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The use of electronic consultations is associated with lower specialist referral rates: a cross-sectional study using population-based health administrative data

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Abstract

Background. The referral-consultation process can be difficult to navigate. Electronic consultations (eConsults) can help streamline referrals by facilitating inter-provider communication.
Objective. We evaluated the potential effect of eConsult on specialist referral rates in Ontario among family physicians providing comprehensive care.
Methods. We conducted a retrospective 1:3 matched cohort study examining total referrals and referrals to all available medical specialties from primary care providers between 1 April 2014 and 31 March 2015. We used multivariable random effects Poisson regression analysis to compare referral rates between eConsult and non-eConsult users while adjusting for relevant patient and provider characteristics. Referral rates were expressed per physician, per 100 patients and per 100 patient encounters.
Results. There were 113 197 referrals across all medical specialties made by 119 eConsult physicians and 352 matched controls. Referral rates per physician were significantly lower in the eConsult group for all specialty groupings [unadjusted rate ratio (RR) = 0.87, 95% confidence interval (CI) = 0.80–0.95; adjusted RR = 0.92, 95% CI = 0.85–1.00]. Referral rates per patient were lower among eConsult physicians (unadjusted RR = 0.91, 95% CI = 0.84–0.98) but this difference was not statistically significant after adjustment (adjusted RR = 0.96, 95% CI = 0.90–1.02). No statistically significant difference was observed when referrals were expressed per 100 patient encounters.
Conclusion. This is the first Canadian study to examine the potential effect of eConsult on overall referrals at a population level. Our findings demonstrate that using eConsult service is associated with fewer referrals from primary to specialist care, with considerable potential for cost savings to our single-payer system.

Key words: Access to care, consultation, primary care, quality of care, telemedicine.

Introduction

Referrals to specialists are a routine part of primary care and form an important part of patient care. However, the referral-consultation process is complex, inefficient and difficult to navigate and carries ample opportunities for errors or miscommunications that can result in lengthy wait times, unnecessary specialist appointments, duplicate testing, delayed diagnoses, inappropriate treatment and potential harm (1–3). Given these concerns, it is not surprising that the referral-consultation process has been a longstanding source of frustration for patients and providers (4,5).

Electronic consultation (eConsult) services can improve the referral-consultation process by facilitating direct, asynchronous communication between primary care providers (PCPs), including family physicians and nurse practitioners, and specialists. Implemented in several countries worldwide, eConsult services have been shown to reduce wait times, improve access to specialist advice and increase PCP and specialist satisfaction with the primary care–specialty care interface (6–8). In Canada, the Champlain BASE™ (Building Access to Specialists through eConsultation) service has demonstrated a positive impact on PCP referral behaviour, with two-thirds of cases resolved without the patient requiring a face-to-face specialist visit (9). However, eConsult's impact on overall referral patterns has not yet been studied at a population level. The objective of this study was to examine the association between the use of eConsult and PCP referral rates in Ontario, Canada's most populous province. We hypothesized that the use of eConsult by family physicians will result in a reduction in referral rates to specialist physicians.

Methods

Study design

We conducted a retrospective 1:3 matched cohort study using administrative health care data covering the period 1 April 2014 to 31 March 2015. Ethical approval was obtained from the Ottawa Hospital Research Ethics Board (Protocol #2009848-01H and #2013624-01H) and the Sunnybrook Health Sciences Centre Research Ethics Board.

Setting

The eConsult service is a secure, web-based application that provides quick access to specialist care for nonurgent cases (9–11). Providers are able to submit a patient-specific question to a specialty service and receive a response within 7 days, though the actual response time has averaged less than 2. The service was freely available to all PCPs in several regions across Ontario during the study period.

Data collection

Data for this study were obtained from two sources. First, we used the following databases housed at the Institute for Clinical Evaluative Sciences (ICES), a nonprofit research institute that houses Ontario's administrative health data using encoded identifiers: Registered Persons Database (demographic data for all residents eligible for provincial health care); Ontario Health Insurance Program (OHIP) billing claims system (for ~95% of physician services in Ontario); the Client Agency Program Enrolment Registry (CAPE; patient enrolment with individual primary care physicians); and the ICES Physician Database (physician demographic information, training and practice setting). We also used 2006 Statistics Canada Census data to assign income quintile to patients based on their postal code

Second, we used the Champlain BASE™ eConsult utilization data, which was routinely collected between 1 April 2014 and 31 March 2015. These data were transferred to ICES and linked to the administrative data using physicians' unique encoded identifiers (i.e. encrypted College of Physician and Surgeons of Ontario license number). All analyses were carried out at ICES.

Physician cohort creation

We used the ICES Physician Database to identify all active family physicians in Ontario (n = 13617) and excluded all physicians who (i) did not list their recorded specialty as 'General Practice/Family Practice', 'Family Practice with Emergency Medicine', or 'Community Medicine/Public Health'; (ii) exhibited extreme practice patterns (i.e. having worked <44 days and >260 days in a year or having billed for more than 100 individual patients in a day); (iii) did not provide comprehensive care (e.g. billed codes in fewer than seven primary care activity areas per year); or (iv) functioned as specialists in focused practices.

After applying the exclusion criteria, we defined two groups: (i) active eConsult users (n = 119), defined as those who completed their second eConsultation prior to 1 April 2014, which marked the beginning of the study period; and (ii) non-eConsult users (n = 8031). From all nonusers of eConsult service, we excluded those who had billed the Ontario fee code K738, which is for physician to physician eConsult (n = 468).

We created a control cohort of non-eConsult user physicians by matching one eConsult physician to three control physicians on characteristics previously shown to influence specialist referral rates, including sex, practice location rurality, location of training (Canada or foreign), primary practice model type (capitation: interdisciplinary, capitation: noninterdisciplinary, or fee for service) and patient panel size (12,13). Approximately, three quarters of Ontario residents are enrolled with family physicians practicing in one of several types of reimbursement and organizational practice models. Categories of these models in Ontario during the study period included: capitation: interdisciplinary (e.g. family health teams with allied health support), capitation: noninterdisciplinary (e.g. family health networks, family health organizations), fee for service (e.g. nonpatient enrolment model) and other. We used a percentage match macro (Greedy method) to match eConsult physicians with control physicians (14). Exact matches were produced for sex, rurality, foreign trained and primary practice model type; physicians were also matched on panel size within ±340 patients (14).

Patient rosters creation

We created annual patient rosters for each family physician in the two comparison cohorts. Panel size was determined using a standard method, which attributes patients to family physicians (15,16). Briefly, the CAPE database was used to identify all patients who were rostered to each physician. Patients not assigned to a physician were 'virtually' rostered to the family physician who billed the highest amount of core primary care codes for that patient. We excluded patients who were ineligible for OHIP at the start of each fiscal year, those with a postal code outside of Ontario and/or those with a date of last contact exceeding 9 years. Complete panels were used to calculate panel size for each physician.

Patient characteristics were ascertained at the end of each fiscal year. We used the Registered Persons Database to obtain patient age, sex and residential postal code. Based on postal code conversion, we assigned patients to income quintile (with lowest = 1, highest = 5) and rurality category based on the Rurality Index of Ontario scores,

which were urban (0–10), nonurban (10–39) and remote (40+). We assigned comorbidity using the Johns Hopkins Adjusted Clinical Groups Case-Mix Assignment software (Sun Microsystems Inc., Santa Clara, CA) by assigning from 0 up to 32 distinct aggregated diagnosis groups (ADGs), with a higher number of ADGs reflecting a higher level of diagnosed comorbidity (17). We used the OHIP database to determine the number of patient visits in the previous year.

Outcome measures

Our primary outcomes were the total number of referrals and the number of referrals to all medical specialties that were available via eConsult at the beginning of the study period. Referral rates were expressed per physician, per patient seen, and per patient encounter (to account for physician workload). Referrals were excluded if they were (i) sent to other family physicians (as opposed to specialists), (ii) initiated by a provider other than the patient's family physician, (iii) directed to a specialty that the family physician could not access via eConsult for at least 6 months prior to the referral (a list of specialties available at the beginning of the study period is presented in Appendix 1), or (iv) the patient encounter with the specialist was for follow-up appointments rather than initial referrals (identified by parsing patient histories for 2 years prior to the referral date). Multiple visits to the same specialist were counted as a single referral; visits to multiple specialists of the specialty type were counted as multiple referrals. Patients who did not visit their PCP during the study period were excluded.

Data analysis

Descriptive statistics were generated to describe patient and physician characteristics for the two comparison cohorts, as well as all non-eConsult physicians in Ontario. We compared the baseline distribution of characteristics between groups using standardized differences, with less than 0.1 indicating good balance between groups. We used multivariable random effects Poisson regression analysis to compare specialist referral rates between the two cohorts. The unit of analysis was the physician. The dependent variable was the total number of referrals for each physician over the study period. We conducted three separate analyses of referral rates using (i) no offset term, (ii) the natural log of the number of patients with at least one encounter in the study period as an offset term and (iii) the natural log of the total number of patient encounters during the study period as an offset term. Our primary independent variable, eConsult participation, was specified as a dichotomous variable (eConsult versus matched control non-eConsult user). By exponentiating the regression coefficient for eConsult participation, we obtained rate ratios (RR) together with 95% confidence intervals (CI) comparing referrals (i) per physician, (ii) per 100 patients and (iii) per 100 patient encounters between eConsult and matched control physicians. To account for matching, an indicator for each matched set was specified as a random effect. We also adjusted our model for aggregated patient characteristics (mean age, proportion of female patients, proportion of urban patients, mean number of ADGs) and provider characteristics (proportion of patients over age 65 and years of experience). We used SAS Version 9.4 (SAS Institute, Cary, NC) for all analyses.

Results

Our study included 119 eConsult physicians and 352 matched control non-eConsult Ontario physicians caring for almost half a million Ontario patients. Table 1 presents provider and patient characteristics for eConsult physicians, matched controls and all Ontario physicians not registered for the eConsult service. In general, matching by physician sex, rurality (urban, suburban, rural), foreign trained, primary practice model type and patient panel size produced comparable patient populations. In comparison with all Ontario family physicians, both eConsult and matched controls had higher proportions of female physicians and physicians practicing in the capitation interdisciplinary model. In contrast, the proportions of foreign-trained physicians, physicians practicing in fee-for-service model and suburban practices were lower among eConsult physicians. Furthermore, eConsult physicians and their matched controls had shorter mean years since graduation than all Ontario family physicians. The patient population of eConsult physicians and their matched controls were comparable.

A total of 113 197 referrals were completed during the study period across all medical specialties: 25 551 by eConsult physicians and 87 646 by non-eConsult physicians. Dermatology received the most referrals (11%), followed by general surgery (10%), obstetrics and gynaecology (9%), Gastroenterology (7%), and Otolaryngology (7%). eConsult physicians and non-eConsult physicians referred most frequently to the same specialties (Table 2).

The observed mean and standard deviation of numbers of referrals per physician, per patient, and per patient encounter for eConsult and matched control physicians are presented in Table 3. eConsult physicians had lower mean numbers of referrals compared with their matched physicians for all specialties including those not available via eConsult (214.71, SD = 121.95 versus 248.99, SD = 146.18) and for specialties available via eConsult (164.52, SD = 96.25 versus 189.97, SD = 113.4). A similar difference was observed when referrals were expressed per 100 patients seen by eConsult physicians versus matched controls for all specialties (32.11, SD = 10.68 versus 35.48, SD = 12.97) and for eConsult specialties (24.62, SD = 8.61 versus 27.16, SD = 10.64).

The results of the multivariable Poisson regression model, comparing referral rates between the eConsult physicians and matched controls before and after adjusting for patient and provider characteristics, are presented in Table 4. Before and after adjustment, referral rates for eConsult physicians were significantly lower than those for non-eConsult physicians (RR = 0.87, 95% CI = 0.80–0.95 and RR = 0.92, 95% CI = 0.85–1.00 respectively). Similarly, referral rates expressed per patient were lower among eConsult physicians (unadjusted RR = 0.91, 95% CI = 0.84–0.98); however, this difference was no longer statistically significant after adjusting for patient and provider characteristics (adjusted RR = 0.96, 95% CI = 0.90–1.02).We observed no statistically significant difference when referrals were expressed per 100 patient encounters. In all models, female sex and higher number of ADGs were associated with higher referrals, while proportion of older patients (those over 65 years) was associated with lower rates of referrals.

Discussion

This is the first Canadian study to examine the potential effect of eConsult on overall referrals on a population basis, by directly comparing referrals by eConsult physicians with those of a matched control cohort using health administrative data. eConsult physicians had consistently lower mean number of referrals in comparison with their matched controls, even after adjusting for patient characteristics previously reported to affect referral rates. This finding suggests the potential for considerable cost savings. Even a 4% reduction in referral rates (half of what we observed in our study) would be significant

Table 1. Provider- and patient-level characteristics for eConsult exposure

Characteristics	All Ontario *n* = 8485	eConsult physicians *n* = 119	Matched control physicians *n* = 352	Standardized difference[a]
Provider level				
Female (*n*, %)	3709 (44.1)	88 (73.95)	259 (73.58)	0.01
Years since graduation (mean, SD)	25.21 (12.33)	18.21 (10.17)	21.53 (12.12)	0.3
Foreign trained (*n*, %)	2583 (30.71)	10 (8.4)	30 (8.52)	0.00
Model type (*n*, %)				
Capitation: interdisciplinary	2208 (26.25)	64 (53.78)	192 (54.55)	0.02
Capitation: noninterdisciplinary	2446 (29.08)	36 (30.25)	103 (29.26)	0.02
Fee for service	3705 (44.05)	19 (15.97)	57 (16.19)	0.01
Other	52 (0.62)	NA	NA	NA
Rurality (*n*, %)				
40+	507 (6.03)	13 (10.92)	34 (9.66)	0.04
10–39	1349 (16.04)	7 (5.88)	21 (5.97)	0.00
<10	6555 (77.93)	99 (83.19)	297 (84.38)	0.03
Years registered for eConsult (mean, SD)	NA	1.58 (0.8)	NA	NA
Number of patients in roster	1374.65 (783.92)	1034.19 (448.42)	1026.99 (444.7)	0.02
Patient level	*n* = 11 608 401	*n* = 123 069	*n* = 361 501	
Female (*n*, %)	6 033 708 (51.98)	68 825 (55.92)	209 765 (58.03)	0.04
Age in years (mean, SD)	41.69 (22.56)	40.04 (22.51)	42.18 (22.89)	0.09
Age category (*n*, %)				
0–17	2 041 674 (17.59)	24 072 (19.56)	63 970 (17.7)	0.05
18–25	1 203 753 (10.37)	12 828 (10.42)	35 928 (9.94)	0.02
26–40	2 264 303 (19.51)	24 865 (20.2)	68 335 (18.9)	0.03
41–65	4 218 561 (36.34)	43 636 (35.46)	131 263 (36.31)	0.02
66+	1 880 110 (16.2)	17 668 (14.36)	62 005 (17.15)	0.08
Income quintile (*n*, %)				
1	2 093 004 (18.03)	15 301 (12.43)	57 380 (15.87)	0.10
2	2 218 492 (19.11)	21 325 (17.33)	65 907 (18.23)	0.02
3	2 335 620 (20.12)	24 394 (19.82)	69 618 (19.26)	0.01
4	2 505 258 (21.58)	29 304 (23.81)	79 938 (22.11)	0.04
5	2 348 462 (20.23)	31 910 (25.93)	85 330 (23.6)	0.05
Missing	107 565 (0.93)	835 (0.68)	3328 (0.92)	0.03
Rurality (*n*, %)				
40+	8 532 662 (73.50)	93 634 (76.08)	271 983 (75.24)	0.07
10–39	2 201 447 (18.96)	12 470 (10.13)	46 268 (12.8)	0.08
<10	735 400 (6.34)	16 114 (13.09)	38 623 (10.68)	0.02
Missing	138 892 (1.2)	851 (0.69)	4627 (1.28)	0.06
Number of ADGs in 1 year prior to cohort entry (mean, SD)	5.06 (3.5)	4.82 (3.41)	5.01 (3.49)	0.05
Number of primary care visits in 1 year prior to cohort entry (mean, SD)	2.66 (3.85)	2.19 (3.01)	2.33 (3.28)	0.05

ADGs, aggregated diagnosis groups; NA, not applicable.

[a]Standardized difference is reported for the comparison between the eConsult physicians and their patients compared to the matched control group physicians and their patients.

on a population level in Ontario, representing an estimated annual total of 13 682 fewer referrals, which, assuming an average cost of $150 for a face-to-face visit (18), translates to a potential cost savings of $2 052 300 per year. These savings are likely even greater after including other costs frequently incurred during or following a typical referral (e.g. patient travel costs, time off work, repeat/duplication of diagnostic testing, follow-up specialist visits) (19).

There are several reasons why using eConsult could lower referral rates. First, participating providers consistently report that the specialist response often enabled them to manage the patient without sending them for a face-to-face specialist visit in two-thirds of cases (9,20). These rates compare favourably to other eConsult systems reported in the literature, where the resolution rates without a visit have been reported to range from 19% to 68% (6,7,21). Second, providers report high levels of satisfaction with the Champlain BASE™ eConsult service, citing its speed, the greater confidence it gave them when treating patients, and its educational benefits, which could guide their delivery of future patient care (20). The latter findings are in line with previous reports demonstrating that knowledge-sharing methods employed by the newer models of specialty consultation such as eConsult systems may increase PCPs' ability to manage common specialty problems over time (6,7,22). Oliveira and colleagues provided direct evidence that participation of GPs in teleconsultations, which provide opportunities for continuing education and are a form of interactive case-based learning, are associated with overall reductions in referral rates and the associated variability observed among GPs (23). Similarly, Evans *et al.* demonstrated that an intervention involving an educational approach decreased actual referral rates and the variation in referral rates, while improving quality as judged by the participating GPs (24).

Studying referral patterns in primary care is challenging and there is wide variability in methodology, reported rates and potential confounding factors (12,25,26). Physician referral decisions are often

Table 2. Distribution of specialist referrals (overall and by eConsult exposure)

Specialty group	eConsult physicians	Match control physicians	Overall
	% (*n*)	% (*n*)	% (*n*)
Dermatology	9.6 (2452)[3]	10.7 (9379)[1]	10.5 (11831)[1]
General surgery	10.2 (2602)[2]	10.1 (8885)[2]	10.1 (11487)[2]
Obstetrics and gynaecology	10.4 (2652)[1]	9.0 (7927)[3]	9.3 (10579)[3]
Gastroenterology	8.2 (2094)[4]	7.1 (6188)[5]	7.3 (8282)[4]
Otolaryngology	6.7 (1701)[5]	7.4 (6471)[4]	7.2 (8172)[5]
Orthopaedic surgery	5.1 (1300)	6.1 (5386)	5.9 (6686)
Cardiology	4.5 (1149)	5.1 (4448)	4.9 (5597)
Internal medicine	5.2 (1334)	4.1 (3636)	4.4 (4970)
Urology	3.5 (903)	4.2 (3666)	4.0 (4569)
Neurology	3.0 (756)	3.8 (3351)	3.6 (4107)
Plastic surgery	2.6 (665)	3.2 (2799)	3.1 (3464)
Psychiatry	2.6 (657)	3.0 (2669)	2.9 (3326)
Respiratory	3.7 (933)	2.7 (2324)	2.9 (3257)
Ophthalmology	2.6 (660)	2.7 (2324)	2.6 (2984)
Unknown	3.6 (919)	2.3 (2045)	2.6 (2964)
Paediatrics	2.6 (660)	2.6 (2288)	2.6 (2948)
Physical medicine	2.6 (670)	2.0 (1768)	2.2 (2438)
Rheumatology	1.5 (392)	2.3 (2041)	2.1 (2433)
Clinical immunology	1.2 (298)	2.0 (1786)	1.8 (2084)
Endocrinology	1.4 (355)	1.7 (1475)	1.6 (1830)
Haematology	2.0 (512)	0.9 (754)	1.1 (1266)
Paediatric clinical immunology	1.8 (471)	0.8 (672)	1.0 (1143)
Vascular surgery	0.6 (157)	0.8 (689)	0.7 (846)
Nephrology	0.8 (206)	0.7 (622)	0.7 (828)
Anaesthesiology	1.0 (261)	0.5 (472)	0.6 (733)
Geriatric medicine	0.3 (68)	0.7 (595)	0.6 (663)
Neurosurgery	0.4 (94)	0.5 (437)	0.5 (531)
Diagnostic radiology	0.5 (123)	0.4 (348)	0.4 (471)
Infectious diseases	0.3 (87)	0.4 (368)	0.4 (455)
Thoracic surgery	0.3 (66)	0.4 (317)	0.3 (383)
Critical care	0 (0)	0.3 (290)	0.3 (290)
Paediatric cardiology	0.4 (95)	0.2 (159)	0.2 (254)
Medical oncology	0.1 (21)	0.2 (196)	0.2 (217)
Medical genetics	0.1 (23)	0.1 (105)	0.1 (128)
Paediatric neurology	0.2 (39)	0.1 (85)	0.1 (124)
Paediatric gastroenterology	0.2 (61)	0.1 (62)	0.1 (123)
Cardiac surgery	0 (8)	0.1 (99)	0.1 (107)

Only specialties with more than 100 referrals are shown. The superscript numbers indicate the rank order of number of referrals.

Table 3. Observed mean number of referrals per physician, per patient seen and per patient encounter for eConsult and matched control physicians

	eConsult physicians (*n* = 119)	Matched control physicians (*n* = 352)
Number of referrals per physician (mean, SD)		
All specialties	214.71 (121.95)	248.99 (146.18)
Specialties available on eConsult at the beginning of the study	164.52 (96.25)	189.97 (113.4)
Number of referrals per 100 patients seen		
All specialties	32.11 (10.68)	35.48 (12.97)
Specialties available on eConsult at the beginning of the study	24.62 (8.61)	27.16 (10.64)
Number of referrals per 100 patient encounters		
All specialties	12.00 (4.21)	12.21 (4.74)
Specialties available on eConsult at the beginning of the study	9.23 (3.46)	9.36 (3.91)

List of specialties available on eConsult at the beginning of the study available in Appendix 1.

influenced by a complex and unique mix of factors at the patient, physician and system level (12,25). Many studies of referral rates include small data sets collected over brief periods, making them susceptible to the effect of random variation due to chance, which has been shown to explain as much as 15% of the observed variation in the case of 24-fold difference in referral rates amongst 201 GPs (26).

Table 4. Unadjusted and adjusted rate ratios of physician referral rates by eConsult status

	Unadjusted			Adjusted[a]		
	RR	95% CIs	*P* Value	RR	95% CIs	*P* Value
Model 1: referral rate per physician (no offset term)						
eConsult versus control physician	0.874	0.802–0.952	0.002	0.922	0.852–0.998	0.045
Aggregate patient characteristics						
Mean age				1.025	1.008–1.042	0.004
Proportion females				1.589	1.003–2.516	0.049
Proportion urban				1.206	0.940–1.546	0.142
Mean number of ADGs				1.308	1.221–1.402	<.0001
Aggregate provider characteristics						
Proportion of patients over 65 years				0.214	0.075–0.615	0.005
Years of experience				1.000	0.996–1.004	0.907
Model 2: referral rate per patients seen by physician (the natural log of the number of patients with at least one encounter in the study period as an offset term)						
eConsult versus control physician	0.906	0.838–0.979	0.013	0.957	0.899–1.019	0.175
Aggregate patient characteristics						
Mean age				1.023	1.011–1.036	0.0003
Proportion females				1.735	1.339–2.249	<0.001
Proportion urban				1.287	1.169–1.417	<0.001
Mean number of ADGs				1.305	1.241–1.372	<0.001
Aggregate provider characteristics						
Proportion of patients over 65 years				0.191	0.087–0.420	<0.001
Years of experience				1.001	0.9698–1.003	0.6572
Model 3: referral rate per 100 patient visits (the natural log of the total number of patient encounters during the study period as an offset term)						
eConsult versus control physician	0.995	0.922–1.073	0.899	1.024	0.957–1.096	0.496
Aggregate patient characteristics						
Mean age				1.030	1.015–1.044	<0.001
Proportion females				2.107	1.554–2.859	<0.001
Proportion urban				1.342	1.190–1.513	<0.001
Mean number of ADGs				1.188	1.123–1.256	<0.001
Aggregate provider characteristics						
Proportion of patients over 65 years				0.128	0.054–0.306	<0.001
Years of experience				0.997	0.994–1.001	0.1099

ADGs, aggregated diagnosis groups.

[a]All regression models were adjusted for aggregate patient characteristics for the patients attributed to and seen by the primary care physician during the study period (contribute to the denominator).

To account for some of these complexities, we analysed referrals between eConsult and non-eConsult users in three ways: per physician, per patient seen and per patient encounter, while adjusting for relevant patient and provider characteristics. Considering that eConsult is an intervention directed at changing physician referral behaviour, comparing referral rates at the physician level was of particular importance. While analysis of referral rates by physician and per 100 patients revealed that eConsult physicians were significantly less likely to refer than their matched non-eConsult controls, no difference was observed when referral rates were analysed per 100 encounters. We used the latter approach to account for individual physician workload, as it has previously identified markedly different groups of high-referring physicians (27). In our study, the overall rates of referral were lower than the reported literature for both eConsult and non-eConsult physicians, which may account for the lack of observable difference between groups. Another possibility is that some patients in the eConsult scheduled follow-up visits with their PCPs to discuss the specialist's advice, resulting in more encounters per patient in the eConsult group. This issue requires future study.

Our study relied on health administrative databases, which have certain limitations, such as capturing about 95% outpatient physician encounters (28). We used claims for specialist's visits as a proxy for referrals from primary care. Health administrative databases contain no referral data for salaried primary care physicians working in community health centres and no referral data for nurse practitioners (PCPs who do refer to specialty care), which limits the generalizability of our study. At the time of our study, nurse practitioners represented 19% of eConsult users in our region. This could have important implications for our observed referral rates in the study since past research has shown that primary care model is significantly associated with referral rate (13,29). Our decision to exclude physicians who work <44 days and >260 days in a year, while made to avoid capturing physicians who do not practice family medicine, may have also excluded some family doctors with atypical practices. When comparing referral rates based on location of physician training, we distinguished only between those trained internationally. We were unable to distinguish between PCPs trained in different countries outside Canada, who may have different referral patterns between one another. We also note that our study was not designed to look at the long-term effects of eConsult and that we cannot exclude the possibility that other unmeasured factors, including random variation, confounded the relationship between referral rates and use of eConsult service. Despite our efforts to match the groups on characteristics known to affect referral rates, the likelihood of a difference in provider practice patterns between the eConsult physicians, who self-selected to use this service, and the control group

physicians must be acknowledged. Finally, we acknowledge the fact that we may not have adjusted for all possible confounders and hence any interpretation of differences between groups should take into account the limitations in the ability to draw causal inferences.

Our results are very encouraging but highlight a need for more research to establish a direct association between eConsult participation and reduced referral rates. Similarly, whether the trends that we observed reflect a change in the appropriateness of referrals amongst the eConsult users requires further investigation. Although administrative data have been used extensively to determine population-level primary care performance, they do not allow evaluation of the appropriateness of any one specific referral, but rather can provide the detail needed to describe the overall picture of the referral patterns. In fact, no guidance exists on how to optimally define and study the appropriateness of referrals (30). In an in-depth discussion of referral process by Davies *et al*., the authors emphasize that no one knows what the right referral rates would be for any given specialty area and there is no agreement about the criteria that could be used to define what it should be (31).

Conclusion

Our findings demonstrate that using eConsult service is associated with fewer referrals from primary to specialist care, with considerable potential for cost savings to our single-payer system. Given the challenging and imperfect nature of studying referral patterns in primary care, we highlight a need for more research to establish a direct association between eConsult participation and reduced referral rates.

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Appendix 1

List of specialties available at the beginning of the study period

1. Anaesthesiology
2. Cardiology
3. Dermatology
4. Endocrinology
   a. Paediatric Endocrinology
5. Otolaryngology
6. Gastroenterology
   a. Paediatric Gastroenterology
7. Medical Genetics
8. Haematology
9. Infectious Diseases
   a. Clinical Immunology
   b. Paediatric Clinical Immunology
   c. Paediatric Infectious Diseases
10. Internal Medicine
11. Nephrology
   a. Paediatric Nephrology
12. Neurology
13. Obstetrics and Gynaecology
14. Orthopaedic Surgery
15. Psychiatry
16. Respirology
17. Rheumatology
   a. Paediatric Rheumatology
18. Urology
19. Paediatric Cardiology
20. Paediatrics
21. Paediatric Haematology/Oncology
22. Paediatric Neurology
23. Paediatric Respirology
24. Diagnostic Radiology