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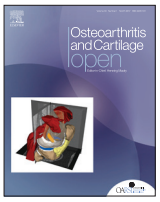

Implementing an osteoarthritis management program to deliver guideline-driven care for knee and hip osteoarthritis in a U.S. academic health system

Kathryn A. Miller [a,b,*], Linda M. Baier Manwell [a], Christie M. Bartels [c], Tommy Yue Yu [d], Divya Vundamati [e], Marley Foertsch [e], Roger L. Brown [f]

[a] Division of General Internal Medicine, Department of Medicine, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA
[b] UW Health, University of Wisconsin-Madison, Madison, WI, USA
[c] Division of Rheumatology, Department of Medicine, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA
[d] University of Wisconsin School of Medicine and Public Health, Madison, WI, USA
[e] Department of Medicine, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA
[f] Research Design and Statistics Unit, Schools of Nursing, Medicine, and Public Health, University of Wisconsin-Madison, Madison, WI, USA

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ABSTRACT

Objective: Assess implementation feasibility and outcomes for an Osteoarthritis Management Program (OAMP) at an academic center.
Design: This open study assessed an OAMP designed to deliver care in 1–5 individual or group visits across ≤12 months. Eligibility included adults with knee or hip osteoarthritis with ≥1 visit from 7/1/2017–1/15/2021. A multidisciplinary care team provided: education on osteoarthritis, self-management, exercise, weight loss; pharmacologic management; assessments of mood, sleep, quality of life, and diet. Clinic utilization and growth are reported through 2022. Patient outcomes of body mass index (BMI), pain, and function were analyzed using multivariable general linear models. OAMP outcomes were feasibility and sustainability.
Results: Most patients were locally referred by primary care. 953 patients attended 2531 visits (average visits 2.16, treatment duration 187.9 days). Most were female (72.6%), older (62.1), white (91.1%), and had medical insurance (95.4%). Obesity was prevalent (84.7% BMI ≥30, average BMI 40.9), mean Charlson Comorbidity Index was 1.89, and functional testing was below average. Longitudinal modeling revealed statistically but not clinically significant pain reduction (4.4–3.9 on 0–10 scale, $p = 0.002$). BMI did not significantly change ($p = 0.87$). Higher baseline pain and BMI correlated with greater reductions in each posttreatment. Uninsured patients had shorter treatment duration. Increasing clinic hours (4–24 h weekly) and serving 953 patients over four years demonstrated OAMP sustainability.
Conclusions: OAMP implementation was feasible and sustainable. Patients with high baseline pain and BMI were more likely to improve. Noninsurance was a barrier. These results contribute to understanding OAMP outcomes in U.S. healthcare.

1. Introduction

1.1. Study background

Amid growing osteoarthritis (OA) prevalence due to aging populations and rising rates of obesity [1], international guidelines recommend evidence-based, patient-centered OA care [2–7]. They advise that all patients receive OA education, support for self-management, exercise advice, and weight management recommendations prior to pharmacological or surgical interventions. However, in traditional OA management, most patients do not receive recommended treatments [8–10]. In 2015, we performed a medical record review (n =

* Corresponding author. Division of General Internal Medicine, Department of Medicine, University of Wisconsin School of Madison and Public Health, 2828 Marshall Court, Suite 100, Madison, WI 53705, USA. Tel.: +1 608 2631631.
E-mail addresses: kmiller5@uwhealth.org (K.A. Miller), lbaier@wisc.edu (L.M. Baier Manwell), cb4@medicine.wisc.edu (C.M. Bartels), yu68@wisc.edu (T.Y. Yu), DVundamati@uwhealth.org (D. Vundamati), MFoertsch@uwhealth.org (M. Foertsch), roger.brown@wisc.edu (R.L. Brown).

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40) of hip and knee OA care in our US academic healthcare system [11]. Only one-third of patients received guideline-based care. Our findings are comparable to other studies which report that less than half of patients receive guideline-congruent care [8–10].

Given continued gaps in care despite evidence-based guidelines, dedicated Osteoarthritis Management Programs (OAMPs) have been implemented internationally to address these gaps. OAMPs are defined by four fundamental components: tailored to the needs of the patient; package of care with ongoing assessments and progression; two or more core non-surgical/pharmacological OA treatments (i.e., education, exercise, weight loss); and optional evidence-based adjunctive treatments as necessary [12]. OAMPs have been implemented globally, and early results indicate reductions in patient pain, improved function, reduced body weight, and delay to total joint replacement [13–22].

OAMPs vary in context and structure based on local environments, allowing them to address needs of their populations. They have been implemented in a variety of settings, serve different patient populations, vary in the type of intervention as well as dose and intensity, and employ different types of clinicians to provide care [23]. Due to these differences, assessing the scalability, feasibility, and overall value of the OAMP model is challenging. Additional information regarding the structure, model of care, patient population, acceptability, and implementation of OAMPs will help us understand if they improve care.

Our objective was to develop and implement a guideline-driven OAMP to address gaps in care at our academic center and to assess the effect on care. This report describes implementation outcomes and patient baseline characteristics over the first five years, and care outcomes from the first three-and-a-half years of OAMP operations.

2. Methods

2.1. Study design and setting

This pragmatic cohort study assesses outcomes from an OAMP implemented at a large university medical center in an urban area in southcentral Wisconsin. Wisconsin, located in the upper midwestern United States, has a population of nearly six million people. Most are white (86.6%), 30% live in rural areas (90% of land is rural), and 18.7% are over age 65. Nearly all (93.1%) have a high school education, 10.7% live in poverty, and 95.4% have medical insurance. Our health system provides primary care for the surrounding geographic region and tertiary care for the State. All study research procedures were approved by the university's Health Sciences Institutional Review Board.

Our OAMP was structured to fit within the clinical structure of the health system and to address the needs of patients with a higher body mass index (BMI) who were not receiving guideline-based OA care in other service lines of the system. The OAMP was designed in 2016 by a multidisciplinary group of stakeholders including patients, clinicians, and administrative leadership during a series of eight meetings. A medical record review of 40 patients with OA, and interviews with a subset of these patients and their providers, were conducted to understand the current state of care [11,24]. Knee and hip OA were chosen as OAMP focus areas due to high prevalence. The intervention was based on Osteoarthritis Research International (OARSI) osteoarthritis care guidelines [2] and OAMP priorities [12] and focused on: decreasing gaps between guideline-recommended and received care, improving knee/hip-specific outcomes, and reducing the negative impact of OA-associated conditions.

The OAMP opened in July 2017 (Fig. 1). The intended dose and intensity of care intervention was 1–5 visits over 12 months. Up to five visits was presumed adequate to provide patient-centered care offered by the OAMP: OA management optimization, patient self-management tools, and discharge plans to help primary care providers resume care. This limit also ensured visit capacity for new patient access.

At each visit, patients were seen by a team comprised of a General Internal Medicine Physician (MD), a physical therapist (PT), and a registered dietitian (RD). Each visit started with the MD who provided: 1) assessments of patient symptoms including pain and function, pharmacologic/non-pharmacologic treatments, health history; 2) review of available radiographs; 3) patient education on basic OA self-management strategies including pain monitoring and role/importance of physical activity and weight management; 4) medication recommendations for pain control and weight management, when appropriate; 5) joint injections, if indicated; and 6) coordinated and optimized care for relevant comorbid conditions. The PT provided: 1) functional testing; 2) additional education on using physical activity to manage OA; 3) individualized exercise programs; and 4) recommendations for assistive devices, when appropriate. The RD provided information on ways to improve daily nutrition and, if weight loss was indicated, assistance with a structured diet program chosen by the patient.

All team members received education on OARSI's osteoarthritis guidelines [2] and motivational interviewing, as well as specific OA training according to their discipline. Education, delivered via didactic teaching and case-based discussions, was repeated annually for everyone. Patient care was individualized, goal-oriented, and followed evidence-based and guideline-driven care algorithms commonly used as Osteoarthritis Quality Indicators [9,10]. Templates for Clinic Notes and After-Visit Summary/Patient Instructions ensured standardization. Particular attention was paid to the biopsychosocial model of pain and included assessments of sleep, mood, disordered eating patterns, and quality of life. Pharmacologic management was based on shared decision-making between patient and provider.

Patients could choose a traditional face-to-face clinic visit or group visits. For traditional visits, patients met one-on-one with the MD, RD, and PT sequentially; total time of 1.5–2.0 h for their initial visit and 1.0–1.5 h for a follow-up visit. Care team members walked patients to the next clinician and provided a synopsis so patients did not have to repeat information. This also facilitated information sharing, resulting in more comprehensive care plans.

Group visits, led by care team members, were held in a community room at the OAMP site. Each group visit cohort of up to 12 patients met for six 90-min appointments, two weeks apart. A 30-min optional exercise session followed each appointment; these sessions were adapted to meet individual physical function. Group visits, which provided an opportunity to obtain support for more intensive lifestyle changes and OA management, were created several years after OAMP opening when it became apparent that some patients would benefit from peer support. Group visits also increased OAMP visit capacity. Telemedicine became a third care option in May of 2020 during the COVID-19 pandemic, first as telephone visits and then as video visits.

2.1.1. Participants

Study participants included adult patients with hip or knee OA who attended at least one OAMP visit between July 1, 2017, and January 15, 2021. Patients referred for an orthopedic consult to our institution for knee/hip OA were offered a visit at either the OAMP or the traditional orthopedic clinic. Patients with a BMI >40 or who preferred to avoid surgery were encouraged to schedule in the OAMP.

2.1.2. Study variables and measures

Study outcomes involved both OAMP implementation and patient results. Implementation outcomes focused on the feasibility of starting and sustaining an OAMP: patient referral sources; patient referral area; adherence to the OAMP model for the intended number of visits and treatment duration; patient utilization vs. non-attendance rates for in-person, group, and telemedicine visits; and OAMP growth over time.

Patient outcomes were confined to metrics available within the electronic health record (EHR). Services were billed through patient insurance. Outcomes included changes in BMI, pain, and function over time. Measures included patient weight, height, Charlson Comorbidity Index (CCI) [25], Visual Analog Pain Scale (VAS) of 0–10 [26], Hip Disability and Osteoarthritis Outcome Score (HOOS) [27], Knee

Disability and Osteoarthritis Outcome Score (KOOS) [28], and Veterans Rand 12-Item Health Survey (VR-12) [29,30]. The self-administered HOOS and KOOS questionnaires assess short- and long-term symptoms and function related to hip or knee injury and OA. Each contains five separately-scored subscales: Pain, other Symptoms, Function in daily living (ADL), Function in Sport and Recreation (Sport/Rec), and hip or knee-related Quality of Life (QOL). The VR-12 is a self-administered instrument from which physical and mental health component summary scores are derived. The 12 items query general health, physical functioning, role limitations resulting from physical or mental health problems, pain, energy, mental health, and social functioning.

The HOOS, KOOS, and VR-12 were chosen because they were available to administer to patients using the institution's EHR. Physical function was measured using the Timed Up & Go (TUG) [31] and the 30-Second Chair Stand [32]. These tests are recommended by OARSI to evaluate function [33]. All measures, except CCI, were repeated at every visit.

2.1.3. Data sources

The variables were collected as part of OAMP clinical care and no separate research data was collected. Some variables were included in visit notes and had to be manually extracted from the medical record: TUG and chair stand results, employment status (working/retired/disabled/unemployed), use of assistive devices (yes/no), sleep interruption by joint pain (yes/no), how mood is impacted by joint pain (open-ended question), and current life stressors (open-ended question). The medical record review was performed by a trained medical student using a standard data extraction form. A study physician independently reviewed 10% of the records to confirm accuracy. Remaining study data was queried from discrete fields in the EHR and directly exported into the study database: patient age, sex, race, ethnicity, primary spoken language, weight, height, BMI, CCI, co-morbid conditions, medical insurance type, presenting OA diagnosis, VAS pain scores, HOOS scores, KOOS scores, and VR-12 scores. Patients could complete the HOOS, KOOS, and VR-12 prior to each visit through the EHR Patient Portal. Those who did not complete these prior to the visit were given a tablet computer to complete them at the visit.

Data regarding OAMP implementation was exported directly from the EHR: referral source and referral location for each patient; number of visits attended by each patient; treatment duration; and types of visits (in-person/group/telemedicine). OAMP utilization data was obtained from the health system's electronic utilization dashboards: number of patient visits, visit non-attendance rates, and lag time for new patient appointments (time from request for initial appointment to time first visit was completed). Utilization data was collected for July 1, 2017, through

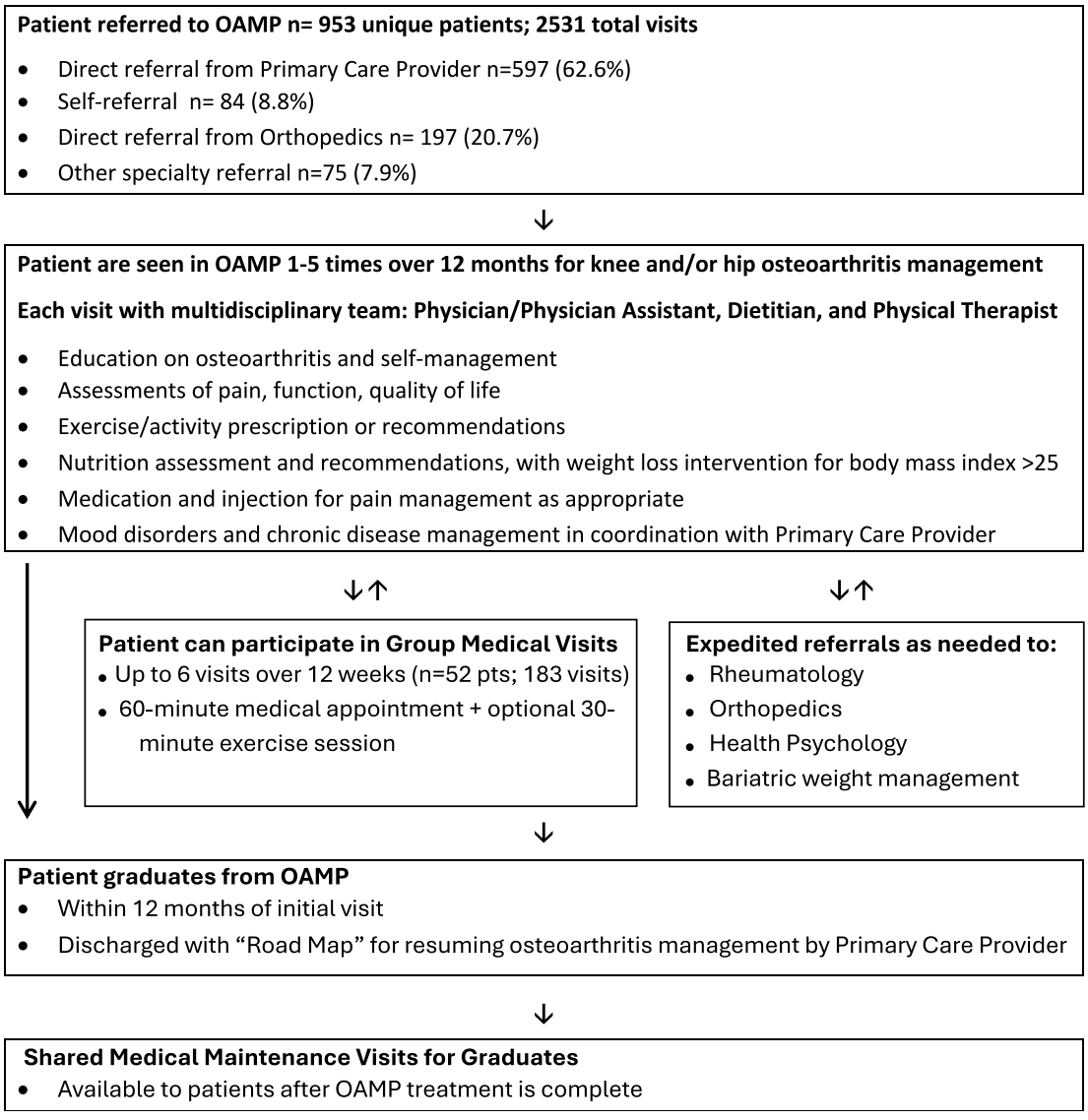

Fig. 1. Osteoarthritis Management Program (OAMP) components and target sample completion.

December 31, 2022.

2.1.4. Statistical methods

Descriptive statistics on patient characteristics were analyzed using Stata (Version 18.0). Continuous variables are reported using means and standard deviations; categorical or binary data are reported using frequencies and percentages. Kaplan-Meier curves and logrank tests [34] were used to assess the proportion of each patient's involvement with the treatment program by the patient's characteristics (e.g., sex, level of pain, insurance status, CCI). The analyses account for patients who completed treatment as well as patients who were withdrawn due to lack of follow up. This method provides an analysis of differential time to treatment completion. Additionally, a general linear mixed model for longitudinal panel analysis was conducted over a 12-month period of treatment. Modeled variables included VR-12 mental health and physical health component scores and KOOS and HOOS Activities of Daily Living subscale scores. For this study, we only analyzed and reported the HOOS and KOOS ADL subscale information because it had the least amount of missing data and it seemed to be the most relevant information reported by this patient population. Due to the large amounts of missing data for self-administered measures (HOOS, KOOS, VR-12), imputation was not considered. Our longitudinal panel models were marginal general linear mixed models for repeated measurements, so all available data was used.

Finally, improvements in pain and BMI were assessed using logistic regression modeling of the binary outcomes of any improvement versus non-improvement over the total treatment period. No study size pre-analysis or calculations were done as this was a pragmatic cohort study.

3. Results

3.1. Program utilization

Availability of the new OAMP was announced at regular department meetings for the institution's primary care physicians and orthopedic surgeons. No additional outreach was necessary due to an immediate influx of referrals. At OAMP opening in July 2017, appointments were available 4 h per week. The care team was comprised of one physician, one registered dietitian, one physical therapist, and one behavioral health clinician (Table 1 reports clinical full-time equivalency for each.). As referrals increased, new patient visit lag time increased from 20.5 days in 2017 to 89.5 days by 2019. Staff and hours were added over the next several years to expand capacity. Care is currently offered 24 h per week by a team comprised of a clinical full-time equivalent (cFTE) of 0.2 physician, 0.4 physician assistant, 0.6 registered dietitian, 0.6 physical therapist, and 0.2 behavioral health clinician. The number of patient visits increased annually, except in 2020 amid the COVID-19 pandemic. During the height of the pandemic, care was delivered via telemedicine. Volume of telemedicine visits was low at this time and has remained so.

The percent of scheduled appointments that patients did not attend ("no-show rate") was 8% of all appointments from 2017 through the end of 2022 (Table 1). This was higher than the average rate for the health system overall (5.6%) and for the orthopedics clinics specifically (3.8%). OAMP no-show rates were higher for in-person appointments compared to telemedicine visits. No-show rates decreased over time: 2018 (10.2%) and 2019 (12.1%) versus 2020 (6%) and 2021 (7.7%).

Over half of patients (62.6%) were referred to the OAMP from primary care (Fig. 1). Another 20.7% were referred by orthopedic surgeons. Most referring providers (73%) were from the same health system in the same geographic area as the OAMP (Table 2). However, one-quarter of patients were referred by providers outside the health system, including patients who traveled from neighboring U.S. states for care.

3.2. Patient utilization

Patients attended a mean of 2.6 ± 2.2 OAMP visits (Table 2). Many (40.7%) attended only one visit, while 5.8% made more than six. This exceeded the five-visit maximum presumed adequate to acquire knowledge/self-management strategies that would allow a return to primary care physicians for OA care. In real life, these patients desired and were allowed additional visits which aligned with the OAMP's patient-centered approach. Duration of treatment from first to final visit for patients who attended at least two OAMP visits was 187.9 ± 198.7 days. Duration was shorter for patients who lacked medical insurance or had a CCI score of ≥4 (Fig. 2).

Four cohorts of patients attended group medical visits. Each cohort was scheduled for six visits over three months. Fifty-two patients participated, resulting in a total of 183 visits or an average 3.5 visits each. 100% of patients who attended a group visit attended the optional exercise session.

3.3. Patient characteristics at initial visit

OAMP patients (Table 3) were predominantly female (72.6%), older in age (62.1 ± 10.8), white (91.1%), and English-speaking (98.5%). Half (48.5%) were employed, 31.6% were retired, and 7.3% were disabled and unable to work. Most (95.4%) had health insurance, primarily Medicare (51.2%) or commercial insurance (38.8%). A mean CCI score of 1.9 ± 0.7 indicated a moderate risk of mortality or higher resource use. Most common presenting OA diagnoses involved the knee (42.6% bilateral, 30.8% unilateral). Hip OA was less common (17% unilateral, 5.3% bilateral). Most patients (77.3%) were obese; mean BMI was 40.9 ± 10.

Average baseline pain was moderate at 4.4 ± 2.8 on the VAS and half of patients used an assistive device. OA affected sleep and job performance and over one-third reported falling. General health scores were low with a mean VR-12 physical score of 29.1 ± 9.0 and a mean mental health score slightly below the population average at 48.1 ± 12.9. The mean VR-12 score in an adult population is 50 ± 10. on a 0–100 scale, worst to best [35]. Activities of daily living (ADLs) were impacted by osteoarthritis. Patients with hip OA scored a mean of 48.1 ± 23.7 on the HOOS ADL subscale and patients with knee OA scored a mean of 52.1 ± 19.3 on the KOOS ADL subscale (scales 1–100, >60 is better

Table 1
Osteoarthritis management patient utilization.

	Visits				Did not attend visit ("no-show")				Access	Clinical Full-time Equivalent (cFTE)				
	Total Visits	In-person	Phone visits	Video visits	Total Visits	In-person	Phone Visits	Video Visits	Days to New Patient Visit	MD	PA	PT	RD	BH
2017[a]	111	111	0	0	N/A	N/A	N/A	N/A	N/A	0.1	0	0.1	0.1	0.1
2018	658	658	0	0	75 (10.23%)	10.23%	0	0	63	0.2	0.2	0.4	0.4	NA
2019	863	863	0	0	119 (12.12%)	12.12%	0	0	89.5	0.2	0.2	0.4	0.4	NA
2020[b]	730	436	138	156	64 (8.06%)	11.60%	3.50%	1.30%	11.5	0.2	0.4	0.6	0.6	NA
2021	1829	1498	83	248	153 (7.72%)	8.60%	1.20%	4.20%	32	0.2	0.4	0.6	0.6	0.2
2022	1969	1790	62	117	125 (6%)	6.10%	0	7.10%	39	0.2	0.4	0.6	0.6	0.2

[a] Clinic opened July 1, 2017.

[b] Covid 19 Pandemic with clinic closures from 3/9/20–5/31/20 and limited in-person visit capacity; Abbreviations: MD = Physician; PA = Physician Assistant; PT = Physical Therapist; RD = Registered Dietician, BH = Behavioral Health Clinician.

Table 2
Osteoarthritis Management Program Utilization (n = 953 unique patients; n = 2531 visits).

Referral Location, n (%)	
From within Health System, County-wide (Local)	705 (73%)
From within Health System, other Wisconsin counties	8 (0.8%)
Outside Health System, County-wide (Local)	100 (10.5%)
Outside Health System, other Wisconsin counties/northern Illinois	140 (14.7%)
Visits (n = 2531)	
Visits per participant, mean (SD)	2.60 (2.2)
1 visit	388 (40.7%)
2–3 visits	339 (35.6%)
4–6 visits	171 (17.9%)
>6 visits	55 (5.8%)
Treatment Duration (days)	
Patients with >1 visit (n = 566), mean (SD)	187.95 (198.7)
Group Visits	
Number of unique patients	52 (5.5%)
Number of group patient visits	183 (7.2% of total clinic visits)
Mean visits per group participant	3.5

performance). Functional testing revealed lower than expected normal values for a population of this age. Mean TUG time was 12.3 ± 7.5 s (≥12 = greater fall risk); mean chair stand time was 11.5 ± 4.8 reps (below average scores are normalized for age/sex and signify a risk for falling).

3.4. Patient outcomes

Outcomes included changes in pain, BMI, functional testing (TUG, chair stand), KOOS/HOOS ADL subscales, and VR-12 subscales over time (Fig. 3). For patients with at least two recorded pain scores over their treatment period (n = 486), half (240, 49.4%) reported decreased pain. Pain changed significantly from 4.4 ± 2.8 to 3.9 ± 2.8 on the VAS (t = 3.00, p = 0.002) over the entire treatment period, and 4.2 ± 2.7 to 4.1 ± 2.8 (t = 0.28, p = 0.77) after one year. Neither patient sex (p = 0.46) nor OA location (p = 0.78) predicted improvement. Logistic regression modeling revealed that higher baseline pain predicted a decrease in pain over the total treatment period. Patients with moderate baseline pain (VAS 4–6) had an adjusted odds ratio (AOR) of 2.72 (95% CI 1.65–4.46, p = 0.00) compared to patients with mild pain (VAS 1–3). Patients with severe baseline pain (VAS 7+) showed the largest reductions (AOR 5.13, 95% CI 2.92–8.97, p = 0.00) compared to those with mild pain. Overall number of OAMP visits did not predict pain reduction; the odds ratio for patients with ≥4 visits compared to those with 2–3 visits was 0.69 ± 0.16 (95 % CI 0.44–1.07, p = 0.104).

Most patients with at least two recorded BMI values (n = 343) experienced decreased BMI (n = 285, 83%). This reduction did not reach statistical significance: mean of 41.3 ± 9.6 to 40.5 ± 9.7 (t = 1.28, p = 0.280) over the entire treatment period, and 42.4 ± 9.1 to 40.9 ± 9.1 (t = 1.47, p = 0.14) after one year. Decreased BMI was not predicted by sex (p = −0.87) or OA location (p = 0.61). Logistic regression modeling revealed that patients with higher BMI baseline levels were significantly more likely to lose weight than those with lower levels: BMI of 40–49.9 (AOR 4.183, 95% CI 1.59–11.02, p = 0.004) and BMI of 50+ (AOR 3.642, 95% CI 1.276–10.39, p = 0.016) compared to those with BMI of <25. Reduction in BMI over the treatment period did not predict pain reduction (Table 4).

Osteoarthritis location did predict BMI reduction (Fig. 4). Patients with hip OA and higher baseline BMI had increased odds of BMI

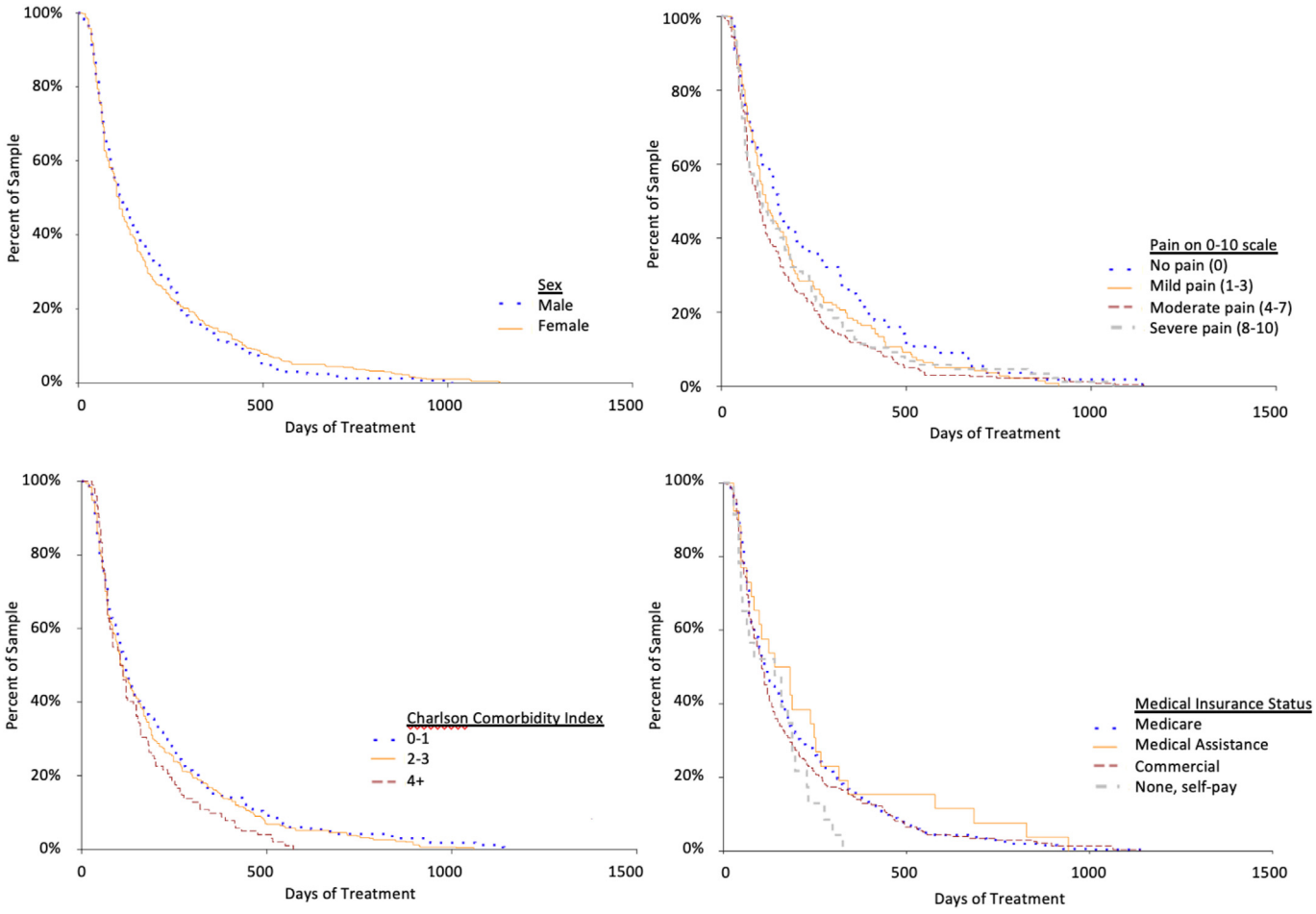

Fig. 2. Duration of OAMP treatment by patient characteristics.

Table 3
Patient characteristics at initial clinic visit.

Baseline Characteristic	Total n = 953	Female n = 692 (72.6%)	Male n = 261 (27.4%)	Test Statistics False Discovery Rate p-value
Age in years, mean (SD)	62.1 (10.8)	61.9 (10.8)	62.5 (10.5)	t = 0.68 p = 0.617
18-49	103 (10.8)	82 (11.8)	21 (8.0)	$\chi2 = 5.75$ (4) p = 0.421
50-59	270 (28.3)	190 (27.4)	80 (30.6)	
60-69	342 (35.9)	255 (36.8)	87 (33.3)	
70-79	199 (20.9)	136 (19.6)	63 (24.1)	
≥80	39 (4.1)	29 (4.2)	10 (3.8)	
Race, n (%)				
White	868 (91.1)	628 (90.7)	240 (91.9)	$\chi2 = 1.27$ (3) p = 0.773
Black	65 (6.8)	48 (6.9)	17 (6.5)	
Other	11 (1.2)	8 (1.1)	3 (0.3)	
Patient declined	9 (0.9)	8 (1.1)	1 (0.1)	
Ethnicity				
Hispanic/Latino	18 (1.9)	17 (2.4)	1 (0.3)	$\chi2 = 5.39$ (2) p = 0.178
Not Hispanic/Latino	931 (97.7)	673 (97.5)	258 (99.2)	
Patient declined	4 (0.4)	2 (0.3)	2 (0.8)	
Language, n (%)				
English	939 (98.5)	681 (98.4)	258 (98.8)	$\chi2 = 1.21$ (2) p = 0.621
Non-English	12 (1.3)	10 (1.4)	2 (0.77)	
Missing data	2 (0.2)	1 (0.1)	1 (0.4)	
Employment, n (%)				
Working	462 (48.5)	320 (46.2)	142 (54.4)	$\chi2 = 11.9$ (4) p = 0.115
Retired	301 (31.6)	218 (31.5)	83 (31.8)	
Disabled	70 (7.3)	53 (7.6)	17 (6.5)	
Unemployed	39 (4.1)	35 (5.05)	4 (1.5)	
Not recorded	81 (8.5)	66 (9.5)	15 (5.7)	
Insurance, n (%)				
Medicare	488 (51.2)	361 (52.2)	127 (48.6)	$\chi2 = 2.26$ (3) p = 0.617
Medicaid	51 (5.4)	39 (5.6)	12 (4.6)	
Commercial	370 (38.8)	263 (38.0)	107 (41.0)	
Self-pay	44 (4.6)	29 (4.2)	15 (5.7)	
Charlson Comorbidity Index, mean (SD)	1.89 (0.66)	1.88 (0.66)	1.92 (0.65)	t = 0.866 p = 0.568
Osteoarthritis Diagnosis, n (%)				
Unilateral Knee OA	293 (30.8)	224 (32.3)	69 (26.4)	$\chi2 = 15.7$ (5) p = 0.115
Bilateral Knee OA	406 (42.6)	302 (43.6)	104 (39.8)	
Unilateral Hip OA	162 (17.0)	103 (14.8)	59 (22.6)	
Bilateral Hip OA	51 (5.3)	33 (4.7)	18 (6.9)	
Knee + Hip OA	26 (2.7)	22 (3.2)	4 (1.5)	
Non-Knee or Hip OA	15 (1.6)	8 (1.1)	7 (2.6)	
Body Mass Index, mean (SD)	40.9 (10.0)	41.0 (9.9)	40.8 (10.3)	t = 0.274 p = 0.820
<19	3 (0.31)	1 (0.14)	2 (0.8)	$\chi2 = 76.07$ (6) p = 0.568
19–24.9	52 (5.4)	35 (5.1)	17 (6.5)	
25–29.9	73 (7.6)	52 (7.5)	21 (8.0)	
30–34.9	114 (11.9)	78 (11.3)	36 (13.8)	
35–39.9	142 (14.9)	108 (15.6)	34 (13.0)	
40–49.9	318 (33.4)	219 (31.6)	99 (37.9)	
50+	163 (17.1)	121 (17.5)	42 (16.1)	
Not recorded	88 (9.2)	78 (11.3)	10 (3.8)	
Use of Assistive Devices				
Yes	448 (50.3)	340 (52.9)	108 (43.7)	$\chi2 = 6.08$ (1) p = 0.115
No	441 (49.6)	302 (47.0)	139 (56.2)	
OA impacts sleep				
Yes	599 (68.4)	443 (70.5)	156 (63.1)	$\chi2 = 4.47$ (1) p = 0.130
No	276 (31.5)	185 (29.4)	91 (36.8)	
OA impacts job				
Yes	383 (82.9)	262 (81.8)	121 (85.2)	$\chi2 = 0.77$ (1) p = 0.568
No	79 (17.1)	58 (18.1)	21 (14.7)	
Falls				
Yes	316 (36.4)	222 (35.6)	94 (38.6)	$\chi2 = 0.70$ (1) p = 0.568
No	550 (63.5)	401 (64.3)	149 (61.3)	
Self-Report Health Questionnaires, n (%)				
Mean Pain (Visual Analog Scale 0–10), mean (SD)	4.44 (2.8)	4.52 (2.79)	4.23 (2.80)	t = −1.30 p = 0.355
Pain ratings by severity category, n (%)				
None = 0	101 (10.6)	71 (10.3)	30 (11.5)	$\chi2 = 3.06$ (3) p = 0.568
Mild = 1-3	250 (26.2)	170 (24.5)	80 (30.6)	
Moderate = 4-6	290 (30.4)	214 (30.9)	76 (29.1)	
Severe = 7-10	239 (25.1)	177 (25.5)	62 (23.7)	
Not recorded, n = 880/953 (0.08%)				
Veterans Rand 12 Item Health Survey (VR-12), mean (SD)				

(*continued on next page*)

Table 3 (*continued*)

Baseline Characteristic	Total n = 953	Female n = 692 (72.6%)	Male n = 261 (27.4%)	Test Statistics False Discovery Rate p-value
Physical health summary measure, n = 624/953 (65.4%)	29.14 (9.04)	28.61 (8.97)	30.41 (9.09)	z = 2.37 p = 0.115
Not recorded, n = 329/953 (34.5%)				
Mental health summary measure, n = 620/953 (65.0%)	48.14 (12.91)	47.61 (13.31)	49.42 (11.84)	z = 1.35 p = 0.355
Not recorded, n = 333/953 (34.9%)				
Hip Disability and Osteoarthritis Outcome Score (HOOS), mean (SD)				
Activities of Daily Living assessment, n = 239/953 (25.1%)	48.1 (23.7)	44.72 (24.0)	53.3 (22.4)	z = 1.99 p = 0.135
Not recorded, n = 714/953 (74.9%)				
Knee Disability and Osteoarthritis Outcome Score (KOOS), mean (SD)				
Activities of Daily Living assessment, n = 725/953 (75.8%)	52.14 (19.3)	52.37 (19.44)	51.33 (18.94)	z = −0.32 p = 0.74
Not recorded, n = 228/953 (23.9%)				
Functional Tests				
Timed Up & Go (TUG), mean (SD)				
Seconds to rise, walk 10 feet, return, and sit n = 495/953 (51.9%)	12.25 (7.54)	13.54 (9.22)	12.08 (5.54)	z = −2.11 p = 0.130
Not recorded, n = 458/953 (48.1%)				
30-Second Chair Stand, mean (SD)				
Rise and sit repetitions n = 495/953 (51.9%)	11.49 (4.78)	11.34 (4.62)	11.88 (5.16)	z = 1.97 p = 0.135
Not recorded, 458/953 (48.1%)				

reduction during the first year of treatment. For example, a patient with a BMI of 56 had an approximately 90% probability of reduction. Patients with knee osteoarthritis and a higher baseline BMI also trended toward BMI reduction, however this finding did not reach statistical significance.

For patients with at least two recorded KOOS ADL subscale scores (n = 143), 63% improved (n = 90, 62.9%). For patients with at least two HOOS ADL subscale scores (n = 58), 60% improved (n = 36, 60%). Neither baseline BMI nor sex predicted improvements in KOOS or HOOS scores. When comparing face-to-face and group visit data, no differences were found for any measures including pain, BMI, TUG, chair stand,

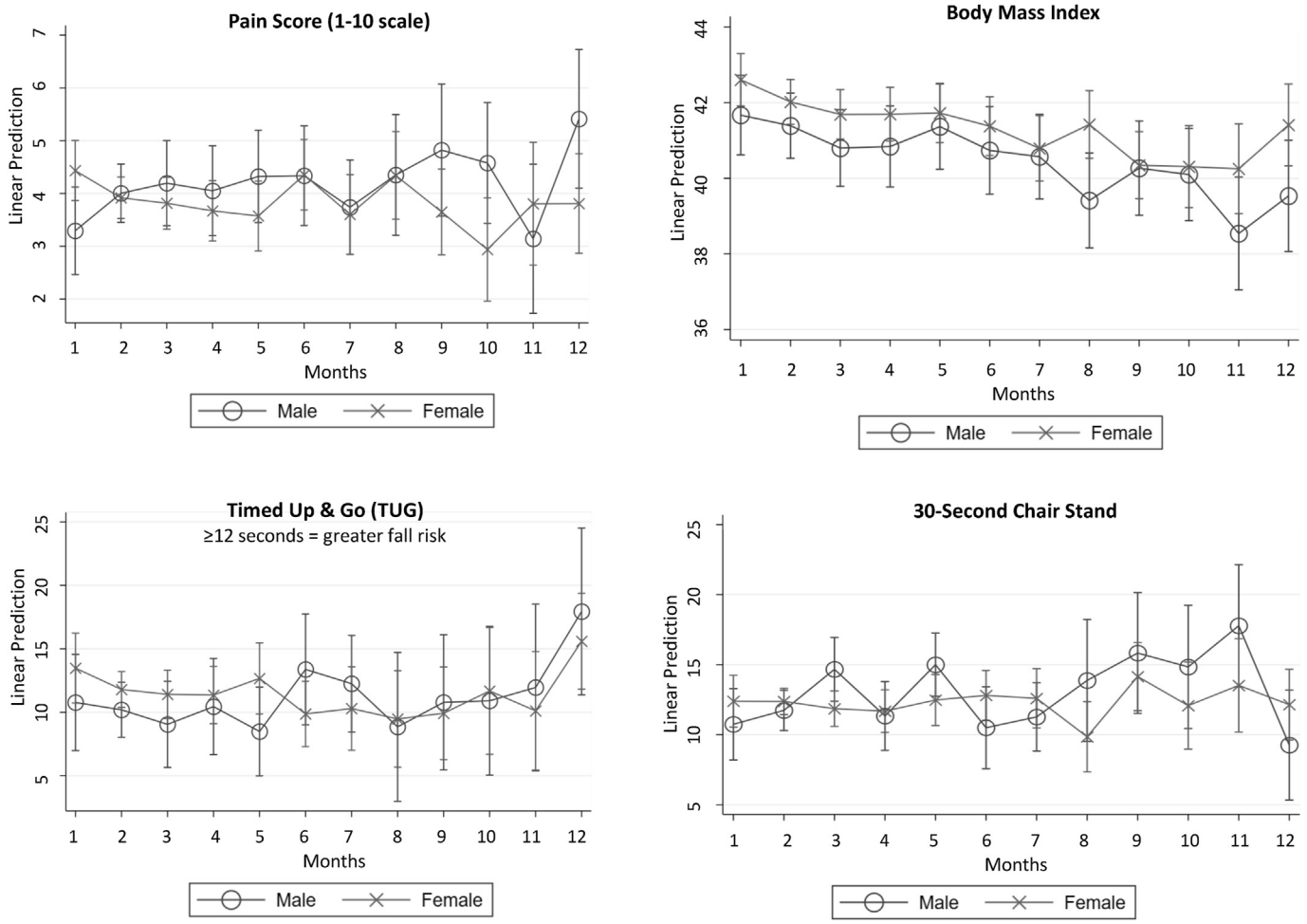

Fig. 3. Change in patient outcomes over the first 12 months of treatment.

Table 4
Predictors of improvement in pain and body mass index over one year by osteoarthritis location.

Knee Osteoarthritis						
Odds of improvement in pain over one year	Odds ratio	Standard error	z	P>|z|	95% confidence interval	
Body Mass Index	0.939	0.018	−3.08	0.002	0.903	0.977
Charlson Comorbidity Index						
2-3	3.12	1.64	2.17	0.030	1.11	8.77
4+	1.41	1.08	0.45	0.654	0.31	6.36
Pain	1.58	0.132	5.48	0.000	1.34	1.86
Age	1.01	0.029	0.40	0.692	0.954	1.07
Sex						
Female	1.13	0.430	0.33	0.743	0.538	2.38
Race						
Black	2.19	1.89	0.91	0.365	0.401	11.9
Constant	0.936	1.89	−0.03	0.974	0.017	49.3
Hip Osteoarthritis						
Odds of improvement in pain over one year	Odds ratio	Standard error	z	P>|z|	95% confidence interval	
Body Mass Index	1.01	0.046	0.30	0.763	0.927	1.10
Charlson Comorbidity Index						
2-3	0.546	0.642	−0.51	0.607	0.054	5.46
4+	1.91	3.36	0.37	0.710	0.061	59.5
Pain	2.06	0.423	3.55	0.000	1.38	3.08
Age	1.00	0.054	0.07	0.946	0.902	1.11
Sex						
Female	7.52	6.29	2.41	0.016	1.45	38.8
Race						
Black	1.00					
Constant	0.0254	1.07	−0.87	0.384	6.58e-06	98.7
Knee Osteoarthritis						
Odds of improvement in BMI over one year	Odds ratio	Standard error	z	P>|z|	95% confidence interval	
Body Mass Index	1.0	0.014	0.77	0.444	0.982	1.040
Charlson Comorbidity Index						
2-3	0.777	0.305	−0.64	0.522	0.359	1.679
4+	0.321	1.82	−2.00	0.046	0.105	0.9781
Pain	0.956	0.04	−0.91	0.365	0.869	1.052
Age	1.03	0.021	1.54	0.124	0.991	1.075
Sex						
Female	1.2	0.333	0.72	0.474	0.710	2.083
Race						
Black	0.997	0.551	−0.00	0.996	0.337	2.94
Constant	0.202	0.293	−1.10	0.271	0.011	3.466
Hip Osteoarthritis						
Odds of improvement in BMI over one year	Odds ratio	Standard error	z	P>|z|	95% confidence interval	
Body Mass Index	1.107	0.0373	3.04	0.002	1.036	1.183
Charlson Comorbidity Index						
2-3	0.2223	0.2021	−1.65	0.098	0.0374	1.320
4+	0.2596	0.334	−1.05	0.296	0.0207	3.25
Pain	0.819	0.0779	−2.09	0.037	0.6806	0.9877
Age	1.075	0.044	1.75	0.079	0.9915	1.166
Sex						
Female	0.8799	0.4714	−0.24	0.811	0.3078	2.514
Race						
Black	1.791	2.321	0.45	0.653	0.1414	22.70
Constant	0.0037	0.0 1	−1.87	0.062	0.0000	1.309

McKelvey & Zavoina's R2 = 0.402.
McKelvey & Zavoina's R2 = 0.612.
McKelvey & Zavoina's R2 = 0.036.
McKelvey & Zavoina's R2 = 0.273.

HOOS/KOOS ADL scales, or VR-12 subscales. We encountered a large amount of missing data for HOOS, KOOS, VR-12, BMI, pain, and functional test information (Table 3).

4. Discussion

4.1. OAMP utilization

This pragmatic study [36] of a guideline-driven OAMP developed by an academic healthcare system demonstrated the feasibility of implementing and sustaining an OAMP in U.S. clinical care. Six-fold growth over four years indicated program demand and sustainability. Most patients adhered to the intended model of 1–5 visits over one year. Rapid growth in referrals and appointments demonstrated a high demand for this specialized care. The referral area was large, with patients willing to drive 2+ hours to be seen. The health care organization supported the OAMP's initial adoption and ongoing growth, recognizing that demand for care signaled an unmet need for patients who are not surgical candidates due to high BMI, comorbidities, and other factors.

Given that most patients do not receive guideline-recommended care [8,10,11,23], removing barriers to systematic comprehensive care is critical. This OAMP was designed to facilitate care and remove known

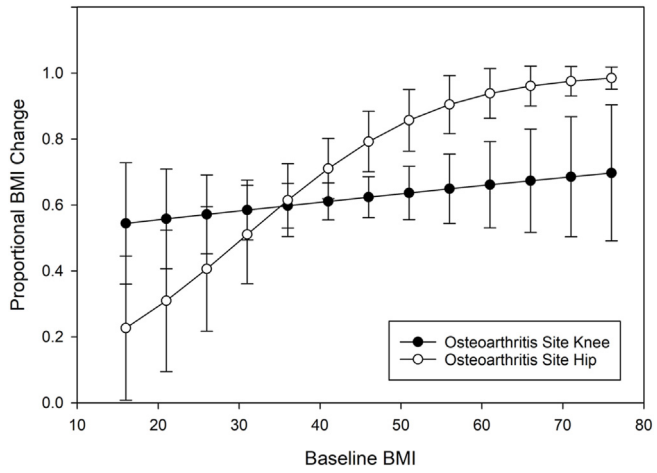

Fig. 4. Proportional changes in body mass index by osteoarthritis site (hip or knee).

barriers within our system. We found that treatment length (range 1–15 visits) was associated with two factors. Uninsured patients had the shortest duration, suggesting that cost was likely a barrier. A high CCI score was also associated with shorter duration; more significant comorbid conditions may have affected participation or prioritization of this program.

The 8% no-show rate was higher than that for our health care system (5.6%) and for our orthopedic clinics (3.8%). Contributing factors may be that our OAMP patient population had multiple comorbidities and high levels of pain which can affect appointment attendance [37,38]. We decreased the no-show rate over time by adding a second reminder call one business day prior to each appointment. Telemedicine visits had a lower no-show rate, likely due to reduced travel and mobility barriers. Nevertheless, our OAMP no-show rate was much lower than those reported in other studies across different specialties and settings [37,38].

4.2. Patient baseline characteristics and outcomes

Our OAMP population was older and comprised more women than the general Wisconsin population (39.6 versus. 62.1 years of age, 49.8% versus 72.6% female). However, our older and predominantly female population is similar to populations for OAMPs implemented in other settings [20,39,40]. Our cohort, however, was medically complex with a higher BMI. This may be partly due to referral patterns in our system where a BMI >40 is considered a higher surgical risk for total joint replacement. Both TUG and chair stand scores predicted a high fall risk for our population [31,32].

Patients who started OAMP treatment with higher pain levels and higher BMI were more likely to experience improvements in both, as might be expected. Unexpectedly, there was no correlation between weight loss and pain improvement. Patients with hip osteoarthritis were more likely to experience decreases in BMI than patients with knee OA ($p = 0.002$).

No other baseline patient characteristics predicted improvement including age, sex, insurance type, or dose of treatment (duration/number of appointments). This is consistent with other OAMP studies that report difficulties predicting outcomes based on baseline patient characteristics [41–43]. Predictors for positive change seen in other studies were improved self-efficacy (we did not measure), improvement in the chair stand (not a predictor for us), shorter duration since symptom onset, and less severe disease [44].

4.3. Limitations and next steps

Despite a larger real-world cohort, this study has several limitations. It was conducted at one academic medical center and may not represent OAMPs implemented in other settings. Much of our population was morbidly obese which might have impacted study outcomes. Results for self-administered assessments of pain and function after the initial patient visit (HOOS/KOOS/VR-12) were limited by a high amount missing data. Contributors to this included variability in clinic staff, patient objections to repeated completion of questionnaires and functional testing, and lack of clinical resources to ensure test completion. The large number of uncompleted questionnaires highlights an important challenge for evaluating OAMP outcomes; we recommend limiting outcome assessments to one or two primary measures.

Future research is needed to better understand the patient experience and acceptability of the OAMP model, assess the impact of OAMP care on outcome rates of total joint replacement, and compare cost effectiveness between OAMP care and more traditional models of OA care.

As a highly prevalent, growing, and under-treated chronic disease, OA is a prime target for innovative care models–like the OAMP–which can systematically deliver non-surgical management as endorsed by OARSI. This study revealed that OAMP implementation is feasible and scalable over time in three visit formats. However, outcome data showing the impact on pain or long-term arthroplasty need is still limited. This study is an important step toward understanding the demand and impact of OAMP programs in real-world settings in the United States.

CRediT author statement

Miller, Kathryn: conceptualization, validation, investigation, data curation, writing- original draft, writing-review & editing, supervision. Baier, Linda: validation, data curation, writing- original draft, writing – review & editing, visualization, supervision, project administration. Bartels, Christie: conceptualization, writing – review and editing, visualization, supervision. Yu, Tommy: validation, investigation, data curation, writing-review and editing. Vundamati, Divya: validation, investigation, data curation, writing-review and editing. Froesch, Marley: validation, data curation, writing-review and editing. Brown, Roger: methodology, software, validation, formal analysis, writing- original draft, writing-review and editing.

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Declaration of competing interest

All authors declare that they have no conflicts of interest.

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