The Effect of an Inpatient Smoking Cessation Treatment Program on Hospital Readmissions and Length of Stay

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BACKGROUND: Most clinical research involving tobacco dependence treatment is related to outpatient interventions and focuses on health outcomes. Inpatient smoking cessation treatment has been found to be cost-effective in the Canadian healthcare system, but the finding's applicability to US health systems is unclear.

OBJECTIVE: The objective of this study is to estimate the impact of an inpatient tobacco cessation treatment program on 30-day readmission rates and length of stay (LOS).

METHODS: Participants were 28,994 patients admitted to the hospital between July 2012 and July 2014. Smokers were identified through the electronic medical records system and were offered cessation treatment. Program effects were estimated by using a difference-in-differences approach, comparing all smokers to all nonsmokers before versus after introduction of the program. Readmission rates were modeled by using probit regression; LOS was modeled by using truncated negative binomial regression. Models controlled for age, sex, race, payer, hospital department, severity of illness, and intensive care unit days.

RESULTS: The hospital-initiated smoking cessation intervention had no significant effect on 30-day readmission rates or LOS. Other control variables had the expected signs and were statistically significant.

CONCLUSIONS: The evaluation of an inpatient tobacco dependence treatment did not find significant short-term changes in healthcare utilization in the first 30 days after initial hospitalization. *Journal of Hospital Medicine* 2017;12: 880-885. Published online first August 23, 2017. © 2017 Society of Hospital Medicine.

Successful smoking cessation interventions result in substantial gains in health and life expectancy by reducing smoking-related illnesses and preventing premature deaths.[1,2] The Department of Health and Human Services recommends clinicians use hospitalization as "an opportunity to promote smoking cessation" and "to prescribe medications to alleviate withdrawal symptoms"[3] because individual readiness to quit may be high during hospitalizations. A meta-analysis of 50 studies (21 from the United States) examining the efficacy of hospital-initiated smoking cessation interventions concluded that smoking cessation support programs that began in the hospital and continued for at least 1 month postdischarge significantly increase the likelihood of patients being smoke-free in the long term.[4] The most efficacious strategies included counseling and pharmacotherapy rather than counseling alone.[3] Most inpatient smoking cessation studies have focused on quit-rates or medical outcomes, while fewer studies have looked at healthcare utilization.

However, previous research has shown that smoking cessation for inpatients has relatively immediate economic and health benefits. Patients who quit smoking during hospitalizations for cardiovascular disease are less likely to be readmitted or to die during follow-up.[5,6] Patients with acute myocardial infarction (AMI), unstable angina, heart failure, and chronic obstructive pulmonary disease who received an inpatient smoking cessation intervention had reductions in inpatient readmission rates.[7] A 1% reduction in overall smoking rates would lead to an annual reduction of 3,022 hospitalizations for stroke and 1,684 hospitalizations for AMI.[8] One comprehensive program, the Ottawa Model for Smoking Cessation (OMSC), found that a hospital-initiated intervention increased long-term cessation rates by 15% in cardiac patients and by 11% in general hospital populations.[9,10] The applicability of this result to US healthcare systems is unknown. This paper adds to the existing literature by evaluating the impact of an inpatient smoking cessation program on healthcare utilization among patients hospitalized for any reason, rather than solely focused on those with cardiopulmonary diagnoses.

The current study focuses on an inpatient smoking cessation program at a teaching hospital in the Rocky Mountain region. The hospital implemented a smoking cessation treatment program on July 1, 2013, based on the OMSC. The goal was to identify and support inpatient adult smokers who wanted to make a quit attempt and help them remain smoke-free after discharge. The objective of the current study was to determine the effect of the program on 30-day readmission rates and length of stay (LOS) of the index hospitalization. Although the general cost effectiveness of

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properly structured smoking cessation programs are well established,[11-13] the healthcare utilization effects of inpatient smoking cessation programs are not well understood.

METHODS

Data

The study population consists of patients over age 18 who were admitted to the hospital between July 1, 2012, and July 1, 2014. Baseline smoking status was assessed at hospital admission and recorded in Epic (Epic Systems Corporation, Verona, Wisconsin), the electronic medical records system, as a current smoker (every day and some days), former smoker, never smoker, and never assessed. To check the accuracy of recorded smoking status, a random sample of 819 inpatients was selected and contacted via telephone for verification; 93% of Epic-identified smokers confirmed that they were smokers at hospital admission.[14]

Intervention

The intervention, which launched July 13, 2014, modified the Epic system to automatically alert providers viewing a tobacco user's medical record that the patient should receive standardized orders for a bedside consultation with a Tobacco Treatment Specialist (TTS) and a prescription for nicotine replacement therapy (NRT) while in the hospital.[15] Previously, referrals for tobacco treatment were done on an ad-hoc basis by the physician, and NRT was not routinely available. This system-level intervention standardized and automated the referral process. For patients with a bedside consultation order, TTS used a patient-centered approach (motivational interviewing) to explore patients' motivation to quit smoking and offered NRT to improve comfort and safety while in the hospital. Patients who chose to make a quit attempt received a free 2-week supply of NRT at discharge and 6 months of free follow-up counseling by interactive voice response (IVR) telephone technology that included (a) prerecorded advice keyed to individual patient needs, (b) a warm-transfer option to speak with a live TTS (later dropped), and (c) a collection of patient smoking and cessation treatment measures.[15]

Statistical Analysis

We used an intent-to-treat (ITT) framework for the analysis, which considers everyone eligible for the treatment to be in the treatment group. The approach ignores treatment nonacceptance, nonadherence, protocol deviations, withdrawal from treatment, and cessation outcomes, thus providing conservative estimates of outcomes.[16-18]

Readmission rates and LOS were estimated by using a "difference-in-differences" model, comparing outcomes between smokers before versus after the introduction of the cessation treatment program with nonsmokers before versus after program introduction. The difference-in-differences method looks at the difference pre-and-post in the exposed group (smokers) and unexposed group (nonsmokers). Subtracting the difference between the 2 groups gives an estimate of the policy effect controlling for background trends.[19] The smoking cessation treatment effect on readmission is measured by the coefficient on the interaction term between the smoking variable and an indicator that the program is operational. The coefficient is the "difference-in-differences."

Other control variables include demographic factors (gender, age, race), hospitalization payer (Medicare, Medicaid, commercial), and the service line of the admission. We also included a severity of illness variable from the APR-DRG Grouper (3M, Maplewood, Minnesota)[20] and the number of days spent in the intensive care unit. For the readmission model, we included LOS as a control variable, because individuals with longer LOS had a better opportunity to access the intervention.

For readmissions, the model was estimated by using a probit model, predicting the effect of each of the intervention variables and the control variables on the marginal probability of a readmission. Because patients can appear in both the pre- and postyears, clustered standard errors were used, which correct for the lack of independence from multiple observations from the same individual.[21] For LOS, a truncated negative binomial model was used. The negative binomial model is a specification for count models with a mass of observations plus a long right tail. The truncation is because zero and negative values for LOS are not possible. The dependent variable represents the number of days the individual was hospitalized. For both models, the reported coefficients represent the marginal effect of the independent variable on the dependent variable. This was calculated using the "margins" command in Stata version 13 (StataCorp LLC, College Station, Texas).

RESULTS

Descriptive statistics for the sample are provided in Table 1. Total sample size was 28,994. Of these, 24,619 (84.9%) were nonsmokers and 4375 (15.1%) were smokers. The overall readmission rate was 9.8%. The readmission rate for nonsmokers (10.0%) was higher than for smokers (9.3%), although the difference was not statistically significant. Similarly, the overall mean LOS was identical for nonsmokers and smokers (4.8 days). Average LOS increased slightly from pre- to postprogram among nonsmokers (4.6-4.9 days) and smokers (4.5-5.0 days). There were a number of statistically significant differences between smokers and nonsmokers. Smokers were more likely to be black and to be in the moderate, major, and extreme health severity categories and to have their hospitalization paid for by Medicaid.

During the first 9 months of the project, 88% of the eligible inpatient smokers (n = 802) consented to the consult. Consults were completed for 93% of those who consented (n = 746). Twenty-seven percent of inpatients who received a consult reported smoking at least 1 pack of cigarettes per day; approximately half of these reported being in either the "precontemplation" or "contemplation" stages of readiness to quit tobacco. Free 2-week NRTs were ordered for 39% of inpatients who received a consult, while 22% of inpatients

TABLE 1. Descriptive Statistics for Sample

Characteristics	Nonsmoker	Smoker	Total Sample
Rehospitalization overall (%)	10.0%	9.3%	9.8%
Rehospitalization preintervention (%)	9.9%	8.9%	9.8%
Rehospitalization postintervention (%)	10.0%	9.7%	10.0%
Mean overall length of stay (SE)	4.8 (0.05)	4.8 (0.13)	4.8 (0.05)
Mean preintervention length of stay (SE)	4.6 (0.07)	4.5 (0.15)	4.6 (0.09)
Mean postintervention length of stay (SE)	4.9 (0.08)	5.0 (0.20)	4.9 (0.10)
Mean age (SE)[a]	50.2 (0.12)	47.7 (0.23)	49.9 (0.11)
Mean ICU days (SE)[b]	0.71 (0.02)	0.85 (0.05)	0.73 (0.02)
Female (%)[a]	32.6	25.1	31.5
Race (%)			
White[b]	64.3	62.5	64.0
Black[a]	11.8	19.7	12.9
Other[a]	22.7	16.9	21.8
Severity of illness (%)			
Minor[a]	33.4	25.2	32.2
Moderate[a]	39.3	42.5	39.8
Major[a]	22.4	26.7	23.0
Extreme[b]	4.8	5.6	4.9
Primary payer			
Private[a]	32.1	16.6	29.8
Medicaid[a]	24.8	35.8	26.5
Medicare[a]	31.7	27.7	31.1
Other[a]	11.4	19.9	12.6
Service line			
General medicine[a]	24.8	38.9	26.9
General surgery[b]	9.0	8.0	8.9
Cardiology/cardiac surgery[a]	7.6	9.3	7.9
Obstetrics[a]	21.9	7.0	19.7
Other	36.7	36.8	36.7
Sample size (n) (%)	24,619 (84.9)	4,375 (15.1)	28,994

[a]$P < .01$.

[b]$P < .05$.

NOTE: Student t tests and $\chi 2$ tests were performed to determine the differences in the proportion of variables among nonsmokers and smokers. Abbreviations: ICU, intensive care unit; SE, standard error.

who received a consult completed 3 or more IVR counseling calls (out of 5 total calls). Thirty percent of inpatients who received a consult enrolled in the follow-up program and reported remaining tobacco free 6 months after hospital discharge.[22]

In the probit analysis, the smoking cessation intervention (Smoker*post intervention) showed no significant effect on the probability of readmission (Table 2). The coefficient is positive ($\beta = 0.008$) and statistically insignificant ($P = 0.36$). This indicates that we failed to reject the null hypothesis that there was not a systematic difference in the probability of readmission because of the smoking cessation intervention. Other significant variables generally had the expected relationship with readmission rates. Smokers were 1.6% less likely to be readmitted than nonsmokers ($P = 0.01$), controlling for other factors.

Similar results were found in the truncated negative binomial analysis of LOS (Table 3).

The program effect on smoker LOS was statistically insignificant ($\beta = 0.008$; $P = 0.36$). Smokers overall had a shorter LOS than nonsmokers ($\beta = -0.090$; $P = 0.01$), controlling for other factors. Overall LOS was longer postintervention ($\beta = 0.047$; $P < 0.01$). The control variables generally had the same relationship for the LOS model as for the readmission model.

DISCUSSION

This study investigated the effect of an inpatient smoking cessation program, based on a successful Canadian model, on inpatient readmission rates and LOS. The program showed no effect on 30-day readmission rates or LOS. We see several

TABLE 2. Results of Difference-in-Differences Probit Analysis on Readmissions

Variable	Marginal Probability	*P* Value	95% Confidence Interval	
Smoker	–0.016	.01	–0.029	–0.004
Postintervention	–0.003	.42	–0.009	0.004
Smoker*Post (dif-in-dif)	0.008	.36	–0.009	0.025
Female	–0.009	.03	–0.017	–0.001
Age	–0.0004	.00	–0.001	0.000
Black	–0.012	.04	–0.022	–0.001
Other race	–0.009	.06	–0.019	0.000
Medicaid	0.006	.41	–0.008	0.020
Medicare	0.038	.00	0.023	0.052
Other payer	–0.023	.00	–0.036	–0.010
General medicine	–0.018	.00	–0.026	–0.009
General surgery	–0.017	.01	–0.028	–0.005
Cardiology	–0.030	.00	–0.042	–0.019
Obstetrics	–0.066	.00	–0.075	–0.057
Severity of illness: moderate	0.045	.00	0.035	0.056
Severity of illness: major	0.072	.00	0.058	0.086
Severity of illness: extreme	0.085	.00	0.058	0.112
Length of stay	0.002	.00	0.001	0.002
ICU days	–0.001	.04	–0.002	0.000

NOTE: N = 28,994; Wald $\chi 2$ (19) = 572.96; prob > $\chi 2$ = 0.0000. Abbreviations: dif-in-dif, difference-in-differences; ICU, intensive care unit.

potential explanations for the absence of a detectable impact.

First, the ITT approach reflected real-world implementation of smoking cessation services. The ITT approach adopts the hospital's perspective because the hospital will assess overall effectiveness without regard to programmatic limitations. The intervention group for this analysis included individuals who were offered but declined treatment, individuals who accepted treatment but failed to quit smoking, and individuals who both accepted treatment and quit smoking. If the analysis had focused only on the latter group, an effect would have been more likely to be found. Further analysis of the subset of patients who accepted the intervention and quit smoking is warranted. Nevertheless, hospitals cannot expect all inpatient smokers, or even a majority, to embrace an offer of cessation treatment. This also emphasizes the challenges hospitals will face in offering tobacco cessation programs to smokers in a timely way. Reasons for patients not receiving orders varied but included issues with weekend admissions.

Second, the timeframe of the analysis is limited to the inpatient stay (for LOS) and 30 days (for readmission). A longer-term analysis might have found an effect. However, we examined this from the hospital perspective. For the hospital, LOS is a key cost driver; thus, reductions in LOS would create a strong financial incentive for hospitals to implement smoking cessation programs. Similarly, reducing readmissions is now a priority for hospitals because of new Medicare rules that penalize hospitals for readmissions. Thus, the 2 outcomes we examined are outcomes that are financially important to hospitals.

There are several limitations to our analysis. First, the difference-in-differences model assumes that in the absence of treatment, the average change in the dependent variables would have been the same for both the treatment and control groups, also known as the parallel trends assumption. Specification tests showed this assumption was met for the preperiod. Second, our study relies on electronic health record data to identify smokers. However, 93% of individuals who were identified as smokers confirmed their smoking status upon interview. Finally, we looked at all categories of inpatient admissions. Improvement in LOS and short-term readmission rates may be limited to patients admitted for specific conditions, such as cardiovascular and respiratory conditions.

There are a number of plausible reasons for our null finding. First, the "dose" of intervention may have been too weak; that is, the number of smokers who were offered the treatment, accepted the treatment, and adhered to the treatment may have been too low, leading to too few smokers quitting smok-

TABLE 3. Results of Difference-in-Differences Truncated Negative Binomial Model of Length of Stay

Variable	Marginal Effect	*P* Value	95% Confidence Interval	
Smoker	−0.090	.01	−0.160	−0.021
Post intervention	0.047	.00	0.016	0.078
Smoker*post (dif-in-dif)	0.008	.84	−0.073	0.089
Female	−0.087	.00	−0.132	−0.043
Age	−0.001	.38	−0.003	0.001
Black	−0.120	.00	−0.178	−0.062
Other race	−0.028	.32	−0.084	0.027
Medicaid	0.184	.00	0.107	0.260
Medicare	0.105	.01	0.030	0.179
Other payer	−0.124	.00	−0.191	−0.058
General medicine	−0.511	.00	−0.566	−0.456
General surgery	0.103	.00	0.036	0.171
Cardiology	−0.321	.00	−0.390	−0.252
Obstetrics	−0.421	.00	−0.497	−0.344
Severity of illness: moderate	0.424	.00	0.374	0.474
Severity of illness: major	1.113	.00	1.054	1.172
Severity of illness: extreme	1.581	.00	1.475	1.687
Smoker	0.239	.00	0.180	0.298
ICU days	0.085	.00	0.076	0.094
Constant	0.790	.00	0.681	0.899

NOTE: N = 28,994; truncation point: 0; Wald $\chi 2$ (19) = 4547.46. Abbreviations: dif-in-dif, difference-in-differences; ICU, intensive care unit.

ing and, thus, no effect of the intervention on our outcomes. This follows directly from the ITT design of the study.[23] This suggests that hospitals who wish to adopt smoking cessation programs need to focus on ensuring a timely offering of treatment and encouragement of uptake by smokers.

A second reason for the null finding may have been the short duration for the NRT, which was only offered for 2 weeks. Research suggests that use of NRT for less than 4 weeks is associated with a reduced likelihood of smoking cessation.[24] However, a review of the literature concludes that the duration of NRT is less important than the dosage and the combination of NRT with other forms of smoking cessation therapy.[25] It is important to note that this study used NRT; other treatments such as Chantix could have different effectiveness.[26,27] Further research on different treatment approaches, including longer duration of NRT, would be appropriate.

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