Outcome Monitoring and Clinical Decision Support in Polyarticular Juvenile Idiopathic Arthritis

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ABSTRACT. ***Objective.*** Inconsistent assessment and treatment may impair juvenile idiopathic arthritis (JIA) outcomes. We aimed to improve polyarticular JIA (rheumatoid factor–positive and –negative) outcomes by standardizing point-of-care disease activity monitoring and implementing clinical decision support (CDS) to reduce treatment variation.

Methods. We performed a quality improvement initiative in an outpatient pediatric rheumatology practice. The interventions, implemented from April to November 2016, included standardized disease activity measurement, disease activity target review, and phased introduction of polyarticular JIA CDS to guide medication selection, dosing, treatment duration, and tapering. Process measures included visit-level target attestation (goal: 50%) and CDS use (goal: 15%). Our goal was to reduce the polyarticular JIA clinical Juvenile Arthritis Disease Activity Score (cJADAS-10) by at least 10%. Included patients had at least 2 visits from April 2016 through July 2017, and were classified as having early (≤ 6 mos) or established disease (> 6 mos).

Results. Patients with polyarticular JIA (n = 97; 81% established disease) were observed for 10.3 months (interquartile range: 6.4–12.3). Target attestation and CDS use occurred in a mean of 77% and 45% of polyarticular JIA visits, respectively. The median cJADAS-10 decreased significantly in both early (16.5 to 2.7, $p < 0.001$) and established polyarticular JIA (2.1 to 1.0, $p = 0.01$). A high proportion of patients with early disease received biologic therapy (73.7%). In established disease, although prescription of nonbiologic and biologic disease-modifying antirheumatic drugs remained similar overall, adalimumab prescribing increased (12.8% to 23.1%, $p = 0.008$).

Conclusion. Implementation of structured disease activity monitoring and CDS in polyarticular JIA was associated with significant reductions in disease activity scores in both early and established disease. (First Release October 15 2019; J Rheumatol 2020;47:273–81; doi:10.3899/jrheum.190268)

Key Indexing Terms:
JUVENILE IDIOPATHIC ARTHRITIS CLINICAL DECISION SUPPORT SYSTEMS
OUTCOMES ASSESSMENT

Juvenile idiopathic arthritis (JIA), the most common pediatric rheumatologic condition, causes joint pain, swelling, damage, and impaired physical function and quality of life[1,2,3]. Two subtypes, rheumatoid factor (RF)–negative and RF-positive polyarticular JIA, affect 5 or more joints in the first 6 months of disease and comprise 20–25% of all JIA cases. Children with polyarticular JIA experience prolonged periods of active disease and require longterm therapies[4,5]. Although biologic and nonbiologic disease-modifying antirheumatic drugs (DMARD) are effective in polyarticular JIA, treatment approaches vary widely[6].

Differences in evaluation and management likely contribute to outcome variation. In adults with rheumatoid arthritis (RA), monitoring disease activity using standardized outcome measures and adjusting treatment accordingly [i.e., treat to target (TTT)] is associated with reduced disease activity, disability, and joint damage[7,8], but the critical components of TTT have not been clearly established. In 2015, the American College of Rheumatology recommended TTT for RA[9], and recently, an international task force published recommendations for TTT implementation in JIA[10]. Additionally, augmenting TTT with treatment protocols may be more effective than TTT alone[11]. A study in patients with treatment-naive oligoarthritis and RF-negative polyarticular JIA documented that standardized evaluation and treatment escalation results in high rates of

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inactive disease, regardless of initial therapy[12,13]. The efficacy of TTT paired with clinical decision support (CDS) outside the research setting has not been evaluated in JIA.

Our goal was to improve polyarticular JIA outcomes by standardizing point-of-care disease activity monitoring and implementing CDS to reduce treatment variation. Our hypothesis was that systematic disease activity review combined with CDS will reduce disease activity in polyarticular JIA.

MATERIALS AND METHODS

Context. Children's Hospital of Philadelphia (CHOP) is a tertiary-care medical center. The Division of Rheumatology consists of 9 attending physicians, 5 fellow physicians, 3 nurses, and support staff. Because we treat over 500 patients with JIA, we identified improving JIA disease monitoring and outcomes as high priorities. Our improvement team consisted of 2 rheumatologists, a rheumatology fellow, a rheumatology nurse, an improvement advisor, and a data analyst. The Rheumatology Division Chief and hospital Chief Quality Officer served as executive sponsors. Two Executive Committee members from the Pediatric Rheumatology Care and Outcomes Improvement Network (PR-COIN) were advisers. We followed the Standards for Quality Improvement Reporting Excellence Guidelines for reporting our quality improvement (QI) work[14].

Interventions. To reduce polyarticular JIA disease activity, we focused on standardizing outcome measures, ensuring point-of-care outcome measure review, and using local treatment best practices. PR-COIN promotes systematic measurement of disease activity, physical function, and pain in JIA[12]. We adapted our key driver diagram (Figure 1) from the PR-COIN model to support work in our local context and focused on identifying active disease, reducing treatment variation, and improving patient/family collaboration[12].

Outcome measures. To identify and monitor active disease, physical function, and pain, we developed an automated outcome assessment method. We created a Research Data Capture (REDCap)[15] survey to collect patient/parent and physician components of the clinical Juvenile Arthritis Disease Activity Score (cJADAS-10)[16], the Patient Reported Outcomes Measurement Information System (PROMIS) Upper Extremity and Mobility short forms[17,18], and pain scores [0–10, visual analog scale (VAS)]. The cJADAS-10 is the sum of the patient/parent global assessment of well-being (0–10, VAS), the physician's global assessment (PGA) of disease activity (0–10), and the active joint count (AJC; maximum of 10). We selected the cJADAS-10 to allow for a disease activity assessment during the clinic visit without testing inflammatory markers. The PROMIS measures of physical function were selected based on the ease of administration and ability to discriminate patients with active and inactive disease[19]. We began collecting outcomes at all outpatient visits in February 2016.

Outcome measure completion and review. Patients 8 years or older or caregivers completed the survey on a tablet prior to the physician encounter. After the clinical evaluation, the physician completed the joint count and PGA, and viewed the cJADAS-10, PROMIS T scores, and pain score within REDCap. The polyarticular JIA cJADAS-10 interpretation was displayed using published disease activity cutoffs for clinical inactive disease (CID, < 1), and low (1.01–2.5), moderate (2.51–8.5), and high disease activity (> 8.5)[16].

To facilitate outcome assessment at the bedside, we included a link to the REDCap survey in the electronic health record (EHR) and included outcome data interpretation in the after-visit instructions for physicians to review with patients and caregivers. The after-visit instructions included standard uveitis, laboratory screening, and vaccination recommendations written in language that patients and families reviewed for readability and content.

Physicians completed their disease activity, physical function, and pain score interpretation in an EHR flowsheet that automatically populated a "JIA Disease Assessment" section in the after-visit instructions. Clinicians entered 1 of 3 options for disease activity target attestation: "not active (at target)," "active (not at target)," and "active (at target)." Hand and arm function, mobility, and pain assessments were entered as "at target" or "not at target" based on PROMIS upper extremity function and mobility values.

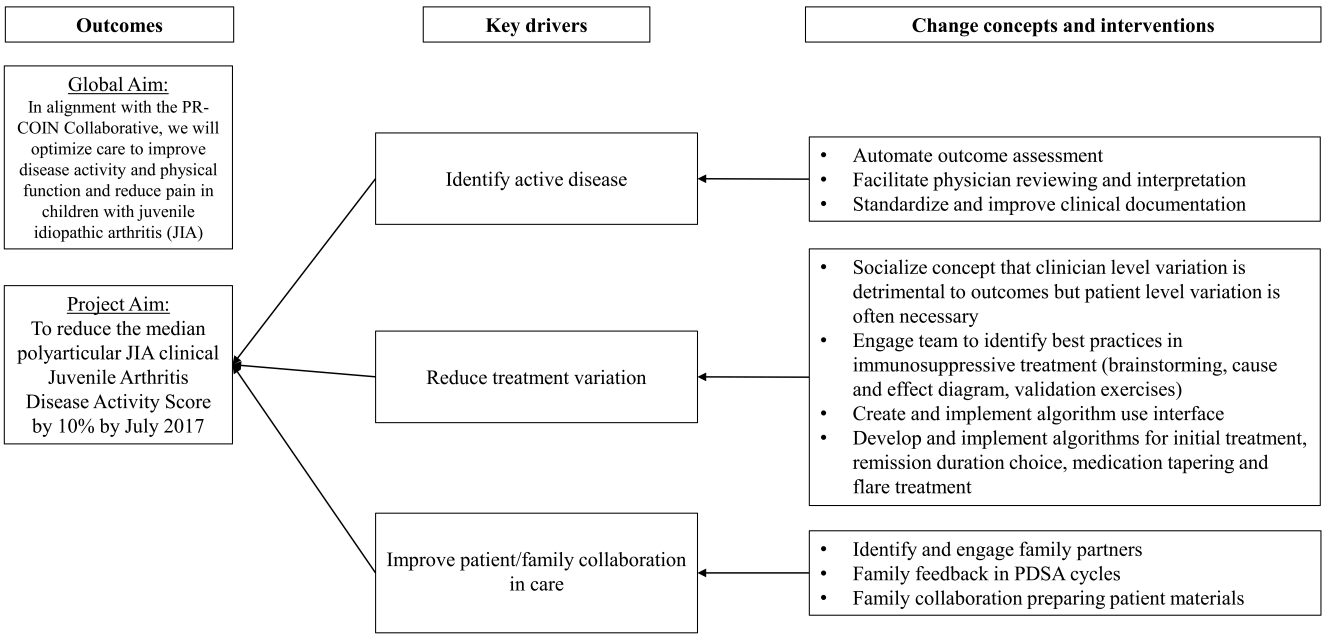


Figure 1. Key driver diagram for the polyarticular JIA improvement project. The key driver diagram served as a model to depict the relationship between the project aim, key drivers, change concepts, and interventions. PR-COIN: Pediatric Rheumatology Care and Outcomes Improvement Network; PDSA: Plan-Do-Study-Act.

CDS development and implementation. We developed algorithms to reflect local polyarticular JIA medication management preferences (available upon request). To develop CDS, we distributed standard cases to identify polyarticular JIA treatment choices. We identified a high level of polyarticular JIA practice variation among physicians based on questions about treatment choices embedded in the cases. We used the information to reinforce the need to develop treatment standards during algorithm design sessions. Algorithm development for each arthritis phase (new diagnosis, remission, medication tapering, flare) began with brainstorming sessions to identify decision-making nodes. Algorithm drafts were developed and amended based on physician feedback.

New diagnosis algorithms were adapted from polyarticular JIA consensus treatment plans for use in our local context[5]. Key concepts included (1) choice of initial therapy based on poor prognostic features (RF and/or cyclic citrullinated peptide positivity, neck and/or hip disease, and radiographic damage)[20], and (2) timing of and indications for treatment escalation based on cJADAS-10 definitions of low, moderate, and high disease activity.

For patients with inactive disease, algorithms were developed to support treatment duration and medication tapering decisions. The recommended treatment duration was based on (1) prognostic features, (2) need for medication changes or dose escalation to achieve inactive disease, and (3) history and severity of disease flares. Medication tapering for patients with inactive disease included standard dose and medication interval changes based on the relevant medication.

Polyarticular JIA flare algorithms were based on current medications (no treatment, nonbiologic DMARD monotherapy, biologic DMARD monotherapy, and combined therapy) and flare severity (minor, major). The algorithms specified (1) optimal dosing of current medications, (2) transitioning medications within a class, and (3) adding medications from a different class.

We translated algorithms into CDS using branching logic in the physician component of the REDCap survey to display relevant treatment guidance at the point of care (Figure 2). A pilot from April 2016 to September 2016 demonstrated that CDS was used in 8 of 17 patients (47%) with new polyarticular JIA flares. Clinicians agreed to expand CDS use to additional polyarticular JIA cases, prompting us to implement the expanded CDS modules in November 2016.

Staff education. We conducted interactive lectures describing TTT concepts. Physicians received training regarding cJADAS-10 interpretation including the quantitative definitions of inactive and active disease. For most patients, CID was the treatment target. However, low disease activity was considered an acceptable target for patients with longstanding, refractory arthritis. We instructed clinicians to discuss and reconcile cJADAS-10 values for which the clinician and parent/patient assessments were discordant. We reviewed CDS concepts and emphasized clinician autonomy to make treatment decisions based on patient characteristics.

Study of interventions. Our QI team met biweekly to review uptake of disease activity review (target attestation), CDS use, and outcome and balancing measures. We developed an automated data visualization tool using Qlikview software that updated daily.

Measures. The process measures were polyarticular JIA disease activity target attestation and CDS use. Target attestation was defined as the monthly proportion of all polyarticular JIA outpatient visits with disease activity target assessments (goal: 50%). CDS use was defined as the monthly proportion of polyarticular JIA outpatient visits in which the clinician indicated CDS use in the REDCap survey (goal: 15%). Our process measure goals were selected based on our estimate of the minimum change required to reduce the median preintervention polyarticular JIA cJADAS-10 by at least 10%.

The primary outcome measure was the median cJADAS-10 in patients with clinician-defined polyarticular JIA (RF-negative and -positive) and at least 2 outpatient visits after the interventions began in April 2016 through July 2017. Followup concluded when we implemented a new JIA continuous quality improvement intervention. Secondary outcome measures included the proportion of patients with CID[16], CID or low disease activity[16,21], and those with AJC and PGA values of zero. We assessed the proportions of patients with PROMIS upper extremity and mobility T scores > 45 (0.5 SD below the population mean), and those with pain scores < 3. Analysis of physical function measures was limited to those 5 years of age and older at the baseline visit.

Balancing measures were developed to reflect potential unintended consequences of enhanced disease activity monitoring and standardized treatment. We designed the balancing measures to identify greater chronic steroid use, magnetic resonance imaging (MRI) use, intraarticular steroid injections, and infections. Chronic steroid use was defined as the monthly proportion of patients with polyarticular JIA seen within 450 days on a hospital registry indicating prescription of > 2 consecutive weeks of steroids within 18 months[22]. Visit-level MRI use and steroid injections represented the percentage of completed MRI scans and intraarticular steroid injections on the day of a polyarticular JIA outpatient visit or prior to a subsequent visit. Standardized documentation of patient-reported infections occurred at each visit starting in December 2016 and included the number of illnesses requiring antibiotics since the previous visit.

Analysis methods. Process and balancing metric data were displayed and analyzed using statistical process control charts[23]. Outcome and medication use analyses were stratified based on disease duration. Patients were classified as having early polyarticular JIA if ≤ 6 months elapsed since diagnosis at the initiation of followup. Differences in means and medians were assessed using paired t tests and the Wilcoxon signed-rank test, respectively. Differences in proportions were assessed using McNemar's test for paired data, with exact methods if any cell had 5 or fewer patients. We used 2-sided tests of hypotheses, and p values of < 0.05 were considered statistically significant.

Ethical considerations. This effort met the definition of a quality improvement project not requiring regulatory approval. The Institutional Review Board at Children's Hospital of Philadelphia approved the retrospective analysis of patient-level outcomes and medication use (18-015367).

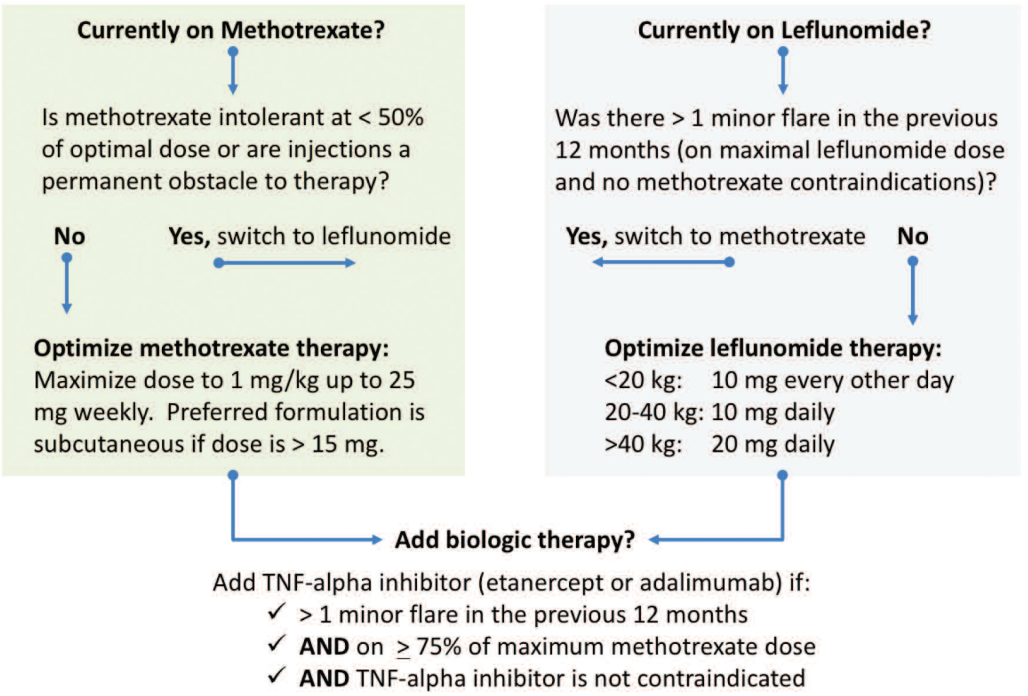
RESULTS

Cohort characteristics. We identified 434 outpatient polyarticular JIA visits from April 2016 through July 2017. There were 97 individuals with at least 2 visits during this time, with a mean baseline age of 12.2 years [interquartile range (IQR) 8.5–15.6]. Eighty-one (83.5%) were female and 79 (81.4%) were white. RF positivity was noted in 18 (18.6%), and 81% had disease for > 6 months at the baseline evaluation. The median number of visits with complete disease activity scoring was 3 (IQR 2–4) over 10.3 months (IQR 6.4–12.3).

Process measures. From October 2016 through July 2017, the mean monthly target attestation in polyarticular JIA visits was 77% (Figure 3A). Of the 213 visits with target attestation, patients were classified as "not active (at target)" in 67.1% (median cJADAS-10 0.6, IQR 0.1–2.4) and "active (not at target)" in 31.9% (median cJADAS-10 9.0, IQR 5.3–14.6). Patients were classified as "active (at target)" in only 2 encounters.

Beginning in April 2016, we performed a pilot test of CDS for new polyarticular JIA flares. CDS was used in about 9% of total polyarticular JIA encounters over a 6-month period. After we implemented our complete CDS module in November 2016, clinicians used CDS in 45% of polyarticular JIA encounters, which met the criteria for special cause variation (Figure 3B).

A. Minor flare on nonbiologic DMARD monotherapy.



B. Major flare on combined nonbiologic and bDMARD therapy.

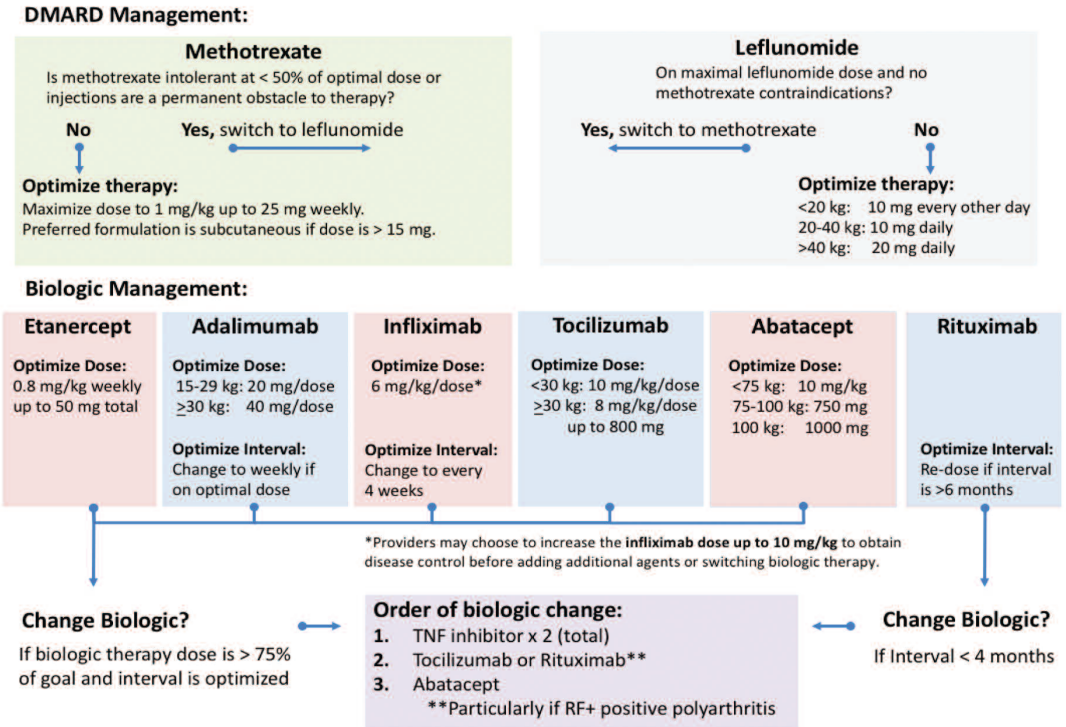
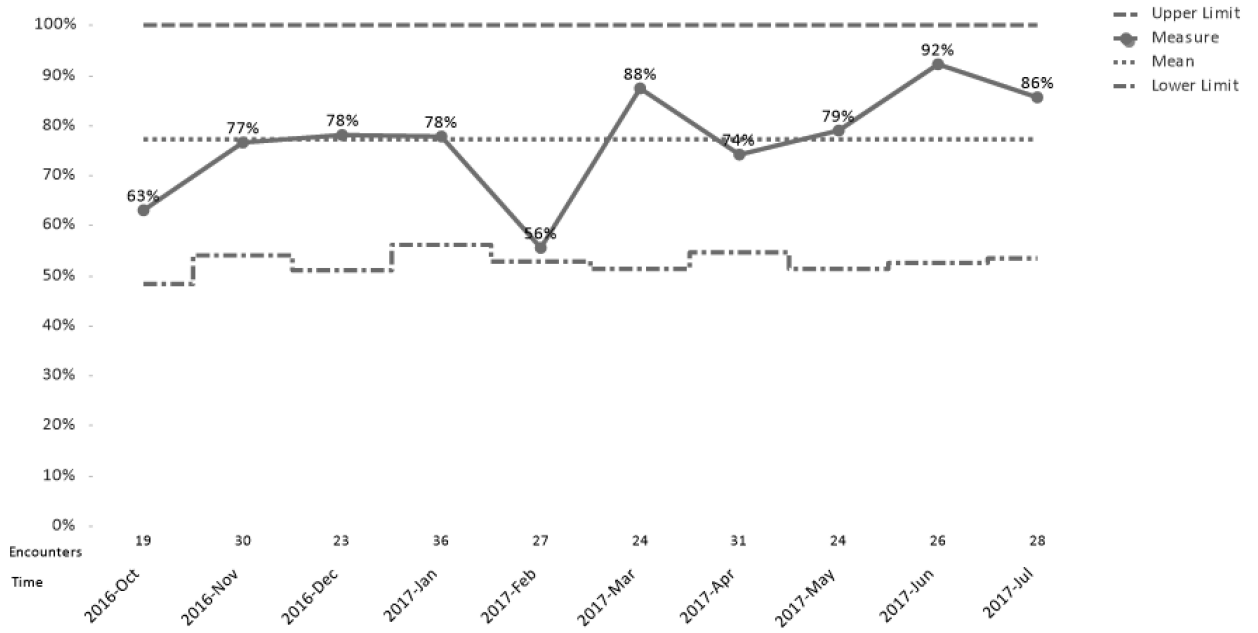


Figure 2. Sample clinical decision support algorithms for minor flare on nonbiologic DMARD monotherapy and major flare on combined nonbiologic and bDMARD therapy. The algorithms shown are 2 examples of decision support for arthritis flare management viewed by clinicians at the point of care. Algorithms were created to support medication treatment choices throughout the polyarticular JIA course based on local treatment preferences. Legal disclaimer: These treatment algorithms are based upon the opinions of staff members of Children's Hospital of Philadelphia. Treatment should be individualized and based upon the clinical condition of each patient. DMARD: disease-modifying antirheumatic drug; bDMARD: biologic DMARD; JIA: juvenile idiopathic arthritis; TNF-alpha: tumor necrosis factor-α; RF: rheumatoid factor.

A. Target attestation in all patients with JIA.



B. Clinical decision support use in all patients with polyarticular JIA.

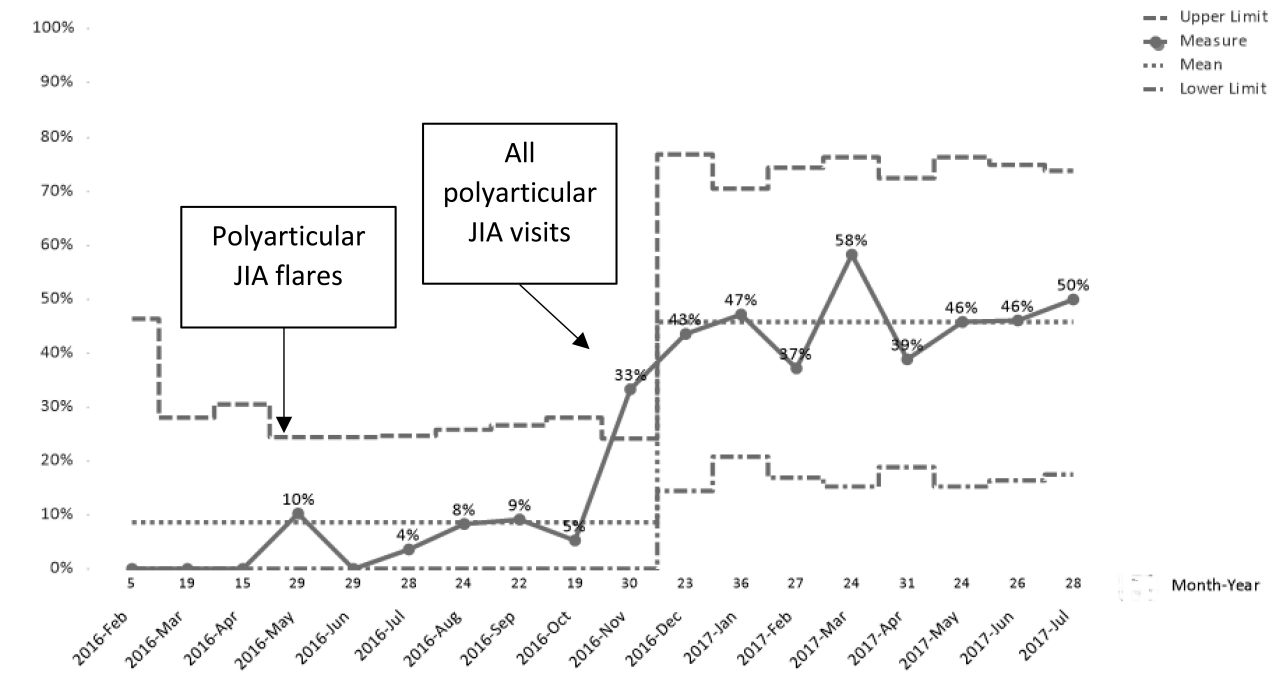


Figure 3. Polyarticular JIA visit-level disease target attestation and clinical decision support use statistical process control charts. The statistical process control charts demonstrate the monthly proportion of all polyarticular JIA outpatient visits with disease activity target attestation (A) and clinical decision support use (B). JIA: juvenile idiopathic arthritis.

Outcome measures. In both early and established polyarticular JIA, cJADAS-10 scores improved significantly (Table 1). In early disease, cJADAS-10 scores decreased from a median of 16.5 to 2.7 ($p < 0.001$), with significant decreases in all cJADAS-10 components. The proportion of patients with CID increased from 5.3% to 26.3% ($p = 0.12$), and with cJADAS-10 indicating CID or low disease activity from 5.3% to 47.4% ($p = 0.008$). Low disease activity according to Magni-Manzoni criteria (PGA ≤ 3.4, patient/parent global ≤ 2.1 and AJC ≤ 1) increased from 5.3 to 42.1% ($p = 0.02$). The proportion with mobility scores > 45 (31.6% to 63.2%, $p = 0.03$) and pain scores < 3 improved significantly (26.3% to 68.4%, $p = 0.008$).

In established disease, cJADAS-10 scores decreased from 2.1 to 1.0 ($p = 0.01$) with the change driven by significant reductions in the PGA and joint count. Patients with established disease and PGA and joint count values of zero increased significantly (60.3% to 80.8%, $p = 0.004$). Pain and physical function scores remained stable.

Balancing measures. The monthly proportion of patients with polyarticular JIA receiving chronic steroid therapy within the previous 18 months did not change significantly, ranging from 6–10%. MRI use did not change significantly and was associated with 8% of visits. The proportion of visits in which patients required intraarticular steroid injections decreased from 7% to 3.6%, yet this did not meet criteria for special cause variation. The rate of infection requiring antibiotics during the observation period was 29 per 100 person-years (95% CI 16.2–49.8). There were no serious infections requiring hospitalization.

Medication use. We assessed changes in medication use among those with early and established disease (Table 2). The majority of those with early polyarticular JIA were treated with nonbiologic (63.2%) and bDMARD (73.7%), with 47.4% taking combined therapy. In established polyarticular JIA, fewer were treated with methotrexate by the end of followup (57.7% to 44.9%, $p = 0.04$), and nonbiologic DMARD monotherapy was less common (30.8% to 19.2%, $p = 0.02$). However, of those not taking DMARD at baseline, DMARD were initiated in 10 (35.7%). Therapy with bDMARD remained stable, from 59.0% to 66.7% ($p = 0.11$), but adalimumab (ADA) therapy increased (12.8% to 23.1%, $p = 0.008$). Of the 8 biologic starts among those with established polyarticular JIA, five (62.5%) were among those not taking therapy at baseline.

Two of 19 patients with early polyarticular JIA (10.5%) stopped the therapy, while nine (12.9%) of those with established polyarticular JIA who were taking medicine at baseline discontinued therapy. Only 2 of eight patients (25%) with established polyarticular JIA remained stable while receiving no therapy.

DISCUSSION

After standardizing the JIA disease activity monitoring and using CDS to guide treatment, polyarticular JIA disease activity decreased significantly. We exceeded our target attestation and CDS use goals, and among those with both early and established polyarticular JIA, disease activity improved significantly. While pain and mobility improved among those with early disease, physical function and pain remained stable among those with established polyarticular JIA. At the conclusion of followup, a high proportion of patients with early polyarticular JIA were exposed to nonbiologic and bDMARD therapy, and those with established disease were likely to continue medications. There was a suggestion of greater bDMARD use among those with established disease,

Table 1. Changes in disease activity, physical function, and pain in polyarticular JIA.

Variables	Early Disease, n = 19			Established Disease, n = 78		
	Baseline	Final	p	Baseline	Final	p
Disease Activity						
cJADAS-10 (median, IQR)	16.5 (13.6–19.0)	2.7 (0.2–7.9)	< 0.001	2.1 (0.4–5.9)	1.0 (0.3–3.7)	0.01
Patient global (median, IQR)	4.8 (2.6–6.1)	2 (0.2–3.9)	0.01	0.9 (0.3–2.9)	1.0 (0.2–2.4)	0.98
PGA (median, IQR)	4 (3–5)	0 (0–3)	0.002	0 (0–2)	0 (0–0)	< 0.001
Joint count (median, IQR)	7 (5–11)	0 (0–4)	0.001	0 (0–1)	0 (0–0)	0.01
CID (%, cJADAS-10 ≤ 1)	1 (5.3)	5 (26.3)	0.12	31 (39.8)	40 (51.3)	0.11
CID or LDA (%, cJADAS-10 ≤ 2.5)	1 (5.3)	9 (47.4)	0.008	45 (57.7)	49 (62.8)	0.43
LDA (%, Magni-Manzoni[a])	1 (5.3)	8 (42.1)	0.02	44 (56.4)	51 (65.4)	0.14
AJC and PGA = 0	2 (10.5)	11 (57.9)	0.004	47 (60.3)	63 (80.8)	0.004
PROMIS Upper Extremity						
Function ≥ 45 (%, n = 83)[b]	4 (23.5)	9 (52.9)	0.06	53 (69.7)	57 (75.0)	0.32
PROMIS Mobility ≥ 45 (%, n = 83) [b]	6 (31.6)	12 (63.2)	0.03	57 (74.0)	59 (76.6)	0.62
Pain score < 3 (%)	5 (26.3)	13 (68.4)	0.008	57 (73.1)	58 (74.4)	0.80

[a] Physician global assessment ≤ 3.4, parent/patient global assessment ≤ 2.1, active joint count ≤ 1. [b] PROMIS scores were reported for those patients 5 years of age and older. JIA: juvenile idiopathic arthritis; cJADAS-10: clinical Juvenile Arthritis Disease Activity Score; IQR: interquartile range; CID: clinical inactive disease; LDA: low disease activity; PROMIS: Patient Reported Outcomes Measurement Information System; AJC: active joint count; PGA: physician's global assessment.

Table 2. Changes in medication use in polyarticular JIA.

Variables	Early Disease*, n = 19			Established Disease**, n = 78		
	Baseline	Final	p	Baseline	Final	p
Medication use						
Nonbiologic DMARD therapy, n (%)	5 (26.3)	12 (63.2)	0.09	50 (64.1)	42 (53.9)	0.18
Methotrexate, n (%)	5 (26.3)	10 (52.6)	0.23	45 (57.7)	35 (44.9)	0.04
Leflunomide, n (%)	0 (0)	2 (10.5)	0.50	5 (6.4)	7 (9.0)	0.63
bDMARD therapy, n (%)	2 (10.5)	14 (73.7)	< 0.001	46 (59.0)	52 (66.7)	0.11
TNF-α inhibitor therapy	2 (10.5)	11 (57.9)	0.003	44 (56.4)	49 (62.8)	0.18
Etanercept	2 (10.5)	8 (42.1)	0.03	25 (32.1)	24 (30.8)	1.0
Adalimumab	0 (0)	2 (10.5)	0.50	10 (12.8)	18 (23.1)	0.008
Infliximab	0 (0)	1 (5.3)	1.0	9 (11.5)	7 (9.0)	0.50
Other biologic therapy	0 (0)	3 (15.8)	0.25	2 (2.6)	3 (3.9)	1.0
Treatment regimen						
Nonbiologic DMARD monotherapy, n (%)	5 (26.3)	3 (15.8)	0.68	24 (30.8)	15 (19.2)	0.02
bDMARD monotherapy, n (%)	2 (10.5)	5 (26.3)	0.37	20 (25.6)	25 (32.1)	0.20
Nonbiologic and bDMARD therapy, n (%)	0 (0)	9 (47.4)	0.004	26 (33.3)	27 (34.6)	0.81
No longer receiving therapy	12 (63.2)	2 (10.5)	0.02	8 (10.3)	11 (14.1)	0.60

* Less than or equal to 6 months since diagnosis. ** Greater than 6 months since diagnosis. JIA: juvenile idiopathic arthritis; DMARD: disease-modifying antirheumatic drug; bDMARD: biologic DMARD; TNF-α: tumor necrosis factor-α.

and ADA prescribing increased significantly. The incidence of infection requiring antibiotics during the observation period was comparable to or lower than previously reported infection rates[24,25,26].

TTT is a recommended yet infrequently implemented care model. Although TTT is a recommended approach in early and established RA, a study of 46 providers at 11 sites showed that no TTT components were documented in 64% of clinic visits[27]. Both single and multicenter approaches to implement TTT have been successful[28,29], but the effect of these interventions on outcomes was not assessed.

A recent international task force recommended a TTT paradigm for JIA[10]. Consistently with that report, our data suggest that important framework components are (1) aiming for CID in most patients using a standardized disease activity measure, (2) assessing disease activity measurements at the point of care, (3) maintaining CID, and (4) communicating TTT concepts with families. Our work was novel in that we developed a method to support consistent treatment guidance at the point of care in both early and established polyarticular JIA, and may represent a sustainable approach to implementing best practices or consensus treatment plans across a network.

Though TTT is an accepted care model, ideal implementation methods have not been established. In RA, TTT is intended to be applicable to any clinical setting, independent of local resources. A metaanalysis of TTT studies demonstrated that while unstructured "tight control" approaches are effective, standardized treatment adjustments were associated with greater improvement in disease activity[11]. Our work does not resolve whether TTT with CDS is superior to an unstructured approach. However, we sustained our greater level of communication around medication prescribing and consider it to be an important part of our practice strategy.

Several factors contributed to achieving our goals. First, we measured standard JIA outcomes in need of improvement. Reducing disease activity, optimizing physical function, and improving pain were readily accepted as divisional goals. Second, engaging team members throughout the algorithm design process helped to maximize algorithm use. We included team members from the beginning and designed treatment algorithms to reflect decision making in our clinical setting. A key communication method was to suggest that algorithms were not intended to apply to all patients and the clinician should deviate based on clinical judgment and shared decision making. When we set out the algorithms, clinicians did not consider using them to be a major practice change. Third, we involved patients and caregivers, which ensured that our communication methods concerning target attestation and CDS use were readily accepted. In particular, parents wanted the team to communicate that clinicians were not following a "cookbook," but rather using local best practices to aid shared decision making. In the future, we plan to standardize communication regarding setting treatment targets. Fourth, we developed a vision of spread. CDS was initially implemented for patients with polyarticular JIA only. We have since completed CDS for enthesitis-related arthritis and expect to develop modules for other JIA subtypes. Additionally, the CDS can be tested and implemented at other centers, with or without modification based on local treatment preferences.

There are several limitations to our approach. First, although clinicians indicated frequent CDS use, we are not certain whether the process of developing our care standards, CDS use, or target attestation were responsible for changes in medication prescribing. Second, our approach allowed for flexibility in the final determination of whether the patient was "at target" when the patient/caregiver assessment

indicated active disease, but the joint count and PGA were normal. This discordance is well described[30], and in fact often had a simple explanation, such as a recent injury or a known pain syndrome. Our results suggest that physician target attestation was appropriate because the median cJADAS-10 in patients labeled "not active (at target)" was within the inactive disease range. Third, although we developed an automated CDS delivery method, it was still challenging to access at the point of care, requiring separate clinician authentication, which limited its usefulness. We are currently identifying methods to seamlessly incorporate CDS into the clinical workflow. Fourth, it is challenging to discern the exact effect of CDS use on outcomes. We found instances in which clinicians reported not using CDS, but treatment decisions were consistent with CDS concepts. Future studies are needed to determine the effect of using CDS on clinical outcomes. Fifth, we cannot exclude the possibility that a systematic bias among those with established disease contributed to lower physician components of the cJADAS-10, because the patient-reported outcomes remained stable. Sixth, we did not have a control group, because this project was intended to improve the quality of care for all patients with polyarticular JIA in our practice. While longitudinal improvement in the cJADAS-10 would be expected in patients with early disease, the significant improvement we observed in patients with established disease would be less likely.

Our QI initiative demonstrates that structured disease activity monitoring coupled with CDS is a feasible and sustainable method to improve JIA outcomes. Future multicenter implementation research studies are needed to assess whether our results are generalizable to other centers. It will be important to determine whether CDS augments an unstructured TTT approach and to assess the effect on the cost of care and patient experience.

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