

MILLIMAN REPORT

Knee Osteoarthritis in a Commercially Insured Population: A Claims-Based Analysis

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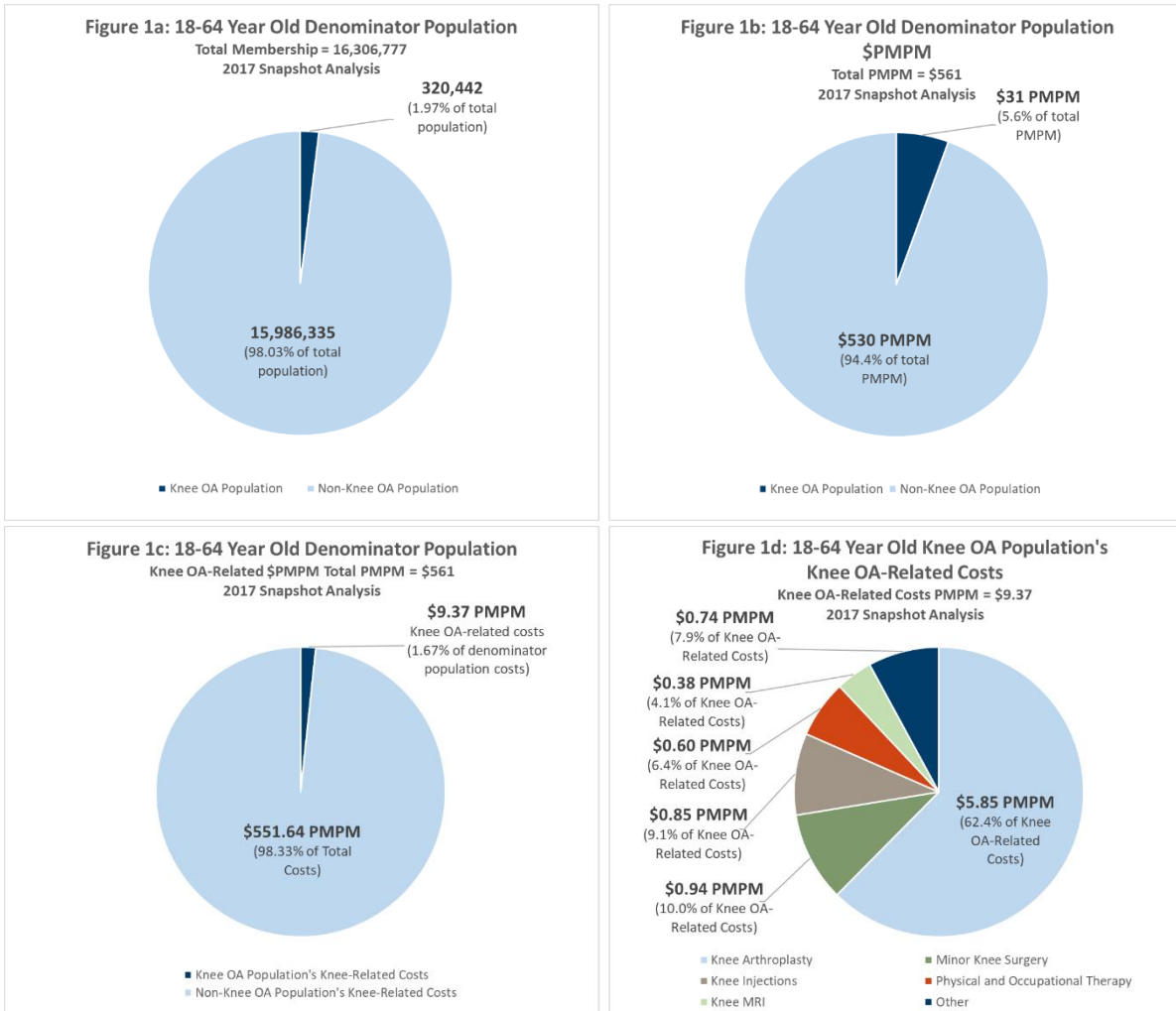
Executive Summary

There were an estimated 15 million people living with knee osteoarthritis (OA) in the United States in 2012 [1]. As the population continues to age and the rates of obesity increase, a 40% increase in knee OA prevalence is expected to by 2025 [2]. A significant portion of the costs to treat knee OA are incurred by commercial insurers/employers, as more than half of people with symptomatic knee OA are under 65 years of age [1]. In this study, we review annual treatment patterns and healthcare expenditures incurred by commercially insured knee OA patients (snapshot analysis). We also examine a commercially insured knee OA population's utilization of knee OA-related services over a 4-year period, in order to understand treatment patterns over time (longitudinal analysis). See methodology section for details of knee OA and knee OA-related service identification.

COMMERCIAL CLAIM DATA ANALYSIS KEY FINDINGS

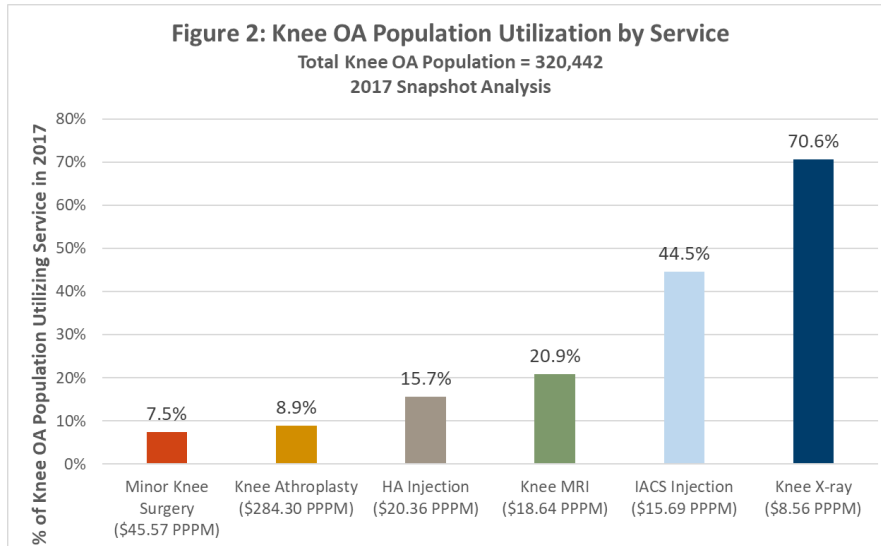
2017 Snapshot Analysis of Knee OA Population: 18-64 year old commercially insured population

The prevalence rate of knee OA was 1.97% among the 18-64 year old population and the knee OA population accounted for 5.6% of the total 18-64 year old population's annual costs. Knee OA-related costs accounted for 1.67% of the total 18-64 year old population's annual costs and 31.1% of the knee OA population's annual costs. Knee arthroplasty was the biggest contributor to knee OA-related costs, contributing 62.4%.



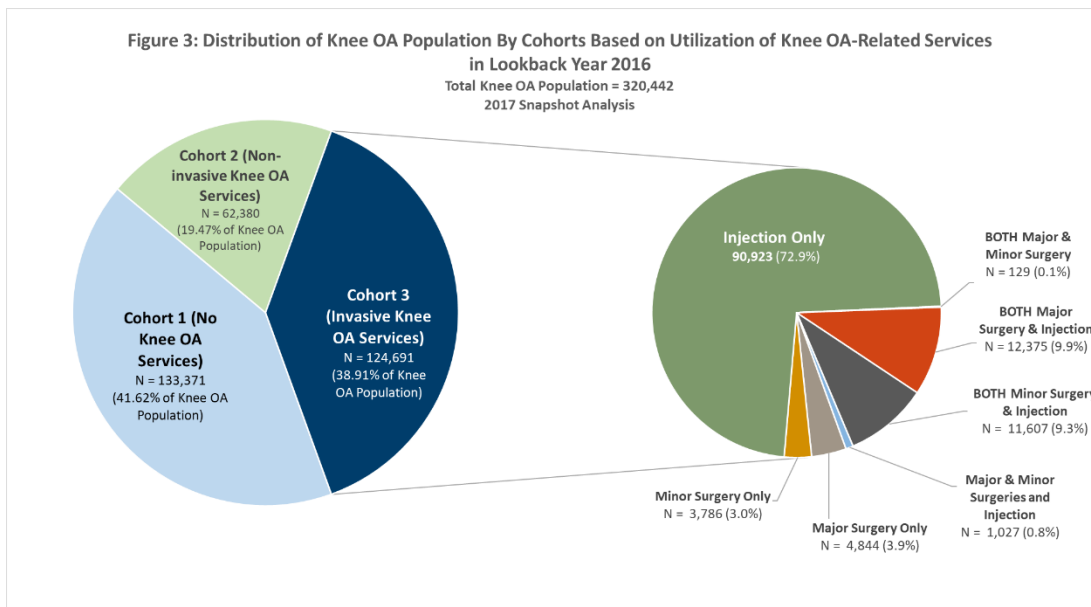
PMPM = Per Member Per Month; Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman Consolidated Health Sources Database (CHSD) Commercial Claims Database, 2017

Figure 2 provides the annual utilization of knee OA-related diagnostics and treatments. Among the 2017 knee OA population, 71% received a knee x-ray, 44.5% received an intra-articular corticosteroid (IACS) knee injection, 20.9% received a knee magnetic resonance imaging (MRI), 15.7% received a hyaluronic acid (HA) knee injection and 8.9% received knee replacement surgery.



PPPM = Per Patient Per Month; Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman CHSD Commercial Claims Database, 2017

The knee OA population’s utilization of knee OA services varies in the 2017 index year and the prior year. In order to segment the 2017 knee OA population into varying levels of severity, we split the population into three cohorts based on the knee OA services they utilized in 2016. Cohort 1, with no knee OA-related services of interest in 2016 (41.6%), was the largest group, followed by Cohort 3, with invasive knee OA-related services (38.9%), and Cohort 2, with non-invasive knee OA-related services (19.5%). Cohort 3 had the highest cost of knee OA-related services in 2017 (\$7,387), followed by Cohort 2 (\$4,993) and Cohort 1 (\$3,935). Cohort 1 had the highest rate of diagnostics (MRI and x-ray), orthopedist visits, IACS injections, and minor knee surgery. Cohort 3 had the highest rate of injections (all types combined), knee arthroplasty, and physical therapy visits.



Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman CHSD Commercial Claims Database, 2017
 Cohort 1: No knee OA services of interest in 2016; Cohort 2: non-invasive knee OA services of interest including diagnostics and physical therapy; Cohort 3: Invasive knee services in 2016 including knee injections and minor and major surgery.

2014-2017 Longitudinal Analysis of Knee OA Population: 18-64 year old commercially insured population

We identified knee OA patients meeting our criteria in the index year 2014 and required they have 5 years of eligibility (all months of 2013-2017) in order to follow care patterns over 4 years. A 2013 lookback was used to establish utilization of knee OA diagnostics and treatments in the year prior to the 2014 index year and to assign members to one of the three cohorts described above.

Figure 4 provides key summary findings of the longitudinal analysis. For all three cohorts of knee OA patients, utilization of knee OA-related services continued to persist over the 3 years following 2014. By 2017, 41.7%, 50.1%, and 58.9% of knee OA patients in Cohort 1, 2, and 3 respectively, continued to utilize knee OA-related services. In particular, over the 3 years following the index year (2015-2017), the total utilization of knee arthroplasty was 8.8% in the 2014 index year and an additional 12.2% had a knee arthroplasty between 2015 and 2017. For the other knee OA-related services, the incidence was highest in 2014 but continued to be substantial over the subsequent 3 years. Along with the high rate of knee injections and surgeries, 39.2% of the total knee OA population had a claim for physical or occupational therapy over the 4-year longitudinal period, with a rate of 30.3%, 20.0%, and 37.4% for Cohorts 1, 2, and 3, respectively. We note that in this analysis, we cannot distinguish whether knee OA-related services are for diagnosis or treatment of the same or different knee over the 4-year period.

FIGURE 4: INCREMENTAL UTILIZATION OF KNEE OA-RELATED SERVICES

Service Type	Total Knee OA Population (N=75,082)		Cohort 1: No Knee OA Services of Interest in 2013 (N = 33,727, 45% of Knee OA Population)		Cohort 2: Non-Invasive Knee OA Services of Interest in 2013 (N = 13,549, 18% of Knee OA Population)		Cohort 3: Knee OA Invasive Procedures in 2013 (N = 27,806, 37% of Knee OA Population)	
	% of Knee OA Population Utilizing Service in 2014 Index Year	Additional % of Knee OA Population Utilizing Service during 2015-2017 ¹	% of Knee OA Population Utilizing Service in 2014 Index Year	Additional % of Knee OA Population Utilizing Service during 2015-2017 ¹	% of Knee OA Population Utilizing Service in 2014 Index Year	Additional % of Knee OA Population Utilizing Service during 2015-2017 ¹	% of Knee OA Population Utilizing Service in 2014 Index Year	Additional % of Knee OA Population Utilizing Service during 2015-2017 ¹
Knee Arthroplasty (Total, Partial, & Revision)	8.8%	12.2%	5.6%	10.1%	8.4%	9.4%	12.9%	16.2%
Arthroscopy and Other Minor Knee Surgery	9.3%	5.7%	10.3%	6.0%	9.7%	5.1%	7.8%	5.6%
Hyaluronic Acid Injection (Knee)	18.8%	9.1%	14.1%	9.0%	12.3%	7.7%	27.5%	9.9%
IACS Injection (Knee)	41.2%	12.5%	45.0%	10.1%	28.2%	13.1%	42.8%	15.2%
Unspecified Product Injection (Knee)	11.7%	7.6%	9.9%	6.7%	8.4%	6.4%	15.6%	9.4%
Knee MRI	23.1%	11.1%	30.0%	9.6%	21.9%	11.4%	15.2%	12.9%
Physical and occupational therapy	23.4%	15.8%	21.3%	9.0%	12.3%	7.7%	27.5%	9.9%

¹ Knee OA population incurring services in 2015-2017 but not in 2014

Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman CHSD Commercial Claims Database, 2013-2017

CONSIDERATIONS FOR PAYERS/EMPLOYERS

The cost burden of knee OA is high among the US commercially insured working age population. Many existing treatments to manage the progression and/or reduce the symptoms of knee OA are expensive and have questionable efficacy. There is evidence of overutilization of certain tests and treatments for knee OA in the US (see Background section for sources). This claims-based analysis identifies knee OA diagnostic and treatment patterns that may highlight opportunities for improving the efficiency of managing this chronic condition.

CAVEATS

This report was commissioned by Emovi, Inc., who manufactures KneeKG™, a knee kinesiography exam device that is indicated for appropriate assessment of the 3D knee motion in patients who have impaired movement functions of an orthopedic cause. It is intended for medical use to provide information used in physical evaluation and physical planning purposes.

This document provides summary results for a commercially insured knee OA population's costs and utilization of knee OA-related services using 2013-2017 IBM MarketScan® and Milliman CHSD Commercial Data. Use of different datasets, years, and methodology will produce different results. The findings reflect the research of the authors; Milliman does not endorse any product or organization. If this report is reproduced, we ask that it be reproduced in its entirety, as pieces taken out of context can be misleading. As with any economic or actuarial analysis, it is not possible to capture all factors that may be significant.

Background

Over fifteen million people in the US suffered from symptomatic knee osteoarthritis (OA) in 2011-2012, based on an analysis of a nationally representative cross-sectional population survey [1]. This knee OA population included 6.6 million people (8% prevalence) between 45 and 64 years of age, with 51% having advanced knee OA [1]. It also included 1.7 million people (2% prevalence) among adults under age 45, with approximately one-third having advanced disease [1]. Prevalence of symptomatic knee OA increases with age; prevalence is similar in males and females in the <45 year old population and higher in females in the 45+ population [1]. In the US, the lifetime risk of developing symptomatic knee OA is 45% [3]. Knee OA prevalence is expected to increase 40% by 2025, due to an aging population and increasing rates of obesity [2]. With more than half of all people with symptomatic knee OA under 65 years of age, knee OA has significant functional and cost implications for the working age population [1]. Employers and commercial payers bear a significant portion of the medical cost and disability impact of knee OA progression.

Knee OA is a chronic, progressive condition that can limit mobility and is accompanied by varying levels of pain. The knee OA patient journey varies greatly according to factors such as age, weight, fitness level, pain tolerance, and lifestyle. The high value clinical pathway for knee OA begins with the diagnosis of OA based on patient signs and symptoms, including persistent knee pain, limited knee stiffness, reduced function, crepitus, restricted movement, and bony enlargement [4]. X-rays are commonly incorporated into the initial evaluation, though they are not considered essential in patients over 45. Initial treatments take a holistic approach and involve coaching patients on participation in self-management, strengthening, low-impact aerobic exercise, neuromuscular exercise, and weight loss for individuals with a body mass index (BMI) ≥ 25 [5] [6]. For individuals with persistent knee pain and x-rays diagnostic of OA, MRI is not usually indicated unless the patient's symptoms are not explained by the radiographic findings (e.g., stress fracture) or the appropriate treatment option requires additional imaging [7] [8]. Early pharmacologic treatment for OA includes topical or oral nonsteroidal anti-inflammatory agents (NSAIDs). According to clinical guidelines, the evidence is generally inconclusive or unfavorable toward a number of more intensive therapies, such as IACS or HA injections, arthroscopy, and the prescription of opioids [6]. Total knee arthroplasty (TKA) is appropriately considered for patients with moderate to severe knee pain that has a substantial impact on quality of life and is not adequately controlled by 3 months of non-surgical management [4] [5].

When medication no longer works to control pain and functional impairment becomes significant, full or partial joint replacement is often recommended [9]. Knee replacement rates continue to increase over time, as the treatment has become the standard of care for end-stage knee OA, including both multi-compartmental/TKA and unicompartmental (UKA) surgeries [10]. One study projects an 855% increase in the volume of TKA from 2012 to 2050 [11]. Researchers estimate that 54% of symptomatic knee OA patients will receive a TKA over their lifetime [12]. Though many cases ultimately end in TKA, knee OA patients spend an average of 13 years exhausting various non-surgical pain-relief options, including nonsteroidal anti-inflammatory drugs (NSAIDs), before undergoing a knee replacement surgery [13].

There is evidence of some overutilization of certain diagnostic tests and treatments for knee OA in the US. Below, we summarize the literature that describes current inefficiencies in the management of knee OA patients due to practice patterns that remain inconsistent with the published evidence.

Knee OA Surgery

The aging population and worsening obesity epidemic cannot completely explain the rapidly increasing rates of TKA. From 1999 to 2008, the utilization rate of TKA surgeries in the US more than doubled for the total population and tripled for individuals age 45 to 64 [12]. Over the same 10 years, the US population increased by 11%, and the number of obese individuals increased by 23% [12]. A 2014 longitudinal cohort study classified 34.3% of examined TKA procedures as "inappropriate", based on prior evidence and various pre-operative data including functional status, extent of radiographic arthritis, age, and knee joint impairment [14]. In addition, 90% of patients who undergo TKA will have the prosthetic joint last for only 15 years [15], and the survival rate of the prosthetics in younger patients is lower (76% at 10 years) [16]. In 2010, 55,000 revision arthroplasty surgeries were performed in the US,

48% of which occurred in patients under age 65 [10]. These numbers are expected to rise significantly as the number of TKA surgeries increases over time, yielding a projection of nearly 3.5 million such revision operations annually by 2030 [17]. In addition, patient expectations following TKA can also be overly optimistic. For example, in one study, 85% of patients expected to be completely pain-free after TKA while only 43% reported full relief of knee pain [18].

Knee arthroscopy, a minor surgery that historically has been more frequently performed on middle-aged and older knee OA patients [19], is also reported to be overutilized for the knee OA population. A meta-analysis of nine trials examining the benefits of arthroscopic partial meniscectomy (APM) and debridement determined that any benefit derived from the procedure was small and fully disappeared one to two years after the surgery [20]. Studies have also reported that trials of arthroscopic surgery do not result in improvement of pain scores in the short or long term, and show no benefit over exercise or placebo interventions [21]. Orthopedic surgeons, physiotherapists, and epidemiologists have recommended against knee arthroscopy for knee OA patients, stating that they “make a strong recommendation against the use of arthroscopy in nearly all patients with degenerative knee disease, based on linked systematic reviews; further research is unlikely to alter this recommendation” [22]. Despite the lack of evidence of benefit from APM, except for a small subset of patients, a 2016 analysis of Medicare patients found high rates of APM-only surgery, reflecting a continued disparity between evidence and practice for one of the most common operations performed in the US [23].

Knee Injections

HA knee joint injections are another high-cost treatment for knee OA with reports of unnecessary utilization. Although numerous HA products have been approved for use in the US, the efficacy of HA injections for knee OA remains disputed, with meta-analyses and societal clinical guidelines drawing disparate conclusions [6]. In 2013, the American Academy of Orthopaedic Surgeons (AAOS) published a best-evidence systematic review and concluded that available data did not support the routine use of HA for knee OA [6]. However, HA injections continue to be commonly used in the treatment of knee OA, with a study of patients undergoing TKA between 2005 and 2012 demonstrating that approximately 15% of individuals received at least one HA injection in the 12 months prior to surgery [24]. There is also some evidence that IACS injections, which are commonly used for pain relief in knee OA, do not have a long-term impact on knee pain and may also have unintended long-term negative effects in some patients [25] [26]. These negative outcomes can include accelerated OA progression, subchondral insufficiency fracture, complications of osteonecrosis, and rapid joint destruction including bone loss [25].

Knee MRI

There are also indications that MRI may be overutilized as a diagnostic test for knee OA patients. The American College of Radiology appropriateness criteria for chronic knee pain state that MRI of the knee is usually not appropriate as a subsequent imaging procedure when initial x-rays demonstrate degenerative changes [27], unless symptoms are not explained by the radiographic findings or the appropriate treatment option requires additional imaging. However, a 2018 study found that 13.1% of patients with radiographically obvious knee OA referred for TKA received an MRI within the 3 months prior to referral, with scans more likely to be ordered by non-physicians or non-academic physicians [28].

Opioid Use for OA

A Cochrane review of the evidence found a small average benefit of questionable clinical relevance for non-tramadol opioid use for OA, contrasted with a significant increase in the risk of adverse events [29]. Furthermore, the American Association of Hip and Knee Surgeons has stated that opioids should be avoided for the treatment of hip and knee osteoarthritis and should be reserved for certain circumstances, such as patients who are not candidates for arthroplasty and have failed non-opioid treatment [30]. However, prescribing rates of opioids for hip, knee, and joint OA remained stable between 2007 and 2014 [31], suggesting that opioids continue to be used to manage pain associated with OA, despite evidence questioning their benefit and identifying their potential for harm.

Non-invasive Knee OA Treatment

The reported overutilization of invasive treatments raises the question as to whether non-invasive treatments of knee OA could more effectively modify or delay the trajectory of knee OA progression. There is some evidence to support

the promotion of more conservative therapies to reduce pain from knee OA in the short-term, particularly for patients experiencing moderate levels of pain [32]. In a randomized controlled trial that used a knee kinesiography examination versus no knee kinesiography examination to direct targeted education, knee physiotherapy and home exercises, the former cohort had statistically significant reduction in knee OA pain and improved activity levels compared to the latter group [33]. There is some evidence that the combination of PT and exercise may delay or prevent knee OA patients from requiring surgical interventions [34].

Study Objective

The objective of this study was to analyze the treatment patterns of knee OA care in a commercially insured population and quantify the cost associated with that care. We examined the knee OA population characteristics on an annual “snapshot” basis and over a 4-year longitudinal period. Our intention was to provide commercial payers and employers with real world evidence of knee OA-related service utilization, cost, and patterns of care among a working age population.

Snapshot Analysis (2017)

Although the prevalence of knee OA in the 45-64 year old population has been reported as 8% [1], the percentage of knee OA individuals that seek medical care in a given year will be lower. We performed a “snapshot” analysis of 2017 commercial claims data to better understand the percentage of commercially insured adults who seek care for their knee OA on an annual basis, their utilization of knee OA-related services, and the costs of knee OA care.

KNEE OA IDENTIFICATION AND KNEE OA SERVICE UTILIZATION METHODOLOGY

The 2017 snapshot analysis examined 2016-2017 IBM MarketScan® and Milliman CHSD commercial claims data (see description in [Data Sources and Methodology](#) section). Members were required to have continuous enrollment from January 2016 through January 2017, both medical and pharmacy coverage, and be an active employee or dependent of an active employee. Members were also required to be ≥ 18 years of age at the start of 2016 and < 65 in 2017. The resulting 2017 index year denominator population contained 16,306,777 members.

We identified 320,442 knee OA patients in the 2017 18-64 year old population using the following criteria:

- 2 or more qualified claims coded with knee OA diagnosis within the 24 months of 2016-2017, on separate dates of service (for a definition of qualified claims and knee OA diagnosis codes, see [Appendix 1A](#))
- OR 1 qualified claim coded with a knee OA diagnosis AND a claim for a knee surgery, knee diagnostic test, knee injection, knee orthosis, or knee OA physical or occupational therapy claim within the 24 months of 2016-2017 (both required claims could occur on the same day)
- At least one knee OA qualifying claim in 2017

In order to evaluate patterns of care in 2017, while considering historical knee OA care utilized in a 2016 lookback year, we segmented the 2017 knee OA population into the following three mutually exclusive cohorts:

1. Knee OA prevalent population with no knee OA services of interest in 2016 (Cohort 1)
 - This population could have PCP visits, pain relief medications, and other services not categorized as “of interest” for the purposes of this analysis
2. Knee OA prevalent population with non-invasive knee OA services of interest in 2016 but no invasive knee OA services in 2016 (Cohort 2)
3. Knee OA prevalent population with knee OA invasive procedures in 2016 (Cohort 3)

The knee OA service claims used to designate assignment to one of the three cohorts appear in [Figure 5](#). For full patient identification algorithms and code lists, see the [Methodology](#) section and [Appendix 1](#).

FIGURE 5: KNEE OA-RELATED SERVICES OF INTEREST

Knee OA-Related Services used in Cohort Categorization		
Cohort 1: No Knee OA Services of Interest in 2016	Cohort 2: Non-Invasive Knee OA Services of Interest in 2016	Cohort 3: Knee OA Invasive Procedures in 2016 ²
None ¹	Knee computed tomography (CT)	Diagnostic knee arthrotomy
	Knee x-ray	Diagnostic knee arthroscopy
	Knee ultrasound	Knee arthrotomy
	Knee magnetic resonance imaging (MRI)	Knee arthroscopy
	Knee arthrography	Other minor knee surgery
	Knee radiostereometric analysis (RSA)	Knee Injections including hyaluronic acid (HA), IACS, chondrocyte implant, stem cell, PRP, prolotherapy
	Motion analysis	
	Knee orthosis	
	Physical and occupational therapy for knee	Knee arthroplasty (total, partial, revision)

¹ Patients in Cohort 1 had no knee OA services of interest in their lookback year, but they could have had any of the following claims: assistive walking devices, lower extremity orthoses, acupuncture, chiropractic, TENS, massage therapy, osteopathic manipulation, non-physician practitioner (NPP) or other provider office visits, education, opioids, NSAIDs, or supplements.

² Patients in Cohort 3 were categorized based on the invasive knee-related claims that they had in their lookback year, but they could also have had non-invasive knee OA services of interest noted for Cohort 2

PREVALENCE AND DEMOGRAPHICS

Figure 6 provides the characteristics of the 2017 index year knee OA population. Key findings include:

- The prevalence of members with knee OA in the commercial 18-64 year old population was 1.97%
- The prevalence increases steadily with age; almost 80% of the knee OA population was ≥ 50
- Approximately 42% of the knee OA population had no knee OA services of interest in 2016 (Cohort 1)
- Of the 58% who had at least one knee OA claim of interest in 2016 (Cohorts 2 and 3), 67% had invasive procedures in 2016 (Cohort 3)
- The majority of the knee OA population was female: 58.4% women vs 41.6% men
- The median age for the total knee OA prevalent population was 56 years

FIGURE 6: KNEE OA 2017 SNAPSHOT POPULATION DEMOGRAPHICS

Age Bands ¹	Members 18 or Older (Denominator Population)	Total Knee OA Population		Cohort 1: No Knee OA Services of Interest in 2016		Cohort 2: Non-Invasive Knee OA Services of Interest in 2016		Cohort 3: Knee OA Invasive Procedures in 2016		
		N = 320,442		N = 133,371 (42% of Total Knee OA Population)		N = 62,380 (19% of Total Knee OA Population)		N = 124,691 (39% of Total Knee OA Population)		
		Prevalence by Age Band	% of Knee OA Population	Prevalence by Age Band	% of Knee OA Population	Prevalence by Age Band	% of Knee OA Population	Prevalence by Age Band	% of Knee OA Population	
Population	16,306,777	1.97%	100.00%	0.82%	41.62%	0.38%	19.47%	0.76%	38.91%	
Male	To 25	894,508	0.05%	0.13%	0.02%	0.06%	0.01%	0.03%	0.01%	0.04%
	25 - 29	706,561	0.08%	0.19%	0.04%	0.10%	0.02%	0.04%	0.02%	0.05%
	30 - 34	736,278	0.20%	0.47%	0.10%	0.24%	0.05%	0.11%	0.05%	0.12%
	35 - 39	835,641	0.41%	1.06%	0.21%	0.54%	0.09%	0.23%	0.11%	0.29%
	40 - 44	861,011	0.81%	2.18%	0.40%	1.07%	0.16%	0.44%	0.25%	0.68%
	45 - 49	978,783	1.50%	4.58%	0.71%	2.15%	0.29%	0.87%	0.51%	1.55%
	50 - 54	1,016,950	2.49%	7.90%	1.13%	3.57%	0.44%	1.41%	0.92%	2.92%
	55 - 59	1,041,106	3.69%	12.00%	1.61%	5.22%	0.67%	2.17%	1.42%	4.61%
	60 - 64	842,266	5.00%	13.14%	2.06%	5.41%	0.96%	2.52%	1.98%	5.21%
	Total	7,913,104		41.63%		18.34%		7.83%		15.46%
Female	To 25	865,847	0.06%	0.15%	0.02%	0.07%	0.01%	0.04%	0.02%	0.05%
	25 - 29	724,383	0.08%	0.18%	0.04%	0.09%	0.02%	0.05%	0.02%	0.05%
	30 - 34	796,791	0.19%	0.47%	0.09%	0.22%	0.05%	0.12%	0.05%	0.13%
	35 - 39	915,820	0.46%	1.32%	0.22%	0.62%	0.10%	0.28%	0.15%	0.42%
	40 - 44	936,721	1.05%	3.08%	0.47%	1.39%	0.22%	0.65%	0.36%	1.05%
	45 - 49	1,060,375	2.01%	6.65%	0.87%	2.87%	0.40%	1.32%	0.74%	2.46%
	50 - 54	1,104,207	3.44%	11.85%	1.40%	4.83%	0.67%	2.30%	1.37%	4.72%
	55 - 59	1,114,723	4.88%	16.97%	1.88%	6.54%	0.97%	3.38%	2.03%	7.05%
	60 - 64	874,806	6.48%	17.69%	2.44%	6.65%	1.28%	3.50%	2.76%	7.53%
	Total	8,393,673		58.37%		23.28%		11.64%		23.45%
Median Age (years)		56		56		56		57		

Notes: ¹Age Band is based on the patient's age at the end of 2017; Sourced from an analysis of IBM MarketScan[®] Commercial Claims Database and Milliman Commercial Claims Database, years 2016 through 2017

KNEE OA-RELATED COSTS AND UTILIZATION

Figure 7 provides details of the knee OA population costs on a total adult population per member per year and per member per month (PMPY/PMPM) basis and on a knee OA population per patient per year (PPPY) basis. Costs for knee OA-related services include all facility and professional costs associated with the services. We present allowed costs, which include the amount paid by payers in addition to patient cost sharing. Key findings include:

- The knee OA population total costs account for 5.6% of the total 18-64 year old denominator population costs
- The knee-related costs for the knee OA population (31.1% of the knee OA population costs) account for 1.67% of the 18-64 year old denominator population costs
- The knee OA population with invasive knee OA-related claims in the year prior (Cohort 3) has the highest knee OA-related cost in the 2017 index year

FIGURE 7: KNEE OA 2017 ANNUAL POPULATION COSTS AS A PORTION OF 2017 DENOMINATOR POPULATION COSTS

	Denominator population	Total Knee OA Population	Cohort 1: No Knee OA Services of Interest in 2016	Cohort 2: Non-Invasive Knee OA Services of Interest in 2016	Cohort 3: Knee OA Invasive Procedures in 2016
Number of Members	16,306,777	320,442	133,371	62,380	124,691
Prevalence	100.0%	1.97%	0.82%	0.38%	0.76%
Percent of Knee OA Population		100.0%	41.62%	19.47%	38.91%
PPPY: All Costs		\$17,591	\$14,619	\$18,284	\$20,423
PMPY: All Costs	\$6,732	\$375	\$130	\$76	\$170
PMPM: All Costs	\$561	\$31	\$11	\$6	\$14
Percent of Denominator Cost		5.6%	1.9%	1.1%	2.5%
PPPY: Knee-related Costs		\$5,465	\$3,935	\$4,993	\$7,374
Knee-related Costs as a % of All Costs		31.1%	26.9%	27.3%	36.1%
PMPY: Knee-related Costs		\$112	\$34	\$20	\$58
PMPM: Knee-related Costs		\$9.37	\$2.84	\$1.66	\$4.87
Knee-related Costs as a % of Denominator Cost		1.67%	0.51%	0.30%	0.87%

Notes: PPPY = Per Knee OA Patient Per Year; PMPY = Per Member Per Year; PMPM = Per Member Per Month; Denominator Population consists of members aged 18-64 years; Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman Commercial Claims Database, years 2016 through 2017

Figure 8 provides the age distribution of full and partial knee arthroplasty (TKA/UKA) procedures in the 2017 knee OA population. 8.5% of knee OA patients had at least one TKA/UKA procedure (revisions not included). This compares to 8.9% of knee OA patients receiving any type of knee arthroplasty (total, partial, or revision) in Figure 9A. The 0.4% difference is due to revision procedures, which were not included in Figure 8.

Of those with a TKA/UKA, 25% are aged 62-64. The average knee arthroplasty surgery costs per patient and other average knee-related costs per surgery patient do not vary significantly among the age bands.

FIGURE 8: KNEE OA 2017 FULL AND PARTIAL KNEE ARTHROPLASTY PATIENT POPULATION AGE DISTRIBUTION

Age Band ¹	Number of TKAs/UKAs	Distribution of TKAs/UKA Procedures	Average Surgery-Related Costs per Surgery Patient	Average Other Knee-Related Costs per Surgery Patient
To 25	3	0.0%	\$26,441	\$3,858
25 - 29	4	0.0%	\$43,072	\$2,500
30 - 34	26	0.1%	\$37,317	\$5,772
35 - 39	113	0.4%	\$32,976	\$4,784
40 - 44	525	1.7%	\$34,038	\$5,479
45 - 49	1,817	6.0%	\$35,343	\$3,957
50 - 54	4,951	16.3%	\$35,221	\$4,014
55 - 59	9,975	32.8%	\$35,545	\$3,726
60	2,591	8.5%	\$36,371	\$3,358
61	2,621	8.7%	\$35,625	\$3,698
62	2,665	8.7%	\$35,117	\$3,496
63	2,589	8.6%	\$36,511	\$3,378
64	2,439	8.0%	\$35,999	\$3,490
Total	30,319	100.0%	\$35,605	\$3,720

Notes: ¹Age Band is based on the patient's age at the end of 2017; Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman Commercial Claims Database, years; 2016 through 2017

Figures 9A-9D provide utilization and costs of knee OA-related services for the total knee OA population by each of the three cohorts. Key findings include:

- Costs associated with knee replacement surgery contribute 62.4% of the total knee OA-related spend in 2017, with 8.9% of the knee OA population incurring a knee replacement surgery
- Cohort 3 had the highest cost of knee OA-related services in 2017 followed by Cohort 2 and Cohort 1: Cohort 3 (\$7,387), Cohort 2 (\$4,993), and Cohort 1 (\$3,935)
- 20.9% of knee OA patients had an MRI in 2017
- 44.5% and 15.7% of patients received IACS and HA injections in 2017, respectively
- 7.5% of patients received an arthroscopy or other minor knee surgery in 2017
- 25.3% of patients received physical or occupational knee therapy

FIGURE 9A: 2017 TOTAL KNEE OA POPULATION: 2017 ANNUAL INCIDENCE & COST OF KNEE OA-RELATED SERVICES

Total Knee OA Population (N=320,442)								
Service Type	Percent of Patients with Service	Utilization / Patient for Patients with Service	Utilization Type	Average Allowed Cost per Service	Percent of Total Spend on Knee OA-Related Services	Average Allowed Cost PPPY	Average Allowed Cost PMPY	Average Allowed Cost PMPM
Any Knee OA Service of Interest	99.7%⁴				100.0%	\$5,465	\$112	\$9.37
Knee x-ray	70.6%	1.6	procedures	\$86	1.9%	\$103	\$2	\$0.18
Knee MRI	20.9%	1.1	procedures	\$934	4.1%	\$224	\$5	\$0.38
Physical and Occupational Knee Therapy	25.3%	10.4	sessions	\$129	6.4%	\$351	\$7	\$0.60
Orthopedist Office Visits for Knee OA	45.0%	1.6	visits	\$116	1.6%	\$87	\$2	\$0.15
PCP Office Visits (Knee OA-related)	50.9%	2.1	visits	\$137	2.7%	\$150	\$3	\$0.26
Hyaluronic Acid Injection (Knee)	15.7%	1.1	courses	\$1,340	4.5%	\$244	\$5	\$0.42
IACS Injection (Knee)	44.5%	1.4	days	\$285	3.4%	\$188	\$4	\$0.32
Unspecified Product Injection (Knee) ¹	11.1%	2.0	days	\$281	1.2%	\$66	\$1	\$0.11
Arthroscopy and Other Minor Knee Surgery	7.5%	1.1	surgeries	\$6,438	10.0%	\$547	\$11	\$0.94
Knee Arthroplasty (Total, Partial, & Revision)	8.9%	1.1	surgeries	\$32,454	62.4%	\$3,412	\$70	\$5.85
Opioid ²	8.8%	1.9	scripts	\$31	0.1%	\$5	\$0	\$0.01
Non-opioid analgesic, including NSAIDs ²	6.6%	1.5	scripts	\$26	0.0%	\$3	\$0	\$0.00
Other Knee-related Services ³	15.9%	N/A	N/A	N/A	1.6%	\$83	\$2	\$0.14

Notes: ¹Includes general injection codes that did not have a corresponding NDC or HCPCS code for injected drug type

²We are unable to identify the condition for which this medication was prescribed

³Includes CT, ultrasound, arthrography, RSA, motion analysis, diagnostic arthroscopy/arthrotomy, assistive walking devices, lower extremity orthoses, acupuncture, chiropractic, TENS, massage therapy, osteo manipulation, nonphysician practitioner (NPP) or other provider office visits, education, and supplements

⁴This number is not 100% because members can qualify as having knee OA based on other claim types coded with knee OA

PPPY = Per Patient Per Year; PMPY = Per Member Per Year; PMPM = Per Member Per Month; Denominator Population consists of members aged 18-64 years; Knee OA-related costs include professional, facility, and drug costs where indicated; Costs shown are allowed costs, which include both payment by the payer and patient cost-sharing;

Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman Commercial Claims Database, years 2016 through 2017

FIGURE 9B: 2017 ANNUAL INCIDENCE & COST OF KNEE OA-RELATED SERVICES FOR COHORT 1

Cohort 1: No Knee OA Services of Interest in 2016 (N = 133,371, 42% of Knee OA Population)								
Service Type	Percent of Patients with Service	Utilization /Patient for Patients with Service	Utilization Type	Average Allowed Cost per Service	Percent of Total Spend on Knee OA-Related Services	Average Allowed Cost PPPY	Average Allowed Cost PMPY	Average Allowed Cost PMPM
Any Knee OA Service of Interest	99.9%⁴				100.0%	\$3,935	\$34	\$2.84
Knee x-ray	90.3%	1.5	procedures	\$88	3.1%	\$123	\$1	\$0.09
Knee MRI	27.6%	1.1	procedures	\$904	7.1%	\$279	\$2	\$0.20
Physical and Occupational Knee Therapy	23.2%	8.6	sessions	\$127	6.6%	\$261	\$2	\$0.19
Orthopedist Office Visits for Knee OA	51.0%	1.6	visits	\$121	2.5%	\$100	\$1	\$0.07
PCP Office Visits (Knee OA-related)	53.8%	1.9	visits	\$137	3.6%	\$143	\$1	\$0.10
Hyaluronic Acid Injection (Knee)	11.4%	1.0	courses	\$1,287	4.0%	\$157	\$1	\$0.11
IACS Injection (Knee)	49.2%	1.3	days	\$280	4.6%	\$180	\$2	\$0.13
Unspecified Product Injection (Knee) ¹	8.9%	1.8	days	\$289	1.2%	\$47	\$0	\$0.03
Arthroscopy and Other Minor Knee Surgery	8.4%	1.1	surgeries	\$6,351	15.0%	\$589	\$5	\$0.43
Knee Arthroplasty (Total, Partial, & Revision)	5.3%	1.1	surgeries	\$32,299	50.0%	\$1,969	\$17	\$1.42
Opioid ²	7.8%	1.8	scripts	\$29	0.1%	\$4	\$0	\$0.00
Non-opioid analgesic, including NSAIDs ²	6.0%	1.4	scripts	\$30	0.1%	\$3	\$0	\$0.00
Other Knee-related Services ³	16.1%	N/A	N/A	N/A	2.0%	\$74	\$1	\$0.05

Notes: ¹Includes general injection codes that did not have a corresponding NDC or HCPCS code for injected drug type

²We are unable to identify the condition for which this medication was prescribed

³Includes CT, ultrasound, arthrography, RSA, motion analysis, diagnostic arthroscopy/arthrotomy, assistive walking devices, lower extremity orthoses, acupuncture, chiropractic, TENS, massage therapy, osteo manipulation, nonphysician practitioner (NPP) or other provider office visits, education, and supplements

⁴This number is not 100% because members can qualify as having knee OA based on other claim types coded with knee OA

PPPY = Per Patient Per Year; PMPY = Per Member Per Year; PMPM = Per Member Per Month; Denominator Population consists of members aged 18-64 years; Knee OA-related costs include professional, facility, and drug costs where indicated; Costs shown are allowed costs, which include both payment by the payer and patient cost-sharing;

Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman Commercial Claims Database, years 2016 through 2017

FIGURE 9C: 2017 ANNUAL INCIDENCE & COST OF KNEE OA-RELATED SERVICES FOR COHORT 2

Cohort 2: Non-Invasive Knee OA Services of Interest in 2016 (N = 62,380, 19% of Knee OA Population)								
Service Type	Percent of Patients with Service	Utilization /Patient for Patients with Service	Utilization Type	Average Allowed Cost per Service	Percent of Total Spend on Knee OA-Related Services	Average Allowed Cost PPPY	Average Allowed Cost PMPY	Average Allowed Cost PMPM
Any Knee OA Service of Interest	99.2%⁴				100.0%	\$4,993	\$20	\$1.66
Knee x-ray	53.7%	1.6	procedures	\$90	1.6%	\$82	\$0	\$0.03
Knee MRI	18.8%	1.1	procedures	\$984	4.3%	\$217	\$1	\$0.07
Physical and Occupational Knee Therapy	24.6%	10.3	sessions	\$128	6.8%	\$338	\$1	\$0.11
Orthopedist Office Visits for Knee OA	39.1%	1.6	visits	\$116	1.5%	\$77	\$0	\$0.03
PCP Office Visits (Knee OA-related)	60.4%	2.2	visits	\$134	3.8%	\$188	\$1	\$0.06
Hyaluronic Acid Injection (Knee)	9.3%	1.1	courses	\$1,387	2.9%	\$146	\$1	\$0.05
IACS Injection (Knee)	29.7%	1.3	days	\$348	2.9%	\$144	\$1	\$0.05
Unspecified Product Injection (Knee) ¹	7.5%	1.9	days	\$348	1.0%	\$51	\$0	\$0.02
Arthroscopy and Other Minor Knee Surgery	7.2%	1.1	surgeries	\$6,512	10.9%	\$542	\$2	\$0.18
Knee Arthroplasty (Total, Partial, & Revision)	7.9%	1.1	surgeries	\$33,244	62.2%	\$3,105	\$12	\$1.03
Opioid ²	9.1%	1.9	scripts	\$28	0.1%	\$5	\$0	\$0.00
Non-opioid analgesic, including NSAIDs ²	6.7%	1.5	scripts	\$23	0.1%	\$3	\$0	\$0.00
Other Knee-related Services ³	15.7%	N/A	N/A	N/A	1.9%	\$95	\$0	\$0.03

Notes: ¹Includes general injection codes that did not have a corresponding NDC or HCPCS code for injected drug type

²We are unable to identify the condition for which this medication was prescribed

³Includes CT, ultrasound, arthrography, RSA, motion analysis, diagnostic arthroscopy/arthrotomy, assistive walking devices, lower extremity orthoses, acupuncture, chiropractic, TENS, massage therapy, osteo manipulation, nonphysician practitioner (NPP) or other provider office visits, education, and supplements

⁴This number is not 100% because members can qualify as having knee OA based on other claim types coded with knee OA

PPPY = Per Patient Per Year; PMPY = Per Member Per Year; PMPM = Per Member Per Month; Denominator Population consists of members aged 18-64 years; Knee OA-related costs include professional, facility, and drug costs where indicated; Costs shown are allowed costs, which include both payment by the payer and patient cost-sharing;

Sourced from an analysis of IBM MarketScan[®] Commercial Claims Database and Milliman Commercial Claims Database, years 2016 through 2017

FIGURE 9D: 2017 ANNUAL INCIDENCE & COST OF KNEE OA-RELATED SERVICES FOR COHORT 3

Cohort 3: Knee OA Invasive Procedures in 2016 (N = 124,691, 39% of Knee OA Population)								
Service Type	Percent of Patients with Service	Utilization /Patient for Patients with Service	Utilization Type	Average Allowed Cost per Service	Percent of Total Spend on Knee OA-Related Services	Average Allowed Cost PPPY	Average Allowed Cost PMPY	Average Allowed Cost PMPM
Any Knee OA Service of Interest	99.8%⁴				100.0%	\$7,374	\$58	\$4.87
Knee x-ray	58.0%	1.8	procedures	\$81	1.2%	\$91	\$1	\$0.06
Knee MRI	14.7%	1.1	procedures	\$963	2.3%	\$167	\$1	\$0.11
Physical and Occupational Knee Therapy	27.9%	11.9	sessions	\$131	6.2%	\$456	\$4	\$0.30
Orthopedist Office Visits for Knee OA	41.6%	1.7	visits	\$108	1.1%	\$78	\$1	\$0.05
PCP Office Visits (Knee OA-related)	43.0%	2.2	visits	\$140	1.9%	\$138	\$1	\$0.09
Hyaluronic Acid Injection (Knee)	23.4%	1.2	courses	\$1,357	5.3%	\$389	\$3	\$0.26
IACS Injection (Knee)	46.9%	1.6	days	\$274	3.0%	\$220	\$2	\$0.15
Unspecified Product Injection (Knee) ¹	15.2%	2.2	days	\$262	1.3%	\$93	\$1	\$0.06
Arthroscopy and Other Minor Knee Surgery	6.6%	1.1	surgeries	\$6,512	6.8%	\$503	\$4	\$0.33
Knee Arthroplasty (Total, Partial, & Revision)	13.3%	1.1	surgeries	\$32,287	69.7%	\$5,142	\$41	\$3.40
Opioid ²	9.7%	1.9	scripts	\$34	0.1%	\$7	\$0	\$0.00
Non-opioid analgesic, including NSAIDs ²	7.0%	1.5	scripts	\$24	0.0%	\$3	\$0	\$0.00
Other Knee-related Services ³	15.8%	N/A	N/A	N/A	1.2%	\$87	\$1	\$0.06

Notes: ¹Includes general injection codes that did not have a corresponding NDC or HCPCS code for injected drug type

²We are unable to identify the condition for which this medication was prescribed

³Includes CT, ultrasound, arthrography, RSA, motion analysis, diagnostic arthroscopy/arthrotomy, assistive walking devices, lower extremity orthoses, acupuncture, chiropractic, TENS, massage therapy, osteo manipulation, nonphysician practitioner (NPP) or other provider office visits, education, and supplements

⁴This number is not 100% because members can qualify as having knee OA based on other claim types coded with knee OA

PPPY = Per Patient Per Year; PMPY = Per Member Per Year; PMPM = Per Member Per Month; Denominator Population consists of members aged 18-64 years; Knee OA-related costs include professional, facility, and drug costs where indicated; Costs shown are allowed costs, which include both payment by the payer and patient cost-sharing;

Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman Commercial Claims Database, years 2016 through 2017

Additional Detail on Cohort 3’s Invasive Procedures in 2016

For Cohort 3, the population with knee OA invasive procedures in 2016, we provide the frequency of major knee surgery (total, partial, or revision knee arthroplasty), minor knee surgery (arthroscopy and arthrotomy), and knee injections in the 2016 lookback period:

- 14.7% of members had a major knee surgery
- 13.3% of members had a minor knee surgery
- 27.1% of members had either major or minor knee surgery
- 27.7% of members had an HA knee injection
- 74.0% of members had a IACS knee injection
- 10.7% of members had both major surgery and any knee injection
- 10.1% of members had both minor surgery and any knee injection

Figure 10 provides a comparison of knee OA service utilization and cost among the three 2017 knee OA cohorts. Key findings include:

- Cohort 3's PMPM contribution to total population spend is the highest of the 3 cohorts
- Cohort 1 had highest rate of diagnostics (MRI and knee x-ray), orthopedist visits, IACS injections and minor knee surgery
- Cohort 3 had highest rate of HA injections, knee arthroplasty, and physical therapy visits

FIGURE 10: 2017 TOTAL KNEE OA-RELATED ALLOWED COSTS BY SERVICE CATEGORY

Service Type	Total Knee OA Population		Cohort 1: No Knee OA Services of Interest in 2016		Cohort 2: Non-Invasive Knee OA Services of Interest in 2016		Cohort 3: Knee OA Invasive Procedures in 2016	
	N = 320,442		N = 133,371 (42% of Knee OA Population)		N = 62,380 (19% of Knee OA Population)		N = 124,691 (39% of Knee OA Population)	
	PPPY = \$5,465		PPPY = \$3,935		PPPY = \$4,993		PPPY = \$7,374	
	Percent of Patients with Knee OA Service	Allowed PMPM Cost by Knee OA Service Category	Percent of Patients with Knee OA Service	Allowed PMPM Cost by Knee OA Service Category	Percent of Patients with Knee OA Service	Allowed PMPM Cost by Knee OA Service Category	Percent of Patients with Knee OA Service	Allowed PMPM Cost by Knee OA Service Category
Any Knee OA Service of Interest	99.7%⁴	\$9.37	99.9%⁴	\$2.84	99.2%⁴	\$1.66	99.8%⁴	\$4.87
Knee x-ray	70.6%	\$0.18	90.3%	\$0.09	53.7%	\$0.03	58.0%	\$0.06
Knee MRI	20.9%	\$0.38	27.6%	\$0.20	18.8%	\$0.07	14.7%	\$0.11
Physical and Occupational Knee Therapy	25.3%	\$0.60	23.3%	\$0.19	24.6%	\$0.11	27.9%	\$0.30
Orthopedist Office Visits for Knee OA	45.0%	\$0.15	51.0%	\$0.07	39.1%	\$0.03	41.6%	\$0.05
PCP Office Visits (Knee OA-related)	50.9%	\$0.26	53.8%	\$0.10	60.4%	\$0.06	43.0%	\$0.09
Hyaluronic Acid Injection (Knee)	15.7%	\$0.42	11.4%	\$0.11	9.3%	\$0.05	23.4%	\$0.26
IACS Injection (Knee)	44.5%	\$0.32	49.2%	\$0.13	29.7%	\$0.05	46.9%	\$0.15
Unspecified Product Injection (Knee) ¹	11.1%	\$0.11	8.9%	\$0.03	7.5%	\$0.02	15.2%	\$0.06
Arthroscopy and Other Minor Knee Surgery	7.5%	\$0.94	8.4%	\$0.43	7.2%	\$0.18	6.6%	\$0.33
Knee Arthroplasty (Total, Partial, & Revision)	8.9%	\$5.85	5.3%	\$1.42	7.9%	\$1.03	13.3%	\$3.40
Opioid ²	8.8%	\$0.01	7.8%	\$0.00	9.1%	\$0.00	9.7%	\$0.00
Non-opioid analgesic, including NSAIDs ²	6.6%	\$0.00	6.0%	\$0.00	6.7%	\$0.00	7.0%	\$0.00
Other Knee-related Services ³	15.9%	\$0.14	16.1%	\$0.05	15.7%	\$0.03	15.8%	\$0.06

Notes: ¹Includes general injection codes that did not have a corresponding NDC or HCPCS code for injected drug type

²We are unable to identify the condition for which this medication was prescribed

³Includes CT, ultrasound, arthrography, RSA, motion analysis, diagnostic arthroscopy/arthrotomy, assistive walking devices, lower extremity orthoses, acupuncture, chiropractic, TENS, massage therapy, osteo manipulation, nonphysician practitioner (NPP) or other provider office visits, education, and supplements

⁴This number is not 100% because members can qualify as having knee OA based on other claim types coded with knee OA

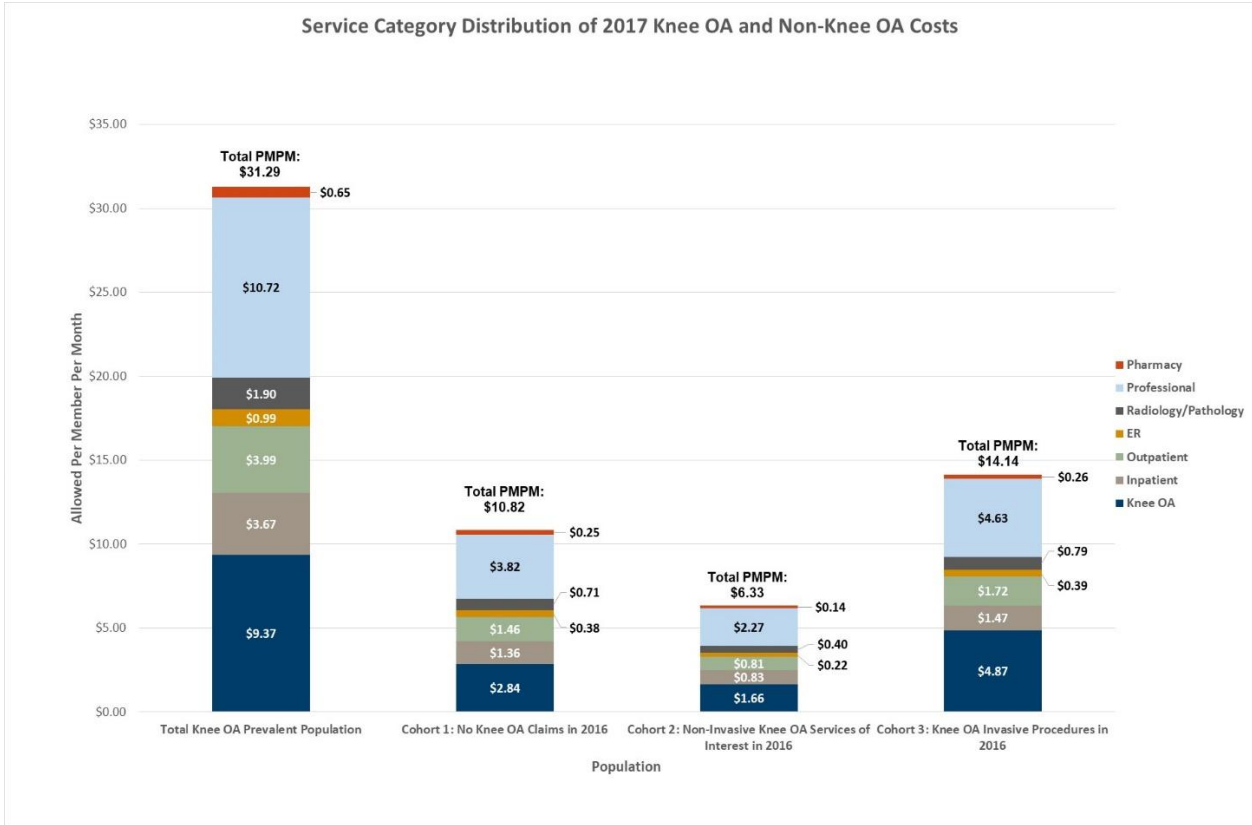
PPPY = Per Patient Per Year; PMPY = Per Member Per Year; PMPM = Per Member Per Month; Denominator Population consists of members aged 18-64 years; Knee OA-related costs include professional, facility, and drug costs where indicated; Costs shown are allowed costs, which include both payment by the payer and patient cost-sharing;

Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman Commercial Claims Database, years 2016 through 2017

Figure 11 provides a comparison of knee OA and non-knee-related costs among the three cohorts. Key findings include:

- Professional and outpatient costs make up the majority of non-knee-related costs for knee OA patients
- Knee-related services make up 26.2%, 26.2%, and 34.4% of all costs for Cohorts 1, 2, and 3, respectively, and include all service types: pharmacy, professional, radiology/pathology, ER, outpatient, and inpatient

FIGURE 11: TOTAL 2017 PMPM ALLOWED COSTS BY SERVICE CATEGORY FOR THE TOTAL KNEE OA POPULATION



Notes: PMPM = Per Member Per Month; Denominator Population consists of members aged 18-64 years; Knee OA-related costs include professional, facility, and drug costs where indicated; Costs shown are allowed costs, which include both payment by the payer and patient cost-sharing. Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman Commercial Claims Database, years 2016 through 2017

Longitudinal Analysis (2014-2017)

The literature reports possible overutilization of knee OA-related invasive services in the knee OA population (see Background section for details). In addition, the majority of knee OA-related costs occur within 2 years of a knee replacement surgery. A substantial portion of knee OA-related interventions and healthcare costs occur within the 3 to 6 months prior to a TKA, with diagnostic procedures such as MRI commonly occurring within 2 years and alternative treatments, such as physical therapy, occurring within 1 year [35]. These interventions, including imaging, procedures, physical therapy, and injections, occur at a high frequency in close proximity to UKA and TKA procedures, resulting in substantial costs [35] [36]. We conducted a longitudinal analysis to understand patterns of care in the knee OA population over a 4-year period, identifying patients with knee OA in 2014 and following them through 2017.

KNEE OA IDENTIFICATION AND ELIGIBILITY REQUIREMENTS

The longitudinal analysis examined 2013-2017 IBM MarketScan® and Milliman CHSD commercial claims data (see description of claim data sources in [Data Sources and Methodology](#) section). Members were required to have continuous enrollment from January 2013 through December 2017 (or until they turned 65), medical and pharmacy coverage, and be an active employee or dependent of an active employee. Members were also required to be ≥ 18 years of age at the start of 2013 and < 64 at the end of 2014. The resulting denominator population consisted of 4,139,320 members.

Using the same logic that we used for our snapshot analysis, we identified 75,082 knee OA patients meeting the eligibility criteria. We used the same three cohort designations and knee OA-related service claim designations as used for the snapshot analysis. For full patient identification algorithms and code lists, see the [Methodology](#) section and [Appendix 1](#).

DEMOGRAPHIC INFORMATION

[Figure 12](#) provides a demographic summary of the 2014 index year knee OA longitudinal population.

FIGURE 12: DEMOGRAPHICS OF THE 2014 INDEX YEAR KNEE OA LONGITUDINAL POPULATION

Age Bands ¹	Total Knee OA Population			Cohort 1: No Knee OA Services of Interest in 2013			Cohort 2: Non-Invasive Knee OA Services of Interest in 2013			Cohort 3: Knee OA Invasive Procedures in 2013		
	Knee OA Patients	% of Knee OA Pop.	Median Age	Knee OA Patients	% of Knee OA Pop.	Median Age	Knee OA Patients	% of Knee OA Pop.	Median Age	Knee OA Patients	% of Knee OA Pop.	Median Age
Total	75,082	100.00%	55	33,727	44.92%	55	13,549	18.05%	55	27,806	37.03%	56
Male	31,743	42.28%	55	14,918	19.87%	55	5,528	7.36%	55	11,297	15.05%	56
Female	3,339	57.72%	55	18,809	25.05%	55	8,021	10.68%	55	16,509	21.99%	56

Notes: Age Band is based on the patient's age at the end of 2014; Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman CHSD Commercial Claims Database, years 2013 through 2017

UTILIZATION SUMMARY

Figure 13A provides a summary of year over year utilization of knee OA-related services for the total 2014 knee OA population, regardless of whether a patient had the same service in a previous year. Figure 13B provides the year of first time utilization of a service, including utilization in 2014. We also include the annual utilization of knee-OA related services in the 2013 look back year but do not consider the 2013 utilization in the first time utilization figures. Key findings for the total 2014 knee OA population include:

- First time utilization of knee OA-related services across service types overwhelmingly occurs in the 2014 index year
- 49.5% continue to get knee OA-related services in 2017 (note that diagnosis coding does not allow us to identify whether the service was for the same or different knee over the time period)
- In the years following 2014, a significant percentage of patients have first time knee arthroplasty: 8.8% (2014), 6.5% (2015), 4.9% (2016), 4.5% (2017)
- Only 39.1% of knee OA patients have 1+ claims for physical or occupational therapy over the 4 years
- Almost a quarter of knee OA patients had an MRI in 2014 (23.1%)
- High utilization of injections, both IACS and HA, occurred in 2014 (41.2% and 18.5%, respectively)
- 9.3% of patients received an arthroscopy or other minor knee surgery in 2014

FIGURE 13A: YEAR OVER YEAR INCIDENCE OF KNEE OA-RELATED SERVICES FOR THE 2014 INDEX YEAR KNEE OA POPULATION

2014 Total Knee OA Population (N=75,082)				
Service Type	2014	2015	2016	2017
Any Knee OA Service of Interest	99.7%⁴	59.0%	52.0%	49.5%
Knee x-ray	73.2%	30.4%	28.1%	26.6%
Knee MRI	23.1%	7.5%	6.4%	6.1%
Physical and Occupational Knee Therapy	23.4%	13.5%	9.8%	9.1%
Orthopedist Office Visits for Knee OA	48.3%	22.1%	17.2%	15.5%
PCP Office Visits (Knee OA-related)	43.9%	23.7%	21.8%	21.0%
Hyaluronic Acid Injection (Knee)	18.5%	11.1%	8.7%	7.8%
IACS Injection (Knee)	41.2%	20.0%	17.7%	16.1%
Unspecified Product Injection (Knee) ¹	11.8%	6.9%	5.3%	4.8%
Arthroscopy and Other Minor Knee Surgery	9.3%	3.6%	2.0%	1.8%
Knee Arthroplasty (Total, Partial, & Revision)	8.8%	6.5%	4.9%	4.5%
Opioid ²	6.8%	7.0%	7.6%	7.4%
Non-opioid analgesic, including NSAIDs ²	4.7%	4.9%	5.5%	5.9%
Other Knee-related Services ³	15.1%	7.7%	6.4%	6.3%

Notes: ¹Includes general injection codes that did not have a corresponding NDC or HCPCS code for injected drug type

²We are unable to identify the condition for which this medication was prescribed

³Includes CT, ultrasound, arthrography, RSA, motion analysis, diagnostic arthroscopy/arthrotomy, assistive walking devices, lower extremity orthoses, acupuncture, chiropractic, TENS, massage therapy, osteo manipulation, nonphysician practitioner (NPP) or other provider office visits, education, and supplements

⁴This number is not 100% because members can qualify as having knee OA based on other claim types coded with knee OA

Sourced from an analysis of IBM MarketScan[®] Commercial Claims Database and Milliman Commercial Claims Database, years 2013 through 2017

FIGURE 13B: YEAR OVER YEAR INCIDENCE OF FIRST KNEE OA-RELATED SERVICES SINCE 2014 FOR THE 2014 INDEX YEAR KNEE OA POPULATION

Total Knee OA Population (N=75,082) % of the Population Utilizing Service for the First Time					
Service Type	2014	2015	2016	2017	% with 1+ Services in 4 Years ²
Knee x-ray	73.2%	6.9%	4.0%	2.8%	86.1%
Knee MRI	23.1%	5.3%	3.6%	3.0%	34.2%
Physical and Occupational Knee Therapy	23.4%	7.8%	4.9%	4.1%	39.1%
Orthopedist Office Visits for Knee OA	48.3%	7.9%	4.7%	3.4%	63.4%
PCP Office Visits (Knee OA-related)	43.9%	8.6%	6.4%	5.0%	62.5%
Hyaluronic Acid Injection (Knee)	18.8%	5.1%	2.6%	2.1%	27.9%
IACS Injection (Knee)	41.2%	5.9%	4.3%	3.2%	53.7%
Unspecified Product Injection (Knee) ¹	11.7%	3.8%	2.4%	2.0%	19.4%
Arthroscopy and Other Minor Knee Surgery	9.3%	3.1%	1.6%	1.3%	14.9%
Knee Arthroplasty (Total, Partial, & Revision)	8.8%	5.8%	3.9%	3.4%	21.0%

Notes: ¹Includes general injection codes that did not have a corresponding NDC or HCPCS code for injected drug type

²This column is not additive of the preceding year columns because the denominator population used in these calculations was for the 2014 population, and did not account for members who aged out or left for other reasons

Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman Commercial Claims Database, years 2013 through 2017

Figures 14A and 14B provide a summary of year over year utilization for the members of the 2014 index population who were categorized into Cohort 1. Key findings for the 2014 Cohort 1 knee OA population include:

- 41.7% continue to get knee OA-related services in year 2017
- A significant percentage of patients have first time knee arthroplasty in the years following 2014: 5.6% (2014), 5.2% (2015), 3.8% (2016), 3.5% (2017)

FIGURE 14A: YEAR OVER YEAR INCIDENCE OF KNEE OA-RELATED SERVICES FOR THE 2014 INDEX YEAR KNEE OA POPULATION: COHORT 1

Cohort 1: No Knee OA Services of Interest in 2013 (N = 33,727, 45% of Knee OA Population)					
Service Type	2013	2014	2015	2016	2017
Any Knee OA Service of Interest	11.7%	99.9%⁴	51.0%	43.6%	41.7%
Knee x-ray	0.0%	90.2%	23.5%	23.1%	22.0%
Knee MRI	0.0%	30.0%	7.2%	5.7%	5.4%
Physical and Occupational Knee Therapy	0.0%	21.3%	12.8%	8.2%	7.6%
Orthopedist Office Visits for Knee OA	0.4%	53.4%	19.1%	14.1%	12.9%
PCP Office Visits (Knee OA-related)	3.4%	47.7%	20.1%	18.1%	17.5%
Hyaluronic Acid Injection (Knee)	0.0%	14.1%	8.3%	6.3%	5.7%
IACS Injection (Knee)	0.0%	45.0%	16.9%	14.2%	13.1%
Unspecified Product Injection (Knee) ¹	0.0%	9.9%	5.4%	3.9%	3.6%
Arthroscopy and Other Minor Knee Surgery	0.0%	10.3%	4.1%	1.9%	1.7%
Knee Arthroplasty (Total, Partial, & Revision)	0.0%	5.6%	5.2%	3.8%	3.5%
Opioid ²	5.6%	6.1%	6.3%	6.6%	6.4%
Non-opioid analgesic, including NSAIDs ²	4.2%	4.3%	4.3%	4.8%	5.4%
Other Knee-related Services ³	0.3%	15.7%	6.9%	5.3%	5.2%

Notes: ¹Includes general injection codes that did not have a corresponding NDC or HCPCS code for injected drug type

²We are unable to identify the condition for which this medication was prescribed

³Includes CT, ultrasound, arthrography, RSA, motion analysis, diagnostic arthroscopy/arthrotomy, assistive walking devices, lower extremity orthoses, acupuncture, chiropractic, TENS, massage therapy, osteo manipulation, nonphysician practitioner (NPP) or other provider office visits, education, and supplements

⁴This number is not 100% because members can qualify as having knee OA based on other claim types coded with knee OA

Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman Commercial Claims Database, years 2013 through 2017

FIGURE 14B: YEAR OVER YEAR INCIDENCE OF FIRST TIME KNEE OA-RELATED SERVICES SINCE 2014 FOR THE 2014 INDEX YEAR KNEE OA POPULATION: COHORT 1

Cohort 1: No Knee OA Services of Interest in 2013 (N = 33,727, 45% of Knee OA Population) % of the Population Utilizing Service for the First Time					
Service Type	2014	2015	2016	2017	% with 1+ Services in 4 Years ²
Knee x-ray	90.2%	1.8%	1.2%	0.9%	93.8%
Knee MRI	30.0%	4.8%	2.9%	2.4%	39.6%
Physical and Occupational Knee Therapy	21.3%	7.5%	4.3%	3.6%	35.9%
Orthopedist Office Visits for Knee OA	53.4%	6.5%	3.4%	2.6%	65.3%
PCP Office Visits (Knee OA-related)	47.7%	7.0%	5.2%	4.3%	63.1%
Hyaluronic Acid Injection (Knee)	14.1%	5.2%	2.4%	1.9%	23.2%
IACS Injection (Knee)	45.0%	4.7%	3.3%	2.7%	55.1%
Unspecified Product Injection (Knee) ¹	9.9%	3.3%	2.0%	1.7%	16.6%
Arthroscopy and Other Minor Knee Surgery	10.3%	3.6%	1.4%	1.2%	16.3%
Knee Arthroplasty (Total, Partial, & Revision)	5.6%	4.8%	3.2%	2.7%	15.6%

Notes: ¹Includes general injection codes that did not have a corresponding NDC or HCPCS code for injected drug type

²This column is not additive of the preceding year columns because the denominator population used in these calculations was for the 2014 population, and did not account for members who aged out or left for other reasons

Sourced from an analysis of IBM MarketScan[®] Commercial Claims Database and Milliman Commercial Claims Database, years 2013 through 2017. First-time utilization does not consider utilization in 2013 lookback year.

Figures 15A and 15B provide a summary of year over year utilization for the members of the 2014 index population who were categorized into Cohort 2. Key findings for the 2014 Cohort 2 knee OA population include:

- Over 50% of patients continued to utilize knee OA-related services in each of the 4 years
- Knee x-ray was the most common service in the 2013 lookback year to categorize patients into Cohort 2
- In the 4 years examined, IACS knee injection was the most common service, with 41.4% of patients having at least one injection over the 4 years

FIGURE 15A: YEAR OVER YEAR INCIDENCE OF KNEE OA-RELATED SERVICES FOR THE 2014 INDEX YEAR KNEE OA POPULATION: COHORT 2

Cohort 2: Non-Invasive Knee OA Services of Interest in 2013 (N = 13,549, 18% of Knee OA Population)					
Service Type	2013	2014	2015	2016	2017
Any Knee OA Service of Interest	99.5%	99.4%⁴	59.0%	52.3%	50.1%
Knee x-ray	66.1%	58.2%	28.8%	26.2%	25.2%
Knee MRI	20.5%	21.9%	7.7%	6.8%	6.7%
Physical and Occupational Knee Therapy	15.0%	23.5%	12.5%	9.4%	8.8%
Orthopedist Office Visits for Knee OA	40.4%	44.3%	21.2%	16.5%	15.4%
PCP Office Visits (Knee OA-related)	49.4%	51.3%	28.8%	26.1%	24.5%
Hyaluronic Acid Injection (Knee)	0.0%	12.3%	6.8%	5.9%	5.6%
IACS Injection (Knee)	0.0%	28.2%	13.8%	13.4%	12.4%
Unspecified Product Injection (Knee) ¹	0.0%	8.4%	4.9%	4.1%	3.5%
Arthroscopy and Other Minor Knee Surgery	0.0%	9.7%	3.2%	1.9%	1.7%
Knee Arthroplasty (Total, Partial, & Revision)	0.0%	8.4%	4.9%	4.0%	3.7%
Opioid ²	7.2%	7.0%	7.0%	7.6%	7.5%
Non-opioid analgesic, including NSAIDs ²	5.3%	4.7%	5.1%	5.6%	5.6%
Other Knee-related Services ³	10.0%	14.8%	7.5%	6.6%	6.7%

Notes: ¹Includes general injection codes that did not have a corresponding NDC or HCPCS code for injected drug type

²We are unable to identify the condition for which this medication was prescribed

³Includes CT, ultrasound, arthrography, RSA, motion analysis, diagnostic arthroscopy/arthrotomy, assistive walking devices, lower extremity orthoses, acupuncture, chiropractic, TENS, massage therapy, osteo manipulation, nonphysician practitioner (NPP) or other provider office visits, education, and supplements

⁴This number is not 100% because members can qualify as having knee OA based on other claim types coded with knee OA

Sourced from an analysis of IBM MarketScan[®] Commercial Claims Database and Milliman Commercial Claims Database, years 2013 through 2017

FIGURE 15B: YEAR OVER YEAR INCIDENCE OF FIRST TIME KNEE OA-RELATED SERVICES SINCE 2014 FOR THE 2014 INDEX YEAR KNEE OA POPULATION: COHORT 2

Cohort 2: Non-Invasive Knee OA Services of Interest in 2013 (N = 13,549, 18% of Knee OA Population) % of Population Utilizing Service for the First Time					
Service Type	2014	2015	2016	2017	% with 1+ Services in 4 Years ²
Knee x-ray	58.2%	8.0%	5.1%	4.1%	74.3%
Knee MRI	21.9%	5.3%	3.7%	3.2%	33.3%
Physical and Occupational Knee Therapy	23.5%	7.0%	4.6%	3.8%	37.8%
Orthopedist Office Visits for Knee OA	44.3%	7.1%	4.6%	3.2%	58.3%
PCP Office Visits (Knee OA-related)	51.3%	7.5%	5.8%	4.2%	67.5%
Hyaluronic Acid Injection (Knee)	12.3%	3.9%	2.4%	2.0%	20.0%
IACS Injection (Knee)	28.2%	5.8%	4.9%	3.5%	41.4%
Unspecified Product Injection (Knee) ¹	8.4%	3.0%	2.2%	1.7%	14.8%
Arthroscopy and Other Minor Knee Surgery	9.7%	2.8%	1.4%	1.2%	14.8%
Knee Arthroplasty (Total, Partial, & Revision)	8.4%	4.2%	3.2%	2.8%	17.8%

Notes: ¹Includes general injection codes that did not have a corresponding NDC or HCPCS code for injected drug type

²This column is not additive of the preceding year columns because the denominator population used in these calculations was for the 2014 population, and did not account for members who aged out or left for other reasons

Sourced from an analysis of IBM MarketScan[®] Commercial Claims Database and Milliman Commercial Claims Database, years 2013 through 2017. First-time utilization does not consider utilization in 2013 lookback year.

Figures 16A and 16B provide a summary of year over year utilization for the members of the 2014 index population who were categorized into Cohort 3. Key findings for the 2014 Cohort 3 knee OA population include:

- The majority of patients continue to get knee OA-related services in all 4 years, with 58.9% still receiving services in 2017
- Significant first time utilization of knee arthroplasty continues in all years: 12.9% (2014), 7.7% (2015), 5.3% (2016), 4.5% (2017)
- Significant differences between the any-use HA injections in Figure 16A (16.5% in 2015, 13.0% in 2016, 11.6% in 2017) and the first-time use HA injections in Figure 16B (5.5% in 2015, 2.8% in 2016, 2.2% in 2017) indicate that many knee OA patients are receiving multiple courses of HA injections

FIGURE 16A: YEAR OVER YEAR INCIDENCE OF KNEE OA-RELATED SERVICES FOR THE 2014 INDEX YEAR KNEE OA POPULATION: COHORT 3

Cohort 3: Knee OA Invasive Procedures in 2013 (N = 27,806, 37% of Knee OA Population)					
Service Type	2013	2014	2015	2016	2017
Any Knee OA Service of Interest	100.0%	99.6%⁴	68.6%	62.1%	58.9%
Knee x-ray	75.0%	59.8%	39.4%	35.3%	33.1%
Knee MRI	27.4%	15.2%	7.8%	7.0%	6.7%
Physical and Occupational Knee Therapy	27.3%	25.7%	14.9%	11.9%	11.2%
Orthopedist Office Visits for Knee OA	48.3%	43.9%	26.1%	21.3%	18.8%
PCP Office Visits (Knee OA-related)	39.1%	35.8%	25.6%	24.4%	23.6%
Hyaluronic Acid Injection (Knee)	33.7%	26.8%	16.5%	13.0%	11.6%
IACS Injection (Knee)	62.7%	42.8%	26.7%	24.1%	21.6%
Unspecified Product Injection (Knee) ¹	18.9%	15.8%	9.7%	7.7%	7.0%
Arthroscopy and Other Minor Knee Surgery	16.5%	7.8%	3.1%	2.3%	2.1%
Knee Arthroplasty (Total, Partial, & Revision)	15.1%	12.9%	8.7%	6.7%	6.2%
Opioid ²	7.7%	7.6%	7.8%	8.8%	8.6%
Non-opioid analgesic, including NSAIDs ²	5.1%	5.2%	5.4%	6.5%	6.8%
Other Knee-related Services ³	19.0%	14.7%	9.0%	7.7%	7.4%

Notes: ¹Includes general injection codes that did not have a corresponding NDC or HCPCS code for injected drug type

²We are unable to identify the condition for which this medication was prescribed

³Includes CT, ultrasound, arthrography, RSA, motion analysis, diagnostic arthroscopy/arthrotomy, assistive walking devices, lower extremity orthoses, acupuncture, chiropractic, TENS, massage therapy, osteo manipulation, nonphysician practitioner (NPP) or other provider office visits, education, and supplements

⁴This number is not 100% because members can qualify as having knee OA based on other claim types coded with knee OA

Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman Commercial Claims Database, years 2013 through 2017

FIGURE 16B: YEAR OVER YEAR INCIDENCE OF FIRST TIME KNEE OA-RELATED SERVICES SINCE 2014 FOR THE 2014 INDEX YEAR KNEE OA POPULATION: COHORT 3

Cohort 3: Knee OA Invasive Procedures in 2013 (N = 27,806, 37% of Knee OA Population) % of Population Utilizing Service for the First Time					
Service Type	2014	2015	2016	2017	% with 1+ Services in 4 Years ²
Knee x-ray	59.8%	12.7%	6.9%	4.5%	82.4%
Knee MRI	15.2%	5.8%	4.5%	3.6%	28.1%
Physical and Occupational Knee Therapy	25.7%	8.6%	5.9%	4.8%	43.7%
Orthopedist Office Visits for Knee OA	43.9%	10.0%	6.4%	4.7%	63.5%
PCP Office Visits (Knee OA-related)	35.8%	11.1%	8.1%	6.1%	59.3%
Hyaluronic Acid Injection (Knee)	27.5%	5.5%	2.8%	2.2%	37.4%
IACS Injection (Knee)	42.8%	7.5%	5.1%	3.8%	58.0%
Unspecified Product Injection (Knee) ¹	15.6%	4.6%	3.0%	2.4%	25.0%
Arthroscopy and Other Minor Knee Surgery	7.8%	2.7%	1.8%	1.5%	13.4%
Knee Arthroplasty (Total, Partial, & Revision)	12.9%	7.7%	5.3%	4.5%	29.1%

Notes: ¹Includes general injection codes that did not have a corresponding NDC or HCPCS code for injected drug type

²This column is not additive of the preceding year columns because the denominator population used in these calculations was for the 2014 population, and did not account for members who aged out or left for other reasons

Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman Commercial Claims Database, years 2016 through 2017. First-time utilization does not consider utilization in 2013 lookback year.

Implications for Payers/Employers

In the US commercially insured working age population, the cost burden of knee OA is high, as more than half of people with symptomatic knee OA are under 65 years of age [1]. In addition, the incidence of knee OA is expected to steadily increase as the population continues to age, the commercially insured workforce ages, and rates of obesity increase [24]. Many existing treatments to manage the progression and/or reduce the symptoms of knee OA are expensive and have questionable efficacy while overutilization of certain tests and treatments for knee OA in the US has been widely reported (see Background section for sources).

Our snapshot analysis highlighted some of this potential overutilization. For example, clinical guidelines do not typically recommend MRI as a diagnostic for knee OA, yet 20.9% of our commercial knee OA population received at least one knee MRI in 2017. IACS injections have been reported to seldom improve knee OA pain in the long-term and may have long-term negative effects in some knee OA patients, yet we identified that 44.5% of commercial knee OA patients received at least one IACS knee injection in 2017. HA injections have been reported to have limited evidence of efficacy and are not recommended by the AAOS, yet 15.7% of commercial knee OA patients in our study received at least one HA knee injection in 2017. Full or partial knee arthroplasty (TKA/UKA) has become a common end-point for knee OA patients, even though the replacement knees have only a 10-15 year lifespan, and there is evidence that inappropriate patients are being referred for surgery. Our population had 8.9% of patients receive a UKA/TKA in 2017, and these services resulted in 62.4% of knee-related costs. Knee arthroscopy is reported to be overutilized and is shown to provide little to no long-term benefits, yet 7.5% of patients received a knee arthroscopy or other minor knee surgery in 2017, accounting for 10.0% of knee-related costs. Along with the high use of knee injections and knee surgery, we identified only 25.3% of the 2017 knee OA population receiving physical or occupational knee OA therapy, despite evidence that PT and exercise can improve functionality among knee OA patients and potentially delay surgical intervention.

The longitudinal analysis similarly highlighted potential overutilization for the 2014 index year knee OA population. By the end of 2017, 21% had knee arthroplasty, 27.9% had a HA knee injection, 53.7% had an IACS knee injection, 34.2% had a knee MRI, and 14.9% had minor knee surgery including knee arthroscopy, while only 39.1% had physical or occupational therapy.

The literature on conservative medical management of knee OA is limited. Further analysis of practice patterns and patterns of care for the knee OA population is warranted to identify opportunities to manage overutilization and inappropriate utilization of knee OA diagnostics and treatments for some knee OA patients.

Data Sources & Methodology

DATA SOURCES

- 2013-2017 IBM MarketScan®: The MarketScan® database represents the inpatient and outpatient healthcare service use of approximately 30 million individuals nationwide who are covered by the benefit plans of large employers, health plans, and government and public organizations. The MarketScan® database links paid claims and encounter data to detailed patient information across sites and types of providers, and over time. Member identification codes are consistent from year-to-year and allow for multiyear longitudinal studies. The database contains diagnosis codes; procedure codes and diagnosis-related group (DRG) codes; national drug codes (NDCs); and site of service information and the amounts allowed and paid by commercial insurers.
- 2013-2017 Milliman Consolidated Health Sources Database (CHSD) Commercial Claim Data: The CHSD contains proprietary historical claims experience from several of Milliman’s Health Cost Guideline (HCG) data contributors. The database contains annual enrollment and paid medical and pharmacy claims for over 20 million commercially insured individuals covered by the benefit plans of large employers, health plans, and governmental and public organizations nationwide.

DERIVATION OF STUDY POPULATION

Snapshot (2017)

- Denominator Population:
 - Members having continuous enrollment from January 2016 through January 2017.
 - Members were required to have both medical and pharmacy coverage and be an active employee or dependent of an active employee.
 - Members ≥ 18 years of age at the start of 2016 and < 65 at the end of 2017.
- Knee OA Prevalent Population:
 - With 2 or more qualified claims coded with knee OA diagnosis within the 24 months of 2016-2017 on separate dates of service [see [Appendix 1A&1D](#)]
 - OR with 1 qualified claim coded with a knee OA diagnosis AND a claim for a knee surgery, diagnostic test, injection, knee orthosis, or knee OA physical or occupational therapy claim within the 24 months of 2016-2017 (both required claims can occur on the same day) [see [Appendix 1A-1I](#)]
 - Must have at least one qualifying claim in 2017 [see [Appendix 1A](#)]
- Knee OA Cohorts
 - The knee OA population was then separated into 3 cohorts based on their 2016 lookback year:
 1. Knee OA population with no knee OA claims in 2016
 2. Knee OA population with knee OA claims in 2016 but no invasive procedures in 2016
 3. Knee OA population with knee OA invasive procedures in 2016

Population Identification Data Step		Members Meeting Criteria
1	Members having continuous enrollment throughout 2016 and at least in the month of January 2017. Members also are ≥ 18 years of age at the start of the lookback year (2016), and < 64 at the end of 2017.	16,306,777*
2	Members with at least 1 Dx claim for knee OA or at least 1 Dx claim for knee pain with a general OA Dx code in 2016-2017.	487,793
3	Members with 2 or more Dx claims for knee OA or 1 Dx claim and a diagnostic test or injection/treatment claim in 2016-2017 (Must have 1+ Dx claim or diagnostic test or injection/treatment claim in 2017).	320,442**

*Denominator Population

**Knee OA Total Population

Knee OA Prevalence Requiring at least 1 Dx claim (Step 2)	3.0%
Knee OA Prevalence Requiring 2 or more Dx claims (Step 3: Knee OA Total Prevalent Population)	2.0%

Longitudinal (2013-2017)

- Denominator Population:
 - Members having continuous enrollment from January 2013 through December 2017 or until they turned 65.
 - Members were required to have both medical and pharmacy coverage and be an active employee or dependent of an active employee.
 - Members ≥ 18 years of age at the start of 2013 and < 64 at the end of 2014.
- Knee OA Population:
 - With 2 or more qualified claims coded with knee OA diagnosis within the 24 months of 2013-2014 on separate dates of service [see [Appendix 1A&1D](#)]
 - OR with 1 qualified claim coded with a knee OA diagnosis AND a claim for a knee surgery, diagnostic test, injection, knee orthosis, or knee OA physical or occupational therapy claim within the 24 months of 2013-2014 (both required claims can occur on the same day) [see [Appendix 1A-1I](#)]
 - Must have at least one qualifying claim in 2014 [see [Appendix 1A](#)]
- Knee OA Cohorts
 - The knee OA population was then separated into 3 cohorts based on their 2013 lookback year:
 1. Knee OA population with no knee OA services of interest in 2013
 2. Knee OA population with non-invasive knee OA services of interest in 2016 but no invasive knee-related procedures of interest in 2013
 3. Knee OA population with knee OA invasive procedures in 2013

Population Identification Data Step		Members Meeting Criteria
1	Members having continuous enrollment from January 2013 through December 2017 or until they turned 65.	4,139,320
2	Members having both medical and pharmacy coverage and being an active employee or dependent of an active employee.	114,890
3	Members ≥ 18 years of age at the start of 2013 and < 64 at the end of 2014. Members with 2 or more Dx claims for knee OA or 1 Dx claim and a diagnostic test or injection/treatment claim in 2013-2014 (Must have 1+ Dx claim or diagnostic test or injection/treatment claim in 2014).	75,082*

*Knee OA Total Population

Appendices

APPENDIX 1: CODE LISTS

APPENDIX 1A: QUALIFIED CLAIMS TYPES FOR DISEASE IDENTIFICATION

Claim Type	CPT/HCPCS Code	Revenue Code
Outpatient	99201-5, 99211-5, 99241-5, 99341-5, 99347-50, 99381-7, 99391-7, 99401-4, 99411-2, 99429, 99455-6, G0402, G0438-9, G0463, G0466-8, T1015	0510-7, 0519-23, 0526-9, 0982-3
Non-acute inpatient	99304-10, 99315-6, 99318, 99324-8, 99334-7	0118, 0128, 0138, 0148, 0158, 0190-4, 0199, 0524-5, 0550-2, 0559
Acute inpatient	99221-3, 99231-3, 99238-9, 99251-5, 99291, 99468-9, 99471-2, 99475-80	010x, 0110-5, 0117, 0119-25, 0127, 0129-35, 0137, 0139-45, 0147, 0149-55, 0157, 0159-60, 0164, 0166-75, 0179, 0200-4, 0206-14, 0219, 0720-2
Observation	99217-20, 99224-6, G0378-9	
Emergency department	99281-5, G0380-4	0450-2, 0456, 0459, 0981

APPENDIX 1B: KNEE DIAGNOSTICS

Claim Type	HCPCS Code
X-ray	73560, 73562, 73564-5
CT	73700-2
Arthrography	73580
MRI	73718-23, 73725
Ultrasound*	76881-2
RSA	0350T
Motion analysis	96000-1, 96004
Diagnostic arthroscopy/arthrotomy	29870, 27330

*Requires a corresponding Knee OA Dx code

APPENDIX 1C: KNEE NON-OPERATIVE TREATMENT*

Claim Type	HCPCS Code
Knee orthosis	L1810, L1812, L1820, L1830-4, L1836, L1840, L1843-8, L1850-2
Occupational therapy*	97003-4, 97165-9
Physical Therapy*	97001-2, 97161-4
Other Therapy*	97005-6, 97010, 97012, 97014, 97016, 97018, 97022, 97024, 97026, 97028, 97032-6, 97039, 97110, 97112-3, 97116, 97127, 97139, 97140, 97150, 97170-2, 97530, 97533, 97535, 97542, 97545-6, 97750, 97755, 97760-3, 97799

*Requires a corresponding Knee OA Dx code

APPENDIX 1D: KNEE OSTEOARTHRITIS DIAGNOSIS (DX)

Code Type	General Osteoarthritis Paired with Knee Pain Codes	Knee Osteoarthritis Codes
ICD-9-CM	71509-10, 71518, 71520, 71528, 71530, 71538, 71580, 71589-90, 71598, 71946	71516, 71526, 71536, 71596
ICD-10-CM	M1990-3, M158-9, M25561-2, M25569, M25661-2, M25669, M25761-2, M25769	M170, M172, M174-5, M179-12, M1730-2

APPENDIX 1E: THERAPEUTIC ARTHROSCOPY AND OTHER MINOR KNEE SURGERY

Procedure Type	HCPCS Code
Arthrotomy	27331-5, 27403
Arthroscopy	29866-8, 29871, 29873-7, 29879, 29880-7, G0289
Other	27347, 27415-6, G0428

APPENDIX 1F: KNEE REPLACEMENT

Code Type	Partial Knee Replacement Codes	Total Knee Replacement Codes
ICD-9-PCS		8154
HCPCS	27446	27447
ICD-10-PCS	0SRC0L9, 0SRC0LA, 0SRC0LZ, 0SRC0M9, 0SRC0MA, 0SRC0MZ, 0SRC0N9, 0SRC0NA, 0SRC0NZ, 0SRD0L9, 0SRD0LA, 0SRD0LZ, 0SRD0M9, 0SRD0MA, 0SRD0MZ, 0SRD0N9, 0SRD0NA, 0SRD0NZ, 0SRV0J9, 0SRV0JA, 0SRV0JZ, 0SRV0K9, 0SRV0KA, 0SRV0KZ, 0SRW0J9, 0SRW0JA, 0SRW0JZ, 0SRW0K9, 0SRW0KA, 0SRW0KZ	0SRC069, 0SRC06A, 0SRC06Z, 0SRC07Z, 0SRC0EZ, 0SRC0J9, 0SRC0JA, 0SRC0JZ, 0SRC0KZ, 0SRD069, 0SRD06A, 0SRD06Z, 0SRD07Z, 0SRD0EZ, 0SRD0J9, 0SRD0JA, 0SRD0JZ, 0SRD0KZ, 0SRT07Z, 0SRT0J9, 0SRT0JA, 0SRT0JZ, 0SRT0KZ, 0SRU07Z, 0SRU0J9, 0SRU0JA, 0SRU0JZ, 0SRU0KZ

APPENDIX 1G: REMOVAL/REVISION KNEE ARTHROPLASTY

Code Type	Removal Codes	Revision Codes
ICD-9-PCS	8006	0080-4, 8155
HCPCS		27486-7
ICD-10-PCS	0QPD04Z, 0QPD05Z, 0QPD07Z, 0QPD0JZ, 0QPD0KZ, 0QPF04Z, 0QPF05Z, 0QPF07Z, 0QPF0JZ, 0QPF0KZ, 0SPC04Z, 0SPC05Z, 0SPC07Z, 0SPC08Z, 0SPC09Z, 0SPC0EZ, 0SPC0JC, 0SPC0JZ, 0SPC0KZ, 0SPC0LZ, 0SPC0MZ, 0SPC0NZ, 0SPD04Z, 0SPD05Z, 0SPD07Z, 0SPD08Z, 0SPD09Z, 0SPD0EZ, 0SPD0JC, 0SPD0JZ, 0SPD0KZ, 0SPD0LZ, 0SPD0MZ, 0SPD0NZ, 0SPT0JZ, 0SPU0JZ, 0SPV0JZ, 0SPW0JZ	0SWC04Z, 0SWC05Z, 0SWC07Z, 0SWC08Z, 0SWC09Z, 0SWC0JC, 0SWC0JZ, 0SWC0KZ, 0SWC34Z, 0SWC35Z, 0SWC37Z, 0SWC38Z, 0SWC3JC, 0SWC3JZ, 0SWC3KZ, 0SWC44Z, 0SWC45Z, 0SWC47Z, 0SWC48Z, 0SWC4JC, 0SWC4JZ, 0SWC4KZ, 0SWCX4Z, 0SWCX5Z, 0SWCX7Z, 0SWCX8Z, 0SWCXJC, 0SWCXJZ, 0SWCXKZ, 0SWD04Z, 0SWD05Z, 0SWD07Z, 0SWD08Z, 0SWD09Z, 0SWD0JC, 0SWD0JZ, 0SWD0KZ, 0SWD34Z, 0SWD35Z, 0SWD37Z, 0SWD38Z, 0SWD3JC, 0SWD3JZ, 0SWD3KZ, 0SWD44Z, 0SWD45Z, 0SWD47Z, 0SWD48Z, 0SWD4JC, 0SWD4JZ, 0SWD4KZ, 0SWDX4Z, 0SWDX5Z, 0SWDX7Z, 0SWDX8Z, 0SWDXJC, 0SWDXJZ, 0SWDXKZ

APPENDIX 1H: KNEE INJECTIONS

Code Type	HCPCS Codes	NDC Codes
Injection - general large joint*	20610-1	
Guidance - general*	76942, 77002	
Hyaluronic Acid	J7318, J7320-9, Q9980, C9220, C9413, C9465, Q4084-6, C9471, J3470-3, J7317, J7319	85836015153, 21695031301, 21695031303, 35356003401, 35356003403, 54868421900, 58468009001, 66267092103, 68115053503, 68258893503, 21695049301, 58468009003, 68258893506, 35356003501-2, 59676036001, 18837026502, 21695037402, 35356021901, 35356003601-2, 55566410001, 08024072412, 08024072420, 54569554300, 89122072412, 89122072420, 08363776101, 89130555501, 87541030091, 59676082001, 89130444401, 62295308702, 62295308902, 62295324903, 89122049663, 89130311101, 87541030131, 89130202001
PRP	0232T	
Stem cells	38206, 38241, M0075	
Prolotherapy	M0076	
Chondrocytes*	J7330, 27412, S2112	

Corticosteroid-general*	J0702, J1020, J1030, J1040, J1094-5, J1100, J1700, J1710, J1720, J2650, J2920, J2930, J3300-4, C9469, Q9993	3029305, 3029320, 3029328, 3049420, 9000302, 9000501, 9001103-4, 9001305-6, 9001612, 9001820, 9003928, 9003930, 9003932-3, 9004722, 9004725-7, 9011319, 9019016, 9027401, 9028002-3, 9028051-2, 9030602, 9030612, 9069801, 9075801, 9076502, 9079601, 9082501, 9090013, 9090020, 9090908, 9090916, 9091205, 9092003, 9307301, 9307303, 9307322-3, 9338901, 9347501, 9347503, 9347522-3, 69017701-2, 69017801-2, 69017901-2, 69019201-2, 69454101-2, 69454301-2, 69454501-2, 69454701-2, 85056605, 85432001, 409321705, 409321805, 409485605, 409568401, 409568423, 409568502, 409568523, 517072001, 517490125, 517490525, 517493025, 641036721, 641036725, 641614501, 641614525, 641614601, 641614625, 703003101, 703003104, 703004301, 703004501, 703005101, 703005104, 703006301, 703350104, 703351304, 703352401, 703352403, 781308475, 781308571, 781308575, 781313171, 781313195, 781313271, 781313295, 781313670, 781313775, 781324375, 781324572, 12280023201, 12280025601, 12280025605, 21695036001, 21695036010, 21695058710, 21695084830, 21695084910, 21695085005, 21695095201, 21695095205, 21695095210, 23490201501, 23490202601, 23490202605, 23490203002, 23490203005, 23490541300-1, 23490541401, 23490642201, 23490800200, 25021080705, 25021080810, 25021081030, 35356008201, 35356008301, 35356008401, 35356017805, 35356048310, 35356048405, 40042004805, 45861011701, 45861012401, 45861012501, 45861012801, 45861012901, 45861013101, 45861013201, 45861013301, 45861013401, 45861013901, 45861014101, 49836000420, 49836000519, 49836000617, 49836000721, 49836000818, 49836000920, 49836001020, 49836001117, 49836001219, 49836001321, 49836001418, 49836001520, 49836001720, 49836001817, 49836001919-20, 49836002117, 49836002219, 49836052401, 49836074001, 49836074201, 49999041505, 49999043425, 50653000601, 53217006701, 53217013201, 53225323001, 53225333501, 53225344001, 53225361001, 53225365001, 53225366001, 53225366501, 53225410501, 53225421001, 53225431501, 54569138400, 54569139800, 54569155500-1, 54569182701, 54569190101, 54569221300, 54569223200, 54569302700-1, 54569304000, 54569337400, 54569393400-1, 54569394600, 54569426500, 54569464800-2, 54569472800, 54569546500, 54569664900, 54569665000, 54643105500, 54868020600, 54868023400, 54868023500-2, 54868060500, 54868076800, 54868087100, 54868087106, 54868118500-1, 54868199400, 54868334400, 54868362300, 54868363700-1, 54868389600-2, 54868450800, 54868609900, 54868619900, 55045321203, 55045324301, 55045324305, 55045324801, 55045324803-4, 55045350901-2, 55045380301, 55150023701, 55150023805, 55150023930, 55154394005, 55154394105, 55154394205, 55154936405, 55390020910, 55390021010, 55390021801, 55390021901, 55390025801, 55390025901, 57866304602, 57866389501, 58016485501, 58016489301, 58016489701, 58016919101, 58016979901, 58016993401, 59088035100, 61219082101, 62295301602, 62295301802, 62295305706, 62295305807, 62295305907, 62295311507, 62295311701, 62295311901-2, 62295312107, 62295312207, 62295320307, 62295320407, 62295320506-7, 62295320601-2, 62295320807, 62295328407, 62295331702, 63187034801, 63187034901, 63187035001, 63187035101, 63187035201, 63323016501, 63323016505, 63323016516, 63323016526, 63323016530, 63323025503, 63323025803, 63323026530, 63323050601, 63323050616, 63323051610, 67457042000, 67457042010, 67457042100, 67457042130, 67457042200, 67457042254, 67457042300, 67457042312, 68258889805, 68258890305, 68258890605, 68258890705, 68258892502, 68258892601, 68258895605, 68258896202, 68258897201-2, 68258897205, 68258899300-1, 68258899305, 69101071001, 69101071101, 69263081001, 69263081101, 69263081201, 69263081301, 69263081801, 69263082001, 69263082101, 69263082201, 69420400101, 69420400201, 69677007102, 70121100001, 70121100005, 70121100101, 70121100105, 70121104901, 70121104905, 70121116801, 70121116901, 70801000301, 71300650501, 71300655501, 76045010610, 76420022001, 76420022201, 76420024001, 76420026001, 76420026201, 76420027001, 76420052001, 76420052401, 76420072001, 76420074001, 76420074201, 76420074301, 76420074401, 76420075001, 76420075501, 76420076001, 76420076501, 76420076601, 76420076701, 76420076901, 76420077001, 76420077501, 76420078001, 76420078201, 76420078501, 76420079501, 76420081001
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*Requires a corresponding Knee OA Dx code

APPENDIX 11: KNEE RELATED DX

Code Type	ICD-9 Codes	ICD-10 Codes
Arthritis	71106, 71196, 71626, 71636, 71666	M00061-2, M00069, M00161-2, M00169, M00261-2, M00269, M00861-2, M00869, M08861-2, M08869, M0896-2, M08969, M13161-2, M13169, M13861-2, M13869
Arthropathy	71116, 71126, 71136, 71146, 71156, 71166, 71176, 71186, 71286, 71296, 71616, 71646, 71656, 71686, 71696	M02061-2, M02069, M02161-2, M02169, M02261-2, M02269, M02861-2, M02869, M07661-2, M07669, M11861-2, M11869, M12061-2, M12069, M12561-2, M12569, M12861-2, M12869, M14861-2, M14869
Bursa and Bursitis		M7040-2, M7050-2, M71061-2, M71069, M71161-2, M71169, M71461-2, M71469, M71561-2, M71569, M71861-2, M71869
Cystic meniscus		M23000-7, M23009, M23011-2, M23019, M23021-2, M23029, M23031-2, M23039, M23041-2, M23049, M23051-2, M23059, M23061-2, M23069
Derangement of Knee	7179, 71789, 71886	M223X1-2, M223X9, M23200-7, M23209, M23211-2, M23219, M23221-2, M23229, M23231-2, M23239, M23241-2, M23249, M23251-2, M23259, M23261-2, M23269, M23300-7, M23309, M23311-2, M23319, M23321-2, M23329, M23331-2, M23339, M23341-2, M23349, M23351-2, M23359, M23361-2, M23369, M238X1-2, M238X9, M2390-2
Dislocation of Knee	71826, 71836, 71876, 8363-4, 83650-4, 83660-4, 83669	M2200-2, M24361-2, M24369, M24461-2, M24469, S83104A/D/S, S83105A/D/S, S83106A/D/S, S83114A/D/S, S83115A/D/S, S83116A/D/S, S83124A/D/S, S83125A/D/S, S83126A/D/S, S83134A/D/S, S83135A/D/S, S83136A/D/S, S83144A/D/S, S83145A/D/S, S83146A/D/S, S83194A/D/S, S83195A/D/S, S83196A/D/S
Gout		M10061-2, M10069, M10161-2, M10169, M10261-2, M10269, M10361-2, M10369, M10461-2, M10469, M1A0610-1, M1A0620-1, M1A0690-1, M1A1610-1, M1A1620-1, M1A1690-1, M1A2610-1, M1A2620-1, M1A2690-1, M1A3610-1, M1A3620-1, M1A3690-1, M1A4610-1, M1A4620-1, M1A4690-1
Knee Sprain	8440-3, 8448-9	S83401A/D/S, S83402A/D/S, S83409A/D/S, S83411A/D/S, S83412A/D/S, S83419A/D/S, S83421A/D/S, S83422A/D/S, S83429A/D/S, S83501A/D/S, S83502A/D/S, S83509A/D/S, S83511A/D/S, S83512/D/S, S83519A/D/S, S83521A/D/S, S83522A/D/S, S83529A/D/S, S8360XA/D/S, S8361XA/D/S, S8362XA/D/S, S838X1A/D/S, S838X2A/D/S, S838X9A/D/S, S8390XA/D/S, S8391XA/D/S, S8392XA/D/S
Knee Tear	8360-2	S83200A/D/S, S83201A/D/S, S83202A/D/S, S83203A/D/S, S83204A/D/S, S83205A/D/S, S83206A/D/S, S83207A/D/S, S83209A/D/S, S83211A/D/S, S83212A/D/S, S83219A/D/S, S83221A/D/S, S83222A/D/S, S83229A/D/S, S83231A/D/S, S83232A/D/S, S83239A/D/S, S83241A/D/S, S83242A/D/S, S83249A/D/S, S83251A/D/S, S83252A/D/S, S83259A/D/S, S83261A/D/S, S83262A/D/S, S83269A/D/S, S83271A/D/S, S83272A/D/S, S83279A/D/S, S83281A/D/S, S83282A/D/S, S83289A/D/S, S8330XA/D/S, S8331XA/D/S, S8332XA/D/S
Osteoarthritis	71516, 71526, 71536, 71596	M170, M1710-2, M172, M1730-2, M174-5, M179
Subluxation of Knee		M2210-2, S83101A/D/S, S83102A/D/S, S83103A/D/S, S83111A/D/S, S83112A/D/S, S83113A/D/S, S83121A/D/S, S83122A/D/S, S83123A/D/S, S83131A/D/S, S83132A/D/S, S83133A/D/S, S83141A/D/S, S83142A/D/S, S83143A/D/S, S83191A/D/S, S83192A/D/S, S83193A/D/S
Synovitis	71926	M12261-2, M12269, M67861-4, M67869, M65161-2, M65169, M67361-2, M67369, M7120-2
Other Knee Condition	71956, 73036, 71936, 73076, 73006, 73016, 73026, 7176, 71946, 71606, 71966, 71986, 71996, 73086, 73096, 72931, 71916, 72660, 72669, 71906, 71785, 7366, 71846, 71216, 71226, 71236, 71856	S80911A/D/S, S80912A/D/S, S80919A/D/S, M25661-2, M25669, M02361-2, M02369, M6750-2, M222X1-2, M222X9, M2240-2, M228X1-2, M228X9, M2290-2, M7650-2, M12361-2, M12369, M25761-2, M25769, M9240-2, M93261-2, M93269, M2340-2, M25561-2, M25569, M79661-2, M79669, M79604-6, M12161-2, M12169, M25861-2, M25869, M2350-2, M25361-2, M25369, M11061-2, M11069, M12461-2, M12469, M25061-2, M25069, M67461-2, M67469, M25262, M25269, M05061-2, M05069, M25461-2, M25469, M23601-2, M23609, M23611-2, M23619, M23621-2, M23629, M23631-2, M23639, M23641-2, M23649, M23671-2, M23679, M21061-2, M21069, M21161-2, M21169, M21261-2, M21269, S8700XA/D/S, S8701XA/D/S, S8702XA/D/S, S8000XA/D/S, S8001XA/D/S, S8002XA/D/S, M24561-2, M24569, M94261-2, M94269, M11161-2, M11169, M11261-2, M11269, M14661-2, M14669, M24661-2, M24669

APPENDIX 2: 0 – 64 POPULATION METRICS

APPENDIX 2A: KNEE OA 2017 SNAPSHOT POPULATION DEMOGRAPHICS

Age Bands ¹	Members 18 or Older (Denominator Population)	Total Knee OA Population		Cohort 1: No Knee OA Services of Interest in 2016		Cohort 2: Non-Invasive Knee OA Services of Interest in 2016		Cohort 3: Knee OA Invasive Procedures in 2016	
		N = 320,442		N = 133,371 (42% of Total Knee OA Population)		N = 62,380 (19% of Total Knee OA Population)		N = 124,691 (39% of Total Knee OA Population)	
		Prevalence by Age Band	% of Knee OA Population	Prevalence by Age Band	% of Knee OA Population	Prevalence by Age Band	% of Knee OA Population	Prevalence by Age Band	% of Knee OA Population
Population	21,731,168	1.47%	100.00%	0.61%	41.62%	0.29%	19.47%	0.57%	38.91%
Male	To 19	2,592,908	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	19 – 24	1,073,776	0.04%	0.13%	0.02%	0.06%	0.01%	0.03%	0.01%
	25 – 29	706,561	0.08%	0.19%	0.04%	0.10%	0.02%	0.04%	0.02%
	30 – 34	736,278	0.20%	0.47%	0.10%	0.24%	0.05%	0.11%	0.05%
	35 – 39	835,641	0.41%	1.06%	0.21%	0.54%	0.09%	0.23%	0.11%
	40 – 44	861,011	0.81%	2.18%	0.40%	1.07%	0.16%	0.44%	0.25%
	45 – 49	978,783	1.50%	4.58%	0.71%	2.15%	0.29%	0.87%	0.51%
	50 - 54	1,016,950	2.49%	7.90%	1.13%	3.57%	0.44%	1.41%	0.92%
	55 - 59	1,041,106	3.69%	12.00%	1.61%	5.22%	0.67%	2.17%	1.42%
	60 - 64	842,266	5.00%	13.14%	2.06%	5.41%	0.96%	2.52%	1.98%
	Total	10,685,280		41.63%		18.34%		7.83%	
Female	To 19	2,479,885	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	19 - 24	1,038,177	0.05%	0.15%	0.02%	0.07%	0.01%	0.04%	0.01%
	25 - 29	724,383	0.08%	0.18%	0.04%	0.09%	0.02%	0.05%	0.02%
	30 - 34	796,791	0.19%	0.47%	0.09%	0.22%	0.05%	0.12%	0.05%
	35 - 39	915,820	0.46%	1.32%	0.22%	0.62%	0.10%	0.28%	0.15%
	40 - 44	936,721	1.05%	3.08%	0.47%	1.39%	0.22%	0.65%	0.36%
	45 - 49	1,060,375	2.01%	6.65%	0.87%	2.87%	0.40%	1.32%	0.74%
	50 - 54	1,104,207	3.44%	11.85%	1.40%	4.83%	0.67%	2.30%	1.37%
	55 - 59	1,114,723	4.88%	16.97%	1.88%	6.54%	0.97%	3.38%	2.03%
	60 - 64	874,806	6.48%	17.69%	2.44%	6.65%	1.28%	3.50%	2.76%
	Total	11,045,888		58.37%		23.28%		11.64%	
Median Age (years)		56		56		56		57	

Notes: ¹Age Band is based on the patient's age at the end of 2017; Sourced from an analysis of IBM MarketScan[®] Commercial Claims Database and Milliman Commercial Claims Database, years 2016 through 2017

APPENDIX 2B: KNEE OA 2017 ANNUAL POPULATION COSTS AS A PORTION OF 2017 DENOMINATOR POPULATION COSTS

	Denominator population	Total Knee OA Population	Cohort 1: No Knee OA Services of Interest in 2016	Cohort 2: Non-Invasive Knee OA Services of Interest in 2016	Cohort 3: Knee OA Invasive Procedures in 2016
Number of Members	21,731,168	320,442	133,371	62,380	124,691
Prevalence	100.0%	1.47%	0.61%	0.29%	0.57%
Percent of Knee OA Population		100.0%	41.6%	19.5%	38.9%
PPPY: All Costs		\$17,591	\$14,619	\$18,284	\$20,423
PMPY: All Costs	\$5,715	\$280	\$97	\$57	\$127
PMPM: All Costs	\$476	\$23	\$8	\$5	\$11
Percent of Denominator Cost		4.9%	1.7%	1.0%	2.2%
PPPY: Knee-related Costs		\$5,465	\$3,935	\$4,993	\$7,374
Knee-related Costs as a % of All Costs		31.1%	26.9%	27.3%	36.1%
PMPY: Knee-related Costs		\$84	\$25	\$15	\$44
PMPM: Knee-related Costs		\$7.00	\$2.12	\$1.24	\$3.64
Knee-related Costs as a % of Denominator Cost		1.47%	0.45%	0.26%	0.76%

Notes: PPPY = Per Knee OA Patient Per Year; PMPY = Per Member Per Year; PMPM = Per Member Per Month; Denominator Population consists of members aged 0-64 years; Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman Commercial Claims Database, years 2016 through 2017

APPENDIX 2C: 2017 KNEE OA POPULATION: 2017 ANNUAL INCIDENCE & COST OF KNEE OA-RELATED SERVICES

Total Knee OA Population (N=320,442)								
Service Type	Percent of Patients with Service	Utilization / Patient for Patients with Service	Utilization Type	Average Allowed Cost per Service	Percent of Total Spend on Knee OA-Related Services	Average Allowed Cost PPPY	Average Allowed Cost PMPY	Average Allowed Cost PMPM
Any Knee OA Service of Interest	99.7%⁴				100.0%	\$5,465	\$84	\$7.00
Knee x-ray	70.6%	1.6	procedures	\$86	1.9%	\$103	\$2	\$0.13
Knee MRI	20.9%	1.1	procedures	\$934	4.1%	\$224	\$3	\$0.29
Physical and Occupational Knee Therapy	25.3%	10.4	sessions	\$129	6.4%	\$351	\$5	\$0.45
Orthopedist Office Visits for Knee OA	45.0%	1.6	visits	\$116	1.6%	\$87	\$1	\$0.11
PCP Office Visits (Knee OA-related)	50.9%	2.1	visits	\$137	2.7%	\$150	\$2	\$0.19
Hyaluronic Acid Injection (Knee)	15.7%	1.1	courses	\$1,340	4.5%	\$244	\$4	\$0.31
IACS Injection (Knee)	44.5%	1.4	days	\$285	3.4%	\$188	\$3	\$0.24
Unspecified Product Injection (Knee) ¹	11.1%	2.0	days	\$281	1.2%	\$66	\$1	\$0.08
Arthroscopy and Other Minor Knee Surgery	7.5%	1.1	surgeries	\$6,438	10.0%	\$547	\$8	\$0.70
Knee Arthroplasty (Total, Partial, & Revision)	8.9%	1.1	surgeries	\$32,454	62.4%	\$3,412	\$52	\$4.37
Opioid ²	8.8%	1.9	scripts	\$31	0.1%	\$5	\$0	\$0.01
Non-opioid, including NSAIDS ²	6.6%	1.5	scripts	\$26	0.0%	\$3	\$0	\$0.00
Other Knee-related Services ³	15.9%	N/A	N/A	N/A	1.6%	\$83	\$1	\$0.11

Notes: ¹Includes general injection codes that did not have a corresponding NDC or HCPCS code for injected drug type

²We are unable to identify the condition for which this medication was prescribed

³Includes CT, ultrasound, arthrography, RSA, motion analysis, diagnostic arthroscopy/arthrotomy, assistive walking devices, lower extremity orthoses, acupuncture, chiropractic, TENS, massage therapy, osteo manipulation, nonphysician practitioner (NPP) or other provider office visits, education, and supplements

⁴This number is not 100% because members can qualify as having knee OA based on other claim types coded with knee OA

PPPY = Per Patient Per Year; PMPY = Per Member Per Year; PMPM = Per Member Per Month; Denominator Population consists of members aged 0-64 years; Knee OA-related costs include professional, facility, and drug costs where indicated; Costs shown are allowed costs, which include both payment by the payer and patient cost-sharing; Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman Commercial Claims Database, years 2013 through 2017

APPENDIX 2D: KNEE OA POPULATION WITH NO KNEE OA SERVICES OF INTEREST IN 2016: 2017 ANNUAL INCIDENCE & COST OF KNEE OA-RELATED SERVICES

Cohort 1: No Knee OA Services of Interest in 2016 (N = 133,371, 42% of Knee OA Population)								
Service Type	Percent of Patients with Service	Utilization /Patient for Patients with Service	Utilization Type	Average Allowed Cost per Service	Percent of Total Spend on Knee OA-Related Services	Average Allowed Cost PPPY	Average Allowed Cost PMPY	Average Allowed Cost PMPM
Any Knee OA Service of Interest	99.9%⁴				100.0%	\$3,935	\$25	\$2.12
Knee x-ray	90.3%	1.5	procedures	\$88	3.1%	\$123	\$1	\$0.07
Knee MRI	27.6%	1.1	procedures	\$904	7.1%	\$279	\$2	\$0.15
Physical and Occupational Knee Therapy	23.2%	8.6	sessions	\$127	6.6%	\$261	\$2	\$0.14
Orthopedist Office Visits for Knee OA	51.0%	1.6	visits	\$121	2.5%	\$100	\$1	\$0.05
PCP Office Visits (Knee OA-related)	53.8%	1.9	visits	\$137	3.6%	\$143	\$1	\$0.08
Hyaluronic Acid Injection (Knee)	11.4%	1.0	courses	\$1,287	4.0%	\$157	\$1	\$0.08
IACS Injection (Knee)	49.2%	1.3	days	\$280	4.6%	\$180	\$1	\$0.10
Unspecified Product Injection (Knee) ¹	8.9%	1.8	days	\$289	1.2%	\$47	\$0	\$0.03
Arthroscopy and Other Minor Knee Surgery	8.4%	1.1	surgeries	\$6,351	15.0%	\$589	\$4	\$0.32
Knee Arthroplasty (Total, Partial, & Revision)	5.3%	1.1	surgeries	\$32,299	50.0%	\$1,969	\$13	\$1.06
Opioid ²	7.8%	1.8	scripts	\$29	0.1%	\$4	\$0	\$0.00
Non-opioid, including NSAIDS ²	6.0%	1.4	scripts	\$30	0.1%	\$3	\$0	\$0.00
Other Knee-related Services ³	16.1%	N/A	N/A	N/A	2.0%	\$74	\$0	\$0.04

Notes: ¹Includes general injection codes that did not have a corresponding NDC or HCPCS code for injected drug type

²We are unable to identify the condition for which this medication was prescribed

³Includes CT, ultrasound, arthrography, RSA, motion analysis, diagnostic arthroscopy/arthrotomy, assistive walking devices, lower extremity orthoses, acupuncture, chiropractic, TENS, massage therapy, osteo manipulation, nonphysician practitioner (NPP) or other provider office visits, education, and supplements

⁴This number is not 100% because members can qualify as having knee OA based on other claim types coded with knee OA

PPPY = Per Patient Per Year; PMPY = Per Member Per Year; PMPM = Per Member Per Month; Denominator Population consists of members aged 0-64 years; Knee OA-related costs include professional, facility, and drug costs where indicated; Costs shown are allowed costs, which include both payment by the payer and patient cost-sharing; Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman Commercial Claims Database, years 2013 through 2017

APPENDIX 2E: 2017 KNEE OA POPULATION WITH NON-INVASIVE KNEE OA SERVICES OF INTEREST IN 2016: 2017 ANNUAL INCIDENCE & COST OF KNEE OA-RELATED SERVICES

Cohort 2: Non-Invasive Knee OA Services of Interest in 2016 (N = 62,380, 39% of Prevalent Knee OA Population)								
Service Type	Percent of Patients with Service	Utilization /Patient for Patients with Service	Utilization Type	Average Allowed Cost per Service	Percent of Total Spend on Knee OA-Related Services	Average Allowed Cost PPPY	Average Allowed Cost PMPY	Average Allowed Cost PMPM
Any Knee OA Service of Interest	99.2%⁴				100.0%	\$4,993	\$15	\$1.24
Knee x-ray	53.7%	1.6	procedures	\$90	1.6%	\$82	\$0	\$0.02
Knee MRI	18.8%	1.1	procedures	\$984	4.3%	\$217	\$1	\$0.05
Physical and Occupational Knee Therapy	24.6%	10.3	sessions	\$128	6.8%	\$338	\$1	\$0.08
Orthopedist Office Visits for Knee OA	39.1%	1.6	visits	\$116	1.5%	\$77	\$0	\$0.02
PCP Office Visits (Knee OA-related)	60.4%	2.2	visits	\$134	3.8%	\$188	\$1	\$0.05
Hyaluronic Acid Injection (Knee)	9.3%	1.1	courses	\$1,387	2.9%	\$146	\$0	\$0.04
IACS Injection (Knee)	29.7%	1.3	days	\$348	2.9%	\$144	\$0	\$0.04
Unspecified Product Injection (Knee) ¹	7.5%	1.9	days	\$348	1.0%	\$51	\$0	\$0.01
Arthroscopy and Other Minor Knee Surgery	7.2%	1.1	surgeries	\$6,512	10.9%	\$542	\$2	\$0.13
Knee Arthroplasty (Total, Partial, & Revision)	7.9%	1.1	surgeries	\$33,244	62.2%	\$3,105	\$9	\$0.77
Opioid ²	9.1%	1.9	scripts	\$28	0.1%	\$5	\$0	\$0.00
Non-opioid, including NSAIDS ²	6.7%	1.5	scripts	\$23	0.1%	\$3	\$0	\$0.00
Other Knee-related Services ³	15.7%	N/A	N/A	N/A	1.9%	\$95	\$0	\$0.02

Notes: ¹Includes general injection codes that did not have a corresponding NDC or HCPCS code for injected drug type

²We are unable to identify the condition for which this medication was prescribed

³Includes CT, ultrasound, arthrography, RSA, motion analysis, diagnostic arthroscopy/arthrotomy, assistive walking devices, lower extremity orthoses, acupuncture, chiropractic, TENS, massage therapy, osteo manipulation, nonphysician practitioner (NPP) or other provider office visits, education, and supplements

⁴This number is not 100% because members can qualify as having knee OA based on other claim types coded with knee OA

PPPY = Per Patient Per Year; PMPY = Per Member Per Year; PMPM = Per Member Per Month; Denominator Population consists of members aged 0-64 years; Knee OA-related costs include professional, facility, and drug costs where indicated; Costs shown are allowed costs, which include both payment by the payer and patient cost-sharing; Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman Commercial Claims Database, years 2013 through 2017

APPENDIX 2F: 2017 KNEE OA POPULATION WITH KNEE OA INVASIVE PROCEDURES IN 2016: 2017 ANNUAL INCIDENCE & COST OF KNEE OA-RELATED SERVICES

Cohort 3: Knee OA Invasive Procedures in 2016 (N = 124,691, 19% of Knee OA Population)								
Service Type	Percent of Patients with Service	Utilization /Patient for Patients with Service	Utilization Type	Average Allowed Cost per Service	Percent of Total Spend on Knee OA-Related Services	Average Allowed Cost PPPY	Average Allowed Cost PMPY	Average Allowed Cost PMPM
Any Knee OA Service of Interest	99.8%⁴				100.0%	\$7,374	\$44	\$3.64
Knee x-ray	58.0%	1.8	procedures	\$81	1.2%	\$91	\$1	\$0.04
Knee MRI	14.7%	1.1	procedures	\$963	2.3%	\$167	\$1	\$0.08
Physical and Occupational Knee Therapy	27.9%	11.9	sessions	\$131	6.2%	\$456	\$3	\$0.23
Orthopedist Office Visits for Knee OA	41.6%	1.7	visits	\$108	1.1%	\$78	\$0	\$0.04
PCP Office Visits (Knee OA-related)	43.0%	2.2	visits	\$140	1.9%	\$138	\$1	\$0.07
Hyaluronic Acid Injection (Knee)	23.4%	1.2	courses	\$1,357	5.3%	\$389	\$2	\$0.19
IACS Injection (Knee)	46.9%	1.6	days	\$274	3.0%	\$220	\$1	\$0.11
Unspecified Product Injection (Knee) ¹	15.2%	2.2	days	\$262	1.3%	\$93	\$1	\$0.05
Arthroscopy and Other Minor Knee Surgery	6.6%	1.1	surgeries	\$6,512	6.8%	\$503	\$3	\$0.25
Knee Arthroplasty (Total, Partial, & Revision)	13.3%	1.1	surgeries	\$32,287	69.7%	\$5,142	\$30	\$2.54
Opioid ²	9.7%	1.9	scripts	\$34	0.1%	\$7	\$0	\$0.00
Non-opioid, including NSAIDS ²	7.0%	1.5	scripts	\$24	0.0%	\$3	\$0	\$0.00
Other Knee-related Services ³	15.8%	N/A	N/A	N/A	1.2%	\$87	\$1	\$0.04

Notes: ¹Includes general injection codes that did not have a corresponding NDC or HCPCS code for injected drug type

²We are unable to identify the condition for which this medication was prescribed

³Includes CT, ultrasound, arthrography, RSA, motion analysis, diagnostic arthroscopy/arthrotomy, assistive walking devices, lower extremity orthoses, acupuncture, chiropractic, TENS, massage therapy, osteo manipulation, nonphysician practitioner (NPP) or other provider office visits, education, and supplements

⁴This number is not 100% because members can qualify as having knee OA based on other claim types coded with knee OA

PPPY = Per Patient Per Year; PMPY = Per Member Per Year; PMPM = Per Member Per Month; Denominator Population consists of members aged 0-64 years; Knee OA-related costs include professional, facility, and drug costs where indicated; Costs shown are allowed costs, which include both payment by the payer and patient cost-sharing; Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman Commercial Claims Database, years 2013 through 2017

APPENDIX 2G: 2017 TOTAL KNEE OA-RELATED ALLOWED COSTS BY SERVICE CATEGORY

Service Type	Total Knee OA Population		Cohort 1: No Knee OA Services of Interest in 2016		Cohort 2: Non-Invasive Knee OA Services of Interest in 2016		Cohort 3: Knee OA Invasive Procedures in 2016	
	N = 320,442		N = 133,371 (42% of Knee OA Population)		N = 62,380 (19% of Knee OA Population)		N = 124,691 (39% of Knee OA Population)	
	PPPY = \$5,465		PPPY = \$3,935		PPPY = \$4,993		PPPY = \$7,374	
	Percent of Patients with Knee OA Service	Allowed PMPM Cost by Knee OA Service Category	Percent of Patients with Knee OA Service	Allowed PMPM Cost by Knee OA Service Category	Percent of Patients with Knee OA Service	Allowed PMPM Cost by Knee OA Service Category	Percent of Patients with Knee OA Service	Allowed PMPM Cost by Knee OA Service Category
Any Knee OA Service of Interest	99.7%⁴	\$7.00	99.9%	\$2.12	99.2%	\$1.24	99.8%	\$3.64
Knee x-ray	70.6%	\$0.13	90.3%	\$0.07	53.7%	\$0.02	58.0%	\$0.04
Knee MRI	20.9%	\$0.29	27.6%	\$0.15	18.8%	\$0.05	14.7%	\$0.08
Physical and Occupational Knee Therapy	25.3%	\$0.45	23.2%	\$0.14	24.6%	\$0.08	27.9%	\$0.23
Orthopedist Office Visits for Knee OA	45.0%	\$0.11	51.0%	\$0.05	39.1%	\$0.02	41.6%	\$0.04
PCP Office Visits (Knee OA-related)	50.9%	\$0.19	53.8%	\$0.08	60.4%	\$0.05	43.0%	\$0.07
Hyaluronic Acid Injection (Knee)	15.7%	\$0.31	11.4%	\$0.08	9.3%	\$0.04	23.4%	\$0.19
IACS Injection (Knee)	44.5%	\$0.24	49.2%	\$0.10	29.7%	\$0.04	46.9%	\$0.11
Unspecified Product Injection (Knee)	11.1%	\$0.08	8.9%	\$0.03	7.5%	\$0.01	15.2%	\$0.05
Arthroscopy and Other Minor Knee Surgery	7.5%	\$0.70	8.4%	\$0.32	7.2%	\$0.13	6.6%	\$0.25
Knee Arthroplasty (Total, Partial, & Revision)	8.9%	\$4.37	5.3%	\$1.06	7.9%	\$0.77	13.3%	\$2.54
Other Knee-related Services ¹	15.9%	\$0.11	16.1%	\$0.04	15.7%	\$0.02	15.8%	\$0.04

Notes: ¹Includes general injection codes that did not have a corresponding NDC or HCPCS code for injected drug type

²We are unable to identify the condition for which this medication was prescribed

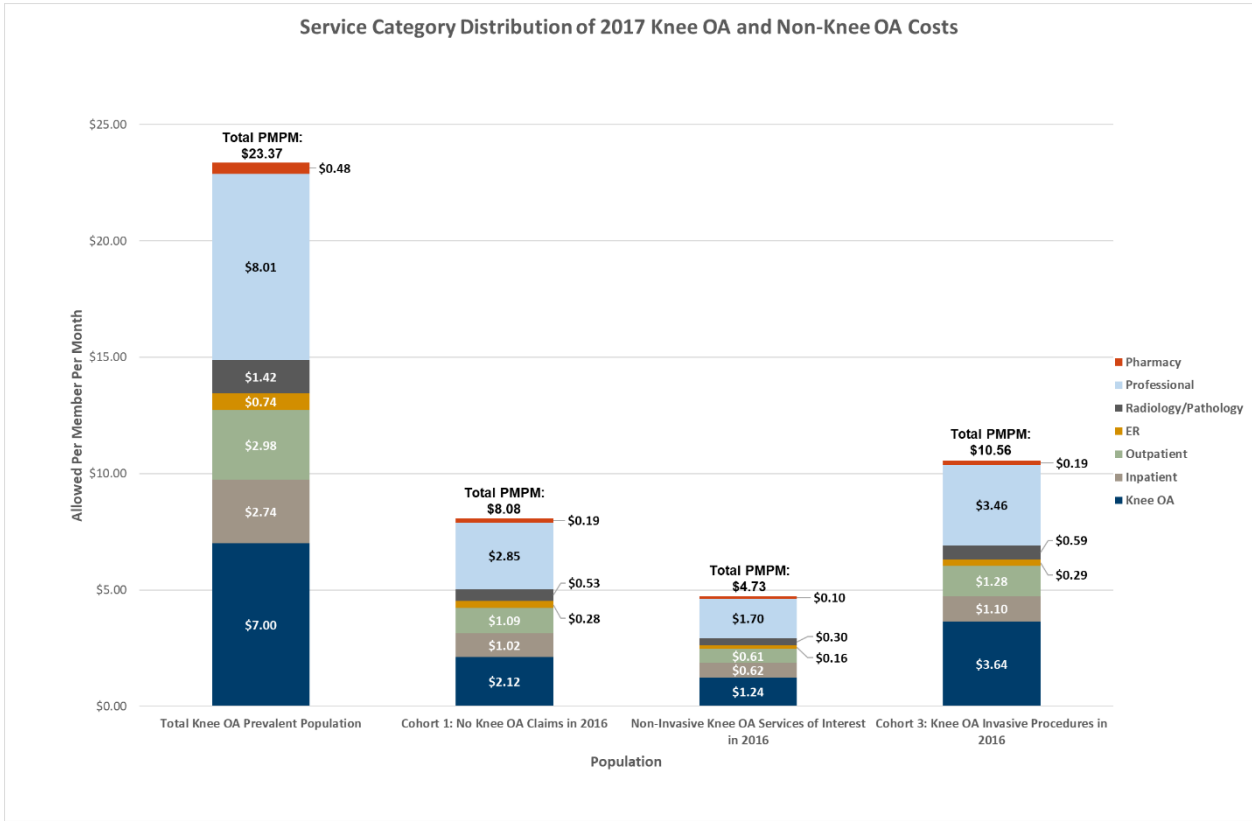
³Includes CT, ultrasound, arthrography, RSA, motion analysis, diagnostic arthroscopy/arthrotomy, assistive walking devices, lower extremity orthoses, acupuncture, chiropractic, TENS, massage therapy, osteo manipulation, nonphysician practitioner (NPP) or other provider office visits, education, and supplements

⁴This number is not 100% because members can qualify as having knee OA based on other claim types coded with knee OA

PPPY = Per Patient Per Year; PMPY = Per Member Per Year; PMPM = Per Member Per Month; Denominator Population consists of members aged 0-64 years; Knee OA-related costs include professional, facility, and drug costs where indicated; Costs shown are allowed costs, which include both payment by the payer and patient cost-sharing;

Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman Commercial Claims Database, years 2016 through 2017

APPENDIX 2H: TOTAL 2017 ALLOWED COSTS BY SERVICE CATEGORY



Notes: PMPM = Per Member Per Month; Denominator Population consists of members aged 0-64 years; Knee OA-related costs include professional, facility, and drug costs where indicated; Costs shown are allowed costs, which include both payment by the payer and patient cost-sharing. Sourced from an analysis of IBM MarketScan® Commercial Claims Database and Milliman Commercial Claims Database, years 2016 through 2017

APPENDIX 2I: POPULATION IDENTIFICATION

Population Identification Data Step		Members Meeting Criteria
1	Members having continuous enrollment throughout 2016 and at least in the month of January 2017. Members also are < 64 at the end of 2017.	21,731,168*
2	Members with at least 1 Dx claim for knee OA or at least 1 Dx claim for knee pain with a general OA Dx code in 2016-2017.	487,793
3	Members with 2 or more Dx claims for knee OA or 1 Dx claim and a diagnostic test or injection/treatment claim in 2016-2017 (Must have 1+ Dx claim or diagnostic test or injection/treatment claim in 2017).	320,442**

*Denominator Population

**Knee OA Total Population

Knee OA Prevalence Requiring at least 1 Dx claim (Step 2)	2.2%
Knee OA Prevalence Requiring 2 or more Dx claims (Step 3: Knee OA Total Prevalent Population)	1.5%

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