Determining the Cost-Effectiveness Of a Computer-Based Smoking Cessation Intervention in Primary Care

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ABSTRACT

Purpose: To evaluate the incremental effectiveness and cost-effectiveness of a staged-based, computerized smoking cessation intervention relative to standard care in an urban managed care network of primary care physicians.

Design: Decision-analytic model based on results of a randomized clinical trial.

Methodology: Patient outcomes and cost estimates were derived from clinical trial data. Effectiveness was measured in terms of 7-day point-prevalence abstinence at 6 months post-intervention. Quality-adjusted life years (QALYs) and cost-effectiveness (CE) were calculated, with CE measured as cost per patient per life year saved and per quality-adjusted life years saved. CE estimates were adjusted to account for partial behavior change as measured in terms of progression in stage of readiness to quit. Sensitivity analyses were conducted to evaluate the robustness of key model assumptions.

Principal findings: Intervention patients were 1.77 times more likely to be smoke-free at 6 months follow-up than those in standard care (p=.078). The intervention generated an additional 3.24 quitters per year. Annualized incremental costs were $5,570 per primary care practice, and $40.83 per smoker. The mean incremental cost-effectiveness ratio was $1,174 per life year saved ($869 per QALY). When the intervention impact on progression in stage of readiness to quit was also considered, the mean incremental cost-effectiveness ratio declined to $999 per life year saved ($739 per QALY).

Conclusions: From a physician's practice perspective, the stage-based computer tailored intervention was cost-effective relative to standard care. Incorporation of partial behavior change into the model further enhanced favorability of the cost-effectiveness ratio.

Key words: cost-effectiveness, smoking cessation, primary care, expert system, stages of change

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INTRODUCTION

Despite the substantial and well-documented health risks associated with cigarette smoking, an estimated 46.5 million adults in the United States (U.S.) still smoke (U.S. Department of Health and Human Services, 2004). In recognition of the vital role primary care physicians (PCPs) have to play in promoting smoking cessation, clinical practice guidelines recommend that primary care physicians (PCPs) routinely ask patients whether they smoke, assess and advise smokers to quit, assist smokers in finding appropriate treatments, and arrange appropriate follow-up (Centers for Disease Control and Prevention, 1991; Agency for Health Care Policy and Research, 1996; Fiore et al., 2000).

To date, however, physician adoption of this 5-step strategy (the "5A's" — Ask, Advise, Assess, Assist, and Arrange) has been poor, primarily due to clinicians' lack of knowledge and proficiency in providing smoking cessation counseling (Coleman et al., 1996; Thorndike et al., 1998; Cabana et al. 1999). To address these barriers, we tested a multi-component intervention versus standard care in a randomized clinical trial. Primary care physicians were randomly selected from a panel of primary care providers in a large managed care network in New York City and randomized to either an intervention condition or to standard care. PCPs in the intervention group received a 40-minute in-office training session on the smoking cessation guidelines

along with a brief computer-generated "expert system" report that summarized the patient's smoking history and listed strategies to facilitate progression toward quitting. The expert system report was derived from prior empirical research (Prochaska et al., 1993; Prochaska et al., 2001; Prochaska et al., 2005; Hopkins et al., 2001; Fiore et al., 2000). A more detailed description of the study intervention and design, results, and statistical adjustment for practice setting on individual smoking quit rates can be found elsewhere (Unrod et al., 2006).

Cost-effectiveness is increasingly recognized as an important yardstick by which to measure the value of a clinical procedure or intervention. Using the perspective of the individual physician practice, we evaluated the incremental cost-effectiveness of this expert system intervention on PCPs and patients using data from our clinical trial. We compared the life years and quality-adjusted life years (QALYs) saved of smokers in the intervention condition compared to those in standard care. We also examined the impact of including adjuvant smoking cessation therapy-related costs. We hypothesized that over 6 months, the expert system intervention would be cost-effective compared to the cost-effectiveness of other smoking cessation interventions offered in the primary care setting.

METHODS

Design

We used a randomized prospective design to compare outcome differences between the intervention and usual care conditions. A 2-stage stratification plan was used to randomly assign primary care practices to the intervention or to usual care. In the first stage, all primary care practices in the 4 largest boroughs of New York City (NYC) (i.e., Bronx, Brooklyn, Manhattan and Queens) were divided into 6 areas, each containing an approximately equal number of primary care practices. In the second stage, PCPs from practice settings within each area were randomly selected and assigned to either intervention or control. Only one PCP per practice setting was selected.

Subjects

Participants in the randomized trial included urban primary care physicians and their patients who were current smokers. Potentially eligible primary care physicians who were actively practicing in one of the four boroughs were identified using a list of physician members provided by a large managed care organization (MCO) collaborating with study investigators. The MCO had contracts with an estimated 80 percent of PCPs practicing in those boroughs. PCPs were selected via a random number generator and then contacted. Those who agreed to participate gave their informed consent prior to study enrollment.

Consenting PCPs were then screened to determine whether they met the eligibility requirements: 1) specialty in either internal medicine or family practice; 2) patient volume of at least 75 visits per week; 3) willingness to allow study staff to recruit patients during office hours; 4) plan to continue in active practice in same location for the next 12 months; 5) patient panel primarily English-speaking; and 6) composition of patient panel less than 25 percent geriatric. Of the 579 PCPs selected for recruitment, 70 met the eligibility criteria and successfully completed the study (35 assigned to the intervention condition and 35 to usual care). Of the remainder, 13% did not meet eligibility requirements, 32% refused to participate, and 45% could not be reached.

Smokers within each participating PCP's practice were recruited by study staff members over a 10-day period until 10 smokers were enrolled. The office administrative assistant gave each patient a form designed to assess whether they were current smokers or not. To be eligible, smokers were required to: 1) be age 18 or older; 2) have smoked within the past 7 days; 3) have smoked at least 100 cigarettes in their lifetime; 4) be English-speaking; and, 5) not have plans to switch their primary care provider for the next 12 months. A total of 5,826 patients were screened of whom 879 (15%) met eligibility criteria.

The smoking screening form was collected by a study research assistant. Eligible smokers gave informed consent and completed a 20-minute computer-based assessment of their smoking history.[1] Intervention condition smokers also received a one-page, computer-generated expert system report to take to their medical appointment. Immediately after the medical visit, participants underwent a second assessment in which they were asked for demographic information and whether the PCP had conducted the 5As with them. Participants were contacted by telephone 6 months later for a follow-up interview to assess smoking behavior outcomes. Self-reported abstinence was validated biochemically. Smokers were paid $20 for the initial office assessments and $10 for completing the 6 month follow-up. PCPs in the standard care condition received $150 for study participation; those in the intervention condition received $200.

Intervention

PCPs assigned to the intervention condition received 30 minutes of training in smoking cessation counseling techniques along with instruction in the interpretation and clinical application of the expert system re-

[1] Specifically, questions addressed the following topics: quantity smoked, dependence, stage of readiness to quit, past attempts to quit, self-efficacy about quitting, the perceived benefits and drawbacks of smoking, and medical conditions exacerbated by smoking.

port. The expert system report consisted of one page divided into two sections. The first half included a synopsis of the patient's smoking profile. The second half included a list of stage-matched interventions to facilitate the patient's progression toward quitting. After the assessment was completed, the research assistant gave a copy of the expert system report to the office administrator to place in the patient's medical chart. To estimate cost, we assumed that the research assistant's job of helping each smoker to complete the computer-based assessment would be undertaken by the office administrator.

Measurement of costs

Cost estimates and abstinence levels were derived from the clinical trial results. Patients in both the intervention and control groups varied in terms of their stage of readiness to quit smoking. For most analyses, we combined those in the pre-contemplation and contemplation stages into a single pre-preparation stage because the samples were small. In the final analysis, we examined the effects of changes in stage of readiness on quit rates for all three stages.

Because the expert system was installed in PCPs' offices and then offered to all smokers, the PCP practice was used as the study level of aggregation, and the fixed upfront system costs were allocated to its smokers. All aggregated cost statistics were at the practice-year level of analysis (i.e., intervention practice cost per smoker per year). Practice-level smoker costs were also aggregated across all PCP practices in the U.S. to obtain a national estimate

PCPs in the intervention condition reviewed the expert system report 95% of the time for an average of 2.5 minutes. PCPs in the intervention condition were nearly 50% more likely than those in the control condition to discuss the "5 A's," and spent 4.2 minutes (versus 1.5 minutes, respectively) doing so.

TABLE 1
Basic model parameters

Practice volume		
Visits/practice/week		110.60
Physician work weeks/year		47.20
Total practice visits/year		5,220.32
Unique patients/year		631.70
New patients/total patients/year		0.12
Staffing costs		
RN cost per minute		$0.61
Office administrator cost per minute		$0.21
MD cost per minute		$3.29
Computer Technician cost per minute		$0.61
Workstation statistics		
Technician installation time (minutes)		60
PCP initial training time (minutes)		40
Expected computer lifetime (years)		10
Computer hardware cost		$2,046
Computer software cost		$300
Practice smokers		
Probability of smoking		0.22
Unique smokers/year		136.40
Total smokers over computer lifetime		285.00
Smoking cessation asking/assisting/counseling	*Intervention*	*Control*
Office administrator "asking" about smoking per patient (minutes)	0.50	0.00
Probability smoker uses expert system	0.95	0.00
Office administrator assisting smoker (minutes)	2.00	0.00
PCP 5A counseling time, initial visit:		
Probability PCP reviewed expert system	0.95	0.00
PCP review time (minutes)	2.50	0.00
Probability PCP discussed 5As	0.90	0.62
Initial visit: 5A counseling time (minutes)	4.20	1.50
Brochure costs	$2.00	0.00
PCP 5A counseling time, follow up visit:		
Probability PCP discussed quitting	0.36	0.29
Follow-up visit: 5A counseling time (minutes)	6.20	5.30

SOURCES: Visits & physician workweeks: AMA, "Physician Marketplace Statistics, 1997/98." AMA Center for Health Policy Research, 1997 SMS; probability of smoking: CDC website: «www.cdc.gov/»; RN and office administrator costs: Business and Legal Reports; MD costs derived from Medicare office visit fees and CPT 2002 expected times with patient (AMA, 2002); Ask/discuss probabilities derived from PCP self-reports of performance.

Practice statistics & staffing costs

Table 1 summarizes model parameters. We assumed that the typical practice experienced 12 new patients per 100 patients seen per year based on the National Ambulatory Medicare Care Survey (Woodwell &

Cherry, 2004). This proportion, applied to total annual visits, gave an average annual patient panel per PCP of 632 unique patients.[2] We used the 2004 national average smoking rate of 21.6%, taken from the CDC website.[3] This rate implies 136.5 smokers, on average, in a physician's practice.

Medicare allowable fees were used to cost physician time. The PCP's average cost was based on a weighted average of visit frequencies among new patients in Common Procedural Terminology (CPT) office visit codes 99201–203. Multiplying relative value units (RVUs) by the 2002 Medicare Fee Schedule conversion factor ($37.8975) and dividing by the CPT 20-minute average guideline time per patient results in a physician-per-minute effective wage of $3.29 (American Medical Association, 2002).

Analysis perspective

Analyses were undertaken primarily from the perspective of the individual physician's practice. Costs included in the analysis are presented in Table 2. The cost of adjuvant smoking cessation treatment per smoker, although not a cost born by the PCP practice, was also included because of its relevance for managed care.

TABLE 2
Costs associated with implementing the expert system

Characteristic	Intervention	Control
Upfront installation & training costs		
Total workstation costs (excluding PCP)	$2,382.60	$0.00
PCP training cost	131.60	0.00
Total workstation and training costs	2,514.20	0.00
Total upfront costs/computer lifetime smokers	8.82	0.00
Direct costs		
Office administrator "asking" cost per smoker	4.02	0.00
Office administrator assistance time per smoker	0.42	0.00
PCP report review per smoker	7.81	0.00
PCP 5A counseling cost per smoker (including brochures)		
Initial visit	14.48	3.08
Follow-up visit	7.26	5.06
Total	21.74	8.14
Total practice costs per smoker	42.10	8.14
Adjuvant therapy costs per smoker[1]	47.08	40.21
Total cessation costs		
Per smoker by stage of readiness to quit		
Pre-preparation	85.66	38.45
Preparation	94.17	61.73
Total	89.18	48.35
Per practice		
Excluding adjuvant therapy	5,742.44	1,110.30
Total	12,164.15	6,594.94

[1]The cost of adjuvant therapy, when used, was based on a frequency-weighted average of several different nicotine replacement (NRT) products and Zyban. NRT products included the patch (29 users in the intervention group), inhalers (14), gum (22), lozenge (4), and low-nicotine (or nicotine-free) cigarettes (2). Costs of alternative modes of therapy, including acupuncture and hypnosis, were not estimated (these were used by less than 2% of all study participants). Cost for each type of adjuvant therapy was based on 12 weeks of use. We assumed that failed quitters would incur only one-half the adjuvant therapy costs of successful quitters (Cromwell, 1997). Lower control group costs are attributable to lower likelihoods of using adjuvant therapy when making a quit attempt.

Calculation of incremental cost-effectiveness ratios

The numerator in the incremental cost-effectiveness ratio was the difference in costs between the intervention and usual care. The denominator was the difference in life years saved or QALYs between the intervention and usual care.

Intervention and control smoker quit rates were calculated overall and by stage. Quit rates were debited using a 45% relapse rate, a standard rate derived from the literature (Cromwell et al., 1997). Overall benefits were calculated using a weighted average of incremental quit rates (intervention minus control) multiplied by expected quality-adjusted life-years saved (QALYs) from not smoking (using tables from Fiscella & Franks, 1996). Incremental cost-effectiveness ratios (ICERs) were calculated as the intervention-control differences in per-smoker costs, divided by the difference in total quitters adjusted for relapse, and life-years saved (LYS) at the practice level.

Statistical analyses

Because a key element of the randomized clinical study design involved the nesting of patients within

[2] The national figures are different from those based on practices in the clinical trial. The number of patients screened per week was 89 (20% less than the national figure, 110). This is explained by the relatively high physician-population ratio in New York City compared with the nation as a whole.

[3] Of patients actually screened during the clinical trial, only 12% were smokers, a rate considerably less than the national average. We used the national rate to be more generalizable to the national smoking population

physician practice, we analyzed patient outcomes using generalized (7-day point prevalence) and mixed (longest quit attempt, number of quit attempts, and stage-of-change progression) linear model analysis of variance approach to adjust for interclass correlation. We analyzed physician outcomes using a hierarchic generalized linear model analysis of variance.

Sensitivity analyses

We conducted 4 sensitivity analyses. We varied: 1) the amount of the amount of time PCPs spent in reviewing the expert system report and providing smoking cessation counseling per smoker; 2) the proportion of smokers within each stage of readiness to quit smoking; 3) the costs associated with purchasing and installing the computer work station; and 4)the underlying smoking quit rate.

RESULTS

A total of 70 PCPs participated in the study, with 35 randomized to the intervention condition and 35 to standard care. Of smokers, 270 patients were randomized to the intervention condition and 248 to standard care. At six months follow-up, 237 patients remained in the intervention condition and 228 in standard care.

Effectiveness

Intervention group PCPs exceeded those in the standard care condition in terms of performance of each of the 5 As (all $p<.005$). In terms of the primary endpoint, intervention group patients were more likely than those in the standard care group to be smoke-free at 6 months follow-up (12 percent versus 8 percent 7-day point prevalence abstinence, $p<.078$). A subanalysis showed that those intervention group smokers who were in the preparation stage were significantly more likely to be smoke-free at 6 months follow-up than their counterparts in standard care ($p<0.05$). In addition, intervention patients surpassed those in standard care in terms of forward progression in stages of change ($F=3.84$, $df=465$, $p<.05$), and in terms of number of days quit (18.4 versus 12.2, $p<.05$) but not on number of quit attempts.

Expert system costs

The costs of the expert system are summarized in Table 2 on page 51. Total intervention costs averaged $89.18 per smoker in the experimental group. The $40.83 difference per smoker ($89.18–$48.35) consists of $8.82 in extra workstation and PCP training costs, $21.41 ($7.81+$21.74 – $8.14) higher costs incurred by office support staff and in the initial and follow-up PCP smoking cessation counseling visits, and $6.89 extra in adjuvant therapy costs. Excluding adjuvant therapy costs because they are not borne by the practice, annual expert system costs were $5,742 ($42.10 x 136.4 smokers), or $4,632 more than currently incurred by "standard care" practices ($1,110).

7-day point-prevalence abstinence

Table 3 summarizes the percentage reporting 7-day point-prevalence abstinence by treatment condition and stratified by stage-of-readiness to quit, assuming a 45% relapse rate (Cromwell et al., 1997). Seven day point-prevalence abstinence was 12.2% in the intervention group versus 7.9% in the standard care condition (6.7% versus 4.3%, respectively, after adjusting for expected relapse rates). Higher relapse-adjusted abstinence in the intervention group generated 3.24 more quitters per year (9.17 versus 5.93) in the average sized practice.

Intervention cost effectiveness

The incremental cost-effectiveness of the intervention for pre-preparation patients was $4,757 per net quitter. This rate was derived as the difference in intervention and standard care costs divided by 1.35, the extra number of quitters in the intervention group. Because of their higher abstinence level, smokers in the preparation stage showed much lower incremental costs per quitter than those in the pre-preparation stage, $735 versus $4,757. Aggregating across stages, the overall incremental cost-effectiveness per net quitter was $1,715 (See Table 3, above). The overall incremental cost effectiveness for the expert system intervention, discounted at 3%, was $1,174. The overall incremental cost effectiveness of the intervention, based on quality-adjusted life-years saved, was $869.

Cost effectiveness accounting for stage progression

When analyses of smoking cessation interventions rely only on observed quit rates, the ensuing cost effectiveness estimates may be conservative in that they fail to incorporate data on partial behavior change (Wagner & Goldstein, 2004). Simply by advancing a smoker's stage of readiness to quit, a smoking cessation intervention can increase the quit rate occurring *after* the study period. Table 4, above, gives the number of successful quits and smokers in nine stage cells for the intervention and standard care groups. Row totals (at the right) are baseline stage counts; column totals (at the bottom) are 6-month stage counts. Individual cells give the number of quitters divided by smoker stage-of-readiness at 6 months. Bolded diagonal cells indicate quits for smokers who remained in their original stage-of-readiness at 6 months (e.g., 2 in pre-contemplation, 8 in contemplation, 17 in preparation). Of the 237 intervention group smokers, 29 quit during the study period (12.2% abstinent), while for the standard care group it was 18/228, or 7.9% abstinent. As shown on the diagonals in Table 4, the percentage abstinent was higher in the intervention condition versus standard care for smokers in the pre-contemplation and preparation groups and slightly lower for those in the contemplation group.

TABLE 3
Percent 7-day point prevalence abstinence and cost-effectiveness of expert system

	Intervention	Control	Difference[1]	P Value
Pre-preparation				
6-month 7-day point-prevalence abstinence	7.90%	6.10%	+1.8%	
Total adjusted quitters[1]	5.94	4.59	+1.35	
Preparation				
6-month 7-day point-prevalence abstinence	18.3%	10.3%	+8.0%	
Total adjusted quitters[1]	13.76	7.74	+6.02	
Overall				
6-month 7-day point-prevalence abstinence	12.20%	7.90%	+4.3%	0.078
Total adjusted quitters[1]	9.17	5.93	+3.24	
Incremental cost-effectiveness per net Quitter				
Prepreparation[2]			$4,757[4]	
Preparation[2]			$735[4]	
Overall			$1,715[4]	
Overall incremental cost-effectiveness				
Per life year saved[3]			$1,174[4]	
Per QALY life year saved			$869[4]	

[1] Intervention and control figures assume all smokers in a given stage.
[2] Previous research has shown that smokers who quit can expect to add an extra 4.66 years to their lives, or 5.075 quality adjusted life years (Fiscella & Franks, 1996; Adams & Benson, 1992). However, as these additional years generally come later in life, discounting future extra years of life by a 3% discount rate significantly reduces the present value of years-of-life-saved to 1.46 and QALY-adjusted years to 1.97 (Cromwell et al., 1997; Fiscella & Franks, 1996).
[3] Frequency-weighted difference in intervention and control costs per smoker based on adjuvant therapy use divided by difference in number of net quitters or life-years saved.
[4]Overall rate is a weighted average by stage.

Off-diagonal percentages reporting 7-day point-prevalence abstinence were similar, with one important difference: Remaining contemplation and preparation smokers in the standard care group reported a much higher rate of stage regression than their intervention group counterparts: 28% (54/(113+97-18)) vs. 18% ((36-1)/(125+98-27)). To estimate the potential post-study effects of the intervention, we added an estimate of the potential gain (loss) in quitters from stage progression (regression) to the total number of quitters in each diagonal cell. The projected net change in quitters accounting for stage movement was +0.2 for the intervention and –1.44 for the standard care group, a 1.64 difference. The revised 7-day point-prevalence abstinence for the intervention group was 29.2/237 = 12.32% compared with 16.56/228 = 7.26% for the standard care group. This adjustment widened the gap in intervention versus standard care percent abstinent from 0.043 (=.122-.079) to 0.051 (= .1232- .0726).

The net change in number of intervention versus standard care group quitters due to movement into a different stage of readiness reduced incremental cost per quitter from $1,715 to $1,459. The incremental intervention costs per life-year saved declined from $1,174 to $999 (a 15% reduction) and from $869 to $740.

Sensitivity analyses

Results of the sensitivity analyses showed that if PCP time spent reviewing the expert system report and providing the smoking cessation counseling 5A's were increased by 50% for both the initial and follow-up visit combined, costs per net quitter and per life year saved would rise by 57%. Similarly, if 75% of smokers were in the pre-preparation stage pre-intervention (instead of the 59% found in the study sample), the cost per net quitter and life year saved would increase by 57%. Conversely, if the proportion of smokers in the Preparation stage were 50% (as opposed to the study 41%), both costs would be reduced by 16%. Increasing workstation-related costs or reducing computer lifetimes by 50% resulted in an increase in cost per life-year saved of 15% to 18%. The underlying smoking quit rate in NYC (7.9%, based on our control group's quit rate) was higher than the national average of 5%. Adjusting our intervention and control group quit

TABLE 4
Quit rates by stage of readiness to quit smoking at baseline versus 6 months follow-up assessment

	6 month stage			
Baseline stage	Precontemplation (Quits/Smokers)[1]	Contemplation (Quits/Smokers)[1]	Preparation (Quits/Smokers)[1]	Total (Quits/Smokers)
Intervention				
Precontemplation	**2/6**	0/5	0/3	2/14 (14.3%)
Contemplation	0/3	**8/92**	1/30	9/125 (7.2%)
Preparation	0/1	1/32	**17/65**	18/98 (18.4%)
Total	2/10 (20%)	9/129 (7%)	18/98 (18.4%)	29/237 (12.2%)
Control				
Precontemplation	**0/8**	0/8	0/2	0/18 (0%)
Contemplation	0/10	**7/75**	1/28	8/113 (7.1%)
Preparation	0/3	0/41	**10/53**	10/97 (10.3%)
Total	0/21 (0%)	7/124 (5.6%)	11/83 (13.3%)	18/228 (7.9%)

[1] Numbers in cells are quitters divided by smokers at 6 months.

rates downward by the ratio of the national to the New York City quit rate (.05/.079) raised cost per life-year saved by 61%.

DISCUSSION

Our analysis contributes to the smoking cessation literature in two ways. First, although a number of studies have established the cost-effectiveness of single smoking cessation interventions, none have addressed the effect of an intervention targeted at both physicians and patients simultaneously. Second, although movement in stage of readiness to change is recognized as an important factor to incorporate in cost-effectiveness analyses, ours is the first study in the smoking cessation literature to do so (Wagner & Goldstein, 2004). The incremental yearly cost of implementing the expert system intervention would be $4,632 per physician practice, excluding adjuvant therapy costs. With adjuvant therapy costs, the incremental yearly cost would be $5,570 per practice, and expert system implementation would yield approximately 3.24 extra quitters after allowing for a 45% relapse rate. These quitters would each enjoy nearly 1.5 extra years of life, or a total of 1.68 million extra life-years (and 2.26 million extra QALYs) if adopted by all PCPs in the U.S. The mean cost-effectiveness ratio for each additional quitter was estimated to be $1,174 per life year saved and $869 per QALY. These estimates are substantially below the cost-effectiveness thresholds of $20,000 and $50,000 per QALY typically used as benchmarks (Azimi & Welch, 1998). We found that the cost-effectiveness results were even more favorable. Not only did the expert system intervention yield a higher quit rate but it also appeared to minimize stage regression. Our estimated costs per year of life saved and per QALY saved compare favorably with those reported for similar smoking cessation interventions (Cummings et al., 1989; Fiscella & Franks, 1996). They also approximate the cost-effectiveness ratios published for smoking cessation interventions delivered by nonphysician healthcare professionals (Marks, 1990; McGhan et al., 1996; Krumholz et al., 1993). Despite the slightly higher cost of the expert system compared with lower intensity smoking cessation interventions (Altman et al., 1987; Windsor et al., 1988; Tillgren et al., 1993; Tillgren et al., 1995), it was significantly less expensive than a similar primary care smoking cessation counseling intervention conducted by Kaplan and Anderson (1988) for which a mean cost-effectiveness ratio of $8,313 was reported. Collectively, enhanced primary care smoking cessation interventions appear to offer a highly cost-effective response to a major health risk (Warner, 1997).

Limitations

A few limitations of our demonstration study are worth noting. The incremental 7-day point prevalence abstinence estimates, both overall (4.3%) and among smokers in the preparation stage (8.0%), were much higher than those seen in other studies testing similar interventions (Cromwell et al., 1997). Second, the testing of our expert system intervention was confined to the four boroughs of NYC. Due to various contextual factors (e.g., a series of state-sponsored public health initiatives promoting smoking cessation, a $3 per pack cigarette tax), the incremental gains associated with the use of an expert system intervention might have been smaller in NYC than would have been seen in other places

where the base smoking rate is higher. Lastly, lower-than-expected smoking rates created challenges for recruitment, resulting in smaller-than-anticipated sample sizes. Study underpowering may have contributed to the marginal significance of the outcome. Despite this, however, the statistically significant improvement seen in PCP adherence to the 5A's, and the significant improvement in abstinence levels among those in the intervention group's preparation stage smokers, suggests that this intervention is a promising addition to smoking cessation interventions.

Overall, our results suggest that an expert system intervention is a cost-effective approach for assisting smokers to quit. Future research should enlist a larger, more geographically diverse set of primary care practices that have viable computer systems. Going forward, smoking cessation programs need to take greater advantage of the rapid computerization of the physician's office.

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