Hip and Knee Bundled Care Evaluation

Report #2: Trends in Characteristics of Patients Receiving Hip and Knee Replacements

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About this Report

This is the second report on the evaluation of the primary unilateral hip and knee Bundled Care initiative. This second comparative effectiveness report focuses on the characteristics of patients receiving hip and knee replacements and post-acute rehabilitation settings. Our first report examined the trends in performance metrics during the first year of Bundled Care. Updated results accounting for annual trends are included in this report.

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Executive Summary

In April 2018, the Ministry of Health introduced Bundled Care for primary unilateral hip and knee replacement for a voluntary group of 33 acute care hospitals and, in April 2019, this became mandatory for all Ontario hospitals performing these procedures. Bundled Care in Ontario is associated with a bundled funding arrangement which provides a single payment rate per patient that covers non-physician costs from decision-to-treat through post-acute rehabilitation with the bundle holder held responsible for the care coordination and cost for the entire episode of care. Part of the intent of Bundled Care is more efficient use of resources and shifting care to the most appropriate/least expensive setting. Whenever there are payment reforms, such as Bundled Care, however, there is concern about patient selection (i.e. cream skimming) to reduce costs of care.

The evaluation of the Bundled Care initiative compared trends in patient characteristics, rehabilitation setting and performance metrics before (April 1, 2015, to March 31, 2018) and after (April 1, 2018, to March 31, 2019) the implementation of Bundled Care between the early adopter facilities, where approximately two-thirds of all primary unilateral hip and knee replacements occurred, and the late adopter facilities.

Time series analysis showed very few differences in trends between early and late adopter groups. We examined the characteristics of patients receiving hip and knee replacements and found no changes in joint replacement patients' demographic characteristics attributable to Bundled Care. However, patient complexity at early adopter hospitals during the bundled payment period revealed that joint replacement patients were potentially less complex, and continued monitoring of the prevalence of rheumatoid arthritis and diabetes is recommended.

Over the pre-bundle period, patients who received their hip or knee replacement at an early adopter hospital were more likely to be discharged to inpatient rehabilitation and less likely to receive home care physiotherapy services than patients discharged from late adopter hospitals. We observed a significant change in post-acute rehabilitation setting among the early adopters over the first year of implementation of Bundled Care. In particular, a large increase was observed in the proportion of joint replacement patients receiving their rehabilitation in outpatient clinics coincident with decreases in the proportions of patients receiving home care physiotherapy (hip and knee) and discharged to inpatient rehabilitation (knee only).

There were no significant changes in performance metrics attributable to Bundled Care with the exception of knee replacement length of stay - after the start of Bundled Care the rate of decrease in length of stay accelerated slightly for patients treated in early adopter hospitals. That there was no negative impact on any of the performance metrics (e.g. readmissions, ED visits, mortality, adverse events) can be interpreted as the desired outcome for the implementation of Bundled Care. However, we do not know the impact of Bundled Care and the shift in post-acute care setting on patient-reported outcome measures (PROMs), including pain and function, or on patient-experience measures. PROMs are being collected as part of Bundled Care and these data should be examined once enough longitudinal data have been collected. The patient and caregiver perspective, as well as providers' perspectives, are also needed to have a complete "Quadruple-Aim" picture of the impact of Bundled Care for primary hip and knee replacement surgery.

A. Context

The Ministry of Health (MOH) launched Bundled Care for primary unilateral hip and knee replacements for a voluntary group of hospitals in April 2018. Bundled Care is a single payment made to a bundle holder to cover the cost of all services required for an episode of care that may include multiple settings and providers. The intent of bundled payment models is to encourage greater provider coordination and, in turn, better patient transitions, reduced service duplication, and incentivizing less costly alternative care settings.

Hip and Knee Bundled Care is an extension of the six Integrated Funding Model pilot projects, which recommended that the MOH proceed with scaling Bundled Care for surgical procedures across Ontario.¹ Primary unilateral hip and knee replacements were selected as the initial surgical procedures to implement an acute and post-acute care funding bundle.

A Bundled Hip and Knee QBP Task Group (Appendix B) advised the MOH on how to define the patient cohort, the total price of the bundle, and process/outcome indicators to monitor for the hip and knee Bundled Care model. HSPN was asked to evaluate the implementation of the Hip and Knee Bundled Care initiative and participate in an MOH-Health Quality Ontario (HQO) led Bundled Hip and Knee QBP Evaluation Working Group (Appendix C).

B. Objectives

The HSPN evaluation of hip and knee Bundled Care sought to answer two main questions:

- 1. How is Bundled Care being implemented for hip/knee replacements in Ontario?
- 2. What is the impact of the primary unilateral hip and knee replacement bundles on key quality and performance metrics?

The first question was addressed through case studies using semi-structured interviews of key stakeholders in seven voluntary early adopter bundle holders and their partners.

This report addresses the second question and presents the findings from the first year of implementation using a comparative effectiveness analysis. Specifically, in this report we compare the trends in patient characteristics, rehabilitation setting and performance metrics before (April 1, 2015, to March 31, 2018) and after (April 1, 2018, to March 31, 2019) the implementation of Bundled Care between the 33 early adopter facilities and the late adopter facilities.

¹ Walker K, Embuldeniya G, Hall RE, Kirst M, Wodchis WP. Integrated Funding Models Central Evaluation. HSPRN; 2019.

C. Methods

C.1 Data Sources

Health administrative datasets used in this work include:

Discharge Abstract Database (DAD)

The DAD is compiled by the Canadian Institute for Health Information and contains administrative, clinical (diagnoses and procedures/interventions), demographic, and administrative information for all admissions to acute care hospitals, rehab, chronic, and day surgery institutions in Ontario. At ICES, consecutive DAD records are linked together to form 'episodes of care' among the hospitals to which patients have been transferred after their initial admission. This database, along with SDS, were used to capture primary unilateral hip and knee replacement patients, readmissions, as well as patient characteristics.

National Ambulatory Care Reporting System – Clinic Lite (NACRS-CL)

NACRS is compiled by the Canadian Institute for Health Information and contains administrative, clinical (diagnoses and procedures), demographic, and administrative information for all patient visits made to hospital- and community-based ambulatory care centres (emergency departments, day surgery units, hemodialysis units, and cancer care clinics). New for 2018/19, NACRS-CL was created to capture a summary record of a patient's outpatient rehabilitation services provided by organizations that partnered with a bundle holder. It is important to note that the use of NACRS-CL for hip and knee patients started with the bundle care initiative and was initially only required for patients from early adopter hospitals.

Ontario Health Insurance Plan Claims Database (OHIP)

The OHIP claims database contains information on inpatient and outpatient services provided to Ontario residents eligible for the province's publicly funded health insurance system by fee-for-service health care practitioners and "shadow billings" for those paid through non-fee-for-service payment plans. The OHIP database is used primarily by physicians, but also includes publicly funded physiotherapy visits. The main data elements include patient and provider identifiers (encrypted), code for service provided, date of service, associated diagnosis, and fee paid. This database was used to capture outpatient physiotherapy clinic visits.

Registered Persons Database (RPDB)

The RPDB provides basic demographic information (age, sex, location of residence, date of birth, and date of death for deceased individuals) for those issued an Ontario health insurance number. The RPDB also indicates the time periods for which an individual was eligible to receive publicly funded health insurance benefits and the best-known postal code for each registrant on July 1st of each year. This database was used to capture patient demographics.

Same Day Surgery (SDS)

The SDS is compiled by the Canadian Institute for Health Information and contains administrative, clinical (diagnoses and procedures), demographic, and administrative information for all patient visits made to day surgery institutions in Ontario. The main data elements include patient demographics, clinical data (diagnoses, procedures, physician), administrative data (institution/hospital number etc.), financial data, service-specific data elements for day surgery and emergency. This database, along with DAD, was used to capture hip and knee replacement surgeries.

Home Care Database (HCD)

The HCD is a clinical client centric database that captures all services that are provided by or coordinated by Local Health Integration Networks (LHIN; formerly Community Care Access Centres (CCACs)). The data elements captured include information on: client, intake, assessment, admission & discharge, diagnosis and surgical procedure, and care delivery. ICES receives home care data from the

Ontario Ministry of Health and Long-Term Care (MOHLTC). The primary purpose of the information collected through the HCD is to aid in planning and better clinical insight into clients who encounter service through LHINs/CCACs.

Wait Times Information System (WTIS)

WTIS is compiled by Cancer Care Ontario (CCO) and contains wait times for various procedures and interventions, including hip and knee replacement. WTIS data were to be aggregated and provided to the MOH and HSPN.

C.2 Patient Cohort

All patients meeting the criteria for primary unilateral hip and unilateral knee replacement surgery, as identified in the QBP Clinical Handbook,² between April 1, 2015, and March 31, 2019, were included in these analyses.

We included discharges from DAD or SDS with recorded Canadian Classification of Interventions (CCI) procedure codes 1VA53** for hip replacements or 1VG53** for knee replacements, excluding primary cement spacer procedures (codes 1.VA.53.LA-SL-N and 1.VG.53.LA-SL-N), classified as elective cases (Admission Category = 'L') and patients aged 18 years or older at admission to hospital with a valid encrypted health card number (ICES Key number). We excluded discharges with cancer-related most responsible diagnosis (MRDx) (ICD-10-CA of C** or D** recorded as MRDx), trauma-related diagnoses (ICD-10-CA of S00** - T32** recorded as MRDx) and revisions (intervention status attribute recorded as R).

Comparator Groups

Early adopters of Bundled Care were defined as those hospitals that volunteered for and received bundled payments starting April 1, 2018 (see Appendix D for the list of hospitals). All other hospitals performing unilateral hip and knee replacements were considered late adopters.³

C.3 Measures

Volumes

A count of primary hip and knee replacements meeting the cohort definition.

Patient Characteristics

We evaluated changes in patient characteristics to assess any unintended consequences, for example cream skimming, and equity concerns, specifically:

Demographics: sex (% of hip and knee joint replacement patients who were female), age (mean), and neighbourhood income quintile (% residing in a low-income neighbourhood (quintile 1-3));

Morbidities relevant to joint replacement: rheumatoid arthritis⁴ (% of hip and knee joint replacement patients with rheumatoid arthritis), diabetes mellitus⁵, obesity⁶, cardiac disease (any of: congestive heart failure, acute myocardial infarction, coronary artery disease and arrythmia) and hypertension; and

² Health Quality Ontario; Ministry of Health and Long-Term Care. Quality-based procedures: Clinical handbook for primary hip and knee replacement. Toronto: Health Quality Ontario; 2013 November. 95 p. Available from: http://www.hqontario.ca/evidence/publica-tions-and-ohtac-recommendations/clinical-handbooks.

³ The late adopters started hip and knee Bundled Care when it became mandatory in April 2019. As such, during the evaluation period reported herein, late adopters of bundled care had not yet commenced the intervention.

⁴ Widdifield J, Bombardier C, Bernatsky S, Paterson JM, Green D, Young J, Ivers N, Butt DA, Jaakkimainen RL, Thorne JC, Tu K. An administrative data validation study of the accuracy of algorithms for identifying rheumatoid arthritis: the influence of the reference standard on algorithm performance. BMC musculoskeletal disorders. (2014) 15(1):216.

⁵ Lipscombe L, Hwee J, Webster L, Shah B, Booth G, Tu K. Identifying diabetes cases from administrative data: a population-based validation study. BMC Health Services Research. (2018) 18:316.

⁶ DAD record with ICD 10 code E66* or an OHIP record with ICD 9 code 278 within 2-years of hip or knee replacement surgery discharge date.

Generic measure of morbidity/complexity: Charlson Comorbidity Index⁷ (% of hip and knee joint replacement patients with a score of 0).

Post-Acute Rehabilitation Setting

Discharge to Inpatient Rehabilitation

The percentage of inpatient hip or knee primary joint replacements discharged to inpatient rehabilitation defined using discharge disposition and institution to type variables in the DAD.

Home care Physiotherapy within 14-days

The percentage of hip or knee primary joint replacement patients who received physiotherapy in their home within 14-days of discharge from acute care. We excluded patients from hospitals that received approved agency status.⁸

Outpatient Rehabilitation

The percentage of hip or knee primary joint replacements with a physiotherapy (specialty '80' or '81') visit recorded in OHIP within 90-days of discharge or with a NACRS Clinic Lite record.

Performance Metrics

Index Event Total Length of Stay (LOS)

Average total LOS for all primary hip of knee joint replacement inpatient surgeries regardless of discharge destination.

Alternate Level of Care (ALC)

The proportion of inpatient hip and knee primary joint replacements where the patient had at least one ALC day. ALC is a designation for patients occupying a hospital bed, but who do not require the intensity of services provided in the acute care setting.⁹

Adverse Event within 90-days

The proportion of hip or knee primary joint replacements where the patient experienced an adverse event within 90 days of discharge. Adverse events include: (a) Mechanical complications; (b) Periprosthetic joint infection; (c) Acute myocardial infarction; (d) Pneumonia; (e) Sepsis/ Septicemia/Shock; (f) Surgical site bleeding; (g) Pulmonary embolism; (h) Deep vein thrombosis; (i) Urinary tract infection; and (j) In-hospital death.

Surgeon Follow-up within 12-Weeks

The proportion of hip or knee primary joint replacements where the patient had a post-operative visit with a surgeon within 12 weeks of discharge.

Risk-Adjusted ED Visit within 30-Days

Risk-adjusted proportion of patients who underwent primary hip or knee joint replacement and had an urgent ED visit within 30-days of discharge. Risk adjustment factors include age, gender, Charlson Comorbidity Index, year, and previous inpatient admissions.

Risk-Adjusted Acute Admission within 30-Days

Risk-adjusted proportion of patients who underwent primary hip or knee joint replacement and had a non-elective admission to any acute care hospital within 30-days of discharge. Risk adjustment factors include age, gender, Charlson Comorbidity Index, year, and previous inpatient admissions.

⁷ Charlson Comorbidity Index calculated using index hospital record. Deyo et al, Adapting a Clinical Comorbidity Index for use with ICD-9-CM administrative databases, J of Clinical Epidemiology, 1992 45(6):613-9.

⁸ An approved agency may arrange and/or provide home care services. Approved agencies were expected to report home care services through the provincial homecare database, but this was not done consistently.

⁹ <u>https://www.cihi.ca/en/alc</u>

Risk-Adjusted 30-day Mortality

Risk-adjusted 30-day all-cause mortality rate among patients who underwent primary hip or knee joint replacement. Risk adjustment factors include age, gender, Charlson Comorbidity Index, year, and previous inpatient admissions.

Revision within 365-Days

The proportion of hip and knee joint replacement surgeries where the patient received a revision within 365 days of discharge from hospital after primary surgery. There has not been sufficient follow-up time to have complete reporting on this outcome in the post-intervention period.

Wait Time 1

The 90th percentile wait time 1, which is the time that the patient waits for a first consultation with a clinician measured from the time the referral is received to the date the first consultation with a clinician occurs less any dates affecting readiness for consult (DARC).

Wait Time 2

The 90th percentile wait time 2, which is the time that the patient waits from the Decision to Treat (DTT) date to the date the procedure was performed.

C.4 Statistical Analyses

Our first analysis aimed to assess whether there were differences in the patient populations treated in early adopter or late adopter hospitals. Stratified by hip and knee replacements, bivariate analyses were performed to compare baseline (April 1, 2015 to March 31, 2018) patient characteristics, post-acute rehabilitation setting and performance metrics between early and late adopter hospitals. A standardized difference (std difference) ≥ 0.10 was considered a meaningful difference.

We also use time-series analysis to determine whether the trends in patient characteristics, postacute rehabilitation setting and performance metrics changed after the implementation of Bundled Care. Using an Interrupted Time Series (ITS) design, we used segmented regression to compare changes in outcomes prior to and after Bundled Care for early and late adopters. An autoregressive error model was used to correct for autocorrelation (serially correlated errors). Durbin-Watson statistics were used to diagnose autocorrelation. Backward elimination of non-significant autoregressive terms was used to select the appropriate lag. To account for seasonality, sine ($sin(2\pi*time/12)$) and cosine ($cos(2\pi*time/12)$) functions were included in each model. Fitted residuals were checked for white noise. Heteroscedasticity (non-constant variance of the error term) was tested using the portmanteau Q and Lagrange multiplier tests.

D. Findings

Pre-Bundled Care Patient Characteristics, Post-Acute Rehabilitation and Performance Metrics (April 2015 to March 2018)

Table 1 provides patient characteristics, post-acute rehabilitation and performance metrics, by early and late adopter groups, in the three-year period prior to the Bundled Care initiative. Approximately two-thirds of all primary unilateral hip and knee replacements were performed in the early adopter hospitals.

Patient Characteristics

During the baseline period, females represent 54.6% and 61.9% of primary unilateral hip and knee replacement patients, respectively, and the average hip and knee patient was 67.0 and 67.8 years of age, respectively. A socio-economic gradient was only observed in the primary unilateral hip replacement patients with more hip surgeries performed for individuals from high income neighborhoods the early adopter group: 16.1% of surgeries in the early adopted group were performed on patients residing in the lowest

neighbourhood income quintile (Q1) while 25.3% were performed on patients residing in the highest neighbourhood income quintile (Q5), whereas in the late adopter group, the proportions were 17.8% (Q1) and 21.1% (Q5) (std difference=0.1 for Q5).

The overall prevalence of rheumatoid arthritis, diabetes and obesity among hip replacement patients in the baseline period were 4.5%, 19.5% and 8.9%, respectively, and 5.8%, 28.3% and 13.7%, respectively, for knee replacement patients. The prevalence of cardiac disease and hypertension were 25.9% and 63.1% among hip replacement patients and 27.9% and 72.7% among knee replacement patients; cardiac disease was higher among hip replacement patients from early adopter hospitals (27.2% vs 23.1%, std difference=0.1). The majority of primary unilateral hip and knee replacement patients had a Charlson Comorbidity Index of 0 (83.6% and 78.5%, respectively). We found no demographic or comorbidity differences between patients in early and late adopter hospitals in the pre-bundle period (standardized differences < 0.10), except as noted for cardiac disease and the highest income quintile.

Post-Acute Rehabilitation Setting

In the pre-bundle period, patients who received their hip or knee replacement at an early adopter hospital were more likely to be discharged to inpatient rehabilitation than late adopter hospitals (7.2% vs 3.7%, std difference=0.15, for hip and 4.5% vs 2.4%, std difference=0.11, for knee) and less likely to receive home care physiotherapy services than patients discharged from late adopter hospitals (42.4% vs 51.1%, std difference=0.18, for hip and 35.6% vs 49.4%, std difference=0.28, for knee). However, in terms of outpatient rehabilitation, hip replacement patients from early adopter hospitals were less likely to receive outpatient rehabilitation than those from late adopter hospitals (18.0% vs 22.7%, std difference=0.12), while for knee replacement patients, there were no meaningful differences between early and late adopters in the proportion of patients receiving outpatient rehabilitation (26.7% vs 27.9%, std difference=0.03).

Performance Metrics

In terms of performance over the pre-Bundled Care period, there were no meaningful differences in performance between early and late adopters during the baseline period (std differences<0.10) except that early adopters had lower rates of surgeon follow-up at 12-weeks for hip replacements compared to late adopters (94.8% vs 97.7%, std difference=0.15). The overall mean LOS was 3.0 days and 2.8 days for hip and knee, respectively. Very few hip and knee patients had at least one ALC day (2.2% and 1.3% for hip and knee, respectively). Overall, primary unilateral hip and knee procedures had positive post-index event outcomes; there were low rates of 30-day acute admissions (3.4% and 2.8% for hip and knee, respectively), 30-day mortality (0.1% and 0.1% for hip and knee, respectively), 90-day adverse events (2.1% and 2.3% for hip and knee, respectively), and 365-day revisions (1.6% and 1.1% for hip and knee, respectively). However, the 30-day ED visit rate was 15.5% and 17.1% for primary unilateral hip and knee replacements, respectively.

		Hip			Кпее				
		Overall (N=45,809)	Early Adopter Bundled Care (N=30,946)	Late Adopter Bundled Care (N=14,863)	Std. Dif. [¥]	Overall (N=77,727)	Early Adopter Bundled Care (N=50,381)	Late Adopter Bundled Care (N=27,346)	Std. Dif. [¥]
Patient Characteristics									
Sex	F	25,016 (54.6%)	17,165 (55.5%)	7,851 (52.8%)	0.05	48,144 (61.9%)	31,403 (62.3%)	16,741 (61.2%)	0.02
	Μ	20,793 (45.4%)	13,781 (44.5%)	7,012 (47.2%)		29,583 (38.1%)	18,978 (37.7%)	10,605 (38.8%)	
Age	Mean ± SD	67.03 ± 11.15	67.15 ± 11.02	66.79 ± 11.41	0.03	67.75 ± 9.05	67.82 ± 9.00	67.62 ± 9.12	0.02
Neighbourhood Income Quintile	1 lowest	7,617 (16.6%)	4,972 (16.1%)	2,645 (17.8%)	0.05	13,848 (17.8%)	8,536 (17.0%)	5,312 (19.4%)	0.06
	2	8,836 (19.3%)	5,745 (18.6%)	3,091 (20.8%)	0.06	16,091 (20.7%)	10,260 (20.4%)	5,831 (21.3%)	0.02
	3	9,024 (19.7%)	6,069 (19.6%)	2,955 (19.9%)	0.01	16,408 (21.1%)	10,737 (21.3%)	5,671 (20.8%)	0.01
	4	9,335 (20.4%)	6,309 (20.4%)	3,026 (20.4%)	0	15,466 (19.9%)	10,073 (20.0%)	5,393 (19.7%)	0.01
	5 highest	10,949 (23.9%)	7,815 (25.3%)	3,134 (21.1%)	0.1	15,836 (20.4%)	10,721 (21.3%)	5,115 (18.7%)	0.06
Specific Conditions	Rheumatoid Arthritis	2,040 (4.5%)	1,485 (4.8%)	555 (3.7%)	0.05	4,535 (5.8%)	2,972 (5.9%)	1,563 (5.7%)	0.01
	Diabetes	8,915 (19.5%)	6,025 (19.5%)	2,890 (19.4%)	0	21,994 (28.3%)	14,332 (28.4%)	7,662 (28.0%)	0.01
	Obesity	4,062 (8.9%)	2,780 (9.0%)	1,282 (8.6%)	0.01	10,660 (13.7%)	6,796 (13.5%)	3,864 (14.1%)	0.02
	Cardiac	11,854 (25.9%)	8,424 (27.2%)	3,430 (23.1%)	0.1	21,664 (27.9%)	14,685 (29.1%)	6,979 (25.5%)	0.08
	Hypertension	28,908 (63.1%)	19,872 (64.2%)	9,036 (60.8%)	0.07	56,537 (72.7%)	37,119 (73.7%)	19,418 (71.0%)	0.06
Charlson Comorbidity Index [€]	0	38,304 (83.6%)	25,704 (83.1%)	12,600 (84.8%)	0.05	60,983 (78.5%)	38,965 (77.3%)	22,018 (80.5%)	0.08
	1	5,316 (11.6%)	3,693 (11.9%)	1,623 (10.9%)	0.03	12,551 (16.1%)	8,467 (16.8%)	4,084 (14.9%)	0.05
	2	1,791 (3.9%)	1,259 (4.1%)	532 (3.6%)	0.03	3,558 (4.6%)	2,513 (5.0%)	1,045 (3.8%)	0.06
	3+	398 (0.9%)	290 (0.9%)	108 (0.7%)	0.02	635 (0.8%)	436 (0.9%)	199 (0.7%)	0.02
Post-Acute Rehabilitation Setting									
Discharge to Inpatient Rehabilitation		2,761 (6.1%)	2,216 (7.2%)	545 (3.7%)	0.15	2,949 (3.8%)	2,282 (4.5%)	667 (2.4%)	0.11
Home care PT within 14-Days [†]		18,229 (45.6%)	10,636 (42.4%)	7,593 (51.1%)	0.18	27,806 (41.2%)	14,308 (35.6%)	13,498 (49.4%)	0.28
Outpatient Rehabilitation		8,942 (19.5%)	5,566 (18.0%)	3,376 (22.7%)	0.12	21,093 (27.1%)	13,461 (26.7%)	7,632 (27.9%)	0.03
Performance Metrics									
Length of stay	Mean ± SD	3.01 ± 3.10	3.10 ± 3.25	2.82 ± 2.77	0.09	2.84 ± 1.92	2.86 ± 2.01	2.79 ± 1.73	0.04
Alternate Level of Care		998 (2.2%)	721 (2.3%)	277 (1.9%)	0.03	1,013 (1.3%)	730 (1.5%)	283 (1.0%)	0.04
Acute Admission within 30-Days		1,548 (3.4%)	995 (3.2%)	553 (3.7%)	0.03	2,179 (2.8%)	1,353 (2.7%)	826 (3.0%)	0.02
ED Visit within 30-Days		7,118 (15.5%)	4,750 (15.3%)	2,368 (15.9%)	0.02	13,297 (17.1%)	8,375 (16.6%)	4,922 (18.0%)	0.04
30-Day Mortality Rate		54 (0.1%)	33 (0.1%)	21 (0.1%)	0.01	60 (0.1%)	41 (0.1%)	19 (0.1%)	0
Adverse Event within 90-Days		969 (2.1%)	595 (1.9%)	374 (2.5%)	0.04	1,785 (2.3%)	1,133 (2.2%)	652 (2.4%)	0.01
Surgeon Follow-Up within 12-Weeks		43,879 (95.8%)	29,351 (94.8%)	14,528 (97.7%)	0.15	75,374 (97.0%)	48,627 (96.5%)	26,747 (97.8%)	0.08
Revision within 365-Days		744 (1.6%)	464 (1.5%)	280 (1.9%)	0.03	871 (1.1%)	548 (1.1%)	323 (1.2%)	0.01

Table 1. Baseline Characteristics of Primary Unilateral Hip and Knee Replacement Patients from Early and Late Adopters of Bundled Care Pre-Bundled Care Initiative (April 2015-March 2018)

* Standardized differences 0.1 or greater are considered to meaningful differences between groups; Charlson score was based on diagnostic codes found in the index record;

⁺ Hospitals that received approved agency status during the evaluation period were excluded (N=6 hospitals).

Interrupted Time Series Analysis (see Appendix A for regression estimates)

This section displays time-series graphs of patient characteristics, post-acute rehabilitation setting and performance measures for early versus late-adopter sites over a 4-year period from 2015-2019, with the Bundled Care start for early adopters indicated at April 2018. Predicted scores were generated from interrupted time-series regression models using sine and cosine functions to adjust for seasonality.

Volumes

During the first month of the pre-Bundled Care period (April 2015), an estimated 1,154 and 1,964 primary unilateral hip and knee replacements, respectively, were performed in Ontario with approximately two-thirds performed at early adopters of Bundled Care. In both the early and late adopters, prior to the start of the intervention, the number of surgeries was increasing at a total rate of 6.7 and 11.1 additional surgeries per month overall for hip and knee, respectively. There was no significant difference in the rate of increase for early and late adopters of Bundled Care. Each year, the lowest volumes were during the summer months (July and August), as well as during December.

For hip replacement, there was no immediate change in volumes attributable to the start of Bundled Care. However, for knee replacements, there was an immediate and statistically significant jump in the volume of knee surgeries for early adopters right after the Bundled Care initiative began (April 2018), which was not observed in the late adopters. During the year after Bundled Care implementation (April 2018 to March 2019), monthly knee replacement volume continued its significant upward trend (i.e., positive slope) at late adopters. By comparison, monthly volumes were decreasing significantly over the post-intervention period for early adopters. Nevertheless, the overall volume of knee procedures completed at early adopters during the first year of Bundled Care (April 2018 to March 2019) increased relative to the year prior.



Primary Unilateral Knee Replacement



Figure 1. Total Primary Unilateral Hip (left) and Knee (right) Replacement Volume, Monthly (April 2015 to March 2019), by Early and Late Bundled Care Adopter

Patient Characteristics

The contrast of patient characteristics for early and late adopters provides an indication of whether there are any differences in the types of patients treated in the respective groups and whether the composition of patients changed for either group after the start of the Bundled Care initiative (as an indication of patient selection).

Age

At the outset of the baseline period (April 2015), the estimated average age of hip and knee replacement patients from early adopters was 67.0 and 67.7 years of age, respectively, and was similar in late adopters. There were no significant changes in mean age of hip or knee replacement patients over the evaluation period for either early or late adopters of Bundled Care. Similarly, there were no significant changes in the percentage of hip and knee patients over 75 years old attributable to Bundled Care. Bundled Care did not lead to patient selection on the basis of age.



Primary Unilateral Knee Replacement

Figure 2. Total Primary Unilateral Hip (left) and Knee (right) Replacement Mean Age (Years), Monthly (April 2015 to March 2019), by Early and Late **Bundled Care Adopter**

Sex

At the outset of the baseline period (April 2015), 55.1% and 62.6% of hip and knee replacement patients from early adopter facilities were female vs 52.9% and 61.5% at late adopter facilities, respectively. In the three-year baseline period, the percentage of primary unilateral hip replacement patients that were female was stable in early and late adopter hospitals.

The percentage of female primary unilateral hip and knee replacement patients from early adopter hospitals remained steady following the start of Bundled Care on April 1, 2018. Similarly, no changes were observed for primary unilateral knee replacement patients from late adopter hospitals. However, in April 2018 there was an immediate -6.1% (p<0.001) decrease in the percentage of female primary unilateral hip replacement patients from late adopter hospitals, which was followed by a 0.75% (p<0.0001) increase per month. By the end of the first year of Bundled Care, the percentage of female hip patients from late adopters returned to near baseline levels. Longer-term data are required to see if the noted trajectory continue, or if the percentage of female patients from late adopters re-stabilizes. Nevertheless, given there was no change among early adopters, Bundled Care does not appear to be associated with patient selection on the basis of sex.



Figure 3. Total Primary Unilateral Hip (left) and Knee (right) Replacement Percentage Female, Monthly (April 2015 to March 2019), by Early and Late Bundled Care Adopter

Neighbourhood Income Quintile

At the outset of the baseline period (April 2015), the estimated percentage of hip and knee replacement patients who resided in lower income quintile neighbourhoods (quintile 1-3) was higher in the late adopter hospitals than the early adopter hospitals (58.9% vs 53.6% (p<0.0001) and 61.7% vs 59.5% (p<0.001), for hip and knee, respectively). In the three-year baseline period, the percentage of hip replacements performed on patients from lower income neighbourhoods remained stable but decreased slightly for knee replacement patients from the early adopter group (p<0.05). This decrease was not significantly different from the baseline trend in the late adopter group.

There were no significant changes in level or slope in the post-intervention period (April 2018-March 2019) for primary unilateral hip or knee replacement patients from early or late adopter hospitals. Bundled Care did not result in any change in the proportion of joint replacement surgeries being done on patients from lower income neighbourhoods in the one-year following the start of the Bundled Care funding initiative.



Figure 4. Total Primary Unilateral Hip (left) and Knee (right) Replacement Percentage Low Neighbourhood Income (Quintile 1-3), Monthly (April 2015 to March 2019), by Early and Late Bundled Care Adopter

Rheumatoid Arthritis

At the outset of the baseline period (April 2015), the estimated percentage of primary unilateral hip replacement patients with rheumatoid arthritis was higher in early adopter hospitals (4.9% vs 3.9%, p<0.05, for late adopters), but lower for knee replacement patients (5.6% vs 6.5%, p<0.001, for late adopters). In the three-year baseline period, this remained stable (no statistically significant change) for hip replacements performed at early and late adopter hospitals. The baseline trend for knee replacement patients from early adopters was increasing, while at late adopter hospitals the baseline trend was decreasing.

Following the roll out of the Bundled Care initiative (April 2018) there was a statistically significant jump (p<0.05) in the percentage of hip replacements performed on patients with rheumatoid arthritis followed by a small decreasing trend throughout the rest of the fiscal year at early adopter hospitals. These changes were not significantly different than those observed for the late adopter hospitals.

With respect to knee replacements performed on patients with rheumatoid arthritis, a decreasing trend in the post-bundled period was observed for early adopters (p<0.05) as well as an observed increase in rheumatoid arthritis among late adopter sites after the start of Bundled Care. This change, while statistically significant, did not result in substantially lower percentages of joint replacement patients with rheumatoid arthritis. Late adopter sites appeared to have picked up the volumes of patients with rheumatoid arthritis that were not treated in early adopter sites. Additional follow-up time is required to determine whether this decreasing trend in the percentage of knee replacement patients with rheumatoid arthritis from early adopters continues.



Figure 5. Total Primary Unilateral Hip (left) and Knee (right) Replacement Percentage of Patients with Rheumatoid Arthritis, Monthly (April 2015 to March 2019), by Early and Late Bundled Care Adopter

Diabetes Mellitus

At the outset of the baseline period (April 2015), the estimated percentage patients undergoing hip replacement surgery who had diabetes was statistically significantly lower at early adopter hospitals compared to late adopters (18.7% vs 20.1%, p<0.05), but among knee replacement patients, diabetes was similar at early and late adopter hospitals (27.9% vs 28.3%). In the three-year baseline period, the percentage of hip and knee replacement patients with diabetes was increasing significantly (p<0.05) at early adopter hospitals, but not at late adopter hospitals.

There were no statistically significant changes in level or slope in the percentage of hip replacement patients from early adopter hospitals in the post-Bundled Care funding period. For early adopter hospitals, there was a significant decrease (p<0.05) in slope in the percentage of knee replacement patients with diabetes following the start of Bundled Care. This change in slope, while statistically significantly different than that observed for the late adopters (p<0.05), did not result in substantially lower percentages of knee replacement patients with diabetes. Additional follow-up time is required to determine whether this decreasing trend in early adopters continues.



Figure 6. Total Primary Unilateral Hip (left) and Knee (right) Replacement Percentage of Patients with Diabetes Mellitus, Monthly (April 2015 to March 2019), by Early and Late Bundled Care Adopter

Obesity

At the outset of the baseline period (April 2015), there was no difference between early and late adopters in the estimated percentage of patients undergoing hip replacement who were obese (8.8% vs 9.0%), while there were significantly fewer obese knee replacement patients from early adopters (14.1% vs 16.1%, p< 0.001). In the three-year baseline period, there were no significant changes in the percentage of hip replacements being performed on obese patients in either early or late adopters. For knee replacements, the percentage of obese patients was decreasing significantly faster at late adopter hospitals than at early adopters (p<0.05).

For both hip and knee replacements, the post-intervention trend for early adopters was not significantly different from the trend during the baseline period suggesting Bundled Care did not have an impact on the proportion of joint replacement surgeries being done on obese patients.



Figure 7. Total Primary Unilateral Hip (left) and Knee (right) Replacement Percentage Obese, Monthly (April 2015 to March 2019), by Early and Late Bundled Care Adopter

Primary Unilateral Knee Replacement

Cardiac Disease

At the outset of the baseline period (April 2015), the estimated percentage of hip and knee replacement patients who had a history of cardiac disease was higher at early adopter hospitals than at late adopter hospitals (27.5% vs 23.9%, p<0.0001, for hip and 29.6% vs 26.8%, p<0.0001, for knee). In the pre-Bundled Care period, there were no significant changes in the percentage of hip or knee replacement patients with cardiac disease from either early or late adopter hospitals. The percentage of primary unilateral hip and knee replacement patients with a history of cardiac disease from early adopter hospitals remained steady following the start of Bundled Care on April 1, 2018. Bundled Care did not appear to be associated with selecting patients on the basis of a history of cardiac disease.



Figure 8. Total Primary Unilateral Hip (left) and Knee (right) Replacement Percentage of Patients with a History of Cardiac Disease, Monthly (April 2015 to March 2019), by Early and Late Bundled Care Adopter

Hypertension

At the outset of the baseline period (April 2015), the estimated percentage of hip and knee replacement patients who had hypertension was higher at early adopter hospitals than at late adopter hospitals (65.4% vs 62.5%, p<0.05, for hip and 74.5% vs 72.4%, p<0.05, for knee). There were no significant changes in the percentage of hip or knee replacement patients with hypertension over the evaluation period for either early or late adopters of Bundled Care. Bundled Care did not lead to patient selection on the basis of hypertension.



Figure 9. Total Primary Unilateral Hip (left) and Knee (right) Replacement Percentage of Patients with Hypertension, Monthly (April 2015 to March 2019), by Early and Late Bundled Care Adopter

Primary Unilateral Knee Replacement

Charlson Comorbidity Index

At the outset of the baseline period (April 2015), the estimated percentage of hip and knee replacement patients who had a Charlson Comorbidity Index (CCI; calculated on index hospital record) of 0 was similar in early and late adopter hospitals, 82.3% vs 83.0% and 76.8% vs 77.7%, respectively. The percentage of hip replacement patients with a Charlson Comorbidity Index of 0 remained relatively stable throughout the evaluation period for early adopters and was not statistically significantly different from the changes observed for late adopters. For knee replacement patients, in the three-year baseline period the percentage of patients with CCI of 0 was increasing significantly for late adopters, but stable for early adopters. In the post-intervention period, there was no statistically significant change in level or slope for the early adopters, while there was a reduction in slope for the late adopters. There were no changes in Charlson Comorbidity Index attributable to Bundled Care.



Figure 10. Total Primary Unilateral Hip (left) and Knee (right) Replacement Percentage Charlson Comorbidity Index 0, Monthly (April 2015 to March 2019), by Early and Late Bundled Care Adopter

Post-Acute Rehabilitation Setting

The contrast of post-acute rehabilitation setting for early and late adopters provides an indication of whether post-acute care setting changed for either group after the start of the Bundled Care initiative.

Discharged to Inpatient Rehabilitation

Overall, less than 10% of hip and knee replacement patients were discharged to inpatient rehabilitation during the baseline period. At the outset of the baseline period (April 2015), the estimated percentage of primary unilateral hip and knee replacement patients discharged to inpatient rehabilitation was higher for the early adopters than late adopters (7.8% vs 3.4%, p<0.0001 and 5.0% vs 2.3%, p<0.0001, respectively).

The percentage of patients discharged to inpatient rehabilitation was decreasing for early adopters throughout the evaluation period (both pre- and post-intervention), but the rate of decrease accelerated significantly for knee replacement patients, decreasing by 0.2% (p<0.001) per month following the start of Bundled Care. A similar pattern was observed for hip replacement patients from early adopters but was not statistically significant. These changes in slope were not observed among patients from late adopters suggesting the decrease in inpatient rehabilitation following joint replacement surgery is associated with the Bundled Care initiative.

Home care Physiotherapy within 14-days¹⁰

In April 2016,¹¹ the estimated percentage of primary unilateral hip and knee replacement patients receiving home care physiotherapy within 14-days of discharge was 44.6% and 38.9% for the early adopters and 46.6% and 44.5% for the late adopters. In the two-year baseline period, the percentage of joint replacement patients from early adopters who received home care physiotherapy remained stable. For knee replacement patients from late adopters, the pre-intervention slope was significantly greater than that for early adopters.

In the one-year period following the start of the Bundled Care initiative, the rate of decrease accelerated significantly, by 1.3% and 1.0% per month (p<0.05) for hip and knee replacements, respectively, in the early adopter hospitals. This change is in contrast to that observed for knee replacement patients from late adopters where no change was observed. This suggests an association between the Bundled Care initiative and a significant decrease in the percentage of patients receiving home care physiotherapy following joint replacement surgery (knee replacement in particular).

Outpatient Rehabilitation

Overall less than 25% of hip and knee replacement patients were receiving publicly funded outpatient-based rehabilitation in the baseline period. At the outset of the baseline period (April 2015), the estimated percentage of primary unilateral hip replacement patients receiving publicly funded outpatient rehabilitation was significantly lower for early adopters relative to late adopters (14.2% vs 17.9%, p<0.05), but for knee replacement patients, outpatient rehabilitation for patients from early and late adopters was not significantly different (23.4% vs 21.2%). In the three-year baseline period, there was a gradual increase in outpatient rehabilitation use in both early and late adopters.

At the start of Bundled Care (April 2018), there was an immediate increase in the percentage of hip and knee replacement patients from early adopter hospitals utilizing outpatient rehabilitation (+23.8%, p<0.0001, and +30.5%, p < 0.0001, respectively). This result, however, may be conflated by the launch of an additional outpatient rehabilitation reporting system, NACRS-CL, at the same time. Prior to Bundled Care, publicly funded outpatient rehabilitation was under Episode of Care (EOC) funding and recorded in the MOH's Medical Claims Electronic Data Transfer system and ICES' OHIP dataset. Only after April 1, 2018, was publicly funded outpatient rehabilitation, funded through the Bundled Care initiative,

¹⁰ Hospitals that received approved agency status during the evaluation period were excluded (N=6 hospitals).

¹¹ Due to substantial heteroscedasticity of the 2015-16 data, the baseline period was reduced to two years starting April 2016.

recorded in NACRS-CL. In the year following the start of Bundled Care, there was a slight decreasing trend among knee replacement patients from early adopters, but because the NACRS-CL is a discharge dataset it is not inclusive of all patients receiving outpatient rehabilitation in the 2018/19 fiscal year, particularly in the last quarter. See Appendix E from summary outpatient rehabilitation statistics. Bundled Care appears to be associated with an increase in the percentage of patients reported as receiving publicly funded outpatient rehabilitation following hip and knee replacement.



Primary Unilateral Hip Replacement



••• Early Adopter — Early Adopter Linear Trend ---Early Adopter Predicted





Primary Unilateral Knee Replacement

Bundled Care Start

Apr 2019

Apr 2018





Performance Metrics

The contrast of performance metrics for early and late adopters provides an indication of whether there are any differences in performance between the respective groups and whether the performance measures changed for either group after the start of the Bundled Care initiative.

Length of Stay

At the outset of the pre-bundled period (April 2015), the estimated mean LOS for primary unilateral hip and knee replacement was 3.4 days and 3.2 days for early adopters and 3.2 days and 3.1 days for late adopters, respectively. In both groups and for both procedures, mean LOS was decreasing over time. After the start of the Bundled Care initiative (April 2018), the rate of decline in average LOS accelerated for primary unilateral knee replacements performed at early adopter hospitals, while the rate of decline remained unchanged for late adopter hospitals. No significant change in level or slope was observed for hip replacements in the post-intervention period. Bundled Care was associated with a very small change in LOS for knee replacement patients.



Figure 12. Total Primary Unilateral Hip (left) and Knee (right) Replacement Length of Stay, Monthly (April 2015 to March 2019), by Early and Late Bundled Care Adopter

Alternate Level of Care

At the outset of the pre-bundled period (April 2015), the estimated percentage of primary unilateral hip and knee replacement patients with at least one ALC day was 2.9% and 2.0% days for early adopters and 2.0% and 1.1% among late adopters, respectively. In the pre-intervention period, early adopter hospitals had a significant decreasing trend in the percentage of hip and knee patients with at least one ALC day. This decreasing slope was significantly different than the trend observed for late adopter hospitals. The start of Bundled Care funding in April 2018, was not, however, associated with any significant change in the slope or level of the percentage of hip and knee replacement patients with at least one ALC day from either the early or late adopter hospitals.



Figure 13. Total Primary Unilateral Hip (left) and Knee (right) Replacement Percentage ALC, Monthly (April 2015 to March 2019), by Early and Late Bundled Care Adopter

Adverse Event within 90-Days

At the outset of the pre-bundled period (April 2015), the estimated percentage of primary unilateral hip and knee replacement patients with an adverse event within 90-days of discharge was 1.9% and 2.4% for early adopters and 2.4% and 2.4% for late adopters, respectively. There were no statistically significant changes in the percentage of hip and knee replacement patients with an adverse event within 90-days of discharge from early or late adopter hospitals during the evaluation period.



Primary Unilateral Knee Replacement

Figure 14. Total Primary Unilateral Hip (left) and Knee (right) Replacement Percentage Adverse Event within 90-Days, Monthly (April 2015 to March 2019), by Early and Late Bundled Care Adopter

Surgeon Follow-up within 12-Weeks

At the outset of the pre-bundled period (April 2015), the estimated percentage of primary unilateral hip and knee replacement patients with a surgeon follow-up within 12-weeks of discharge was 94.5% and 96.7% for early adopters and 98.0% and 98.1% for late adopters, respectively. There was no significant change in the percentage of patients with a follow-up visit with a surgeon during the study period.



Figure 15. Total Primary Unilateral Hip (left) and Knee (right) Replacement Percentage Surgeon Follow-up within 12-Weeks, Monthly (April 2015 to March 2019), by Early and Late Bundled Care Adopter

Risk-Adjusted ED Visit within 30-Days

At the outset of the pre-bundled period (April 2015), the risk adjusted percentage of unilateral hip and knee patients with an ED visit within 30-days of discharge was 13.9% and 16.1% for early adopters and 15.6% and 17.8% for late adopters, respectively. During the pre-intervention period (April 2015 to March 2018), there was a significant increase over time for hip replacement patients from early adopter hospitals which was not observed in the late adopters. There were no statistically significant changes in slope or level following the start of the intervention for either procedure. Bundled Care was not associated with a change in risk-adjusted ED visits within 30-days for joint replacement patients.





Primary Unilateral Knee Replacement

Risk-Adjusted Acute Admission within 30-Days

At the outset of the pre-bundled period (April 2015), the percentage of primary unilateral hip and knee replacement patients who experienced an acute admission within 30-days of discharge was 3.1% and 2.9% for early adopters and 4.0% and 3.5% for late adopters, respectively. There were no statistically significant changes in risk adjusted acute admission within 30-days during the evaluation period.



Figure 17. Total Primary Unilateral Hip (left) and Knee (right) Replacement Percentage Acute Admission within 30-Days, Monthly (April 2015 to March 2019), by Early and Late Bundled Care Adopter

Risk-adjusted Mortality within 30-Days

Primary Unilateral Hip Replacement

The risk adjusted percentage of patients who died within 30-days of discharge was approximately 0.1% throughout the evaluation period.



Primary Unilateral Knee Replacement

Figure 18. Total Primary Unilateral Hip (left) and Knee (right) Replacement Percentage Dead within 30-Days, Monthly (April 2015 to March 2019), by Early and Late Bundled Care Adopter

Wait Time 1 – Time from Referral to First Orthopaedic Surgical Appointment

Health Quality Ontario indicates that 90 percent of priority 4 patients referred for joint replacement surgery, who account for most of these referrals (87.4% in 2019¹²), should have their first visit with the surgeon within 182 days.¹³ At the outset of the pre-bundled period (April 2015), the 90th percentile time from referral to first orthopaedic surgical appointment for hip and knee replacements was shorter for early adopters than late adopters (153 vs 191 days, p<0.0001, for hip and 163 vs 181 days, for knee). During the baseline period, wait time 1 remained reasonably steady for hip and knee patients from early and late adopters.

After the start of Bundled Care, no significant change in level or slope of the 90th percentile time from referral to first orthopaedic surgical appointment was observed for hip or knee replacement patients from early adopters of Bundled Care. There was, however, a significant difference in the change in slope in the post-Bundled Care period for hip replacement patients from late adopters. Nevertheless, because no changes were observed among early adopters, we find no impact from Bundled Care on wait time 1.



Primary Unilateral Hip Replacement 90th Percentile Wait Time 1 Primary Unilateral Knee Replacement 90th Percentile Wait Time 1

Figure 19. Total Primary Unilateral Hip (left) and Knee (right) Replacement 90th Percentile Wait Time 1 (Days), Monthly (April 2015 to March 2019), by Early and Late Bundled Care Adopter

¹² Priority 4 patients are defined as the progress of the disease/disability is minimal <a href="https://www.hqontario.ca/System-Performance/Wait-Times-for-Surgeries-and-Procedures/Wait-Times-for-Orthopedic-Surgeries-including-Hip-Replacement-and-Knee-Replacement/Time-to-Patients-First-Orthopedic-Surgeries-Including-Hip-Replacement-and-Knee-Replacement/Time-to-Patients-First-Orthopedic-Surgeries-Including-Hip-Replacement-and-Knee-Replacement/Time-to-Patients-First-Orthopedic-Surgeries-Including-Hip-Replacement-and-Knee-Replacement/Time-to-Patients-First-Orthopedic-Surgeries-Including-Hip-Replacement-Includi

¹³ https://www.hgontario.ca/System-Performance/Measuring-System-Performance/Measuring-Wait-Times-for-Orthopedic-Surgeries

Wait Time 2 – Time from Decision to Having Orthopaedic Surgery

Health Quality Ontario indicates that 90 percent of priority 4 patients receiving joint replacement surgery, who account for most of these surgeries (81.4% in 2019¹⁴), should have their surgery within 182 days of decision to treat surgically.¹⁵ At the outset of the pre-bundled period (April 2015), 90% of patients waited no longer than 187 and 192 days for hip and knee replacement surgery, respectively, from the time the decision was made to have surgery to the time the surgery was done (wait time 2) at the early adopters and 192 and 202 days, respectively, at late adopters. In the pre-Bundled Care period, wait time 2 was stable for hip replacements at early adopters, while it was increasing by over 4 days per month for late adopters. For knee replacement patients, over the pre-Bundled Care period wait time 2 was increasing at both early and later adopters. However, the rate of increase was significantly greater for late adopters than for early adopters; on average, an increase of 6 vs 2 days per month and, by the end of the baseline period, wait time 2 was well above the target for both hip and knee replacements among late adopters.

After the start of Bundled Care, there were no significant changes in level or slope for the early adopters. For late adopters, however, the slope leveled off for hip replacements in the year following the start of Bundled Care. Nevertheless, because no changes in level or slope were observed following the start of Bundled Care among early adopters, we find no impact from Bundled Care on wait time 2.



Figure 20. Total Primary Unilateral Hip (left) and Knee (right) Replacement 90th Percentile Wait Time 2 (Days), Monthly (April 2015 to March 2019), by Early and Late Bundled Care Adopter

¹⁴ Priority 4 patients are defined as the progress of the disease/disability is minimal https://www.hqontario.ca/System-Performance/Wait-Times-for-Surgeries-and-Procedures/Wait-Times-for-Orthopedic-Surgeries-including-Hip-Replacement-and-Knee-Replacement/Time-from-Decision-to-Having-Orthopedic-Surgery

¹⁵ https://www.hqontario.ca/System-Performance/Measuring-System-Performance/Measuring-Wait-Times-for-Orthopedic-Surgeries

E. Conclusions

In this report we examined trends in patient characteristics, post-acute rehabilitation settings and performance metrics before and after the start of Bundled Care. Given the focus of Bundled Care is, in part, to improve efficiency through a single payment for an episode that includes acute and rehabilitative care, bundle holders are incentivized to reduce their costs.

One way of reducing costs is through patient selection (i.e., cream skimming). This does not appear to be happening to a great extent in Ontario. Bundled Care had no impact on the demographic profiles of hip and knee replacement patients.

When we looked at patient morbidities (rheumatoid arthritis, diabetes mellitus and obesity) previously reported to be associated with higher cost or increased length of stay^{16,17,18,19}, we found no conclusive evidence of wide-spread cream skimming. However, we did observe a small but statistically significant change in trend (decrease) for the percentage of knee replacement patients with rheumatoid arthritis and diabetes in the year following the Bundled Care initiative among the early adopters that was not observed among the late adopter hospitals. This suggests continued monitoring of the proportion of knee replacements patients with rheumatoid arthritis and diabetes is warranted. It should be explored whether these conditions (rheumatoid arthritis in particular) create a differential cost that is not accounted for in the pre-set Bundled Care price.

In an attempt to reduce costs, shifting care to a less expensive setting where appropriate is expected to occur following the implementation of Bundled Care. We observed significant shifts in the post-acute rehabilitation setting among early adopters of Bundled Care. Specifically, for early adopters, there were reductions in the percentage of joint replacement patients discharged to inpatient rehabilitation (knee) and receiving home-based rehabilitation (hip and knee) over time and a corresponding dramatic immediate increase (~25-30%) in the percentage of patients attending outpatient rehabilitation. It will be important to determine whether the shifts in rehabilitation setting following the implementation of the Bundled Care initiative have an impact on patient outcomes and experience.

Bundled Care did not result in any significant changes in the recommended performance metrics, except for a very small acceleration in the rate of decrease in knee replacement length of stay, which can be interpreted as the desired outcome for the implementation of Bundled Care. However, we do not know the impact on patient-reported outcome measures (PROMs) or patient-experience measures post-joint replacement. PROMs are being collected as part of Bundled Care and these data should be examined once sufficient longitudinal data have been collected. The patient and caregiver perspective as well as providers' perspectives are also needed to have a complete "Quadruple-Aim" picture of the impact of Bundled Care for primary hip and knee replacement surgery.

¹⁶ El Bitar YF, Illingworth KD, Scaife SL, Horberg JV, Saleh KJ. Hospital Length of Stay following Primary Total Knee Arthroplasty: Data from the Nationwide Inpatient Sample Database. The Journal of Arthroplasty. (2015) 30(10):1710-1715.

¹⁷ Kim SH. Morbid obesity and excessive hospital resource consumption for unilateral primary hip and knee arthroplasty. J Arthroplasty. (2010) 25(8):1258-66.

¹⁸ Silber JH, Rosenbaum PR, Kelz RR, Reinke CE, Neuman MD, Ross RN, et al. Medical and financial risks associated with surgery in the elderly obese. Ann Surg. (2012) 256(1):79-86.

¹⁹ Goodman SM, Ravi B, Hawker G. Outcomes in rheumatoid arthritis patients undergoing total joint arthroplasty. International Journal of Clinical Rheumatology. (2014) 9(6):585-593.

Appendix A – ITS Estimates

	Age		Sex (Fe	emale)	Neighbourhood Income Quintile (1-3)	
	Hip (Years (SE))	Knee (Years (SE))	Hip (% (SE))	Knee (% (SE))	Hip (% (SE))	Knee (% (SE))
Early Adopter	67.01 (0.16)***	67.67 (0.1)***	55.14 (0.51)***	62.64 (0.41)***	53.62 (0.42)***	59.52 (0.39)***
Late Adopter	-0.13 (0.22)	-0.01 (0.14)	-2.26 (0.71)*	-1.12 (0.57)	5.23 (0.59)***	2.16 (0.55)**
Time (April 1, 2015, to March 31, 2018)	0.01 (0.01)	0.01 (0)	0.02 (0.03)	-0.02 (0.02)	0.04 (0.02)	-0.04 (0.02)*
Time (April 1, 2015, to March 31, 2018) x Late Adopter	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.03)	0 (0.03)	-0.06 (0.03)	0.04 (0.03)
Bundled Care Start (April 1, 2018)	-0.15 (0.36)	0.27 (0.22)	-0.55 (1.17)	0.1 (1.04)	0.43 (1.07)	0.52 (1.17)
Bundled Care Start (April 1, 2018) x Late Adopter	-0.13 (0.48)	-0.18 (0.3)	-5.58 (1.56)**	0.24 (1.38)	-0.33 (1.41)	-1.09 (1.57)
Time (April 1, 2018, to March 31, 2019)	0.01 (0.04)	-0.03 (0.03)	-0.04 (0.14)	-0.07 (0.13)	-0.24 (0.13)	-0.07 (0.15)
Time (April 1, 2018, to March 31, 2019) x Late Adopter	0.07 (0.06)	0.07 (0.04)	0.78 (0.19)***	0.02 (0.17)	0.27 (0.17)	0.09 (0.2)

*** p<0.0001; ** p<0.001; * p<0.05

	Rheumatoid Arthritis		Diabete	s Mellitus	Obesity	
	Hip (% (SE))	Knee (% (SE))	Hip (% (SE))	Knee (% (SE))	Hip (% (SE))	Knee (% (SE))
Early Adopter	4.85 (0.27)***	5.61 (0.16)***	18.69 (0.3)***	27.89 (0.27)***	8.82 (0.39)***	14.1 (0.37)***
Late Adopter	-0.99 (0.38)*	0.87 (0.22)**	1.38 (0.41)*	0.42 (0.37)	0.14 (0.54)	2.02 (0.51)**
Time (April 1, 2015, to March 31, 2018)	0 (0.01)	0.02 (0.01)*	0.04 (0.01)*	0.03 (0.01)*	0.01 (0.02)	-0.03 (0.02)
Time (April 1, 2015, to March 31, 2018) x Late Adopter	0 (0.02)	-0.06 (0.01)***	-0.08 (0.02)**	-0.04 (0.02)*	-0.03 (0.03)	-0.08 (0.03)*
Bundled Care Start (April 1, 2018)	1.37 (0.6)*	0.28 (0.46)	-1.63 (0.87)	1.1 (0.68)	0.43 (0.86)	0.59 (0.81)
Bundled Care Start (April 1, 2018) x Late Adopter	-0.91 (0.81)	-0.69 (0.62)	3.32 (1.14)*	-1.14 (0.89)	-0.47 (1.15)	-1.04 (1.09)
Time (April 1, 2018, to March 31, 2019)	-0.21 (0.07)*	-0.14 (0.06)*	0.05 (0.11)	-0.2 (0.08)*	-0.04 (0.1)	0.11 (0.1)
Time (April 1, 2018, to March 31, 2019) x Late Adopter	0.1 (0.1)	0.27 (0.08)**	-0.15 (0.14)	0.34 (0.11)*	0.11 (0.14)	0.14 (0.13)



	Cardiac Disease		Hypert	tension	Charlson Comorbidity Index (No morbidity)		
	Hip (% (SE))	Knee (% (SE))	Hip (% (SE))	Knee (% (SE))	Hip (% (SE))	Knee (% (SE))	
Early Adopter	27.52 (0.46)***	29.55 (0.29)***	65.4 (0.72)***	74.48 (0.57)***	82.34 (0.5)***	76.83 (0.45)***	
Late Adopter	-3.63 (0.64)***	-2.77 (0.41)***	-2.9 (1.01)*	-2.1 (0.79)*	0.62 (0.7)	0.89 (0.63)	
Time (April 1, 2015, to March 31, 2018)	-0.01 (0.02)	-0.03 (0.01)	-0.07 (0.04)	-0.04 (0.03)	0.04 (0.02)	0.02 (0.02)	
Time (April 1, 2015, to March 31, 2018) x Late Adopter	-0.04 (0.03)	-0.04 (0.02)	-0.02 (0.05)	-0.03 (0.04)	0.06 (0.03)	0.13 (0.03)***	
Bundled Care Start (April 1, 2018)	-0.49 (1.05)	0.01 (0.86)	0.23 (1.6)	-0.12 (1.25)	0.66 (1.1)	-0.57 (0.99)	
Bundled Care Start (April 1, 2018) x Late Adopter	3.19 (1.4)*	0.27 (1.16)	0.41 (2.15)	0.52 (1.69)	-0.08 (1.49)	-0.8 (1.34)	
Time (April 1, 2018, to March 31, 2019)	-0.12 (0.13)	0.05 (0.11)	-0.07 (0.19)	-0.01 (0.15)	-0.03 (0.13)	0.23 (0.12)	
Time (April 1, 2018, to March 31, 2019) x Late Adopter	0.01 (0.17)	0.16 (0.15)	0.2 (0.26)	0.06 (0.21)	-0.06 (0.18)	-0.34 (0.16)*	

*** p<0.0001; ** p<0.001; * p<0.05

	Discharged to Inpatient Rehabilitation		Home Care PT	within 14-Days	Outpatient Rehabilitation	
	Hip (% (SE))	Knee (% (SE))	Hip (% (SE))	Knee (% (SE))	Hip (% (SE))	Knee (% (SE))
Early Adopter	7.76 (0.32)***	4.97 (0.17)***	44.64 (2.7)***	38.94 (2.57)***	14.2 (1.36)***	23.43 (0.84)***
Late Adopter	-4.39 (0.44)***	-2.69 (0.23)***	2 (3.9)	5.53 (3.09)	3.65 (1.83)*	-2.19 (1.18)
Time (April 1, 2015, to March 31, 2018)	-0.03 (0.02)*	-0.02 (0.01)*	-0.13 (0.11)	-0.14 (0.11)	0.22 (0.07)*	0.19 (0.04)***
Time (April 1, 2015, to March 31, 2018) x Late Adopter	0.05 (0.02)*	0.03 (0.01)*	0.24 (0.16)	0.29 (0.13)*	0.07 (0.09)	0.2 (0.06)*
Bundled Care Start (April 1, 2018)	-0.06 (0.7)	0.82 (0.41)*	0.52 (3.22)	-2.71 (2.04)	23.78 (1.88)***	30.47 (1.87)***
Bundled Care Start (April 1, 2018) x Late Adopter	-2.4 (0.95)*	-0.77 (0.55)	1.84 (4.17)	-2.73 (2.57)	-21.21 (2.54)***	-30.9 (2.49)***
Time (April 1, 2018, to March 31, 2019)	-0.12 (0.08)	-0.17 (0.05)**	-1.28 (0.43)*	-0.95 (0.31)*	-0.51 (0.35)	-0.76 (0.24)*
Time (April 1, 2018, to March 31, 2019) x Late Adopter	0.32 (0.12)*	0.17 (0.07)*	0.9 (0.54)	1.04 (0.35)*	-0.7 (0.38)	-0.14 (0.3)

	Volume		Length	of Stay	Alternate Level of Care	
	Hip (# (SE))	Knee (# (SE))	Hip (Days (SE))	Knee (Days (SE))	Hip (% (SE))	Knee (% (SE))
Early Adopter	788.11 (13.79)***	1274.52 (28.29)***	3.41 (0.04)***	3.17 (0.02)***	2.86 (0.16)***	1.97 (0.11)***
Late Adopter	-421.77 (19.39)***	-585.18 (39.61)***	-0.23 (0.06)**	-0.09 (0.02)***	-0.88 (0.23)**	-0.91 (0.16)***
Time (April 1, 2015, to March 31, 2018)	4.05 (0.66)***	7.19 (1.22)***	-0.02 (0)***	-0.02 (0)***	-0.03 (0.01)**	-0.03 (0.01)***
Time (April 1, 2015, to March 31, 2018) x Late Adopter	-1.42 (0.92)	-3.26 (1.78)	0 (0)	0 (0)	0.02 (0.01)*	0.03 (0.01)*
Bundled Care Start (April 1, 2018)	-1.02 (30.71)	117.86 (54.44)*	-0.09 (0.1)	0.03 (0.04)	0.05 (0.42)	0.33 (0.29)
Bundled Care Start (April 1, 2018) x Late Adopter	-30.82 (40.05)	-147.28 (69.5)*	0.05 (0.13)	-0.11 (0.06)	-0.36 (0.57)	-0.23 (0.39)
Time (April 1, 2018, to March 31, 2019)	-2.14 (3.82)	-20.34 (6.86)*	-0.01 (0.01)	-0.01 (0.01)*	-0.03 (0.05)	-0.02 (0.04)
Time (April 1, 2018, to March 31, 2019) x Late Adopter	5.8 (5.05)	23.77 (8.76)*	0.01 (0.02)	0.02 (0.01)*	0.02 (0.07)	0.02 (0.05)

*** p<0.0001; ** p<0.001; * p<0.05

	Adverse Event	within 90-Days	Surgeon Follov We	v-Up within 12- eks	ED Visits within 30-Days	
	Hip (% (SE))	Hip (% (SE))	Hip (% (SE))	Hip (% (SE))	Hip (% (SE))	Knee (% (SE))
Early Adopter	1.85 (0.17)***	2.43 (0.16)***	94.48 (0.39)***	96.72 (0.21)***	13.86 (0.45)***	16.09 (0.42)***
Late Adopter	0.59 (0.24)*	-0.04 (0.22)	3.52 (0.55)***	1.37 (0.3)***	1.73 (0.62)*	1.67 (0.59)*
Time (April 1, 2015, to March 31, 2018)	0.01 (0.01)	-0.01 (0.01)	0.02 (0.02)	-0.01 (0.01)	0.05 (0.02)*	0.02 (0.02)
Time (April 1, 2015, to March 31, 2018) x Late Adopter	0 (0.01)	0.01 (0.01)	-0.03 (0.03)	0 (0.01)	-0.07 (0.03)*	-0.02 (0.03)
Bundled Care Start (April 1, 2018)	0.01 (0.39)	-0.15 (0.34)	-0.45 (0.87)	0.13 (0.52)	0.37 (1.16)	0.75 (0.94)
Bundled Care Start (April 1, 2018) x Late Adopter	-0.81 (0.52)	0.14 (0.46)	0.68 (1.17)	-0.22 (0.7)	1.2 (1.54)	0.7 (1.26)
Time (April 1, 2018, to March 31, 2019)	-0.02 (0.05)	0.03 (0.04)	0.03 (0.11)	0.04 (0.06)	-0.17 (0.14)	-0.21 (0.11)
Time (April 1, 2018, to March 31, 2019) x Late Adopter	0.08 (0.06)	-0.04 (0.06)	-0.03 (0.14)	-0.02 (0.09)	0.12 (0.19)	0.12 (0.15)

	Acute Admissio	n within 30-Days	Mortality wi	thin 30-Days
	Hip (% (SE))	Hip (% (SE))	Hip (% (SE))	Knee (% (SE))
Early Adopter	3.14 (0.22)***	2.87 (0.15)***	0.12 (0.03)**	0.12 (0.03)**
Late Adopter	0.82 (0.3)*	0.61 (0.21)*	0.01 (0.04)	-0.03 (0.04)
Time (April 1, 2015, to March 31, 2018)	0.01 (0.01)	0 (0.01)	0 (0)	0 (0)
Time (April 1, 2015, to March 31, 2018) x Late Adopter	-0.02 (0.02)	-0.01 (0.01)	0 (0)	0 (0)
Bundled Care Start (April 1, 2018)	-0.33 (0.54)	0.49 (0.37)	-0.04 (0.08)	0 (0.07)
Bundled Care Start (April 1, 2018) x Late Adopter	1.05 (0.72)	-0.23 (0.5)	-0.01 (0.1)	0.12 (0.09)
Time (April 1, 2018, to March 31, 2019)	0.02 (0.07)	-0.07 (0.04)	0.01 (0.01)	0 (0.01)
Time (April 1, 2018, to March 31, 2019) x Late Adopter	-0.09 (0.09)	0.02 (0.06)	-0.01 (0.01)	-0.02 (0.01)

*** p<0.0001; ** p<0.001; * p<0.05

	Wait	Time 1	Wait 1	lime 2
	Hip (Days (SE))	Knee (Days (SE))	Hip (Days (SE))	Knee (Days (SE))
Early Adopter	152.57 (4.94)***	162.79 (6.62)***	186.52 (4.79)***	191.59 (4.14)***
Late Adopter	38.09 (6.96)***	17.99 (9.3)	5.63 (7.92)	10.33 (5.38)
Time (1 April 2015 to 31 March 2018)	-0.36 (0.24)	0.32 (0.31)	0.41 (0.23)	1.8 (0.18)***
Time (1 April 2015 to 31 March 2018) x Late Adopter	-0.55 (0.34)	-0.07 (0.44)	3.95 (0.38)***	3.92 (0.27)***
Bundled Care Start (1 April 2018)	-9.86 (10.38)	-20.07 (12.92)	-16.05 (14.2)	-17.67 (12.66)
Bundled Care Start (1 April 2018) x Late Adopter	-15.95 (14.15)	7.26 (17.78)	-5.53 (17.55)	-31.4 (17.23)
Time (1 April 2018 to 31 March 2019)	-1 (1.31)	-1.79 (1.6)	0.67 (1.9)	-0.3 (1.64)
Time (1 April 2018 to 31 March 2019) x Late Adopter	4.38 (1.71)*	0.91 (2.19)	-7.77 (2.18)**	-2.95 (2.18)

OHT CENTRAL EVALUATION - Formative Evaluation: Findings from the Organizing for OHTs Survey

Appendix B – Bundled Hip/Knee QBP Task Group Membership

Fredrika Scarth (Co-Chair) - MOH Patti Cochrane (Co-Chair) - Trillium Health Partners **Daniel Ball - William Osler Health System** Dr. Nigel Clements - Trillium Health Partners Pete Crvenkovski - Erie St. Clair LHIN Imtiaz Daniel - Ontario Hospital Association Dr. Jeffrey Gollish - Holland Orthopedic & Arthritic Centre Erik Hellsten - Health Quality Ontario Charissa Levy – Rehabilative Care Alliance/GTA Rehab Network Sherry McGeough - Central CCAC Scott McLeod - Central West LHIN Malcolm Moffat - Sunnybrook Health Sciences Centre Tomi Nieminen - St. Michael's Hospital Dr. Peter Nord - Providence Healthcare /Rehab Care Alliance **Tom Peirce - HNHB CCAC Stephen Peterson - Health Quality Ontario Chris Sulway - Toronto Central LHIN** Dr. Jim Waddell - St. Michael's Hospital

Secretariat:

Debra Bell - Home and Community Care Branch Allison Costello - HQO Liaison and Program Development Branch Yasmin Kassam - HQO Liaison and Program Development Branch Jillian Paul - Policy and Innovation Branch Neil McMullin - Policy and Innovation Branch Mehul Mehta - Health Sector Models Branch Jenny Moloney - Policy and Innovation Branch Bisola Otepola - HQO Liaison and Program Development Branch Audrey Pereira - Health Sector Models Branch Simon Rabinovitch - Policy and Innovation Branch Jane Wang - HQO Liaison and Program Development Branch Lilly Whitham - HQO Liaison and Program Development Branch



Appendix C – Bundled Hip/Knee QBP Evaluation Working Group Membership

Margo Orchard (co-chair) - MOH Stephen Petersen (co-chair) – Health Quality Ontario Irfan Dhalla - Health Quality Ontario Erik Hellsten - Health Quality Ontario Michael Beckett - Health Quality Ontario Naushaba Degani - Health Quality Ontario Kevin Walker - HSPN Walter Wodchis - HSPN **Bisola Otepola - MOH** Fredrika Scarth - MOH Kamil Malikov - MOH Lilly Whitham - MOH Neil McMullin - MOH Qing Huang - MOH Imtiaz Daniel - Ontario Hospital Association Dean Fergusson - Ottawa Hospital Research Institute Danielle Jane - St Michael's Hospital Hans Kreder - Sunnybrook Hospital Chris Sulway - Toronto Central Local Health Integration Network Nancy Kraetschmer - Toronto Central Local Health Integration Network Gillian Hawker - Women's College Hospital, University of Toronto, ICES

Appendix D – Early Bundled Care Adopter Hospitals

Windsor Regional Hospital **Bluewater Health Chatham-Kent Health Alliance** St Josephs Health Care System-Hamilton **Joseph Brant Memorial Hospital** Hamilton Health Sciences Corp **Niagara Health System** William Osler Health Centre Halton Healthcare Services Corp **Trillium Health Centre Toronto East General Hospital (The)** Women's College Hospital University Health Network Sunnybrook Health Sciences Centre Mount Sinai Hospital **Providence St Josephs and St Michaels Healthcare** North York General Hospital Southlake Regional Health Centre Markham Stouffville Hospital **Ross Memorial Hospital Peterborough Regional Health Centre** Lakeridge Health Corporation **Quinte Healthcare Corporation Kingston Health Sciences Centre Hospital Montfort Queensway-Carleton Hospital Royal Victoria Hospital Soldiers Memorial Hospital Health Sciences North Dryden Regional Health Centre** Lake-of-the-Woods District Hospital **Riverside Health Care Facility Thunder Bay Regional Health Sciences Centre**

Appendix E – NACRS-CL Summary Statistics

Joint Replacement	Variable	N	Mean	Median	Maxi-	Mini-
Unilateral Hip Replacement	Time in OP rehabilitation (days)	3687	47.0	43	352	1
	Time to first OP visit (days)	3666	25.5	18	296	0
	RN visits	14	2.3	1	17	1
	RN duration (minutes)	14	71.8	45	360	15
	RPN visits	175	5.9	6	14	1
	RPN duration (minutes)	175	88.9	90	210	15
	OT visits	n<6	SUPP	SUPP	SUPP	SUPP
	OT duration (minutes)	n<6	120.0	160	185	15
	OTA visits	7	1.0	1	1	1
	OTA duration (minutes)	7	44.3	40	70	30
	PT visits	3573	4.7	4	45	1
	PT duration (minutes)	3577	168.2	135	1465	15
	PTA visits	666	4.4	4	21	1
	PTA duration (minutes)	1197	126.6	80	1950	6
	SPL visits	0				
	SPL duration (minutes)	0				
	CDA visits	0				
	CDA duration (minutes)	0				
	SW visits	n<6	SUPP	SUPP	SUPP	SUPP
	SW duration (minutes)	n<6	SUPP	SUPP	SUPP	SUPP
	Other visits	0				
	Other duration (minutes)	0				
Unilateral Knee Replacement	Time in OP rehabilitation (days)	7770	48.3	43	358	1
	Time to first OP visit (days)	7737	10.1	6	365	0
	RN visits	207	6.8	7	19	1
	RN duration (minutes)	207	106.3	108	435	10
	RPN visits	437	6.1	6	18	1
	RPN duration (minutes)	437	92.1	90	270	15
	OT visits	7	6.9	7	20	1
	OT duration (minutes)	7	283.1	255	650	12
	OTA visits	15	1.5	1	3	1
	OTA duration (minutes)	15	70.7	40	300	15
	PT visits	7143	9.2	8	49	1
	PT duration (minutes)	7144	239.7	203	1689	1
	PTA visits	2274	6.1	5	40	1
	PTA duration (minutes)	4494	173.3	135	1903	5
	SPL visits	n<6	SUPP	SUPP	SUPP	SUPP
	SPL duration (minutes)	n<6	SUPP	SUPP	SUPP	SUPP
	CDA visits	0				
	CDA duration (minutes)	0			•	
	SW visits	6	7.3	6.5	18	1
	SW duration (minutes)	7	208.6	170	585	20
	Other visits	n<6	SUPP	SUPP	SUPP	SUPP
	Other duration (minutes)	n<6	SUPP	SUPP	SUPP	SUPP