Evaluation of Health Links on health services utilization in the Central Ontario health region: a propensity-matched difference-in-differences study

(Short title: Health services utilization following Ontario's Health Links)

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ABSTRACT

BACKGROUND: Health Links are a new model of providing care coordination for high-cost, high-needs patients in Ontario, Canada. We evaluated (hospital-related) utilization outcomes among Health Links patients in the Central Local Health Integration Network (LHIN) of Ontario, in the 1-year pre- vs. post-program enrolment and compared to similar complex comparators.

METHODS: We identified all patients who received a Health Links coordinated care plan before January 1, 2015 using linked registry and health administrative data. Propensity scores were used to match (1:1) enrollees (registry) with comparators (administrative data). Five measures of Health Link performance were evaluated – rates of hospitalization, emergency department visits, days in acute care, 30-day readmissions and 7-day post-discharge primary care follow-up – using a difference-in-differences approach with generalized estimating equations.

RESULTS: We matched 313 enrollees (of 344 in the registry, 91%) to comparators. All measured socio-demographic and health utilization characteristics were balanced between groups (all standardized differences < 0.10). For enrollees, the rate of days in acute care (per person-year) increased by 35% (IRR=1.35, CI: 1.11-1.65) post- vs. pre-index, but differences were non-significant for all other measures. Difference-in-differences analyses revealed greater reductions in hospitalization, ED visits and acute care days among comparators post-index, relative to enrollees.

INTERPRETATION: Initial implementation of the Health Links program in the Central LHIN did not reduce select indicators of Health Link performance among enrollees. As the Health Links program evolves and standardization is implemented, future research may reveal effects from the Health Links initiative in other outcomes or with additional follow-up time.

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INTRODUCTION

Multiple studies have shown that utilization of healthcare resources is highly concentrated among a small number of patients. Data from Canada suggest that high-cost users (the top 5% of the population) account for two-thirds of annual healthcare spending (1), including 29% of payments for physician services (2) and 61% of hospital and home care costs (3). Similar findings have been reported in the United States (4-6). With limited healthcare resources available, transforming the delivery of healthcare services to better meet the needs of the most complex patients is required for health system sustainability.

In response, Ontario's Ministry of Health and Long-Term Care (MOHLTC) launched Health Links, an ambitious strategy aimed to better provide coordinated, community-based healthcare for patients with complex health and social needs (7). The program started with 26 early adopter Health Links in December 2012, and 82 were in operation throughout the province by the end of 2015 (8). Each Health Link is voluntary and operates under a low-rules approach (9,10), having the flexibility to determine how coordinated care will be delivered within regional contexts. Patients are typically referred into Health Links during a presentation to the healthcare system, based on (any of) being high-risk of inpatient admission or readmission, having multiple inpatient and/or emergency visits in the past year, having multiple coexisting chronic conditions (11) or socioeconomic challenges (such as low income or lack of social support). Once enrolled, patients are provided with intensive care coordination including multidisciplinary care, and a patient-centered coordinated care plan is completed that outlines the patient's needs, goals, providers, treatments and appointments. These processes aim to engage patients and their care providers to ensure the plan is being followed, ensure patients are taking the right medications, and ensure patients have a care provider they can call who knows them (7), all with the aims of improving access to care, reducing wait times and preventing unnecessary hospital and emergency visits (12).

We implemented a quasi-experimental propensity-matched cohort difference-in-differences analysis of patients enrolled in three Health Links from one health region to determine: 1) whether enrolment in Health Links is associated with differences in healthcare utilization among enrollees after

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(vs. prior to) program enrolment, and 2) how the (pre-post) difference in utilization patterns among enrolled patients compares to trends among similarly complex patients who were not enrolled.

METHODS

Setting

Residents of Ontario, Canada have publicly-funded universal health insurance that covers costs of medically necessary care. Patient encounters with the healthcare system are recorded in health administrative datasets. The administration and coordination of local healthcare in the province is divided into 14 geographically defined health regions (Local Health Integration Networks). The Central health region (Central LHIN) was used for this analysis because they had three Health Links operating prior to 2015 and a single complete patient registry with one data custodian (Central Community Care Access Centre, CCAC) who could provide permission for linkage to health administrative data. The Central LHIN comprises sections of Toronto, Etobicoke, York Region and South Simcoe and is home to 1.8 million residents.

Data

A registry of Health Links candidates was obtained from the Central CCAC that included information collected on eligible patients from August 2013 through May 2016 recorded in the Client Health and Related Information System. This web-based platform is used by frontline care providers to access information on patients and their care plan. Coverage of the number of care plans completed in the registry for the Central LHIN is comparable to data reported elsewhere (13). The registry was transferred to the Institute for Clinical Evaluative Sciences and linked deterministically to population-based health administrative data at the individual level using unique, encoded identifiers (Appendix 1). We limited our evaluation to Health Link enrolment up to December 31, 2014 to facilitate 1-year pre-post analysis with complete administrative data, thereby assessing the early stages of the Health Links program. The Research Ethics Board of the Sunnybrook Health Sciences Centre approved the study.

Population

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From the registry, we identified all patients (enrollees) with a care plan completed (index date) on or before December 31, 2014. This signified the start of Health Link care. We excluded enrollees who had missing demographic information, were enrolled in a Health Link outside of the Central LHIN or refused/declined to participate. For enrollees with multiple entries in the registry, we selected the earliest record. Among eligible enrollees, index dates ranged from May 2013 to December 2014.

To create a comparator population pool (individuals that did not receive Health Links care), all Ontarians in the Registered Persons Database were randomly assigned an index date based on the distribution of index dates among eligible enrollees. We included individuals into the full comparator pool if they had complete socio-demographic information, were alive at index, were eligible for healthcare coverage, were within the age range of selected enrollees, were affiliated with one of the Central LHIN's Health Link catchment areas, and were not among individuals identified in the registry. We then included only complex, high needs patients (11), defined as having an active diagnosis (within 1-year of index) of 4 or more conditions (of a list of 55 conditions defined by the MOHLTC to define the Health Links target population) (Appendix 2).

Baseline Covariates

For eligible enrollees and the full comparator population pool, we identified baseline covariates (at index) including: age, sex, rurality (using the Rurality Index of Ontario) (14), neighbourhood-level income quintile, and primary care model affiliation (Family Health Team; Group; Organization; other model: or no model) (15,16). Comorbidity was measured using the Collapsed Adjusted Clinical Groups (Johns Hopkins ACG Software, v10) with 1-year retrospective data. Health system utilization 1-year prior to index included the number of oncology, dialysis, primary care and specialist visits, home care services and mental health inpatient episodes. The number of emergency department (ED) and acute care admissions were identified within each quarter prior to index (i.e., 1-3, 4-6, 7-9, and 10-12 months prior).

Propensity-Matched Cohort

A propensity score for the probability of enrolment into Health Links was established for the study population (enrollees and comparator population pool). The final logistic regression model included

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all identified baseline covariates. Continuous health system utilization variables were transformed using a square-root term, and 2-way interactions were included between all healthcare utilization variables.

We created a propensity-matched cohort by using the nearest-neighbour greedy algorithm to match enrollees with a comparator (1:1, without replacement). Enrollee-comparator pairs were matched on the logit of their propensity score (within 0.10 standard deviations) and on their index date (within 90 days). Covariate balance between selected enrollees and comparators was assessed using standardized differences (SDiff). A SDiff≥0.10 indicates imbalance (17). To assess potential selection biases, we assessed SDiffs between matched enrollees and comparators in several additional baseline measures not included in the propensity model, including: 1) receipt of palliative care (outpatient or inpatient setting) prior to index, and 2) the number of oncology, dialysis, primary care and specialist visits, home care services and mental health inpatient episodes within each quarter prior to index. We also compared 3) mortality in the 1-year post-index period and assessed selection bias by 4) comparing SDiffs in baseline covariates between enrollees matched vs. not matched for study inclusion.

Outcome Measures

Outcome measures included rates of acute hospitalizations, ED visits, days in acute care, 30-day hospital readmissions, and primary care follow-up within 7-days of discharge. Full definitions are provided in Appendix 3. These measures were selected a priori to reflect key performance markers for Health Links that are measurable with available administrative data (8,18). Each indicator was measured 1-year prior to index, and again 1-year after index (or to death).

Statistical Analyses: Difference-in-Differences Estimation

Comparative effectiveness evaluation was performed on each measure using difference-in-differences approach with generalized estimating equations and robust error variances on individual-level data. Acute hospitalizations, ED visits, and days in acute care were modeled with a negative binomial distribution and log link, including a log of person-years offset term to account for differences in the follow-up period due to deaths. For the post-discharge readmissions and primary care follow-up measures, we modeled the number of events (readmitted or received follow-up) specifying a Poisson

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distribution with the total number of hospitalizations (per person, pre and post) as an offset term in the model. Each regression model included binary variables for enrolment status (enrollee or comparator), time period (pre- or post-index) and a two-way interaction term between these variables, the difference-in-differences estimator. As such, pre-post differences among enrollees (objective 1) and difference-in-differences (objective 2) were obtained from the same regression model. All models used an unstructured correlation structure to control for repeated measurements within individuals.

RESULTS

A total of 344 enrollees and 34,816 comparators were candidates for propensity matching (Figure 1). From the full comparator pool, a match was found for 313 Health Link enrollees for analyses (91% of eligible candidates). Table 1 shows SDiffs in baseline characteristics of enrollees and comparators, before and after matching. Post-matching, all covariates included in the propensity model were balanced between groups (SDiffs<0.10). Mean age of selected enrollees was 75.6 years (range=23-98), 40% were male, and the mean RIO was 6.4 indicating a predominantly urban residence. More than 95% of enrollees (and matched comparators) had acute minor, acute major and chronic medical unstable diagnoses. Enrollees were frequent health system users, particularly in the home care sector.

As robustness checks, matched enrollee and comparator groups were balanced pre-index in palliative care use (enrollees=10.2%, comparators =11.5%, SDiff=0.041), and nearly all continuous health system indicators measured quarterly (exception: mean mental health admissions 7-9 months prior to index, SDiff=0.102). Post-index, 1-year mortality was comparable between groups (enrollees=26.5%, comparators=24.9%, SDiff=0.037). Appendix 4 compares differences between matched vs. unmatched enrollees. Comorbidity and prior utilization across all sectors were higher (SDiff>0.10) among enrollees where no comparator match was found (n=31).

Table 2 shows results from the regression models. Among Health Link enrollees, there were no statistically significant reductions in any of the indicators post- vs. pre-index. For example, acute hospitalization rate changed from 2.26 to 2.07 per person-year, but not to a statistically significant degree

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(incidence rate ratio (IRR) = 0.91, 95% confidence interval (CI): 0.79-1.05). Days in acute care (per person-year), by contrast, increased from 18.4 to 24.9 (IRR=1.35, CI: 1.11-1.65).

Difference-in-differences estimators were significant for hospitalizations (IRR=1.74, CI: 1.40-2.17), ED visits (IRR=1.61, CI: 1.18-2.20) and days in acute care (IRR=1.51, CI: 1.06-2.15), indicating greater reductions in these outcomes in the comparator population post- vs. pre-index, relative to the difference among enrollees. No statistically significant difference-in-differences were detected for readmissions or post-discharge physician follow-up. Visual inspection of longitudinal plots confirmed parallel trends (Appendix 5), validating the difference-in-differences estimations.

INTERPRETATION

We found that hospital-related utilization patterns were comparable after (vs. before) enrolment for the initial patients enrolled in the Central LHIN's 3 'early adopter' Health Links, except for average days in acute care, which increased. In contrast, trends among high-user comparators from the same jurisdiction (selected from health administrative data and matched on socio-demographics, comorbidities, and health system utilization) decreased for inpatient stays, ED visits and acute care days, relative to enrollees.

Health Links started in late 2012 using a low-rules bottom-up approach. Possible explanations for the non-significant pre-post differences among enrollees that we observed are that the delivery of coordinated care by Health Links may have been poorly defined within local contexts at program onset. Optimal practices in the provision of coordinated care, improving access to primary care services, and improving patient engagement have since been recognized and encouraged throughout operating Health Links (8). At onset the Central LHIN Health Links care providers were referring only their most complex cases for the intervention (Bowman J, North York General Hospital. Personal communication. 18 August 2016); complex but medically-stable patients were ruled out. This is supported in the enrollees' healthcare utilization patterns in our data, and their high 1-year mortality relative to previous reports of Ontario's high-cost population (19). Moreover, the observed rates of acute care days among the enrollees may be driven in part by this high mortality, because hospital use increases sharply at the end of life (20). For

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enrollees, one immediate marker for benchmarking is timely post-discharge follow-up, as our data show that <40% of enrollee discharges had a primary care physician visit within 7 days. In contrast, differential patterns observed amongst comparators may be due to other unmeasured factors such as availability of home support networks, social determinants of health beyond income, or unmet healthcare needs. As such, residual confounding is probable, contributing to the significant difference-in-differences estimation. However, the 'regression to the mean' observed in the comparator group is somewhat expected because only one-third of high-cost users remain high-cost in subsequent years (19,21). Similar trends have also been observed in studies evaluating interventions among high-user chronic patients (22,23).

Improved integration takes many forms (24) and is targeted towards varying patient populations which limits comparability across studies. Our findings are consistent with a recently published quasi-experimental study from the United Kingdom that found modest increases in hospital admissions and readmissions among at-risk patients who received multidisciplinary team case management (25). A randomized controlled trial of guided care teams for multimorbid older adults in the United States showed no reductions in hospital or ED use during the 20 months after receiving initial care (26). In Quebec, Canada, health services utilization was comparable between older frail adults assigned to the PRISMA community-based care model, relative to comparators, 1-year after intervention; trends in ED visits were lower in the experimental group only after 4-years of follow-up (27). Evaluation of the preliminary stages of the Health Links initiative within other jurisdictions and province-wide are forthcoming. Importantly, the results presented here are from one region of Ontario where each active Health Link (n=3) was led by an acute hospital. Provincially, Health Links are led by various organizations including hospitals, Family Health Teams, Community Care Access Centres, Community Health Centres, or community support agencies in single- or co-leadership models (10,28) and have adopted different strategies in terms of governance structure, leadership, and approach to integration (29). The method that Health Links use to identify their target population varies and has evolved over time to a more standardized approach following further guidance from the MOHLTC (8). The effectiveness of varying models of Health Links

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has yet to be explored and will require a provincial patient registry and further data collection from Health Link organizations.

Limitations:

Several important limitations of this work are notable. Our analysis was limited to hospital-related outcomes using available administrative data. Other measures specific to coordinated care, such as patient experience and system access are important but could not be measured. Likewise, we were unable to quantify changes in total healthcare costs pre- vs. post-index due to data availability. Our analysis was limited to 313 enrollees receiving care within 1 (of 14) LHIN with 3 Health Links in operation. This limits our generalizability, particularly given the flexible nature of the intervention across provincial jurisdictions. Selection bias cannot be ruled out as 31 HL enrollees (9%) who had higher pre-enrolment healthcare utilization and greater chronic morbidity went unmatched. Our models therefore underestimate the pre-index enrollee means in measured outcomes, and potentially also under-estimate the full effect of Health Links on the highest-risk group of patients (i.e., more modest reductions may not be detected). Lastly, residual confounding in the selection of matched comparators is possible, despite several robustness checks.

Conclusion:

In conclusion, utilization patterns of hospital-related care did not decrease among the first enrollees to Health Links in Ontario's Central LHIN. However, this analysis is restricted to enrolment prior to January 2015, and as the Health Links program has evolved it is possible that improvements to health system outcomes may become evident. Additional research is therefore needed to confirm these findings in other jurisdictions of Ontario with additional follow-up data, as well as to quantify additional measures of patient experience.

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LIST OF ABBREVIATIONS:

CCAC – Community Care Access Centre;

CI – confidence interval;

ED – emergency department;

IRR – incidence rate ratio;

LHIN – Local Health Integration Networks;

MOHLTC – Ontario's Ministry of Health and Long-Term Care;

SDiff – standardized difference

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AUTHOR CONTRIBUTIONS:

All of the authors were involved in the conception and design of the study. Yu Qing Bai and Kevin Walker prepared the analytical plan. Luke Mondor was responsible for data preparation and statistical analysis, and prepared the initial draft of the manuscript. Walter P Wodchis guided data acquisition and was the primary investigator of the study, responsible for project oversight. All of the authors revised the manuscript critically for important intellectual content. All of the authors have reviewed the article and approved the final version for publication.

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DISCLAIMER:

The authors declare that no competing interests exist.

DATA AVAILABILITY:

The data set from this study is held securely in coded form at the Institute for Clinical Evaluative Sciences (ICES). While data sharing agreements prohibit ICES from making the data set publicly available, access may be granted to those who meet pre-specified criteria for confidential access, available at www.ices.on.ca/DAS.

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FIGURE (CAPTIONS AND FOOTNOTES) AND TABLES:

Figure 1: Study flow diagram

Insert Figure 1 here

Notes:

Abbreviations: LHIN = Local Health Integration Network; RPDB = Registered Persons Database; CCP = Coordinated Care Plan; HL = Health Link; SD = Standard Deviation

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Table 1: Comparison of characteristics of Health Link enrollees and comparators, before and after matching.

	BEFORE MATCHING			AFTER MATCHING		
	ALL ENROLLEES	FULL COMPARATOR POOL	SDiff	SELECTED ENROLLEES	SELECTED COMPARATORS	SDiff
	N=344	N=34,820		N=313	N=313	
Age at Index, Mean ± SD	75.5 ± 14.3	69.9 ± 15.5	0.376	75.6 ± 13.9	75.5 ± 15.0	0.010
Male Sex, n (%)	136 (39.5%)	15,470 (44.4%)	0.099	126 (40.3%)	125 (39.9%)	0.007
Area-based Income Quintile, n (%)						
1 (lowest)	66 (19.2%)	4,708 (13.5%)	0.154	58 (18.5%)	64 (20.4%)	0.048
2	65 (18.9%)	5,548 (15.9%)	0.078	58 (18.5%)	59 (18.8%)	0.008
3	65 (18.9%)	7,526 (21.6%)	0.068	61 (19.5%)	65 (20.8%)	0.032
4	82 (23.8%)	9,676 (27.8%)	0.090	76 (24.3%)	69 (22.0%)	0.053
5 (highest)	66 (19.2%)	7,362 (21.1%)	0.049	60 (19.2%)	56 (17.9%)	0.033
Rurality (RIO), Mean ± SD	6.7 ± 9.1	5.1 ± 6.8	0.207	6.4 ± 8.9	6.8 ± 8.6	0.045
Health Link, n (%)						
South Simcoe	168 (48.8%)	8,846 (25.4%)	0.500	152 (48.6%)	155 (49.5%)	0.019
Southwest York	12 (3.5%)	13,895 (39.9%)	0.985	12 (3.8%)	16 (5.1%)	0.062
North York Central	164 (47.7%)	12,079 (34.7%)	0.266	149 (47.6%)	142 (45.4%)	0.045
Primary Care Model Affiliation, n (%)						
Family Health Team	56 (16.3%)	2,928 (8.4%)	0.241	52 (16.6%)	53 (16.9%)	0.009
Family Health Group	123 (35.8%)	15,711 (45.1%)	0.192	115 (36.7%)	105 (33.5%)	0.067
Family Health Organization	110 (32.0%)	9,006 (25.9%)	0.135	97 (31.0%)	105 (33.5%)	0.055
Other	9 (2.6%)	1,302 (3.7%)	0.064	7 (2.2%)	9 (2.9%)	0.040
Not Rostered in a model	46 (13.4%)	5,873 (16.9%)	0.098	42 (13.4%)	41 (13.1%)	0.009
Comorbidity (CADGs 1-12), n (%)						

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Acute Minor	332 (96.5%)	29,315 (84.2%)	0.427	301 (96.2%)	304 (97.1%)	0.053
Acute Major	332 (96.5%)	31,134 (89.4%)	0.280	301 (96.2%)	304 (97.1%)	0.053
Likely to Recur	286 (83.1%)	25,326 (72.7%)	0.253	257 (82.1%)	254 (81.2%)	0.025
Asthma	52 (15.1%)	4,131 (11.9%)	0.095	45 (14.4%)	39 (12.5%)	0.056
Chronic Medical Unstable	330 (95.9%)	27,667 (79.5%)	0.518	299 (95.5%)	302 (96.5%)	0.049
Chronic Medical Stable	315 (91.6%)	30,039 (86.3%)	0.169	285 (91.1%)	283 (90.4%)	0.022
Chronic Specialty Stable	34 (9.9%)	3,150 (9.0%)	0.029	33 (10.5%)	35 (11.2%)	0.021
Eye/ Dental	55 (16.0%)	4,569 (13.1%)	0.081	53 (16.9%)	51 (16.3%)	0.017
Chronic Specialty Unstable	80 (23.3%)	7,008 (20.1%)	0.076	68 (21.7%)	74 (23.6%)	0.046
Psychosocial	238 (69.2%)	20,928 (60.1%)	0.191	213 (68.1%)	204 (65.2%)	0.061
Preventive/ Administrative	221 (64.2%)	10,477 (30.1%)	0.728	197 (62.9%)	191 (61.0%)	0.039
Pregnancy	Suppr.	308 (0.9%)	0.078	Suppr.	Suppr.	0.000
Prior Utilization (1yr), Mean ± SD						
Dialysis visits	1.2 ± 12.4	1.1 ± 12.6	0.008	0.9 ± 10.5	1.5 ± 14.6	0.052
Oncology visits	0.5 ± 3.5	0.6 ± 3.7	0.032	0.4 ± 3.2	0.4 ± 2.8	0.018
Primary Care visits	26.4 ± 22.0	16.4 ± 14.2	0.539	24.7 ± 20.5	24.7 ± 17.5	0.001
Specialist visits	66.4 ± 47.7	25.8 ± 29.2	1.026	62.9 ± 46.7	64.5 ± 52.2	0.031
Home Care services	121.5 ± 176.3	22.7 ± 79.2	0.722	114.2 ± 171.6	126.4 ± 187.3	0.068
Mental Health hospitalizations	0.1 ± 0.5	0.0 ± 0.3	0.122	0.1 ± 0.5	0.1 ± 0.3	0.057
ED visits (1yr), Mean ± SD						
1-3 months prior	2.4 ± 2.7	0.4 ± 1.0	0.985	2.2 ± 2.3	2.3 ± 2.9	0.044
4-6 months prior	1.5 ± 2.6	0.4 ± 1.0	0.584	1.4 ± 2.1	1.3 ± 2.0	0.042
7-9 months prior	1.2 ± 1.9	0.4 ± 1.0	0.569	1.1 ± 1.7	1.1 ± 1.9	0.000
10-12 months prior	1.2 ± 2.2	0.3 ± 0.9	0.498	1.0 ± 1.8	1.0 ± 2.2	0.011
Hospitalizations (1yr), Mean ± SD						

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1-3 months prior	1.2 ± 1.1	0.1 ± 0.4	1.316	1.1 ± 1.0	1.1 ± 0.9	0.024
4-6 months prior	0.6 ± 0.9	0.1 ± 0.4	0.680	0.6 ± 0.9	0.5 ± 0.8	0.064
7-9 months prior	0.5 ± 0.8	0.1 ± 0.4	0.571	0.4 ± 0.7	0.4 ± 0.7	0.055
10-12 months prior	0.4 ± 0.8	0.1 ± 0.4	0.414	0.3 ± 0.8	0.3 ± 0.6	0.090

Note: only mean ± SD values reported for continuous variables. Median values also balanced between groups after matching. No missing data were present for any variable.
SDiff = Standardized difference; SD = standard deviation; RIO = Rurality Index for Ontario; CADGs = Johns Hopkins Collapsed Adjusted Clinical Groups; ED = emergency department; Suppr. = Cell suppressed due to small sizes (n<5)

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Table 2: Results from difference-in-differences analysis for select indicators

Measure	Mean or Rate (95% CI) Pre-Index Period[1]	Post-Index Period	Pre/Post Difference	*p-val*	Difference- in-Differences	*p-val*
Hospitalizations[2]						
Health Link Enrollees	2.26 (2.06-2.49)	2.07 (1.81, 2.36)	0.91 (0.79, 1.05)	0.218	1.74 (1.40, 2.17)	<0.001
Comparator Group	2.06 (1.89-2.26)	1.08 (0.91, 1.29)	0.53 (0.44, 0.63)	<0.001		
Emergency Department Visits[2]						
Health Link Enrollees	3.02 (2.42, 3.78)	3.10 (2.09, 4.59)	1.02 (0.80, 1.31)	0.849	1.61 (1.18, 2.20)	0.003
Comparator Group	3.52 (2.97, 4.18)	2.24 (1.72, 2.9)	0.64 (0.52, 0.77)	<0.001		
Days in Acute Care[2]						
Health Link Enrollees	18.4 (16.3, 20.8)	24.9 (20.7, 30.0)	1.35 (1.11, 1.65)	0.003	1.51 (1.06, 2.15)	0.023
Comparator Group	19.9 (17.3, 23.1)	17.9 (13.5, 23.8)	0.90 (0.66, 1.21)	0.482		
30-Day readmissions, %						
Health Link Enrollees	30.4 (26.1, 35.4)	36.2 (31.2, 41.9)	1.19 (0.95, 1.49)	0.129	1.43 (0.96, 2.13)	0.076
Comparator Group	25.6 (22.2, 29.5)	21.2 (16.2, 27.8)	0.83 (0.61, 1.14)	0.250		
7-Day primary care follow-up, %						
Health Link Enrollees	36.5 (32.6, 41.9)	37.5 (32.7, 43.1)	1.03 (0.88, 1.20)	0.725	1.01 (0.76, 1.33)	0.962
Comparator Group	34.9 (31.0, 39.3)	35.7 (29.0, 44.0)	1.02 (0.82, 1.28)	0.849		

Notes:

[1] All pre-index comparisons (enrollees vs. comparators) not statistically significant

[2] Rates per person-year presented, with incidence rate ratios as differences

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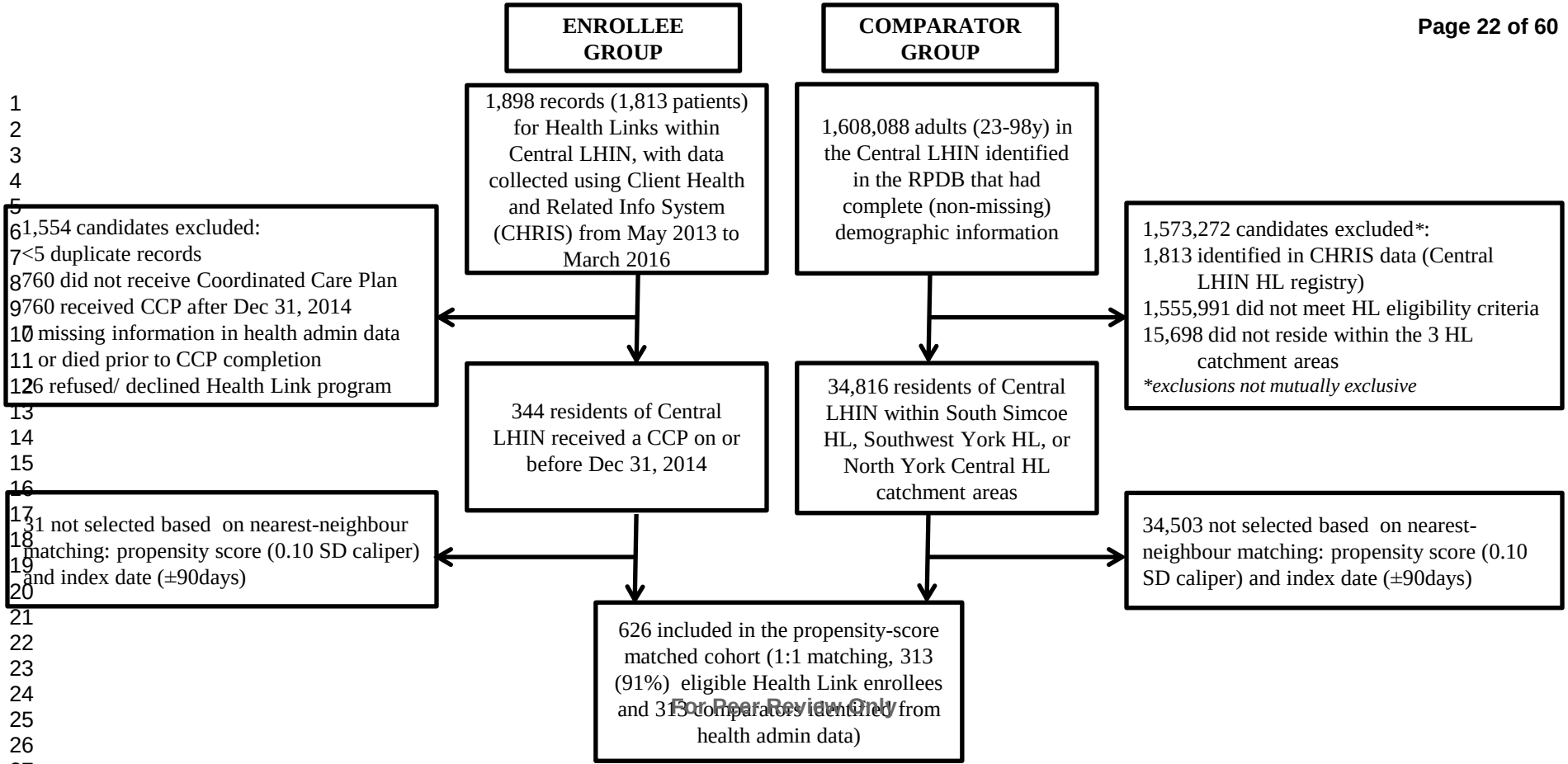

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Evaluation of Health Links on health services utilization in the Central Ontario health region: a propensity-matched difference-in-differences study

Authors: Luke Mondor, Kevin Walker, Yu Qing Bai, Walter P. Wodchis

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Appendix 5: Longitudinal (parallel trends) plots for each outcome.

Appendix 1: Administrative datasets used in this study

Dataset	Description	Variables
Registered Persons Database (RPDB)	A population-based registry that contains demographic information for all residents of Ontario who have registered for health insurance.	Age, Sex, Geographic location, Death
Canadian Institute for Health Information Discharge Abstract Database (DAD)	Contains administrative and clinical information on all admissions/discharges from acute care facilities in Ontario	Inpatient hospital episodes, Johns Hopkins 12 CADGs, MOHLTC target population
National Ambulatory Care Reporting System (NACRS)	Visits for all hospital- and community-based ambulatory care services (day surgery, outpatient clinic visits, emergency department visits) provided to Ontario residents	Emergency visits, Oncology visits, Dialysis visits, Johns Hopkins 12 CADGs, MOHLTC target population
Ontario Mental Health Reporting System (OMHRS)	Contains data on adult designated inpatient mental health beds (incl. general, provincial psychiatric, and specialty psychiatric facilities) using the Resident Assessment Instrument - Mental Health	Mental health hospital episodes, MOHLTC target population
Ontario Health Insurance Plan Claims Database (OHIP)	Claims for all physician services provided to Ontario residents	Primary care visits, Specialist visits, Johns Hopkins 12 CADGs, MOHLTC target population
Institute for Clinical Evaluative Sciences Physician Database (IPDB)	Yearly information on all physicians practicing in Ontario, including main specialty	Primary care visits, Specialist visits
Client Agency Program Enrolment (CAPE)	Contains a roster of patients that have registered with a primary care organization in Ontario, including a patients' association to specific physician and enrolment model type	Primary care model affiliation
National Rehabilitation Reporting System (NRS)	Contains client data collected from adult inpatient rehabilitation facilities in Ontario	MOHLTC target population
Corporate Provider Database (CPDB)	Contains information about health care providers in Ontario, including program eligibility information	Primary care model affiliation
2006 Canadian Census (Census)	Contains aggregated, area-level data for Ontario and Canada that describes demographic information of the population, including markers not captured with health administrative data	Rurality, Income
Continuing Care Reporting System (CCRS)	Contains clinical and demographic information on residents receiving facility-based continuing care services in Ontario	MOHLTC target population
Home Care Database (HCD)	Visits for all publicly-funded home care services provided to Ontario residents	MOHLTC target population

Source: http://www.ices.on.ca/DAS [accessed June 2017]

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Appendix 2: Supplemental information of the selection of the comparator pool

We identified a cohort of complex, high needs patients residing in the Central LHIN that were not enrolled in the Health Links program. All Ontarians in the RPDB were randomly assigned an index date based on the distribution of index dates (coordinated care plan completion date) of Health Link enrollees (n=344). Socio-demographics (age, sex, location, rurality, neighbourhood-level income quintile) were then identified for all individuals based on this date. We included individuals into the full comparator pool if they had complete socio-demographic information (no missing values for age, sex, rurality of residence and income quintile), were alive at index, were eligible for OHIP coverage, were within the age range of selected HL enrollees, and were not among Health Link enrollees identified in the full CHRIS dataset.

Remaining individuals were assigned to a Health Link geographical catchment area based on the location of their usual provider of primary care (identified by their formal physician that is contractually responsible for their care [CAPE data] or for patients not rostered in a primary care program, by virtual rostering [assigning patients to a physician based on frequency of health services provided prior to index identified in the OHIP files]) or on the location of their home residence (for those without any usual provider of care). Only individuals assigned to a Health Link catchment area matching that of the 3 Central LHIN Health Links were included. Geographic boundary files for the Health Link catchment areas were provided by the MOHLTC.

Last, we restricted the full comparator pool to include only complex, high needs patients. We used the MOHLTC definition of high-cost patients to identify all remaining individuals with an active diagnosis (within 1-year of their randomly assigned index date) of 4 or more conditions from a list of 55 priority conditions. The selected conditions were decided on by the Measurement and Performance Sub-Committee (of the Health Links Advisory Table) that included members from Local Health Integration Networks (LHINs), the Institute for Clinical Evaluative Sciences (ICES) and health services providers. Each condition was identified from multiple data sources, including DAD, NACRS, OMHRS, NRS, CCRS, HCD, and OHIP. Conditions included: amyotrophic lateral sclerosis (ALS), amputation, anemia, anxiety, arthritis, asthma, bipolar disorder, brain injury, chronic obstructive pulmonary disease (COPD), cardiac arrhythmia, cerebral palsy, coagulation defects, coma, congenital malformations, congestive heart failure, Crohn's disease/colitis, cystic fibrosis, dementia, depression, developmental disorders, diabetes, eating disorders, epilepsy and seizures, fractures, human immunodeficiency virus and acquired immune deficiency syndrome (HIV/AIDS), hemiplegia/ hemiparesis, hernia, hip replacement, Huntington's chorea, hypertension, influenza, ischemic heart disease, knee replacement, liver disease, low birth weight baby, malignant neoplasm, meningitis, muscular dystrophy, osteoporosis, other perinatal conditions, pain management, palliative care, paralysis, Parkinson's disease, peripheral vascular disease, personality disorders, pneumonia, renal failure, schizophrenia and delusions, sepsis, stroke, substance-related disorders, transplant and ulcers.

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Appendix 3: Outcome Definitions

Acute hospitalizations: included all acute hospitalization episodes (aggregated discharges and transfers from the same acute event) where the patient was discharged during the 1-year pre- or post-index period (DAD data). All causes of hospitalization were included, except for external causes of hospitalization and mental disorders. We did not measure avoidable hospitalizations specifically (i.e., hospitalizations for ambulatory care sensitive conditions [ACSCs]) because in Ontario, ACSCs are monitored only for individuals aged 0-74 years[1]. In our study population, >60% (n=193) of selected enrollees were ineligible (75 years of age or older).

Emergency department visits: included all unplanned visits to an Ontario emergency department during the 1-year pre- or post-index period that did not result in an inpatient stay (NARCS data). All acuity levels were considered, and patients were limited to one visit per day.

Days in acute care: included the total number of days in acute care (i.e., total length of hospital stay) among patients discharged during the 1-year pre- or post-index period (DAD data). We counted only the days within the accrual window; hospital episodes that extended beyond the 1-year look back/ look forward were censored at the 1-year date. Similar to the *acute hospitalizations* indicator, all causes of hospitalization were included, except for external causes of hospitalization and mental disorders.

30-day readmissions: included all index acute hospitalization episodes where the patient was discharged during the 1-year pre- or post-index period (DAD data). Index hospitalization episodes were excluded if the patient died in hospital, was discharged against medical advice, or if the discharge date was in the last 30-days of the pre- or post-index period (to allow for complete follow-up). For each index event, we then followed the patient prospectively for 30 days to identify any urgent inpatient readmissions for any cause.

7-day primary care follow-up: included all index acute hospitalization episodes where the patient was discharged during the 1-year pre- or post-index period (DAD data). Index hospitalization episodes were excluded if the patient died in hospital, was discharged against medical advice, or if the discharge date was in the last 7-days of the pre- or post-index period (to allow for complete follow-up). For each index event, we then followed the patient prospectively for 7 days to identify whether a visit to a primary care physician occurred (OHIP and IPDB data).

For each indicator, pre- and post-index measures were combined into a longitudinal dataset for analysis (one record per person, pre- and post-index).

[1] Ministry of Health and Long-Term Care (MOHLTC). Hospitalizations for Ambulatory Care Sensitive Conditions (ACSC). [Internet]. Toronto; [accessed October 6, 2016]. Available from: http://www.health.gov.on.ca/en/pro/programs/ris/docs/hospitalizations_for_ambulatory_care_sensitive_conditions_en.pdf

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Appendix 4: Comparison of characteristics of matched Health Link enrollees (n=313) with Health Link enrollees that were not matched and therefore not included in the propensity-matched difference-in-differences analysis (n=31).

	NON-MATCHED ENROLLEES	SELECTED ENROLLEES	SDiff
	N=31	N=313	
Age at Index, Mean ± SD	73.9 ± 18.1	75.6 ± 13.9	0.109
Male Sex, n (%)	10 (32.3%)	126 (40.3%)	0.167
Income Quintile, n (%)			
1 (lowest)	Suppr.	58 (18.5%)	0.176
2	Suppr.	58 (18.5%)	0.100
3	Suppr.	61 (19.5%)	0.179
4	Suppr.	76 (24.3%)	0.119
5 (highest)	Suppr.	60 (19.2%)	0.005
Rurality (RIO), Mean ± SD	10.0 ± 10.9	6.4 ± 8.9	0.359
Health Link, n (%)			
South Simcoe	Suppr.	152 (48.6%)	0.061
Southwest York	Suppr.	12 (3.8%)	0.282
North York Central	Suppr.	149 (47.6%)	0.016
Primary Care Model, n (%)			
Family Health Team	Suppr.	52 (16.6%)	0.105
Family Health Group	Suppr.	115 (36.7%)	0.238
Family Health Organization	Suppr.	97 (31.0%)	0.229
Other	Suppr.	7 (2.2%)	0.208
Not Rostered in a model	Suppr.	42 (13.4%)	0.015
Comorbidity (CADGs), n (%)			
Acute Minor	31 (100.0%)	301 (96.2%)	0.282
Acute Major	31 (100.0%)	301 (96.2%)	0.282
Likely to Recur	29 (93.5%)	257 (82.1%)	0.355
Asthma	7 (22.6%)	45 (14.4%)	0.213
Chronic Medical Unstable	31 (100.0%)	299 (95.5%)	0.306
Chronic Medical Stable	30 (96.8%)	285 (91.1%)	0.241
Chronic Specialty Stable	Suppr.	33 (10.5%)	0.292
Eye/ Dental	Suppr.	53 (16.9%)	0.331
Chronic Specialty Unstable	12 (38.7%)	68 (21.7%)	0.376
Psychosocial	25 (80.6%)	213 (68.1%)	0.291
Preventive/ Administrative	24 (77.4%)	197 (62.9%)	0.321
Pregnancy	Suppr.	Suppr.	0.080

Appendix 3 (*continued*):

	NON-MATCHED ENROLLEES	SELECTED ENROLLEES	SDiff
Prior Utilization (1yr), Mean ± SD			
Dialysis visits	4.4 ± 24.6	0.9 ± 10.5	0.188
Oncology visits	1.3 ± 5.4	0.4 ± 3.2	0.215
Primary Care visits	43.8 ± 28.8	24.7 ± 20.5	0.766
Specialist visits	101.4 ± 43.8	62.9 ± 46.7	0.849
Home Care services	195.1 ± 207.2	114.2 ± 171.6	0.425
Mental Health hospitalizations	0.2 ± 0.7	0.1 ± 0.5	0.196
ED visits (1yr), Mean ± SD			
1-3 months prior	4.5 ± 4.8	2.2 ± 2.3	0.620
4-6 months prior	3.3 ± 5.5	1.4 ± 2.1	0.462
7-9 months prior	2.7 ± 3.2	1.1 ± 1.7	0.631
10-12 months prior	3.0 ± 4.2	1.0 ± 1.8	0.598
Hospitalizations (1yr), Mean ± SD			
1-3 months prior	2.2 ± 1.3	1.1 ± 1.0	0.947
4-6 months prior	1.2 ± 1.1	0.6 ± 0.9	0.628
7-9 months prior	1.0 ± 1.2	0.4 ± 0.7	0.603
10-12 months prior	0.7 ± 0.8	0.3 ± 0.8	0.478
Total health care encounters (1yr)	364.5 ± 211.5	211.2 ± 181.2	0.780

SDiff = Standardized difference; SD = standard deviation; RIO = Rurality Index for Ontario; CADGs = Johns Hopkins Collapsed Adjusted Clinical Groups; ED = emergency department; Suppr = Values suppressed due to small sizes (N≤5 in one or more cells for variable);
Total health care encounters equals sum of prior (past 1-year) dialysis visits, oncology visits, primary care visits, specialist visits, home care services, mental health hospitalizations, emergency department visits, and acute hospitalizations;

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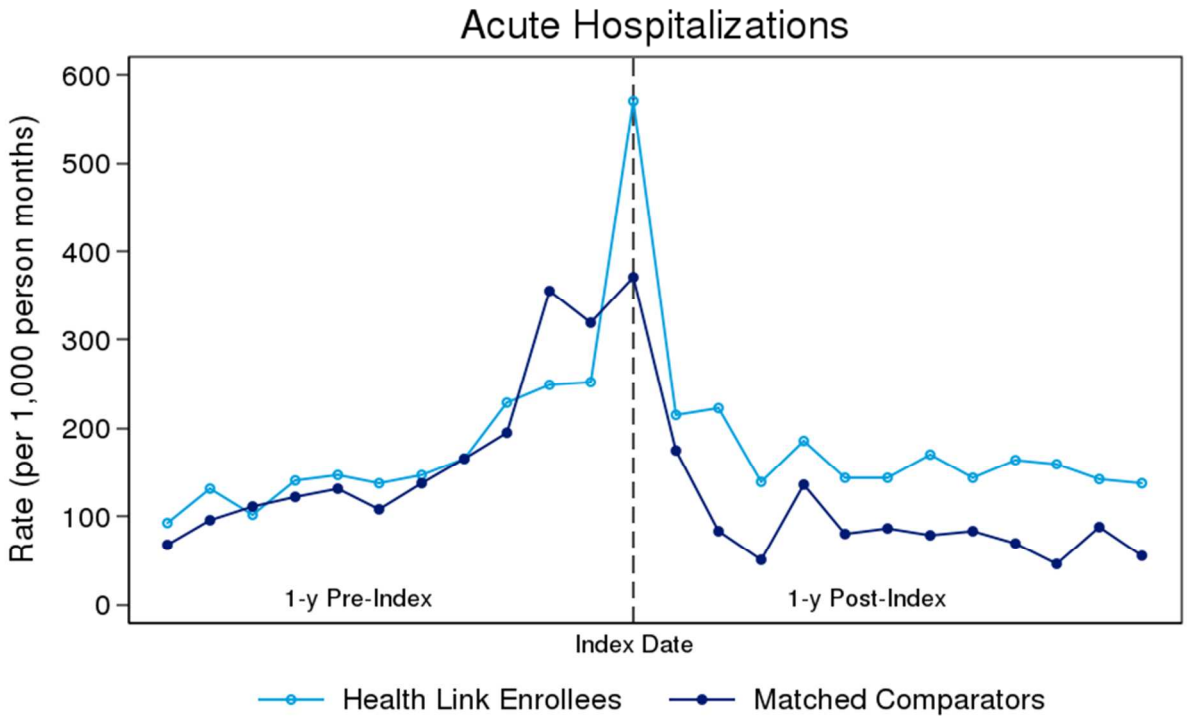
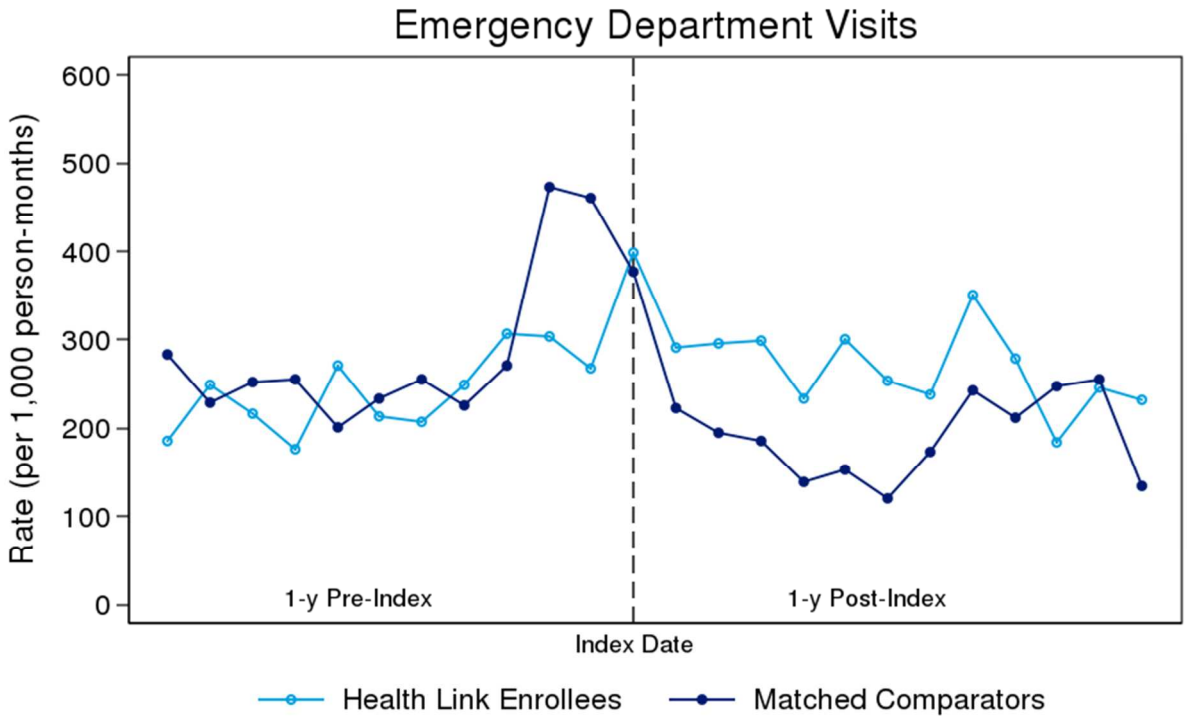
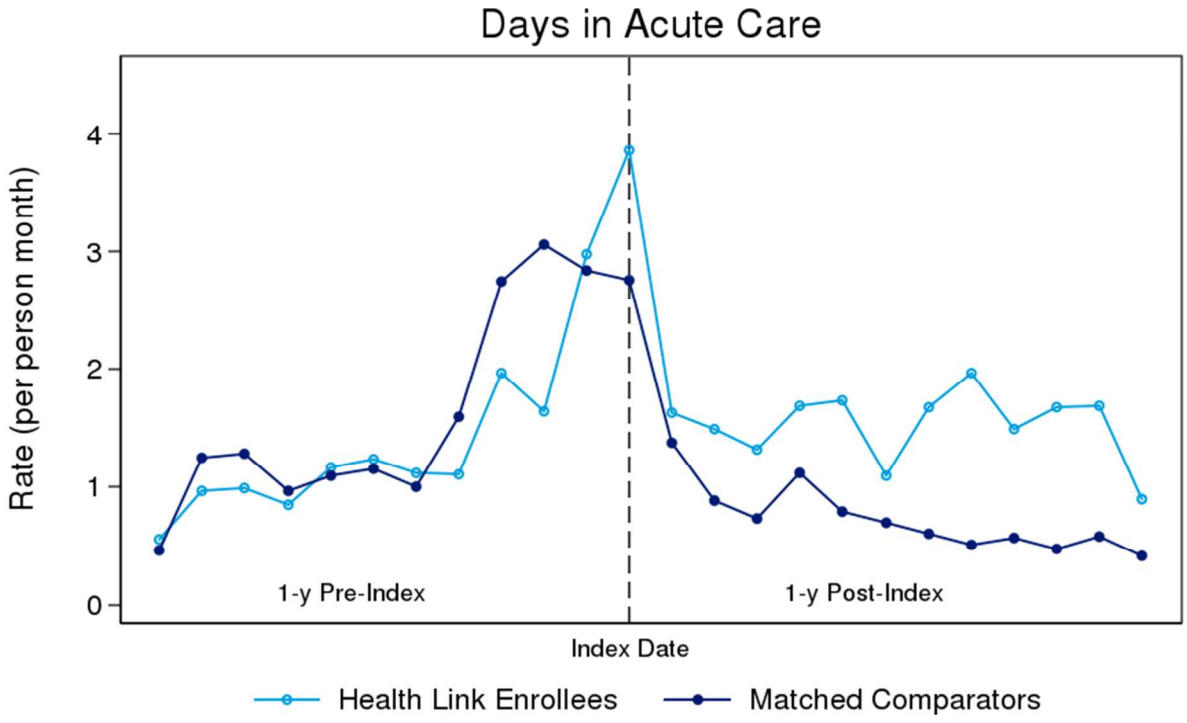
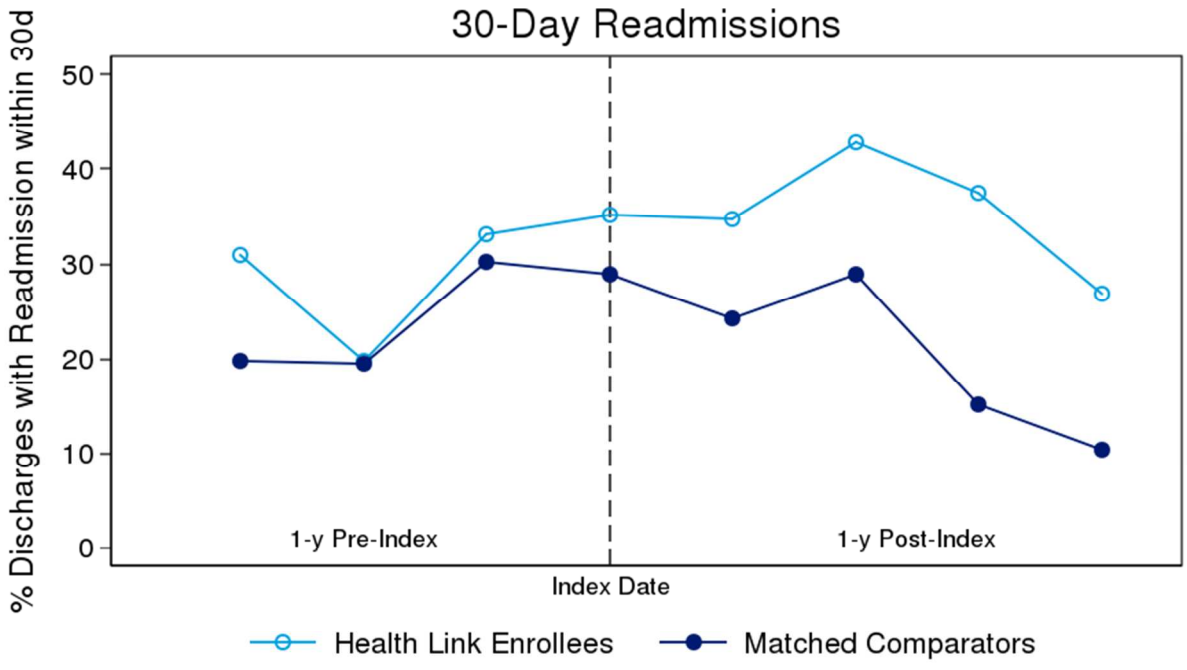
Appendix 5: Longitudinal (parallel trends) plots for each outcome.

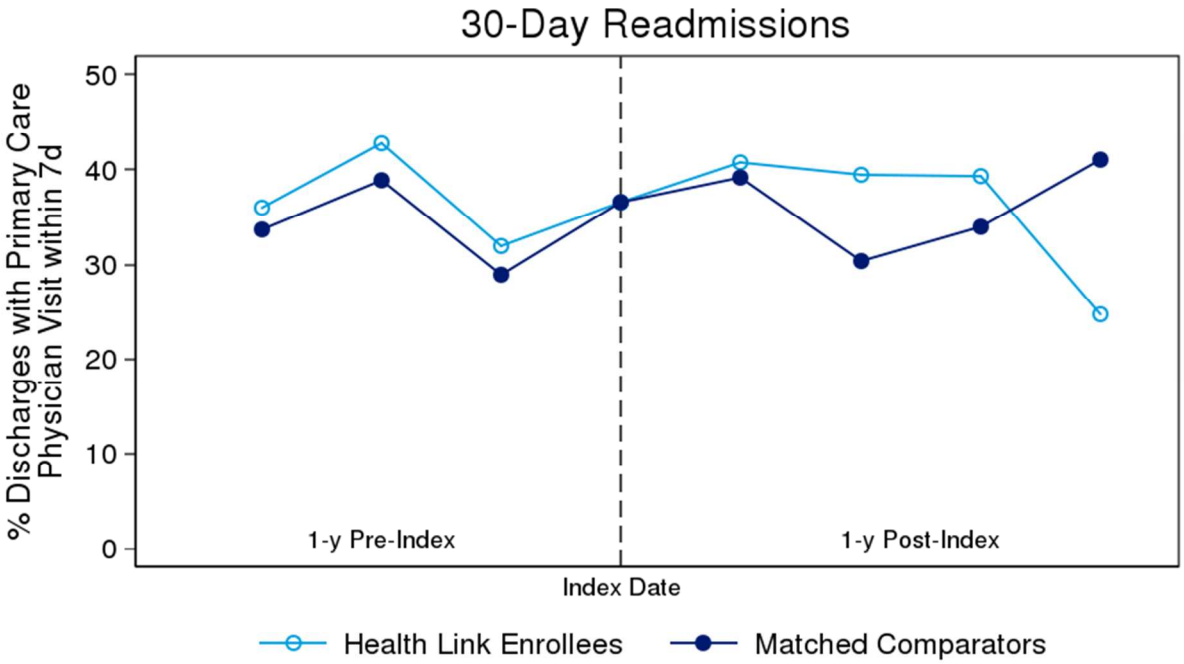








*Estimates reflect % of discharges with a readmission within 30-days in prior quarter, due to small number of discharges at monthly-level



*Estimates reflect % of discharges where the patient visited a primary care physician within 7-days in prior quarter, due to small number of discharges at monthly-level

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Reporting guidelines checklist (RECORD statement)

Evaluation of Health Links on health services utilization in the Central Ontario health region: a propensity-matched difference-in-differences study

Authors: Luke Mondor, Kevin Walker, Yu Qing Bai, Walter P Wodchis

	No	STROBE items	RECORD items	Location in manuscript where items are reported
Title and abstract				
	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found	RECORD 1.1: The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included. RECORD 1.2: If applicable, the geographic region and timeframe within which the study took place should be reported in the title or abstract. RECORD 1.3: If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract.	Included. 1.1 Methods, Abstract 1.2 Included in Title and Abstract 1.3 Methods, Abstract
Introduction				
Background rationale	2	Explain the scientific background and rationale for the investigation being reported		Paragraphs 1-2 (lines 23-44)

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Objectives	3	State specific objectives, including any pre-specified hypotheses		Paragraph 3 (lines 45-49)
Methods				
Study Design	4	Present key elements of study design early in the paper		Introduction (lines 45-49) and Methods.
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection		"Setting" sub-section (lines 52-60)
Participants	6	*(a) Cohort study* - Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study* - Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study* - Give the eligibility criteria, and the sources and methods of selection of participants *(b) Cohort study* - For matched	RECORD 6.1: The methods of study population selection (such as codes or algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided. RECORD 6.2: Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided. RECORD 6.3: If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of	Included. 6.1 "Population" sub-section (lines 72-86) and Appendix 2 6.2 n/a 6.3 Figure 1 flow diagram

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		studies, give matching criteria and number of exposed and unexposed *Case-control study* - For matched studies, give matching criteria and the number of controls per case	individuals with linked data at each stage.	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable.	RECORD 7.1: A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and effect modifiers should be provided. If these cannot be reported, an explanation should be provided.	"Propensity-Matched Cohort" and "Outcome Measures" sub-sections (lines 96-117) and Appendix 3.
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group		Appendix 1
Bias	9	Describe any efforts to address potential sources of bias		"Propensity-Matched Cohort" sub-section (lines 96-111)
Study size	10	Explain how the study size was arrived at		Figure 1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why		"Statistical Analysis: Difference-in-differences estimation" sub-section (lines 118-130)

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Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) *Cohort study* - If applicable, explain how loss to follow-up was addressed *Case-control study* - If applicable, explain how matching of cases and controls was addressed *Cross-sectional study* - If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses		(a) "Statistical Analysis: Difference-in-differences estimation" sub-section (lines 118-130). (b) n/a (c) Table 1, "No missing data were present for any variable" (d) "Statistical Analysis: Difference-in-differences estimation" sub-section (lines 118-130). (e) n/a
Data access and cleaning methods		..	RECORD 12.1: Authors should describe the extent to which the investigators had access to the database population used to create the study population.	"Data" sub-section (lines 61-71)

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			RECORD 12.2: Authors should provide information on the data cleaning methods used in the study.	
Linkage		..	RECORD 12.3: State whether the study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided.	"Data" sub-section (lines 61-71)
Results				
Participants	13	(a) Report the numbers of individuals at each stage of the study (*e.g.*, numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed) (b) Give reasons for non-participation at each stage. (c) Consider use of a flow diagram	RECORD 13.1: Describe in detail the selection of the persons included in the study (*i.e.,* study population selection) including filtering based on data quality, data availability and linkage. The selection of included persons can be described in the text and/or by means of the study flow diagram.	Paragraph 1 (lines 132-139) and Figure 1
Descriptive data	14	(a) Give characteristics of study participants (*e.g.*, demographic, clinical, social) and information on exposures and potential		Table 1.

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		confounders (b) Indicate the number of participants with missing data for each variable of interest (c) *Cohort study* - summarise follow-up time (*e.g.*, average and total amount)		
Outcome data	15	*Cohort study* - Report numbers of outcome events or summary measures over time *Case-control study* - Report numbers in each exposure category, or summary measures of exposure *Cross-sectional study* - Report numbers of outcome events or summary measures		Table 2
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were		Paragraphs 3 and 4 (lines 147-157) and Table 2

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		categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period		
Other analyses	17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses		Paragraph 2 (lines 140-146)
Discussion				
Key results	18	Summarize key results with reference to study objectives		Paragraph 1 (lines 159-164)
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	RECORD 19.1: Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported.	"Limitations" sub-section (lines 196-208)
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence		Paragraphs 2 and 3 (lines 165-195)

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Generalisability	21	Discuss the generalisability (external validity) of the study results		"Limitations" sub-section (lines 196-208)
Other Information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based		Included.
Accessibility of protocol, raw data, and programming code		..	RECORD 22.1: Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	Included.

*Reference: Benchimol EI, Smeeth L, Guttmann A, Harron K, Moher D, Petersen I, Sørensen HT, von Elm E, Langan SM, the RECORD Working Committee. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. 2015 Oct 6;12(10):e1001885. doi: 10.1371/journal.pmed.1001885

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