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Financial Benefit of a Smoking Cessation Program Prior to Elective Colorectal Surgery

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Abstract

Background—Cigarette smoking increases the risk of postoperative complications nearly 2-fold. Preoperative smoking cessation programs may reduce complications as well as overall postoperative costs. We aim to create an economic evaluation framework to estimate the potential value of preoperative smoking cessation programs for patients undergoing elective colorectal surgery.

Methods—A decision-analytic model from the payer perspective was developed to integrate the costs and incidence of 90-day postoperative complications and readmissions for a cohort of patients undergoing elective colorectal surgery after a smoking cessation program versus usual care. Complication, readmission and cost data were derived from a cohort of 534 current smokers and recent quitters undergoing elective colorectal resections in Washington State's Surgical Care and Outcomes Assessment Program linked to Washington State's Comprehensive Hospital

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Abstract Reporting System. Smoking cessation program efficacy was obtained from the literature. Sensitivity analyses were performed to account for uncertainty.

Results—For a cohort of patients, the base case estimates imply that the total direct medical costs for patients who underwent a preoperative smoking cessation program were on average \$304 (95% CI \$40–\$571) lower per patient than those under usual care during the first 90 days after surgery. The model was most sensitive to the odds of recent quitters developing complications or requiring readmission, and smoking program efficacy.

Conclusions—A preoperative smoking cessation program is predicted to be cost-saving over the global postoperative period if the cost of the intervention is below \$304 per patient. This framework allows the value of smoking cessation programs of variable cost and effectiveness to be determined.

Keywords

Smoking Cessation Program; Tobacco; Surgery; Colorectal; Cost

BACKGROUND

Smoking significantly increases the risk of complications after surgery, and smokers make up nearly 25% of all surgical patients.¹ The pre-operative setting has often been overlooked as a time to educate and motivate patients to quit smoking, yet an upcoming operation represents a “teachable moment” and an opportunity to modify patient behavior.² Current smoking is associated with higher odds of post-operative infections, pulmonary complications, neurologic complications and intensive care unit admission.³ Prospective studies of pre-operative smoking cessation programs have shown that the risk conferred by smoking is modifiable, with lower rates of overall morbidity and wound complications in patients who were able to stop smoking.^{4,5} Approximately 10 million procedures are performed in the United States on people who smoke every year.² Assisting patients in quitting pre-operatively has the potential to make a significant impact on post-operative complications and their associated costs.

Previous economic evaluations have shown smoking cessation programs to be highly cost-effective in the long-term,^{6–7} but most focus on interventions in primary care and few have been linked to surgical interventions. A study of veterans undergoing general surgical procedures provided the first evidence of higher direct inpatient costs for current smokers who smoked within 1 year of surgery compared with those who quit more than 1 year preoperatively.⁸ However the generalizability of this study to the typical surgical population was called into question by a population-based study of patients who underwent inpatient surgical procedures that showed no difference in direct inpatient operative costs when patients were categorized by smoking status.⁹ If not through lowering direct costs, cigarette cessation may impact health care utilization through long-term benefits related to permanent cigarette cessation. Advice from surgeons and the experience of undergoing surgery appears to be potentially influential on long term smoking. Undergoing major surgery is associated with twice the likelihood of long-term smoking cessation² and randomized controlled studies show one-year cessation rates between 12 and 37.5%.¹⁰ Knowing the incremental

costs and complications of current smokers over those who quit preoperatively can allow us to estimate the immediate cost savings of smoking cessation and provides a convenient benchmark to budget pre-operative intervention programs. In this study, the goal was to create a cost modeling framework to define the potential short term value of pre-operative smoking cessation programs for patients undergoing surgery.

METHODS

Study population

A cohort of patients who had undergone elective colorectal surgery and who smoked cigarettes within the year prior to surgery was assembled using in-hospital clinical data from the Surgical Care and Outcomes Assessment Program (SCOAP) linked to the Washington State's Comprehensive Hospital Abstract Reporting System (CHARS). SCOAP is a statewide quality improvement program that draws data from medical records at more than 55 hospitals in Washington State by trained, audited abstractors using standardized definitions. CHARS includes patient identifiers that allow linkage to SCOAP and tracking of subsequent hospitalization after a SCOAP index admission at any medical center in the state for any diagnosis. The CHARS data set also contains ICD-9 diagnosis and procedure codes and hospitalization charges. Data from 41 hospitals, totaling 6,090 patients, were available during the study period of between January 2011 and December 2011. These dates were chosen as they represent the first year of data that included information regarding tobacco use. Only patients with complete SCOAP or CHARS data were included in this study (5,556 patients excluded). Patients were categorized as either current smokers (smoked within 30 days pre-operatively) or recent quitters (quit smoking 31–364 days pre-operatively). Differences in baseline characteristics were described using a chi-squared testing.

Patients undergoing colorectal surgery were chosen for this study due to the availability of detailed postoperative complication information and an overall high complication rate compared to other types of operations. The initial hospitalization associated with the patient's first surgery, or index hospitalizations, were categorized as either complicated or non-complicated based on the presence or absence of postoperative variables as described in the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP),¹¹ with slight modifications, including the addition of anastomotic leak as a complication specific to this population (Appendix, Table S1). Due to the inability to distinguish index operations from reoperations during the same hospitalization in CHARS, the 'reoperation' complication was not included. Prolonged length of stay (LOS) was defined as greater than 2 standard deviations above the median of the cohort population. ICD-9 codes for complications and procedures were based on prior studies^{12,13} with additional clarification from the Centers for Medicare & Medicaid reference as needed.¹⁴ As the CHARS ICD-9 diagnosis code field was limited to nine entries and most of the complications were also coded in SCOAP, a patient was considered to have a complication if it was listed in either record. Readmissions were defined as admission to any Washington State hospital within 90 days of the index operation for any reason.

Decision Model

A decision-analytic model was developed to assess the potential impact of a pre-operative smoking cessation program. Probability of smoking cessation prior to surgery for was estimated using the weighted mean efficacy of smoking cessation program intervention arms (50.3%) and control arms (32.8%) of all studies included in the Cochrane Collaboration meta-analysis of preoperative smoking cessation programs.¹⁰ (Figure 1) A baseline probability pathway of complication or readmission was created based on the data from current smokers. A multivariate logistic regression adjusting for patient variables that differed between the current smokers and recent quitters was constructed and used to determine probability pathway for recent quitters. Figure 2 displays the event pathway model for both current smokers and recent quitters after either exposure to a smoking cessation program or usual care. The final probability of a patient arriving at each endpoint was the combined probabilities of events along the pathway to that endpoint.

Costs of Postoperative Complications

Total direct costs of the index hospitalization, first readmission and second or greater (combined) readmission were obtained from CHARS, which lists the total in-hospital charges for each hospitalization episode. Charges were converted to costs using the Medicare cost to charge ratio for 2011¹⁵ based on hospital urban or rural status¹⁶ and adjusted for inflation to 2016 dollars.¹⁷ To account for the skewed nature of the data, costs were modeled using a generalized linear model with a gamma distribution and a log link. The regression model was adjusted for those variables found to be different between current smokers and recent quitters, in addition to insurance status (public/non-public).

Outcomes Assessment and Sensitivity Analyses

The main outcome was the difference in 90-day direct medical costs of hospitalizations between cohorts exposed and unexposed to smoking cessation programs. Final costs for each cohort were calculated by multiplying each pathway's combined probability by the total cost of that pathway, then adding these cost probabilities together. One-way sensitivity analyses were conducted with univariate analysis to assess the impact of the model on all transition probabilities and cost variables using the 95% confidence intervals from the regression models and the most effective⁵ and least effective¹⁸ smoking cessation programs from the meta-analysis.¹⁰ Analyses were carried out using Microsoft Excel (2011, Microsoft Corp, Redmond, WA) and Stata 12.1 (StataCorp, College Station, TX). The use of linked CHARS-SCOAP data has been reviewed by the Washington State Institutional Review Board, study # D-031908-H.

RESULTS

There were 534 patients who reported smoking within one year of surgery and underwent elective colorectal resections in 2011 at 41 SCOAP hospitals, of which 381 (71.3%) were current smokers and 153 (28.7%) were recent quitters. Current smokers were significantly younger than recent quitters, and had lower prevalence of hypertension, sleep apnea, coronary artery disease and steroid use. (Table 1) After adjustment for these patient-level covariates, there remained no significant differences in the probability of a complication

during the index hospitalization (AOR 0.842 95% CI 0.526–1.348) or subsequent readmissions (1.123 95% CI 0.511–2.465) between current smokers and recent quitters. Probabilities for each event along the pathway were calculated for both current smokers and recent quitters. (Table 2 and Figure 2)

Using these inputs in the decision model, we predicted the average cost of the index hospitalization and 90-day readmissions for patients undergoing colorectal resections to be \$27,681 for current smokers and \$26,340 per patient for recent quitters. Using this same model, we predicted the average cost of the index hospitalization and 90-day readmissions for patients exposed to a smoking cessation program to be \$28,099 (95% CI \$23,031 – \$32,557), compared to an average of \$27,795 (95% CI \$23,601 – \$32,597) for those under usual care. Thus, a smoking cessation program with the base case efficacy in assisting patients to quit smoking would likely save on average \$304 (95% CI \$40 – \$571) per patient within the first 90 days after surgery.

Figure 2 demonstrates the impact of varying model factors on the difference in complication costs per patient. The model was most sensitive to changes in the odds of readmission given no complications, the odds of a complicated index hospitalization and changes in the efficacy of smoking cessation programs. Variation in hospitalization costs remained consistent in all situations with the exception of cost of the first readmission for recent quitters.

Due to concerns about over-estimation of the prevalence of complications in the base case scenario by including patients that had coded complications in either database (SCOAP or CHARS), a one-way sensitivity analysis to assess the impact of only including those patients with complications in both databases (13.9%). This change resulted in mean 90-day direct medical costs that were \$329 less for recent quitters compared to current smokers.

DISCUSSION

This study provides a costing framework to determine the potential short-term cost savings per patient partaking in a smoking cessation program prior to undergoing colorectal surgery. The cost of the initial hospitalization, complications and 90-day readmission was \$304 less per patient for those exposed to smoking cessation programs than patients who underwent usual care. Therefore, a cigarette cessation program that costs, on average \$304 or less per patient would be expected to be cost saving. Although there was no significant difference in the probability of a complicated index hospitalization or readmission between current smokers and recent quitters, the cost savings were consistently driven by lower costs for hospitalizations of recent quitters. The main variability in the model came from the wide confidence intervals for the readmission and complicated treatment of recent quitters and the efficacy of the smoking cessation program.

The results of this study are congruent with those of Kamath *et al*⁸ whose fully adjusted estimate of the 30-day direct inpatient costs for a cohort of veterans undergoing general surgical procedures was \$25,101 for former smokers and \$25,390 for current smokers – a difference of \$289. However, the population in the Kamath *et al* study was dissimilar to this

study as they compared patients who had smoked in the 12 months prior to surgery with those who quit 12 months or more preoperatively, and our study looked at two subsets of the former group. In addition, their population only included veterans, and hence the generalizability to the entire population is questioned. A more comparable population may be that in the Warner *et al* study,⁹ who compared “daily or less than daily” smokers to “past cigarette smoker but not currently using.” In their propensity-matched model, there was no significant difference in the direct inpatient costs for current and former smokers, with current smokers having slightly lower costs (−\$107, 95% CI: −\$1257, \$1044). However, unbalanced covariates resulted in former smokers being older, more likely to be married and have undergone cardiovascular surgery than current smokers. That study did not comment on the prevalence of complications in the two groups.

Costs of smoking cessation programs vary widely based on intensity, length and resources used. Medicare reimburses an average of \$14 for 3–10 minutes of smoking cessation counseling (Healthcare Common Procedure Coding System (HCPCS) 99406) and \$27 for more than 10 minutes (HCPCS 99407).²⁰ However, estimates of counseling costs may be as high as \$175 based on the per-minute physician time^{21–23} and \$163 for intense quit line counseling.²³ The cost of 30 days of nicotine replacement therapy varies based on the mode of delivery, with the patch (\$67–221), gum (\$79–157) and lozenge (\$142–157) being cheaper and the nicotine inhaler (\$32–463) and nasal spray (\$408–413) more expensive.^{6, 22,23,25–27} Prescription medications varenicline and bupropion also require significant resources (\$110–290 and \$238–379, respectively).^{21–23,29,30}

By focusing only on the immediate postoperative period, the early savings and benefits relevant to many payers in the system are highlighted, but the benefits of quitting smoking for those able to remain tobacco free are likely underestimated. The work of Slatore *et al* estimated these enduring benefits. In their cost-efficacy analysis of a pre-operative smoking cessation program for smokers with lung cancer undergoing operative treatment, the incremental cost effectiveness ratio was \$16,707 per quality-adjusted life year in the first year, assuming a 24% continued cessation rate in the treatment arm. That study assumed equal rates of post-operative complications in recent quitters and continued smokers.

There were several limitations to our study that must be considered to put our results in context. Not all potential post-operative complications were taken into consideration, limited to those described by NSQIP. Categorization of patients who had complications in either the SCOAP or CHARS database potentially led to an over-estimation of complication prevalence, but the one-way sensitivity analysis showed that this had a minimal effect on the main outcome of interest. The population included all patients undergoing elective colorectal resections and did not differentiate based on the type of operation, which could impact the cost of hospitalization. Relatedly, we were unable to differentiate readmission for complications from those planned readmissions/reoperations (e.g. ostomy reversal), however the effect of this is expected to be small as the majority of these procedures would not be performed within 90 days of the initial procedure. The model inputs were derived from primary data from a relatively small sample, highlighting present limitations in evidence and more explicitly pointing out assumptions related to the value of cessation and of cigarette cessation programs. Additionally, due to the observational methods employed real

differences may exist between patients that recently quit or continued smoking. Our data is limited by the fields present in SCOAP, and although major comorbidities are compared among groups (Table 1), this does not entirely rule out one group having potentially better health than the other. Furthermore, we were unable to assess if recent quitters had quit with or without the benefit of a smoking cessation program; potentially leaving inherent heterogeneity within this cohort that could bias results.

Our method of categorization of patients into groups of current smokers (smoked within 30 days pre-operatively) or recent quitters (quit smoking 31–364 days pre-operatively) poses several issues. Some may argue that having quit smoking 4 weeks prior to surgery could no longer be categorized as a “current smoker”, however in doing this we remain certain to include all wavering tobacco use in the current smoker category. This ultimately strengthens our observations in that the potential bias would sway the effectiveness of smoking cessation programs towards the null hypothesis. Furthermore, as popularity of nicotine replacement therapy and use of alternate nicotine delivery devices such as e-cigarettes increases, many patients who were otherwise believed to be not smoking may be consuming varied amounts of daily nicotine. Nicotine replacement therapy is not tracked in the SCOAP database, therefore it is unknown how many patients may be still using nicotine and what effect that may have on the outcome or cost of their healthcare utilization. In our study, patients categorized as “recent quitters” may be continuing to use nicotine replacement, possibly underestimating the benefits of smoking cessation.

However, given these limitations and that only specific complications were examined over a short time frame, the estimated cost savings that resulted from this analysis are likely a conservative estimate. Additional benefits, such as quality of life, productivity, lower indirect costs and long-term health benefits, could exist that were not included in this analysis.

CONCLUSIONS

A preoperative smoking cessation program is predicted to be cost-saving over the global post-operative period if the cost of the intervention is below \$304 per patient. This proposed framework allows payers and policymakers to determine the value of cigarette cessation and therefore the cost and effectiveness of proposed smoking cessation programs that would be most optimal for a population of patients. These findings should be helpful in promoting the broader use of cigarette smoking cessation programs in anticipation of surgery.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

Decision tree entrance for a cohort of smokers undergoing elective colorectal surgery, either under preoperative smoking cessation program or usual care. Probability of patients continuing as current smokers or becoming recent quitters is displayed for each treatment course.

Figure 2.

Decision tree continuation from figure 1 for cohort of smokers undergoing elective colorectal surgery who have now either continued smoking or become recent quitters. Superscript designations (a-l) indicate probability of events and associated costs as reported on Table 2.

Figure 3.

Tornado diagram for one-way sensitivity analysis of model variables compared to the base case scenario of \$304 (solid black line). The transition probabilities not included in the figure remained cost-saving. OR represents the adjusted odds of the probability outcome when comparing recent quitters (RQ) to current smokers.

Table 1

Patient Characteristics by Smoking Status (Column Percentages)

Characteristics	Recent Quitters	Current Smokers	p-value
Number (%)	153 (28.7%)	381 (71.3%)	
Age, mean (SD)	62.6 (14.3)	55.9 (12.4)	<0.001
Sex (% male)	79 (51.6%)	184 (48.3%)	0.485
Race (% white)	137 (89.5%)	322 (84.5%)	0.131
BMI >30	54 (35.3%)	123 (32.3%)	0.504
Hypertension	91 (59.5%)	148 (38.8%)	<0.001
Diabetes	23 (15.0%)	46 (12.1%)	0.357
Asthma	19 (12.4%)	32 (8.4%)	0.153
Sleep Apnea	23 (15.0%)	21 (5.5%)	<0.001
CAD	21 (13.7%)	23 (6.0%)	0.003
Steroid use	11 (7.2%)	9 (2.4%)	0.008
Albumin <3.2g/dL	12 (7.8%)	33 (8.7%)	0.758
ASA Class			0.509
1	2 (1.3%)	5 (1.3%)	
2	80 (53.3%)	224 (60.2%)	
3	63 (42.0%)	130 (35.0%)	
4/5	5 (3.3%)	13 (3.5%)	
Pack years, mean (SD)	29.9 (25.9)	29.9 (20.6)	0.998
Public insurance	82 (53.6%)	169 (44.4%)	0.053
Cancer	41 (26.8%)	76 (19.9%)	0.084
Death in Hospital	2 (1.3%)	4 (1.0)	0.999

ASA, American Society of Anesthesiologists, CAD, Coronary Artery Disease

Table 2

Probabilities and Costs of Transition Points

	Event Probability, Adjusted	95% CI	Cost of Event, Adjusted	95% CI
Current Smokers (n=381)				
Uncomplicated admission ^a	0.761	0.518, 0.852	\$18,865	\$17,629, \$20,100
Complicated admission ^b	0.239	0.148, 0.482	\$36,946	\$33,081, \$40,813
First readmission given no complications ^c	0.237	0.101, 0.377	\$15,390	\$9,924, \$20,854
First readmission given complications ^d	0.390	0.085, 0.602	\$15,514	\$6,758, \$24,270
Second readmission given no complications ^e	0.275	0.057, 0.624	\$11,576	\$7,092, \$16,060
Second readmission given complications ^f	0.383	0.042, 0.903	\$14,627	\$7,611, \$21,642
Recent Quitters (n=153)				
Uncomplicated admission ^g	0.799	0.678, 0.874	\$17,523	\$15,823, \$19,224
Complicated admission ^h	0.201	0.126, 0.322	\$34,319	\$29,833, \$38,805
First readmission given no complications ⁱ	0.336	0.201, 0.559	\$10,334	\$4,923, \$15,746
First readmission given complications ^j	0.890	0.358, 1.00	\$10,417	\$5,128, \$15,708
Second readmission given no complications ^k	0.254	0.091, 0.710	\$6,964	\$3,827, \$10,099
Second readmission given complications ^l	0.707	0.182, 1.00	\$8,798	\$5,093, \$12,503

^{a-l} Location of event probability and cost along pathway in Figure 2