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Ninety-day and one-year healthcare utilization and costs after knee arthroplasty

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SUMMARY

Objectives: This study examined ninety-day and one-year postoperative healthcare utilization and costs following total knee arthroplasty (TKA) from the health sector and patient perspectives.
Design: This study relied on: 1) patient-reported medical resource utilization data from diaries in the Knee Arthroplasty Pain Coping Skills Training (KASTPain) trial; and 2) Medicare fee schedules. Medicare payments, patient cost-sharing, and patient time costs were estimated. Generalized linear mixed models were used to identify baseline predictors of costs.
Results: In the first ninety days following TKA, patients had an average of 29.7 outpatient visits and 6% were hospitalized. Mean total costs during this period summed to $3,720, the majority attributed to outpatient visit costs (84%). Over the year following TKA, patients had an average of 48.9 outpatient visits, including 33.2 for physical therapy. About a quarter (24%) of patients were hospitalized. Medical costs were incurred at a decreasing rate, from $2,428 in the first six weeks to $648 in the last six weeks. Mean total medical costs across all patients over the year were $8,930, including $5,328 in outpatient costs. Total costs were positively associated with baseline Charlson comorbidity score ($P < 0.01$). Outpatient costs were positively associated with baseline Charlson comorbidity score ($P = 0.03$) and a bodily pain burden summary score ($P < 0.01$). Mean patient cost-sharing summed to $1,342 and time costs summed to $1,346.
Conclusions: Costs in the ninety days and year after TKA can be substantial for both healthcare payers and patients. These costs should be considered as payers continue to explore alternative payment models.

Introduction

Half of patients with knee osteoarthritis are expected to undergo a total knee arthroplasty (TKA) and as of 2010, there are an estimated 4.7 million individuals in the United States who have undergone a TKA[1,2]. This number is expected to grow considerably as the annual number of TKAs is projected to grow from approximately 620,000 in 2010 to 1.38 million by 2020[3,4]. In 2015, the average cost of a TKA was approximately $16,000 per discharge, summing to almost $10 billion in inpatient costs alone[3].

Inpatient and rehabilitation costs within 30 days post-TKA have been well documented and are a large focus for cost savings in recent Medicare bundled payment models[5–10]. However, patients are staying in the hospital for shorter periods of time, and larger proportions of patients receive follow-up care at home rather than in rehabilitation facilities[5,9]. There is less information about the comprehensive, longer-term post-TKA experience, including costs for all types of outpatient services, out-of-pocket costs for patients, and whether patient-reported pain measures are associated with

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medical resource use and costs in a patient population with moderate to high levels of pain catastrophizing.

The Knee Arthroplasty Pain Coping Skills Training (KASTPain) trial (NCT01620983) was a randomized clinical trial designed to test whether Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) Pain Scale scores one year after TKA differed across patients receiving one of three interventions: pain coping skills training, arthritis education, or usual care[11]. While each treatment arm experienced large improvements in the primary outcome of WOMAC Pain, the trial found no statistically significant differences for primary and secondary outcomes across the three treatment arms. A secondary objective of the trial was to examine medical resource utilization in the year after TKA.

In this paper, we report ninety-day and one-year healthcare resource utilization and costs after TKA from both a health sector perspective, as well as a patient perspective. The health sector perspective encompasses both health care payer medical costs and patient out-of-pocket spending on medical services, providing a broader perspective than the traditional health care payer perspective[12]. The patient perspective includes patient out-of-pocket spending on medical services as well as patient time costs, providing a broader view than only consideration of patient copayments. We also evaluate whether baseline characteristics, including pain scores and level of pain catastrophizing, are associated with medical resource use and costs.

Methods

This study relied on two data sources: 1) patient-reported healthcare resource utilization data from the KASTPain clinical trial; and 2) publicly available Medicare payment schedules, including patient cost-sharing policies for fee-for-service Medicare beneficiaries without supplemental health insurance.

Perspectives

The health sector perspective accounted for Medicare payer costs and patient out-of-pocket spending on direct medical resource use. The patient perspective accounted for patient out-of-pocket spending as well as the value of patient time spent receiving medical care, consistent with recommendations from the Second Panel on Cost-Effectiveness in Health and Medicine[12].

Resource use from clinical trial

The KASTPain trial was a randomized clinical trial conducted from January 2013 to June 2017 at five academic medical centers. In the trial, 402 patients with knee osteoarthritis who were moderate to high pain catastrophizers were randomized to receive one of three treatment arms: pain coping skills training, arthritis education, or usual care[11].

Ninety-day and one-year healthcare utilization after TKA was based on health care diaries from the KASTPain clinical trial. Beginning at hospital discharge and for one year of follow up in the trial, patients reported healthcare resource use in a six-week diary for the first 48 weeks. A four-week diary was then filled out to complete one year of data collection. Patients reported the number, length of stay, and reason for hospitalizations; number of emergency room or urgent care facility visits; and number and hours spent on visits with physical therapy outside of inpatient rehabilitation, occupational therapy or nursing, orthopedic surgeons, other physicians (family physicians and specialists) and other providers (dieticians, chiropractors, etc; see supplementary file 1 for the diary data collection form). Based on the reported reason for hospitalization, three study team members categorized the hospitalization as related to TKA or not.

Inpatient costs

For hospital admissions within the year following TKA, inpatient costs consisted of hospital facility fees and physician professional fees for inpatient visits. Inpatient facility fees were estimated by assigning Diagnosis Related Group (DRG) codes based on the reason for hospitalization, along with the associated average total payment according to 2015 Medicare inpatient charge data (Appendix Table S1)[13]. These costs were then inflated to 2018 dollars based on the Consumer Price Index for medical care[14]. For inpatient professional fees, we assigned a Current Procedural Terminology (CPT) code of 99223 to the day of admission and a CPT code of 99239 to the day of discharge to account for the higher workload of clinicians on those days (Appendix Table S2)[15]. For all days in between, we assigned a daily physician professional fee based on the CPT code of 99233. Costs were assigned using the national average payment amount according to the 2018 Medicare Physician Fee Schedule (Appendix Table S2). Patient cost-sharing for inpatient facility fees was determined by assuming that each inpatient admission would cost patients a $1,340 inpatient deductible per 2018 Medicare rates[16]. Patient cost-sharing for inpatient physician professional services was calculated as 20% of inpatient physician professional fees.

Emergency department costs

Patients did not distinguish between emergency departments and urgent care facilities when reporting visits. Without this information, we assumed that all were emergency department visits when estimating costs. Emergency department costs consisted of a facility fee and a professional fee. The facility fee was estimated based on the Ambulatory Payment Classification (APC) code 5025 for level 5 type A emergency department visit, which was associated with a $520.85 payment rate and $104.10 minimum unadjusted copayment in 2018[17]. The professional fee was estimated based on the CPT code 99285 for an emergency department visit, which was paid at an average rate of $176.04 in 2018[15]. Patient cost-sharing was calculated as 20% of $176.04, or $35.21[18].

Outpatient costs

To assign costs to outpatient visits, CPT codes were first assigned to all types of outpatient visits and procedures, and corresponding payments were assigned using the 2018 Medicare Physician Fee schedule (Appendix Table S3). Visits to orthopedic surgeons reported in the first two health diaries were assigned a cost of zero to account for Medicare global surgery bundled payments for medical services incurred within 90 days of the knee arthroplasty procedure[19]. Patient copayments for all other outpatient visits were calculated as 20% of total professional payments[20].

Cost of patient time

Patient time spent receiving medical care was valued based on an average post-tax wage rate plus fringe benefits, as recommended[12]. Based on reported weekly median salaries of $854, $873, $879, and $893 per quarter from quarter 4 of 2017 to quarter 3 of 2018, the annual salary in the US was calculated to be $45,487[21]. Assuming an effective individual income tax rate of 25.3% after including federal (14%), state (3.7%), Social Security (6.2%), and Medicare (1.45%) taxes, and that fringe benefits account for 31.7% of total compensation, then the average cost of time spent on medical care was approximately $21.51 per hour to the patient[22–25]. This hourly rate was applied to time spent receiving medical care to quantify the value of patient time.

Statistical analysis

Patients who completed at least seven diaries were included in the analyses of medical resource use and costs. For patients without data for one or two diaries, missing resource use and costs for those periods were imputed using patient-level mean estimates across completed diaries. Baseline demographic, clinical, and pain-related measures were compared using chi-square tests for frequencies, and *t*-tests for means. For skewed distributions, median values were compared using Wilcoxon rank-sum tests.

Descriptive statistics, were reported for counts of healthcare resource use and costs. Mean costs were reported for each six-week period represented in the patient diaries. Since the final diary lasted only four weeks, costs during that period were multiplied by a factor of 1.5 to make six-week cost comparisons consistent.

Independent baseline predictors of one-year total medical costs and outpatient costs were assessed separately using generalized linear mixed models accounting for clustering by site with gamma error distributions and log links. Total medical costs and outpatient costs were calculated from the health sector perspective. Baseline covariates that could influence medical resource use and costs included age, gender, race or ethnic group, income level categorized in six levels, body mass index, whether patients were using opioids, modified Charlson comorbidity index[26], treatment arm, and several validated pain and self-efficacy measures, including the WOMAC pain score[27], pain catastrophizing score[28], a pain location questionnaire[29,30] which allowed for the creation of a summary score for bodily pain burden, and arthritis self-efficacy[31]. The pain location questionnaire was designed to identify the number of chronically painful body regions (e.g., low back, right shoulder, and right hip). Patients were instructed to identify the regions that have been painful for at least the prior three months. Scores ranged from 0 (no painful body regions) to 16 (all listed body regions were painful). From this questionnaire, a composite variable was derived that includes both number of bodily pain sites and the severity of pain rated for each body region from "none" to "severe." Because postoperative physical therapy is a major source of costs during the recovery period[9], we determined whether the same baseline variables were associated with the total number of physical therapy visits using a generalized linear mixed model accounting for clustering by site with a negative binomial error distribution and log link. All associations were tested with a two-sided *P*-value of 0.05. All analyses were performed using SAS 9.4.

Additional analysis: rehabilitation facility use and costs

Two of the five sites in the clinical trial systematically collected inpatient rehabilitation and skilled nursing facility (SNF) stay information. This allowed us to report the number, mean length, and mean cost of rehabilitation stays for those two sites. Inpatient rehabilitation stay costs were estimated as $20,657 per stay based on 2018 Medicare data[32]. SNF stay costs were estimated based on 2013 Medicare data as $492 per day when the length of stay was available, and $12,239 per stay when length of stay was not available[33]. These costs were then inflated to 2018 dollars based on the Consumer Price Index for medical care[14].

Results

Population

Among the 402 patients randomized in the trial, 384 underwent TKA and 326 (85% of those who underwent TKA) patients completed at least seven of the nine healthcare diaries. In aggregate, the final sample was missing 38 of 2,934 diaries, while those who were excluded for having less than seven healthcare diaries were missing 603 of 684 diaries. The final sample for the current study was similar to those who were excluded for having too many missing diaries in baseline age, sex, body mass index, race or ethnic group, and scores for arthritis self-efficacy, pain (WOMAC), pain catastrophizing, and bodily pain burden (Table I). Those who were excluded had slightly lower income levels, as well as slightly higher opioid use prior to surgery compared to the final study population; however, none of these differences were statistically significant ($P \geq 0.05$).

Medical resource use in the first 90 days following TKA

In the 90 days following TKA, 6% of patients were hospitalized. Of those, 86% had only one hospitalization, and 78% of hospitalizations were knee-related. The mean number of outpatient visits was 29.7, and the median number of outpatient visits was 27.1. The majority of these visits (77%, or 22.7 visits) were for physical therapy.

Medical resource use over the entire one-year period

In the year after TKA, the mean number of outpatient visits was 48.9, and the median was 41.3 (Table II). The majority (70%) of visits were for physical therapy, with a mean of 36.6 h and a median of 27.8 h spent on these visits. A total of 79 patients (24%) were hospitalized in the year after TKA. Of these, the majority of patients had only one hospitalization (51 patients, or 65%), and 53% of hospitalizations were knee-related. The mean inpatient days across all the patients were 1.1 with 0.5 inpatient days attributable to knee-related admissions and 0.6 days to non-knee related admissions. A slightly higher number of patients ($n = 94$; 29%) visited the emergency room or an urgent care clinic; of these, the majority ($n = 58$; 62%) of patients had only one such visit in the year after TKA.

Breakdown of costs

Medical costs, including both payer and patient out-of-pocket expenditures, were incurred at a decreasing rate throughout the year as mean total medical costs decreased from $2,428 in the first six-week diary period to $648 in the last six-week diary period (Fig. 1). In the first 90 days, mean total medical costs were $3,720, of which 84% were outpatient costs, 13% were inpatient costs, and 3% were emergency room costs. Of the inpatient costs, 82% were for knee-related hospitalizations.

Across the one-year period following TKA, mean total medical costs across all patients were $8,930, of which 60% were outpatient costs, 36% were inpatient costs, and 4% were emergency room costs (Fig. 2). The majority (71%) of outpatient costs were attributable to physical therapy visits. Of the inpatient costs, 61% were knee-related.

In the year after TKA, the median total medical cost was $5,370, with per-patient costs ranging from $436 to $90,066. Outliers included individuals with 6.5 hospitalizations, 33 inpatient days, and inpatient costs of $76,702. When limited to knee-related inpatient costs, outliers were less extreme, including patients with a maximum of 3 hospitalizations, 14 inpatient days, and inpatient costs of $18,713.

Baseline characteristics associated with total medical costs, outpatient costs, and physical therapy visits

One-year total medical costs, outpatient costs, and number of physical therapy visits were not statistically significantly different

Table I
Patient characteristics

	Study Population (patients reporting at least 7 of 9 diaries) [$N = 326$]	Excluded Population (patients reporting six or fewer diaries) [$N = 76$]
	Mean (SD) or N (%)	Mean (SD) or N (%)
Age (years)	63 (8)	63 (8)
Sex (female)	218 (67%)	49 (64%)
Body mass index (kg/m^2)	32 (6)	32 (7)
Race or ethnic group		
White	204 (63%)	45 (59%)
African American	114 (35%)	29 (38%)
Asian	8 (2%)	0 (0%)
Declined to answer	0 (0%)	2 (3%)
Current income		
<$10,000	32 (10%)	10 (13%)
$10,000 to $24,999	65 (20%)	19 (25%)
$25,000 to $49,999	72 (22%)	19 (25%)
$50,000 to $99,999	80 (25%)	14 (18%)
≥$100,000	46 (14%)	7 (9%)
Declined	31 (10%)	7 (9%)
Modified Charlson comorbidity *	8 (4)	10 (5)
Opioid use at baseline	99 (30%)	28 (37%)
Arthritis Self-efficacy Scale †	49 (17)	49 (19)
WOMAC pain Scale ‡	11 (3)	12 (4)
Pain Catastrophizing Scale §	30 (9)	30 (10)
Summary Bodily Pain Burden Score ‖	11 (9)	12 (9)
Treatment type		
Pain coping skills	106 (33%)	24 (32%)
Arthritis education	107 (33%)	28 (37%)
Usual care	113 (35%)	24 (32%)

* Modified Charlson comorbidity score range is 0–45. Higher scores, greater comorbidity burden.
† Arthritis Self-efficacy Scale range is 0–80. Higher scores, greater self-efficacy.
‡ WOMAC Pain Scale range is 0–20. Higher scores, more function-limiting pain.
§ Pain Catastrophizing Scale range is 0–52. Higher scores, more pain catastrophizing.
‖ Summary Bodily Pain Burden score range is 0–44. Higher scores, more bodily pain burden.

Table II
Summary of medical resource use and costs in year following total knee arthroplasty ($n = 326$)

	Number of Hospitalizations or Visits		Days or Hours Spent on Visits*		Costs, $	
	Mean (SD) [median]	(25th, 75th percentiles) Maximum	Mean (SD) [median]	(25th, 75th percentiles) Maximum	Mean (SD) [median]	(25th, 75th percentiles) Maximum
Inpatient	Hospitalizations		Days			
Knee-related	0.2 (0.4) [0]	(0, 0) 3	0.5 (1.6) [0]	(0, 0) 14	1,991 (5,492) [0]	(0, 0) 33,593
Non-knee related	0.2 (0.5) [0]	(0, 0) 4.5	0.6 (2.9) [0]	(0, 0) 33	1,250 (5,479) [0]	(0,0) 76,702
Total inpatient	0.3 (0.7) [0]	(0, 0) 6.5	1.1 (3.4) [0]	(0, 0) 33	3,241 (7,830) [0]	(0, 0) 76,702
Emergency department/Urgent care	0.4 (0.9) [0]	(0, 1) 7.9	n/a	n/a	361 (759) [0]	(0, 836) 6,571
Outpatient	Visits		Hours			
Physical Therapy	33.2 (23.3) [27.6]	(18,42) 144	36.6 (31.1) [27.8]	(16.9, 44.8) 198.4	3,823 (2,681) [3,176]	(2,070, 4,829) 16,558
Occupational Therapy	3.6 (7) [0]	(0, 5) 73	2.8 (7.6) [0]	(0, 3) 86	407 (791) [0]	(0, 567) 8,280
General Practitioner	6.1 (6) [4.8]	(2,8) 37	7.1 (8.8) [4]	(1.5, 9) 52.5	550 (547) [431]	(181, 726) 3,356
Orthopedic Surgeon	3.9 (2.6) [3]	(2,5) 20	4.9 (5.7) [3]	(1.5, 6) 50.5	353 (236) [272]	(181, 453) 1,814
Other Provider	2.1 (5.5) [0]	(0, 2) 48	2.4 (7.2) [0]	(0, 1.9) 84	195 (499) [0]	(0, 181) 4,353
Total outpatient	48.9 (28.4) [41.3]	(30, 62) 164	53.8 (39.8) [42.1]	(27, 68.4) 225.7	5,328 (3,174) [4,483]	(3,158, 6,754) 18,713
Total	n/a	n/a	n/a	n/a	8,930 (9,390) [5,370]	(3,624, 9,991) 90,066

n/a = not available due to lack of data or incompatibility combining across category types (e.g., days vs hours).
* Inpatient time measured in days; outpatient time measured in hours.

across the three treatment arms. Both higher baseline modified Charlson comorbidity index and summary score for bodily pain burden were associated with higher total medical costs, higher outpatient costs, and a higher number of physical therapy visits, prior to adjusting for all baseline variables. Specifically, as the baseline modified Charlson comorbidity index increased by one

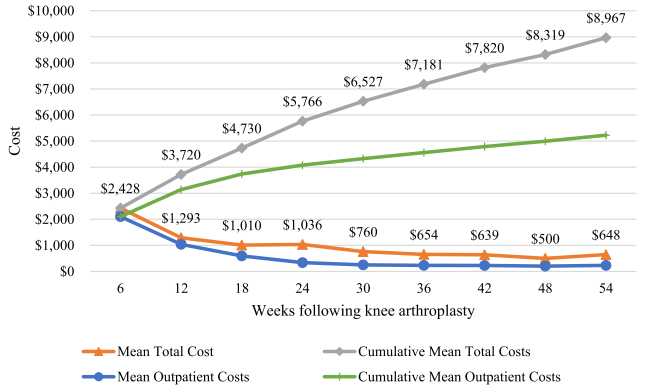

Fig. 1. Mean total and outpatient costs every six weeks in the year after knee arthroplasty.

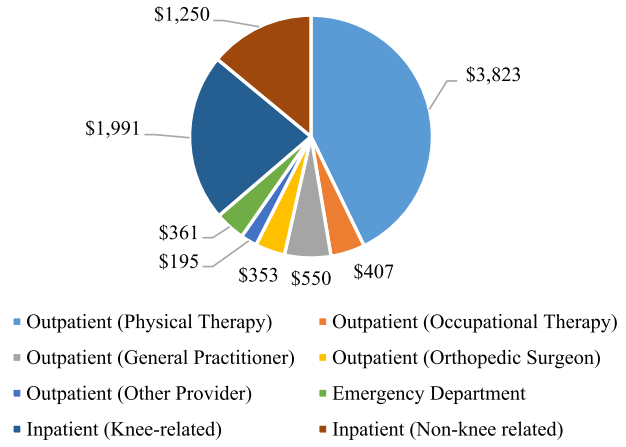

Fig. 2. Cost drivers of mean healthcare costs.

unit, total medical costs, outpatient costs, and number of physical therapy visits increased by a factor of 1.04 (95% CI: 1.02–1.07; $P = 0.0003$), 1.03 (95% CI: 1.01–1.04; $P = 0.0002$), and 1.02 (95% CI: 1.00–1.04; $P = 0.0289$), respectively. As the baseline summary score for bodily pain burden increased by one unit, total medical costs, outpatient costs, and number of physical therapy visits increased by a factor of 1.01 (95% CI: 1.00–1.02; $P = 0.0161$), 1.02 (95% CI: 1.01–1.02; $P < 0.0001$), and 1.01 (95% CI: 1.01–1.02; $P = 0.0004$), respectively. Prior to adjusting for all baseline variables, a higher baseline WOMAC pain score was associated with higher total medical costs and a higher number of physical therapy visits. Specifically, as WOMAC pain score increased by one unit, total medical costs increased by a factor of 1.03 (95% CI: 1.00–1.05; $P = 0.0161$) and number of physical therapy visits increased by a factor of 1.03 (95% CI: 1.01–1.05; $P = 0.0125$).

When adjusting for all baseline variables, the modified Charlson comorbidity score was the only variable which was independently associated with higher total costs in the year following TKA. As the modified Charlson comorbidity score increased by one unit, mean total costs increased by a factor of 1.04 (95% CI: 1.01–1.07; $P = 0.003$). Therefore, given mean total costs of $8,930, when the modified Charlson comorbidity score increased by one unit, the mean total costs increased to $9,287 (95% CI: $9,019-$9,555). When limiting the analysis to outpatient costs, the Charlson comorbidity score remained an independent predictor (means ratio: 1.02; 95% CI: 1.00–1.03; $P = 0.03$) along with the summary score for bodily pain burden (means ratio: 1.01; 95% CI: 1.00–1.02; $P = 0.001$).

When further limiting the analysis to the number of physical therapy visits, as the summary score for bodily pain burden increased by one unit, the mean number of physical therapy visits also increased by a factor of 1.01 (95% CI: 1.00–1.02 or $P = 0.033$). Those with a baseline income of $100,000 or more had a higher mean number of physical therapy visits than those with a baseline income of less than $10,000 (40, 95% CI: 26-63 vs 30, 95% CI: 19-47 or $P = 0.03$).

Patient out-of-pocket costs

In the 90 days after TKA, Medicare patients without supplemental insurance were estimated to have been responsible for $614 in cost-sharing. Of this, patients would pay $523 for outpatient care, $71 for inpatient care, and $19 for emergency care out-of-pocket. Patients reported spending approximately 33 h receiving care in the 90 days after TKA, which resulted in time costs of approximately $710. Seventy-six percent of this time was spent on outpatient visits, of which 78% of time was spent specifically on physical therapy.

Patients were estimated to spend $1,342 in cost-sharing in the year after TKA. Of this, $888 would be for outpatient care, $394 for inpatient care, and $60 for emergency care. Of the outpatient cost-sharing, the majority (71%) of patient cost-sharing was attributed to physical therapy ($637), followed by general practitioner visits ($92), occupational therapy visits ($68), orthopedic surgeon visits ($59), and other provider visits. Patient cost-sharing per diary period decreased over time, from $403 in the first diary period to $98 in the last diary period.

The estimated value of patient time spent receiving medical care in the year following TKA summed to $1,346. Of this, the 53.8 h spent seeking outpatient care represented the majority of time costs ($1,157).

Additional analysis: rehabilitation facility use and costs

In the one year after TKA, 7 out of 108 patients (6%) at one clinical trial site had a rehabilitation facility stay (either inpatient rehabilitation or SNF stay), with a mean length of stay of 28 days, and a mean cost of $17,844. At the second clinical trial site, 8 of the 97 patients (8%) had a rehabilitation facility stay, with a mean length of stay of 12 days, and a mean cost of $12,995. All rehabilitation facility stays occurred within the first 90 days after the TKA.

Discussion

Although the clinical trial in which the data on medical resource use were collected did not detect a difference in WOMAC pain scores across study interventions, it provided a unique opportunity to examine medical resource use patterns and associated costs among patients who catastrophized about their pain and are potentially at risk for greater healthcare utilization and costs. Such utilization and cost information can be particularly useful for studies evaluating the cost-effectiveness of TKA or post-TKA management strategies[34–38]. Our study found that when excluding costs for the TKA procedure and institutional rehabilitative care, Medicare and patients combined spend almost $9,000 in the year after TKA per patient on a mix of outpatient, inpatient, and emergency department services. Of this, over $5,000 are spent on outpatient services, and of this, the majority (72%) is spent on physical therapy services.

Past studies investigating physical therapy use after TKA have focused on the sixty-day period after the procedure, with averages ranging from 10 to 18 physical therapy visits[39–42]. This study found that physical therapy use continued beyond the sixty days post-TKA, with an average of 23 visits in the first 90 days and 33 visits in the first year.

Medicare bundled payment models currently being tested account for post-TKA care within 30 or 90 days of the procedure[8]. Major drivers of cost savings from these models have been reduction in inpatient implant costs as well as decreased use of inpatient rehabilitation and skilled nursing facilities[5]. Utilization of such institutional rehabilitation will likely decrease further as younger and more active people receive TKAs and the interest in performing TKAs in an outpatient setting continues to grow[43–46]. This study found that Medicare spends over $3,000 per patient in the 90 days after the initial TKA. Of this, over $2,500 is spent on outpatient services, and of this, 83% is spent on physical therapy services. For the 6–8% of patients who had rehabilitation stays, Medicare spends an additional $13,000 to $18,000. As time periods covered by bundled payments for TKA or capitated payments for all medical care are extended, it is important to understand longer-term resource use and costs and to identify predictors associated with these outcomes.

In this study, a higher baseline comorbidity burden was associated with higher total and outpatient costs in the year after TKA. This may support a broader self-management approach that addresses multiple comorbidities prior to surgery. This may align well with growing interest in behavioral treatment protocols focused on multiple behavior change targets[47]. Additionally, a higher baseline summary score for bodily pain burden was associated with higher outpatient costs in the year after TKA as well as a higher number of physical therapy visits. A previous study by Falvey and colleagues also found that severe pain at baseline was associated with higher physical therapy utilization[39]. In the future, the baseline summary score for bodily pain may be a useful predictor of higher physical therapy use, especially in a population of pain catastrophizers.

Another lesson learned from this study is the overall cost in the year after TKA to patients. For an average three-day hospital stay, Medicare patients without supplemental health insurance pay $1,605 in deductible and coinsurance for the initial TKA[16,20]. This study revealed that on average, patients pay an additional $1,342 out of pocket in the year after TKA. Additionally, although resource use patterns across individual patients varied, nearly all patients incurred significant time costs seeking outpatient care following TKA, particularly for physical therapy with a mean of 33 visits requiring 36 h of time. Altogether, patient cost-sharing for the initial TKA and then medical resource use in the year after TKA, as well as lost time, summed to $4,293 in the first year. Patients with limited incomes should be counseled about expected costs as we observed evidence that patients with lower incomes had fewer physical therapy visits. Whether these patients self-rationed their visits to limit out-of-pocket costs or lost wages due to time away from work to attend physical therapy visits is unknown. Further investigation may be warranted to understand the causative factors.

Limitations

One limitation of this study is that healthcare resource use was based on patient report. Ideally, we would have had access to all patients' medical claims. However, patients often did not receive all medical care at the trial site, and the numerous private payers to which medical claims were submitted made ascertaining them impracticable. We attempted to limit recall bias by informing patients at trial initiation that they should record all of their medical encounters using the diaries designed for the trial and that they would be asked to report the information every six weeks throughout the follow-up period. Additionally, all patients received reminder phone calls for each diary and help if needed, from a data collector who was blinded to group assignment. Six weeks is much shorter than the median recall period of four and a half months used in other clinical trials collecting resource use data[48].

Also, although almost 60% of trial participants were less than 65 years of age, we relied on Medicare fee schedules and patient cost-sharing policies to estimate patients' out-of-pocket costs due to their public availability, as well as relevance for Medicare bundled payment models. Since Medicare enrollees may also have supplemental insurance that covers out-of-pocket costs, the patient out-of-pocket costs reported in this paper represent the upper limit of costs incurred by Medicare beneficiaries.

In conclusion, this study found that beyond the initial TKA, there were substantial costs for both payers and patients in the year following TKA. The majority of these costs were spent on outpatient physical therapy. Comorbidity and bodily pain burden were associated with higher costs and use of physical therapy. These costs and predictors should be accounted for in future value-based payment arrangements for TKA and post-TKA care. Furthermore, patients should be made aware of their expected out-of-pocket medical spending and time costs after the initial TKA.

Contributions

- Conception and design (SDR, AH, YL).
- Analysis and interpretation of the data (SDR, AH, YL).
- Drafting of the article (AH, SDR, YL, DLR, FJK, DCA, JS, RAP, LD).
- Critical revision of the article for important intellectual content (SDR, AH, YL, DLR, FJK, DCA, JS, RAP, LD).
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Competing interests

None of the authors reports conflicts of interest.

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Supplementary data

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