, including the number of individual counseling visits and days of pharmacotherapy were compared with a negative binomial regression because data were over dispersed (the variance exceeded the mean), rendering the assumption of the Poisson regression inappropriate. GLM regressions with a log linkage function and gamma distribution were used to determine whether the cost of smoking cessation services differed by treatment group, avoiding the inappropriate assumption of normal distribution and homoscedastic errors (17). Logistic regression was used to compare abstinence outcomes by treatment group assignment.

Model

The cost of smoking cessation treatment is incurred in the short-term, while most of the benefit is not realized until years later. We used a model to project the lifetime effect of smoking cessation on health care cost and outcomes. Our primary outcome of interest was morbidity adjusted survival, expressed in the standard measure used in cost-effectiveness analysis, the QALY (Quality Adjusted Life Year). We constructed a Markov model with two non-absorbing states, smoker and former smoker.

Parameters used in the model are presented in Table 1. Long-term transition rates between current smokers and former smokers were derived from the literature. We estimated the long-term spontaneous cessation rate among smokers to be 4.3% per year (18). We estimated the long-term relapse rates among former smokers to be 15.0% in the first year after a sustained one-year quit (19) and diminishing in subsequent years (19-22). Mortality among smokers and former smokers was estimated by adjusting gender and age specific U.S. mortality rates of never smokers. We used published estimates of the additional hazard faced by smokers and by former smokers relative to never smokers (23-33). Because this trial enrolled older smokers, and since there is some evidence that the survival disparity between current and former smokers varies with age and gender, we used age and gender-specific estimates of this additional hazard. The model was run in 3 month cycles, the interval of follow-up assessments in the study. It was calibrated against published studies of mortality rates among smokers and former smokers (34, 35) and reports of the expected years lifetime for smokers at the time of a permanent quit (35, 36). The base-case model estimated that quitting at age 56.7 results in a discounted gain of 1.18 QALYs or 1.35 life-years, a benefit similar to that found by other models (2, 3, 11, 37, 38).

Trial data were used to provide the first year cost of smoking cessation services and the smoking status of each group at the end of follow-up. The model assumed the mean age of trial participants. We used published estimates of quality of life (39) and health care cost (34) of former smokers and current smokers that were age and gender specific. These cost data were from an analysis of data from three U.S. surveys that estimated the effect of smoking on all health care costs, and not just that attributable to smoking related disease. We made the simplifying assumption that cost, survival, and quality of life in former smokers is unaffected by the length of time since quitting.

All future life years, costs, and QALYs were discounted at 3% per annum. Costs were expressed in 2010 U. S. dollars. The statistical significance of the cost-effectiveness finding was addressed by conducting a probabilistic sensitivity analysis, a Monte Carlo analysis that selected 1,000 sets of parameters at random from their estimated probability distributions. This analysis sampled from parameters used in the model, including: the cost and effectiveness of E-CBT, population age and gender, relapse rates, excess mortality of current and former smokers relative to never smokers, and the effect of smoking on health care cost, as well as the discount rate. Distributions were from trial data and developed in the literature review. The resulting distribution of ICERs (Incremental Cost-Effectiveness Ratios) reflects the uncertainty of the estimates of cost and effectiveness from the trial and the uncertainty of parameters about long-term differences in cost and outcomes between smokers and former smokers obtained from the literature. An ICER was estimated from each random selection. Using different thresholds for cost-effectiveness over the range of $10,000-$100,000/ QALY, we found the percentage that was above the threshold (not cost-effective). This percentage represents the p-value of the test of the statistical hypothesis that the intervention was cost-effective (40). The model was constructed using commercially available software (TreeAge 2012). An appendix with a more complete description of the model, input parameters, and sensitivity analyses is available on online (web citation to be inserted after consultation with editor).

Results

The trial randomized 402 participants. They were an average of 56.7 years of age and had been smoking for 37.8 years. The characteristics of the participants are given in Table 2. There were no significant differences between treatment groups in any of these characteristics. The table also reports the smoking cessation services provided during the 8 week baseline period, prior to randomization.

Utilization and cost of smoking cessation services

Table 3 provides information on the utilization and cost of smoking cessation services received after randomization until the end of follow-up at two years. The four columns in the left half of table 3 correspond to each of the four possible groups in the factor randomization. The four columns in the right half of the table compare participants who did and did not receive E-NRT and E-CBT.

Participants randomized to E-NRT received a mean of 648 pieces of nicotine gum during this period, significantly more than the 7 pieces received by those randomized to the condition without E-NRT, as specified in the protocol. Participants randomized to E-CBT received a mean of 4.4 individual counseling sessions, compared 0.1 sessions in those randomized to the group without E-CBT, a significant difference also reflecting the treatment specified in the trial protocol. Individual counseling sessions were a mean of 32 minutes long, with an average cost of $37.56.

There were no significant differences between treatment groups in smoking cessation services received outside of the study. There were no significant differences in utilization of smoking cessation services attributable to the interaction of assignment to both E-NRT and E-CBT.

The table also provides a detailed breakdown of the cost of smoking cessation services received during the trial. Participants randomized to E-NRT incurred a mean of $436 in smoking cessation services, compared to $155 among those randomized to the condition without E-NRT ($p < .001$). This additional $281 (95% confidence interval $175-$409) in cost largely reflected the much higher cost for nicotine gum. Participants randomized to E-CBT incurred a mean of $338 in smoking cessation services compared to $255 in those randomized to the condition without E-CBT. The $83 extra cost of E-CBT was statistically significantly different ($p=.012$, with 95% confidence interval $22-$212).

There were no significant differences between treatment groups in the cost of smoking cessation services received outside of the study, and no significant additional cost caused by the interaction of assignment to both E-NRT and E-CBT; the effect of assignment to these groups on cost was additive.

Trial Findings Used in the Cost-effectiveness Model

Table 4 reports data from the trial that were used to model the cost-effectiveness of E-CBT, including the cost by treatment group assignment and abstinence status and the percentage of individuals who were abstinent at the final follow-up visit by treatment group assignment. Most participants were followed for 104 weeks, but we used 64 or 52 week status if there was no later follow-up. (There was no significant difference in the proportion of patients followed by treatment arm). Abstinence status was available for 378/402 (94.0%) of study participants. At the final visit, 50.0% of those randomized to E-CBT were abstinent from cigarettes, compared to 37.2% in the group randomized to the condition without E-CBT ($p < .05$, odds ratio 1.69, confidence interval 1.18-2.54). There was no significant effect of E-NRT on abstinence.

Cost-effectiveness model

Patients randomized to E-NRT incurred more costs and had no better outcomes than those randomized to the condition without E-NRT. Relapse prevention with E-NRT was dominated, that is, it was not cost-effective.

We modeled the long-term incremental effect of E-CBT on morbidity adjusted survival, expressed as QALYs. The model employed the quit rates observed at the final follow-up visit. Using the mean age of trial participants, 56.7 years, the model projected that each successful quit resulted in a gain of 1.17 QALYs.

Cost-effectiveness findings

Lifetime health care cost (including smoking cessation services) was $137,013 with E-CBT. This was $947 more than the $136,066 projected lifetime cost of those without E-CBT. The model projected that those assigned to E-CBT would enjoy an additional 9.68 QALYs, or 0.15 more QALYs than the 9.53 QALYs of those without E-CBT. The ICER (Incremental Cost Effectiveness Ratio) was thus$947/0.15 QALY, or $6,324/QALY.

Sensitivity analyses found the results to be highly robust. Ignoring the quality adjustment, and estimating an ICER using years of life as the measure of effectiveness, the model projects 13.35 discounted years of life with E-CBT, or 0.17 years more than the 13.18 years of life for those randomized to be without E-CBT. The corresponding ICER was $5,487/LY.

The most significant parameter was age at treatment initiation. Providing E-CBT at age 50 had an ICER of $1,324/QALY. Providing E-CBT at age 80 had an ICER of $6,843.

We considered the effect of including only the cost of the smoking cessation intervention; that is, assuming that smoking cessation had no effect on the cost of subsequent health care services. With this assumption, E-CBT cost $338 or $83 more than the $255 smoking cessation services without E-CBT. The corresponding ICER was $557/QALY.

A probabilistic sensitivity analysis was used to evaluate the uncertainty of the model estimates. The 95% confidence interval for the additional cost of E-CBT was –$331 – $2,081; the interval for the additional QALY from E-CBT was 0.035- 0.280. Using a threshold of $50,000/QALY as the criteria for cost cost-effectiveness, the hypothesis that E-CBT is cost-effective was significant with p = 0.004 (that is, 99.6% of the replicates were cost-effective at this threshold).

Discussion

This randomized clinical trial determined that a 12 week smoking cessation treatment followed by Extended Cognitive Behavioral Therapy (E-CBT) was a cost-effective use of health care resources, with an ICER (Incremental Cost Effectiveness Ratio) of $6,324 per Quality Adjusted Life Year (QALY). Like other smoking cessation interventions, this is well below the commonly used threshold for judging cost-effectiveness (the range of $50,000-$100,000/QALY in the United States).

Extended nicotine replacement therapy added to treatment cost but was not effective. This intervention was thus dominated by 12 weeks of initial treatment without extended nicotine replacement therapy. Meta-analyses of smoking cessation trials have found abundant evidence that nicotine replacement therapy is an effective aid to smoking cessation, but there is uncertainty about the benefit of extending treatment. This trial did not find any marginal benefit from extending nicotine replacement therapy. This finding conflicts with recent meta-analyses, which found nicotine replace therapy effective for relapse prevention (5, 10).

In contrast to the current trial, these meta-analyses did not find cognitive behavioral therapy to be effective for relapse prevention. The cognitive behavioral therapy intervention in this trial differed from the intervention tested in other studies. It was more resource intensive, with up to 11 individual sessions. In other trials, cognitive behavioral therapy ranged from a single session to as many as 10 visits, often in group visits or by telephone. Finally, this trial had greater power to detect the effect of the intervention. It involved more participants, followed them for a longer period, and had better follow-up rates than many other trials.

We acknowledge several limitations of this study. We did not measure health care cost during the trial, and relied on the literature for the difference in the cost of health services used by smokers and former smokers. This limitation may not be a serious one. Had we gathered these cost data, it would have covered only the first 2 years after randomization. The cost-effectiveness analysis requires an estimate of lifetime health care costs. These were projected using literature on the cost of smoking, and a model of the effect of smoking on survival. A sensitivity analysis that excluded the health care costs of smokers reduced the incremental cost-effectiveness ratio. This is because our model projects that smoking cessation increases lifetime health care cost, with the effect of longer life outweighing the cost savings from reduced smoking-related disease.

We used a simple model with only two non-absorbing health states, current and former smoker. Its estimate of the benefit of smoking cessation are similar to that of more complex models that include separate health states for different smoking-related diseases. Our model projected that each successful quit resulted in a gain of 1.17 discounted QALYs. This projection was at the mean age of trial participants, 56.7 years. Other models have projected the lifetime benefits from smoking cessation in the range of 0.69-2.2 QALYs, with most estimates at the higher end of this range (2, 3, 11). Other models have reported that the benefit of smoking cessation is less in older smokers (3).

We applied our trial findings to a simpler, direct method for assessing the cost-effectiveness of smoking cessation interventions (41). This method values the benefits of smoking cessation in life years and ignores health care costs other than the cost of the intervention itself. We applied this method to trial findings. The result was an incremental gain in effectiveness of 0.13 life years and an incremental cost-effectiveness ratio of $622/LY. With these same assumptions, our model projects a gain of 0.17 life years and an incremental cost-effectiveness ratio of $482/LY.

Warner observed that as smoking cessation treatments are made more resource intensive, they will undoubtedly have higher cost-effectiveness ratios (42). This reflects the economic law of diminishing marginal returns. This law holds that if enough additional resources are used in production, less value is generated by each additional dollar of cost. More resource intensive smoking cessation interventions may still have cost-effectiveness ratios that are low enough to consider them cost-effective, but Warner found few evaluations of more resource intensive smoking cessation treatment. There have been few studies in the following decade to close this gap.

We studied a more resource intensive approach to relapse prevention, extended cognitive behavior therapy. It had an incremental cost effectiveness ratio of $6,324 per quality adjusted life year, similar to the ratio found in other studies. For example, brief physician advice had a cost-effectiveness ratio of less than $5,000 and the addition of pharmacotherapy to counseling for smoking cessation had a cost-effectiveness of less than $2,000 (4).

The incremental cost-effectiveness of smoking cessation treatments is so low that there is reason to believe that more expensive treatments will still be cost-effective. Research is needed to identify more intensive and extended treatments, addressing the most refractory smokers.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This publication was made possible by grant numbers R01 DA02538, K05 DA016752, K23 DA018691 and P50 DA 09253 from the National Institute on Drug Abuse. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the NIH/NIDA. The authors wish to thank Dr. Ronald Pilato for his clinical contributions.

Support: Supported by the National Institute on Drug Abuse

References

1. Cummings SR, Rubin SM, Oster G. The cost-effectiveness of counseling smokers to quit. Jama. 1989; 261:75–9. [PubMed: 2491762]
2. Cromwell J, Bartosch WJ, Fiore MC, Hasselblad V, Baker T. Cost-effectiveness of the clinical practice recommendations in the AHCPR guideline for smoking cessation. Agency for Health Care Policy and Research. Jama. 1997; 278:1759–66. [PubMed: 9388153]
3. Fiscella K, Franks P. Cost-effectiveness of the transdermal nicotine patch as an adjunct to physicians' smoking cessation counseling. Jama. 1996; 275:1247–51. [PubMed: 8601956]
4. Song F, Raftery J, Aveyard P, et al. Cost-effectiveness of pharmacological interventions for smoking cessation: a literature review and a decision analytic analysis. Med Decis Making. 2002; 22:S26–37. [PubMed: 12369228]
5. Coleman T, Agboola S, Leonardi-Bee J, et al. Relapse prevention in UK Stop Smoking Services: current practice, systematic reviews of effectiveness and cost-effectiveness analysis. Health Technol Assess. 2010; 14:1–152. iii–iv. [PubMed: 21040645]
6. Ronckers ET, Groot W, Ament AJ. Systematic review of economic evaluations of smoking cessation: standardizing the cost-effectiveness. Med Decis Making. 2005; 25:437–48. [PubMed: 16061896]
7. Woolacott NF, Jones L, Forbes CA, et al. The clinical effectiveness and cost-effectiveness of bupropion and nicotine replacement therapy for smoking cessation: a systematic review and economic evaluation. Health Technol Assess. 2002; 6:1–245.
8. Hajek P, Stead LF, West R, Jarvis M, Lancaster T. Relapse prevention interventions for smoking cessation. Cochrane Database Syst Rev. 2009 CD003999.
9. Lancaster T, Hajek P, Stead LF, West R, Jarvis MJ. Prevention of relapse after quitting smoking: a systematic review of trials. Arch Intern Med. 2006; 166:828–35. [PubMed: 16636207]
10. Agboola S, McNeill A, Coleman T, Leonardi Bee J. A systematic review of the effectiveness of smoking relapse prevention interventions for abstinent smokers. Addiction. 2010; 105:1362–80. [PubMed: 20653619]
11. Chirikos TN, Herzog TA, Meade CD, Webb MS, Brandon TH. Cost-effectiveness analysis of a complementary health intervention: the case of smoking relapse prevention. Int J Technol Assess Health Care. 2004; 20:475–80. [PubMed: 15609798]

12. Taylor M, Leonardi-Bee J, Agboola S, McNeill A, Coleman T. Cost effectiveness of interventions to reduce relapse to smoking following smoking cessation. Addiction. 2011; 106:1819–26. [PubMed: 21561499]
13. Hall SM, Humfleet GL, Munoz RF, et al. Extended treatment of older cigarette smokers. Addiction. 2009; 104:1043–52. [PubMed: 19392908]
14. Rimer BK, Orleans CT, Keintz MK, Cristinzio S, Fleisher L. The older smoker. Status, challenges and opportunities for intervention. Chest. 1990; 97:547–53. [PubMed: 2306958]
15. Orleans CT. Reducing tobacco harms among older adults: a critical agenda for tobacco control. Tob Control. 1997; 6:161–3. [PubMed: 9396093]
16. Montgomery AA, Peters TJ, Little P. Design, analysis and presentation of factorial randomised controlled trials. BMC Med Res Methodol. 2003; 3:26. [PubMed: 14633287]
17. Manning WG, Mullahy J. Estimating log models: to transform or not to transform? J Health Econ. 2001; 20:461–94. [PubMed: 11469231]
18. Levy DT, Graham AL, Mabry PL, Abrams DB, Orleans CT. Modeling the impact of smoking-cessation treatment policies on quit rates. Am J Prev Med. 2010; 38:S364–72. [PubMed: 20176309]
19. Hawkins J, Hollingworth W, Campbell R. Long-term smoking relapse: a study using the british household panel survey. Nicotine Tob Res. 2010; 12:1228–35. [PubMed: 21036960]
20. Gilpin EA, Pierce JP, Farkas AJ. Duration of smoking abstinence and success in quitting. J Natl Cancer Inst. 1997; 89:572–6. [PubMed: 9106646]
21. Wetter DW, Cofta-Gunn L, Fouladi RT, et al. Late relapse/sustained abstinence among former smokers: a longitudinal study. Prev Med. 2004; 39:1156–63. [PubMed: 15539050]
22. Krall EA, Garvey AJ, Garcia RI. Smoking relapse after 2 years of abstinence: findings from the VA Normative Aging Study. Nicotine Tob Res. 2002; 4:95–100. [PubMed: 11906685]
23. Woloshin S, Schwartz LM, Welch HG. The risk of death by age, sex, and smoking status in the United States: putting health risks in context. J Natl Cancer Inst. 2008; 100:845–53. [PubMed: 18544745]
24. Woloshin S, Schwartz LM, Welch HG. Risk charts: putting cancer in context. J Natl Cancer Inst. 2002; 94:799–804. [PubMed: 12048267]
25. Prescott E, Osler M, Andersen PK, et al. Mortality in women and men in relation to smoking. Int J Epidemiol. 1998; 27:27–32. [PubMed: 9563690]
26. Friedman GD, Tekawa I, Salder M, Sidney S. Smoking and mortality: the Kaiser Permanente experience. Changes in cigarette-related disease risks and their implications for prevention and control. Monogr. Natl. Cancer Inst. 1997; 97:472–499.
27. Kenfield SA, Stampfer MJ, Rosner BA, Colditz GA. Smoking and smoking cessation in relation to mortality in women. JAMA. 2008; 299:2037–47. [PubMed: 18460664]
28. LaCroix AZ, Lang J, Scherr P, et al. Smoking and mortality among older men and women in three communities. N Engl J Med. 1991; 324:1619–25. [PubMed: 2030718]
29. Kawachi I, Colditz GA, Stampfer MJ, et al. Smoking cessation in relation to total mortality rates in women. A prospective cohort study. Ann Intern Med. 1993; 119:992–1000. [PubMed: 8214996]
30. Streppel MT, Boshuizen HC, Ocke MC, Kok FJ, Kromhout D. Mortality and life expectancy in relation to long-term cigarette, cigar and pipe smoking: the Zutphen Study. Tob Control. 2007; 16:107–13. [PubMed: 17400948]
31. Bjartveit K, Tverdal A. Health consequences of sustained smoking cessation. Tob Control. 2009; 18:197–205. [PubMed: 19228666]
32. Taylor DH Jr. Hasselblad V, Henley SJ, Thun MJ, Sloan FA. Benefits of smoking cessation for longevity. Am J Public Health. 2002; 92:990–6. [PubMed: 12036794]
33. van Baal PH, Hoogenveen RT, de Wit GA, Boshuizen HC. Estimating health-adjusted life expectancy conditional on risk factors: results for smoking and obesity. Popul Health Metr. 2006; 4:14. [PubMed: 17083719]
34. Sloan, FA. The price of smoking. MIT Press; Cambridge, Mass.: 2004.
35. Bronnum-Hansen H, Juel K. Estimating mortality due to cigarette smoking: two methods, same result. Epidemiology. 2000; 11:422–6. [PubMed: 10874549]

36. Howard P, Knight C, Boler A, Baker C. Cost-utility analysis of varenicline versus existing smoking cessation strategies using the BENESCO Simulation model: application to a population of US adult smokers. Pharmacoeconomics. 2008; 26:497–511. [PubMed: 18489200]

37. Javitz HS, Swan GE, Zbikowski SM, et al. Cost-effectiveness of different combinations of bupropion SR dose and behavioral treatment for smoking cessation: a societal perspective. Am J Manag Care. 2004; 10:217–26. [PubMed: 15032259]

38. Godfrey C, Parrott S, Coleman T, Pound E. The cost-effectiveness of the English smoking treatment services: evidence from practice. Addiction. 2005; 100(Suppl 2):70–83. [PubMed: 15844290]

39. Wang, LY.; Linda, C.; Lowry, R., et al. Life Years Saved, Quality-Adjusted Life Years Saved and Cost-Effectiveness of a School-Based Tobacco Prevention Program Handbook of Disease Burdens and Quality of Life Measures. Springer; New York: p. 1681-1697.

40. van Hout BA, Al MJ, Gordon GS, Rutten FF. Costs, effects and C/E-ratios alongside a clinical trial. Health Econ. 1994; 3:309–19. [PubMed: 7827647]

41. Stapleton JA, West R. A direct method and ICER tables for the estimation of the cost-effectiveness of smoking cessation interventions in general populations: application to a new cytisine trial and other examples. Nicotine Tob Res. 2012; 14:463–71. [PubMed: 22232061]

42. Warner KE. Cost effectiveness of smoking-cessation therapies. Interpretation of the evidence-and implications for coverage. Pharmacoeconomics. 1997; 11:538–49. [PubMed: 10168094]

43. Hyland A, Li Q, Bauer JE, et al. Predictors of cessation in a cohort of current and former smokers followed over 13 years. Nicotine Tob Res. 2004; 6(Suppl 3):S363–9. [PubMed: 15799599]

44. Vogl M, Wenig CM, Leidl R, Pokhrel S. Smoking and health-related quality of life in English general population: implications for economic evaluations. BMC Public Health. 2012; 12:203. [PubMed: 22429454]

Table 1

Model parameters obtained from literature review

Parameter	Parameter value	Source
Quit rate among current smokers (% per year)	4.3%	(18) (43)
Relapse rate among former smokers after one year of abstinence (% per year)		(19-22)
Year 2 after initial quit	15%	
Year 3-5 after initial quit	5%	
Year 6-9 after initial quit	2%	
Year 10+ after initial quite	1%	
Excess mortality relative to never smokers		(25, 26, 28, 32)
Female current smokers age 55-74	2.533	
Female current smokers age 75+	1.666	
Female former smokers age 55-74	1.411	
Female former smokers age 75+	1.111	
Male current smokers age 55-74	2.550	
Male current smokers age 75+	1.992	
Male former smokers age 55-74	1.326	
Male former smokers age 75+	1.074	
Preference-based quality of life		(44)
Female moderate smokers age 55-64	0.7815	
Female moderate smokers age 65-74	0.7575	
Female moderate smokers age 75+	0.7112	
Female former smokers age 55-64	0.8020	
Female former smokers age 65-74	0.7802	
Female former smokers age 75+	0.7358	
Male moderate smokers age 55-64	0.7648	
Male moderate smokers age 65-74	0.7520	
Male moderate smokers age 75+	0.6778	
Male former smokers age 55-64	0.7827	
Male former smokers age 65-74	0.7709	
Male former smokers age 75+	0.6987	
Annual health care cost (2010 $U.S.)		(34)
Female current smokers age 51-65	$3,134	
Female current smokers age 66+	$10,061	
Female former smokers age 51-65	$2,452	
Female former smokers age 51+	$9,336	
Male current smokers age 51-65	$3,561	
Male current smokers age 66+	$7,915	

Parameter	Parameter value	Source
Male former smokers age 51-65	$2,592	
Male former smokers age 66+	$7,674	

Table 2

Baseline characteristics of study participants (n=402)

		SD
Mean age (years)	56.7	(5.8)
Distribution by age group		
50 – 55	51.7%	
56 – 60	26.4%	
61 – 65	13.9%	
66 – 70	5.7%	
71 – 75	0.8%	
76 – 80	1.5%	
Male Gender	59.7%	
Marital status		
Single	17.8%	
Married	32.4%	
Divorced	29.2%	
Race/ethnicity		
Caucasian	80.0%	
African American	8.1%	
Asian Pacific Islander	2.3%	
Education		
High school	8.8%	
Some college	35.5%	
Completed college	21.9%	
Some graduate work	8.6%	
Graduate/professional degree	21.9%	
Mean years of smoking	37.8	(8.2)
Mean number of cigarettes smoked per day	21.5	(8.9)
Lifetime history of major depressive disorder	15.4%	
Lifetime diagnosis of alcohol dependence	18.1%	
Smoking services received in the 8 weeks prior to randomization		
Physician services (visits)	3.5	(0.9)
Bupropion (pills)	136.6	(55.6)
Nicotine replacement therapy (pieces)	439.2	(233.6)
Group counseling (sessions)	4.0	(1.5)
Cost (dollars)	598.81	(176.98)

NIH-PA Author Manuscript
NIH-PA Author Manuscript

Table 3

Mean utilization and cost by treatment group assignment

	Brief Treatment (n=100)	Extended Cognitive Behavioral Treatment alone (n=99)	Extended Nicotine Replacement Therapy alone (n=99)	E-CBT & E-NRT (n=104)	With Cognitive Behavioral Treatment (n=203)	Without Cognitive Behavioral Treatment (n=199)	With Extended Nicotine Replacement Therapy (n=203)	Without Nicotine Replacement Therapy (n=199)
Smoking provided cessation services								
Study provided services								
Bupropion (pills)	0	0	0	0	0	0	0	0
Nicotine replacement therapy (pieces)	5 [b,c]	9 [d,e]	781 [b,d,f]	521 [c,e,f]	271	391	648 [h]	7[h]
Individual counseling (sessions)	0.1 [a,c]	4.1 [a,d]	0.1 [d,f]	4.7 [c,f]	4.4 [g]	0.1 [g]	2.5	2.1
Outside-of-study services								
Nicotine replacement therapy (pieces)	110	129	136	115	121	123	126	119
Anti-depressant for smoking cessation (days)	4.3 [a,b,c]	8.9 [a]	7.2 [b]	8.3 [c]	8.6	5.7	7.7	6.6
Other out-of-study treatment (sessions)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Smoking cessation services cost								
Study provided services								
Nicotine replacement therapy	$1.99 [b,c]	$3.53 [d,e]	$312.25 [b,d]	$208.38 [c,e]	$108.48	$156.34	$259.04 [h]	$2.76 [h]
Individual counseling	$2.45 [a,c]	$109.45 [a,d]	$1.41 [d,f]	$141.84 [c,f]	$126.04 [g]	$1.94 [g]	$73.35	$55.68
Outside-of-study services								
Nicotine replacement therapy	$47.11	$54.24	$56.03	$47.33	$50.70	$51.55	$51.57	$50.65
Anti-depressant for smoking cessation	$14.93	$31.04	$24.57	$29.04	$30.02	$19.72	$26.86	$22.94
Other out-of-study treatment	$26.65	$19.85	$24.19	$26.39	$23.20	$25.43	$25.32	$23.27
Total, smoking cessation services cost	$93.13 [a,b,c]	$218.11 [a,d,e]	$418.46 [b,d]	$452.97 [c,e]	$338.43 [g]	$254.98 [g]	$436.14 [h]	$155.30 [h]

Values in the same row with a common letter were significantly different with $p < .05$

Table 4

Model inputs based on trial data

Variable	Mean [SD]
Treatment effectiveness (% abstinent at end of follow-up)	
With E-CBT	50.0
Without E-CBT	37.2
Cost of initial smoking cessation services (2010 $ U.S.)	
Sustained abstinence with E-CBT	$409.96 [534.33]
Sustained abstinence without E-CBT	$339.57 [630.27]
Continued smoking with E-CBT	$308.73 [388.85]
Continued smoking without E-CBT	$225.27 [381.03]
Male (percent)	60.3
Age (years)	58.7 [5.8]

Table 5

Lifetime cost-effectiveness model

Strategy	With Extended Cognitive Behavior Therapy	Without Extended Cognitive Behavior Therapy	Difference
Cost			
Cost of initial treatment	338	255	83
Discounted cost of health services	136,675	135,811	864
Total discounted cost	137,013	136,066	947
Outcomes			
Discounted Life Years	13.35	13.18	0.17
Discounted Quality Adjusted Life Years	9.68	9.53	0.15
Incremental Cost-Effectiveness Ratio (ICER)			
$/LY	5,487		
$/QALY	6,324		