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Research

Effect of a multimorbidity intervention on health care utilization and costs in Ontario: randomized controlled trial and propensity-matched analyses

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Abstract

Background: Patients with multimorbidity require coordinated and patient-centred care. Telemedicine IMPACT Plus provides such care for complex patients in Toronto, Ontario. We conducted a randomized controlled trial (RCT) comparing health care utilization and costs at 1-year postintervention for an intervention group and 2 control groups (RCT and propensity matched).

Methods: Data for 82 RCT intervention and 74 RCT control participants were linked with health administrative data. We created a second control group using health administrative data–derived propensity scores to match (1:5) intervention participants with comparators. We evaluated 5 outcomes: acute hospital admissions, emergency department visits, costs of all insured health care, 30-day hospital readmissions and 7-day family physician follow-up after hospital discharge using generalized linear models for RCT controls and generalized estimating equations for propensity-matched controls.

Results: There were no significant differences between intervention participants and either control group. For hospital admissions, emergency department visits, costs and readmissions, the relative differences ranged from 1.00 (95% confidence interval [CI] 0.39–2.60) to 1.67 (95% CI 0.82–3.38) with intervention costs at about Can$20 000, RCT controls costs at around Can$15 000 and propensity controls costs at around Can$17 000. There was a higher rate of follow-up with a family physician for the intervention participants compared with the RCT controls (53.13 v. 21.43 per 100 hospital discharges; relative difference 2.48 [95% CI 0.98–6.29]) and propensity-matched controls (49.94 v. 28.21 per 100 hospital discharges; relative difference 1.81 [95% CI 0.99–3.30]).

Interpretation: Despite a complex patient-centred intervention, there was no significant improvement in health care utilization or cost. Future research requires larger sample sizes and should include outcomes important to patients and the health care system, and longer follow-up periods. **Ontario ClinicalTrials.gov:** 104191.

Multimorbidity is common[1,2] and is associated with a burden on patients and the health care system.[3] Care for patients with multimorbidity must consider the incremental challenges that multiple chronic conditions confer upon patients over and above the burden conferred by each individual condition.[2,3] As such, patients with multimorbidity require care coordinated by teams of providers and care that attends to them as a whole person, not as a sum of their diseases.[3–5] Although interventions aimed at improving health care, including for complex patients, have been mounted in Ontario, few have been evaluated.[6] Further, interventions specifically targeted for patients with multimorbidity worldwide have had mixed results;[7–12] only 2[11,12] have examined the effect of interventions on health care utilization.

We report the effect on health services outcomes for patients enrolled in the Ontario arm of a clinical trial called Patient-centred Innovations for Persons with Multimorbidity (PACE in MM).[13] The first objective was to compare health care utilization and costs between intervention and control patients before and after the intervention. Anticipating a small sample size for a community-based complex intervention, the decision was made a priori[13] to include a second objective where health care utilization and costs for intervention patients were examined relative to propensity-matched controls derived from health administrative data.

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Methods

With values of coordinated team-based and patient-centred care as pillars, the PACE in MM project conducted 2 randomized controlled trials (RCTs) of primary care delivery for people with multimorbidity — 1 in Quebec and 1 in Ontario.[13] In Ontario, the patient-reported outcomes were as follows: the Health Education Impact Questionnaire (heiQ), Self-Efficacy for Managing Chronic Disease scale (SEM-CD), Veteran's Rand 12-Item Health Survey (VR-12), the EuroQol 5 Dimension quality of life measure (EQ-5D), Kessler Psychological Distress Scale (K6) and the health behaviour survey.[14] The effects of the intervention on these patient-reported health outcomes[14,15] are reported elsewhere.

The Ontario intervention took place in the highly diverse neighbourhoods of central and east Toronto from 2016 to 2017. Nine team-based family practices, along with solo practices and emergency departments affiliated with those teams, provided care for complex patients with high health care utilization through Telemedicine IMPACT Plus, hereafter referred to as the intervention.[16] The intervention consisted of a meeting between the patient and a nurse, where the patient's goals for care were elaborated. There was also a subsequent case conference of about 6 providers relevant to the patient's needs, including the patient and a family physician known to the patient.[14] Patients aged 18 to 80 years were the target population and had to have 3 or more chronic conditions and be referred by their provider to receive the intervention. Patients were excluded if they had cognitive impairment, were illiterate or had previously received the intervention. For this current analysis, the follow-up period was 1 year postintervention. Further details of the Ontario RCT can be found in Appendix 1, available at www.cmajopen.ca/content/11/1/E45/suppl/DC1 and Appendix 2, available at www.cmajopen.ca/content/11/1/E45/suppl/DC1.

Data sources

The data for participant information for the PACE in MM Ontario RCT were gathered from patient questionnaires completed through a telephone interview by a research assistant upon patient enrolment in the study. The research assistant was unaware of the participants' RCT assignment during interviews. Questionnaire data were transferred from paper, then verified by another research assistant and stored in the study database. The questionnaire asked participants about their chronic condition history, coordination of health care, patient-centredness, patient-reported outcomes (heiQ, SEM-CD, VR-12, EQ-5D, K6, and health behaviours), costs of uninsured health care and demographic characteristics. Variables relevant to the health administrative analysis were age, sex, education, household income, marital status, employment and a list of patients' chronic conditions. These variables were stored in the PACE in MM Ontario RCT database (hereafter referred to as the PACE database) along with participants' assigned index dates, RCT assignments (intervention or control) and Ontario Health Insurance Plan (OHIP) numbers.

Health administrative data were obtained through ICES (Toronto). ICES is an independent, nonprofit research institute whose legal status under Ontario's health information privacy law allows it to collect and analyze health care and demographic data, without consent, for health system evaluation and improvement. In January 2020, the PACE database was transferred to ICES (Toronto). Data from the PACE database and ICES health administrative databases were linked using unique encoded identifiers (derived from OHIP numbers) and analyzed at ICES. Appendix 3, available at www.cmajopen.ca/content/11/1/E45/suppl/DC1, describes the health administrative data sets used in analyses.

Overall methods and outcome measures

We conducted 2 analyses. The first analysis compared intervention participants to RCT control patients (hereafter called RCT analysis). The second compared intervention participants to propensity-matched controls identified in health administrative data (hereafter called propensity-matched analysis). A priori, we expected the sample size for the RCT to be modest and therefore included a 5:1 propensity-matched analysis to increase power.[13] This process created an analytical sample in which measured confounding factors were balanced between intervention arms. Below, the 2 analyses are described separately. All analyses were conducted using SAS version 9.4 (SAS Institute).

For both analyses, 5 outcomes were obtained from health administrative data from the 1-year postindex date: acute hospital admissions, emergency department visits, costs (total included all health care expenditures that had been allocated to patient encounters for insured health care), 30-day hospital readmissions for patients who had at least 1 hospital admission and 7-day follow-up with a family physician after hospital discharge for patients who had at least 1 hospital admission. Appendix 4, available at www.cmajopen.ca/content/11/1/E45/suppl/DC1 provides definitions for each outcome, including data sources used. Measures were chosen a priori to show important markers for PACE in MM success.[13] Minor adjustments from protocol were made to some outcome definitions to align with measures available in health administrative data.

Samples

For the RCT analysis, there were 86 intervention participants and 77 control participants.[14] Participants were included if they were successfully linked to health administrative databases (Appendix 1).

For the propensity-matched analysis, participants from the PACE intervention group were included in this analysis if they were successfully linked to health administrative databases. The index date used for intervention participants was the date they received the intervention.

To create a pool of eligible comparators, we assigned all Ontarians in the Registered Persons Database a pseudo-index date. This date was based on the quarterly distribution of all index dates for only the intervention participants in the PACE database. From this pool, we excluded people who did not have a physician encounter recorded in OHIP 1 year before

their pseudo-index date, were in hospital at pseudo-index date, were enrolled in Family Health Teams that participated in PACE in MM, were a rural resident or resided outside of the forward sortation areas (i.e., first 3 digits of a postal code) of PACE participants, were missing income or rurality data, were a resident of a long-term care facility before pseudo-index or died within 1 year of pseudo-index (Figure 1 describes the propensity-matched study hierarchy).

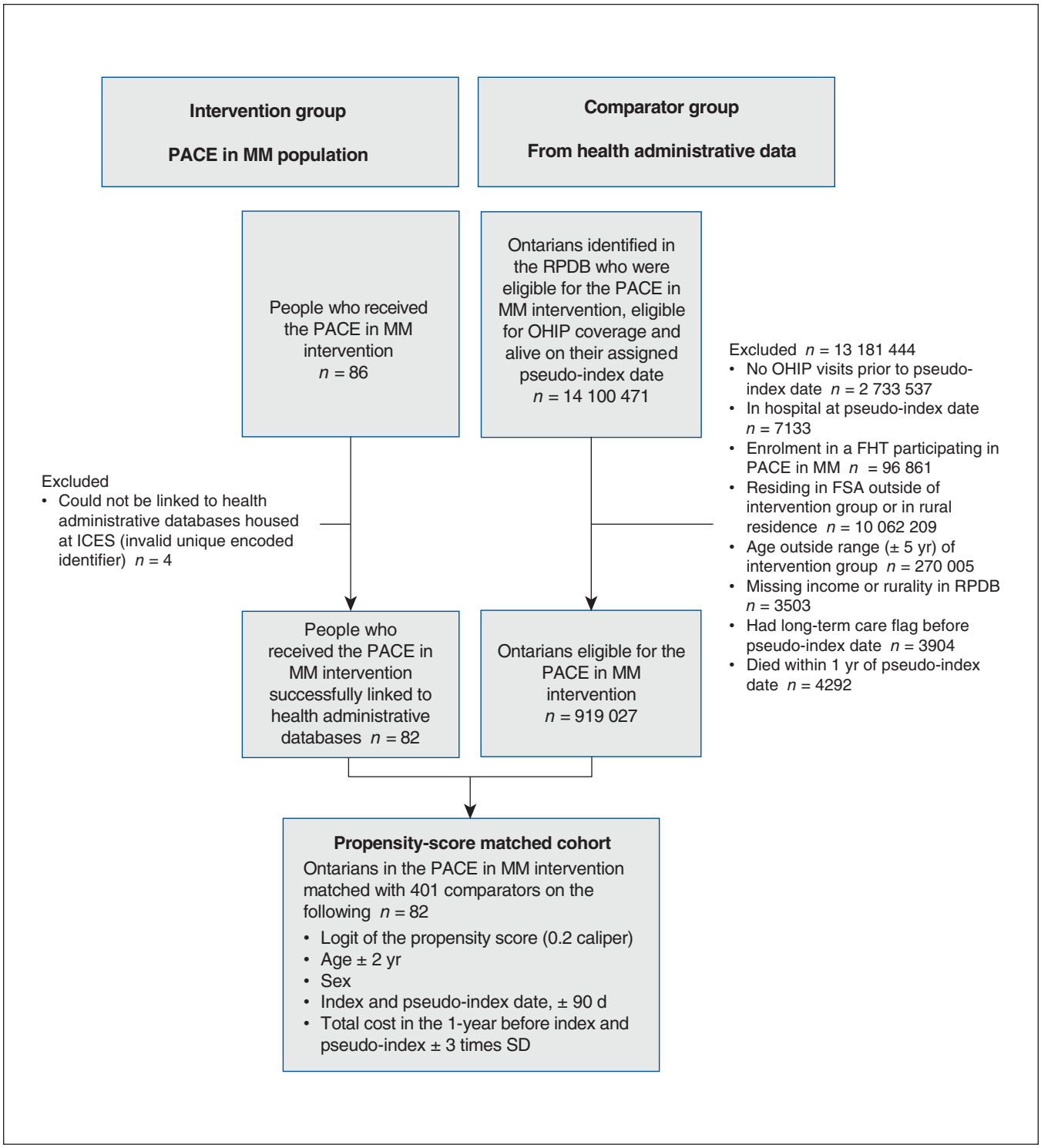

Figure 1: Propensity-matched analysis study hierarchy. Note: FHT = Family Health Team, FSA = forward sortation area, OHIP = Ontario Health Insurance Plan, PACE in MM = Patient-centred Innovations for Persons with Multimorbidity, RPDB = Registered Persons Database, SD = standard deviation.

Covariates

For the RCT analysis, covariates were obtained from the PACE database: age, sex, education, household income, marital status, employment and a list of the patient's chronic conditions; a variable was created for the number of chronic conditions. Covariates were used to describe and compare intervention and control groups.

For the propensity-matched analysis (for intervention participants and for the comparator pool population from which we drew the propensity-matched controls), we defined covariates — at index or pseudo-index date, respectively — including age, sex, rurality (defined using the Rurality Index of Ontario[17]) and neighbourhood-level income quintile. The history of 17 conditions were defined based on retrospective data from ICES databases as described in Appendix 5, available at www.cmajopen.ca/content/11/1/E45/suppl/DC1. The 17 conditions represent a subset of the most substantial conditions from a population perspective; these have been used extensively for multimorbidity research in Ontario.[1,18–23] In addition, we identified the number of urgent hospital admissions (Discharge Abstract Database), emergency department visits (National Ambulatory Care Reporting System), visits to family physicians and specialists (OHIP) and total costs[24] incurred across the health care system. These utilization variables were derived for the 1 year before index or pseudo-index as well as quarterly, leading to index or pseudo-index.

To create the propensity-matched cohort, people in the comparator pool were matched 5-to-1 to people in the intervention group using propensity score methods without replacement. Propensity scores were derived from logistic regression modelling the probability of enrolment in the intervention as a function of variables relevant to patients with multimorbidity including age (modelled as a restricted cubic spline), sex, income quintile, rurality, history of 17 chronic conditions and quarterly counts of health care utilization including urgent admissions, emergency department visits, visits to family physicians and specialists and total costs. Utilization variables were transformed using a square-root function before modelling. We created a propensity-score–matched cohort using the nearest-neighbour greedy algorithm to match 3 to 5 comparators for every person in the intervention group.[25] People were matched by sex (hard match), the logit of the propensity score (within 0.20 standard deviations [SD]),[26] age (hard match within 2 yr), index or pseudo-index date (within 90 d) and total costs in the year before index or pseudo-index (hard match within 3 SD in overall population). To assess quality of the match, we used standardized differences, weighted for many-to-1 matching,[27] to compare baseline characteristics of the intervention group and comparators. A standardized difference of less than 0.10 is indicative of good balance between groups.[28]

Statistical analysis

The effects of the intervention on acute hospital admissions and emergency department visits were estimated using a negative binomial distribution, log link function and log of person-time offset term. Costs were modelled using a γ distribution, log link function and log of person-time offset. In addition, for these 3 outcomes we conducted a sensitivity analysis disregarding person-time contribution (i.e., no offset was used). For 30-day hospital readmissions and 7-day follow-up with a family physician, data were modelled using a Poisson distribution and a log link function with number of index discharges as the offset term (i.e., people without a hospital discharge were excluded from the analyses). For these 2 outcomes, estimated values were presented as a rate per 100 discharges.

For the RCT analysis, differences in health care utilization 1 year after index dates for PACE intervention group compared with the control group (control used as reference group) were estimated using univariate regression with generalized linear model including a single covariate for RCT assignment (intervention or control).

For the propensity-matched analysis, differences in health care utilization in the year before and after index or pseudo-index for the PACE intervention group compared with the propensity-score-matched controls were estimated using generalized estimating equations to account for correlated data. Each model included a binary covariate for treatment group, a binary variable for time (pre- or postindex or pseudo-index) and the 2-way interaction between treatment and time. This latter term is the ratio of 2 ratios; that is, the risk ratios for the post compared with the pre differences for the intervention group and control group. We have termed this a relative difference, which represents the ratio of the relative changes in the outcomes post- compared with pre-intervention. An exchangeable correlation structure was used to account for correlation between records. The parallel trends of quarterly data were checked visually to ensure model assumptions were valid.

Ethics approval

The Western University Health Sciences Research Ethics Board (106921) approved this study.

Results

A total of 82 of 86 (95.3%) participants from the PACE intervention group and 74 of 77 (96.1%) from the control group were successfully linked to health administrative data. It was not possible to link 7 participants as the unique encoded identifiers required to link were invalid; therefore, these 7 participants had to be excluded from the analysis. Table 1 reports the baseline characteristics. Three control group participants died in the 1-year follow-up period.

Table 2 reports the results of the generalized linear model analysis comparing health care utilization and costs at the 1-year postindex date between the intervention and control participants. There were no significant differences for any of the outcomes of acute hospital admissions, emergency department visits, costs, 30-day hospital readmissions and 7-day follow-up with a family physician. For 7-day follow-up with a family physician, intervention participants had 2.48 times the follow-up compared with control participants (p = 0.06). Appendix 6a, available at www.cmajopen.ca/content/11/1/E45/suppl/DC1, provides the observed values for these outcomes.

Table 1: Randomized controlled trial analysis: baseline characteristics

Characteristic	No. (%)*	
	Control *n* = 74	Intervention *n* = 82
Age, yr, mean ± SD	62.8 ± 14.0	62.1 ± 13.9
No. of chronic conditions per participant, mean ± SD	6.0 ± 2.3	6.2 ± 2.4
Sex		
Female	48 (64.9)	53 (64.6)
Male	26 (35.1)	29 (35.4)
Education level		
Incomplete secondary school	8 (10.8)	10 (12.2)
Completed secondary school	11 (14.9)	10 (12.2)
Some university or completed college	25 (33.8)	24 (29.3)
Completed bachelor's degree	14 (18.9)	27 (32.9)
Completed graduate or professional degree	16 (21.6)	11 (13.4)
Household income in Can$		
< 20 000	16 (21.6)	20 (24.4)
20 000–59 999	26 (35.1)	17 (20.7)
≥ 60 000	23 (31.1)	34 (41.5)
Missing data	9 (12.2)	11 (13.4)
Marital status		
Married	36 (48.6)	36 (43.9)
Separated or divorced	15 (20.3)	17 (20.7)
Widower	10 (13.5)	8 (9.8)
Never married	13 (17.6)	21 (25.6)
Employment		
Employed	13 (17.6)	16 (19.5)
Unemployed	27 (36.5)	29 (35.4)
Retired from paid work	33 (44.6)	37 (45.1)
Missing	1 (1.4)	0 (0.0)

*Unless indicated otherwise.
Note: SD = standard deviation.

Propensity-matched analysis

A total of 82 participants from the PACE intervention group were successfully matched to health administrative data. The mean age at index for this group was 62 (SD 14) years and nearly two-thirds were women (65%). People from the lowest (29%) and highest (24%) area-based income quintiles were overrepresented in the data. On average, people in the PACE intervention group had a history of 5.4 (SD 2.4) out of 17 conditions. The most common diagnoses were osteoarthritis (78% of participants), mood and anxiety disorders (78%), hypertension (61%) and cancer (59%). In the year before intervention, the PACE group had on average 9.5 family physician visits (SD 9.9), 12.0 specialist visits (SD 15.3), 0.4 urgent hospital admissions (SD 0.9), 1.3 emergency department visits (SD 2.7) and incurred Can$19 900 in health care costs (SD $27 900). Appendix 6b, available at www.cmajopen.ca/content/11/1/E45/suppl/DC1, provides the observed values for these outcomes.

In propensity-score matching, we matched the 82 intervention participants to 401 comparators. Seventy-nine intervention participants were matched to 5 comparators; 3 were matched to only 2 comparators. Baseline covariates were balanced between matched groups (Table 3) with the exception of family physician visits in the quarter before index or pseudo-index (standardized difference = 0.126) and specialist visits in the second quarter nearest to index or pseudo-index (standardized difference = 0.191, data not shown).

Table 4 reports the relative differences between intervention participants and controls. Across the 5 outcomes, there were no significant differences. This suggests that the change

Table 2: Randomized controlled trial analysis: results for outcomes 1-year postindex date through generalized estimating equations

Measure*	Mean estimate (CI)			*p* value
	Intervention group *n* = 82	Control group *n* = 74	Relative difference†	
Acute hospital admissions, mean per patient-year	0.49 (0.28–0.87)	0.34 (0.18–0.65)	1.43 (0.61–3.38)	0.413
Emergency department visits, mean per patient-year	0.94 (0.61–1.44)	0.93 (0.59–1.45)	1.02 (0.55–1.88)	0.963
Costs, mean $ per patient-year	19 619 (15 368–25 046)	15 424 (11 927–19 946)	1.27 (0.89–1.81)	0.184
30-day hospital readmissions, rate per 100 discharges‡	28.13 (14.63–54.05)	25.00 (11.92–52.44)	1.13 (0.42–3.02)	0.815
7-day follow-up with family physician rate per 100 discharges‡	53.13 (33.03–85.46)	21.43 (9.63–47.70)	2.48 (0.98–6.29)	0.056

Note: CI = confidence interval.
*Definitions of outcomes:
Acute hospital admissions included all urgent acute hospital admissions taking place during the 1-year pre- or postindex period (Discharge Abstract Database [DAD] data). All causes of hospital admission were included, except for external causes of hospital admission or where the admission category was for newborns or stillbirths. Only the first separation in a hospital episode was considered (i.e., transfers were excluded).
Emergency department visits included all unplanned visits to an Ontario emergency department during the 1-year pre- or postindex period that did not result in an inpatient stay (National Ambulatory Care Reporting System data). All acuity levels were considered and patients were limited to 1 visit per day.
Cost included all health care expenditures that have been allocated to patient encounters for health care in the 1-year pre- or postindex period.[1] Costs are in Can$2018. Out-of-pocket expenses or insurance compensation paid out by third-party payers are not considered in this costing methodology.
Thirty-day readmissions included all index acute hospital admissions where the patient was discharged during the 1-year pre- or postindex period (DAD data). Index hospital admissions 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 postindex period (to allow for complete follow-up). For each index event, we followed the patient prospectively for 30 days to identify any urgent inpatient readmissions for any cause.
Seven-day primary care follow-up included all index acute hospital admissions where the patient was discharged during the 1-year pre- or postindex period (DAD data). Index hospital admissions 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 postindex period (to allow for complete follow-up). For each index event, we followed the patient prospectively for 7 days to identify whether a visit to a primary care physician occurred (Ontario Health Insurance Plan and ICES Physician Database data).
†Relative difference is the ratio of the intervention group mean estimate to the control group mean estimate.
‡Sample size: intervention = 16, control = 17. Sample for this outcome only includes those participants who had hospital discharge in the period 1 year following their index date.

in utilization or costs before compared with after index for the PACE intervention group was no different than the matched comparator group. Plots of crude quarterly data validated the parallel trend assumption required for the analysis (not shown).

Interpretation

We report the analysis of 5 hospital-based and cost outcomes for an RCT that provided patient-centred care for people with multimorbidity. The RCT and the propensity-matched analyses found no significant postindex differences in health care utilization or costs between intervention and control participants. For one outcome (7-d follow-up with a family physician), intervention participants had 2.48 times (RCT analysis) and 1.8 times (propensity-matched analysis) the follow-up compared with control participants, but in both analyses, 95% confidence intervals included the null value. The difference found in this study can suggest clinical and policy importance and provide hypothesis generation for future studies.

The RCT findings from this health administrative analysis (RCT and propensity-matched comparisons) are congruent with findings on patient-reported outcomes at 4 months in the Ontario arm of the PACE in MM RCT.[14] Results are also consistent with similar interventions.[11,12] Another propensity-matched study of a community intervention called Health Links for people with multiple chronic conditions in Ontario found no effect on acute hospital admissions, readmissions or timely follow-up with primary care providers 7 days after hospital discharge.[11] This study included components similar to those in the PACE in MM RCT, such as intensive care coordination, multidisciplinary care and a patient-centred coordinated care plan outlining the patient's needs, goals, providers, treatments and appointments.[11] Our results regarding the hospital admission outcome also correspond with the findings of Salisbury and colleagues,[12] who reported no difference in 15-month hospital admissions between intervention and control patients in a patient-centred RCT for management of multimorbidity. We identified other studies that tested complex interventions for people with multimorbidity, but these did not have health care utilization outcomes.[7–10]

Limitations

We conducted a pragmatic trial in which the providers, rather than the researchers, were responsible for identifying eligible patients and then recruiting them into the trial; therefore, our sample size was based on the numbers our sites were able to recruit. However, we recruited until we reached the minimum sample size to detect a difference in the means of our primary outcome, which was a total sample size of 128, not including dropouts, as described in Stewart and colleagues.[14]

Regarding the outcomes of 30-day hospital readmissions and 7-day follow-up with a family physician for patients who had at least 1 hospital admission, the comparison group is no longer equivalent to the intervention group, as we restricted the analysis to those who had a hospital admission, which happened postrandomization.

Table 3: Propensity-matched analysis: comparison of characteristics of intervention and comparator groups before and after matching

Characteristic	Before matching, no. (%)*			After matching, no. (%)*		
	Full control pool *n* = 919 027	Intervention group *n* = 82	Standardized difference	Matched controls *n* = 401	Matched intervention group *n* = 82	Standardized difference
Age at index date, yr, mean ± SD	48.1 ± 16.6	62.0 ± 13.9	0.916	62.26 ± 13.85	62.05 ± 13.89	0.004
Sex, female	500 932 (54.5)	53 (64.6)	0.207	259 (64.6)	53 (64.6)	0.001
2008 Rurality Index for Ontario	0.5 ± 3.3	0.3 ± 1.6	0.093	0.27 ± 2.18	0.26 ± 1.56	0.006
Income quintile (area)						
Q1 (lowest)	250 292 (27.2)	24 (29.3)	0.045	130 (32.4)	24 (29.3)	0.068
Q2	202 409 (22.0)	8 (9.8)	0.340	29 (7.2)	8 (9.8)	0.091
Q3	181 609 (19.8)	16 (19.5)	0.006	72 (18.0)	16 (19.5)	0.040
Q4	115 786 (12.6)	14 (17.1)	0.126	70 (17.5)	14 (17.1)	0.010
Q5 (highest)	168 931 (18.4)	20 (24.4)	0.147	100 (24.9)	20 (24.4)	0.013
History of comorbidities						
Acute MI	10 540 (1.1)	6 (7.3)	0.310	22 (5.5)	6 (7.3)	0.080
Cardiac arrhythmia	43 872 (4.8)	19 (23.2)	0.550	97 (24.2)	19 (23.2)	0.012
Asthma	136 220 (14.8)	23 (28.0)	0.327	110 (27.4)	23 (28.0)	0.011
Cancer	307 310 (33.4)	48 (58.5)	0.520	243 (60.6)	48 (58.5)	0.045
Congestive heart failure	14 121 (1.5)	16 (19.5)	0.613	66 (16.5)	16 (19.5)	0.089
COPD	19 593 (2.1)	14 (17.1)	0.524	69 (17.2)	14 (17.1)	0.007
Chronic coronary syndrome	58 931 (6.4)	24 (29.3)	0.626	116 (28.9)	24 (29.3)	0.005
Dementia	7957 (0.9)	7 (8.5)	0.369	26 (6.5)	7 (8.5)	0.084
Diabetes	121 533 (13.2)	29 (35.4)	0.534	147 (36.7)	29 (35.4)	0.033
Hypertension	243 883 (26.5)	50 (61.0)	0.740	258 (64.3)	50 (61.0)	0.071
Other mental health conditions	199 619 (21.7)	44 (53.7)	0.698	229 (57.1)	44 (53.7)	0.066
Mood or anxiety	422 683 (46.0)	64 (78.0)	0.700	313 (78.1)	64 (78.0)	0.006
Osteoarthritis	357 160 (38.9)	64 (78.0)	0.867	307 (76.6)	64 (78.0)	0.041
Osteoporosis	44 518 (4.8)	9 (11.0)	0.229	41 (10.2)	9 (11.0)	0.032
Renal disease	21 327 (2.3)	12 (14.6)	0.453	57 (14.2)	12 (14.6)	0.000
Rheumatoid arthritis	8451 (0.9)	≤ 5	0.284	20 (5.0)	≤ 5	0.021
Stroke	13 061 (1.4)	6 (7.3)	0.291	26 (6.5)	6 (7.3)	0.009
Multimorbidity (≥ 2 of 17 conditions)	532 801 (58.0)	77 (93.9)	0.926	384 (95.8)	77 (93.9)	0.089
Multimorbidity (≥ 3 of 17 conditions)	343 401 (37.4)	74 (90.2)	1.318	348 (86.8)	74 (90.2)	0.100
Use of services, mean ± SD, yr						
Family physician visits	4.5 ± 5.3	9.5 ± 9.9	0.622	10.21 ± 10.16	9.46 ± 9.91	0.087
Specialist visits	2.6 ± 5.2	12.0 ± 15.3	0.817	12.21 ± 16.71	11.96 ± 15.26	0.089
Acute admissions, urgent	0.0 ± 0.2	0.4 ± 0.9	0.599	0.37 ± 0.81	0.44 ± 0.93	0.060
Acute admissions	0.1 ± 0.3	0.5 ± 1.0	0.642	0.46 ± 0.88	0.54 ± 1.01	0.074
Emergency department visits	0.3 ± 1.0	1.3 ± 2.7	0.499	1.30 ± 2.69	1.34 ± 2.70	0.007
Total costs, yr	3001.9 ± 10 023.8	19 867.6 ± 27 900.2	0.805	18 050.08 ± 23 663.50	19 867.60 ± 27 900.19	0.026

*Except where otherwise indicated.
Note: COPD = chronic obstructive pulmonary disorder, MI = myocardial infarction, SD = standard deviation.

Table 4: Propensity-matched analysis: results for outcomes 1-year postindex date relative differences

Measure: group	Rate or mean (95% CI)		Risk ratio, post- v. predifference (95% CI)	Relative difference (95% CI)
	Before index date	After index date		
Acute hospital admissions, mean per patient-year				
PACE in MM intervention group	0.44 (0.28–0.69)	0.49 (0.26–0.90)	1.11 (0.59–2.10)	1.67 (0.82–3.38)
Comparator group	0.38 (0.30–0.50)	0.26 (0.18–0.36)	0.67 (0.50–0.89)	
Emergency department visits, mean per patient-year				
PACE in MM intervention group	1.37 (1.04–1.72)	0.95 (0.64–1.44)	0.70 (0.42–1.16)	0.93 (0.54–1.60)
Comparator group	1.34 (0.89–2.13)	1.01 (0.76–1.35)	0.76 (0.61–0.94)	
Costs, mean $ per patient-year				
PACE in MM intervention group	20 163 (14 945-27 202)	19 788 (14 200-27 574)	0.98 (0.68–1.43)	1.09 (0.70–1.68)
Comparator group	19 098 (15 100-24 156)	17 267 (12 699-23 477)	0.90 (0.76–1.08)	
30-day hospital readmissions, rate per 100 discharges*				
PACE in MM intervention group	28.33 (17.93- 44.75)	27.88 (13.07–59.47)	0.98 (0.44–2.19)	1.00 (0.39–2.60)
Comparator group	19.40 (13.55–27.78)	19.02 (11.61–31.15)	0.98 (0.58–1.66)	
7-day follow-up with family physician, rate per 100*				
PACE in MM intervention group	35.01 (22.94–53.44)	49.94 (40.34–61.82)	1.43 (0.93–2.19)	1.81 (0.99–3.30)
Comparator group	35.73 (28.26–45.19)	28.21 (19.47–40.87)	0.79 (0.51–1.22)	

Note: CI = confidence interval, PACE in MM = Patient-centred Innovations for Persons with Multimorbidity.
*Participants who were discharged from hospital in the 1-year period following their index date.

In the propensity-matched analysis, for propensity-matched controls, it was not possible to match for every baseline characteristic collected in the questionnaires as these individual-level characteristics were not available in the health administrative data and therefore could not be included. We cannot rule out the possibility of unmeasured confounding owing to the unavailability of variables such as lifestyle behaviours. In addition, the propensity-matched controls would not have been subject to any placebo effects that might have occurred within the RCT. We excluded participants who died within 1 year of the pseudo-index date, which was not a criterion applied in the RCT; therefore, the controls could have been healthier than the intervention participants. However, we excluded 4292 people who died within 1 year of the pseudo-index date (0.465% of the population), leaving a pool of 919027 for the propensity match. From the 4292, only a small number would have been accepted into the analysis; therefore, it is unlikely that the exclusion of the 4292 would have biased the results. No participants in the intervention group died in the 1 year after the intervention.

For the propensity-matched analysis, there could have been regression to the mean, in that participants were selected for high complexity, and then could have reverted to their long-term average over the 1 year postintervention. However, we attempted to mitigate this concern, by aiming to ensure equivalence in risk of regression to mean by including prior utilization patterns in the propensity matching process.

The majority of the control group in this RCT received usual care within a primary care team-based model. Usual care may have had similarities to the team-based care provided in the intervention which may affect health care utilization.

Our outcomes were limited to hospital care and direct costs of health care services, outcomes relevant to policymakers. The intervention may confer benefits aligned with outcomes that are situated in primary care, such as continuity of care or that consider patient preferences such as improved function, but not confer benefits aligned with health care utilization and costs. Our follow-up period of 1 year may not have been sufficiently long to see benefits from this complex intervention.

Conclusion

The results of this study add to the body of evidence that improving health for people with multimorbidity continues to challenge us.[12,14,15] Despite a complex patient-centred intervention, there was no significant improvement in health care utilization or cost outcomes for patients who received the PACE in MM intervention. Future research requires larger sample sizes, longer follow-up periods, recruitment of patients from family physicians in non-team-based practice models and the incorporation of a wider range of outcomes important to patients and the health care system.

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Data sharing: The data set from this study is held securely in coded form at ICES. Although data sharing agreements prohibit ICES from making the data set publicly available, access may be granted to those who meet prespecified criteria for confidential access, available at https://www.ices.on.ca/DAS. The full data set creation plan and underlying analytic code are available from the authors on request, understanding that the computer programs may rely on coding templates or macros that are unique to ICES and are therefore either inaccessible or may require modification.

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