Supplemental Online Content

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This supplemental material has been provided by the authors to give readers additional information about their work.
eAppendix 1. Cohort determination criteria

Inclusion criteria using the Medicare Master Beneficiary Summary (MBSF) File (2013-2017)

- Beneficiaries residing in CJR and non-CJR MSAs
- Fee-for-service beneficiaries identified as those with fee-for-service Medicare coverage for 12 months in the year
- Beneficiaries between 65-99 years of age
- Old age and not end-stage renal disease as a reason for Medicare entitlement
- Beneficiaries who were alive at the end of the calendar year
- Beneficiaries with no missing data for race/ethnicity, dual-eligibility, or sex

Beneficiaries were attributed to the MSA determined using their zip code at the end of the year.

Beneficiary-year observations in MBSF files (2013 to 2017)
291,492,546

Observations excluded:
- Not residing in CJR treatment/control MSAs (n=113,994,591)
- Not covered by fee-for-service Medicare for entire year (n=64,148,247)
- <65 years or >99 years (n=19,027,299)
- ESRD or old reason for entitlement (n=652,669)
- Expired at end of calendar year (n=3,761,420)
- Sex not classified as male or female (n=21)

Beneficiary-year observations
N=89,908,299
Beneficiaries
N=25,315,251
Inclusion criteria using the Medicare Provider Analysis and Review file (MedPAR) (2013-2017)

- Medicare Severity Diagnosis Related Group (MS-DRG) codes 469 and 470
- Meet MBSF inclusion criteria listed above
- Short, inpatient stays
- Hospitals reimbursed by the Inpatient Prospective Payment System
- Medicare as the primary payor
- Alive during the 90-day episode
- Non-fracture related, elective stays
- Enrolled in Parts A and B of Medicare at the time of admission
- Hospitals not participating in Model 1 or the risk-bearing phase of Models 2 and 3 of the Bundled Payments for Care Improvement initiative
- Inpatient stays for total hip replacement and total knee replacement
- Non-duplicate inpatient stays
- Qualifying stays that do not occur during the 90-day episode of a previous qualifying stay

Inpatient stays in MedPAR files from 2013 to 2017 (N=89,218,592)

Inpatient stays excluded:
- Not admitted for MS-DRG 469/470 (n=85,578,540)
- Did not meet MBSF inclusion criteria listed above (n=2,385,064)
- Not admitted for short, inpatient stays (n=6,198)
- Not admitted to hospitals reimbursed by the Inpatient Prospective Payment System (n=1,764)
- Non-elective stays (n=182,375)
- Medicare not primary payor for inpatient stay (n=67,677)
- Expired during 90-day episode (n=451)
- Admitted for fracture (n=7,073)
- Not enrolled in Medicare Parts A and B at admission (n=17,750)
- Admitted to hospital participating in BPCI Model 1 or in risk-bearing phase of Models 2 or 4 (n=128,457)
- Not admitted for total hip or total knee replacement (n=5,750)
- Duplicate observation (n=103)
- Qualifying stay during the episode of previous stay (both stays/episodes dropped) (n=26,891)

Inpatient stays (N=810,499)
Beneficiaries (N=713,397)
Inclusion criteria from merging the MBSF and MedPAR files (2013-2017)

Note: The files were merged at the beneficiary-level. Two binary indicators (one for hip and one for knee replacements) were created to represent whether a beneficiary had one or more qualifying stay during the year.

- Beneficiaries with joint replacements that meet CJR criteria or beneficiaries who did not undergo any joint replacements
- Beneficiaries with diagnosis of rheumatoid arthritis/osteoarthritis.
- No hip fracture claims

Beneficiary-year cohort (2013-2017):
MBSF (N=89,908,299)
Medpar (N=713,397)

Observations excluded:
- Beneficiaries who underwent joint replacements but the beneficiary/episode did not meet CJR criteria (n=228,431)
- Beneficiaries without rheumatoid arthritis/osteoarthritis (n=64,752,568)
- With hip fracture during the year (n=328,571)

Observations (2013-2017)
- 24,598,729 beneficiary-year
- 9,624,461 beneficiaries
- 250,168 beneficiaries with total hip replacement
- 474,751 beneficiaries with total knee replacement
eAppendix 2. Key variables, model estimation, and sensitivity analysis

Hypotheses for parallel trends assumption

Null hypothesis: In the pre-CJR period, the use of THRs/TKRs for beneficiaries with ADRD (compared to those without ADRD) is not statistically significantly different between treatment and control MSAs.

Alternate hypothesis: In the pre-CJR period, the use of THRs/TKRs for beneficiaries with ADRD (compared to those without ADRD) is statistically significantly different between treatment and control MSAs.

Test for parallel trends assumption for triple differences models

To assess whether the trends in the use of joint replacements for Medicare beneficiaries with or without ADRD were parallel in the period before the CJR was implemented (parallel trends assumption for the triple differences models), we estimated the following models (separate for hip and knee replacements). The data for these models was limited to 2013-2015 (pre-CJR period).

\[
\begin{align*}
\hat{f}(E(Y_{pmt})) &= \beta_0 + \beta_1 \times ADRD_{pmt} + \beta_2 \times CJR_m + \beta_3 \times ADRD_{pmt} \times CJR_m + \beta_4 \times Year_t \\
&\quad + \beta_5 \times Year_t \times ADRD_{pmt} + \beta_6 \times Year_t \times CJR_m + \beta_7 \times Year_t \times ADRD_{pmt} \times CJR_m \\
&\quad + \beta_8 \times X_{pmt} + \beta_{10} \times MSA_m
\end{align*}
\]

\(Y_{pmt}\): Binary indicator of whether patient \(p\) residing in MSA \(m\) in year \(t\) underwent hip (or knee) replacement

\(f(\cdot)\): Linear identity function

\(CJR_m\): Binary indicator of whether MSA \(m\) was a CJR or non-CJR MSA

\(Year_t\): Categorical indicator of the year

\(X_{pmt}\): Vector of patient covariates include age, sex, and 25 chronic conditions identified from the MBSF-CC file

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\( MSA_m \): Fixed effects of MSA represented using a categorical indicator

\( ADRD_{pmt} \): A categorical indicator of ADRD or not.

We used the Wald test to separately test for the statistical significance of \( \beta_5, \beta_6, \) and \( \beta_7 \). A p-value <0.05 on the test for any of the three estimates in a model represented a violation of the parallel trends assumption.

**Results of the parallel trends tests for triple differences models**

The parallel trends tests were statistically significant only for hip replacements in the main analysis.

**Hypotheses for triple differences model:**

Null hypothesis: With CJR implementation, the change in the use of THRs/TKRs for beneficiaries with ADRD (compared to those without ADRD) is not statistically significantly different between treatment and control MSAs.

Alternate hypothesis: With CJR implementation, the change in the use of THRs/TKRs for beneficiaries with ADRD (compared to those without ADRD) is statistically significantly different between treatment and control MSAs.

**Model estimation for triple differences models**

We estimated the following triple differences models (separate for hip and knee replacements) to assess the differential effect of the CJR. The triple differences approach includes estimating three differences: First, the difference between the pre- and post-CJR rates for each ADRD/non-ADRD group in CJR and non-CJR MSAs (difference 1). Second, the difference in difference 1 between CJR and non-CJR MSAs for each ADRD/non-ADRD group (difference 2). Third, the difference in difference 2 between beneficiaries with ADRD compared to those without ADRD (difference 3).
Because of the violation of the parallel trends assumption, we included interactions of $Year_t$ with $ADRD_{pmt}$ and $CJR_m$ (for the hip replacement models) to account for the differential trends in the pre-CJR period.\textsuperscript{1,2}

\[
f[E(Y_{pmt})] = \beta_0 + \beta_1 \times ADRD_{pmt} + \beta_2 \times CJR_m + \beta_3 \times ADRD_{pmt} \times CJR_m + \beta_4 \times Year_t \\
+ \beta_5 \times Post_t + \beta_6 \times Post_t \times ADRD_{pmt} + \beta_7 \times Post_t \times CJR_m \\
+ \beta_8 \times Post_t \times ADRD_{pmt} \times CJR_m + \beta_9 \times X_{pmt} + \beta_{10} \times MSA_m \\
+ \beta_{11} \times Year_t \times ADRD_{pmt} + \beta_{12} \times Year_t \times CJR_m + \beta_{13} \times Year_t \times ADRD_{pmt} \times CJR_m
\]

$Post_t$ is a binary indicator for the CJR implementation phase (Years 2013-2015=0, year 2017=1). The interpretation of other terms is similar to those described previously. $\beta_9$ is the triple differences estimate for CJR’s association hip/knee replacement use for beneficiaries with ADRD as compared to beneficiaries without ADRD.

We used Stata/MP 16.1 for Unix to estimate the models. We used Stata’s margins and lincom commands to test the study hypotheses.
eAppendix 3. Weighting strategy to account for MSA selection probability

We used the method by the Lewin Group to account for an MSA’s probability of selection into the treatment (CJR MSAs) or control (non-CJR MSAs) group. In this approach, the CJR MSAs were assigned a weight of 1 and the non-CJR MSAs were assigned weights to represent the CJR MSAs. These weights for the non-CJR MSAs were obtained by dividing the number of CJR MSAs in each of the 8 strata (constructed by the CMS using quartiles of pre-period episode spending and whether the MSA had above or below median population) by the number of non-CJR MSAs in that stratum.

Source: Lewin Group, CMS Comprehensive Care for Joint Replacements Model: Performance Year 2 Evaluation Report – Appendices, June 2019, Page 29.
**eTable 1. Chronic Conditions for Medicare beneficiaries with a diagnosis of rheumatoid arthritis / osteoarthritis residing in CJR and non-CJR MSAs in 2013**

| Beneficiaries<sup>a</sup> | CJR MSAs | Non-CJR MSAs | Total   | p-value<sup>c</sup> |
|---------------------------|----------|---------------|---------|----------------------|
| N                         | 2,167,927| 2,520,736     | 4,688,663|                      |
| Chronic Conditions<sup>b</sup>: (%) |          |               |         |                      |
| *Acute myocardial infarction* | 18,409 (0.85) | 21,714 (0.86) | 40,123 (0.86) | 0.15 |
| *Anemia*                  | 816,200 (37.65) | 808,494 (32.07) | 1,624,694 (34.65) | <0.001 |
| *Asthma*                  | 167,301 (7.72) | 188,782 (7.49) | 356,083 (7.59) | <0.001 |
| *Atrial fibrillation*     | 255,003 (11.76) | 298,636 (11.85) | 553,639 (11.81) | 0.005 |
| *Benign prostatic hyperplasia* | 208,414 (9.61) | 213,485 (8.47) | 421,899 (9.00) | <0.001 |
| *Breast cancer*           | 101,522 (4.68) | 115,242 (4.57) | 216,764 (4.62) | <0.001 |
| *Cataract*                | 543,316 (25.06) | 611,046 (24.24) | 1,154,362 (24.62) | <0.001 |
| *Chronic Kidney Disease*  | 454,869 (20.98) | 538,214 (21.35) | 993,083 (21.18) | <0.001 |
| *Chronic Obstructive Pulmonary Disease* | 312,479 (14.41) | 360,419 (14.30) | 672,898 (14.35) | <0.001 |
| *Colorectal cancer*       | 33,931 (1.57) | 38,050 (1.51) | 71,981 (1.54) | <0.001 |
| *Congestive Heart Failure* | 451,112 (20.81) | 487,287 (19.33) | 938,399 (20.01) | <0.001 |
| *Depression*              | 442,826 (20.43) | 505,636 (20.06) | 948,462 (20.23) | <0.001 |
| *Diabetes*                | 759,416 (35.03) | 799,106 (31.70) | 1,558,522 (33.24) | <0.001 |
| *Endometrial cancer*      | 9,584 (0.44) | 10,487 (0.42) | 20,071 (0.43) | <0.001 |
| *Glaucoma*                | 323,323 (14.91) | 339,793 (13.48) | 663,116 (14.14) | <0.001 |
| *Hyperlipidemia*          | 1,346,437 (62.11) | 1,524,309 (60.47) | 2,870,746 (61.23) | <0.001 |
| *Hypertension*            | 1,619,670 (74.71) | 1,876,351 (74.44) | 3,496,021 (74.56) | <0.001 |
| *Hypothyroidism*          | 457,063 (21.08) | 526,900 (20.90) | 983,963 (20.99) | <0.001 |
| *Ischemic Heart Disease*  | 900,111 (41.52) | 946,776 (37.56) | 1,846,887 (39.39) | <0.001 |
| *Lung cancer*             | 22,438 (1.03) | 25,765 (1.02) | 48,203 (1.03) | 0.17 |
| *Osteoporosis*            | 288,136 (13.29) | 289,654 (11.49) | 577,790 (12.32) | <0.001 |
| *Prostate cancer*         | 83,373 (3.85) | 98,570 (3.91) | 181,943 (3.88) | <0.001 |
| *Stroke/ Transient ischemic attack* | 117,821 (5.43) | 135,967 (5.39) | 253,788 (5.41) | 0.05 |

Abbreviations: CJR: Comprehensive Care for Joint Replacement Model; MSA: Metropolitan Statistical Area; ADRD: Alzheimer Disease and Related Dementias; %: Column percentage.

Note: <sup>a</sup>Data from the 2013 Master Beneficiary Summary File – Base and Chronic Conditions Segment; <sup>b</sup>Chronic Conditions present at the end of the year as determined by the claims criteria; <sup>c</sup>p-values for Kruskal-Wallis tests (for continuous variables) or chi-square tests (for categorical variables) that test for the distribution of characteristics across CJR and non-CJR MSAs.
eTable 2. Descriptive statistics for Medicare beneficiaries with a diagnosis of rheumatoid arthritis / osteoarthritis residing in CJR and non-CJR MSAs who underwent hip replacement in 2013

|                                | CJR MSAs | Non-CJR MSAs | Total   | p-value<sup>c</sup> |
|--------------------------------|----------|--------------|---------|---------------------|
| **Patients<sup>a</sup>**       |          |              |         |                     |
| N                              | 20,935   | 26,215       | 47,150  |                     |
| ADRD: %                        | 1,589 (7.59) | 1,785 (6.81) | 3,374 (7.16) | 0.001               |
| Age in years: Mean (SD)        | 74.74 (6.66) | 74.52 (6.55) | 74.62 (6.60) | 0.001               |
| Female: %                      | 13,003 (62.11) | 16,273 (62.08) | 29,276 (62.09) | 0.94                |
| Race: %                        |          |              |         | <0.001              |
| Asian                          | 126 (0.60) | 83 (0.32)    | 209 (0.44) |                     |
| Hispanic                       | 115 (0.55) | 53 (0.20)    | 168 (0.36) |                     |
| Non-Hispanic Black             | 955 (4.56) | 1,161 (4.43) | 2,116 (4.49) |                     |
| Non-Hispanic White             | 19,355 (92.45) | 24,468 (93.34) | 43,823 (92.94) |                     |
| North American Native          | 31 (0.15) | 56 (0.21)    | 87 (0.18)  |                     |
| Unknown                        | 178 (0.85) | 197 (0.75)   | 375 (0.80)  |                     |
| Other<sup>d</sup>              | 175 (0.84) | 197 (0.75)   | 372 (0.79)  |                     |
| Dual-eligible: %               | 983 (4.70) | 1,053 (4.02) | 2,036 (4.32) | <0.001              |
| Sum of chronic conditions<sup>b</sup>: Mean (SD) | 4.78 (2.26) | 4.62 (2.22) | 4.69 (2.24) | <0.001              |
| Chronic conditions<sup>b</sup>: % |          |              |         |                     |
| Acute myocardial infarction    | 140 (0.67) | 178 (0.68)   | 318 (0.67)  | 0.89                |
| Anemia                         | 14,593 (69.71) | 16,623 (63.41) | 31,216 (66.21) | <0.001              |
| Asthma                         | 2,133 (10.19) | 2,706 (10.32) | 4,839 (10.26) | 0.63                |
| Atrial fibrillation            | 2,484 (11.87) | 3,002 (11.45) | 5,486 (11.64) | 0.16                |
| Benign prostatic hyperplasia   | 2,950 (14.09) | 3,338 (12.73) | 6,288 (13.34) | <0.001              |
| Breast cancer                  | 1,302 (6.22) | 1,701 (6.49) | 3,003 (6.37) | 0.23                |
| Cataract                       | 5,349 (25.55) | 6,529 (24.91) | 11,878 (25.19) | 0.11                |
| Chronic Kidney Disease         | 3,695 (17.65) | 4,640 (17.70) | 8,335 (17.68) | 0.89                |
| Chronic Obstructive Pulmonary Disease | 2,685 (12.83) | 3,441 (13.13) | 6,126 (12.99) | 0.33                |
| Colorectal cancer              | 404 (1.93) | 508 (1.94)   | 912 (1.93)  | 0.95                |
| Congestive Heart Failure       | 2,731 (13.05) | 3,162 (12.06) | 5,893 (12.50) | 0.001               |
| Depression                     | 4,463 (21.32) | 5,747 (21.92) | 10,210 (21.65) | 0.11                |
| Diabetes                       | 5,191 (24.80) | 6,037 (23.03) | 11,228 (23.81) | <0.001              |
| Endometrial cancer             | 181 (0.86) | 225 (0.86)   | 406 (0.86)  | 0.94                |
| Glaucoma                       | 2,658 (12.70) | 3,125 (11.92) | 5,783 (12.27) | 0.01                |
| Hyperlipidemia                 | 14,711 (70.27) | 18,254 (69.63) | 32,965 (69.92) | 0.13                |
| Hypertension                   | 16,740 (79.96) | 21,076 (80.40) | 37,816 (80.20) | 0.24                |
| Hypothyroidism                 | 5,019 (23.97) | 6,161 (23.50) | 11,180 (23.71) | 0.23                |
| Ischemic Heart Disease         | 7,652 (36.55) | 8,755 (33.40) | 16,407 (34.80) | <0.001              |
| Lung cancer                    | 218 (1.04) | 246 (0.94)   | 464 (0.98)  | 0.26                |
| Osteoporosis                   | 2,876 (13.74) | 3,383 (12.90) | 6,259 (13.27) | 0.01                |
| Prostate cancer                | 1,173 (5.60) | 1,481 (5.65) | 2,654 (5.63) | 0.83                |

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|                                | CJR MSAs  | Non-CJR MSAs | Total   | p-value<sup>c</sup> |
|--------------------------------|-----------|--------------|---------|---------------------|
| Stroke/ Transient ischemic attack | 700 (3.34) | 773 (2.95)  | 1,473 (3.12) | 0.01                |

Abbreviations: CJR: Comprehensive Care for Joint Replacement Model; MSA: Metropolitan Statistical Area; N: Number; ADRD: Alzheimer Disease and Related Dementias; %: Column percentage; SD: Standard deviation.

Notes: <sup>a</sup> Data from the 2013 Master Beneficiary Summary File – Base Segment; <sup>b</sup> Data from the 2013 Master Beneficiary Summary File – Chronic Conditions Segment. Sum of chronic conditions excluding ADRD; <sup>c</sup> p-values for Kruskal-Wallis tests (for continuous variables) or chi-square tests (for categorical variables) that test for the distribution of characteristics across CJR and non-CJR MSAs; <sup>d</sup> Other: This category is included in Medicare's Master Beneficiary Summary File.
**eTable 3.** Descriptive statistics for Medicare beneficiaries with a diagnosis of rheumatoid arthritis / osteoarthritis residing in CJR and non-CJR MSAs who underwent knee replacement in 2013

|                | CJR MSAs | Non-CJR MSAs | Total | p-value<sup>c</sup> |
|----------------|----------|--------------|-------|---------------------|
| **Patients<sup>a</sup>** |          |              |       |                     |
| N              | 42,294   | 55,671       | 97,965|                     |
| ADRD: %        | 3,020 (7.14) | 3,641 (6.54) | 6,661 (6.80) | <0.001            |
| Age in years: Mean (SD) | 74.09 (6.12) | 73.88 (6.07) | 73.97 (6.09) | <0.001            |
| Female: %      | 27,804 (65.74) | 35,989 (64.65) | 63,793 (65.12) | <0.001            |
| Race: %        |          |              |       |                     |
| Asian          | 762 (1.80) | 556 (1.00)   | 1,318 (1.35) | <0.001            |
| Hispanic       | 708 (1.67) | 505 (0.91)   | 1,213 (1.24) |                     |
| Non-Hispanic Black | 2,310 (5.46) | 2,846 (5.11) | 5,156 (5.26) |                     |
| Non-Hispanic White | 37,556 (88.80) | 50,626 (90.94) | 88,182 (90.01) |                     |
| North American Native | 79 (0.19) | 133 (0.24) | 212 (0.22) |                     |
| Unknown        | 318 (0.75) | 329 (0.59)   | 647 (0.66)  |                     |
| Other<sup>d</sup> | 561 (1.33) | 676 (1.21)   | 1,237 (1.26) |                     |
| Dual-eligible: % | 3,419 (8.08) | 3,298 (5.92) | 6,717 (6.86) | <0.001            |
| **Sum of chronic conditions<sup>b</sup>: Mean (SD)** | 4.90 (2.18) | 4.74 (2.16) | 4.81 (2.17) | <0.001            |
| Chronic conditions<sup>b</sup>: % |          |              |       |                     |
| Acute myocardial infarction | 197 (0.47) | 266 (0.48) | 463 (0.47) | 0.79               |
| Anemia         | 27,907 (65.98) | 32,830 (58.97) | 60,737 (62.00) | <0.001            |
| Asthma         | 4,989 (11.80) | 6,686 (12.01) | 11,675 (11.92) | 0.31              |
| Atrial fibrillation | 4,852 (11.47) | 6,284 (11.29) | 11,136 (11.37) | 0.37              |
| Benign prostatic hyperplasia | 5,439 (12.66) | 6,807 (12.23) | 12,246 (12.50) | 0.003            |
| Breast cancer  | 2,686 (6.35) | 3,470 (6.23) | 6,156 (6.28) | 0.45              |
| Cataract       | 11,044 (26.11) | 14,182 (25.47) | 25,226 (25.75) | 0.02              |
| Chronic Kidney Disease | 7,805 (18.45) | 10,143 (18.22) | 17,948 (18.32) | 0.35              |
| Chronic Obstructive Pulmonary Disease | 4,939 (11.68) | 6,383 (11.47) | 11,322 (11.56) | 0.30              |
| Colorectal cancer | 646 (1.53) | 899 (1.61) | 1,545 (1.58) | 0.28              |
| Congestive Heart Failure | 5,434 (12.85) | 6,582 (11.82) | 12,016 (12.27) | <0.001            |
| Depression     | 10,255 (24.25) | 13,128 (23.58) | 23,383 (23.87) | 0.02              |
| Diabetes       | 13,051 (30.86) | 16,661 (29.93) | 29,712 (30.33) | 0.002             |
| Endometrial cancer | 340 (0.80) | 447 (0.80) | 787 (0.80) | 0.99              |
| Glaucoma       | 5,390 (12.74) | 6,904 (12.40) | 12,294 (12.55) | 0.11              |
| Hyperlipidemia | 30,963 (73.21) | 40,490 (72.73) | 71,453 (72.94) | 0.10              |
| Hypertension   | 35,856 (84.78) | 47,239 (84.85) | 83,095 (84.82) | 0.74              |
| Hypothyroidism | 10,807 (25.55) | 13,994 (25.14) | 24,801 (25.32) | 0.14              |
| Ischemic Heart Disease | 15,596 (36.88) | 18,927 (34.00) | 34,523 (35.24) | <0.001            |
| Lung cancer    | 273 (0.65) | 358 (0.64) | 631 (0.64) | 0.96              |
| Osteoporosis   | 5,620 (13.29) | 6,503 (11.68) | 12,123 (12.37) | <0.001            |
| Prostate cancer | 1,852 (4.38) | 2,762 (4.96) | 4,614 (4.71) | <0.001            |

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|                        | CJR MSAs | Non-CJR MSAs | Total   | p-value<sup>c</sup> |
|------------------------|----------|--------------|---------|---------------------|
| Stroke/ Transient ischemic attack | 1,315 (3.11) | 1,760 (3.16) | 3,075 (3.14) | 0.64                |

Abbreviations: CJR: Comprehensive Care for Joint Replacement Model; MSA: Metropolitan Statistical Area; N: Number; ADRD: Alzheimer Disease and Related Dementias; %: Column percentage; SD: Standard deviation.

Notes: <sup>a</sup> Data from the 2013 Master Beneficiary Summary File – Base Segment; <sup>b</sup> Data from the 2013 Master Beneficiary Summary File – Chronic Conditions Segment. Sum of chronic conditions excluding ADRD; <sup>c</sup> p-values for Kruskal-Wallis tests (for continuous variables) or chi-square tests (for categorical variables) that test for the distribution of characteristics across CJR and non-CJR MSAs; <sup>d</sup> Other: This category is included in Medicare’s Master Beneficiary Summary File.
### eTable 4. Descriptive statistics for Medicare beneficiaries with or without a diagnosis of Alzheimer Disease and Related Dementias (ADRD) in 2013

| MSAs: N | Beneficiaries with ADRD | Beneficiaries without ADRD | Total | p-value$^d$ |
|---------|-------------------------|-----------------------------|-------|-------------|
|         | 171                     | 171                         | 171   |             |
| Beneficiaries*: N | 885,432                | 3,803,231                   | 4,688,663 |             |
| Age in years: Mean (SD) | 82.71 (7.70) | 75.84 (7.41) | 77.14 (7.94) | <0.001 |
| Sex: N(%) |                                    |                             |                   |             |
| Female | 628,096 (70.94) | 2,482,826 (65.28) | 3,110,922 (66.35) | <0.001 |
| Male   | 257,336 (29.06) | 1,320,405 (34.72) | 1,577,741 (33.65) |         |
| Race/ethnicity: N (%) |                               |                             |                   | <0.001 |
| Asian  | 30,660 (3.46) | 101,163 (2.66) | 131,823 (2.81) |       |
| Hispanic | 38,179 (4.31) | 73,847 (1.94) | 112,026 (2.39) |       |
| Non-Hispanic Black | 96,232 (10.87) | 310,515 (8.16) | 406,747 (8.68) |       |
| Non- Hispanic White | 703,281 (79.43) | 3,225,151 (84.80) | 3,928,432 (83.79) |     |
| North American Native | 1,859 (0.21) | 8,791 (0.23) | 10,650 (0.23) |       |
| Unknown | 2,924 (0.33) | 24,229 (0.64) | 27,153 (0.58) |       |
| Other$^e$ | 12,297 (1.39) | 59,535 (1.57) | 71,832 (1.53) |       |
| Dual-eligible: N (%) | 298,740 (33.74) | 493,967 (12.99) | 792,707 (16.91) | <0.001 |
| Sum of comorbidities$^b$: Mean (SD) | 5.60 (2.67) | 4.09 (2.41) | 4.37 (2.53) | <0.001 |
| Hip Replacements$^c$: N (%) | 3,374 (0.38) | 43,776 (1.15) | 47,150 (1.01) | <0.001 |
| Knee Replacements$^c$: N (%) | 6,661 (0.75) | 91,304 (2.40) | 97,165 (2.09) | <0.001 |

**Abbreviations:** CJR: Comprehensive Care for Joint Replacement Model; MSA: Metropolitan Statistical Area; N: Number; ADRD: Alzheimer Disease and Related Dementias; %: Column percentage; SD: Standard deviation; IQR: Inter-quartile range.

**Notes:** Distribution of comorbidities for Medicare beneficiaries included in this table, and descriptive statistics for hip and knee replacement patients are presented in eTables 1-3. $^a$ Data from the 2013 Master Beneficiary Summary File – Base Segment and Chronic Conditions Segment; $^b$ Mean of 23 chronic conditions excluding ADRD obtained from the Master Beneficiary Summary File – Chronic Conditions Segment; $^c$ Data from the 2013 Medicare Provider Analysis and Review file; $^d$ p-values for Kruskal-Wallis tests (for continuous variables) or chi-square tests (for categorical variables) that test for the distribution of characteristics across CJR and non-CJR MSAs; $^e$ Other: This category is included in Medicare’s Master Beneficiary Summary File.
eTable 5. Adjusted estimates for parallel trends test from multivariable models examining the use of hip and knee replacement surgeries before the Comprehensive Care for Joint Replacement model was implemented (2013-2015)

|                         | Hip Replacement | Knee Replacement |
|-------------------------|-----------------|------------------|
|                         | Beta estimate x 100 [95% CI x 100] | Beta estimate x 100 [95% CI x 100] |
| **Main Effects**        |                 |                  |
| **Year**                | 0.03*** [0.02, 0.04] | -0.04*** [-0.05, -0.02] |
| **MSA Treatment Status**|                 |                  |
| Non-CJR MSA             | Ref             | Ref              |
| CJR MSA                 | 0.36*** [0.19, 0.53] | 1.56*** [1.30, 1.83] |
| **ADRD**                |                 |                  |
| No                      | Ref             |                  |
| Yes                     | -0.45*** [-0.49, -0.41] | -1.08*** [-1.14, -1.03] |
| **Two-way interactions**|                 |                  |
| Year x MSA Treatment Status | 0.02* [0.00, 0.03] | 0.02 [0.00, 0.04] |
| Year x ADRD             | -0.04*** [-0.06, -0.02] | -0.02 [-0.04, 0.01] |
| MSA Treatment Status x ADRD | 0.08** [0.03, 0.14] | 0.24*** [0.16, 0.31] |
| **Three-way interactions**|               |                  |
| Year x MSA Treatment Status x ADRD | -0.01 [-0.03, 0.02] | 0.00 [-0.03, 0.03] |
| **N**                   |                 |                  |
| N (patients)            | 14,227,321      | 14,227,321       |
| N (MSAs)                | 171             | 171              |

* p<0.05, ** p<0.01, *** p<0.001

Abbreviations: CI: Confidence interval; MSA: Metropolitan Statistical Area; CJR: Comprehensive Care for Joint Replacement model; N: Number; ADRD: Alzheimer Disease and Related Dementias

Notes: Adjusted beta estimates and confidence intervals (multiplied by 100) from patient-level multivariable linear regression models with robust/sandwich estimators of variance. The models controlled for age, sex, race/ethnicity, dual-eligibility, comorbidities, MSA fixed effects, and MSA weights.
eTable 6. Full model estimates from multivariable models examining the use hip or knee replacement surgeries before and after the Comprehensive Care for Joint Replacement model was implemented (2013-2017)

|                                        | Hip Replacements | Knee Replacements |
|----------------------------------------|------------------|-------------------|
|                                        | Beta estimate x 100 | Beta estimate x 100 |
|                                        | [95% CI x 100]   | [95% CI x 100]   |
| **Main Effects**                       |                  |                  |
| **Phase**                              |                  |                  |
| Pre-CJR                                | Ref              | Ref              |
| Post-CJR                               | 0.01 [-0.03, 0.05] | 0.19*** [0.16, 0.23] |
| **MSA Treatment Status**               |                  |                  |
| Non-CJR MSA                            | Ref              | Ref              |
| CJR MSA                                | 0.43*** [0.28, 0.58] | 1.71*** [1.48, 1.93] |
| **ADRD**                               |                  |                  |
| No                                     | Ref              | Ref              |
| Yes                                    | -0.43*** [-0.47, -0.40] | -1.09*** [-1.11, -1.07] |
| **Two-way interactions**               |                  |                  |
| Post-CJR x CJR MSA                     | -0.07** [-0.12, -0.02] | 0.02 [-0.01, 0.06] |
| Post-CJR x ADRD                        | 0.11*** [0.05, 0.17] | 0.02 [-0.02, 0.06] |
| CJR MSA x ADRD                         | 0.08** [0.03, 0.14] | 0.24*** [0.21, 0.26] |
| **Three-way interactions**             |                  |                  |
| Post-CJR x CJR MSA x ADRD              | 0.01 [-0.08, 0.09] | -0.03 [-0.09, 0.02] |
| **Age**                                |                  |                  |
| -0.04*** [-0.04, -0.04]                | -0.10*** [-0.10, -0.10] |
| **Sex**                                |                  |                  |
| Male                                   | Ref              | Ref              |
| Female                                 | -0.02** [-0.03, -0.01] | 0.22*** [0.21, 0.24] |
| **Race**                               |                  |                  |
| Non-Hispanic White                     | Ref              | Ref              |
| Asian                                  | -0.54*** [-0.55, -0.52] | -0.23*** [-0.26, -0.20] |
| Hispanic                               | -0.33*** [-0.34, -0.31] | 0.22*** [0.19, 0.26] |
| Non-Hispanic Black                     | -0.41*** [-0.42, -0.39] | -0.76*** [-0.78, -0.74] |
| North American Native                  | -0.35*** [-0.43, -0.26] | -0.41*** [-0.55, -0.28] |
| Unknown                                | 0.20*** [0.14, 0.25] | -0.05 [-0.12, 0.02] |
| Otherb                                 | -0.51*** [-0.54, -0.49] | -0.21*** [-0.26, -0.16] |
| **Dual-eligibility**                   |                  |                  |
| No                                     | Ref              | Ref              |
| Yes                                    | -0.65*** [-0.66, -0.64] | -1.10*** [-1.11, -1.08] |
| **Chronic conditions**                 |                  |                  |
| Acute myocardial infarction            | -0.37*** [-0.41, -0.33] | -1.04*** [-1.10, -0.99] |
| Anemia                                 | 1.70*** [1.69, 1.71] | 2.90*** [2.88, 2.92] |
| Asthma                                 | 0.34*** [0.32, 0.36] | 1.08*** [1.05, 1.11] |
| Atrial fibrillation                    | 0.04*** [0.02, 0.05] | 0.13*** [0.11, 0.15] |
| Benign prostatic hyperplasia           | 0.47*** [0.45, 0.50] | 0.96*** [0.94, 0.99] |
| Breast cancer                          | 0.26*** [0.23, 0.28] | 0.53*** [0.50, 0.57] |
| Cataract                               | -0.09*** [-0.10, -0.08] | -0.09*** [-0.11, -0.08] |
| Condition                                      | Hip Replacements            | Knee Replacements           |
|-----------------------------------------------|-----------------------------|-----------------------------|
|                                               | Beta estimate x 100          | Beta estimate x 100          |
|                                               | [95% CI x 100]              | [95% CI x 100]              |
| Chronic Kidney Disease                        | -0.36*** [-0.37, -0.35]     | -0.63*** [-0.65, -0.61]     |
| Chronic Obstructive Pulmonary Disease         | -0.19*** [-0.20, -0.17]     | -0.73*** [-0.75, -0.71]     |
| Colorectal cancer                             | 0.04 [0.01, 0.08]           | -0.25*** [-0.30, -0.19]     |
| Congestive Heart Failure                      | -0.41*** [-0.42, -0.40]     | -0.84*** [-0.86, -0.83]     |
| Depression                                    | 0.08*** [0.06, 0.09]        | 0.38*** [0.36, 0.40]        |
| Diabetes                                      | -0.51*** [-0.52, -0.50]     | -0.50*** [-0.51, -0.48]     |
| Endometrial cancer                            | 0.68*** [0.59, 0.78]        | 1.07*** [0.95, 1.20]        |
| Glaucoma                                      | -0.11*** [-0.12, -0.09]     | -0.12*** [-0.14, -0.10]     |
| Hyperlipidemia                                | 0.31*** [0.30, 0.32]        | 0.70*** [0.69, 0.71]        |
| Hypertension                                  | 0.45*** [0.43, 0.46]        | 1.29*** [1.27, 1.30]        |
| Hypothyroidism                                | 0.04*** [0.03, 0.05]        | 0.24*** [0.23, 0.26]        |
| Ischemic Heart Disease                        | -0.17*** [-0.18, -0.16]     | -0.32*** [-0.33, -0.30]     |
| Lung cancer                                   | -0.34*** [-0.38, -0.30]     | -1.11*** [-1.16, -1.06]     |
| Osteoporosis                                  | 0.10*** [0.09, 0.12]        | -0.01 [-0.03, 0.01]         |
| Prostate cancer                               | 0.31*** [0.28, 0.33]        | 0.39*** [0.35, 0.42]        |
| Stroke/ Transient ischemic attack             | -0.39*** [-0.41, -0.38]     | -0.79*** [-0.82, -0.77]     |
| **Year interactions**                         |                             |                             |
| Year                                          | 0.03*** [0.02, 0.04]        | -0.03*** [-0.04, -0.03]     |
| Year x MSA Treatment Status                   | 0.02* [0.00, 0.03]          | NA                          |
| Year x ADRD                                   | -0.04*** [-0.06, -0.02]     | NA                          |
| Year x MSA Treatment Status x ADRD            | -0.01 [-0.03, 0.02]         | NA                          |
| **N**                                         |                             |                             |
| N (beneficiary-year)                          | 19,468,093                  | 19,468,093                  |
| N (MSAs)                                      | 171                         | 171                         |

* p<0.05, ** p<0.01, *** p<0.001

Abbreviations: CI: Confidence interval; MSA: Metropolitan Statistical Area; CJR: Comprehensive Care for Joint Replacement model; N: Number; ADRD: Alzheimer Disease and Related Dementias; NA: Not applicable (because parallel trends assumption not violated)

Notes: Adjusted beta estimates and confidence intervals (multiplied by 100) from patient-level multivariable linear regression models with robust/sandwich estimators of variance. The models controlled for age, sex, race/ethnicity, dual-eligibility, comorbidities, calendar year (and relevant interactions with CJR MSA and ADRD indicator), MSA fixed effects, and MSA weights. The analysis excluded data from 2016 because the CJR was introduced in April 2016, and this implementation precludes the classification of all Medicare beneficiaries into a pre- and post-cohort.

*a Although the MBSF-CC files report data on 27 chronic conditions, only 23 conditions were included as controls. Alzheimer Disease (included as a part of the ADRD variable [key independent variable]), Hip Fractures (exclusion due to emergent/urgent nature of the condition), and Arthritis (cohort limited to arthritis patients only) were excluded as control variables; 

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### eTable 7. Sensitivity Analyses - The Comprehensive Care for Joint Replacement model's association with use of hip and knee replacements for beneficiaries with ADRD compared to beneficiaries without ADRD (2013-2017)

| Analysis                                      | Hip replacement          | Knee replacement         |
|-----------------------------------------------|--------------------------|--------------------------|
|                                               | N    | %-point difference   | N    | %-point difference    |
|                                               |     | (95% CI)             |     | (95% CI)             |
| Main analysis                                 | 19,468,093 | 0.01 (-0.08, 0.09) | 19,468,093 | -0.03 (-0.09, 0.02) |
| Entire cohort                                 | 70,956,768 | -0.01 (-0.04, 0.02) | 70,956,768 | -0.02 (-0.06, 0.03) |
| Intention-to-treat analysis                   | 20,992,092 | 0.00 (-0.08, 0.08) | 20,992,092 | -0.02 (-0.07, 0.03) |
| Medicare’s definition of elective surgeries   | 19,476,933 | 0.01 (-0.08, 0.09) | 19,476,933 | -0.03 (-0.15, 0.08) |
| New ADRD patients                             | 17,102,317 | -0.03 (-0.17, 0.11) | 17,102,317 | -0.09* (-0.18, 0.00) |
| AD only                                       | 19,468,093 | 0.08 (-0.01, 0.17) | 19,468,093 | 0.04 (-0.09, 0.17)  |
| Logistic regression models                    | 19,468,093 | 0.03 (-0.08, 0.14) | 19,468,093 | -0.03 (-0.11, 0.04) |
| 2016 in the post CJR phase                    | 24,598,729 | 0.00 (-0.07, 0.06) | 24,598,729 | -0.01 (-0.06, 0.03) |

* p<0.05, ** p<0.01, *** p<0.001

Abbreviations: MSA: Metropolitan Statistical Area; CJR: Comprehensive Care for Joint Replacement model; SA: Sensitivity analysis; CI: Confidence interval; N: Number; %: Percentage; ADRD: Alzheimer Disease and Related Dementias; AD: Alzheimer Disease

Notes: Adjusted rates from patient-level multivariable linear regression models with robust/sandwich estimators of variance. The models assessed CJR’s association with the use of surgeries for ADRD beneficiaries (versus beneficiaries without ADRD) in CJR MSAs versus non-CJR MSAs. The models controlled for age, sex, race/ethnicity, dual-eligibility, comorbidities, calendar year (and relevant interactions with CJR MSA and ADRD indicator), MSA fixed effects, and MSA weights.

a Percentage point difference in the rates of surgeries for beneficiaries with ADRD (versus beneficiaries without ADRD) in CJR MSAs with CJR implementation versus non-CJR MSAs ("triple difference").
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