Nicotine and Tobacco Research, 2023, **25**, 86–93
https://doi.org/10.1093/ntr/ntac166
Advance access publication 6 July 2022
Original Investigation

Association Between Smoking Cessation Treatment and Healthcare Costs in a Single-Payer Public Healthcare System

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Abstract

Introduction: There has been little investigation of whether the clinical effectiveness of smoking cessation treatments translates into differences in healthcare costs, using real-world cost data, to determine whether anticipated benefits of smoking cessation treatment are being realized.

Aims and Methods: We sought to determine the association between smoking cessation treatment and healthcare costs using linked administrative healthcare data. In total, 4752 patients who accessed a smoking cessation program in Ontario, Canada between July 2011 and December 2012 (treatment cohort) were each matched to a smoker who did not access these services (control cohort). The primary outcome was total healthcare costs in Canadian dollars, and secondary outcomes were sector-specific costs, from one year prior to the index date until December 31, 2017, or death. Costs were partitioned into four phases: pretreatment, treatment, posttreatment, and end-of-life for those who died.

Results: Among females, total healthcare costs were similar between cohorts in pretreatment and posttreatment phases, but higher for the treatment cohort during the treatment phase ($4,554 vs. $3,237, $p < .001$). Among males, total healthcare costs were higher in the treatment cohort during pretreatment ($3,911 vs. $2,784, $p < .001$), treatment ($4,533 vs. $3,105, $p < .001$) and posttreatment ($5,065 vs. $3,922, $p = .001$) phases. End-of-life costs did not differ. Healthcare sector-specific costs followed a similar pattern.

Conclusions: Five-year healthcare costs were similar between females who participated in a treatment program versus those that did not, with a transient increase during the treatment phase only. Among males, treatment was associated with persistently higher healthcare costs. Further study is needed to address the implications with respect to long-term costs.

Implications: The clinical effectiveness of pharmacological and behavioral smoking cessation treatments is well established, but whether such treatments are associated with healthcare costs, using real-world data, has received limited attention. Our findings suggest that the use of a smoking cessation treatment offered by their health system is associated with persistent higher healthcare costs among males but a transient increase among females. Given increasing access to evidence-based smoking cessation treatments is an important component in national tobacco control strategies, these data highlight the need for further exploration of the relations between smoking cessation treatment engagement and healthcare costs.

Introduction

Smoking exacts a heavy burden on the healthcare system. In Ontario, Canada, direct healthcare costs because of smoking are estimated at $2.7 billion annually.[1] While the clinical effectiveness of pharmacological and behavioral smoking cessation treatments is well established,[2,3] whether such treatments are associated with healthcare costs, using real-world data, has received limited attention.[4] Much of

Received: November 2, 2021. Revised: March 2, 2022. Accepted: July 4 2022.

the extant research are economic evaluations examining the cost to provide smoking cessation treatment relative to a quit-based outcome (eg, cost per successful quit attempt, cost per year of life saved)[5] or simulations (eg, Markov-based state transition models such as the Benefits of Smoking Cessation on Outcomes [BENESCO] model,[6] or the European study on Quantifying Utility of Investment in Protection from Tobacco model [EQUIPTMOD][7]). These simulate hypothetical populations using a range of model inputs to evaluate and compare interventions with regard to outcomes such as cost-effectiveness and cost–benefit; however, findings are highly sensitive to model inputs and assumptions.

We are aware of only two studies that measured the actual healthcare costs of smokers who used cessation treatment services. In the first, hospitalized smokers who received tobacco dependence treatment incurred lower healthcare charges in the year following admission compared with those who had not received treatment.[8] The second study compared patients prescribed varenicline versus nicotine patches in general medical practices and found that all-cause total healthcare costs were no different during the first 3 months but were lower for users of varenicline for the remainder of the year.[4] However, these studies had limitations: The first study was limited to costs incurred in hospital settings and both studies were limited to 1 year of follow-up.

The timeframe or phase during which costs are accrued is important. *Prior to treatment*, smokers may experience health issues that lead to increased use of healthcare services and *result in the initiation of smoking cessation treatment. During smoking cessation treatment*, patients may also be motivated to seek other preventive health services or *treatment for other health concerns. Other health services initiated prior or concurrent to smoking cessation treatment may continue for some length of time after smoking cessation treatment* has terminated. The literature on smoking cessation, *per se*, and subsequent real-world healthcare costs, suggests a spike in costs around the time of a cessation attempt that may, or may not, diminish over time.[9,10]

The lack of evidence of real-world healthcare costs across sectors, beyond one year of follow-up, and among the broader population highlights an evidence gap. Additionally, utilization of healthcare services may differ by sex.[11] To address this gap, we used linked administrative healthcare data and a phase-based approach to compare the healthcare costs for females and males who had and had not accessed a smoking cessation treatment program in Ontario, Canada.

Methods

Study Design

This retrospective matched cohort study used data from the Smoking Treatment for Ontario Patients (STOP) program that was previously linked[12] to population-based administrative healthcare databases housed at ICES (https://www.ices.on.ca). All datasets were linked using unique encoded identifiers and analyzed at ICES. This study was approved by the Research Ethics Board of the Centre for Addiction and Mental Health (protocol #110-2019) and follows Reporting of Studies Conducted Using Observational Routinely Collected Health Data (RECORD) guidelines.

Smoking Cessation Treatment Program

The STOP program delivers smoking cessation treatment online and at partnering healthcare and public health organizations across the province of Ontario, Canada. Patients may enroll at a partnering organization delivering the STOP program, provided they are a rostered or registered patient with that organization. Patients are considered enrolled in the program once they provide informed consent to treatment and complete an initial assessment that collects relevant background information (eg, smoking history, psychiatric, and other medical diagnoses, other substance use), prior to receiving treatment. Treatment consists of individually tailored nicotine replacement therapy (NRT) and behavioral counseling. Patients are eligible to receive up to 26 weeks of NRT in a 12-month period; up to 4 weeks of NRT may be dispensed at a single visit (exceptions may be permitted). Type and dose of NRT are tailored based on patient need, preference, and previous history of NRT use. Both long-acting (patch) and several types of short-acting NRT (eg, gum, lozenge, inhaler) are available, and a combination of long-acting and short-acting NRT is permitted. Patch doses exceeding 21 mg per day, alone or in combination with short-acting NRT, are permitted based on the discretion of the health provider. Patient visits are typically every 2–4 weeks; however, the number, frequency, or duration of treatment visits is not prescribed and may vary based on patient need and clinic capacity. The format (ie, individual or group), content, frequency, and duration of counseling provided are also not prescribed and may vary. Providers implementing the STOP program are trained in cessation counseling and continuing education is available to them. The STOP program has been found effective, with 26% of patients self-reporting abstinence at 6-month follow-up.[13]

Cohort Derivation

We previously described the derivation of a larger treatment cohort of smokers who had utilized the STOP program via primary care clinics and a matched control cohort of smokers who had not.[14] For the current analyses, the treatment cohort consisted of patients enrolled between July 1, 2011 and December 31, 2012. The matched control cohort of smokers was obtained from the Ontario component of the 2011/2012 cycle Canadian Community Health Survey (CCHS), a national cross-sectional population-based health survey (see Supplementary Figure 1 for a flow chart of cohort derivation). The index date was the date of program enrollment for the treatment cohort or survey completion for the control cohort. Each individual in the treatment cohort was matched to one control individual using hard (sex and age at index date ±2 years) and propensity score matching (using a greedy algorithm with no replacement based on a caliper width of 0.2 SD of the logit of the estimated propensity score). The propensity score was calculated using multivariable logistic regression including the following variables: age at index date, education, household income, number of cigarettes smoked per day at index, age first started smoking, comorbidity burden and the rate of both emergency department (ED) visits and hospitalizations in the 2 years prior to index date. Missing values of categorical variables were coded as a distinct category and included in the propensity score; missing values of continuous variables were not included in the propensity score and patients were not matched. Age at index and sex were

obtained from the Registered Persons Database (RPDB) and immigration category was obtained from the Immigration, Refugee, and Citizenship Canada Permanent Resident database.[15] Comorbidity burden was derived from The Johns Hopkins ACG® System (Version 10) Aggregated Diagnosis Groups (ADG) scores, which use diagnoses to categorize individuals' combined illnesses; scores were calculated using a 2-year lookback window from index date and categorized into four groups (0, 5, 6–9, 10+), with higher scores indicating greater comorbidity burden.[16] Further details of the matching process and measurement of baseline covariates are provided elsewhere.[14]

Outcomes

The primary outcome was total direct healthcare costs from 1 year prior to index date until December 31, 2017, or death, whichever occurred first. Occurrence and date of death were identified using the RPDB. Total direct healthcare costs in Canadian Dollars (CAD) were derived by applying a person-centered costing approach using a well-established methodology for healthcare costing using administrative data.[17] This algorithm estimates costs associated with hospitalizations (acute and psychiatric), ED visits and other ambulatory care, physician visits and outpatient care, outpatient prescription drugs (covered under the public provincial drug plan), inpatient rehabilitation, complex continuing care, long-term care, and home care. See Supplementary Table 1 for health administrative datasets used for cost ascertainment. The province's universal healthcare system does not include universal coverage for prescription drug costs, but the Ontario Drug Benefit (ODB) plan covers most of the cost of prescription drug products for people 65 y and older and for those receiving social assistance, regardless of age. We included ODB claims for individuals aged 65 y and older only. Costs were adjusted to 2017 CAD using the Consumer Price Index.[18]

The costs associated with the STOP program itself are not included in the costing algorithm and are not included in these analyses. Although publicly funded by the province's Ministry of Health, and available at no out-of-pocket cost to patients, the funding envelope is independent of other healthcare services; as such, utilization of the program and associated costs are not captured in the province's administrative healthcare databases. These costs include smoking cessation pharmacotherapy, administrative costs, and the initial specialized training of health providers in smoking cessation treatment, as well as ongoing training and clinical support for providers offered by STOP.

We used a phase-based approach to examine healthcare costs associated with the use of smoking cessation treatment during distinct treatment phases. Originally developed to analyze costs of cancer care over distinct phases of care,[19] phase-based approaches have also been used to estimate long-term disease-related costs in epilepsy and infectious disease.[20,21] We defined four phases a priori: (1) pretreatment, (2) treatment, (3) posttreatment, and an (4) end-of-life phase, applicable only to those who died on or after the index date. Phases were defined identically for each cohort, with index date as the anchor by which to define phases. Length of the treatment phase was set at 12 months beginning on the index date because the episode of care that begins with enrollment in the smoking cessation treatment program is 12 months. All individuals had a 12-month pretreatment phase immediately prior to the index date. The posttreatment phase varied in length and was defined as the time from the end of the treatment phase until the end of the study follow-up. Given the posttreatment phase duration could vary, we expressed costs per 12-month for comparability across phases. For those who died, we defined the 12 months before death as the end-of-life phase, with remaining observation time assigned first to the treatment phase and then the posttreatment phase.

Analysis

Distributions of baseline characteristics in our matched cohorts were reported, using frequencies and percentages to describe categorical measures and mean and standard deviation to describe continuous measures. Standardized mean differences (SMD) were computed to examine balance in the distributions of baseline characteristics between the treatment and control cohorts; an SMD of >0.1 was considered a meaningful imbalance. We report phase-based mean healthcare costs, overall and by healthcare sector (ED visits, medical hospitalizations, psychiatric hospitalizations, physician services, and all other sectors), with 95% confidence intervals, stratified by sex. Differences in mean costs between treatment and control groups were compared using p values obtained from two-sided two-sample t tests where a value <.05 was considered significant. As a supplementary analysis, we also report the relative percent change (with 95% confidence intervals) in total healthcare costs from the pretreatment phase to the treatment and posttreatment phases, in each cohort, stratified by sex, with differences in mean costs compared using p values. There were no missing data. Analyses were conducted using SAS Enterprise Guide version 7.12 software.

Results

Baseline Characteristics

Supplementary Table 2 describes the characteristics of the 4752 individuals in each of the treatment and control cohorts at index date, stratified by sex. The majority of characteristics were well-balanced between cohorts. Compared to the control cohort, the treatment cohort had a higher proportion of daily smokers (both sexes), greater prevalence of chronic obstructive pulmonary disease (COPD; both sexes), diabetes (males only), and asthma (females only), and a higher number of ADG comorbidities (males only). The treatment cohort also had a higher rate of outpatient visits (males only) in the 2 years prior to index date. Median follow-up times in the treatment and control cohorts were 4.8 and 5.2 years, respectively.

Total Healthcare Costs Comparing Treatment Versus Control Cohorts by Phase

Among females, mean total healthcare costs were higher in the treatment cohort compared with the control cohort ($4554 vs. $3237, $p < .001$) during the treatment phase, but not during other phases (see Table 1). Among males, mean total healthcare costs were higher in the treatment cohort compared with the control cohort during pretreatment ($3911 vs. $2,784, $p < .001$), treatment ($4533 vs. $3105, $p < .001$), and posttreatment phases ($5065 vs. $4922, $p = .001$), but not during the end-of-life phase.

Sector-Specific Healthcare Costs Comparing Treatment Versus Control Cohorts by Phase

A similar pattern emerged for healthcare sector-specific costs as with total costs (see Tables 2 and 3 and Supplementary

Table 1. Total Healthcare Costs for Matched Treatment and Control Cohorts by Treatment Phase

Phase[a]	Pretreatment		Treatment		Posttreatment		End-of-life	
Females								
	Treatment (n = 2397)	Control (n = 2397)	Treatment (n = 2385)	Control (n = 2,375)	Treatment (n = 2,358)	Control (n = 2,332)	Treatment (n = 153)	Control (n = 178)
Mean costs (95% CI)	$3,694 ($3,354, $4,034)	$3,380 ($2,994, $3,765)	$4,554 (**$4,126, $4,981**)	$3,237 (**$2,882, $3,593**)	$4,742 ($4,341, $5,143)	$4,417 ($3,993, $4,841)	$45,064 ($38,349, $51,780)	$53,417 ($41,292, $65,543)
Males								
	Pretreatment		Treatment		Posttreatment		End-of-life	
	Treatment (n = 2,355)	Control (n = 2,355)	Treatment (n = 2,328)	Control (n = 2,331)	Treatment (n = 2,292)	Control (n = 2290)	Treatment (n = 189)	Control (n = 202)
Mean costs (95% CI)	$3,911 (**$3,454, $4,368**)	$2,784 (**$2,359, $3,209**)	$4,533 (**$3,963, $5,103**)	$3,105 (**$2,602, $3,607**)	$5,065 (**$4,519, $5,611**)	$3,922 (**$3,499, $4,346**)	$50,128 ($41,822, $58,433)	$46,177 ($38,741, $53,613)

CI, confidence interval.
[a]The pretreatment phase was 12 months prior to index date, treatment phase was 12 months beginning on the index date; posttreatment phase lasted from the end of the treatment phase until the end of study follow-up or until the beginning of the end-of-life phase (if applicable), but costs were expressed as 12-month costs for comparability across phases; end-of-life phase was the 12 months before death (if applicable). All estimates are in 2017 Canadian dollars. Bold denotes p-value of < .05.

Figures 2 and 3). During the pretreatment phase, among females, the only difference observed was higher mean costs for physician services in the treatment cohort compared with the matched control cohort ($1372 vs. $1166, p < .001). Among males, costs were higher in the treatment cohort versus the control cohort for ED visits ($224 vs. $152, p < .001), physician services ($1229 vs. $841, p < .001) and all other sectors ($1230 vs. $845, p = .002) during the pretreatment phase.

During the treatment phase, mean costs for four of the five sectors were higher among females in the treatment cohort compared with those in the control cohort: ED visits ($241 vs. $200, p = .005), medical hospitalizations ($1037 vs. $593, p < .001), physician services ($1543 vs. $1165, p < .001), and all other sectors ($1570 vs. $1065, p < .001). Only mean costs for psychiatric hospitalizations did not differ. Among males, mean costs for three of the five sectors were higher for those in the treatment cohort compared with the control cohort during the treatment phase: ED visits ($213 vs. $157, p < .001), physician services ($1298 vs. $877, p < .001) and all other sectors ($1690 vs. $1049, p = .002).

During the posttreatment phase, among females, as was the case for the pretreatment phase, the only difference observed between the treatment cohort and control cohort was mean costs for physician services ($1427 vs. $1282, p = .002). Among males, as was the case for the pretreatment and treatment phases, costs were higher in the treatment cohort versus the control cohort for ED visits ($237 vs. $173, p < .001), physician services ($1252 vs. $990, p < .001) and all other sectors ($1950 vs. $1385, p = .002).

During the end-of-life phase, among males, costs were higher in the treatment versus control cohort for all other sectors ($19 735 vs. $14 481, p = .04).

Total healthcare costs relative change from pretreatment phase to treatment and posttreatment phases by cohort

In both cohorts, among males and females, mean total healthcare costs were lowest during the pretreatment phase, increased during the treatment phase, further increased during the posttreatment phase, and were highest during the end-of-life phase (see Table 1); one exception to this pattern was somewhat higher mean costs prior to treatment than during treatment among females in the control cohort. The mean relative percent change in total healthcare costs from pretreatment to treatment and posttreatment in each cohort, stratified by sex, is reported in Supplementary Table 3.

Discussion

In this retrospective matched cohort study, we evaluated the association between utilization of a smoking cessation treatment program and healthcare costs prior to, during, and posttreatment. Among females, total healthcare costs were similar between matched cohorts in the pre- and posttreatment phases, but higher for the treatment cohort during the treatment phase. Among males, total healthcare costs were higher in the treatment cohort during the pretreatment, treatment and posttreatment phases. Healthcare sector-specific costs largely followed a similar pattern as with total costs.

Previous research on smoking cessation treatment and healthcare costs using real-world measurement of healthcare

Table 2. Healthcare Sector-Specific Costs for Matched Treatment and Control Cohorts by Treatment Phase–Females

Phase[a]								
	Pretreatment		Treatment		Posttreatment		End-of-life	
Healthcare sector	Treatment (n = 2,397)	Control (n = 2397)	Treatment (n = 2385)	Control (n = 2375)	Treatment (n = 2358)	Control (n = 2332)	Treatment (n = 153)	Control (n = 178)
ED visits								
Mean costs (95% CI)	$220 ($201, $240)	$216 ($191, $241)	$241 (**$219, $263**)	$200 (**$181, $218**)	$247 ($229, $264)	$233 ($211, $254)	$1,574 ($1,331, $1,817)	$1,616 ($1,379, $1,854)
Medical hospitalizations								
Mean costs (95% CI)	$737 ($569, $906)	$680 ($523, $838)	$1,037 (**$838, $1,237**)	$593 (**$485, $702**)	$976 ($832, $1,119)	$1,054 ($878, $1,230)	$19,726 ($15,083, $24,369)	$24,941 ($15,594, $34,289)
Psychiatric hospitalizations								
Mean costs (95% CI)	$156 ($39, $273)	$280 ($38, $523)	$163 ($82, $243)	$214 ($3, $425)	$254 ($91, $418)	$276 ($54, $498)	$525 ($118, $932)	$493 ($124, $861)
Physician services								
Mean costs (95% CI)	$1,372 (**$1,293, $1,452**)	$1,166 (**$1,105, $1,226**)	$1,543 (**$1,458, $1,628**)	$1,165 (**$1,093, $1,238**)	$1,427 (**$1,359, $1,496**)	$1,282 (**$1,220, $1,344**)	$6,435 ($5,579, $7,290)	$7,516 ($5,592, $9,441)
All other sectors								
Mean costs (95% CI)	$1,208 ($1,052, $1,364)	$1,037 ($900, $1,174)	$1,570 (**$1,364, $1,776**)	$1,065 (**$890, $1,241**)	$1,838 ($1,630, $2,046)	$1,572 ($1,374, $1,769)	$16,804 ($13,264, $20,345)	$18,850 ($15,358, $22,343)

CI, confidence interval; ED, emergency department.
[a]The pretreatment phase was 12 months prior to index date, treatment phase was 12 months beginning on the index date; posttreatment phase lasted from the end of the treatment phase until the end of study follow-up or until the beginning of the end-of-life phase (if applicable), but costs were expressed as 12 months costs for comparability across phases; end-of-life phase was the 12 months before death (if applicable). All estimates are in 2017 Canadian dollars. Bold denotes p-value of <0.05.

Table 3. Healthcare Sector-Specific Costs for Matched Treatment and Control Cohorts by Treatment Phase–Males

Phase[a]								
	Pretreatment		Treatment		Posttreatment		End-of-life	
Healthcare sector	Treatment (n = 2355)	Control (n = 2355)	Treatment (n = 2328)	Control (n = 2331)	Treatment (n = 2292)	Control (n = 2290)	Treatment (n = 189)	Control (n = 202)
ED visits								
Mean costs (95% CI)	$224 (**$205, $243**)	$152 (**$138, $167**)	$213 (**$192, $233**)	$157 (**$139, $174**)	$237 (**$217, $256**)	$173 (**$159, $186**)	$1,729 ($1,455, $2,004)	$1,417 ($1,192, $1,642)
Medical hospitalizations								
Mean costs (95% CI)	$1,056 ($791, $1,321)	$733 ($465, $1,001)	$1,138 ($837, $1,440)	$828 ($577, $1,079)	$1,354 ($1,111, $1,597)	$1,151 ($935, $1,367)	$21,176 ($16,188, $26,164)	$22,371 ($17,258, $27,484)
Psychiatric hospitalizations								
Mean costs (95% CI)	$172 ($88, $256)	$213 ($66, $359)	$195 ($108, $282)	$194 ($44, $345)	$273 ($166, $379)	$223 ($104, $343)	$575 ($0, $1,160)	$1,208 ($0, $3,138)
Physician services								
Mean costs (95% CI)	$1,229 (**$1,150, $1,308**)	$841 (**$781, $900**)	$1,298 (**$1,213, $1,382**)	$877 (**$813, $941**)	$1,252 (**$1,179, $1,324**)	$990 (**$931, $1,049**)	$6,912 ($5,922, $7,903)	$6,700 ($5,768, $7,632)
All other sectors								
Mean costs (95% CI)	$1,230 (**$1,030, $1,431**)	$845 (**$705, $985**)	$1,690 (**$1,418, $1,962**)	$1,049 (**$753, $1,346**)	$1,950 (**$1,659, $2,242**)	$1,385 (**$1,184, $1,587**)	$19,735 (**$15,270, $24,200**)	$14,481 (**$11,879, $17,083**)

CI, confidence interval; ED, emergency department.
[a]The pretreatment phase was 12 months prior to index date, treatment phase was 12 months beginning on the index date; posttreatment phase lasted from the end of the treatment phase until the end of study follow-up or until the beginning of the end-of-life phase (if applicable), but costs were expressed as 12 month costs for comparability across phases; end-of-life phase was the 12 months before death (if applicable). All estimates are in 2017 Canadian dollars. Bold denotes p-value of < 0.05.

costs has been scant. We found two such previous studies. Both reported at least some healthcare costs decreased in the year post-smoking cessation treatment compared with smokers who either received an alternative or no treatment. One study[8] found a decrease in hospital-related healthcare costs 1-year post-discharge among patients who had received inpatient tobacco dependence treatment compared with patients who had not received treatment. However, these findings may not extrapolate to other healthcare sectors or broader general patient populations, as hospital inpatients may be more likely to benefit from intervention during an acute health event.[22] A second study[4] found a decrease in total healthcare costs associated with the use of varenicline compared with NRT between 3 and 12 months posttreatment but did not include an untreated comparison group. Therefore, the extant literature does not provide a strong context in which to place our results. One might expect healthcare costs to decrease with the use of effective smoking cessation treatments based on evidence of the association between smoking cessation, per se, and healthcare costs. Surprisingly, few studies have measured real-world longitudinal costs of people who have quit smoking compared with those who continued to smoke. What has been published suggests that there may be a temporary increase in healthcare costs around the time of smoking cessation as patients access care for various health concerns.[9,10,23] This may reflect patients' medical status at initiation of treatment rather than cessation itself.[23] Taken on the whole, the literature suggests a short-term increase in healthcare costs could stem from a concomitant illness and cessation attempt.

This interpretation is consistent with findings among females in the current study. Total healthcare costs were higher among females during the treatment phase, indicating a transient increase co-occurring with smoking cessation treatment. Sectors driving this increase were ED visits, medical hospitalizations, physician services, and all other sectors, indicating a wide-ranging uptick in healthcare costs. It is possible females in the early stages of an illness episode chose to make a quit attempt and that medical treatment for this illness episode co-occurred with smoking cessation treatment or shortly thereafter. For example, prior to surgery, patients may be advised or required to quit smoking, as cessation prior to surgery reduces the risk of postsurgical complications[24,25]; higher hospitalization costs in the treatment versus control cohort in the 12 months after index suggests that this is one plausible explanation.

In contrast to the transient difference in costs between the treatment and control cohorts among females, our findings among males were of persistently higher total healthcare costs before, during, and after smoking cessation treatment. This was driven by higher costs for ED visits, physician services, and all other sectors (which included prescription drug costs for those 65 and older). Prior healthcare utilization was included in our propensity score matching, reducing the likelihood that observed differences reflect a general inclination to access healthcare services. Persistently higher costs may be explained by residual baseline differences in the burden of chronic disease between males in the matched cohorts; specifically, a higher prevalence of COPD and diabetes, and a greater number of ADG comorbidities, in the treatment versus control cohort. Among females, there was also a higher prevalence of COPD and asthma, but not of ADG comorbidity groups, and this did not translate into higher total costs prior to smoking cessation treatment. As with males, physician services among females were persistently higher in the treatment versus control cohort prior to, during, and following treatment. It is possible that the greater prevalence of chronic respiratory conditions among females in the treatment cohort required ongoing outpatient monitoring and treatment but did not incur increased costs across as many sectors as for males. Although the accelerated rate of decline in lung function in COPD is slowed by quitting smoking,[26,27] underlying lung damage may not be completely reversible.[28] Likewise, although smoking cessation is recommended for individuals with diabetes because it is associated with beneficial outcomes such as decreased macrovascular complications,[29] there is also evidence of poorer glycemic control[30] and increased risk for incident type 2 diabetes[31] for several years post-cessation. Thus, the extent and timeframe within which we might expect healthcare cost savings to occur in a particular population may vary based on type of comorbidities present and associated health improvements we can expect following smoking cessation treatment and cessation.

In our Supplementary Analysis of mean relative percent change in total healthcare costs, among females, costs during the treatment phase increased significantly more among those in the treatment cohort compared with the control cohort. However, overlapping confidence intervals suggest relatively similar increases for the treatment and control cohorts from pretreatment to treatment among males, and from pretreatment to posttreatment among both females and males.

The comparison group is an important consideration when interpreting these findings. When smoking cessation treatments are available, some individuals who smoke will be motivated to quit and will access the available treatment in their quit attempt. However, in the general population of people who smoke, as in our control cohort, there are also those who are motivated to quit and who choose to use smoking cessation aids to assist them in their attempt. In 2012 nearly half (47.6%) of all smokers in Canada had made at least one quit attempt in the past year and more than half (53.9%) of those who had made a quit attempt in the previous 2 years used some form of cessation assistance including quit smoking medicines, counseling, and quitlines.[32] In our study, there may be unknown proportions of individuals in both cohorts that attempted to quit smoking via these routes and this, in turn, may have affected the cost trajectories of the two cohorts. Indeed, it is possible that those in the non-treated cohort were more likely to obtain smoking cessation assistance outside of the health system and this could have affected their healthcare costs. Similarly, smoking cessation attempts may coincide with, or be precipitated by, a health event that motivates the effort to quit. Therefore, the ideal theoretical comparison group for our study would be composed of individuals who smoke and had precipitating, or emergent, health events comparable to those in the treatment cohort, but did not seek smoking cessation treatment. Therefore, the comparison here is whether those who uptake this smoking cessation treatment program, which offers up to 26 weeks of free NRT combined with brief behavioral counseling, differ from the population of those who do not in terms of healthcare costs; it is not a comparison of quit-motivated users and nonusers of smoking cessation treatment generally, nor a comparison of those who quit versus continue to smoke.

Limitations

Although inclusion of a concurrent control group was a strength of this study, the exposure required both motivation to quit smoking and willingness to engage with smoking cessation treatment, neither of which can be randomized. Despite hard and propensity score matching, the cohorts remained unbalanced on some baseline comorbidities and unmeasured or residual confounding is possible. Additionally, the costing algorithm used captures most, but not all, healthcare costs; it does not include the costs of community-based addiction-related care and captures only costs of outpatient drugs covered by the public provincial drug plan. It also does not include all of the costs associated with delivering smoking cessation treatment through the STOP program, including medication costs and administrative support. As such, total healthcare costs incurred by the treatment cohort during the treatment phase are underestimated in the current analysis. Finally, as patients in Ontario do not incur out-of-pocket costs (ie, co-payments) for healthcare services, the generalizability of our results to other jurisdictions where this is not the case should be confirmed.

Conclusions

Individuals who used smoking cessation treatment services had greater healthcare costs compared with individuals who did not use these services; while this association was evident prior to treatment for males and persisted posttreatment, it was temporary for females. Given increasing access to evidence-based smoking cessation treatments is an important component in national tobacco control strategies, these data suggest that economic arguments should only be one component in building evidence-based treatment systems that aim to address the continuing tobacco epidemic.

Supplementary Material

A Contributorship Form detailing each author's specific involvement with this content, as well as any supplementary data, are available online at https://academic.oup.com/ntr.

Acknowledgments

We thank Anna Ivanova, MPH (Nicotine Dependence Service, Center for Addiction and Mental Health) and Evgenia Gatov, MPH (Toronto Public Health/ICES) for project support. Parts of this material are based on data and/or information compiled and provided by the Canadian Institute for Health Information (CIHI), the Immigration, Refugees and Citizenship Canada (IRCC), the Office of the Registrar General (ORG) and Ontario Health (OH). However, the analyses, conclusions, opinions and statements expressed herein are those of the authors and not necessarily those of CIHI, IRCC, ORG, OH or the Ontario Ministry of Health. No endorsement by CIHI, IRCC, ORG, OH or the Ontario Ministry of Health is intended or should be inferred.

Funding

This work was supported by the Canadian Institutes for Health Research (grant number 166116 awarded to DB [PI] and CdO, PS, PK, LR, LZ, RS [Co-Is]). The Smoking Treatment for Ontario Patients (STOP) Program is funded by the Ontario Ministry of Health. The funders had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Declarations of Interest

DB has received investigator-initiated grant support from Pfizer Canada, Ontario Ministry of Health and Long-Term Care, and the Canadian Institutes of Health Research (CIHR). CdO reports receiving grant funding from CIHR, University of Toronto, Medical Research Council, National Institutes of Health, Center for Addiction and Mental Health (CAMH), Ontario Ministry of Health and Long-Term Care, Canadian Center for Applied Research in Cancer Control and Ontario Mental Health Foundation. PS reports receiving funding from Canadian Cancer Society Research Institute (CCSRI), CIHR, Canadian Partnership Against Cancer, CAMH, Health Canada, Medical Psychiatry Alliance, Ontario Ministry of Health and Long-Term Care, Ontario Neurotrauma Foundation and the Public Health Agency of Canada. PS also reports funding from the following commercial organizations: Patient-Centered Outcome Research Institute and Pfizer. PS has received honoraria in the past 3 years from University of Ottawa Heart Institute, Royal College of Physicians and Surgeons of Canada, Royal Victoria Regional Health Center, Department of Family and Community Medicine at the University of Toronto, Northern Ontario School of Medicine, Canadian Partnership Against Cancer, Battle River Treaty 6 Healthcare, Lung Association of Nova Scotia, Exchange Summit, Toronto Public Health, Ontario Association of Public Health Dentistry and ECHO. PS has been retained as an expert witness by the Ontario and New Brunswick provincial governments in litigation against the tobacco industry. PS was a member and co-chaired the Ministry of Health's Ontario Smoke Free Strategy cessation subcommittee. Through an open tender process, Johnson & Johnson, Novartis and Pfizer are vendors of record for providing free/discounted smoking cessation pharmacotherapy for research studies in which PS and LZ are principal or co-investigator. PK reports receiving grant funding in the past 3 years from CIHR and the Ontario Ministry of Health and Long-Term Care. LR reports receiving grant funding in the past 3 years from CIHR, Social Sciences and Humanities Research Council, New Frontiers in Research Fund, Canada Research Chairs and the Connaught Foundation. LZ reports receiving grant funding from Pfizer, Ontario Ministry of Health and Long-Term Care, Health Canada, CIHR, and CCSRI. LZ also received honoraria and travel funds from Pfizer and University of Ottawa Heart Institute. RS reports receiving funding in the past 3 years from CIHR, Terry Fox Research Institute, Garron Family Cancer Center and Sick Kids Foundation, Canadian Society of Colon and Rectal Surgeons, Sunnybrook Foundation, Pediatric Oncology Group of Ontario, Ontario Institute for Cancer Research, PSI Foundation, C17 Research Network, Cancer Care Ontario, Canadian Center for Applied Research in Cancer Control, Canadian Breast Cancer Foundation, Sunnybrook AFP Innovation Fund, CCSRI, Ministry of Health and Long-Term Care and the Ontario Medical Association. No other disclosures were reported.

Data Availability

The data set from this study, composed of STOP program data and ICES data sets, is held securely in coded form at ICES. While data sharing agreements and privacy legislation for the province of Ontario prohibit ICES from making the data set publicly available, access may be granted to those who meet prespecified criteria for confidential access, available at https://www.ices.on.ca/DAS. Requests to access ICES data may be submitted to ICES Data & Analytic Services at das@ices.on.ca, with information available at https://www.ices.on.ca/DAS/Submitting-your-request.

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