RESEARCH PAPER

The Effect of Rostering with a Patient Enrolment Model on Emergency Department Utilization

L'effet de l'inscription des patients, à l'aide d'un modèle d'adhésion, sur l'utilisation des services des urgences

RAAJ TIAGI, PHD
Health Analytics Branch, Ministry of Health and Long-Term Care
Toronto, ON

YURIY CHECHULIN, MPH, MD
Health Analytics Branch, Ministry of Health and Long-Term Care
Toronto, ON

Abstract

Objective: To assess the effect of rostering with a patient enrolment model (PEM) in Ontario on emergency department utilization for non-emergent care.

Data sources/study setting: Administrative data for fiscal years 2006/07 through 2010/11 from the Ontario Ministry of Health and Long-Term Care were used for the analysis.

Study design: Patient-level analysis with a difference-in-difference modelling approach was used to study the relationship. A control group was established using propensity score matching.

Principal finding: Results suggest that rostering with a PEM is associated with a statistically significant reduction in emergency department (ED) (non-emergent) visits in Ontario. More specifically, enrolment with PEMs reduced ED visits by 3% during the study period, translating into cost savings of approximately $8 million for hospitals in Ontario.

Conclusion: This study shows that PEMs have achieved some degree of success in enhancing health system efficiency in Ontario through the reduction in the use of EDs for non-emergent care.

Résumé

Objectif : Évaluer l'effet de l'inscription des clients, à l'aide d'un modèle d'adhésion des patients (MAP), en Ontario, sur l'utilisation des services des urgences pour les soins non urgents.
Sources de données/paramètres de recherche : Des données administratives pour les exercices financiers de 2006/2007 à 2010/2011 provenant du ministère ontarien de la Santé et des Soins de longue durée ont été utilisées pour l'analyse.
Conception de l'étude : Une analyse au niveau des patients ainsi qu'une modélisation de l'écart dans les différences ont été employées pour étudier la relation. Un groupe témoin a été formé au moyen des coefficients de propension.
Principaux résultats : Les résultats font voir que l'inscription des patients à l'aide d'un MAP est associée à une réduction statistiquement significative des visites (non urgentes) aux services des urgences, en Ontario. Plus précisément, l'inscription des patients a permis de réduire les visites aux services des urgences de 3 % au cours de la période d'étude. Cela se traduit par une économie d'environ 8 millions de dollars pour les hôpitaux ontariens.
Conclusion : Cette étude montre que le MAP connaît un certain succès dans l'accroissement de l'efficience du système de santé en Ontario grâce à une réduction de l'utilisation des services des urgences pour des soins non urgents.

There is now considerable evidence suggesting that a strong primary care system not only leads to better health outcomes and higher patient satisfaction, but also lowers healthcare costs for the associated jurisdiction (Atun 2004; Starfield and Shi 2002). Given this evidence, and faced with an aging population and rapidly increasing healthcare costs, countries such as the United States and Canada have introduced various primary care reform strategies with the objective of improving health system efficiency.

For Ontario, the largest province in Canada, reforms to the primary healthcare system have meant a move away from a fee-for-service payment mechanism for family physicians (FPs) and general practitioners (GPs) to non–fee-for-service arrangements involving collaborative health teams and a blend of financial incentives, premiums and other types of payments.[1] The cornerstone of this new arrangement is patient rostering or patient enrolment, where funding and compensation of participating physicians are tied to the number of patients enrolled (in this paper, the terms enrolment and rostering are used interchangeably).

Through rostering, which has emerged as a key component of recent primary care models in many countries such as Australia, the United States and United Kingdom, Denmark, New Zealand and Canada, patients in Ontario enter into a formal agreement with their rostering physician. Under this agreement, patients commit to seek treatment from their enrolling physician while physicians agree to provide comprehensive care to their enrolling patients.

Theoretically, the move towards rostering has been argued on the grounds that such a system leads to better health outcomes for patients through continuity of care and through better access to patient information (because patients return to the enrolling physician, except in emergencies). Further, from a health system perspective, rostering is likely to result in the more efficient use of resources because enrolling physicians are expected to direct their patient to the most appropriate healthcare provider. In other words, by formalizing the relationship between the physician and the patient, patient enrolment models (PEMs) are able to improve the delivery of care and ensure a more appropriate use of health services by patients. An indirect benefit of rostering may be the more appropriate use of emergency departments (EDs), walk-in clinics or other health services. More specifically, rostering may be associated with the reduction in the utilization of EDs for less urgent care. Determining whether such an association exists was the purpose of this study.

The reduction in ED utilization, particularly for minor health conditions, has been the objective of several health jurisdictions around the world for years. Canada, Australia and the United Kingdom have instituted health reforms that include setting targets for the time patients spend in the ED (Guttmann et al. 2011). Studies have reported that 15%–25% of Canadians use ED services at least once a year (Brown and Goel 1994; Chan et al. 2001), and up to 30% primarily for non-urgent problems (Burnett and Grover 1996; Vertesi 2004). According to a 2011 report published by Health Quality Ontario (HQO), one in 20 Ontarians who visited an ED in 2010 left before being seen because they were tired of waiting. Such overcrowding in EDs in Canada and Ontario are a much discussed issue and a cause of concern not only for policy makers but also for the general public.

One reason stated for the observed overcrowding in Ontario's EDs has been the perceived or actual difficulty in accessing a FP or GP. According to the HQO report (2011), one in two Ontarians felt they could have been treated by their primary care provider if care had been available the last time they visited their hospital or ED. Given this backdrop, primary care reforms in Ontario have entailed the growth of diverse PEMs that are alternatives to the predominant fee-for-service model. Through rostering, PEMs seek to ensure that the primary care providers are the first point of contact for patients seeking medical treatment and that once in contact, physicians can direct patients to the most appropriate medical care. For example, all PEMs provide some form of after-hours and weekend care, so patients are able to access care when needed. In other words, the system has been set up to ensure that services such as EDs are used more appropriately, leading to an increased overall efficiency in the healthcare system.

Evidence from countries such as the United States (Christakis et al. 2001; Gill et al. 2000), the United Kingdom (Pickin et al. 2004) and the Netherlands (van Uden et al. 2004) has shown that continuity of primary care or improved primary care access with after-hours care – all features of PEMs – are associated with lower ED use. As well, a study (Howard et al. 2008) conducted in a medium-sized Ontario city, Thunder Bay, with a single ED, found that patients whose physicians practised in a model based on capitation, with contractual agreement to provide some after-hours services and to roster patients, used the ED less often than patients whose physicians practised in other models (fee-for-service). Thus, there exists some empirical evidence suggesting that a non–fee-for-service system is associated with lower ED utilization.

We used administrative data for fiscal years 2006/07 through 2010/11 to analyze the effect of rostering with a PEM on ED utilization in Ontario. While there are studies that measure the effectiveness of PEMs in terms of their impact on physician visits per week (Sarma et al. 2010), or on physician performance of certain services such as colorectal cancer screening or mammograms (Jaakkimainen et al. 2011), those that study the association between PEMs and ED use in Ontario are far fewer. The few that exist are primarily cross-sectional population-based analyses (Glazier et al. 2009) or evaluations based on patient questionnaires conducted in one ED in a single city (Howard et al. 2008).

Alternatively, this study was an individual-level analysis and employed a difference-in-difference modelling approach to study the above relationship for the province of Ontario. While the objective was to understand the association between primary care delivered under a non–fee-for-service setting and the use of ED services, the analysis can inform future government policy work through the identification of any improvement opportunities in the delivery of primary care in Ontario. Our results confirm the findings of studies from other countries: results from the zero-inflated negative binomial (ZINB) model suggest that for the period 2006/07 through 2010/11, rostering with PEM is associated with an average 3.5% reduction in ED visits for non-urgent care (defined as CTAS levels IV and V).[2]

Primary Care Delivery in Ontario

Since the adoption of a universal health insurance system in Canada in 1969, rostering or patient enrolment has been the distinctive characteristic of the provision of primary care in Ontario. Hutchison and colleagues (2001) point out that the first wave of innovation in primary care during the 1970s saw the emergence of alternative organization and funding models such as community health centres (CHCs) and health service organizations (HSOs), the latter providing medical care to rostered patients in Ontario.

After the release of the Romanow Commission's (2002) report on the future of healthcare in Canada, Ontario introduced two new enrolment models – family health networks (FHNs), a blended capitation model, and family health groups (FHGs), an enhanced fee-for-service blended model. While physicians under FHNs are required to roster their patients through a formal enrolment process, physicians under FHGs are encouraged, although not required, to roster their patients. However, FHG physicians receive fee premiums for services provided to rostered patients after-hours and regular fee-for-service provided to non-rostered patients.

FHN physicians, on the other hand, receive an access bonus that is reduced by the cost of services provided to their rostered patients by non-FHN FPs or GPs.[3]

In 2006, Ontario introduced family health organizations (FHOs), a blended capitation model. FHOs harmonized the earlier-introduced HSOs and primary care networks (PCNs); although they are similar to FHNs, FHOs have higher average capitation rates.[4] According to data drawn for 2011 from the CPDB (Corporate Provider Database) and the CAPE (Client Agency Program Enrollment Database), FHOs had the largest percentage of PEM physicians (at 45%) and the largest patient enrolments (at 51%). Even so, almost one-third of Ontario's physicians continue to practise under a pure fee-for-service payment system.[5]

For the purposes of this study, all non–fee-for-service models are grouped together as PEMs. Although there is some variation across PEMs in their payments or benefits to physicians, the models were introduced as alternatives to the dominant fee-for-service model and are designed to alter (through embedded incentives) physician behaviour in the provision of primary care. Arguably then, these models together can be understood as influencers of an alternative means of delivering primary care in Ontario.

Data

Data for the analysis were obtained from the Ontario MOHLTC. Patients with a valid Ontario health number in the Registered Persons Database (RPDB), Ontario's healthcare registry with patient information (age, sex, place of residence) for all people covered by the Ontario Health Insurance Plan (OHIP), were identified for the fiscal years 2006/07 through 2010/11. From this sample, only active health numbers were selected – i.e., those that had at least one (any) claim in the Claims History Database (CHDB) in the past six available years.[6]

The Client Agency Program Enrolment (CAPE), a repository of the association of a registered person with a specific physician at a specific agency in a formally recognized program, was used to identify patient enrolment by physician type. In other words, a case cohort was established by selecting patients (sampled from the RPDB) who became newly rostered with PEMs during the fiscal year 2008/09 and continued with a PEM through the rest of the study period (until 2010/11). Case cohort patients were allowed to move between different PEMs between fiscal years 2008/09 and 2010/11. Note that although patients were enrolling in PEMs prior to 2008/09, for our analysis we chose this as the arbitrary intervention date.

The analysis also required a control cohort. This included patients who were not rostered with a PEM during the entire study period (fiscal years 2006/07 through 2010/11; for the control cohort, the arbitrary intervention date was September 30, 2008). To ensure that the control cohort was similar to our case cohort, we used propensity score matching based on the patient's age, sex and geography.

In the next step we linked the case cohort and the control cohort to the National Ambulatory Care Reporting System (NACRS) to get the number of ED visits.[7] These were defined as CTAS levels IV and V, consisting of relatively less urgent ED cases.

Methodology

To measure the effect of PEM rostering on ED visits in Ontario, we employ the difference-in-difference regression technique. Expressed algebraically, the research design is:

$$Y_{i,t} = \alpha + \beta_1 \, PEM_i + \beta_2 \, T_t + \beta_3 \, (PEM_i)^*(T_t) + \beta_4 \, X_{i,t} + \varepsilon_{i,t}$$

where:

$Y_{i,t}$ = number of emergency department visits for patient i in time period t. For simplicity, we group our data into two time periods, with fiscal years 2006/07 and 2007/08 together representing the pre-intervention period (t=0) and fiscal years 2008/09 through 2010/11 together representing the post-intervention period (t=1); thus ED visits represent the sum of visits in 2006/07 and 2007/08 when t=0 and the sum of ED visits in 2008/09 through 2010/11 when t=1;

T_t is a binary variable: =1 indicating post-intervention, =0 indicating pre-intervention;

PEM_i is a binary variable indicating the case cohort with enrolment with a PEM/non–fee-for-service (=1) or the control cohort established through propensity score matching, with fee-for-service/non-PEM (=0);

$X_{i,t}$ is a vector of other control variables: patient's age (included as a categorical variable), place/LHIN of residence[8] and sex;

$\varepsilon_{i,t}$ is the error term, assumed to be normally distributed; and

$(PEM_i)^*(T_t)$ is the interaction term representing the intervention (enrolment with PEM) effect.

Finally, α, β_1, β_2, β_3 and β_4 are regression parameters to be estimated, with β_3 representing our parameter of interest. β_3 measures the effect of rostering with PEMs on the number of ED visits in Ontario.

The advantage of the difference-in-difference research design is that it permits the establishment of a causal relationship between variables of interest. With this approach, the behavioural change for the control cohort picks up any naturally occurring changes in behaviour over time, while the treatment group/case cohort's behavioural change picks up the same naturally occurring changes over time plus the impact of the intervention (enrolment in PEMs). Thus, a comparison of the changes in behaviour of the two groups that are similar on observable characteristics reveals the impact of the intervention.

One concern in estimating the impact of patient enrolment on ED visits is that of patient selection, which may lead to biased estimates of our parameter of interest, β_3. More specifically, certain PEMs – capitation models (FHNs and FHOs) in particular – may incentivize physicians to "cream-skim" their patients, i.e., choose to roster only healthier patients or those likely to require little care in the future. This would result in a healthier patient sample – or patients less likely to use EDs – under PEMs, and a relatively less healthy patient sample in our control group.

A potential solution to the selection issue would be to introduce several control variables and assume that any difference between the case cohort and control cohort is fully accounted for by these variables. In particular, controlling for factors such as case mix of patients would reduce such bias. However, the data sets that we used do not have extensive clinical or other individual-level information that could be used as potential controls.[9]

Given these shortcomings, we dealt with the selection issue in the following manner: first, we used propensity score matching to construct our control cohort so that this cohort was similar, at least on observable characteristics, to the case cohort. Second, we introduced 96 sub-LHIN–level dummies to control for any geographic or socio-economic variation in ED rates. Finally, assuming that any remaining bias between the case and the control cohorts was based on unobservable patient characteristics that are time-invariant or if there existed "selection on unobservables," then such biases were differenced away under the difference-in-difference regression approach.[10]

Another, perhaps more serious, concern with the above framework is the assumption of normally distributed errors. Clearly, this assumption is violated here because the distribution of ED visits is skewed to the right with a preponderance of zeros; 80% of individuals in our sample had 0 ED visits (Table 1). Given this, we modified the above framework and tested four regression models that offered, successively, more safeguards against misspecification of the conditional mean and the error structure. These count data models are the Poisson model, the negative binomial model, the zero-inflated Poisson (ZIP) model and the ZINB model.

TABLE 1. Total and average emergency department (ED) visits (with standard deviation), 2006/07 through 2010/11

ED visits	Number of ED visits	% ED visits
0	1,722,307	79.6
At least 1	441,545	20.4
Total	2,163,852	100
Average ED visits	0.37	
Standard deviation of ED visits	1.25	

The Poisson specification is a basic econometric model that is able to incorporate the discrete non-negative values of ED visits. However, one restriction of the model is that the mean and variance of the count data be equal. As Table 1 shows, this assumption is violated because the variance of ED visits is much larger than the mean. Theoretically then, the negative binomial model turns out to be more flexible, because under this model the mean and variance are no longer required to be equal. In other words, over-dispersion in the data is no longer an issue.

However, if the major source of dispersion in the data is the preponderance of zero counts, the ZIP or the ZINB models may be more appropriate than the Poisson or the negative binomial model (Karazsia and van Dulmen 2008). This consideration is particularly relevant to our study because 80% of ED visits have a zero count (Table 1).

A key statistical advantage of the zero count models over the Poisson and the negative binomial models is that the former can model the preponderance of zeros as well as the distribution of positive outcomes simultaneously. More specifically, these models first account for the excessive zeros by predicting group membership (a dichotomous outcome) based on predictors in the model and then predicting the frequency of counts for the "non-zero group" (a continuous outcome). The latter process is similar to a standard Poisson or negative binomial model, but after accounting for excessive zeros. The ZIP model accurately reflects the data when over-dispersion occurs due to a preponderance of zeros, while the ZINB model is more appropriate when the over-dispersion is due to factors beyond the inflation of zeros (Karazsia and van Dulmen 2008). Based on likelihood ratio tests for model selection, the ZINB model proved the most appropriate for the data used for the study.

In the next section we present results using the ordinary least squares regression framework and the ZINB model. While the primary objective of this study was to assess the relationship between rostering and emergency department utilization, we use the results from the ZINB model to derive an estimate of the potential financial savings for hospitals in Ontario for fiscal year 2010/11.

Empirical Results

Table 2 presents descriptive statistics for the case cohort – patients enrolled in PEMs starting fiscal year 2008/09 through 2010/11, and the control cohort – patients who were never enrolled in a PEM throughout the study period (2006/07 through 2010/11).

TABLE 2. Characteristics of case cohort and control cohort, for fiscal years 2006/07 through 2010/11

	Case cohort		Control cohort	
	Mean	**n**	**Mean**	**n**
Male	0.511	276,317	0.513	277,729
LHIN of residence				
Erie St. Clair	0.060	32,212	0.060	32,686
South West	0.064	34,412	0.064	34,570
Waterloo Wellington	0.037	20,238	0.041	22,086
Hamilton Niagara Haldimand Brant	0.089	48,239	0.089	48,165
Central West	0.060	32,692	0.062	33,338
Mississauga Halton	0.091	49,434	0.090	48,693

TABLE 2. Continued

	Case cohort		Control cohort	
	Mean	n	Mean	n
Toronto Central	0.104	56,360	0.103	55,618
Central	0.142	76,984	0.143	77,147
Central East	0.129	69,541	0.135	73,207
South East	0.042	22,651	0.044	23,706
Champlain	0.105	56,768	0.101	54,606
North Simcoe Muskoka	0.025	13,468	0.016	8,904
North East	0.037	19,830	0.036	19,503
North West	0.015	8,134	0.016	8,734
Age categories				
0–4 years old	0.028	15,202	0.028	15,276
5–9 years old	0.045	24,521	0.046	25,084
10–14 years old	0.059	31,905	0.057	31,066
15–19 years old	0.072	38,679	0.069	37,569
20–24 years old	0.075	40,500	0.074	39,840
25–29 years old	0.079	42,707	0.077	41,628
30–34 years old	0.08	43,017	0.082	44,531
35–39 years old	0.083	44,979	0.084	45,330
40–44 years old	0.088	47,843	0.086	46,593
45–49 years old	0.09	48,948	0.093	50,562
50–54 years old	0.078	42,321	0.079	42,631
55–59 years old	0.063	34,232	0.061	32,960
60–64 years old	0.051	27,584	0.052	28,010
65–69 years old	0.035	19,024	0.036	19,701
70–74 years old	0.027	14,496	0.027	14,807
75–79 years old	0.021	11,131	0.021	11,182
80–84 years old	0.015	7,931	0.015	8,246
85 plus	0.011	5,943	0.011	5,947
Total number of observations	**540,963**		**540,963**	

Case cohort represents patients that were enrolled in a PEM starting fiscal year 2008/09. The control cohort, derived from propensity score matching, includes patients that were never enrolled in a PEM throughout the study period (2006/07 through 2010/11).

The table indicates that the fraction of males, the fraction of individuals located in different LHINs in Ontario and the fraction of individuals in different age categories are very similar across the two cohorts. This is no surprise because the control cohort was constructed based on propensity score matches of age, sex and location with the case cohort.

To get a more accurate picture of ED visits by cohort type, we analyzed ED visits pre- and post-2008/09, our arbitrary intervention date. Overall, ED visits in Ontario have been climbing upwards over time – for example, between fiscal years 2004/05 and 2010/11, ED visits in Ontario increased from 408 per 1,000 population to 421 per 1,000 population, or by 3% (Table 3). On the other hand, visits defined as ED visits for the purposes of this study – the CTAS IV- and V-level visits representing less severe cases – dropped by 9% over the same period.

TABLE 3. ED visits per 1,000 population in Ontario, by CTAS levels, Ontario

CTAS category	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	Change FY 2004/05 to FY 2010/11	% change FY 2004/05 to FY 2010/11
I–II	42	47	48	53	56	60	66	24	5.9%
III	148	155	155	157	162	171	174	26	6.4%
IV–V	218	213	210	205	197	188	181	–37	–9.1%
Total	**408**	**415**	**414**	**415**	**414**	**419**	**421**	**13**	**3.2%**

Table 4 shows mean emergency department visits (CTAS IV and V) pre- and post-intervention for the case cohort and the control cohort. The table shows that for both cohorts, ED visits declined post-intervention, although the rate of change is higher for enrolled patients.[11] Ideally, for the difference-in-difference research design, mean ED visits pre-intervention (i.e., pre-2008/09) should be similar across the two cohorts. However, mean ED utilization for the control cohort (at 0.37) is lower than the mean ED utilization for the case cohort (at 0.42). One potential reason for this may be that some individuals with a valid health number who appeared to be eligible for OHIP services and were active (i.e., they had at least one claim in the past six years) were in fact not residing in the province (they may have left the province or did not live continuously in the province). This issue could be more likely for individuals in the control cohort, resulting in lower average ED visits for individuals in that cohort.

TABLE 4. Average per-patient ED utilization (visits CTAS levels IV and V), pre- and post-intervention, Ontario (without controls)

	Pre-intervention	Post-intervention
Case cohort	0.42	0.37
Control cohort	0.37	0.32

Case cohort represents patients that were enrolled in a PEM starting fiscal year 2008/09. The control cohort, derived from propensity score matching, includes patients that were never enrolled in a PEM throughout the study period (2006/07 through 2010/11). For this study, the intervention period (rostering with a PEM) was arbitrarily chosen as fiscal year 2008/09.

To establish the relationship between PEM enrolment and ED visits, we controled for patient's age, introduced as five-year groups, with ages 85-plus years as the reference category; person's sub-LHIN of location in Ontario; and whether the individual was female (with male as the reference category), in a regression framework. Table 5 presents results from OLS regression (first column), followed by results from the ZINB regression model.

TABLE 5. Effect of rostering with patient enrolment model (PEM) on emergency department (ED) visits in Ontario using various models

	Ordinary least squares		Zero-inflated negative binomial	
	(1)		(2)	
	Coeff.	SE	IRR	SE
PEM	0.050***	0.002	1.084***	0.006
Period	-0.046***	0.002	0.913***	0.007
PEM*Period	-0.005	0.003	0.965***	0.009
Female (reference=male)	0.000	0.002	1.019***	0.005
Age group (reference = 85 plus)				
0–4 years old	0.211***	0.009	1.266***	0.027
5–9 years old	0.054***	0.009	0.934**	0.027
10–14 years old	0.060***	0.009	0.968	0.027
15–19 years old	0.160***	0.008	1.250***	0.026
20–24 years old	0.165***	0.008	1.261***	0.026
25–29 years old	0.121***	0.008	1.196***	0.026
30–34 years old	0.093***	0.008	1.162***	0.026
35–39 years old	0.064***	0.008	1.129***	0.026
40–44 years old	0.049***	0.008	1.106***	0.026
45–49 years old	0.027**	0.008	1.079**	0.025
50–54 years old	0.016*	0.008	1.035	0.026
55–59 years old	-0.003	0.008	0.984	0.026
60–64 years old	-0.002	0.009	1.001	0.026
65–69 years old	-0.007	0.009	1.005	0.027
70–74 years old	0.023**	0.009	1.088**	0.028
75–79 years old	0.037**	0.010	1.068**	0.029
80–84 years old	0.051***	0.010	1.141***	0.030
Constant	0.407***	0.013	0.611***	0.037
Controls for sub-LHIN (health region of residence)	Yes		Yes	

***p<0.0001, **p<0.05, *p<0.10

IRR = Incidence Rate Ratios with the corresponding Standard Errors (SE); All SEs are robust; total observations = 2,163,852

PEM is a dummy variable coded 1 if case cohort (patients enrolled in a PEM) or 0 if control cohort (patients never enrolled in a PEM throughout the study period); "period" represents the arbitrarily set intervention period (2008/09) and is coded 1 for all time periods post-2008/09 (i.e., fiscal years 2008/09, 2009/10 and 2010/11) and is set 0 for pre-intervention period (fiscal years 2006/07 and 2007/08); the difference-in-difference estimate is represented by the interaction term PEM*Period.

Results from ordinary least squares (OLS) regression in column (1) suggest an inverse (although not statistically significant) effect of rostering with PEM on ED visits, with the coefficient on the interaction term (PEM*Period) of -0.005. As mentioned previously, because the distribution of ED visits is positively skewed, count data models may provide a better fit for the data. In column (2), we present results from the ZINB model. For ease of interpretation, coefficients have been transformed into incidence risk ratios (IRR).

Before we present the results of the ZINB model, it may be instructive to briefly discuss other count data models that were tested against this model. We tested the Poisson model, the negative binomial model and the ZIP model using the same controls as the OLS and the ZINB model (regression results and model selection tests have not been shown but are available upon request.) For the negative binomial model, the dispersion parameter "alpha" was significantly greater than zero, suggesting that the response variable is over-dispersed and is not sufficiently described by the simpler Poisson distribution. While the negative binomial model certainly fit the data better than the Poisson model, we wanted to determine whether zero-inflated models may yet be more appropriate given the preponderance of zeros in our data.

To do so, we first carried out the Vuong test – a likelihood ratio test for model selection. The test compares the ZIP model to a standard Poisson model and the ZINB model to the negative binomial model. For the ZIP model, the *z*-value was positive and significant, suggesting that the ZIP model fit the data better than the standard Poisson model. More importantly, the *z*-value for the ZINB model was also positive and statistically significant, suggesting that the ZINB model is more appropriate than the standard negative binomial.

Next, we conducted a likelihood ratio test to establish whether the ZINB model is more appropriate compared to the ZIP model. The large test statistic with an associated *p*-value of <0.0001 suggests that the ZINB model fit our data better than the ZIP model. We derived two additional measures of model fit: the Akaike's information criterion (AIC) and the Bayesian information criterion (BIC) to compare the ZIP model and the ZINB model. Both these measures were relatively smaller for the ZINB model, suggesting again that the ZINB model is more appropriate for our data, which are over-dispersed and have a preponderance of zeros. (For the ZINB model, the AIC is 3,164,402 and the BIC is 3,165,297. For the ZIP model, the AIC is 3,367,582 and the BIC is 3,368,464.)

Results for the ZINB model in column (2) indicate that enrolment with a PEM is associated with a statistically significant decline in ED visits. For our sample, enrolment with a PEM results in an average 3.5% reduction (IRR = 0.965) in ED visits.

The other variables in column (2) confirm earlier findings. The coefficient on PEM indicates that pre-intervention, ED visits for those enrolled in PEMs are significantly higher than for the control cohort. Further, the coefficient on period suggests that post-intervention, ED visits declined significantly for the non-enrolled group. However, the interaction term suggests that the rate of change of the decline in ED visits is higher for enrolled patients. This finding implies that PEMs have had a significant additional protective effect in terms of the overuse of EDs.

In terms of sex, results suggest that males use EDs more than females. Finally, those very young (0–9 years of age) and those much older (70–84 years of age) use EDs more than those in the 85-plus age group. However, individuals in a number of working age groups (15–49 years) also use emergency departments more than those in the 85-plus age category. This finding reflects the possible overuse of ED facilities for less emergent care by individuals in different age categories.

Together, the above analysis suggests that rostering is associated with a statistically significant reduction in ED visits. This finding suggests that efforts must continue to encourage physicians to enrol patients so that patients with less serious health conditions do not end up crowding Ontario's EDs.

Discussion

Patient rostering was introduced in Ontario as part of the provincial government's primary care reform initiative, with the objective of improving patient care. Through rostering, patients are able to access the healthcare system through the same healthcare provider over time, thereby benefiting from continuity of care. As well, patients have access to primary care providers (in the enrolling group) after-hours and through the telephone health advisory service, thereby improving access to care.

While the above constitute some direct benefits of patient rostering, the objective of this study was to examine any indirect benefits that may arise due to patient rostering. In particular, our objective was to examine whether patient rostering is associated with any reduction in ED utilization for non-urgent care. Such reduction may result if non-urgent patients seek treatment with their rostering healthcare provider, their first point of contact with the health system, rather than at emergency departments.

Our results suggest that PEMs have achieved some degree of success in enhancing health system efficiency in Ontario through the reduction in the use of EDs for non-emergent care. The study shows that enrolment with PEMs reduced ED visits by 3.5% on average for the study period 2006/07 through 2010/11.

The above estimates can be used to derive potential financial savings for hospitals in Ontario for fiscal year 2010/11. The 3.5% estimated reduction in ED visits results in about 55,000 fewer ED visits (CTAS levels IV and V) for rostered patients (from 1,577,214 visits to 1,522,012 visits) for FY 2010/11. With the average cost of such an ED visit at $147.38, the potential cost saving for hospitals is estimated at $8 million (derived by multiplying the mean cost per visit with the reduced number of visits estimated from the model).[12] Further, if the same reduction in ED visits could be achieved for non-enrolled patients (who had 546,251 non-urgent visits), this would result in approximately $2.8 million in additional potential savings for hospitals for the same fiscal year.

These results are in line with other related research that has shown that continuity of care is associated with not only better patient outcomes but also with the more efficient use of the health system. A paper by Glazier and colleagues (2008) shows that in Ontario, patients without a regular family doctor were 1.22 times more likely to visit an ED and 1.32 times more likely to have had a medical, non-elective hospital admission than people who reported having a regular family doctor. Other studies have shown that continuity of care is associated with decreased hospital visits in the United States (Raddish et al. 1999) and reduced ambulatory care–sensitive hospitalizations in Canada (Menec et al. 2006).

The present study is an individual-level analysis of the relationship between rostering and ED utilization. The administrative data in the study, obtained from the Ministry of Health and Long-Term Care, are highly reliable and permit a study of the relationship over time. Previous studies primarily used cross-sectional data to assess this relationship.

Our study has some limitations. First, we did not have access to and were therefore unable to control for population groupers such as Adjusted Clinical Groups or Diagnostic Cost Groups. Usage of such systems for propensity score matching and risk adjustment could further improve model performance. Second, we did not have reliable information for other potentially important factors such as the rural/urban location or patients' ethnic background. However, we used 96 sub-LHIN dummy variables to mitigate somewhat the effect of location on ED utilization. Third, our study was conducted during a period in which coding changes to the triage levels were underway. This may have accounted for the general downward trend observed over time for all patients in their use of EDs for less urgent care. Finally, in terms of the study design, the case and the control groups were not comparable in their ED use at baseline: the case cohort's utilization of EDs for non-urgent care was relatively higher.

In conclusion, our study shows that patient rostering is associated with a statistically significant reduction in non-urgent ED visits. This finding suggests that efforts to encourage rostering of Ontario's patients – thereby improving continuity of care – are likely to result in greater health system efficiencies in the province.

Acknowledgements

The authors would like to thank the two anonymous referees for their helpful comments on an earlier version of this paper. We would also like to thank Kamil Malikov, Sten Ardal and Sherry Wang for their support and helpful suggestions. Any errors and omissions are the responsibility of the authors.

Correspondence may be directed to: Raaj Tiagi, e-mail: rtiagi@gmail.com.

Notes

1. In Ontario, primary care is organized predominantly around family physicians and general practitioners working in solo and small group practices (Hutchison et al. 2001).
2. The Canadian Triage and Acuity Scale (CTAS) levels IV and V represent less complex non-urgent visits that may have, potentially, a primary physician visit substitution. The CTAS, developed by the Canadian Association of Emergency Physicians (CAEP) in 1998, is based on medically acceptable wait times in Canadian EDs. The scale includes five categories, where level I consists of the most urgent cases (resuscitation) and level V constitutes the least urgent (non-urgent) cases. Patients are assigned a category according to level of urgency, and each level has an expected fractile response time indicating maximum waiting time for the type of complaint.
3. The penalty is applied if patients go outside the group, even if they go to a different FHN group. There are further premiums and incentives in these primary care service delivery models; for details, see Muldoon and colleagues (2006).

4. Compared to FHNs, FHOs have a broader basket of fee schedule codes that are subject to capitation and not fee-for-service payment. This presumably explains the higher capitation rates for FHOs.
5. The other PEMs in Ontario include the comprehensive care model (CCM), a fee-for-service blended model; community health centres (CHCs) and Aboriginal health access centres (AHACs), both blended salary models; group health centres (GHCs), a blended capitation model; rural and northern physician group agreements (RNPGAs); and shared care pilot sites (SCPSs). For detailed information on PEMs, see HealthForceOntario (2007).
6. CHDB is the repository of information retained by MOHLTC relating to medical claims submitted by providers of healthcare services to eligible Ontario residents. The database is used in the assessment and processing of claims and is a financial record of monies paid to a provider for services billed on behalf of Ontario residents.
7. NACRS contains data for all hospital-based and community-based ambulatory care, including surgical day/night care, outpatient clinics and EDs. Currently, data submission to NACRS has been mandated in Ontario for emergency rooms, surgical day/night care, dialysis, cardiac catheterization and oncology (including all regional cancer centres).
8. Ontario's 14 local health integration networks (LHINs) are community-based, non-profit organizations funded by the Ministry of Health and Long-Term Care to plan, fund and coordinate services delivered by hospitals, long-term care homes, community care access centres, community support service agencies, mental health/addiction agencies and community health centres.
9. For example, not all patients in our sample were hospitalized; case mix of patients is observed only for the sample of patients that are ever-hospitalized.
10. A related concern is that individual physicians may self-select into different remuneration groups based on unobservable personal preferences, their abilities or other unobservable characteristics (Gaynor and Gertler 1995), which could potentially influence their delivery of care. However, so long as the unobservable heterogeneity is time-invariant, it is differenced away under the difference-in-difference approach.
11. Possible explanations for the downward trend in ED visits may be the change in triaging practice (fewer patients coded as CTAS levels IV and V and instead coded as CTAS III) on account of the revision of the scale in 2008; or, better access to walk-in clinics and primary physicians for all patients regardless of enrolment status.
12. The average hospital cost of an ED visit (CTAS IV and V) was derived from the Ontario Case Costing Initiative (OCCI) database, which has individual patient costs.

References

Atun, R. 2004. "What Are the Advantages and Disadvantages of Restructuring a Health Care System to Be More Focused on Primary Care Services?" Health Evidence Network Report. Copenhagen: WHO Regional Office for Europe. Retrieved April 8, 2014. <http://www.euro.who.int/document/e82997.pdf>.

Brown, E.M. and V. Goel. 1994. "Factors Related to Emergency Department Use: Results From the Ontario Health Survey 1990." *Annals of Emergency Medicine* 24: 1083–91.

Burnett, M.H. and S.A. Grover. 1996. "Use of the Emergency Department for Non-Urgent Care During Regular Business Hours." *Canadian Medical Association Journal* 154: 1345–51.

Chan, B.T.B., M.J. Schull and S.E. Schultz. 2001. Emergency Department Services in Ontario: Research Atlas. Toronto: Institute for Clinical Evaluative Sciences.

Christakis, D.A., L. Mell, T.D. Keopsell, F.J. Zummerman and F.A. Connell. 2001. "Association of Lower Continuity of Care with Greater Risks of Emergency Department Use and Hospitalization in Children." *Pediatrics* 107: 524–29.

Gaynor, M. and P. Gertler. 1995. "Moral Hazard and Risk Spreading in Partnerships." *Rand Journal of Economics* 26(4): 591–613.

Gill, J.M., A.G. Mainous III and M. Nsereko. 2000. "The Effect of Continuity of Care on Emergency Department Use." *Archives of Family Medicine* 9: 333–38.

Glazier, R.H., J. Klein-Geltink, A. Kopp and L. Sibley. 2009. "Capitation and Enhanced Fee-for-Service Models for Primary Care Reform: A Population-Based Evaluation." *Canadian Medical Association Journal* 180(11): E72–81.

Glazier, R., R. Moineddin, M.M. Agha, B. Zagorski, R. Hall, D.G. Manuel et al. 2008. "The Impact of Not Having a Primary Care Physician among People with Chronic Conditions." ICES Investigative Report. Toronto: Institute for Clinical Evaluative Sciences. Retrieved April 8, 2014. <http://www.ices.on.ca/flip-publication/the-impact-of-not-having-a-primary-care-physician-chronic-conditions/index.html#1/z>.

Guttmann, A., M.J. Schull, M.J. Vermeulen and T.A. Stukel. 2011. "Association between Waiting Times and Short Term Mortality and Hospital Admission After Departure from Emergency Department: Population Based Cohort Study from Ontario, Canada." *British Medical Journal* 342: D2983.

HealthForceOntario. 2007 (April). Health Human Resources Toolkit. Retrieved April 8, 2014. <http://www.healthforceontario.ca/upload/en/whatishfo/hhr%20toolkit_june%2029.pdf>.

Health Quality Ontario. 2011. "2011 Report on Ontario's Health System." Health Quality Monitor. Retrieved April 8, 2014. <http://www.longwoods.com/newsdetail/2012>.

Howard, M., J. Goertzen, J. Kaczorowski, B. Hutchison, K. Morris, L. Thabane et al. 2008. "Emergency Department and Walk-in Clinic Use in Models of Primary Care Practice with Different After-Hours Accessibility in Ontario." *Healthcare Policy* 4(1): 73–88.

Hutchison, B., J. Abelson and J. Lavis. 2001. "Primary Care in Canada: So Much Innovation, So Little Change." *Health Affairs* 20(3): 116–31.

Jaakkimainen, R.L., J. Barnsley, J. Klein-Geltink, A. Kopp and R.H. Glazier. 2011. "Did Changing Primary Care Delivery Models Change Performance? A Population-Based Study Using Administrative Data." *BMC Family Practice* 12(44): 1–15.

Karazsia, B.T. and M.H.M. van Dulmen. 2008. "Regression Models for Count Data: Illustrations Using Longitudinal Predictors of Childhood Injury." *Journal of Pediatric Psychology* 33(10): 1076–84.

Menec, V.H., M. Sirski, D. Attawar and A. Katz. 2006. "Does Continuity of Care with a Family Physician Reduce Hospitalizations among Older Adults?" *Journal of Health Services Research and Policies* 11(4): 196–201.

Ministry of Health and Long-Term Care (MOHLTC).

Muldoon, L., M.S. Rowan, R. Geneau, W. Hogg and D. Coulson. 2006. "Models of Primary Care Service Delivery in Ontario: Why Such Diversity?" *Healthcare Management Forum* 19(4): 18–23.

Pickin, D.M., A. O'Cathain, M. Fall, A.B. Morgan, A. Howe and J.P. Nicholl. 2004. "The Impact of a General Practice Co-operative on Accident and Emergency Services, Patient Satisfaction and GP Satisfaction." *Family Practice* 21(2): 180–82.

Raddish, M., S.D. Horn and P.D. Sharkey. 1999. "Continuity of Care: Is It Cost Effective?" *American Journal of Managed Care* 5(6): 727–34.

Romanow, R.J. 2002. Building on Values: The Future of Health Care in Canada – Final Report. Saskatoon: Commission on the Future of Health Care in Canada. Retrieved April 8, 2014. <http://publications.gc.ca/collections/Collection/CP32-85-2002E.pdf>.

Sarma, S., R.A. Devlin and W. Hogg. 2010. "Physicians' Production of Primary Care in Ontario, Canada." *Health Economics* 19: 14–30.

Starfield, B. and L. Shi. 2002. "Policy Relevant Determinants of Health: An International Perspective." *Health Policy* 60(3): 201–18.

van Uden, C.J.T. and H.F. Crebolder. 2004. "Does Setting Up of Out-of-Hours Primary Care Cooperatives Outside a Hospital Reduce Demand for Emergency Care?" *Emergency Medicine Journal* 21: 722–23.

Vertesi, L. 2004. "Does the Canadian Emergency Department Triage and Acuity Scale Identify Non-Urgent Patients Who Can Be Triaged Away from the Emergency Department?" *Canadian Journal of Emergency Medicine* 6: 337–42.