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Three Quality Improvement Initiatives Improved Performance of Rheumatoid Arthritis Disease Activity Measures in Electronic Health Records: Results from an Interrupted Time Series Study

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Abstract

Objective: Applying treat to target strategies in the care of patients with rheumatoid arthritis (RA) is critical for improving outcomes, yet electronic health records (EHRs) have few features to facilitate this strategy. We evaluated the effect of three health-IT initiatives on performance of RA disease activity measures and outcomes in an academic rheumatology clinic.

Methods: We implemented three initiatives designed to facilitate performance of the Clinical Disease Activity Index (CDAI): an EHR flowsheet to input scores, peer performance reports, and an EHR SmartForm including a CDAI calculator. We performed an interrupted time-series trial to assess effects on the proportion of RA visits with a documented CDAI. Mean CDAI scores before and after the last initiative were compared using t-tests. Additionally, we measured physician satisfaction with the initiatives.

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COMPETING INTERESTS
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Results: We included data from 995 patients with 8,040 encounters between 2012 and 2017. Over this period, electronic capture of CDAI increased from 0% to 64%. Performance remained stable after peer reporting and the SmartForm were introduced. We observed no meaningful changes in disease activity levels. However, physician satisfaction increased after SmartForm implementation.

Conclusion: Modifications to the EHR, provider culture, and clinical workflows effectively improved capture of RA disease activity scores and physician satisfaction, but parallel gains in disease activity levels were missing. This study illustrates how a series of health-IT initiatives can evolve to enable sustained changes in practice. Yet, capture of RA outcomes alone may not be sufficient to improve levels of disease activity without a comprehensive treat-to-target program.

Rheumatoid arthritis (RA) is the most common inflammatory arthritis affecting up to 1% of U.S. adults and causing significant disability, excess mortality and economic burden (1). The disease is characterized by pain and swelling in the joints, fatigue, and profound joint stiffness. Over time, inflammation can cause joint deformities and impair physical functioning. Although inflammation can be measured by blood tests such as the erythrocyte sedimentation rate (ESR) or C-reactive protein (CRP), these tests are nonspecific and frequently do not correlate with how patients are feeling (2): the nature of RA makes clinical assessments and patient reported outcomes (PROs) critical to understanding disease activity and its functional consequences.

There is strong evidence that treat-to-target (T2T) strategies can improve RA outcomes (3–6). Like approaches to the treatment of diabetes or hypertension, a T2T approach in RA involves 1) regular assessment of quantitative disease activity measures and 2) changes to medications in order to achieve remission or low disease activity. In order to promote the use of a T2T strategy for RA, the National Quality Forum (NQF) endorsed a quality measure that requires documentation of a standardized RA disease activity score in the electronic health record (EHR) (7, 8). This measure was incorporated into several pay-for-performance programs targeting U.S. rheumatologists (9). Still, collection of disease activity measures remains inconsistent. Data from the American College of Rheumatology's national RISE registry showed that among the 178,931 unique RA patients, only 50% had an RA disease activity score recorded in the EHR, indicating that collection and utilization of these measures are inconsistent in clinical practice (10, 11).

Little has been published about how to best implement disease activity measures to guide treatment in routine clinical work (12). Existing EHRs often require customization to collect RA disease activity measures as structured data, and current efforts to collect these RA outcomes, through mechanisms that require intensive data entry, such as EHR flowsheets, are inefficient, disrupt clinical workflow and decrease provider usage, leading to suboptimal performance of RA quality measures and inadequate implementation of T2T (13). Optimization of the EHR to facilitate collection of RA outcomes has potential to make it easier to apply T2T strategies in routine practice and to comply with national quality performance measures (14).

In this study we implemented a multifaceted quality improvement strategy, including three initiatives to standardize the collection and documentation of a formal disease activity

measure in a large academic rheumatology clinic, including changes to clinic workflows, clinic culture, and modifications of the EHR itself. We examined the effect of each of the three initiatives on the proportion of encounters in which a disease activity score was documented in the EHR. Additionally, we assessed whether the initiatives resulted in concomitant improvements in both physician satisfaction and clinical outcomes over time.

PATIENTS AND METHODS

Study setting

This study was performed in an academic rheumatology clinic at University of California, San Francisco (UCSF), which uses an Epic EHR system. Patients seen by all providers were included in the analysis. Over the study period, providers included at least 18 rotating rheumatology fellows and residents, one nurse practitioner and 35 attending physicians.

The Committee on Human Research at UCSF approved this study.

Patient and data sources

All patients over 18 years of age with at least two International Classification of Diseases (ICD) codes for RA (ICD-9: 714.0 and ICD-10: M05.9) in the EHR between June 1st 2012 and October 31st 2017 were included. We extracted information from the UCSF Epic Clarity Data Warehouse on patient demographics (age, gender, self-reported race/ethnicity, preferred language, insurance), comorbid conditions, encounter dates, encounter provider, and disease activity scores.

Outcomes

The main outcome of interest was whether a disease activity score was captured in structured fields in the EHR for a patient visit. To measure RA disease activity, this clinic used the Clinical Disease Activity Index (CDAI), a validated composite RA disease activity measure (15). It is based on the simple summation of a patient global score on a 0 to 10 scale, a physician global score on a 0 to 10 scale, and the count of swollen and tender joints out of 28 joints. In practice, scores are translated into four categories: remission (CDAI ≤ 2.8), low disease activity (CDAI > 2.8 and ≤ 10), moderate disease activity (CDAI > 10 and ≤ 22) or high disease activity (CDAI > 22) in order to guide clinical decision making.

In addition to the process outcome above, we assessed changes in clinical outcomes after implementation of each of the three initiatives. We examined changes in mean CDAI scores before and after the two final initiatives. We were not able to compare CDAI scores prior to the first initiative (flowsheet) because disease activity scores were neither routinely performed nor captured in structured fields at that time. We also calculated the proportion of patient visits with a CDAI score in the low disease activity or remission categories (CDAI≤10).

Interventions

Over a 5.5-year period, three quality improvement initiatives were implemented in the clinic. Additional detail about each of the initiatives can be found in appendix 1.

Initiative 1 (starting January 2013): EHR flowsheet and workflow changes. With the clinical systems team of the health system, we built an Epic-based flowsheet that allowed providers to input and track disease activity scores using structured fields in the EHR. Workflow changes were made such that clerks handed out a single item questionnaire in the waiting room to collect patient global assessments; nursing staff entered the patient global assessment into a template in the EHR; providers entered the remaining CDAI components into a 3rd party application available on the desktop of all clinic computers. This application calculated the total CDAI score and the provider would subsequently manually enter the total score into a structured template ("flowsheet") within the EHR.

Initiative 2 (starting February 2014): Peer performance reporting. A monthly report disseminated by the rheumatology clinic chief to rheumatology providers contained information on all providers and their individual CDAI performance. The report allowed physicians to benchmark their performance against their peers.

Initiative 3 (starting April 2016): EHR optimization with a SmartForm. In a series of improvements to the existing CDAI flowsheet, which required exiting the note to enter information in a separate window, we implemented an Epic SmartForm, a structured template that could be embedded in the provider's note. The SmartForm included a homunculus tool to help clinicians document the location and number of tender and swollen joints and a CDAI score calculator that automatically called for information from the homunculus and other fields from the EHR (specifically, the patient global score, which was elicited by medical assistants and input into a flowsheet during the patient check-in to clinic). Finally, information from the SmartForm and CDAI calculation populated a "synopsis report" that allowed providers to display a graph of scores over time for each patient.

Provider satisfaction

In order to assess the impact of changing clinical workflows on rheumatologists, we assessed provider satisfaction with disease activity collection and documentation processes, by administering a survey to providers immediately before and 24 months after the third initiative. Providers were asked to rate several domains on 1–10 scales, where 10 represented "very satisfied" and 1 represented "not satisfied": 1) overall satisfaction with disease activity score documentation, 2) satisfaction with the time recording this information in the EHR, 3) satisfaction with the homunculus to denote tender and swollen joint counts and 4) satisfaction with disease activity score visual presentation. Additionally, providers were asked to self-report time spent documenting disease activity (in minutes) during a typical RA patient visit. Survey responses were gathered from 10 providers (4 fellows, 6 attending physicians) pre-implementation and 12 providers (5 fellows, 7 attending physicians) post-implementation.

Statistical analysis

We used descriptive statistics to summarize patient age, gender, self-reported race/ethnicity (White, African American, Hispanic, Asian and Other/multiple), preferred language

(English, Spanish, Chinese and other), baseline Charlson comorbidity score, and insurance type (private, Medicaid and Medicare).

The effect of each of the health-IT initiatives on CDAI documentation was assessed in 3 ways:

1. Control chart: First, we created a control chart (p-chart) to describe the overall trend and stability in performance of CDAI over time. Performance was calculated as the proportion of eligible patients with a documented CDAI, aggregated into monthly intervals. Upper and lower control limits varied based on the number of RA patients encounters in the denominator. A continuous improvement of 6 or more points in a row or the occurrence of 8 or more points on the same side of the centerline is considered a significant trend (16).

2. ITS analysis: Second, quantifiable changes in CDAI performance following each of the initiatives were assessed with an ITS analysis. ITS is a strong quasi-experimental study design that is used to estimate the causal impact of an intervention on its target population without random assignment and is useful when evaluating new health system interventions (17–19). We used 2-week increments and estimated the coefficients by ordinary least square (OLS) linear regression models, in which the errors were assumed to follow a first order autoregressive process. We further specified the model to base the pooled autocorrelation estimate on the autocorrelation of the residuals, and added robust standard errors (20). We expressed the effect of our initiatives on the outcome (whether a CDAI was recorded) as intercept and slope changes.

3. Generalized estimating equation (GEE) model: Third, we used GEE to estimate CDAI performance, adjusting for individual-level factors and accounting for clustering by provider (21). The outcome in this model was CDAI documentation (yes/no for each patient visit). The primary predictors were each of the three health-IT initiatives, and they were encoded to reflect the period following each individual implementation, with the post-implementation period of intervention 1 serving as the baseline. Individual-level factors included age, gender, race/ethnicity, insurance, preferred language, and Charlson comorbidity index (CCI) scores. All included patients had a CCI score ≥1 due to their RA diagnosis (22). For regression analysis CCI was therefore dichotomized to 1 or ≥2. All covariates were tested for non-collinearity.

To assess changes in clinical outcomes over time, the proportion of scores in low/remission (CDAI≤10) each month were examined using a control chart (p-chart), for the subgroup of visits where a CDAI score was recorded. Additionally, we compared mean CDAI during the 12 months before and after the peer reporting initiative and 19 months before and after the SmartForm intervention using t-tests. Paired t-tests were performed on a subgroup of patients with ≥ 1 CDAI before and after initiative 2 and 3.

Analyses were performed using Stata 15 (StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC). For all analyses, p-values <0.05 were used as the criterion for statistical significance.

RESULTS

The analysis included 995 RA patients with a total of 8040 in-person encounters in the UCSF rheumatology clinic during the study period. The sample was 81.8% female and had a mean age of 58.9 years (±15.9; see Table 1). This group was racially and ethnically diverse: 51.1% were non-Hispanic White, 15.9% Asian, 15.9% Hispanic, and 6.1% African-American, and 12.4% reported a language other than English as their preferred language, primarily Chinese or Spanish.

Control chart

The longitudinal control p-chart presents monthly proportions of visits with a CDAI score documented in the EHR (Figure 1a). We included 58 monthly time points; the number of visits each month ranged from 94 to 161. Overall, CDAI documentation increased over time from 0% in 2012 prior to any of the initiatives, to 64% in October 2017, after successful implementation of all three initiatives. We found a dramatic improvement in the proportion of patient visits with a CDAI documented in the EHR during the first 12 months after implementation of the first initiative. Following the second initiative, the peer performance reporting, all 27 points on the p-chart were seen above the centerline (p-bar), indicating that the improvement had stabilized around a new, slightly higher set point. After the SmartForm intervention, we identified a stable CDAI capture trend throughout the entire period, with points varying around the centerline.

ITS analysis

The ITS analysis confirmed that changes seen in the p-chart were statistically significant.

Our results showed that in the first 2-week period immediately following implementation of the first initiative (EHR flowsheet and workflow), there was a significant increase in documentation of CDAI scores from 0% to 28% (CI = [17.9, 38.4]) (Figure 2, Table 2). The post-intervention estimate showed that after the introduction, documentation rate increased at a rate of 1.4% (CI = [0.7, 2.1]) per 2-week period.

Immediately following initiative 2 (peer performance reporting), there was a small, but not significant, increase in documentation rate (4% CI= [−6.2,14.2]) and subsequent stabilization in the post-intervention slope.

In the first 2-week period following the third initiative (EHR optimization with SmartForm), we observed a small reduction in CDAI documentation (−7.3%, $p<0.05$]. The post-intervention trend showed a slight, though non-significant, increase of 0.1% per 2-week period (CI= [−0.1, 0.4]), which resulted in a rise back to near pre-intervention levels over the following 18 months.

GEE model

The GEE results supported the findings of the ITS with respect to the interventions (initiative 2, OR: 2.28 [1.73, 2.10]; initiative 3, OR: 1.77 [1.19, 2.65]). Additionally, odds for having a CDAI recorded following initiative 2 and 3 were similar for adjusted and

unadjusted models and improvements in documentation remained significant in both models (Table 3).

Clinical outcomes

Mean CDAI was stable before and after peer performance reporting (12.4 both pre and post) and increased slightly after SmartForm implementation, from 11.3 to 13.4, $p<0.05$. Paired t-test detected small disease activity improvements after peer performance reporting (n=237, mean CDAI from 12.0 to 10.7, $p<0.05$) but slightly worse scores after SmartForm implementation (n=341, mean CDAI from 11.2 to 12.7, $p<0.05$). Though these changes were statistically significant, they did not exceed the minimally clinically important difference thresholds for CDAI (23). The overall proportion of visits with a CDAI in the low/remission category increased slightly from 42 to 46% during the study period (Figure 1b).

Provider satisfaction surveys

Results from provider surveys showed that on a scale from 1–10, overall provider satisfaction with disease activity documentation increased from 5.4 (±2.5) to 7.5 (±1.4). Similarly, satisfaction with time spent recording necessary information and visual presentation of data increased from 5.6 (±2.6) to 8.2 (±1.7) and from 6.4 (±1.9) to 8.3 (±1.4), respectively. Mean self-reported time for RA patient outcome documentation, including the time to do joint counts, calculate the total CDAI, and input this score into the EHR, decreased from 6.5 (±5.3) minutes to 3.2 (±1.9) minutes.

Engagement of support staff

Additionally, we reviewed the encounters where a CDAI score was not collected to assess engagement and activation of support staff. We found a total of 2605 encounters where a CDAI was not collected during this period (36%). The patient global was missing in 52.2% of these encounters, and this proportion decreased slightly, but significantly, during the study period.

DISCUSSION

Applying treat to target strategies in the routine care of patients with rheumatoid arthritis is critical for improving outcomes, yet electronic health records have few features to facilitate this strategy. This study evaluated three targeted health-IT initiatives designed to standardize the collection of a RA disease activity measure in a large academic rheumatology clinic.

Overall, the three initiatives increased and sustained performance of RA disease activity measures. Introduction of an EHR flowsheet in addition to workflow changes and monthly peer performance reporting significantly improved capture of CDAI scores, and the institution of additional workflow changes and an EHR SmartForm maintained these gains. By the end of the 5.5-year study period, performance of disease activity scores had increased from 0 to 64% of eligible clinic visits. We did not see parallel improvements in RA clinical outcomes, including the proportion of patients in low disease activity or remission, but did see important gains in physician satisfaction after optimization of workflows to capture RA disease activity scores.

The optimizations made to our EHR to improve performance on disease activity measures are not without precedent. Newman and colleagues successfully built and incorporated a health-IT tool, Rheum-Pacer, for documentation of disease activity and other outcomes in a large U.S. rheumatology practice (12). They reported a CDAI documentation rate of 61% over 2 years, which is comparable results reported here. Additionally, they showed significant improvements in quality of care, efficiency of care, and productivity. Collier and colleagues likewise developed a rheumatology-specific tool with a disease activity calculator (DAS-28) integrated into their EHR (24). In that study, most physicians were satisfied with the application and reported that use of the calculator and visualizing trends of disease activity improved patient care. Our initiatives were unique because our IT tools were designed within the EHR rather than in a 3rd party application.

Our study illustrates how quality improvement involving health-IT evolves in stages, with an initial focus on technical feasibility and subsequent attention to culture and clinical workflows. Before the first initiative, it was not technically possible to capture crucial RA measures in structured fields within the EHR, and there was no process for collecting patient reported outcomes such as the patient global assessment score, leaving each provider with a highly inefficient and cumbersome workflow for measuring disease activity. A few providers already used a free-standing application to calculate CDAI scores, and had asked for a delicate way to import the scores into the clinical note. After discussing the rationale behind routine assessment of disease activity as a new quality measure in RA at faculty meetings, it was decided to pursue this through technical alterations to the EHR. The large increase in documentation seen after implementation of the first initiative, therefore seems to suggest an evident, untapped potential, i.e. the clinic was ripe for a technological update. Once capturing the CDAI became technically possible, we were able to maintain gains with changes to the clinic culture – peer performance reports sent out by the clinic leader on a regular basis highlighted how important this activity was for all providers, emphasizing individual provider accountability. Additional modifications, with introduction of the Epic SmartForm and changes to clinic workflows solidified a culture of measurement by improving provider efficiency and ultimately satisfaction. The Consolidated Framework for Implementation Research (CFIR) suggests that many factors influence the adoption and maintenance of an initiative: the outer setting (events happening outside a practice that influence change, such as pay-for-performance programs incentivizing performance on nationally-endorsed quality measures); the inner setting (specific characteristics of the practice itself); initiative characteristics (adaptability, complexity of the EHR flowsheets and SmartForms); implementation process (planning and evaluation activities); and individuals within the practice (their beliefs and readiness for change) (25). The combination of the three initiatives described here may have been successful in improving performance of disease activity measures because in aggregate they addressed each of these components.

Interestingly, following implementation of our last initiative (EHR optimization with SmartForm), we detected a small but significant decrease in disease activity documentation. This might have been because providers needed to adapt to new EHR functionality, including a new EHR-based homunculus. With the SmartForm, the providers additionally had to learn a new, more complex electronic workflow, and this might not have been immediately prioritized in a busy clinic. This phenomenon has been described previously,

and could have accounted for the temporary decline in documentation rate (26, 27). After this brief decline, documentation increased again, possibly because providers gained familiarity and noted efficiency gains with the new tool.

The active phases of the initiatives occurred over a 5.5-year period, which reflects some of the challenges of doing quality improvement work in an academic environment. First, we had limited resources for EHR programming, which resulted in our having to wait in a queue to gain access to an implementation engineer to make changes to the EHR. After waiting, we were able to implement rapid PDSA cycles, although our time with the engineer was limited. Second, although our center has a handful of full-time providers, many of our faculty and fellows have just 1 half day of clinic each week, and may see just 3–5 patients during a given session, only a subset of whom would be RA patients. Cycles to change workflows thus required we found a day with multiple providers and multiple RA patients to inform them of changes and solicit input.

Despite sustained improvements in disease activity measure performance, we observed no parallel improvements in clinical outcomes as measured by CDAI scores. This demonstrates that recording CDAI scores is not, by itself, sufficient to improve disease outcomes, and that a more comprehensive treat-to-target program is needed to affect change in clinical outcomes (28). Such a program could include personalized specification of a disease activity target; effective visualization of disease activity levels and targets for both patients and providers; utilization of interprofessional teams to identify and provide more intensive care to patients who would benefit from tighter disease control; greater use of shared decision making when medication changes are required (29).

Although this study provides important insights into health-IT modifications to improve disease activity measure performance, there are limitations that should be considered. We did not have a control group of providers in our clinic who were not exposed to the interventions, so it is possible that disease activity documentation could have increased over time without our initiatives (17, 30). However, our ITS analysis still addresses important threats to internal validity, because the documentation levels and trends of the pre-intervention periods serve as a control for the post-intervention period. In addition, patients could enter the denominator for the study based on having at least 2 ICD codes for RA. We reviewed a random sample of 36 charts from the study period (June 2016) with at least 1 missing CDAI and found that 11% of these patients did not have a diagnosis of RA. For this reason, it is possible that we underestimated the proportion of RA patients with a CDAI collected. Finally, our work was performed in an academic rheumatology clinic, and may have limited generalizability to other settings where implementation of health IT interventions may be challenging.

In sum, modifications to the EHR, clinic culture, and clinical workflows proved to be effective in increasing performance of disease activity measures for patients with RA while improving provider satisfaction. Future work at our center will address whether the addition of a comprehensive treat-to-target program to our clinics can improve clinical outcomes.

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Appendix 1:: Detailed information about 3 quality improvement initiatives implemented in an academic rheumatology clinic.

Initiative 1 Jan. 2013	**EHR flowsheet and workflow changes**
	Background and objective: Very few providers in our clinic were routinely collecting disease activity scores. For the few that did, these scores were typed into the clinical notes and so were not readily inaccessible at future encounters or for population health management. Before the interventions discussed here, we did not have a built-in method to calculate the CDAI score, but as part of a research study, a research coordinator had built a third party application whereby through single and double clicks providers could designate tender and swollen joints on a homunculus, and by entering values for patient and physician global scores, a total score could be calculated. Our clinical faculty decided as a group to make routine disease activity score collection a priority. As a first step, we focused on 1. expanding the use of the third party CDAI calculator and 2. creating a way for disease activity and functional status to be entered as a structured field in the EHR. *Intervention:* With the clinical systems team of the health system, we built an Epic-based flowsheet that allowed providers to input and track disease activity scores using structured fields in the EHR. Workflow changes were made such that clerks handed out a single item questionnaire in the waiting room to collect patient global assessments; nursing staff entered the patient global assessment into a template in the EHR; providers entered the remaining CDAI components into a 3rd party application available on the desktop of all clinic computers. This application calculated the total CDAI score and the provider would subsequently manually enter the total score into a structured template (“flowsheet”) within the EHR. *Targeted providers:* The initial intervention targeted all providers in the clinic, including faculty and fellows. We held several division-wide education seminars on treat to target, the value of disease activity collection, and upcoming changes to national pay-for-performance programs (although our providers were not subject to financial incentives around disease activity collection). *PDSA cycles:* Although the process was somewhat cumbersome and required clicking in and out of the EHR and into the 3rd party application, this first step did make it possible for providers to input a disease activity score into a structured field into the EHR. For PDSA cycles, we experimented with workflows to appropriately identify RA patients in advance of their visits so clerks could collect patient global scores on the correct patients (RA visits now have a distinct designation for scheduling purposes). We educated fellows on the importance of using a treat-to-target strategy in the care of their RA patients and most full-time clinicians agreed to model this strategy for the fellows by reliably collecting a disease activity score. The active phase of this project lasted 6 months and involved multiple small tests of workflow changes as we implemented the EHR changes and championed adoption of the new workflows.
Initiative 2 February 2014	**Peer performance reporting**
	Background and objective: Despite the success of our first intervention, we saw wide variation in the collection of CDAIs across providers. As a group, we brainstormed about ways we could benchmark different provider performance on CDAI collection. *Intervention:* A monthly report was generated by a research coordinator in the clinic, by extracting data on all RA encounters from the EHR, including provider name and whether or not a CDAI was recorded. The report containing information on all providers and their individual CDAI performance was then disseminated by the rheumatology clinic chief to rheumatology providers via email. The report was un-blinded (names and performance were included), and showed a color-coded grid to indicate on-target (green or CDAI performed at >50% of encounters) or below-target (orange if CDAI performed 1–49% of encounters), or not performed at all (red). It allowed physicians to benchmark their performance against their peers. *Targeted providers*: We targeted faculty only for this intervention. *PDSA cycles:* The active phase of this project lasted 3 months as we made changes to the components and presentation of the reports, such as varying the time intervals for measurement.
Initiative 3 April 2016	**EHR optimization with a SmartForm**

Background and objective: Now that we had more buy-in and multiple providers reliably collecting CDAI, we focused on streamlining the process for inputting the CDAI by reducing the number of EHR clicks required.
Intervention: In a series of improvements to the existing CDAI flowsheet, which required exiting the note to enter information in a separate window, we implemented an Epic SmartForm, a structured template that could be embedded in the provider's note. The SmartForm included a homunculus tool to help clinicians document the location and number of tender and swollen joints and a CDAI score calculator that automatically called for information from the homunculus and other fields from the EHR (specifically, the patient global score, which was elicited by medical assistants and input into a flowsheet during the patient check-in to clinic). This replaced the 3rd party application that we had been using as part of Intervention 1. Finally, information from the SmartForm and CDAI calculation populated a "synopsis report" that allowed providers to display a graph of scores over time for each patient.
Targeted providers: Providers received education upon implementation on using the new tool, and the SmartForm was immediately available to both faculty and fellows. The performance report (initiative 2) was continuously sent out to keep motivating providers to document.
PDSA cycles: Once the new user interface was built, we piloted its use among 2 providers in the clinic before rolling out to all faculty and fellows. PDSA cycles consisted of testing a broad array of adjustments to the workflow and design of the SmartForm. Examples included different EHR location for accessing the SmartForm, the appearance of the Synopsis report, and how values flowed between the SmartForm and the documentation flowsheet. The active phase of this project lasted 6 months as we implemented the EHR changes and championed adoption of the new workflows.

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Significance and Innovations

- Applying treat to target strategies in the care of rheumatoid arthritis (RA) patients is critical for improving outcomes, yet electronic health records (EHRs) have few features to facilitate this strategy.
- We evaluated three health-IT initiatives designed to standardize the collection of RA disease activity measures in the EHRs.
- Modifications to the EHR, provider culture, and clinical workflows effectively improved capture of RA disease activity scores and physician satisfaction, but we did not see parallel gains in patients' disease activity levels.
- Capture of RA outcomes alone may not be sufficient to improve levels of disease activity without a comprehensive treat-to-target program.

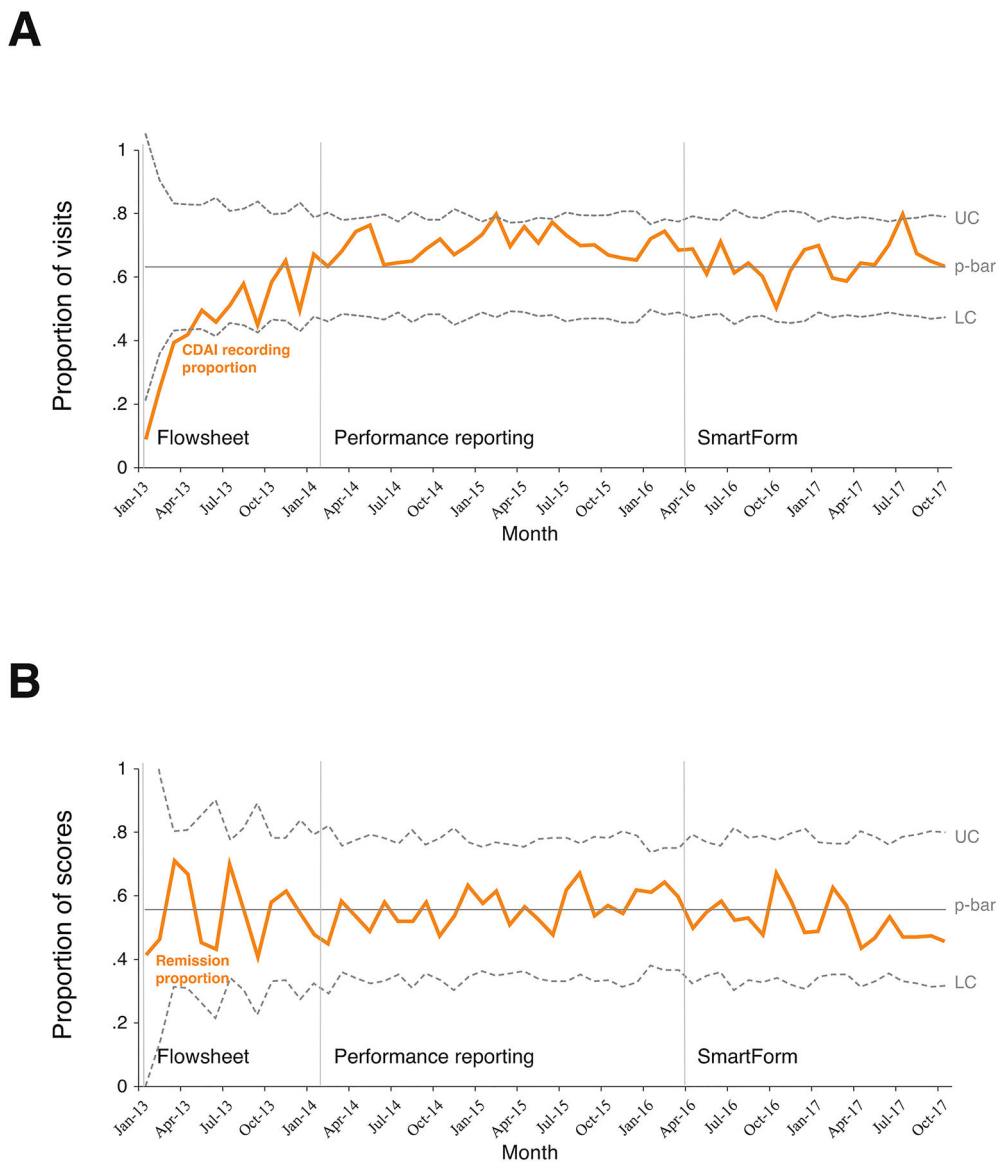

Figure 1.

P-charts showing A) the proportion of visits per month with a clinical disease activity index (CDAI) score documented in the electronic health record and B) the proportion of the documented CDAI scores in remission/low categories per month, during implementation of three quality improvement initiatives in an academic rheumatology clinic.

CDAI: Clinical Disease Activity Index

Vertical lines: Indicate onset of initiatives

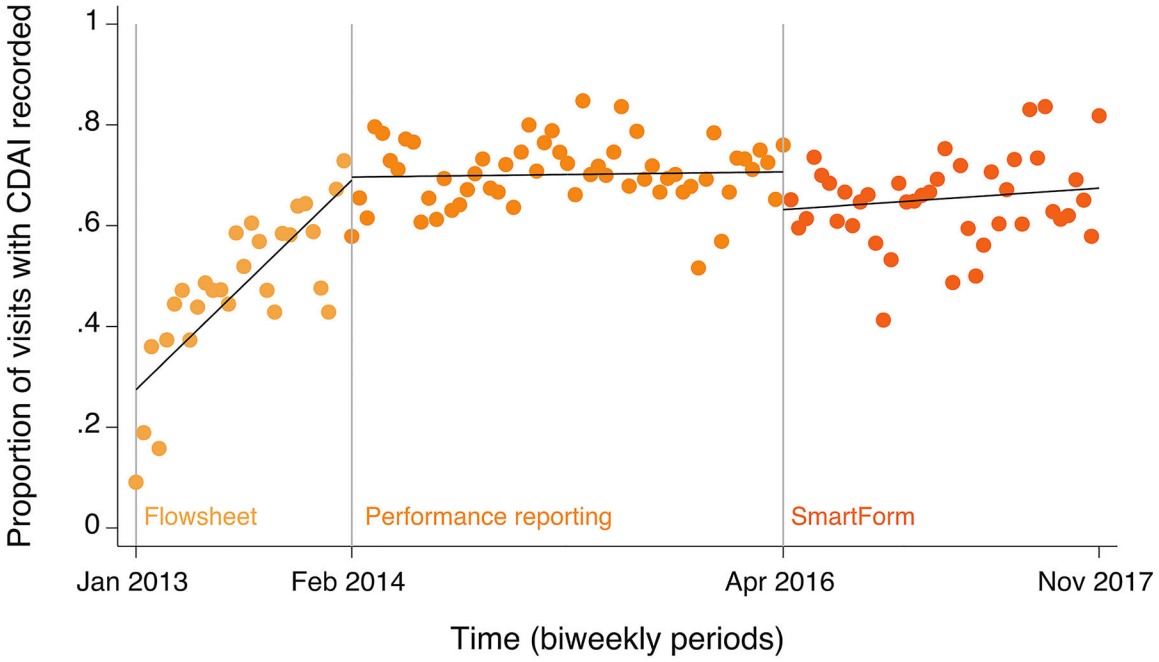

Figure 2.

Interrupted time series (ITS) analysis with mean proportion of CDAI scores recorded in the EHR in biweekly time periods after implementation of three quality improvement initiatives. UC: Upper confidence limit, LC: Lower confidence limit. P-bar: Overall mean of monthly proportion. CDAI: Clinical Disease Activity Index. Vertical lines: Indicate onset of initiatives

Table 1:

Characteristics of the rheumatoid arthritis clinic population.

	N=995 (%)
Age, mean (SD)	58.9 (15.9)
Gender, n (%)	
Female	815 (81.9)
Male	180 (18.1)
Race/ethnicity, n (%)	
Non-Hispanic White	508 (51.1)
African American	61 (6.1)
Asian	158 (15.9)
Hispanic	158 (15.9)
Other[a]	70 (7)
Missing[b]	40 (4)
Preferred language, n (%)	
English	871 (87.5)
Spanish	57 (5.7)
Chinese	41 (4.1)
Other	26 (2.7)
Charlson score, median (IQR)	1.0 (1.0, 2.0)
Insurance, n (%)	
Medicaid	138 (13.9)
Medicare	445 (44.7)
Private	412 (41.4)

N: Number; SD: Standard deviation, IQR: Interquartile range

[a]Includes “Mixed”

[b]Includes “Declined” and “Unknown/Declined”

Table 2:

Results from interrupted time series (ITS) analysis examining trends in CDAI score documentation rate after implementation of three quality improvement initiatives.

	Coefficient [95% CI]	P-value
Initiative 1: Flowsheet		
Level change	**28.1 [17.9, 38.4]**	**<0.001**
Post-intervention trend	**1.4 [0.7, 2.1]**	**<0.001**
Initiative 2: Performance Reporting		
Level change	4.0 [−6.2, 14.2]	0.441
Post-intervention trend	0.01 [−0.10, 0.1]	0.927
ΔTrend	**−1.4 [−2.1, −7.1]**	**<0.001**
Initiative 3: SmartForm		
Level	**−7.3 [−14.4, −0.1]**	**0.048**
Post-intervention Trend	0.1 [−0.1, 0.4]	0.427
ΔTrend	0.1 [−0.2, 0.4]	0.498

CI: Confidence interval.

ΔTrend: Change in trend after intervention compared to trend in previous intervention

Bold font: Indicates statistical significance

Table 3:

Generalized estimating equation (GEE) logistic regression model to account for individual-level factors and clustering by providers on documentation of CDAI scores.

	Unadjusted OR [95 % CI]	P	Adjusted OR[a] [95% CI]	P
Interventions				
1: Flowsheet	1.0 (ref)		1.0 (ref)	
2: Performance reporting	**2.28 [1.73, 2.10]**	**<0.001**	**2.10 [1.64, 2.70]**	**<0.001**
3: SmartForm	**1.77 [1.19, 2.65]**	**0.005**	**1.70 [1.13, 2.56]**	**0.010**

[a]Adjusted for age, preferred language, self-reported race/ethnicity, gender, Charlson score, and insurance category. Clustered on provider.

OR: Odds ratio, CI: Confidence interval

Bold font: Indicates statistical significance