Longitudinal analysis of historical payments and utilization in patients with hip and knee osteoarthritis

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Abstract

Background Osteoarthritis (OA) is a highly prevalent condition associated with substantial clinical and economic burden. Value-based payment reform requires detailed understanding of care utilization. However, previous analyses of OA care have limitations, such as constraining analysis to a single year or to surgical patients. We aimed to more comprehensively characterize health services utilization and payment for hip and knee OA through a 3-year longitudinal analysis, including both operative and non-operative services, using Medicare claims data.

Methods We utilized Medicare Standard Analytic Files available from PearlDiver, Inc. The target population for analysis was patients with osteoarthritis in the hip, knee, or both, identified by ICD-9 diagnosis codes. Patients were limited to those whose 1) first instance of hip or knee OA diagnosis in the payer dataset occurred between 2008 and 2011 and 2) who were continuously active in the payer dataset for one year prior to and three years following diagnosis.

Results Payments for relevant hip and knee OA services were highest during the first year after diagnosis, representing 55.6%, 65.3%, and 51.2% of total payments for patients with knee, hip, or knee and hip OA, respectively. Payments and utilization of services in the second and third treatment years were lower, and similar to the year prior to OA diagnosis. Service-level analysis revealed that total payments were driven by utilization of high-intensity services like surgery, which accounted for 57.7%, 60.6%, and 63.6% of payments in the first year for knee, hip, and knee and hip OA patients, respectively. High utilization of Medical Services like physician-administered medications, arthrocentesis, and physical therapy drove high payments as well, especially later in treatment.

Conclusion Hip and knee OA treatment intensity is highest in the year immediately following a new diagnosis and decreases considerably in the second- and third-years following diagnosis across all relevant service categories. This analysis supports the identification of specific, time-sensitive opportunities to transform hip and knee OA care and payment models to optimize patient-centered outcomes while controlling costs across the episode of care.

Background

Projections indicate that osteoarthritis (OA) will affect 78.4 million adults in the United States by 2040 (1). With a median age of onset of 55 years, hip and knee OA impairs quality of life and accounts for 19% and 41%, respectively, of all OA afflicting 54.4 million American adults (2–4), resulting in a substantial clinical and economic burden. A 2017 investigation found a fourfold increase in total healthcare costs among OA patients compared to matched controls, \$14.5k versus \$3.6k per patient (5). Despite this economic burden, there is evidence that the quality of OA care could be improved on several dimensions, including patient-centered outcomes and efficient use of resources. A recent study indicated that one-third of total knee arthroplasty procedures may be inappropriate (6). This may come at the expense of less invasive approaches and care coordination (7,8). Additionally, fragmentation of care delivered by primary care physicians, specialists, and other healthcare professionals may lead to lower quality care (9). Current payment models do not incentivize these elements of high-value care, nor do they completely consider the appropriateness of high intensity services such as surgery. Strategies to address increasing OA costs have focused on bundled payment programs tied to arthroplasty procedures, and have consistently produced similar clinical outcomes along with lower episode costs (10). These procedural bundles, however, do not address the appropriateness of the surgical episode. Value-based thought leaders like Michael Porter (11) advocate expanding payment reform beyond the procedure level by bundling payments and services at the condition level, based on his research with Twin Cities Orthopedics showing better outcomes and 30% cost reductions with bundled

OA care episodes. Unfortunately, there are no large-scale examples of condition-based bundled payment models for OA or other chronic conditions.

New payment models are necessary to incentivize high-value care for chronic OA and must consider appropriateness of high-intensity services like surgery. Payment reform for chronic hip and knee OA requires a detailed understanding of care utilization and payments. Current analyses have substantial limitations, lacking longitudinal investigation and cohorts inclusive of all patients with OA. Most published literature has focused on spending for patients undergoing total joint arthroplasty (TJA) and short procedural follow-up windows, typically 90 days.

In an effort to address these gaps in the literature surrounding OA, and to more thoroughly understand the nature of OA care in the United States, we attempted to comprehensively characterize hip and knee OA utilization and payment among the Medicare population through a 3-year longitudinal analysis following initial diagnosis, and a 1-year lookback period prior to diagnosis. The purpose of this study was to evaluate payment and utilization of operative and non-operative services associated with the management of hip and knee OA among Medicare beneficiaries. By characterizing payments and utilization of care at the individual service level, we hope to identify salient trends and opportunities for targeted care and payment model transformation beyond procedural bundles for joint replacement and inform effective care and payment model construction and associated policy.

Methods

The data for this study are available through PearlDiver, Inc. ([PearlDiverInc.com](https://www.pearldiverinc.com)) using the Medicare National Sample Administrative Database (SAF5, which includes 5% random sample of physician billing records) of the PearlDiver Patient Record Database. The PearlDiver database contains de-identified and Health Insurance Portability and Accountability Act-compliant patient records and billing codes. The SAF5 subset contains records from 55 million Medicare beneficiaries between 2005 and 2015.

Patients with either osteoarthritis (OA) in the hip, knee, or both, without co-existing rheumatoid arthritis were identified using International Classification of Diseases, 9th Revision (ICD–9) diagnosis codes (Appendix A). For these patients, we identified the first instance of a hip or knee OA diagnosis and an Evaluation and Management Current Procedure Terminology (CPT) code on the same date. For a patient to be included in the analysis cohort, this index date had to occur in the calendar years 2008–2011. Our final inclusion criteria for the analysis cohort was remaining active in the payer dataset for one year prior (washout period) and three years following the index date. Filtering criteria served to ensure completeness of records over 4+ years and capture only the first episode of hip or knee OA on the payer record by ensuring patients were either newly diagnosed with OA or new to payer records. Our process of identifying and tracking patients before and after their index date is described in Figure 1.

Utilization and payment data for these patients were analyzed for medical services relevant to the management of hip or knee OA (Figure 2). These relevant medical services were informed by expert opinion and clinical practice guidelines (12,13). In selecting these medical services, the clinical experience of several of the authors was considered (KB, WJ, RM). Conservative decisions were made to include the broadest array of medical services that might be utilized for OA patients.

While limited Medicare Part D data were available in the PearlDiver database, we chose to exclude calculations of oral drug expenditure in order to focus on inpatient and outpatient services and procedures. Further, calculation of these expenditures would have introduced significantly variability into our results, as we could not be certain of the

relationship between many medications and specific OA symptoms (rather than concurrent ailments) utilizing only administrative claims data.

Medical service utilization and payment data include unique patient count, service date count, total payments, payment per total patients (or per population), service dates per total patients (or per population). Data summaries and analysis were performed using SAS (SAS Institute; Cary, NC).

Results

Applying our trigger and filtering criteria to the SAF5 database, we identified a total of 92,931, 26,797, and 34,315 Medicare beneficiaries that met our criteria for osteoarthritis of the knee, hip, or both, respectively. Table 1 describes each filter used to select patients for analysis, and Table 2 provides additional demographic information on the different cohorts.

Knee Osteoarthritis (Tables 3 and 4)

Year 1

In the first year of care following diagnosis of knee OA, 92,931 unique Medicare beneficiaries accounted for 737,640 service dates, or 41.6% of service dates in the three years following diagnosis. These patients accounted for \$202M in payments in the first year of care (55.6% of payments in the three-year post-diagnosis analysis period).

In the first year of care, *Surgery* accounted for 57.7% (\$117M) of all payments, driven by Total Knee Arthroplasty and Arthroscopy (49.6%, \$100.5M and 7.0%, \$14.9M of payments, respectively). *Medical Services* accounted for 15.8% (\$31.9M) of payments, primarily driven by physical therapy (8.6%, \$17.4M), arthrocentesis (3.0%, \$6.0M), and hyaluronic acid injection (2.6%, \$5.3M). *Radiology* services accounted for 8.1% (\$16.4M) of payments in the first year of care, driven by X-Ray (2.1%, \$4.2M) and Magnetic Resonance Imaging (MRI) (4.3%, \$8.6M). *Evaluation and Management* services accounted for 15.5% (\$31.5M) of payments, which was mostly ambulatory care (10.5%, \$21.4M), inpatient professional fees (2.1%, \$4.3M), and Emergency Department services (2.2%, 4.4M).

In total, 15.3% of patients underwent surgical procedures within one year of diagnosis, with 8.2% and 7.0% of patients undergoing Total Knee Arthroplasty and Arthroscopy, respectively. A substantial proportion of patients received other services, including *Radiology* (78.7% of patients) with 72.9% of patients receiving an X-Ray, 9.2% a CT scan, 20.9% an MRI, and 4.7% ultrasound imaging. *Medical Services* were used by 69.0% of patients, including behavioral health services (0.02%), hyaluronic acid injection (12.1%), corticosteroid injection (46.0%), nutrition services (0.8%), arthrocentesis (45.8%), stimulation (10.1%), PM&R services (13.0%), physical or occupational therapy (32.3%), and chiropractor services (8.9%). *Evaluation and Management* services were driven by ambulatory visits (94.1%), inpatient professional services (11.4%), emergency services (14.9%), and skilled nursing facilities (3.4%).

Medical Services accounted for the most service dates (35.7% of all dates in the first year of care) at 2.8 service dates per patient in the cohort. Physical therapy (18.6%, 1.5 dates per patient), arthrocentesis (10.6%, 0.8 dates per patient), and corticosteroid injection (8.1%, 0.6 dates per patient). *Radiology* accounted for 16.5% of service dates (1.3 dates per patient), driven by X-Ray (13%, 1.0 dates per patient) and MRI (2.9%, 0.2 dates per patient). *Evaluation and Management* services accounted for 21.6% of service dates in the first year of care (1.7 dates per patient), and *Surgery* accounted for just 2.5% of dates and 0.2 dates per patient. Additional breakdown of service dates and payments per patient is provided in Table 4.

Years 2 and 3

Surgery and *Medical Services* accounted for 58.5% (\$53.1M) and 20.4% (\$18.6M) of payments in Year 2, respectively. Total Knee Arthroplasty and Arthroscopy accounted for 54.7% (\$49.7M) and 2.6% (\$2.4M) of total payments, respectively. Physical therapy, arthrocentesis, and hyaluronic acid injection drove the majority of *Medical Services* payments, at 12.2% (\$41.7M), 2.7% (\$2.5M), and 2.7% (\$2.5M), respectively. *Evaluation and Management* services accounted for just 6.7% (\$6.0M) of payments. *Medical Services* and *Radiology* services accounted for the most patients seen in Year 2, at 46.0% and 34.5% of total, respectively, while 5.3% of patients underwent a surgical procedure in Year 2. *Medical Services* made up 42.2% of service dates, while *Evaluation and Management*, *Radiology*, and *Surgery* service dates decreased from Year 1 to 9.8%, 10.8%, and 1.2%, respectively.

In Year 3, *Surgery* accounted for 53.9% (\$38.1M) of total payments (50.2%, \$35.5M Total Knee Arthroplasty, 2.3%, \$1.6M Arthroscopy), while the proportion of payments toward *Medical Services* rose to 25% (\$17.7M), driven by an increased proportion of payments for hyaluronic acid injection (to 3.2%, \$2.3M), arthrocentesis (to 3.1% \$2.2M), and physical therapy (to 14.6%, \$10.3M). The proportion of patients receiving any care decreased from Year 2, with 3.9% of patients receiving undergoing surgery, 30.1% receiving *Radiology* services, and 22.1% utilizing *Evaluation and Management* services.

Evolution of Care

In addition to the 36-month post-diagnosis period, we analyzed payments and utilization for a period of one year prior to initial diagnosis. Utilization and payments for relevant services in the first year following diagnosis increased dramatically from the prior year (56% more service dates, 163% greater payments). Total payments fell by 55% from Year 1 to Year 2 (to \$90.8M), driven by a 30.8% decrease in utilization (service dates). *Evaluation and Management*, *Surgery*, and *Radiology* services drove this decrease in utilization and payment (72.5%, 65.2%, and 56.1% fewer service dates, respectively). Payments fell an additional 22.0% from Year 2 to Year 3 (to \$70.8M), driven by an increased proportion of spending on *Medical Services* as compared to *Surgery*, *Radiology*, and *Evaluation and Management*. Total payments (\$77.1M) and service dates (472,594) were similar in the year prior to diagnosis and second and third years after diagnosis (\$90.8M, 509,910 service dates, and \$70.8M, 524,589 service dates, respectively). The average payment per patient in the cohort was \$2,182, \$978 and \$762, in Years 1, 2, and 3 of care following diagnosis, respectively.

Hip Osteoarthritis (Tables 5 and 6)

Year 1

In the first year of care following diagnosis of hip OA, 26,797 unique patients accounted for 202,836 service dates, or 43.6% of service dates in the three years following diagnosis. These patients accounted for \$62.7M in payments in the first year of care (65.3% of payments in the three-year post-diagnosis analysis period).

In the first year of care, *Surgery* accounted for 60.6% (\$38M) of all payments, driven by Total Hip Arthroplasty (58.8%, \$36.9M). *Medical Services* accounted for 10.9% (\$6.8M) of payments, primarily driven by physical therapy (8.6%, \$5.4M). *Radiology* services accounted for 9.9% (\$6.2M) of payments in the first year of care, driven by X-Ray (2.7%, \$1.7M) and MRI (4.9%, \$3.0M). *Evaluation and Management* services accounted for 15.7% (\$9.8M) of payments, which was mostly ambulatory care (8.4%, \$5.2M), inpatient professional fees (3.4%, \$2.1M), and Emergency Department services (3.0%, 1.8M).

In total, 13.2% of patients underwent surgical procedures within one year of diagnosis, with 10.8% of patients undergoing Total Hip Arthroplasty. A substantial proportion of patients received other services, including *Radiology* (86.7% of patients) with 80.6% of patients receiving an X-Ray, 16% a CT scan, 23.1% an MRI, and 3.5% ultrasound imaging. *Medical Services* were used by 57.6% of patients, including behavioral health services (0.02%), corticosteroid injection (28.5%), nutrition services (0.6%), arthrocentesis (18%), stimulation (9.8%), PM&R services (13.8%), physical or occupational therapy (36%), and chiropractor services (10.1%). *Evaluation and Management* services were driven by ambulatory visits (88.8%), inpatient professional services (17.6%), emergency services (21.7%), and skilled nursing facilities (6.1%).

Medical Services accounted for the most service dates (32.1% of all dates in the first year of care) at 2.4 service dates per patient in the cohort. Physical therapy (20.5%, 1.6 dates per patient), stimulation (4.4%, 0.3 dates per patient), chiropractor services (6.4%, 0.5 dates per patient), and corticosteroid injection (4.8%, 0.4 dates per patient). *Radiology* accounted for 21% of service dates (1.3 dates per patient), driven by X-Ray (16.8%, 1.3 dates per patient) and MRI (3.5%, 0.3 dates per patient). *Evaluation and Management* services accounted for 18.3% of service dates in the first year of care (1.4 dates per patient), and *Surgery* accounted for just 2.4% of dates and 0.2 dates per patient. Additional breakdown of service dates and payments per patient is provided in Table 6.

Years 2 and 3

Surgery and *Medical Services* accounted for 54.1% (\$10.4M) and 21.2% (\$4.1M) of payments in Year 2, respectively. Total Hip Arthroplasty accounted for 52.1% (\$10M) of payments. Physical Therapy drove the majority of *Medical Services* payments, at 16.4% (\$3.2M) of payments. *Evaluation and Management* services accounted for just 4.5% (\$0.9M) of payments. *Medical Services* and *Radiology* services accounted for the most patients seen in Year 2, at 39.9% and 33.8% of total, respectively, while 3.5% of patients underwent a surgical procedure in Year 2. *Medical Services* made up 40.1% of service dates, while *Evaluation and Management*, *Radiology*, and *Surgery* service dates decreased from Year 1 to 4.8%, 11.9%, and 0.9%, respectively.

In Year 3, *Surgery* accounted for 46.7% (\$6.6M) of total payments (44.9%, \$6.4M Total Hip Arthroplasty), while the proportion of payments toward *Medical Services* rose to 26.9% (\$3.8M), driven by an increased proportion of payments for physical therapy (to 20.1%, \$2.8M). The proportion of patients receiving any care decreased from Year 2, with 2.4% of patients receiving undergoing surgery, 28.3% receiving *Radiology* services, and 10.0% utilizing *Evaluation and Management* services.

Evolution of Care

Utilization and payments for relevant services in the first year following diagnosis increased from the prior year (42% more service dates, 127% greater payments). Total payments fell by 69% from Year 1 to Year 2 (to \$19.2M), driven by a 36% decrease in utilization (service dates). *Evaluation and Management*, *Surgery*, and *Radiology* services drove this decrease in utilization and payment (83.3%, 77.1%, and 63.6% fewer service dates, respectively). Payments fell an additional 26.4% in Year 3 (to \$14.1M), driven by an increased proportion of spending on *Medical Services* as compared to *Surgery*, *Radiology*, and *Evaluation and Management*. Total payments (\$27.6M) and service dates (142,760) were greater in the year prior to diagnosis and second and third years after diagnosis (\$19.2M, 129,917 service dates, and \$14.1M, 132,747 service dates, respectively). The average payment per patient in the population was \$2,340, \$717, and \$528 in Years 1, 2, and 3 of care following diagnosis, respectively.

Hip and Knee Osteoarthritis (Tables 7 and 8)

Year 1

Additionally, we identified 34,315 Medicare beneficiaries with both a hip and a knee ICD–9 diagnosis code, at least one of which occurred for the first time on the payer record between 2008 and 2011. This cohort accounted for 693,912 service dates and \$226M in payments over the three year post-diagnosis analysis period, as well as 119,895 service dates and \$37M in the year prior to diagnosis.

In the first year of care, *Surgery* accounted for 63.6% (\$73.5M) of all payments, driven by Total Hip Arthroplasty (33.5%, \$38.7M) and Total Knee Arthroplasty (26.1%, \$30.2M). *Medical Services* accounted for 12.3% (\$14.3M) of payments, primarily driven by physical therapy (7.9%, \$9.2M), arthrocentesis (1.9%, \$2.2M), and hyaluronic acid injection (1.2%, \$1.4M). *Radiology* services accounted for 7.8% (\$9.0M) of payments in the first year of care, driven by X-Ray (2.2%, \$2.6M) and Magnetic Resonance Imaging (MRI) (3.9%, \$4.6M). *Evaluation and Management* services accounted for 14.1% (\$16.3M) of payments, which was mostly made up of ambulatory care (8.8%, \$10.2M), inpatient professional fees (2.5%, \$2.9M), and Emergency Department services (2.1%, 2.4M).

In total, 20.2% of patients underwent surgical procedures within one year of diagnosis, with 6.6%, 8.7%, and 4.4% of patients undergoing Total Knee Arthroplasty, Total Hip Arthroplasty, or Arthroscopy, respectively. A substantial proportion of patients received other services, including *Radiology* (87% of patients) with 82% of patients receiving an X-Ray, 14.6% a CT scan, 26.8% an MRI, and 5% ultrasound imaging. *Medical Services* were used by 71.9% of patients, including behavioral health services (0.01%), hyaluronic acid injection (8.6%), corticosteroid injection (45.3%), nutrition services (0.7%), arthrocentesis (41.6%), stimulation (12.5%), PM&R services (16.6%), physical or occupational therapy (41.4%), and chiropractor services (11.1%). *Evaluation and Management* services were driven by ambulatory visits (92.6%), inpatient professional services (18.2%), emergency services (20.3%), and skilled nursing facilities (6%).

Medical Services accounted for the most service dates (50.2% of all dates in the first year of care) at 3.3 service dates per patient in the cohort. Physical therapy (29.6, 2.0 dates per patient), arthrocentesis (11.6%, 0.8 dates per patient), chiropractor services (7.8%, 0.5 dates per patient), and corticosteroid injection (10.1%, 0.7 dates per patient). *Radiology* accounted for 28.1% of service dates (1.9 dates per patient), driven by X-Ray (22.7%, 1.5 dates per patient) and MRI (4.8%, 0.3 dates per patient). *Evaluation and Management* services accounted for 30.0% of service dates in the first year of care (2.0 dates per patient), and *Surgery* accounted for 4.4% of dates and 0.3 dates per patient. Additional breakdown of service dates and payments per patient is provided in Table 8.

Years 2 and 3

Surgery and *Medical Services* accounted for 64.0% (\$38.8M) and 16.4% (\$10.0M) of payments in Year 2, respectively. Total Knee Arthroplasty and Total Hip Arthroplasty accounted for 30.9% (\$18.7M) and 30.3% (\$18.4M) of total payments, respectively. Physical Therapy, Arthrocentesis, and Hyaluronic Acid Injections drove the majority of *Medical Services* payments, at 10.9% (\$6.6M), 2.1% (\$1.2M), and 1.4% (\$0.9M), respectively. *Evaluation and Management* services accounted for just 7.6% (\$4.6M) of payments. *Medical Services* and *Radiology* accounted for the most patients seen in Year 2, at 56.7% and 54.1% of all patients, respectively, while 9.8% of patients underwent a surgical procedure in Year 2. *Medical Services* made up 50.0% of service dates, while the proportion of *Evaluation and Management*, *Radiology*, and *Surgery* service dates decreased from Year 1 to 14.5%, 17.7%, and 1.9%, respectively.

In Year 3, *Surgery* accounted for 61.8% (\$30.8M) of total payments (29.3%, \$14.6M Total Knee Arthroplasty, 29.5%, \$14.7M Total Hip Arthroplasty), while the proportion of payments toward *Medical Services* rose to 19.5% (\$9.7M), driven by an increased proportion of payments for physical therapy (to 12.7%, \$6.3M). The proportion of patients receiving any care decreased from Year 2, with 7.9% of patients receiving undergoing surgery, 50.3% receiving *Radiology* services, and 39.0% utilizing *Evaluation and Management* services.

Utilization Trends

We observed several trends in service utilization and payments among patient cohorts with osteoarthritis in the knee, hip, or both. Figure 3 provides a comparison of service utilization and payment across all years. Notably, Year 1 accounted for greater utilization and payments than either Years 2 or 3 across all joints. The distribution of payments was heavily skewed toward *Surgery* services, which were more common in the first year of treatment, though utilization of all services declined over time.

Discussion

Transformative care and payment innovation require a detailed, actionable understanding of utilization and payment patterns. Through this analysis of OA service utilization and payment, we aimed to more comprehensively characterize the longitudinal nature of chronic arthritis care, in both a public and private payer setting. Our analysis suggests that there is an early, discrete, previously uncharacterized critical period in both hip and knee OA disease course to which care and payment model reform could be targeted to make an impact on relevant utilization and associated payments in order to appropriately incentivize use of evidence-based clinical practice guidelines and appropriate use criteria that drive higher-value patient-centered care. This opportunity occurs soon after initial diagnosis and management.

Service utilization and intensity relevant to hip or knee OA is significantly and broadly increased in the Medicare population following diagnosis of OA, as compared to the year preceding and the subsequent two years of management. The observed service utilization can be compared to accepted hip and knee OA clinical practice guidelines (13) or appropriate use criteria (14) to identify and characterize specific opportunities for higher value care. For example, a significant proportion of patients with knee OA received hyaluronic acid injections, which do not reflect evidence-based practice, and were not endorsed at the time these data were collected (12,13,15–17). New care delivery and payment models could incentivize a reduction in hyaluronic acid injections, and savings in time and money could be re-allocated to support the delivery of services that are decidedly indicated. For example, nutrition services are evidenced-based for hip and knee osteoarthritis (12,13,15), yet represented just 0.01% of total payments in this analysis. Moreover, a disproportionate amount of total joint arthroplasties occurs in the first year following diagnosis. In light of recent research suggesting that some portion of total knee arthroplasties are not appropriate (6), new care delivery and payment models could incentivize careful consideration of when lower extremity joint replacement is most appropriate. Some have even suggested that total hip arthroplasty may be over-utilized (18). Potential savings related to reduction in utilization could be re-allocated to support alternative conservative measures, care coordination, new team structures, or communication and education tools.

Limitations of this study include those that stem from our administrative claims data sources, which depend on the accuracy and completeness of coding and billing. Relatedly, our analysis sought to identify the first instance of hip or knee OA through Medicare claims, but these may not be true first instances for some patients; these patients may have experienced inconsistency in historical coding or may have been previously diagnosed while on another payer plan. It is worth noting that many patients do not see a doctor when they initially experience OA symptoms, but

rather once their symptoms become severe or they feel prepared for an operation. The frequent event of receiving an operation in the first year after diagnosis could be more related to delayed diagnosis than a premature operative decision. Further, our analysis assumes minimal variation in healthcare costs and global utilization across the calendar years analyzed. In future work, we plan to consider patient variation within each cohort, including age, geographic region, timing of diagnosis and services, and other factors, though these are somewhat limited in claims data. Incorporation of Medicare Part D claims data would allow for calculation of oral drug expenditure, but we do not include this due to the limited availability of this data.

Current and historical payment reform has focused on hip and knee osteoarthritis as one condition, e.g. Medicare Acute Care Episode Demonstration (ACE) (19), Bundled Payments for Care Improvement Initiative (BPCI) (20), Comprehensive Care for Joint Replacement Model (CJR) (21), Bundled Payments for Care Improvement Initiative-Advanced (BPCI-A) (22) which are triggered by either hip or knee OA-related procedures. However, because hip and knee osteoarthritis have different clinical courses; we analyzed patients with these conditions separately, as well as patients who had OA in both joints.

In addition to these limitations, our analysis does not evaluate the timing of relevant services in relation to one another. In the literature, there has been commentary on timing of services with relation to total knee arthroplasty (23,24). While our study focused on total costs, we foresee including service sequencing in future analysis. Our list of relevant services represents a potential area for bias, although these services were selected from a thorough discussion among subject matter experts and review of practice guidelines. Additionally, the cost of treatment certainly varies with intensity of service, geographic location, age and comorbidities, service location and other factors, which we hope to address in future analyses. Lastly, our analysis focused on costs and utilization associated with the management of hip and knee OA, with no consideration of patient-centered outcomes, which are not available through administrative claims data sets. Future efforts should include evaluation of both outcomes and costs in order to understand the value of services delivered to patients with hip and knee OA.

Conclusion

Our work demonstrates that hip and knee OA-related utilization and payments are significantly greater across virtually all relevant services in the year immediately following initial diagnosis and are significantly lower in subsequent years. Additionally, this analysis demonstrates that the greatest proportion of total cost of care for hip and knee OA can be attributed to increased utilization of operative procedures and selective outpatient services. Efforts to reform payments for OA would be most impactful if they address the utilization that drives total cost of care. Alternative payment models focused on reducing unnecessary or low-value services could be impactful for the Medicare population analyzed and potentially for other insurers, should the same trends be present. This analysis also sets a foundation for the identification of specific, time-sensitive opportunities to transform hip and knee OA care, and could inform future payment model innovation that could optimize patient-centered outcomes while controlling costs across the episode of care.

List Of Abbreviations

CPT

Current Procedure Terminology

M

million

E & M

Evaluation and Management

OA

osteoarthritis

ICD–9

International Classification of Diseases, 9th edition

PM&R

Physical Medicine and Rehabilitation

TJA

Total joint arthroplasty

SAF5

Medicare National Sample Administrative Database. Random sample of 5% of physician billings

Declarations

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable

CONSENT FOR PUBLICATION

Not applicable

AVAILABILITY OF DATA AND MATERIAL

The data that support the findings of this study are available through Pearl Diver, Inc. (a subscription online repository of healthcare data and information) but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. The claims data analyzed for this study through Pearl Diver, Inc, are from Centers for Medicare and Medicaid Services (CMS) Limited Data Set files.

COMPETING INTERESTS

No external funds were used to conduct this study.

WJA declares the following: Royalties (DePuy); Speaker Bureau (DePuy); Paid consultant (DePuy); Research support (Stryker, DePuy); Board Membership (AAHKS, Hip Society).

KJB declares the following: Research Support (Agency for Healthcare Research and Quality); Paid consultant (CMMS; Carrum Health, Cardinal Analytix); Unpaid consultant (Harvard Business School Institute for Strategy and Competitiveness); Board of Directors (American Joint Replacement Registry; American Association of Hip and Knee Surgeons Quality Measures Committee).

RCM declares the following: Paid consultant (Stryker, KNG Health Consulting); Research support (Reflexion Health, Zimmer); Board member (North Carolina Orthopaedic Association, Arthroscopy Association of North America).

JO, MGM, JHA and LMM have nothing to declare.

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AUTHORS' CONTRIBUTIONS

JA, JO, RCM, WAJ, KJB designed the study. JA and LMM collected the data. JA, LMM, JO, WAJ, KJB, RCM analyzed the data. JA, MGM, JO wrote the initial draft. All authors read and approved the final manuscript.

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Tables

Table 1 – Sample Inclusion Criteria

	Knee		Hip		Hip & Knee	
	n	%	n	%	n	%
Total Available Medicare Population	55,691,684		55,691,684		55,691,684	
OA in Joint (Hip, Knee, Both) at any point	686,189	1.23%	338,420	0.61%	179,114	0.32%
Excluding OA in both hip and knee	507,075	0.91%	159,306	0.29%		
Excluding Rheumatoid Arthritis	448,884	0.81%	140,958	0.25%	148,119	0.27%
With Eval & Mgmt code on same date	416,504	0.75%	124,783	0.22%	145,601	0.26%
First Instance between 2008-2011	140,958	0.25%	43,659	0.08%	46,147	0.08%
Active 1 year prior, 3 years after diagnosis	92,931	0.17%	26,797	0.05%	34,315	0.06%

Table 2 – Analysis Cohort Demographics

	Hip	Knee	Both
Total	26,797	92,931	34,315
Gender			
Female	16,052	57,754	22,718
Male	10,738	35,147	11,595
Unknown	7	30	2
Age			
64 and Under	3,123	13,006	3,838
65-74	13,676	58,255	20,094
75-84	14,511	44,842	18,702
85 and Over	5,925	13,763	6,352
Unknown	1,616	5,462	2,702
Region			
Midwest	8,057	26,325	10,477
Northeast	5,812	20,003	8,043
South	11,164	42,014	14,630
West	5,406	16,922	6,463
Unknown	57	201	84

SAF5 patient records available via the PearlDiver database do not contain data on race

Categories may not sum to total number of patients due to multiyear or incomplete records

Table 3. Medicare Knee Patients Service Dates and Payments by Service Type and Year

SERVICE	Service Dates, n (%)			Payments, \$ (%)		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
All Services	737,640 (41.6)	509,910 (28.8)	524,589 (29.6)	202,742,778 (55.6)	90,843,398 (24.9)	70,834,436 (19.4)
SURGERY						
All Surgery	18,446 (1.0)	5,972 (0.3)	3,866 (0.2)	116,950,903 (32.1)	53,108,051 (14.6)	38,172,804 (10.5)
Any Arthroplasty	11,597 (0.7)	4,765 (0.3)	2,975 (0.2)	102,539,363 (28.1)	50,572,154 (13.9)	36,380,452 (10.0)
Total Arthroplasty	10,890 (0.6)	4,478 (0.3)	2,699 (0.2)	100,819,420 (27.7)	49,923,315 (13.7)	35,708,474 (9.8)
Total Hip Arthroplasty	27 (0.0)	21 (0.0)	17 (0.0)	242,431 (0.1)	217,872 (0.1)	159,431 (0.0)
Total Knee Arthroplasty	10,865 (0.6)	4,459 (0.3)	2,686 (0.2)	100,576,989 (27.6)	49,705,443 (13.6)	35,549,043 (9.8)
Other Arthroplasty	930 (0.1)	429 (0.0)	388 (0.0)	1,719,943 (0.5)	648,839 (0.2)	671,978 (0.2)
Any Non-Arthroplasty	6,954 (0.4)	1,240 (0.1)	928 (0.1)	14,411,540 (4.0)	2,535,897 (0.7)	1,792,352 (0.5)
Arthroscopy	6,713 (0.4)	1,088 (0.1)	740 (0.0)	14,192,877 (3.9)	2,401,749 (0.7)	1,625,923 (0.4)
Other	254 (0.0)	154 (0.0)	190 (0.0)	218,663 (0.1)	134,148 (0.0)	167,174 (0.0)
IMAGING						
All Imaging	121,872 (6.9)	54,876 (3.1)	49,912 (2.8)	16,386,556 (4.5)	7,292,358 (2.0)	5,843,578 (1.6)
Radiography	95,879 (5.4)	36,156 (2.0)	32,824 (1.9)	4,210,137 (1.2)	1,470,302 (0.4)	1,388,906 (0.4)
Computed Tomography	10,062 (0.6)	6,783 (0.4)	3,932 (0.2)	2,787,408 (0.8)	1,990,278 (0.5)	908,902 (0.2)
Magnetic Resonance	21,616 (1.2)	8,235 (0.5)	7,646 (0.4)	8,638,939 (2.4)	3,189,913 (0.9)	2,808,603 (0.8)
Ultrasound	6,286 (0.4)	5,814 (0.3)	6,857 (0.4)	750,072 (0.2)	641,865 (0.2)	737,167 (0.2)
LABORATORY AND MEDICAL						
All Pathology/Laboratory	174,448 (9.8)	183,746 (10.4)	194,302 (11.0)	5,961,225 (1.6)	5,819,503 (1.6)	5,690,258 (1.6)
All Medical Services	263,345 (14.9)	215,184 (12.1)	234,114 (13.2)	31,964,583 (8.8)	18,567,330 (5.1)	17,699,520 (4.9)
Behavioral Health	17 (0.0)	2,933 (0.2)	10,383 (0.6)	1,600 (0.0)	178,253 (0.0)	663,203 (0.2)
Physician-admin. Medications	82,652 (4.7)	45,586 (2.6)	45,347 (2.6)	5,703,412 (1.6)	2,634,725 (0.7)	2,477,696 (0.7)
Hyaluronic Acid	25,699 (1.5)	12,920 (0.7)	13,059 (0.7)	5,309,938 (1.5)	2,414,394 (0.7)	2,270,280 (0.6)
Corticosteroid	59,579 (3.4)	33,465 (1.9)	32,838 (1.9)	393,474 (0.1)	220,331 (0.1)	204,165 (0.1)
Nutrition Services	804 (0.0)	780 (0.0)	842 (0.0)	61,879 (0.0)	61,271 (0.0)	71,022 (0.0)
Procedures	111,637 (6.3)	62,382 (3.5)	60,538 (3.4)	6,536,449 (1.8)	2,793,876 (0.8)	2,454,823 (0.7)
Arthrocentesis	78,045 (4.4)	34,980 (2.0)	33,453 (1.9)	6,011,107 (1.6)	2,484,796 (0.7)	2,199,151 (0.6)
Stimulation	35,222 (2.0)	27,761 (1.6)	27,321 (1.5)	525,342 (0.1)	309,080 (0.1)	255,672 (0.1)
Rehabilitation	176,950 (10.0)	162,942 (9.2)	173,995 (9.8)	19,619,912 (5.4)	12,886,584 (3.5)	12,016,681 (3.3)
PM&R	30,437 (1.7)	24,075 (1.4)	24,310 (1.4)	673,298 (0.2)	393,746 (0.1)	328,915 (0.1)
Physical/Occupational	137,024 (7.7)	113,922 (6.4)	121,026 (6.8)	17,422,564 (4.8)	11,055,232 (3.0)	10,332,618 (2.8)
Chiropractor	41,440 (2.3)	49,512 (2.8)	53,005 (3.0)	1,524,050 (0.4)	1,437,606 (0.4)	1,355,148 (0.4)
Other	368 (0.0)	104 (0.0)	102 (0.0)	41,331 (0.0)	12,621 (0.0)	16,095 (0.0)

EVALUATION AND MANAGEMENT

All E&M	159,529 (9.0)	50,132 (2.8)	42,395 (2.4)	31,479,511 (8.6)	6,056,156 (1.7)	3,428,276 (0.9)
Ambulatory	148,239 (8.4)	45,293 (2.6)	37,704 (2.1)	21,368,704 (5.9)	4,383,597 (1.2)	2,646,685 (0.7)
Hospital	12,891 (0.7)	3,924 (0.2)	2,740 (0.2)	4,670,469 (1.3)	837,145 (0.2)	370,321 (0.1)
Inpatient	12,296 (0.7)	3,799 (0.2)	2,629 (0.1)	4,337,267 (1.2)	781,940 (0.2)	340,648 (0.1)
Observation	852 (0.0)	139 (0.0)	102 (0.0)	106,582 (0.0)	17,145 (0.0)	11,303 (0.0)
Critical Care	783 (0.0)	141 (0.0)	69 (0.0)	226,620 (0.1)	38,060 (0.0)	18,370 (0.0)
Emergency	14,804 (0.8)	1,966 (0.1)	1,105 (0.1)	4,370,460 (1.2)	584,418 (0.2)	283,632 (0.1)
Skilled Nursing	4,237 (0.2)	1,375 (0.1)	1,071 (0.1)	749,425 (0.2)	166,297 (0.0)	83,100 (0.0)
Other	2,166 (0.1)	635 (0.0)	432 (0.0)	320,200 (0.1)	84,699 (0.0)	44,538 (0.0)

Percentages reflect proportion of service dates or payments for total analysis period (Years 1, 2, and 3)

Other Arthroplasty= revision and partial arthroplasty

PM&R= physical medicine & rehabilitation

PT/OT= physical and occupational therapy

If the number of service dates or total payments was less than 10 but greater than 0, PearlDiver reports the value as 5 throughout.

Table 4. Medicare Knee Patients Service Dates and Payments per Total Patients

SERVICE	Service Dates per Total Patients, n			Payments per Total Patients, \$		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
All Services	7.94	5.49	5.64	2181.65	977.54	762.23
SURGERY						
All Surgery	0.20	0.06	0.04	1258.47	571.48	410.77
Any Arthroplasty	0.12	0.05	0.03	1103.39	544.19	391.48
Total Arthroplasty	0.12	0.05	0.03	1084.88	537.21	384.25
Total Hip Arthroplasty	0.00	0.00	0.00	2.61	2.34	1.72
Total Knee Arthroplasty	0.12	0.05	0.03	1082.28	534.86	382.53
Other Arthroplasty	0.01	0.00	0.00	18.51	6.98	7.23
Any Non-Arthroplasty	0.07	0.01	0.01	155.08	27.29	19.29
Arthroscopy	0.07	0.01	0.01	152.72	25.84	17.50
Other	0.00	0.00	0.00	2.35	1.44	1.80
IMAGING						
All Imaging	1.31	0.59	0.54	176.33	78.47	62.88
Radiography	1.03	0.39	0.35	45.30	15.82	14.95
Computed Tomography	0.11	0.07	0.04	29.99	21.42	9.78
Magnetic Resonance	0.23	0.09	0.08	92.96	34.33	30.22
Ultrasound	0.07	0.06	0.07	8.07	6.91	7.93
LABORATORY AND MEDICAL						
All Pathology/Laboratory	1.88	1.98	2.09	64.15	62.62	61.23
All Medical Services	2.83	2.32	2.52	343.96	199.80	190.46
Behavioral Health	0.00	0.03	0.11	0.02	1.92	7.14
Physician-admin. Medications	0.89	0.49	0.49	61.37	28.35	26.66
Hyaluronic Acid	0.28	0.14	0.14	57.14	25.98	24.43
Corticosteroid	0.64	0.36	0.35	4.23	2.37	2.20
Nutrition Services	0.01	0.01	0.01	0.67	0.66	0.76
Procedures	1.20	0.67	0.65	70.34	30.06	26.42
Arthrocentesis	0.84	0.38	0.36	64.68	26.74	23.66
Stimulation	0.38	0.30	0.29	5.65	3.33	2.75
Rehabilitation	1.90	1.75	1.87	211.12	138.67	129.31
PM&R	0.33	0.26	0.26	7.25	4.24	3.54
Physical/Occupational	1.47	1.23	1.30	187.48	118.96	111.19
Chiropractor	0.45	0.53	0.57	16.40	15.47	14.58
Other	0.00	0.00	0.00	0.44	0.14	0.17
EVALUATION AND MANAGEMENT						
All E & M	1.72	0.54	0.46	338.74	65.17	36.89
Ambulatory	1.60	0.49	0.41	229.94	47.17	28.48
Hospital	0.14	0.04	0.03	50.26	9.01	3.98
Inpatient	0.13	0.04	0.03	46.67	8.41	3.67
Observation	0.01	0.00	0.00	1.15	0.18	0.12
Critical Care	0.01	0.00	0.00	2.44	0.41	0.20
Emergency	0.16	0.02	0.01	47.03	6.29	3.05
Skilled Nursing	0.05	0.01	0.01	8.06	1.79	0.89
Other	0.02	0.01	0.00	3.45	0.91	0.48

Service Dates per Total Patients reflects the ratio of service dates to total number of patients in the cohort, or the number of service dates expected per patient in a given population

Other Arthroplasty= revision and partial arthroplasty

PM&R= physical medicine & rehabilitation

PT/OT= physical and occupational therapy

Table 5. Medicare Hip Patients Service Dates and Payments by Service Type and Year.

SERVICE	Service Dates, n (%)			Payments, \$ (%)		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
All Services	202,836 (43.6)	129,917 (27.9)	132,747 (28.5)	62,710,339 (65.3)	19,221,269 (20.0)	14,142,780 (14.7)
SURGERY						
All Surgery	4,837 (1.0)	1,106 (0.2)	673 (0.1)	38,008,801 (39.6)	10,405,389 (10.8)	6,603,287 (6.9)
Any Arthroplasty	4,471 (1.0)	1,010 (0.2)	569 (0.1)	37,535,310 (39.1)	10,264,794 (10.7)	6,479,774 (6.7)
Total Arthroplasty	4,093 (0.9)	906 (0.2)	488 (0.1)	36,999,419 (38.5)	10,112,092 (10.5)	6,352,669 (6.6)
Total Hip Arthroplasty	4,087 (0.9)	902 (0.2)	488 (0.1)	36,874,479 (38.4)	10,008,822 (10.4)	6,352,488 (6.6)
Total Knee Arthroplasty	11 (0.0)	5 (0.0)	5 (0.0)	124,940 (0.1)	5 (0.0)	5 (0.0)
Other Arthroplasty	420 (0.1)	116 (0.0)	93 (0.0)	535,891 (0.6)	152,702 (0.2)	127,105 (0.1)
Any Non-Arthroplasty	376 (0.1)	98 (0.0)	105 (0.0)	473,491 (0.5)	140,595 (0.1)	123,513 (0.1)
Arthroscopy	67 (0.0)	34 (0.0)	22 (0.0)	190,428 (0.2)	79,396 (0.1)	40,178 (0.0)
Other	312 (0.1)	64 (0.0)	84 (0.0)	283,063 (0.3)	61,199 (0.1)	87,799 (0.1)
IMAGING						
All Imaging	42,524 (9.1)	15,467 (3.3)	13,240 (2.8)	6,191,584 (6.4)	2,153,479 (2.2)	1,625,619 (1.7)
Radiography	34,001 (7.3)	10,224 (2.2)	8,944 (1.9)	1,676,613 (1.7)	446,998 (0.5)	385,664 (0.4)
Computed Tomography	5,217 (1.1)	2,400 (0.5)	1,394 (0.3)	1,346,002 (1.4)	649,720 (0.7)	320,452 (0.3)
Magnetic Resonance	7,062 (1.5)	2,446 (0.5)	2,164 (0.5)	3,049,874 (3.2)	957,236 (1.0)	817,900 (0.9)
Ultrasound	1,117 (0.2)	990 (0.2)	1,089 (0.2)	119,095 (0.1)	99,525 (0.1)	101,603 (0.1)
LABORATORY AND MEDICAL						
All Pathology/Laboratory	53,152 (11.4)	55,016 (11.8)	57,980 (12.5)	1,819,904 (1.9)	1,733,542 (1.8)	1,675,675 (1.7)
All Medical Services	65,190 (14.0)	52,131 (11.2)	56,272 (12.1)	6,853,298 (7.1)	4,070,874 (4.2)	3,806,087 (4.0)
Behavioral Health	5 (0.0)	1,085 (0.2)	3,150 (0.7)	5 (0.0)	65,365 (0.1)	203,500 (0.2)
Physician-admin. Medications	9,769 (2.1)	6,633 (1.4)	6,560 (1.4)	72,195 (0.1)	48,019 (0.0)	46,012 (0.0)
Hyaluronic Acid	17 (0.0)	5 (0.0)	5 (0.0)	1,835 (0.0)	5 (0.0)	5 (0.0)
Corticosteroid	9,751 (2.1)	6,626 (1.4)	6,548 (1.4)	70,288 (0.1)	47,263 (0.0)	43,447 (0.0)
Nutrition Services	174 (0.0)	152 (0.0)	148 (0.0)	13,399 (0.0)	13,341 (0.0)	12,765 (0.0)
Procedures	15,321 (3.3)	8,956 (1.9)	8,447 (1.8)	724,869 (0.8)	314,207 (0.3)	265,059 (0.3)
Arthrocentesis	6,597 (1.4)	3,002 (0.6)	2,824 (0.6)	590,652 (0.6)	244,754 (0.3)	212,162 (0.2)
Stimulation	8,923 (1.9)	6,002 (1.3)	5,631 (1.2)	134,217 (0.1)	69,453 (0.1)	52,897 (0.1)
Rehabilitation	54,249 (11.7)	43,656 (9.4)	45,571 (9.8)	6,040,250 (6.3)	3,628,036 (3.8)	3,275,931 (3.4)
PM&R	8,474 (1.8)	5,715 (1.2)	5,321 (1.1)	178,608 (0.2)	90,733 (0.1)	70,717 (0.1)
Physical/Occupational	41,653 (8.9)	30,850 (6.6)	31,643 (6.8)	5,371,264 (5.6)	3,158,951 (3.3)	2,848,009 (3.0)
Chiropractor	12,987 (2.8)	12,693 (2.7)	13,984 (3.0)	490,378 (0.5)	378,352 (0.4)	357,205 (0.4)
Other	18 (0.0)	13 (0.0)	20 (0.0)	1,917 (0.0)	1,906 (0.0)	2,820 (0.0)
EVALUATION AND MANAGEMENT						
All E & M	37,133 (8.0)	6,197 (1.3)	4,582 (1.0)	9,836,752 (10.2)	857,985 (0.9)	432,112 (0.4)
Ambulatory	32,240 (6.9)	5,180 (1.1)	3,722 (0.8)	5,237,557 (5.5)	541,515 (0.6)	278,135 (0.3)
Hospital	5,623 (1.2)	742 (0.2)	477 (0.1)	2,289,711 (2.4)	157,030 (0.2)	65,857 (0.1)
Inpatient	5,361 (1.2)	702 (0.2)	438 (0.1)	2,120,233 (2.2)	139,727 (0.1)	57,922 (0.1)
Observation	371 (0.1)	42 (0.0)	35 (0.0)	49,775 (0.1)	4,067 (0.0)	3,630 (0.0)
Critical Care	373 (0.1)	29 (0.0)	17 (0.0)	119,703 (0.1)	13,236 (0.0)	4,305 (0.0)
Emergency	6,032 (1.3)	413 (0.1)	271 (0.1)	1,848,054 (1.9)	118,769 (0.1)	70,196 (0.1)
Skilled Nursing	1,916 (0.4)	292 (0.1)	178 (0.0)	391,907 (0.4)	32,225 (0.0)	12,217 (0.0)
Other	517 (0.1)	87 (0.0)	56 (0.0)	68,872 (0.1)	8,446 (0.0)	5,707 (0.0)

Percentages reflect proportion of service dates or payments for total analysis period (Years 1, 2, and 3)

Other Arthroplasty= revision and partial arthroplasty

PM&R= physical medicine & rehabilitation

PT/OT= physical and occupational therapy

If the number of service dates or total payments was less than 10 but greater than 0, PearlDiver reports the value as 5 throughout.

Table 6. Medicare Hip Patients Service Dates and Payments per Total Patients

SERVICE	Service Dates per Total Patients, n			Payments per Total Patients, \$		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
All Services	7.57	4.85	4.95	2340.20	717.29	527.77
SURGERY						
All Surgery	0.18	0.04	0.03	1418.40	388.30	246.42
Any Arthroplasty	0.17	0.04	0.02	1400.73	383.06	241.81
Total Arthroplasty	0.15	0.03	0.02	1380.73	377.36	237.07
Total Hip Arthroplasty	0.15	0.03	0.02	1376.07	373.51	237.06
Total Knee Arthroplasty	0.00	0.00	0.00	4.66	0.00	0.00
Other Arthroplasty	0.02	0.00	0.00	20.00	5.70	4.74
Any Non-Arthroplasty	0.01	0.00	0.00	17.67	5.25	4.61
Arthroscopy	0.00	0.00	0.00	7.11	2.96	1.50
Other	0.01	0.00	0.00	10.56	2.28	3.28
IMAGING						
All Imaging	1.59	0.58	0.49	231.06	80.36	60.66
Radiography	1.27	0.38	0.33	62.57	16.68	14.39
Computed Tomography	0.19	0.09	0.05	50.23	24.25	11.96
Magnetic Resonance	0.26	0.09	0.08	113.81	35.72	30.52
Ultrasound	0.04	0.04	0.04	4.44	3.71	3.79
LABORATORY AND MEDICAL						
All Pathology/Laboratory	1.88	1.98	2.09	64.15	62.62	61.23
All Medical Services	2.83	2.32	2.52	343.96	199.80	190.46
Behavioral Health	0.00	0.03	0.11	0.02	1.92	7.14
Physician-admin. Medications	0.89	0.49	0.49	61.37	28.35	26.66
Hyaluronic Acid	0.28	0.14	0.14	57.14	25.98	24.43
Corticosteroid	0.64	0.36	0.35	4.23	2.37	2.20
Nutrition Services	0.01	0.01	0.01	0.67	0.66	0.76
Procedures	1.20	0.67	0.65	70.34	30.06	26.42
Arthrocentesis	0.84	0.38	0.36	64.68	26.74	23.66
Stimulation	0.38	0.30	0.29	5.65	3.33	2.75
Rehabilitation	1.90	1.75	1.87	211.12	138.67	129.31
PM&R	0.33	0.26	0.26	7.25	4.24	3.54
Physical/Occupational	1.47	1.23	1.30	187.48	118.96	111.19
Chiropractor	0.45	0.53	0.57	16.40	15.47	14.58
Other	0.00	0.00	0.00	0.44	0.14	0.17
EVALUATION AND MANAGEMENT						
All E & M	1.39	0.23	0.17	367.08	32.02	16.13
Ambulatory	1.20	0.19	0.14	195.45	20.21	10.38
Hospital	0.21	0.03	0.02	85.45	5.86	2.46
Inpatient	0.20	0.03	0.02	79.12	5.21	2.16
Observation	0.01	0.00	0.00	1.86	0.15	0.14
Critical Care	0.01	0.00	0.00	4.47	0.49	0.16
Emergency	0.23	0.02	0.01	68.96	4.43	2.62
Skilled Nursing	0.07	0.01	0.01	14.63	1.20	0.46
Other	0.02	0.00	0.00	2.57	0.32	0.21

Service Dates per Total Patients reflects the ratio of service dates to total number of patients in the cohort, or the number of service dates expected per patient in a given population

Other Arthroplasty= revision and partial arthroplasty

PM&R= physical medicine & rehabilitation

PT/OT= physical and occupational therapy

Table 7. Medicare Hip and Knee Patients Service Dates and Payments by Service Type and Year.

SERVICE	Service Dates, n (%)			Payments, \$ (%)		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
All Services	227,986 (32.9)	220,383 (31.8)	246,614 (35.5)	115,532,907 (51.2)	60,600,527 (26.9)	49,857,883 (22.1)
SURGERY						
All Surgery	9,993 (1.4)	4,191 (0.6)	3,009 (0.4)	73,484,146 (32.6)	38,751,068 (17.2)	30,829,571 (13.7)
Any Arthroplasty	8,216 (1.2)	3,603 (0.5)	2,485 (0.4)	69,903,536 (31.0)	37,652,576 (16.7)	29,835,218 (13.2)
Total Arthroplasty	7,616 (1.1)	3,318 (0.5)	2,205 (0.3)	68,835,520 (30.5)	37,094,987 (16.4)	29,310,438 (13.0)
Total Hip Arthroplasty	4,323 (0.6)	1,677 (0.2)	1,129 (0.2)	38,674,428 (17.1)	18,706,390 (8.3)	14,726,378 (6.5)
Total Knee Arthroplasty	3,311 (0.5)	1,662 (0.2)	1,093 (0.2)	30,161,092 (13.4)	18,388,597 (8.2)	14,584,060 (6.5)
Other Arthroplasty	712 (0.1)	358 (0.1)	343 (0.0)	1,068,016 (0.5)	557,589 (0.2)	524,780 (0.2)
Any Non-Arthroplasty	1,824 (0.3)	604 (0.1)	536 (0.1)	3,580,610 (1.6)	1,098,492 (0.5)	994,353 (0.4)
Arthroscopy	1,565 (0.2)	465 (0.1)	399 (0.1)	3,345,884 (1.5)	976,789 (0.4)	870,425 (0.4)
Other	265 (0.0)	141 (0.0)	137 (0.0)	238,105 (0.1)	125,366 (0.1)	123,928 (0.1)
IMAGING						
All Imaging	64,033 (9.2)	39,048 (5.6)	37,489 (5.4)	9,034,199 (4.0)	4,863,026 (2.2)	4,215,427 (1.9)
Radiography	51,631 (7.4)	28,790 (4.1)	27,539 (4.0)	2,591,530 (1.1)	1,298,344 (0.6)	1,255,829 (0.6)
Computed Tomography	6,021 (0.9)	4,020 (0.6)	2,542 (0.4)	1,594,045 (0.7)	1,106,079 (0.5)	595,650 (0.3)
Magnetic Resonance	10,864 (1.6)	5,426 (0.8)	5,290 (0.8)	4,552,528 (2.0)	2,156,119 (1.0)	2,001,891 (0.9)
Ultrasound	2,527 (0.4)	2,640 (0.4)	3,224 (0.5)	296,096 (0.1)	302,484 (0.1)	362,057 (0.2)
LABORATORY AND MEDICAL						
All Pathology/Laboratory	70,276 (10.1)	75,406 (10.9)	81,363 (11.7)	2,432,529 (1.1)	2,428,750 (1.1)	2,376,809 (1.1)
All Medical Services	114,535 (16.5)	110,204 (15.9)	125,552 (18.1)	14,260,449 (6.3)	9,963,444 (4.4)	9,698,625 (4.3)
Behavioral Health	5 (0.0)	858 (0.1)	3,522 (0.5)	5 (0.0)	53,862 (0.0)	237,941 (0.1)
Physician-admin. Medications	28,743 (4.1)	21,179 (3.1)	22,056 (3.2)	1,539,071 (0.7)	963,969 (0.4)	952,898 (0.4)
Hyaluronic Acid	6,577 (0.9)	4,579 (0.7)	4,802 (0.7)	1,379,877 (0.6)	851,146 (0.4)	844,325 (0.4)
Corticosteroid	22,927 (3.3)	16,888 (2.4)	17,461 (2.5)	159,194 (0.1)	112,775 (0.1)	108,573 (0.0)
Nutrition Services	258 (0.0)	280 (0.0)	291 (0.0)	19,577 (0.0)	23,227 (0.0)	23,775 (0.0)
Procedures	41,103 (5.9)	30,890 (4.5)	32,488 (4.7)	2,422,775 (1.1)	1,410,468 (0.6)	1,351,030 (0.6)
Arthrocentesis	26,421 (3.8)	16,694 (2.4)	16,953 (2.4)	2,169,876 (1.0)	1,239,762 (0.5)	1,202,989 (0.5)
Stimulation	15,426 (2.2)	14,415 (2.1)	15,652 (2.3)	252,899 (0.1)	170,706 (0.1)	148,041 (0.1)
Rehabilitation	84,288 (12.1)	85,837 (12.4)	96,905 (14.0)	10,266,305 (4.6)	7,502,973 (3.3)	7,125,467 (3.2)
PM&R	14,048 (2.0)	13,160 (1.9)	13,858 (2.0)	337,349 (0.1)	220,656 (0.1)	185,332 (0.1)
PT/OT	67,444 (9.7)	64,494 (9.3)	73,360 (10.6)	9,169,664 (4.1)	6,619,562 (2.9)	6,316,982 (2.8)
Chiropractor	17,745 (2.6)	21,768 (3.1)	24,008 (3.5)	759,292 (0.3)	662,755 (0.3)	623,153 (0.3)
Other	102 (0.0)	65 (0.0)	68 (0.0)	12,462 (0.0)	8,945 (0.0)	7,514 (0.0)
EVALUATION AND MANAGEMENT						
All E & M	68,418 (9.9)	31,952 (4.6)	30,324 (4.4)	16,321,584 (7.2)	4,594,239 (2.0)	2,737,451 (1.2)
Ambulatory	61,886 (8.9)	27,741 (4.0)	25,420 (3.7)	10,162,751 (4.5)	2,982,967 (1.3)	1,888,799 (0.8)
Hospital	8,399 (1.2)	3,387 (0.5)	2,820 (0.4)	3,099,123 (1.4)	793,173 (0.4)	388,760 (0.2)
Inpatient	8,081 (1.2)	3,259 (0.5)	2,698 (0.4)	2,887,438 (1.3)	744,506 (0.3)	360,281 (0.2)
Observation	498 (0.1)	157 (0.0)	111 (0.0)	69,715 (0.0)	19,595 (0.0)	11,434 (0.0)
Critical Care	453 (0.1)	114 (0.0)	75 (0.0)	141,970 (0.1)	29,072 (0.0)	17,045 (0.0)
Emergency	7,911 (1.1)	2,035 (0.3)	1,390 (0.2)	2,395,190 (1.1)	592,561 (0.3)	341,657 (0.2)
Skilled Nursing	2,697 (0.4)	1,206 (0.2)	997 (0.1)	489,303 (0.2)	167,382 (0.1)	82,112 (0.0)
Other	1,137 (0.2)	446 (0.1)	370 (0.1)	173,968 (0.1)	57,702 (0.0)	36,016 (0.0)

Percentages reflect proportion of service dates or payments for total analysis period (Years 1, 2, and 3)

Other Arthroplasty= revision and partial arthroplasty

PM&R= physical medicine & rehabilitation

PT/OT= physical and occupational therapy

If the number of service dates or total payments was less than 10 but greater than 0, PearlDiver reports the value as 5 throughout.

Table 8. Medicare Hip and Knee Patients Service Dates and Payments per Total Patients

SERVICE	Service Dates per Total Patients, n			Payments per Total Patients, \$		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
All Services	6.64	6.42	7.19	3366.83	1766.01	1452.95
SURGERY						
All Surgery	0.29	0.12	0.09	2141.46	1129.27	898.43
Any Arthroplasty	0.24	0.10	0.07	2037.11	1097.26	869.45
Total Arthroplasty	0.22	0.10	0.06	2005.99	1081.01	854.16
Total Hip Arthroplasty	0.13	0.05	0.03	1127.04	545.14	429.15
Total Knee Arthroplasty	0.10	0.05	0.03	878.95	535.88	425.01
Other Arthroplasty	0.02	0.01	0.01	31.12	16.25	15.29
Any Non-Arthroplasty	0.05	0.02	0.02	104.35	32.01	28.98
Arthroscopy	0.05	0.01	0.01	97.50	28.47	25.37
Other	0.01	0.00	0.00	6.94	3.65	3.61
IMAGING						
All Imaging	1.87	1.14	1.09	263.27	141.72	122.85
Radiography	1.50	0.84	0.80	75.52	37.84	36.60
Computed Tomography	0.18	0.12	0.07	46.45	32.23	17.36
Magnetic Resonance	0.32	0.16	0.15	132.67	62.83	58.34
Ultrasound	0.07	0.08	0.09	8.63	8.81	10.55
LABORATORY AND MEDICAL						
All Pathology/Laboratory	2.05	2.20	2.37	70.89	70.78	69.26
All Medical Services	3.34	3.21	3.66	415.57	290.35	282.64
Behavioral Health	0.00	0.03	0.10	0.00	1.57	6.93
Physician-admin. Medications	0.84	0.62	0.64	44.85	28.09	27.77
Hyaluronic Acid	0.19	0.13	0.14	40.21	24.80	24.61
Corticosteroid	0.67	0.49	0.51	4.64	3.29	3.16
Nutrition Services	0.01	0.01	0.01	0.57	0.68	0.69
Procedures	1.20	0.90	0.95	70.60	41.10	39.37
Arthrocentesis	0.77	0.49	0.49	63.23	36.13	35.06
Stimulation	0.45	0.42	0.46	7.37	4.97	4.31
Rehabilitation	2.46	2.50	2.82	299.18	218.65	207.65
PM&R	0.41	0.38	0.40	9.83	6.43	5.40
Physical/Occupational	1.97	1.88	2.14	267.22	192.91	184.09
Chiropractor	0.52	0.63	0.70	22.13	19.31	18.16
Other	0.00	0.00	0.00	0.36	0.26	0.22
EVALUATION AND MANAGEMENT						
All E & M	1.72	0.54	0.46	338.74	65.17	36.89
Ambulatory	1.60	0.49	0.41	229.94	47.17	28.48
Hospital	0.14	0.04	0.03	50.26	9.01	3.98
Inpatient	0.13	0.04	0.03	46.67	8.41	3.67
Observation	0.01	0.00	0.00	1.15	0.18	0.12
Critical Care	0.01	0.00	0.00	2.44	0.41	0.20
Emergency	0.16	0.02	0.01	47.03	6.29	3.05
Skilled Nursing	0.05	0.01	0.01	8.06	1.79	0.89
Other	0.02	0.01	0.00	3.45	0.91	0.48

Service Dates per Total Patients reflects the ratio of service dates to total number of patients in the cohort, or the number of service dates expected per patient in a given population

Other Arthroplasty= revision and partial arthroplasty

PM&R= physical medicine & rehabilitation

PT/OT= physical and occupational therapy

Figures

Figure 1

Timeline of index date and longitudinal tracking period for patients in the analysis cohort.

Figure 2

Primary Service Categories and specific procedures identified from expert opinion and clinical practice guidelines.

Figure 3

Payments and Service Dates per Total Patients in Medicare Hip, Knee, and Both cohorts

Supplementary Files

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