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Research

Association between registered nurse staffing and management outcomes of patients with type 2 diabetes within primary care: a cross-sectional linkage study

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Abstract

Background: As the organization of primary care continues to evolve toward more interdisciplinary team structures, demonstrating effectiveness of care delivery is becoming important, particularly for nonphysician providers. Nurses are the most common non physician provider within primary care. The purpose of this study was to examine the relation between primary care delivery models that incorporate registered nurses and clinical outcomes of patients with type 2 diabetes.

Methods: Patient data from the Canadian Primary Care Sentinel Surveillance Network were matched with survey data from 15 Family Health Team practices in southeastern Ontario. Included patients were adults with type 2 diabetes mellitus who had at least 1 primary care encounter at a Family Health Team practice that completed the organizational survey between Apr. 1, 2013, and Mar. 31, 2014. The clinical outcomes explored included hemoglobin A_{1c}, fasting plasma glucose, blood pressure, low-density lipoprotein cholesterol and urine albumin:creatinine ratio.

Results: Of the 15 practices, 13 (86.7%) had at least 1 registered nurse. The presence of 1 or more registered nurses in the practice was associated with increased odds of patients' having their hemoglobin A_{1c}, fasting plasma glucose, blood pressure and low-density lipoprotein cholesterol values meet recommended targets. Practices with the lowest ratios of patients with diabetes to registered nurse had a significantly greater proportion of patients with hemoglobin A_{1c} and fasting plasma glucose values on target than did practices with the highest ratios of patients to registered nurse ($p < 0.01$ and $p = 0.03$, respectively).

Interpretation: The findings suggest that registered nurse staffing within primary care practice teams contributes to better diabetic care, as measured by diabetes management indicators. This study sets the groundwork for further exploration of nursing and organizational contributions to patient care in the primary care setting.

Within Ontario, there are currently close to 200 Family Health Teams (FHTs) that deliver comprehensive care using a team structure that often includes physicians and nurses.[1,2] The presence of nursing providers varies across FHTs, which provides an opportunity to explore the impact of this variation on the management of patients with chronic conditions such as type 2 diabetes mellitus. Furthermore, within Canada, nurses form the largest group of health care providers within all sectors of care.[3] The increasing demand for professional and financial accountability means that nurses must be able to demonstrate the effects of their care on patient and system outcomes.[4] As the organization of primary care services moves further toward interdisciplinary models of care, demonstrating the unique contribution of providers within these models is particularly important for nurses employed within this setting.[5–7] To date, the contribution of nurse staffing to clinical or patient outcomes has been explored primarily within acute care, and studies have focused on the relation between staffing levels and patient safety outcomes, such as the occurrence of adverse events.[4,8,9] Within acute care, a reduction in adverse events was significantly associated with a higher number of hours of care delivered by registered nurses.[8,9] Canadian studies using chart abstraction data showed that the number of nurses in a primary care practice was independently and positively associated with health promotion,[10] and the presence of a nurse practitioner was associated with improved chronic disease prevention and management.[11,12] In a cross-sectional study in the United Kingdom, higher staffing

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levels of registered nurses were significantly associated with improved performance of chronic disease care and decreased hospital admissions related to asthma and chronic obstructive pulmonary disease.[13]

There is national and international recognition of the paucity of knowledge on how registered nurses contribute to the delivery of high-quality care in primary care settings.[14,15] Therefore, the purpose of this study was to examine the relation between primary care delivery models that incorporate registered nurses and clinical outcomes in patients with type 2 diabetes. We also sought to determine the feasibility of linking organizational-level survey data to patient health data (organized at the provider level) stored within a large administrative database. Type 2 diabetes was the focus given its high and increasing prevalence in the Canadian population[16] and the important role nurses can play in the prevention and management of diabetes complications.

Methods

Design

We performed a cross-sectional linkage study to explore associations between FHT practices with and without registered nurses and clinical outcomes of patients with type 2 diabetes in southeastern Ontario. Data on nurse staffing levels at primary care practices acquired from a cross-sectional organizational survey were linked with patient data from the Canadian Primary Care Sentinel Surveillance Network (CPCSSN). The study was approved by the Research Ethics Board of the Faculty of Health Sciences, Queen's University, Kingston, Ontario.

Patient sample

The patient sample was drawn from the CPCSSN, a chronic disease surveillance system using electronic medical records. It currently comprises 11 practice-based research networks across Canada, including 1 located in eastern Ontario. The CPCSSN provides access to electronic medical record data collected from patients with various chronic diseases, including diabetes.[17] The sample for the current study consisted of patients with diabetes who were aged 18 to 100 years and who had at least 1 primary care encounter between Apr. 1, 2013, and Mar. 31, 2014. Only patients who received care from a practice located in southeastern Ontario that completed the organizational-level survey were included in the sample. A CPCSSN diagnosis of diabetes includes the presence of the following elements within a patient's electronic medical record: existence of ICD-9 billing data code 250.X, indicating a diagnosis of diabetes mellitus, medications that are specifically used for managing diabetes and laboratory test results that align with a diagnosis of diabetes (e.g., hemoglobin A_{1c} [HbA_{1c}] level > 7.0%, fasting plasma glucose level ≥ 7.0 mmol/L). This diagnostic algorithm has a sensitivity of 95.6% and a specificity of 97.1%.[18] We used a 12-month observation period, as recommended by the Canadian Diabetes Association,[19] to measure quality of care indicators. No distinction was made between type 1 and type 2 diabetes. However, given that more than 90% of Canadians who have diabetes have type 2 diabetes,[16,20,21] most of the patients in the sample would be expected to have type 2 diabetes.

Setting

At the time of the study, there were 15 FHTs located within the South East Local Health Integration Network,[22] including 9 that participated in the Eastern Ontario Network of the CPCSSN. We invited each practice affiliated with these 9 FHTs that contributed data to the CPCSSN during the index year (Apr. 1, 2013, to Mar. 31 2014) to participate in the study. Given that an aspect of the study was to determine the feasibility of linking cross-sectional organizational-level data and patient data housed with the CPCSSN, only practices affiliated with the Eastern Ontario Network of the CPCSSN were sampled.

Date sources

Patient variables

We obtained patient data from the CPCSSN. The CPCSSN database has been assessed for quality, and disease diagnoses have been validated by means of chart abstraction.[23] The demographic and clinical characteristics included were age, sex and number of comorbid conditions. The outcome measures related to diabetes management that we explored included HbA_{1c} level, fasting plasma glucose level, blood pressure, low-density lipoprotein cholesterol level and urine albumin:creatinine ratio. The following targets have been established by the Canadian Diabetes Association to reduce the risk for microvascular or macrovascular complications associated with diabetes: HbA_{1c} level ≤ 7.0%, fasting plasma glucose level < 7.0 mmol/L, blood pressure < 130/80 mm Hg, low-density lipoprotein cholesterol level ≤ 2.0 mmol/L and urine albumin:creatinine ratio < 2.0 mg/mmol.[19] Each of these diabetes indicators should be measured at least once annually.[19]

Organizational variables

We obtained organizational data from a cross-sectional survey in which a modified version of the Measuring Organizational Attributes of Primary Health Care Survey was used.[24] We contacted a lead individual (e.g., administrative lead, executive director) at each site and invited him or her to participate in the study. For practices that agreed to participate, we obtained contact information for a person with knowledge of the organization of the practice and services offered. Survey respondents included administrative leads/managers, administrative personnel, physicians and nurse practitioners. The questionnaire was administered electronically by means of FluidSurveys. In addition, other completion methods (e.g., paper copy of the questionnaire) were offered to the participants. An item on the questionnaire asked respondents to provide physician and nurse staffing data for their practice. Specifically, the respondents were asked about the number of physicians and nurses who worked within their practice. The main exposure variable was the presence/absence of 1 or more registered nurses at the practices. This dichotomized characteristic was used previously in a study exploring the associations between nurse staffing and chronic disease management in primary care.[12]

Linkage of data sources

Data were linked at the organizational level with the use of a unique site identifier maintained by the CPCSSN. To enable the linkage, the CPCSSN provided us with a document containing a list of practices affiliated with each of the participating FHT sites that included the corresponding codes for providers delivering care at each practice. Each participating practice was then assigned a code that matched the codes assigned to each completed organizational survey. These practice codes corresponded to the provider identification codes of each included patient encounter to determine at which practice each patient encounter occurred.

Statistical analysis

We conducted data analysis using SPSS Version 22. Demographic characteristics of the patients were described using descriptive statistics. We used one-way analysis of variance to explore differences in patients' age across practices, and χ^2 analysis to compare all other patient demographic variables and outcome variables across practices. To explore variability in diabetes management across practices, we determined the proportion of patients with diabetes who had each diabetes management test completed and the proportion of those who had each diabetes management indicator on target within the index year.

We built logistic regression models using a traditional epidemiological paradigm with a backward elimination procedure. The exposure variable in each model was the presence/absence of 1 or more registered nurses in the practice. Outcome variables were dichotomized into on target/off target for each of the diabetes management indicators. We included in the modelling 3 dichotomous covariates that can influence the effectiveness of type 2 diabetes management:[19] sex, age (< 65 yr v. ≥ 65 yr) and comorbidity (0 v. ≥ 1 additional chronic conditions). Using a backward elimination strategy, we performed an assessment of modification ($p < 0.05$), followed by an assessment for confounding (i.e., changed the parameter estimate by > 10%). No patient variables modified or confounded the relations.

Last, we explored the effect of the ratio of patients with diabetes to registered nurses. We categorized this ratio into quartiles and explored associations between quartiles and diabetes outcome indicators using one-way analysis of variance. We calculated quartiles based on the number of patients with diabetes per registered nurse. Statistical significance was inferred when $p < 0.05$.

Results

Within the CPCSSN, 6673 patients met the inclusion criteria, and their data were included in the analysis. Eight FHTs with 15 practices completed the organizational-level survey. Characteristics of the providers and patients across all practices are given in Table 1. The average age of the patients was 65.1 (SD 14.0, range 62.4–67.3) years, and significant differences in the average age of patients were noted across practices ($p < 0.05$).

Table 1: Provider and patient profiles across Family Health Team practices in fiscal year 2013/14

Practice no.	No. of patients with diabetes mellitus	Providers			Patients			
		No. of GPs	No. of RNs	No. of patients with diabetes per RN	Male, no. (%)	Age, yr, mean ± SD	Age ≥ 65 yr, no. (%)	≥ 1 comorbid condition, no. (%)
All	6673	–	–	–	3415 (51.2)	65.1 ± 14.0	3690 (55.3)	4734 (70.9)
1	735	18	4	184	352 (47.9)	62.4 ± 14.1*	335 (45.6)	507 (69.0)
2	295	5	1	295	158 (53.6)	63.2 ± 14.9†	144 (48.8)	212 (71.9)
3	315	2	0	NA	155 (49.2)	67.3 ± 14.5	190 (60.3)	264 (83.8)
4	208	4	3	69	91 (43.8)	65.5 ± 13.1	129 (62.0)	196 (94.2)
5	809	8	2	405	457 (56.5)	66.2 ± 13.0	493 (60.9)	375 (46.4)
6	392	2	1	392	233 (59.4)	66.0 ± 13.2	234 (59.7)	334 (85.2)
7	542	7	4	136	251 (46.3)	63.8 ± 14.0†	277 (51.1)	417 (76.9)
8	832	8	6	139	447 (53.7)	67.0 ± 14.5	499 (60.0)	627 (75.4)
9	647	2	2	324	282 (43.6)	62.5 ± 14.0*	305 (47.1)	332 (51.3)
10	191	5	2	96	80 (41.9)	64.7 ± 14.4	94 (49.2)	141 (73.8)
11	304	6	2	152	172 (56.6)	66.4 ± 13.4	183 (60.2)	235 (77.3)
12	170	2	4	42	86 (50.6)	68.5 ± 12.8	112 (65.9)	143 (84.1)
13	448	5	0	NA	233 (52.0)	63.7 ± 14.0‡	237 (52.9)	353 (78.8)
14	504	13	6	84	266 (52.8)	66.0 ± 13.4	292 (57.9)	432 (85.7)
15	281	4	1	281	152 (54.1)	66.2 ± 13.8	166 (59.1)	166 (59.1)

Note: GP = general practitioner, NA = not applicable, RN = registered nurse.
*$p < 0.05$ compared with practices 3, 5, 6, 8, 11, 12, 14 and 15.
†$p < 0.05$ compared with practices 3, 8 and 12.
‡$p < 0.05$ compared with practices 8 and 12.

Thirteen practices (86.7%) had at least 1 registered nurse (average 2.5 per practice, range 0–6). The ratio of patients with diabetes to registered nurse ranged from 42 to 405 across practices.

The proportions of patients at each practice with diabetes management tests completed and with values on target are shown in Table 2. Overall, blood pressure measurements were completed for 5645 patients (84.6%) (range 47.7%–96.6%). Management indicators with the greatest proportion of patients meeting recommended targets were HbA_{1c} (58.3% [range 44.6%–69.7%]) and low-density lipoprotein cholesterol (57.6% [range 32.3%–77.2%]).

Practices that had at least 1 registered nurse were more likely than those with no registered nurse to have patients with the following management indicators on target: blood pressure (odds ratio [OR] 1.51, 95% confidence interval [CI] 1.27–1.81), low-density lipoprotein cholesterol (OR 1.46, 95% CI 1.19–1.79), HbA_{1c} (OR 1.43, 95% CI 1.20–1.69) and fasting blood glucose (OR 1.35, 95% CI 1.08–1.68) (Table 3). These observed relations were independent of patient characteristics. In addition, practices with fewer patients with diabetes per registered nurse were associated with improved diabetes outcomes: a significantly greater proportion of patients in practices with fewer than 91 patients per registered nurse than in those with more than 310 patients per registered nurse met recommended targets for HbA_{1c} and fasting blood glucose ($p < 0.01$ and $p = 0.03$, respectively) (Table 4).

Interpretation

We found considerable variations across FHTs in the proportion of patients who had the recommended diabetes management tests completed and who met the recommended targets.

Table 2: Rates of completion of diabetes management tests and of on-target values

	Management indicator; no. (%) of patients									
	Hemoglobin A_{1c}		Fasting blood glucose		Blood pressure		Low-density lipoprotein cholesterol		Urine albumin:creatinine ratio	
Practice no.	Completed*	On target†	Completed*	On target†	Completed*	On target†	Completed*	On target†	Completed*	On target†
All (n = 6673)	4592 (68.8)	2676 (58.3)	3245 (48.6)	1524 (47.0)	5645 (84.6)	2109 (37.4)	3890 (58.3)	2240 (57.6)	2075 (31.1)	939 (45.2)
1 (n = 735)	592 (80.5)	340 (57.4)	353 (48.0)	164 (46.5)	710 (96.6)	225 (31.7)	478 (65.0)	251 (52.5)	329 (44.8)	156 (47.4)
2 (n = 295)	235 (79.7)	129 (54.9)	112 (38.0)	54 (48.2)	284 (96.3)	94 (33.1)	194 (65.8)	109 (56.2)	136 (46.1)	69 (50.7)
3 (n = 315)	274 (87.0)	154 (56.2)	252 (80.0)	112 (44.4)	284 (90.2)	124 (43.7)	235 (74.6)	131 (55.7)	156 (49.5)	82 (52.6)
4 (n = 208)	99 (47.6)	69 (69.7)	153 (73.6)	109 (71.2)	200 (96.2)	70 (35.0)	158 (76.0)	51 (32.3)	47 (22.6)	27 (57.4)
5 (n = 809)	96 (11.9)	47 (49.0)	84 (10.4)	35 (41.7)	671 (82.9)	215 (32.0)	77 (9.5)	36 (46.8)	29 (3.6)	19 (65.5)
6 (n = 392)	349 (89.0)	193 (55.3)	280 (71.4)	115 (41.1)	366 (93.4)	232 (63.4)	309 (78.8)	208 (67.3)	179 (45.7)	84 (46.9)
7 (n = 542)	432 (79.7)	267 (61.8)	241 (44.5)	109 (45.2)	409 (75.5)	192 (46.9)	334 (61.6)	223 (66.8)	164 (30.3)	56 (34.1)
8 (n = 832)	706 (84.9)	471 (66.7)	645 (77.5)	332 (51.5)	736 (88.5)	318 (43.2)	609 (73.2)	384 (63.1)	356 (42.8)	159 (44.7)
9 (n = 647)	375 (58.0)	197 (52.5)	406 (62.8)	208 (51.2)	475 (73.4)	128 (26.9)	373 (57.7)	168 (45.0)	188 (29.1)	52 (27.7)
10 (n = 191)	157 (82.2)	100 (63.7)	144 (75.4)	60 (41.7)	170 (89.0)	66 (38.8)	132 (69.1)	76 (57.6)	64 (33.5)	29 (45.3)
11 (n = 304)	213 (70.1)	95 (44.6)	198 (65.1)	71 (35.9)	201 (66.1)	92 (45.8)	204 (67.1)	116 (56.9)	105 (34.5)	51 (48.6)
12 (n = 170)	131 (77.1)	77 (58.8)	31 (18.2)	16 (51.6)	144 (84.7)	76 (52.8)	101 (59.4)	78 (77.2)	14 (8.2)	8 (57.1)
13 (n = 448)	326 (72.8)	150 (46.0)	109 (24.3)	34 (31.2)	377 (84.2)	69 (18.3)	179 (40.0)	73 (40.8)	71 (15.8)	31 (43.7)
14 (n = 504)	373 (74.0)	231 (61.9)	126 (25.0)	52 (41.3)	484 (96.0)	148 (30.6)	291 (57.7)	183 (62.9)	172 (34.1)	84 (48.8)
15 (n = 281)	234 (83.3)	156 (66.7)	111 (39.5)	53 (47.7)	134 (47.7)	60 (44.8)	216 (76.9)	153 (70.8)	65 (23.1)	32 (49.2)

*$p < 0.001$ for difference in proportion of patients who had test completed across practices (χ^2 test).
†$p < 0.001$ for difference in proportion of patients who had indicator value on target across practices (χ^2 test).

Table 3: Proportions of patients who met recommended targets for diabetes management indicators, by presence of registered nurse(s) at practice

Variable	Management indicator				
	Hemoglobin A_{1c}	Fasting blood glucose	Blood pressure	Low-density lipoprotein cholesterol	Urine albumin: creatinine ratio
No. of patients	2676	1524	2109	2240	939
≥ 1 registered nurse, no. (%) of patients					
Yes	2372 (88.6)	1378 (90.4)	1916 (90.8)	2036 (90.9)	826 (88.0)
No	304 (11.4)	146 (9.6)	193 (9.2)	204 (9.1)	113 (12.0)
OR (95% CI)	1.43 (1.20–1.69)	1.35 (1.08–1.68)	1.51 (1.27–1.81)	1.46 (1.19–1.79)	0.82 (0.62–1.07)
p value	≤ 0.001	< 0.01	≤ 0.001	≤ 0.001	0.2

Note: CI = confidence interval, OR = odds ratio.

Table 4: Proportions of patients within practices with at least 1 registered nurse who met recommended targets for diabetes management indicators, across quartiles of patients with diabetes per registered nurse

Variable	Management indicator				
	Hemoglobin A_{1c}	Fasting blood glucose	Blood pressure	Low-density lipoprotein cholesterol	Urine albumin: creatinine ratio
No. of patients	2372	1378	1916	2036	826
Patients per registered nurse, no. (%), quartile					
Q1: ≤ 90 patients	744 (31.4)*	346 (25.1)*	552 (28.8)	611 (30.0)	204 (24.7)
Q2: 91–152 patients	906 (38.2)	567 (41.1)	635 (33.1)	751 (36.9)	366 (44.3)
Q3: 153–310 patients	482 (20.3)	315 (22.9)*	282 (14.7)†	430 (21.1)*	153 (18.5)
Q4: ≥ 311 patients	240 (10.1)	150 (10.9)	447 (23.3)	244 (12.0)	103 (12.5)
F-test	4.02	2.94	9.27	2.95	2.46
p value	< 0.01	0.03	< 0.01	0.03	0.06

*$p < 0.05$ for difference with Q4 (analysis of variance).
†$p < 0.05$ for difference with all other quartiles (analysis of variance).

Across all practices, nearly half of patients who had the recommended diabetes management tests completed did not meet the recommended targets. The observed variability in the proportion of patients with diabetes measurements on target across FHT practices was associated with the presence of registered nurse providers.

The low proportions of patients with recommended diabetes management tests completed and values on target in our study are in keeping with the literature. A population-based study conducted in eastern Ontario that explored HbA_{1c} testing showed that 58% of people with diabetes received recommended HbA_{1c} testing and that less than 50% of those tested had HbA_{1c} levels on target.[25,26]

Nurses across all regulatory designations are extensively involved in activities related to chronic disease management.[10,11,27–35] Our finding of a positive relation between the presence of 1 or more registered nurses in FHTs and clinical outcomes of patients with diabetes is consistent with results of studies conducted in other countries.[13,36] Similar findings have also been reported outside of primary care and within other disciplines. In a systematic review in the United States, a greater number of registered nurses in acute care was significantly associated with reduced adverse events and shorter lengths of stay.[8] Smaller patient:physician ratios have also been associated with improved diabetic care.[12]

Limitations

The observed low rates of diabetes test completion may have been due to providers' incorrectly documenting or not documenting care in the patient's electronic medical record. Furthermore, we were unable to determine whether the low rates of test completion were the result of providers' not ordering tests or patients' deciding to not undergo recommended testing. In addition, the sample used in this study (15 FHT

practices) may not be representative of other FHTs in Ontario, and we were unable to determine how practices that participated in the survey differed from those that did not. Given that the unit of analysis in this study was the practice and was quite small, the number of covariates explored in the logistic regression models had to be carefully considered. Although patient characteristics that can affect the management of type 2 diabetes, such as age, sex and presence of additional chronic conditions, were explored as covariates in the logistic regression model, future, larger studies should examine whether other patient, provider and organizational variables affect the observed relations between FHT models incorporating registered nurse providers and patient outcomes. For instance, such provider variables as years of experience and such organizational variables as the presence of other health care providers (e.g., physicians, nurse practitioners) should be taken into consideration. Furthermore, our study was limited by having only 2 practices without registered nurses. As well, there was the risk for an inflated family-wise error rate, since each analysis was conducted using a significance level of $\alpha = 0.05$. Therefore, further investigation is required to better elucidate diabetes management in primary care practices with various levels of registered nurse support. Finally, unlike physicians, registered nurses do not have unique identification codes to use in electronic medical records, and therefore we were unable to determine whether patients had any direct contact with the various nursing providers included in the study (i.e., the specific roles of nurses could not be evaluated).

Conclusion

We used the CPCSSN to explore the relation between FHT practices employing registered nurse providers and indicators of type 2 diabetes management in Canada. Our study showed that it is feasible to link organizational data available at the practice level to patient data with the CPCSSN, which is organized at the site level. Importantly, the ability to explore relations between nurse staffing and diabetes management indicators using a large administrative database is a vital step toward showing nurses' added value within primary care in Canada. In particular, one direction for future research would be exploring how nursing roles and activities affect the management of type 2 diabetes within the primary care setting.

Our findings provide a foundation for further exploration of the effectiveness of the nursing role within primary care. Future studies should explore whether the observed relation between registered nurse presence and diabetic care is attenuated when organizational factors, including other members of the primary care team, are taken into consideration. It will also be important to conduct larger studies of a similar nature to better understand which attributes of different models of care best support the management of patients with chronic diseases, such as type 2 diabetes.

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