Can J Diabetes 43 (2019) 354–360

Contents lists available at ScienceDirect

Canadian Journal of Diabetes

journal homepage: www.canadianjournalofdiabetes.com

Original Research

Effects of Pay-for-Performance for Primary Care Physicians on Preventable Diabetes-Related Hospitalization Costs Among Adults in New Brunswick, Canada: A Quasiexperimental Evaluation

Neeru Gupta PhD [a,*]; René Lavallée BA, Cert [b]; James Ayles BSc, BBA [b]

[a] University of New Brunswick, Department of Sociology, Fredericton, New Brunswick, Canada
[b] Government of New Brunswick, Department of Health, Fredericton, New Brunswick, Canada

Key Messages

- Evidence concerning the effectiveness of pay-for-performance to optimize the delivery of guideline-based medical care for patients with diabetes is deficient.
- This prospective cohort study from New Brunswick, Canada, revealed mixed effects of pay-for-performance for family physicians on excess health-care costs among adults ages 35 years and older with type 1 or type 2 diabetes.
- Health policy decision makers should tread cautiously in developing pay-for-performance programs to incentivize diabetes care.

ARTICLE INFO

Article history:
Received 17 July 2018
Received in revised form
15 November 2018
Accepted 19 November 2018

Keywords:
diabetes mellitus
health economics
health services
medical workforce
pay for performance
primary care physicians

ABSTRACT

Objectives: In New Brunswick, Canada, 13.6% of the population 35 years of age and older is living with type 1 or type 2 diabetes mellitus. To address public health and clinical challenges, pay-for-performance (P4P) for family physicians was introduced in 2010 to enable comprehensive diabetes management. This study assesses the impacts of the P4P scheme on excess health-care costs.
Methods: We used a quasiexperimental study design drawing on linked population-based administrative data sets of physician billings, hospital discharge abstracts and provider and resident registrations. Prospective cohorts of patients with diabetes were identified through a validated algorithm tracing individuals' interactions with the health-care system. We applied propensity-score difference-in-differences estimation for the effects of P4P on preventable diabetes-related hospitalization costs according to patients' exposures to physicians' uptake of the incentive.
Results: Coverage of incentivized care peaked at less than half (44%) of adults with diabetes, who tended to be younger and less often presenting comorbid conditions compared to those whose providers did not claim incentives. The introduction of P4P was attributed to significantly lower diabetes hospitalization costs among newly diagnosed patients (-0.083; $p<0.01$) and improved compensation for physicians. No cost avoidance was established among medium-term and longer-term patients or for hospitalizations for conditions concordant with diabetes.
Conclusions: The effects of New Brunswick's P4P for diabetes care are mixed. Results reflect the deficient evidence base on the effects of P4P on patient-oriented and policymaker-important health outcomes. The high risk for multiple morbidities among patients with diabetes and the heterogeneity of physician responses to performance incentives may be hindering the effectiveness of P4P in improving diabetes outcomes.

RÉSUMÉ

Objectifs : Au Nouveau-Brunswick, au Canada, 13,6 % de la population de 35 ans et plus vit avec le diabète sucré de type 1 ou de type 2. Pour résoudre les enjeux de santé publique et les enjeux cliniques, la

Mots clés :
diabète sucré

* Address for correspondence: Neeru Gupta, PhD, Department of Sociology, University of New Brunswick, 9 Macaulay Lane, PO Box 4400, Fredericton, New Brunswick E3B 5A3, Canada.
E-mail address: neeru.gupta@unb.ca

1499-2671/
https://doi.org/10.1016/j.jcjd.2018.11.006

économie de la santé
services de santé
effectifs médicaux
rémunération au rendement
médecins de premier recours

rémunération au rendement (P4P pour *pay-for-performance*) des médecins de famille était introduite en 2010 pour favoriser la prise en charge globale du diabète. La présente étude a pour objet l'évaluation des répercussions du programme de P4P sur les coûts excessifs des soins de santé.

Méthodes : Nous avons utilisé un plan d'étude quasi-expérimentale qui a recours aux ensembles des données liées administratives et populationnelles sur la facturation des médecins, des résumés de sortie d'hôpital, et des enregistrements des prestataires de soins et des habitants. Nous avons déterminé les cohortes prospectives de patients diabétiques à l'aide d'un algorithme validé qui repère les interactions des individus avec le système de soins de santé. Nous avons appliqué l'estimation en doubles différences sur score de propension aux répercussions de la P4P sur les coûts prévisibles d'hospitalisation liée au diabète conformément aux expositions des patients à l'utilisation des mesures incitatives par les médecins.

Résultats : La couverture des soins fondés sur les mesures incitatives s'élevait à moins de la moitié (44 %) des adultes diabétiques, qui sont plus jeunes et qui présentent moins souvent des affections comorbides que ceux pour lesquels les prestataires ne réclamaient pas les incitatifs. L'introduction de la P4P était associée à des coûts d'hospitalisation liée au diabète significativement plus faibles chez les patients ayant récemment reçu un diagnostic (−0,083; $p < 0,01$) et à une meilleure compensation des médecins. Nous n'avons établi aucune réduction des coûts chez les patients à moyen terme et à long terme ou les hospitalisations en raison d'affections en lien avec le diabète.

Conclusions : Les répercussions de la P4P sur les soins du diabète au Nouveau-Brunswick sont variées. Les résultats indiquent que les données probantes sur les répercussions de la P4P sur les résultats cliniques axés sur le patient et importants pour les décideurs sont déficientes. Le risque élevé de morbidités multiples chez les patients diabétiques et l'hétérogénéité des réponses des médecins à la rémunération au rendement peut nuire à l'efficacité de la P4P pour améliorer les résultats cliniques liés au diabète.

Introduction

The prevalence of diabetes mellitus and many other chronic noncommunicable diseases is increasing rapidly across Canada and around the world—a trend attributable in large part to the population's ageing and to rising rates of overweight and obesity. National surveillance data from the Public Health Agency of Canada indicate that the prevalence of types 1 and 2 diabetes nearly doubled from 4.2% to 8.0% between 2000 and 2012 (1). To address the growing public health and clinical challenges of chronic diseases, financial incentives for the delivery of patient-centred care are increasingly common in many health organizations. Most private and public health insurers in the United States have instituted incentive reimbursements—known as pay-for-performance, or P4P—for improving the quality and/or reducing the costs of health-care delivery (2). In Canada, which has a single-payer health insurance system, the provinces of British Columbia, New Brunswick and Ontario have each introduced P4P in recent years to promote guideline-based chronic disease prevention and management (3–5). In British Columbia and New Brunswick, government-sponsored P4P schemes were initiated in 2007 and 2010, respectively. They were voluntary among physicians in traditional fee-for-service (FFS) remuneration agreements and were set at a flat rate per provider per patient (3,4). In Ontario, where P4P for diabetes management was introduced in 2006, eligibility for the incentive was initially structured around whether the physicians' compensation models were FFS or capitation (5).

Despite the increasing popularity of P4P, evidence of its effectiveness in improving health and health-system outcomes is deficient. Several reviews have examined the effects of P4P on differing indicators of health-care processes, costs and outcomes across various contexts of health-system financing and have reported insufficient evidence of their success (6–9). Based on their systematic review, van Herck et al argued that population-level P4P schemes such as the United Kingdom's Quality and Outcomes Framework tend to result in more uniform outcomes compared to fragmented P4P initiatives such as those spread across the United States (9). In Canada, the P4P scheme in British Columbia was found to be associated with increased physicians' billings of incentivized services but not better continuity of care or lower health-care costs for patients (3). In Ontario, FFS physicians were found to be less responsive to diabetes-management incentives than physicians in a blended capitation model (5).

A previous investigation of New Brunswick's scheme suggested that patients of FFS physicians who claimed the incentive had greater probabilities of receiving the recommended number of glycated hemoglobin laboratory tests compared to patients of physicians who did not claim the incentive (4). The scheme was not found to be associated with improved glycemic control. The study included only patients of FFS physicians (approximately 65% of family physicians) and focused on outcomes associated with diabetes-care plans but did not record the symptoms or other co-morbid conditions that account for much of the morbidity facing patients with diabetes.

This research assesses the extent to which New Brunswick's P4P scheme has been associated with changes in severe morbid events, as measured through acute-care hospitalizations, in adult patients with diabetes, regardless of the providers' remuneration arrangement. Diabetes-related hospitalizations are often referred to as ambulatory care sensitive, that is, preventable and potentially avoidable through appropriate management in primary care (10,11). We used a population-based prospective cohort approach to provide the first comprehensive assessment of New Brunswick's P4P scheme, assessing the effects on preventable hospitalization by physician uptake of the incentive billing option. Our study addressed the following question: Did the introduction of P4P for primary care practitioners result in reduced preventable hospitalization costs among patients with diabetes in the short and medium terms?

Methods

Setting

With a diabetes prevalence rate of 9.8% (12), New Brunswick reflects an image of Canada's future; the national average is not expected to reach this level of disease burden for several years. The province already presents advanced population ageing (median age of 43.9 years) projected for the country as a whole in the year 2038 (13). The impetus for introducing P4P arose from discussions between the provincial government and the medical society about enhancing chronic-disease management in primary care. A

dedicated financial pool was agreed upon for compensating family physicians through New Brunswick Medicare for the provision of or referral for comprehensive diabetes care throughout the year: twice-annual glycated hemoglobin tests, blood pressure and lipids monitoring, weight and nutrition counseling, smoking cessation (if applicable), annual renal function testing, annual foot examination and annual dilated eye examination (14).

The incentive was intended to recognize the additional work required by general practitioners beyond that of regular office visits when providing guideline-based care to patients with diabetes. The incentive could, thus, be considered a stimulus for improving management and coordination of diabetes care (6). A new service-billing code was introduced, offering an additional payment for each patient with diabetes managed according to the care plan in the previous year, as reported by the physicians claiming the incentive. The code could be entered electronically in the billing system as of the beginning of the 2011-12 fiscal year (April 1); it applied to FFS family physicians and also to salaried physicians required to submit shadow billing (14). This and all service codes are also required to be submitted to the electronic billing system by nurse practitioners to ensure consistency in patient histories, maintain provider accountability and inform evidence-based health-care planning and monitoring (15).

Data sources

We conducted a population-based prospective cohort study using 5 linked Department of Health data sets of physician billings, hospital discharge abstracts, provider registrations, resident registrations and cases of diabetes. The former is a database of all medical claims for services rendered to New Brunswick residents, including payments by service code for FFS physicians and shadow billings for physicians and nurse practitioners under salary or alternative payment structures. The hospital discharge abstract database covers diagnoses and procedures for all in-patient stays in New Brunswick. The third source contains information about the primary remuneration type for all physicians and nurse practitioners. The fourth source contains data on patients' Medicare eligibility statuses and demographic characteristics.

Cases of diagnosed diabetes mellitus (types 1 and 2 combined) are captured in a virtual registry constructed from provincial administrative data sets through validated algorithms tracing individuals' interactions with the health-care system (16,17). Cases included patients with 1 or more hospitalizations for diabetes as tabulated from the discharge abstract database according to the International Classification of Diseases (ICD-10 codes E10.x to E14.x) or 2 or more physician claims within 2 years based on search patterns for "diabetes" and related nomenclature. Cases of gestational diabetes were excluded.

Given the context of universal health coverage, the data are essentially a complete recording of all medical and hospital services involving the eligible population. Excluded from the provincial databases are serving members of the Canadian Forces and inmates in federal penitentiaries, who are covered under federal health-care programs. Although it is widely acknowledged that the quality of surveillance information concerning diabetes has increased substantially across Canada during the past decade, case findings from administrative data may be affected by changes in data characteristics or collection methods, such as coding/classification systems, clinical practices, billing methods and patients factors (18).

Outcome measures

Outcomes of interest are public costs for physician and nurse-practitioner services (henceforth referred to as *physician costs*) and for potentially avoidable hospitalizations of patients with diagnosed diabetes. We report all costs in 2009 constant Canadian dollars.

We calculated physician costs in 3 steps. First, we summed all payments to FFS physicians for services to patients with diabetes by fiscal year. Next, for salaried physicians, we imputed costs by service code on the shallow-billing claim based on the mean payment to FFS physicians for the same service. Third, for salaried nurse practitioners, we imputed costs by service code on the shallow-billing claim weighted by the ratio of the mean nurse practitioner salary to physician salary.

Direct hospitalization costs for patients with diagnosed diabetes were measured in the fiscal year of discharge. Potentially avoidable hospitalizations included those attributed to stays with primary diagnostic codes for diabetes (type 1 or type 2). We estimated costs from the resource intensity weights assigned by the Canadian Institute for Health Information to each inpatient case in the discharge abstract database (19). These values represent estimated relative resource consumption, accounting for patients' age groups and health statuses.

We further considered hospitalization costs for ambulatory care-sensitive conditions concordant with diabetes, that is, chronic comorbidities with primary care quality goals shared with diabetes care (20–22). We included 12 concordant conditions: obesity, hyperlipidemia, hypertension, ischemic heart disease, cardiomyopathy, cardiac arrhythmia, congestive heart failure, stroke, coronary atherosclerosis, thromboembolism, chronic kidney disease and polycystic ovarian syndrome.

Analytic approach

We included data from before and after the implementation of P4P for patients exposed to physician uptake of the incentive and those not exposed. Our study pools data from 2009-10 to 2014-15. We distinguished 2 cohorts of patients for analysis: residents 35 and older diagnosed with diabetes (type 1 or type 2) before the study period and residents 35 years and older newly diagnosed with diabetes (assumed type 2 only) in the year before introduction of the incentive scheme.

There was no formal rostering of patients with primary care providers before 2018, so we developed an algorithm to assign patients to the most responsible providers, based on patterns of service billings (including claims for chronic disease management, chart initiation and home or office visits) (Supplementary Figure 1). Patients for whom no primary care medical services were claimed over the 6 years of pooled data, whose providers were offering only temporary or locum services for another physician and who cumulatively spent more than 2 years as inpatients were excluded from the analysis.

We used a rigorous quasiexperimental study design to assess the influence of P4P on physician and preventable hospitalization costs in the adult population 35 years and older living with diagnosed diabetes. The logarithms of medical and hospital costs were used to reduce the effects of skewed data, with substitution of a low-positive value (1 dollar) for handling null-value observations. Quasiexperimental studies have been recognized as appropriate for estimating the effects of complex health and social interventions and yielding unbiased evidence ratings consistent with those of experimental studies (23–26). We used difference-in-differences models to estimate the impact of P4P, with matching on observed patient and provider characteristics and controlling for unobservables. The difference-in-differences approach relies on the construction of dummy variables for pre- and postimplementation of the P4P intervention (period), treated by comparison of whether the most responsible provider ever claimed the incentive (exposed) and their interactions. The model was developed to try to answer counterfactual questions; in our case, for example, would lower

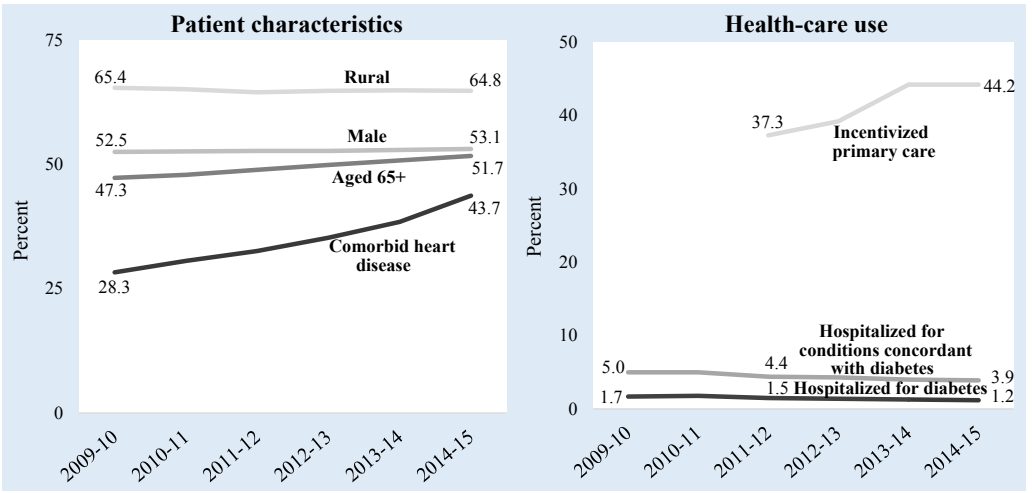


Figure 1. Characteristics and health-care use of the population 35 years and older with type 1 or type 2 diabetes, New Brunswick, 2009-10 to 2014-15.

hospitalization costs by people with diabetes have happened if P4P had not been introduced? This can be expressed mathematically as:

$$Ln(costs_{it}) = \beta_0 + \beta_1 * Period_i + \beta_2 * Exposed_t + \beta_3 * Period_i * Exposed_t + e_{it}$$

We combined the model with Kernel-based propensity score matching (27) to adjust for patient characteristics, including age group, sex, urban/rural residence and selected comorbidities (hypertension, ischemic heart disease). We also adjusted for selected provider characteristics: remuneration model (FFS vs. salaried) and practice size (large practice with 100 or more patients with diabetes vs. fewer patients with diabetes).

We evaluated the counterfactual as the difference between the pre-P4P cost trend projected forward and the post-P4P actual cost averaged across the 4 years of observation. The regression analysis was conducted in Stata (StataCorp, College Station, Texas, United States) using the *diff* package and bootstrap estimation of coefficients and standard errors (28). We set the significance level at $p<0.01$.

Research ethics

Record-level administrative data were accessed only by authorized designated users at the New Brunswick Department of Health in accordance with provincial protocols for the protection of personal information and personal health information. Ethics approval for the secondary analysis of deidentified information was obtained from the University of New Brunswick Research Ethics Board (REB #2017-082).

Results

Characteristics of the adult population with diabetes

We identified 63,768 adult patients 35 years and older living with diabetes mellitus on March 31, 2015. The number of diagnosed diabetes cases had been increasing at an annual rate of 6.0% since 2009, which was considerably faster than the general population's average annual growth rate of 0.8% in this age range over the same period. Although a certain "catch-up" in recorded diabetes prevalence due to improved diagnostics was noted for the 5-year period following the introduction in 2000 of glycated hemoglobin testing in New Brunswick, statistical triangulation across 3 different data sources suggests that the more recent observed growth trend likely has not been influenced by other health system-level changes (12).

Characteristics of the adult population with diabetes include being predominantly rural (65% vs. 58% of the total New Brunswick population), more often affecting men (53% male), demographic ageing (the proportion of seniors 65 years and older increasing from 47% to 52% over 5 years) and rapidly increasing prevalence of comorbid heart disease (from 28% to 44%) (Fig. 1).

Coverage of incentive-based diabetes care was less than half (44%) of adult patients in 2014-15, with the rate stable compared to the previous year (Fig. 1). Downward trends in the rates of hospitalization for diabetes and for conditions concordant with diabetes were observed even before the introduction of P4P.

The mean annual inflation-adjusted physician cost per patient with diabetes increased from $956 (SD=1,397) in 2009-10 to $1,184 (SD=1,743) in 2014-15. Based on 2014-15 data, the mean physician cost was only slightly higher among patients whose providers were FFS ($1,186) compared to salaried ($1,172) (Fig. 2). Upward movement in physician costs was observed before the introduction of P4P among patients of both FFS and salaried providers, that is, a roughly parallel trend among those for whom a performance incentive can be broadly distinguished as an extrinsic vs. an intrinsic motivating factor.

The mean annual cost per patient for hospitalizations for diabetes dropped from $253 (SD=4,712) in 2009-10 to $195 (SD=5,541) in 2014-15 (not shown). This decline was largely

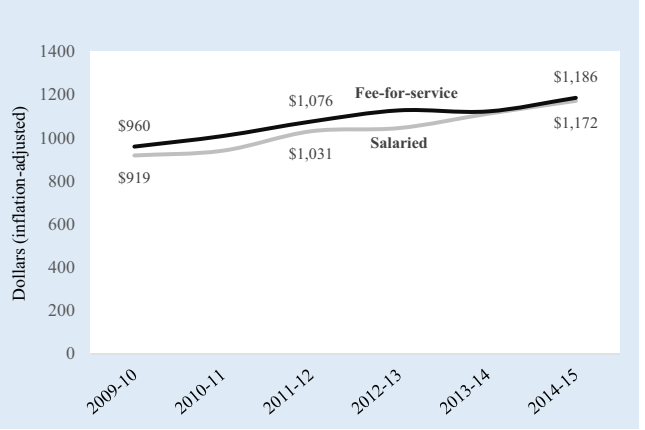


Figure 2. Mean annual physician cost per patient 35 years and older with diabetes, by provider remuneration model, New Brunswick, 2009-10 to 2014-15.

attributable to the decreasing hospitalization rate; among those who were hospitalized for diabetes, the mean cost increased from $14,581 (SD=32,759) to $15,823 (SD=47,428) over the same period. The mean annual cost of hospitalizations for conditions concordant with diabetes decreased from $660 (SD=7,043) to $457 (SD=4,645) between 2009-10 and 2014-15. Among those who were hospitalized for such conditions, the mean cost decreased from $13,263 (SD=28,800) to $11,746 (SD=20,559) over the same period.

Cohort descriptions

Among all diabetes patients in the case database, 47,757 had been diagnosed before the period of observation and were 35 years or older on April 1, 2009 (our baseline cohort). Another 6,950 adult patients were newly diagnosed in 2010-11, that is, the year before the incentive billing system was introduced (our newly diagnosed type 2 diabetes cohort).

The characteristics of the patient groups exposed to physician uptake of P4P and those not exposed, in the 2 study cohorts, are presented in Table 1. In our baseline cohort, patients who had at least 1 incentive billed for their care within the study period tended to be younger and less often presented with comorbid hypertension and heart disease compared to those whose providers did not claim incentives. Urban-rural differences between the exposed and comparison groups were minimal. Patients of providers remunerated via FFS and with larger practices received incentivized care more often than those whose providers were salaried or had smaller practices. Similar patterns were seen in our cohort of patients newly diagnosed with type 2 diabetes. Such differences underlined that the use of propensity score matching for patients in the 2 groups (incentive and nonincentive) was warranted.

Difference-in-differences matching analysis

Among the baseline cohort, costs for potentially avoidable hospitalizations resulting from diabetes and conditions concordant with diabetes were significantly lower among patients exposed to physician uptake of the incentive scheme compared to the nonincentive group; however, the mean (constant dollar) costs had already been significantly lower before the introduction of P4P (Table 2). Although the numeric values of the coefficients themselves are not intrinsically meaningful, the difference-in-differences estimators indicate that the trends in hospitalization costs were actually somewhat (but not significantly) higher in the incentive group than in the nonincentive group. In other words, there is no evidence, 4 years after its introduction, that P4P for diabetes care decreased the burden on the hospital system. We also observed significantly higher physician costs (adjusted estimates) in the incentive group compared to the nonincentive group, attributable to higher post-P4P medical service claims.

In the cohort of patients newly diagnosed with diabetes, we again observed a trend toward significantly higher physician costs in the incentive group, attributable to higher post-P4P medical service claims. We also observed significantly lower costs for diabetes-attributable hospitalizations linked to the introduction of P4P. There is some indication, although not significant, of a trend toward lower hospital costs for conditions concordant with diabetes.

Discussion

Many jurisdictions across Canada, as well as health organizations around the world, have introduced P4P in an attempt to accelerate progress toward the health system goals of enhanced patient care experiences, improved population health and reduced per capita cost of health care. The schemes are highly diverse across contexts; differing financial rewards and implementation mechanisms are used to address different problems (29). Several evaluations have been conducted concerning the effectiveness of such schemes, but the results and conclusions tend to depend on which health conditions and outcome measures are being assessed and how they are being assessed. Few studies have evaluated the effects of P4P on health-care costs (6). In this study, we used a difference-in-differences research design to look at trends in public costs among patients with diabetes for medical services and potentially avoidable hospitalizations surrounding the introduction of a P4P scheme for guideline-based diabetes care in New Brunswick.

After taking into account previously existing trends in health-care use, we found variable effects attributed to P4P: a significant cost reduction in hospitalization costs for diabetes complications in patients who were newly diagnosed at the time of introduction of the P4P scheme but no evidence of cost reduction in the medium term or for hospitalizations due to ambulatory care-sensitive conditions concordant with diabetes. Consistent with recent findings from British Columbia (3), our results showed that P4P has led to significantly improved compensation for physicians caring for patients with chronic disease but not necessarily constrained resource use elsewhere in the health-care system.

This is the first evaluation of New Brunswick's P4P scheme considering common comorbidities of diabetes. Combined with a rapidly increasing prevalence of heart disease and hypertension in patients with diagnosed diabetes, we observed that patients receiving incentivized care tended to be younger and less often presenting these comorbid conditions compared to patients whose providers did not claim incentives. Similar patterns of older and multimorbid patients with diabetes benefitting less from incentivized care have been found in the UK Quality and Outcomes

Table 1
Characteristics of patient cohort groups exposed and not exposed to pay-for-performance for diabetes care

	Baseline cohort (n=47,757)		Newly diagnosed type 2 diabetes cohort (n=6,950)	
	Exposed group (52.8%)	Comparison group (47.2%)	Exposed group (36.2%)	Comparison group (63.8%)
Patient characteristics				
Aged 65 years and older	42.6%	52.7%	28.6%	38.0%
Female	46.9%	48.2%	43.9%	48.8%
Rural residence	65.8%	65.2%	66.6%	65.1%
Comorbid hypertension	28.8%	40.5%	24.7%	31.8%
Comorbid heart disease	25.1%	31.9%	19.4%	24.1%
Provider characteristics				
Fee-for-service	97.5%	82.6%	97.3%	78.9%
Large practice size	64.5%	52.1%	64.0%	50.0%
Cohort size	25,229	22,528	2,515	4,435

Notes: Characteristics at the beginning of the period of observation in the population with diabetes who were 35 years or older; sourced from linked provincial administrative health data sets (before matching). Provider characteristics refer to the most responsible provider (family physician or nurse practitioner) of patients living with diabetes.

Table 2
Difference-in-differences matching regression estimates (and associated standard errors) of the effects of pay-for-performance for diabetes care on health-care costs

	Physician cost		Hospitalization cost for diabetes		Hospitalization cost for conditions concordant with diabetes	
	Exposed group	Comparison group	Exposed group	Comparison group	Exposed group	Comparison group
Baseline cohort of 47,757 patients with diabetes						
Pre-P4P	6.240	6.320	0.106	0.182	0.298	0.494
Difference	−0.080* (0.008)		−0.076* (0.009)		−0.196* (0.013)	
Post-P4P	6.475	6.397	0.112	0.171	0.334	0.525
Difference	0.077* (0.006)		−0.059* (0.007)		−0.191* (0.012)	
Diff-in-diff	**0.157*** (0.009)		**0.017** (0.011)		**0.005** (0.016)	
Cohort of 6,950 patients with newly diagnosed type 2 diabetes						
Pre-P4P	6.115	6.126	0.157	0.116	0.319	0.420
Difference	−0.011 (0.027)		0.041 (0.027)		−0.101 (0.048)	
Post-P4P	6.223	6.067	0.045	0.088	0.208	0.351
Difference	0.156* (0.021)		−0.042* (0.013)		−0.143* (0.030)	
Diff-in-diff	**0.167*** (0.033)		**−0.083*** (0.029)		**−0.042** (0.056)	

Diff-in-diff, difference-in-differences; *P4P,* pay-for-performance.
Notes: The analytical models are linear regression of logged costs, with difference-in-differences estimators in bold, and using propensity score matching for patients' ages, sex, places of residence and comorbidities as well as providers' remuneration models and practice sizes. Bootstrap estimation of robust standard errors are in parentheses.
* $p<0.01$.

Framework (30). More research is needed to understand the drivers of physicians' claiming or not claiming financial incentives for diabetes care in the contexts of the increasing burdens and complexities of multimorbidities.

The use of linked provincial administrative health data sets offers several advantages for health system performance research, but certain limitations should be noted. First, the current analysis excludes public costs for emergency department visits not leading to hospital admission, nonmedical residential and home care, pharmaceuticals, laboratory services and community-based diabetes education by other health-care professionals. Also excluded from the administrative data is information on patients' body mass, physical activity and other common behavioural and socioeconomic risk factors for diabetes and its complications.

We were able to control for selected comorbid conditions, but the appropriateness of their application in maintaining the common trend assumption underlying the difference-in-differences estimation remains uncertain. Also, the completeness of shadow-billing records used to impute costs for salaried physicians and nurse practitioners has not been validated. Previous analyses of P4P in British Columbia and New Brunswick focused only on FFS physicians (3,4). The 2 provincial schemes are similar in that they were designed to compensate primary care practitioners for the extra time required to care for patients with chronic conditions in accordance with clinical guidelines. Our study uniquely incorporated data for salaried physicians and nurse practitioners, who would, arguably, have been held accountable to the same time demands. Minimal observed differences in estimated mean annual per patient costs between FFS vs. salaried practitioners suggest a high degree of shadow-billing compliance in New Brunswick. An earlier analysis by the Department of Health determined that enhanced monitoring and accountability efforts had resulted in 80% of required physicians' and 96% of specialists' submitting shadow billing in 2011-12 (31). It is possible that improvements in the completeness of the physician billings data might be a factor in causing the upward trend in physician costs being overestimated. Similarly, in their assessment of a P4P scheme in a Swedish county, Ödesjö et al cautioned that simultaneous improvements in patient data entry and patients' glycemic control might have led to an overestimation of incentive performance (32).

Conclusions

Our analysis showed that incentive payments to family physicians and nurse practitioners through New Brunswick Medicare for the provision of guideline-based care for patients with diabetes, in the absence of other changes to primary care service delivery, have not resulted in faster declines in potentially avoidable hospital costs compared to those already occurring before the province's P4P initiative was introduced. Some measured post-P4P reductions in costs for hospitalizations due to diabetes were observed in patients newly diagnosed with type 2 diabetes but not in medium-term and longer-term patients and not for concordant conditions, which overlap with diabetes care goals but represent a greater burden on the hospital system. The high risk for multiple morbidities in patients with diabetes and the heterogeneity of physicians' responses to performance incentives may be hindering the effectiveness of P4P to improve the health of the population with diabetes and the outcomes in the health system. Strategies other than performance incentives are needed to improve outcomes for patients with diabetes or, in the absence of information tying the current payment structure to health production, perhaps be based on outcome metrics rather than on care processes.

Supplementary Material

To access the supplementary material accompanying this article, visit the online version of the *Canadian Journal of Diabetes* at www.canadianjournalofdiabetes.com.

Funding

This work received research funding support from Diabetes Canada and the New Brunswick Health Research Foundation and in-kind health data analytics support from the New Brunswick Department of Health. The funding sources had no involvement in the conduct of the research or preparation of the manuscript. Some of the findings were presented at the 2017 World Congress of the International Health Economics Association (Boston, July 8-11) and at the 2018 Global Symposium on Health Systems Research (Liverpool, October 8-12). The views expressed are those of the authors, and do not necessarily represent the official position of the Government of New Brunswick or any other agency.

Author Disclosures

Conflicts of interest: None.

Author Contributions

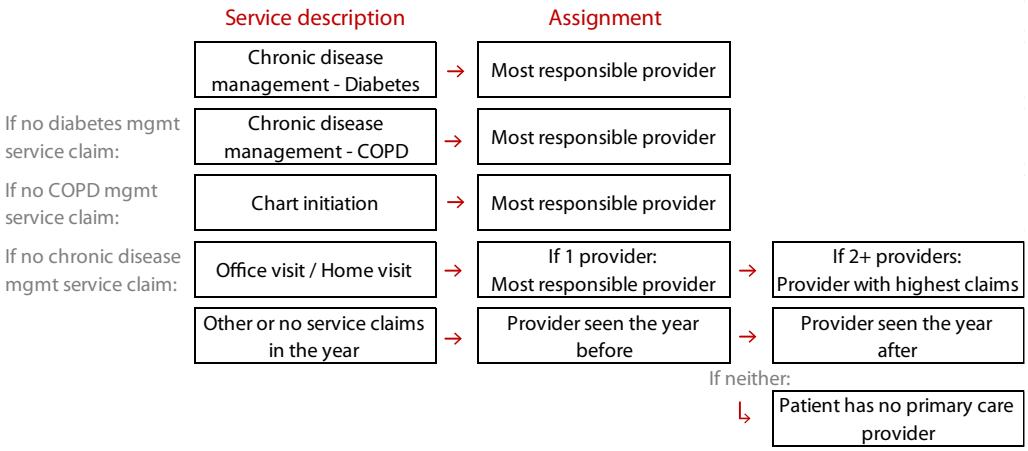
NG conceived the study and wrote the first draft of the manuscript; RL performed data management and modeling; all authors

contributed to the interpretation of data, substantively revised the draft and gave final approval of the submitted version. The corresponding author had final responsibility for the decision to submit for publication. All authors agreed to be accountable for the work.

References

1. Public Health Agency of Canada. Public Health Infobase: Canadian Chronic Disease Surveillance System. Ottawa, Ontario: PHAC, 2017. http://infobase.phac-aspc.gc.ca/ccdss-scsmc/data-tool. Accessed July 8, 2018.
2. Nicholson S, Pauly MV, Wu AYJ, et al. Getting real performance out of pay-for-performance. Milbank Q 2008;86:435–57.
3. Lavergne MR, Law MR, Peterson S, et al. A population based analysis of incentive payments to primary care physicians for the care of patients with complex disease. CMAJ 2016;188:e375–83.
4. LeBlanc E, Bélanger M, Thibault V, et al. Influence of a pay-for-performance program on glycemic control in patients living with diabetes by family physicians in a Canadian province. Can J Diabetes 2016;41:190–6.
5. Kantarevic J, Kralj B. Link between pay for performance incentives and physician payment mechanisms: Evidence from the Diabetes Management Incentive in Ontario. Health Econ 2013;22:1417–39.
6. de Bruin SR, Baan CA, Struijs JN. Pay-for-performance in disease management: A systematic review of the literature. BMC Health Serv Res 2011;11:272.
7. Latham LP, Marshall EG. Performance-based financial incentives for diabetes care: An effective strategy? Can J Diabetes 2015;39:83–7.
8. Scott A, Sivey P, Ait Ouakrim D, et al. The effect of financial incentives on the quality of health care provided by primary care physicians. Cochrane Database Syst Rev 2011;9:CD008451.
9. Van Herck P, De Smedt D, Annemans L, et al. Systematic review: Effects, design choices, and context of pay-for-performance in health care. BMC Health Serv Res 2010;10:247.
10. Gibson OR, Segal L, McDermott RA. A systematic review of evidence on the association between hospitalisation for chronic disease related ambulatory care sensitive conditions and primary health care resourcing. BMC Health Serv Res 2013;13:1–13.
11. Sanmartin C, Khan S, LHAD Research Team. Hospitalizations for ambulatory care sensitive conditions: The factors that matter. Health Research Working Paper Series, No. 007. (catalogue #82-622-X). Ottawa, Ontario: Statistics Canada; 2011.
12. Gupta N. Charting the progression of diabetes mellitus in New Brunswick: Rates, correlates, and implications for accountability in public policy. J New Brunswick Stud 2017;8:69–86.
13. Statistics Canada. Population Projections for Canada (2013 to 2063), Provinces and Territories (2013 to 2038). Ottawa: Statistics Canada, 2015.
14. New Brunswick Department of Health. New Brunswick Physicians' Manual. Fredericton. Canada: Government of New Brunswick, 2016. http://www2.gnb.ca/content/dam/gnb/Departments/h-s/pdf/en/Physicians/new_brunswick_physicians_manual.pdf. Accessed July 8, 2018.
15. New Brunswick Department of Health. Medicare Shadow Billing Manual for Nurse Practitioners. Fredericton. Canada: Government of New Brunswick, 2018. http://www2.gnb.ca/content/dam/gnb/Departments/h-s/pdf/en/Medicare/MedicareShadowBillingManual_NP.pdf. Accessed July 8, 2018.
16. Chen G, Khan N, Walker R, Quan H. Validating ICD coding algorithms for diabetes mellitus from administrative data. Diabetes Res Clin Pract 2010;89:189–95.
17. Feely A, Lix LM, Reimer K. Estimating multimorbidity prevalence with the Canadian Chronic Disease Surveillance System. Health Promot Chron Dis Prev Can 2017;37:215–22.
18. New Brunswick Department of Health. Profiles on Health: Diabetes Mellitus in New Brunswick. Fredericton. Canada: Government of New Brunswick, 2016. http://www2.gnb.ca/content/dam/gnb/Departments/h-s/pdf/en/Publications/Profiles/ProfilesHealthDiabetes.pdf. Accessed July 8, 2018.
19. Canadian Institute for Health Information. Resource Indicators: DAD Resource Intensity Weights and Expected Length of Stay. Ottawa: Canadian Institute for Health Information, 2017.
20. Piette JD, Kerr EA. The impact of comorbid chronic conditions on diabetes care. Diabetes Care 2006;29:725–31.
21. Magnan EM, Palta M, Johnson HM, et al. The impact of a patient's concordant and discordant chronic conditions on diabetes care quality measures. J Diabetes Complications 2015;29:288–94.
22. Petrosyan Y, Bai YQ, Koné Pefoyo AJ, et al. The relationship between diabetes care quality and diabetes-related hospitalizations and the modifying role of comorbidity. Can J Diabetes 2017;41:17–25.
23. Movsisyan A, Melendez-Torres GJ, Montgomery P. Users identified challenges in applying GRADE to complex interventions and suggested an extension to GRADE. J Clin Epidemiol 2016;70:191–9.
24. Meyer BD. Natural and quasi-experiments in economics. J Bus Econ Stat 1995;13:151–61.
25. Fretheim A, Soumerai SB, Zhang F, et al. Interrupted time-series analysis yielded an effect estimate concordant with the cluster-randomized controlled trial result. J Clin Epidemiol 2013;66:883–7.
26. Stuart EA, Huskamp HA, Duckworth K, et al. Using propensity scores in difference-in-differences models to estimate the effects of a policy change. Health Serv Outcomes Res Methodol 2014;14:166–82.
27. Heckman J, Ichimura H, Todd P. Matching as an econometric evaluation estimator. Rev Econ Stud 1998;65:261–94.
28. Villa JM. Simplifying the estimation of difference-in-differences treatment effects. Stata J 2016;16:52–71.
29. Elovainio R. Performance Incentives for Health in High-income Countries: Key Issues and Lessons Learned. World Health Report 2010 Background Paper, No. 32. Geneva: World Health Organization, 2010.
30. Kontopantelis E, Springate DA, Ashcroft DM, et al. Associations between exemption and survival outcomes in the UK's primary care pay-for-performance programme: A retrospective cohort study. BMJ Qual Saf 2016;25:657–70.
31. Auditor General of New Brunswick. Chapter 2: Department of Health. Medicare. Payments to doctors. In: Report of the Auditor General, 2012, vol. 2. Fredericton, Canada: Auditor General, 2012. http://www.agnb-vgnb.ca/content/dam/agnb-vgnb/pdf/Reports-Rapports/2012V2/Chap2e.pdf. Accessed July 8, 2018.
32. Ödesjö H, Anell A, Gudbjörnsdottir S, et al. Short-term effects of a pay-for-performance programme for diabetes in a primary care setting: an observational study. Scand J Prim Health Care 2015;33:291–7.

Supplementary Material



Supplementary Figure 1. Algorithm to assign most responsible provider to patients with diabetes based on the physician billings database. Includes all service claims and shadow-billing claims among family physicians (fee-for-service or salaried) and nurse-practitioners (salaried). Locum tenens physicians were excluded. As of 2018, chronic disease management incentives could be claimed in relation to care provided for patients with diabetes mellitus (types 1 and 2) and/or chronic obstructive pulmonary disease. *COPD*, chronic obstructive pulmonary disease; *mgmt*, management.