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Variability in Glucocorticoid Prescribing for Rheumatoid Arthritis and the Influence of Provider Preference on Long-Term Use of Glucocorticoids

Michael D. George,[1] Joshua F. Baker,[2] Beth Wallace,[3] Lang Chen,[4] Qufei Wu,[1] Fenglong Xie,[4] Huifeng Yun,[4] and Jeffrey R. Curtis[4]

Objective. Glucocorticoids are recommended for short-term use in rheumatoid arthritis (RA), but many patients continue receiving long-term therapy. We evaluated the variability in glucocorticoid prescribing across rheumatologists to inform interventions to limit long-term glucocorticoid use to the lowest dose necessary.

Methods. Two cohorts were created using Medicare data from 2006 to 2015. Using cohort 1 (RA patients receiving disease-modifying antirheumatic drugs [DMARDs]), we calculated each rheumatologist's "provider preference" for glucocorticoids (frequency of use compared to other providers), using the ratio of observed to expected number of patients receiving glucocorticoids to account for case mix. In cohort 2 (RA patients receiving stable DMARD therapy), we evaluated whether provider preference for glucocorticoids could independently predict use of ≥5 mg/day of glucocorticoids 6–9 months after initiation of DMARD therapy.

Results. Using cohort 1 (1,272,644 yearly observations; 385,597 patients), we calculated provider preference among 6,875 rheumatologists (28,936 yearly observations). Provider preference was highly variable, with physicians at the lowest and upper quartiles prescribing glucocorticoids 33% less often to 31% more often (25th and 75th percentiles, respectively) than expected. In cohort 2 (155,539 patients receiving stable DMARD therapy), provider preference was strongly associated with glucocorticoid use ≥5 mg/day at 6–9 months, with a predicted probability of use of 22% (95% confidence interval [95% CI] 21.7–22.7) versus 11% (95% CI 10.2–10.9) for a patient seeing a provider in the highest versus lowest quintile of preference.

Conclusion. Glucocorticoid prescribing for RA varies greatly among rheumatologists, and provider preference is one of the strongest predictors of a patient's long-term glucocorticoid use. These findings raise quality of care concerns and highlight the need for stronger evidence to guide RA treatment.

INTRODUCTION

Glucocorticoids remain a common therapy for the treatment of patients with rheumatoid arthritis (RA). Several studies have demonstrated that the addition of low-dose glucocorticoids to therapy with disease modifying antirheumatic drugs (DMARDs) can improve patient outcomes (1–3), but glucocorticoids also carry risks, including infections, weight gain, diabetes mellitus, cardiovascular disease, and osteoporosis—especially at higher doses (4,5).

Although a number of observational studies suggest greater risk of infection even at glucocorticoid dose of 5 mg per day (6–11), the role of long-term, low-dose glucocorticoids in the treatment of RA remains controversial. Current guidelines from the American College of Rheumatology and the European Alliance of Associations for Rheumatology

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[1]Michael D. George, MD, MSCE, Qufei Wu, MS: University of Pennsylvania, Philadelphia; [2]Joshua F. Baker, MD, MSCE: University of Pennsylvania and Philadelphia Veterans Affairs Medical Center, Philadelphia, Pennsylvania; [3]Beth Wallace, MD: University of Michigan, Ann Arbor; [4]Lang Chen, PhD, Fenglong Xie, PhD, Huifeng Yun, PhD, Jeffrey R. Curtis, MD, MS, MPH: University of Alabama at Birmingham.

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Address correspondence to Michael D. George, MD, MSCE, Division of Rheumatology, 5 White Building, 3400 Spruce Street, Philadelphia, PA 19104. Email: michael.george@pennmedicine.upenn.edu.

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SIGNIFICANCE & INNOVATIONS

- Glucocorticoid prescribing for patients with rheumatoid arthritis varied widely among rheumatologists, even when considering differences in case mix.
- Patients who were seen by a rheumatologist who was a high glucocorticoid prescriber were substantially more likely to receive therapy with long-term glucocorticoids.
- Compared to other patient factors, provider preference for glucocorticoids was one of the strongest predictors of long-term glucocorticoid use.

recommend short-term use of glucocorticoids, preferably for <3 months, in patients starting or changing DMARD therapy (12,13). In contrast, German guidelines recommend starting glucocorticoid treatment at "low to moderately high" doses (e.g., 10–20 mg/day) along with methotrexate, tapering to the lowest possible dose, targeting doses of ≤7.5 mg/day within 3 months (14).

As many as 30–60% of patients with RA continue receiving long-term glucocorticoids (15–18). A number of patient-specific factors may lead to long-term glucocorticoid use, including refractory disease activity, worsening symptoms with glucocorticoid tapering, or inability or reluctance to take biologic therapies to control disease. Physician factors, however, may also play a role, and some physicians may be less aggressive in trying to taper therapy. Given continued controversy in the underlying risks of low-dose glucocorticoids, physicians may vary in their prescribing patterns and their tolerance of long-term glucocorticoid use in RA.

Given the uncertainty and controversy surrounding the safety and optimal role for low-dose glucocorticoids in RA, we hypothesized that there would be substantial variability in glucocorticoid prescribing patterns between providers. Identifying areas of high variability in practice highlights the need for stronger evidence to guide physicians and also suggests potential targets for quality improvement. Additionally, variability among providers may create a "natural experiment"—allowing the use of epidemiologic tools such as instrumental variable analysis to study glucocorticoid safety (19). In the present study, our goals were as follows: 1) examine variability in glucocorticoid prescribing among rheumatologists by developing a measure of "provider preference" for glucocorticoids, 2) identify provider factors associated with higher versus lower provider preference, and 3) test to what degree our measure of provider preference for use of glucocorticoids can predict a subsequent patient's long-term glucocorticoid use, beyond the 3–6 months of glucocorticoid "bridge therapy" commonly used to allow slower acting DMARDs to exert their full effect.

PATIENTS AND METHODS

This retrospective cohort study was conducted using Medicare claims data from 2006 to 2015. Medicare is a public health plan covering more than 90% of adults ages 65 years or older in the US. Younger individuals with disabilities (e.g., RA) may also be covered by Medicare (20). We created 2 separate cohorts of patients. First, we created a large cohort of patients with RA who were new or prevalent DMARD users (cohort 1) to develop our measure of provider preference for glucocorticoids based on how frequently a provider's patients were treated with glucocorticoids relative to other providers. Then we created a smaller cohort of patients with RA who had been receiving stable DMARD therapy for ≥9 months (cohort 2) to test to what degree provider preference for glucocorticoids could predict long-term glucocorticoid use independent of patient factors.

Cohort 1 (all RA cohort) and measuring provider preference for glucocorticoids. We created a measure of provider preference for glucocorticoids for each rheumatologist in the data set based on the prevalence of glucocorticoid use for the provider's RA patients in each calendar year. To do this, we identified the patients with RA seen by the rheumatologist within each calendar year, measuring preference separately in each year to allow preference to change over time. In each calendar year, we identified patients with ≥2 diagnoses for RA, as determined by an International Classification of Diseases, Ninth Revision (ICD-9) code of 714.x, recorded ≥7 days apart who either 1) filled a prescription or received an infusion of a biologic DMARD (bDMARD) or targeted synthetic DMARD (tsDMARD) or 2) filled a prescription for methotrexate and received no biologics or tsDMARDs during that year. Patients could be new users or prevalent users of their DMARD (i.e., received DMARDs in the previous calendar year). We excluded patients with diagnoses of psoriatic arthritis (PsA), ankylosing spondylitis (AS), inflammatory bowel disease (IBD), or systemic lupus erythematosus (SLE) during that calendar year and required that patients have ≥180 days of available follow-up after the first filled prescription or infusion. Patients were considered glucocorticoid users if they received a ≥30 day supply of glucocorticoids within 90 days of the first bDMARD/tsDMARD or methotrexate prescription of that year, based on filled prescriptions for oral prednisone, prednisolone, or methylprednisolone. Patients could contribute observations to each qualifying calendar year but had to meet the same inclusion/exclusion criteria described above each year.

For each patient, we identified the treating rheumatologist using the National Provider Index number from the most recent rheumatology outpatient visit (Medicare provider type 66) prior to the first bDMARD/tsDMARD or methotrexate prescription of the year that included an RA diagnosis. We then defined each individual rheumatologist's preference for glucocorticoids for any year in which they treated at least 10 qualifying RA patients (to enable stable preference estimates) in that year. Preference was

recalculated each year, which allowed a provider's preference to change over time. Provider preference was defined as the ratio of the observed number of patients with RA receiving glucocorticoids compared to the expected number of patients with RA receiving glucocorticoids, based on each physician's case mix. To obtain the expected number, we predicted each patient's probability of receiving glucocorticoids based on a predefined set of patient characteristics and then summed the predicted probabilities for the patients seen by each provider.

Predicted probability of receiving glucocorticoids was calculated by including all patients in a logistic regression model with glucocorticoid use as the outcome and covariates including age, sex, race, calendar year, type of DMARD, receipt of a new bDMARD/tsDMARD, methotrexate, or other conventional synthetic DMARD (csDMARD) in the preceding 3 months (capturing new use versus prevalent use), Charlson comorbidity index score, and each individual component comorbidity from the preceding year (including chronic obstructive pulmonary disease [COPD]). The coefficients from this model were then used to calculate the predicted probability of glucocorticoid use for each patient based on the patient's characteristics. In this analysis, we aimed to include a limited set of commonly available patient factors and did not include measures of health care utilization or use of other medications, such as opioids, that are likely also to vary substantially across providers.

Cohort 2 (stable DMARD RA cohort) and evaluating ability of provider preference to predict a patient's long-term glucocorticoid use. To determine to what degree provider preference could predict glucocorticoid use in a patient with RA receiving stable DMARD therapy, we identified a separate cohort of patients. Patients included in this cohort had ≥2 diagnoses of RA ≥7 days apart, had initiated a bDMARD/tsDMARD or methotrexate without a bDMARD/tsDMARD, and had continued receiving their DMARD continuously for at least 9 months (no new bDMARD/tsDMARD initiation and no gaps in DMARD therapy of >90 days). Index date was defined as the date 6 months after initiation of DMARD course. All patients were required to have 6 months of preceding data before the DMARD course date—this 6-month period and the first 6 months of the DMARD course were the baseline period. We excluded patients with PsA, AS, IBD, SLE, malignancy, or HIV during the baseline period and also measured covariates during this window.

The primary outcome of interest was an average glucocorticoid dose of ≥5 mg/day in the 3 months after the index date (6–9 months after DMARD initiation) based on filled prescriptions for oral prednisone, prednisolone, and methylprednisolone (Figure 1). The treating rheumatologist was again identified based on the last outpatient visit with a rheumatologist that included a diagnosis of RA before the index date. The provider preference for glucocorticoids for this rheumatologist was obtained from the larger cohort after subtracting out the contribution of the patient of interest, to ensure patients were not contributing to their own provider preference measure. As a sensitivity analysis, we also evaluated alternative outcomes—any glucocorticoid use of ≥10 mg/day and glucocorticoid use of any dose.

We used multivariable logistic regression analysis to determine whether provider preference for glucocorticoids (observed/expected ratio divided into quintiles) could predict use of ≥5 mg/day of glucocorticoids 6–9 months after DMARD initiation, adjusting for a comprehensive set of covariates, including demographic and clinical characteristics (age, race, sex, year, region, urban versus rural residence, skilled nursing facility residence, zip code–based median household income, number of previous biologics, type of DMARD use, use of nonsteroidal anti-inflammatory drugs, opioids, and antibiotics in the 90 days before

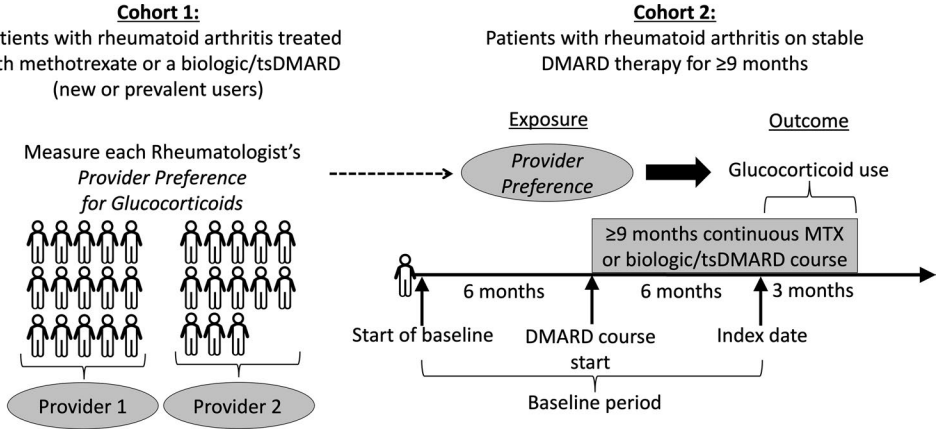

Figure 1. Study design. In cohort 1 (all rheumatoid arthritis [RA] cohort), provider preference for glucocorticoids for each rheumatologist was determined by evaluating all qualifying patients with RA seen by a rheumatologist in a given year and dividing the observed number of the rheumatologist's patients who received glucocorticoids by the expected number of patients receiving glucocorticoids based on patient characteristics. In cohort 2 (stable receiving disease-modifying antirheumatic drug [DMARD] RA cohort), we evaluated patients with RA with at least 9 months of continuous treatment with methotrexate (MTX) or a biologic DMARD/targeted synthetic DMARD (tsDMARD) and 6 months of preceding data before DMARD course initiation to determine whether the treating rheumatologist's provider preference for glucocorticoids was independently associated with glucocorticoid use in the 3 months after the index date (6–9 months after starting the DMARD course).

the index date), comorbidities (Charlson comorbidity index score, diabetes mellitus, hypertension, chronic kidney disease, COPD, asthma, cerebrovascular disease, obesity, congestive heart failure, coronary artery disease, peptic ulcer disease, extraarticular RA, anemia, myocardial infarction, depression, and chronic pain), and medical history (number of outpatient visits, rheumatology visits, hospitalizations, infections that required hospitalization, and emergency department visits in the past year; also, use of durable medical equipment and cancer screening). Analysis was clustered by patient to account for patients contributing observations in multiple years. Because some patients receiving methotrexate may not have been receiving "stable" DMARD therapy due to dose increases or addition of other csDMARDs, we also conducted a sensitivity analysis limited to patients receiving continuous bDMARD/tsDMARD therapy.

Provider characteristics associated with greater glucocorticoid prescribing. Provider characteristics (sex, practice type, employment, years in practice, US medical school graduate, region, years in practice) were identified using the 2017 American Medical Association (AMA) Physician Masterfile (21). We used a multivariable generalized estimating equation model with an exchangeable correlation structure to evaluate associations between provider characteristics and likelihood of having a higher provider preference for glucocorticoid use. We defined "higher" provider preference first as an observed/expected preference of >1 (observed number of RA patients receiving glucocorticoids greater than expected number based on case mix). We then alternatively defined a higher glucocorticoid prescriber as prescribers with an observed/expected preference for prescribing glucocorticoids in the >80th percentile (top quintile) versus the ≤80th percentile. Results are expressed as the median (interquartile range [IQR]) or as odds ratios (ORs) (95% confidence intervals [95% CIs]).

RESULTS

Identifying provider preference for glucocorticoids (cohort 1 [all RA cohort]). We identified 385,597 patients contributing to 1,272,644 yearly observations, with 56.3% receiving a bDMARD/tsDMARD and 43.7% receiving methotrexate without a bDMARD/tsDMARD during a given year. Of these observations, 1,204,836 (94.7%) were associated with a rheumatologist who saw at least 10 qualifying patients during that calendar year. In total, 6,875 unique providers saw at least 10 qualifying RA patients (median 32 RA patients [IQR 18–54 RA patients]) and contributed 28,936 yearly observations.

The distribution of provider preference for glucocorticoids is shown (Figure 2), with observed/expected measures of glucocorticoid use ">1" indicating more use than expected based on patient characteristics in that rheumatologists' practice, and observed/expected measure "<1" indicating less use than expected. Provider preference was highly variable, with an IQR of 0.67 (33% lower prescribing than expected) to 1.31 (31% greater prescribing than expected). The median observed proportion of

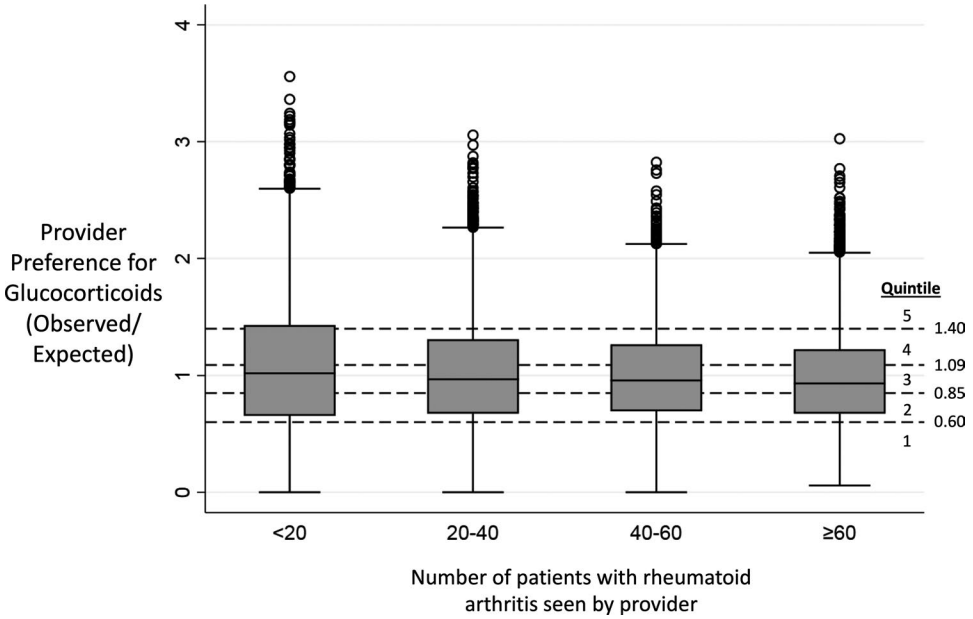

Figure 2. Variability in provider preference for glucocorticoids, assessed among rheumatologists seeing at least 10 patients with rheumatoid arthritis in a given calendar year. An observed/expected measure of ">1" represents greater glucocorticoid prescribing than expected based on patient characteristics, while a measure of "<1" represents lower prescribing (e.g., 1.4 = 40% more glucocorticoid prescribing than expected based on patient characteristics). Data are shown as box plots. Each box represents the upper and lower interquartile range. Lines inside the box represent the median. Whiskers represent the range for providers seeing 10–20, 20–40, 40–60, or >60 qualifying patients. Circles indicate outliers. Broken horizontal lines indicate the values of provider preference separating the 5 quintiles of provider preference.

a rheumatologist's patients receiving glucocorticoids was 24.3% (IQR 16.7–33.3%). While variability among physicians seeing a small number of patients (i.e., <20 patients) may be expected due to imprecision in measurement, variability remained high even among rheumatologists seeing a large number of patients (Figure 2). The correlation between provider preference for glucocorticoid use within each rheumatologist's practice was relatively strong from year to year (r = 0.66 for consecutive years).

Provider preference and other predictors of glucocorticoid use in patients receiving stable DMARD therapy (cohort 2 [stable DMARD RA cohort]). We identified 197,352 treatment episodes among 149,857 unique patients with RA who received stable DMARD therapy for at least 9 months. For 155,539 of these treatment episodes (among 120,660 patients), there was an identifiable rheumatologist who had seen ≥10 RA patients during that year in the larger data set. Glucocorticoids were received 6–9 months after DMARD course initiation in 45.3% of patients (median dose of 4.2 mg/day), with 16.4% of patients receiving ≥5 mg/day and 3.4% receiving ≥10 mg/day. Select patient characteristics are shown in Table 1, comparing patients who received ≥5 mg/day versus <5 mg/day of glucocorticoids.

Patients seeing rheumatologists with a higher provider preference for glucocorticoids were more likely to receive ≥5 mg/day of glucocorticoids, independent of other patient characteristics (OR 2.51 [95% CI 2.39–2.63] for highest quintile of preference versus lowest quintile) (a full model is shown in Supplementary Table 1, available on the *Arthritis Care & Research* website at

Table 1. Select characteristics of patients with RA receiving stable DMARD therapy*

	None to <5 mg/day of GCs 6–9 months after DMARD course initiation (n = 85,011)	≥5 mg/day of GCs 6–9 months after DMARD course initiation (n = 70,528)	SMD†
Age, mean ± SD years	69.0 ± 11.4	67.8 ± 11.8	−0.106
Female sex	105,660 (81.2)	19,540 (76.6)	−0.113
White	61,859 (47.6)	51,702 (202.8)	0.038
Methotrexate without bDMARDs/tsDMARDs	64,992 (50.0)	11,955 (46.9)	−0.062
TNF inhibitor	41,507 (31.9)	7,871 (30.9)	−0.023
Abatacept	12,696 (9.8)	2,727 (10.7)	0.031
Rituximab	5,897 (4.5)	1,648 (6.5)	0.085
Tocilizumab	3,766 (2.9)	997 (3.9)	0.056
Tofacitinib	1,186 (0.9)	297 (1.2)	0.025
Glucocorticoid dose			
None	85,011 (65.4)	0 (0.0)	NA
<5 mg	45,033 (34.6)	0 (0.0)	NA
5mg to <10 mg	0 (0.0)	20,173 (79.1)	NA
≥10 mg	0 (0.0)	5,322 (20.9)	NA
Prior biologics			
None	85,326 (65.6)	14,223 (55.8)	−0.202
1	30,960 (23.8)	7,150 (28.0)	0.097
2	9,782 (7.5)	2,714 (10.6)	0.109
≥3	3,976 (3.1)	1,408 (5.5)	0.122
NSAIDs	33,336 (25.6)	6,185 (24.3)	−0.032
Opioids	57,097 (43.9)	15,231 (59.7)	0.321
Charlson comorbidity index score, mean ± SD	2.3 ± 2.6	2.7 ± 2.8	0.166
Diabetes mellitus	27,819 (21.4)	5,834 (22.9)	0.036
Hypertension	75,086 (57.7)	15,369 (60.3)	0.052
Chronic kidney disease	9,971 (7.7)	2,437 (9.6)	0.067
COPD	14,769 (11.4)	4,486 (17.6)	0.178
Asthma	9,716 (7.5)	2,554 (10.0)	0.09
Obesity	12,437 (9.6)	2,910 (11.4)	0.06
Coronary artery disease	25,413 (19.5)	5,615 (22.0)	0.061
Anemia	29,091 (22.4)	6,997 (27.4)	0.118
Extraarticular RA	3,331 (2.6)	1,084 (4.3)	0.093
Hospitalization due to infection in the past year	11,097 (8.5)	3,844 (15.1)	0.204
Hospitalization in the past year	28,820 (22.2)	8,146 (32.0)	0.222

* Values are the number (%) unless otherwise indicated. bDMARDs = biologic disease-modifying antirheumatic drugs; COPD = chronic obstructive pulmonary disease; GCs = glucocorticoids; NA = not applicable; NSAIDs = nonsteroidal antiinflammatory drugs; RA = rheumatoid arthritis; tsDMARDs = targeted synthetic DMARDs; TNF = tumor necrosis factor.
† The standardized mean difference (SMD) is shown, with absolute values of >0.1 considered as potentially meaningful differences between groups.

http://onlinelibrary.wiley.com/doi/10.1002/acr.24382/abstract). Predicted probabilities of glucocorticoid use generated from this model are shown in Figure 3, with a more than two-fold difference in predicted use of ≥5 mg/day ranging from 10.6–22.2% for patients seen by physicians in the lowest versus highest quintile of provider. Results were similar in a sensitivity analysis restricted to patients receiving stable bDMARD/tsDMARD use (Supplementary Figure 1 and Supplementary Table 2, available on the *Arthritis Care & Research* website at http://onlinelibrary.wiley.com/doi/10.1002/acr.24382/abstract). Other factors associated with continued use of ≥5 mg/day of glucocorticoids included male sex, greater number of previous biologics, opioid use, recent antibiotic use, COPD, extraarticular RA, more frequent outpatient visits, previous hospitalization due to infection, previous emergency department visits, and absence of diabetes mellitus, hypertension, chronic kidney disease, or coronary artery disease. Glucocorticoid use was slightly less common in later years. Provider preference was also associated with receiving ≥10 mg/day of prednisone (OR 1.80 [95% CI 1.63–1.98] for highest quintile of preference versus lowest quintile of preference) and any dose of glucocorticoids (OR 3.14 [95% CI 3.03–3.26]) for highest quintile of preference versus lowest quintile of preference) (Supplementary Table 1). Older patients were more likely to receive any dose of glucocorticoid but less likely to receive higher glucocorticoid doses.

Physician characteristics associated with glucocorticoid prescribing. Using the 2016 AMA Masterfile data, we were able to identify physician characteristics for 4,019 providers contributing 24,124 (83.4%) provider-years. Characteristics of physicians are shown in Table 2. In a multivariable model, physicians who were female, part of a solo practice (versus a group practice), in practice for ≥10 years, and who saw a greater number of RA patients were less likely to be high glucocorticoid prescribers (observed/expected prescribing >1) (Table 3). Associations were similar when evaluating predictors of being in top 20th percentile of observed/expected glucocorticoid prescribing, except that solo practice was no longer associated with prescribing preference (Table 3).

DISCUSSION

In this large national cohort study, we created a measure of provider preference for using glucocorticoids for RA management that was adjusted for the case mix of each rheumatologist's practice. We found substantial variability in the prescribing of glucocorticoids among rheumatologists. Among a cohort of patients with RA receiving stable DMARD therapy, provider preference for glucocorticoids was one of the strongest predictors of continued glucocorticoid use at doses of ≥5 mg/day and also predicted higher dose use of ≥10 mg/day. In other words, seeing a provider who frequently treats other patients with RA with glucocorticoids makes it much more likely that a patient will receive long-term glucocorticoids, independent of all other measured patient and disease-related characteristics.

Our finding that glucocorticoid prescribing varies widely between rheumatologists is supported by several previous studies, each with different approaches. Significant variability in both glucocorticoid and DMARD prescribing during the first year after RA diagnosis has been described by Wallace et al (18). Black and colleagues examined general practitioners in the UK and defined

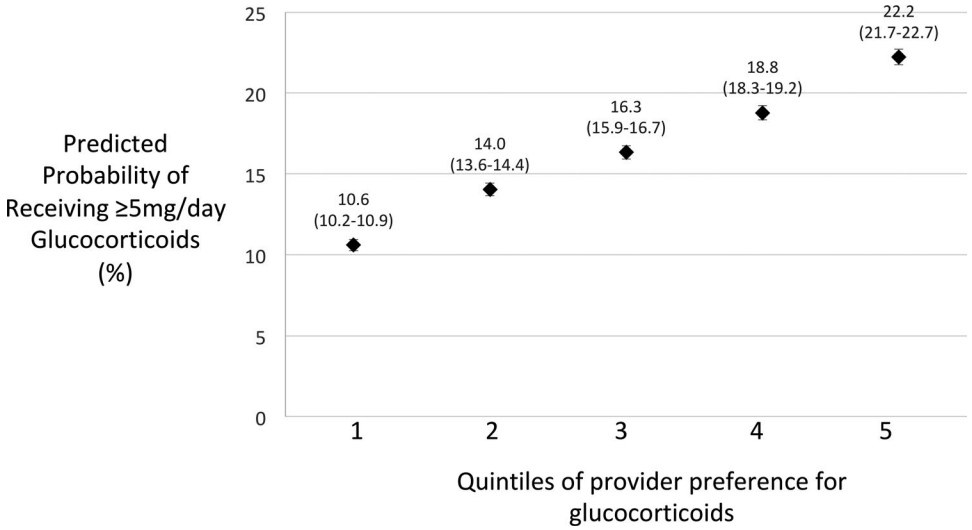

Figure 3. Impact of provider preference on glucocorticoid use in patients receiving stable disease-modifying antirheumatic drug (DMARD) therapy. Predicted probability of a patient receiving ≥5 mg per day of glucocorticoids in the 6–9 months after start of a stable DMARD course, generated from a logistic regression model (Supplementary Table 1, available on the *Arthritis Care & Research* website at http://onlinelibrary.wiley.com/doi/10.1002/acr.24382/abstract) based on the provider preference of the patient's rheumatologist and adjusted for patient demographic characteristics, DMARD type, other medication use, comorbidities, and health care utilization measures. 95% confidence intervals are shown in parentheses, with $P < 0.01$ between all groups.

Table 2. Characteristics of included rheumatologists based on the 2016 American Medical Association Survey*

	Rheumatologists (n = 4,019)
Female sex	1,480 (36.8)
Type of practice	
Office	3,056 (76.0)
Hospital staff	340 (8.5)
Other	623 (15.5)
Employment	
Group practice	2,315 (57.6)
Solo practice	791 (19.7)
Medical school	84 (2.1)
Local government	281 (7.0)
Federal government	481 (12.0)
US medical school graduate	2,746 (68.3)
Region	
Northeast	903 (22.5)
Midwest	881 (21.9)
South	1,451 (36.1)
West	784 (19.5)
Years in practice, %†	
<10 years	17.8
10–29 years	52.6
≥30 years	30.3
Number of qualifying patients with RA treated, %†	
<20	27.0
20–40	32.8
40–60	18.2
≥60	22.0

* Values are the number (%) unless otherwise indicated. RA = rheumatoid arthritis.
† Years in practice and number of qualifying Medicare patients could vary within a provider in different years. Percentages shown are the proportion of provider-year observations (n = 24,124) with these characteristics.

provider preference based on the average proportion of time a physician's patient received glucocorticoids (22). Criswell and Redfearn analyzed a longitudinal panel of RA patients and also found significant variability in glucocorticoid prescribing among the 63 included rheumatologists that persisted after adjusting for patient factors (23). Two aspects of our approach represent an important advance over these prior studies. First, we allowed provider preference to differ from year to year, recognizing that practice patterns can change over time. Second, recognizing that case mix may vary between rheumatologists, we created a measure of provider preference that accounts for differences in the demographic characteristics and comorbidities of a physician's RA patient panel. Even after accounting for variation over time and differences in case mix, we observed a wide range of glucocorticoid prescribing patterns across thousands of providers that likely included the majority of practicing rheumatologists in the US. Although our data was restricted to 2006–2015, reductions in glucocorticoid use over this time frame were small, and results are expected to be similar after 2015.

An additional unique feature of our study is the evaluation of how our provider preference measure can predict long-term glucocorticoid use in a separate cohort of patients with RA receiving stable DMARD therapy, excluding patients with more refractory disease who continued to undergo changes in their RA treatment regimen. Despite the fact that many current RA treatment guidelines recommend only short-term use of glucocorticoids as bridging therapy (12,13), nearly 1 in 6 patients continued to receive ≥5 mg/day of glucocorticoids 6–9 months after starting methotrexate or a new bDMARD or tsDMARD. The predictive ability of our measure of provider preference remained robust even after adjustment for patient factors previously shown to predict glucocorticoid use (22,24,25). Notably, our measure of provider preference was one of the factors most strongly associated with long-term glucocorticoid use. Interestingly, while provider preference was associated with higher dose glucocorticoids ≥10 mg/day, we found even stronger associations with long-term low-dose use—an area of substantial controversy.

Rheumatologists who were male, in practice for less than 10 years, and who saw a smaller number of RA patients were more likely to be high glucocorticoid prescribers. While it is interesting that physicians with more clinical experience, both in terms of years and RA patients seen, tended to be lower prescribers, these associations were modest in magnitude. It is also possible that the types of patients without RA seen by a rheumatologist influence glucocorticoid prescribing for patients with RA, although examining broader practice patterns was beyond the scope of this study.

Identifying high variability in glucocorticoid prescribing has important implications. Areas of high practice variability can identify potential targets for quality improvement and highlight the need for stronger evidence to guide practice. In the absence of clear evidence on who should continue to receive low-dose glucocorticoids beyond 6 months after starting a new DMARD or biologic, we cannot say definitively whether our results reflect overuse of glucocorticoids by some providers, underuse by some providers, or both. It is notable, however, that provider preference was also strongly associated with continued glucocorticoid use of ≥10 mg/day, which is known to carry higher risks and is part of established quality metrics (26). Additionally, our finding that a patient's likelihood of receiving glucocorticoids is highly dependent on the provider they see creates a "natural experiment"—provider preference may be a potential instrumental variable for future pharmacoepidemiologic studies of glucocorticoid safety that have the potential to better address unmeasured confounding (19,27).

Several limitations of the present study are important to note. Some of the measured variability in provider preference may be the result of variability in the severity or refractoriness of the provider's patient panel, which we could not directly measure in these data. We could not directly measure disease activity, which is known to strongly predict glucocorticoid use, but our measure of provider preference was adjusted for expected use based on variables available in administrative data. Additionally, provider preference strongly predicted glucocorticoid use even after adjustment for measures of health care utilization, use of durable medical equipment, opioid use, current biologic use, and

Table 3. Physician characteristics associated with higher glucocorticoid prescribing versus lower glucocorticoid prescribing*

	Observed/expected >1, OR (95% CI)	Top quintile (>80th percentile) of observed/expected, OR (95% CI)
Female physician	0.81 (0.73–0.90)†	0.73 (0.64–0.82)†
Practice type		
Office	Ref.	Ref.
Hospital staff	1.05 (0.77–1.42)	0.93 (0.66–1.32)
Other	1.19 (1.02–1.38)†	1.16 (0.97–1.39)
Employment		
Group practice	Ref.	Ref.
Solo practice	0.83 (0.74–0.94)†	0.99 (0.85–1.15)
Medical school	1.28 (0.90–1.83)	1.11 (0.74–1.64)
Local government	0.95 (0.70–1.29)	1.10 (0.77–1.56)
Federal government	1.03 (0.66–1.60)	0.92 (0.54–1.56)
Other	1.00 (0.84–1.19)	1.08 (0.88–1.32)
Years in practice		
<10	Ref.	Ref.
10–30	0.81 (0.74–0.88)†	0.80 (0.73–0.89)†
≥30	0.88 (0.78–0.99)†	0.84 (0.73–0.96)†
US medical school graduate	0.92 (0.83–1.02)	1.00 (0.88–1.13)
Region		
Northeast	Ref.	Ref.
Midwest	1.09 (0.94–1.25)	1.14 (0.96–1.35)
South	1.11 (0.97–1.26)	1.20 (1.03–1.39)†
West	0.89 (0.77–1.03)	0.92 (0.77–1.10)
Number of qualifying Medicare patients with RA seen in year		
10–20	Ref.	Ref.
20–40	0.85 (0.79–0.90)†	0.71 (0.66–0.77)†
40–60	0.80 (0.73–0.87)†	0.52 (0.47–0.58)†
≥60	0.78 (0.71–0.85)†	0.44 (0.39–0.49)†
Calendar year	1.00 (0.99–1.01)	1.01 (1.00–1.03)†

* Results from two separate multivariable logistic regression models, first evaluating physician associations with an observed/expected measure of glucocorticoid prescribing of ">1" (observed prescribing greater than expected based on patient characteristics), and then physician characteristics associated with being in the top 20th percentile of glucocorticoid prescribing preference based on the observed/expected measure. The observed/expected measure was defined as observed glucocorticoid prescribing divided by expected glucocorticoid prescribing. 95% CI = 95% confidence interval; OR = odds ratio; RA = rheumatoid arthritis; Ref. = reference.
† Statistically significant at $P < 0.05$.

number of previous biologics. Misclassification of glucocorticoid use is possible—some patients may have filled a prescription only for short-term use for flares, may have filled a prescription and not taken it, may have received intramuscular glucocorticoids (not captured in this study), or may have received glucocorticoids for other indications (e.g., COPD, acute bronchitis) or from a non-rheumatologist provider. While these factors could increase prescribing variability, they would be hypothesized to reduce the degree to which provider preference could predict glucocorticoid use. We only had information about a provider's Medicare patients, who might be more likely to receive glucocorticoids, and it is uncertain whether provider behavior would be similar in the treatment of younger, healthier patients with other insurance coverage. The impact on provider preference on glucocorticoid use in younger patients with RA may also differ. Additionally, we recognize that rheumatologists are increasingly reliant on working with advanced practice providers (i.e., physician assistants and nurse practitioners), and these individuals may be the prescribers of glucocorticoids in some cases. While our study included a large number of rheumatologists in the US, behavior could be different among providers seeing only a small number of patients with RA (these physicians were excluded from the present study) or among physicians in other countries. Finally, we measured actual glucocorticoid prescription fills, and it is possible that rheumatologists unsuccessfully attempted to taper glucocorticoid therapy. Unlike a registry or some electronic medical record data systems, administrative claims data are not able to capture the intent to change RA treatments, but only records whether treatment changes were actually made.

In conclusion, there is large variability among rheumatologists in the prescribing of glucocorticoids for patients with RA, highlighting the need for stronger evidence to guide treatment decisions. Rheumatologists who are younger or see fewer RA patients are more likely to use glucocorticoids. A physician's preference for glucocorticoids is one of the strongest predictors that a patient will receive long-term glucocorticoids.

AUTHOR CONTRIBUTIONS

All authors were involved in drafting the article or revising it critically for important intellectual content, and all authors approved the final version to be published. Dr. George had full access to all the study data and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study conception and design. George, Baker, Curtis.
Acquisition of data. George, Chen, Wu, Xie, Yun, Curtis.
Analysis and/or interpretation of data. George, Baker, Wallace, Yun, Curtis.

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