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Geographic Socioeconomic Influences on Disease Activity in Rheumatoid Arthritis in an Academic and Safety Net Hospital System

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Objective. The objective of this study was to analyze the impact of the Area Deprivation Index (ADI) on disease activity and cardiovascular comorbidity in rheumatoid arthritis (RA).

Methods. A retrospective analysis of adult patients with RA was conducted to highlight differences in academic and safety net hospital clinics. Demographics, RA medication history, patient portal engagement, primary care presence, emergency or inpatient visits, RA disease activity and functional scores, Charlson Comorbidity Index (CCI), and cardiovascular disease (CVD) presence were captured. The ADI rank was assigned using nine-digit zip codes. Patients were stratified by the upper versus lower ADI decile group and matched by age, sex, race, ethnicity, insurance, and CCI using propensity score analysis.

Results. Patients with RA from the academic practice (n = 542) and the safety net hospital (n = 496) were assessed. In the academic cohort, those with high ADI scores (>8, more deprivation) had higher RA disease activity scores (Routine Assessment of Patient Index Data 3 mean ± SD: high 13.83 ± 6.94 vs low 11.17 ± 7.37, $P < 0.0001$; Clinical Disease Activity Index mean ± SD: high 11.97 ± 11.74 vs low 9.40 ± 7.97, $P < 0.05$), more functional impairment (Multidimensional Health Assessment Questionnaire mean ± SD: high 2.99 ± 2.29 vs low 2.34 ± 2.23, $P < 0.01$), lower MyChart use ($P < 0.001$), and different smoking history ($P < 0.01$) compared to those with low ADI scores (<3, less deprivation). In the safety net cohort, there was a statistically significant difference only in smoking status ($P < 0.05$). CVD was not significantly different in either cohort.

Conclusion. The absence of differences in RA disease activity and functional impairment in patients suggests that the ADI may not be as effective at predicting RA disease activity specifically in a safety net health care context. Identifying the discrepancies between the two systems may elucidate areas of improvement for patient care.

INTRODUCTION

Rheumatoid arthritis (RA) is a complex condition associated with impairments in quality of life and comorbidities such as premature cardiovascular disease (CVD)[1–4] due to RA-related and traditional risk factors.[1,5,6] In recent years, data from several countries, including the United States, suggest decreasing trends in all-cause and CVD mortality in RA.[7–10] Not all studies have confirmed this, however. The United Kingdom's Norfolk Arthritis Registry did not find differences in all-cause or CVD mortality when comparing RA cohorts from 1990s to those from the 2000s,[11,12] raising questions regarding local lived environment differences. The effects of neighborhood socioeconomic status (SES) have not been well studied in the context of RA disease activity and cardiovascular comorbidities, although accumulating data suggest that socioeconomic influences are the primary drivers of health disparities in RA.[13–16]

There have been numerous approaches to quantifying the socioeconomic effects on RA. SES has been shown to be a predictor in developing RA.[17] Patients with RA from a lower SES have longer wait times for starting therapies, lower adherence to medications, higher disease activity and functional scores, and more joint damage[13,15,18] and are less likely to take anti–tumor

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SIGNIFICANCE & INNOVATIONS

- Patients from neighborhoods experiencing higher deprivation as predicted by the Area Deprivation Index experienced higher rheumatoid arthritis (RA) disease activity in the academic hospital cohort but not in the county safety net hospital cohort.
- Hospital-specific factors may diminish the efficacy of area-based socioeconomic markers in stratifying RA disease activity burden.

necrosis factor biologics and more likely to be taking steroids.[18] These studies have demonstrated the importance of identifying socioeconomic risk factors that may impact RA. However, identifying a feasible and accurate marker for SES that can be used efficiently and broadly continues to remain a challenge.

The Area Deprivation Index (ADI), a metric created in 2003 using 17 US census–derived parameters that measures socioeconomic disadvantage in the United States, presents a unique opportunity to investigate these questions within a safety net hospital and an academic practice. The primary advantage of the ADI is in capturing data that would otherwise entail a lengthy social history. The ADI has been used to study a wide array of diseases.[19,20] One recent study found that patients with RA from the national Rheumatology Informatics System for Effectiveness (RISE) registry with lower neighborhood SES denoted by high ADI scores performed worse on functional and disease activity assessments and had a higher probability for functional decline over time.[21] However, there is still uncertainty about the utility of the ADI when applied at the level of individual hospitals. The ADI was used to investigate the impact of neighborhood socioeconomic deprivation on RA, specifically examining its impact on cardiovascular comorbidity and RA disease activity. This study aimed to determine whether the ADI can predict differences in health outcomes at an academic practice and a safety net hospital.

PATIENTS AND METHODS

Study population. Patients eligible in this retrospective analysis were aged 18 to 89 years old and had a primary visit diagnosis of RA (*International Statistical Classification of Diseases and Related Health Problems, Tenth Revision* [ICD-10] codes: M05x, M06x, M08x) from January 1, 2015, to January 1, 2021, at the university academic practice or the county safety net hospital rheumatology clinics. These practices serve patients from the Dallas–Fort Worth metroplex and beyond. Data were collected on age, ethnicity (Hispanic, non-Hispanic, unknown), race (White, Black, Asian, other), sex, primary insurance plan at time of visit (Medicaid or charity care, Medicare or commercial, unknown), language, address, smoking status (ever, never), patient health portal engagement (active, inactive), primary care physician presence at time of visit, emergency or inpatient visits over five years, history of being prescribed RA medications (ever, never) (Supplemental Table 1), Charlson Comorbidity Index score (CCI; range 0–37), and CVD presence. RA medications included targeted synthetic, biologic, and conventional synthetic disease-modifying antirheumatic drugs (DMARDs). The most recent RA disease activity scores were captured via the Clinical Disease Activity Index (CDAI; range 0–76) and the Routine Assessment of Patient Index Data 3 (RAPID3; range 0–30). Functional impairment scores were assessed via the Multidimensional Health Assessment Questionnaire (MDHAQ; range 0–10) and the Health Assessment Questionnaire II (HAQ-II; range 0–3). At the academic practice, medication prescription information was captured for both internal and local pharmacies. However, at the safety net hospital, only prescriptions filled at the safety net hospital internal pharmacies were captured. Thus, direct comparisons could not be made between hospital systems for medications. EPIC electronic health record (EHR) data goes back to 2009. CCI scores were calculated via coding algorithms using age and ICD codes from the following categories: myocardial infarction, peripheral vascular disease, cerebrovascular disease, dementia, chronic pulmonary disease, rheumatic disease, peptic ulcer disease, mild and severe liver disease, diabetes with and without complications, hemiplegia and paraplegia, renal disease, malignancy and metastasis, and AIDS/HIV[22] (Supplemental Table 2). Patients were determined to have a CVD comorbidity by the presence of any of the following diagnoses in the patient's medical history or problem list: coronary bypass surgery, percutaneous intervention, coronary artery disease, cerebrovascular disease, heart failure, myocardial infarction, or peripheral vascular disease (Supplemental Table 2). The University of Texas Southwestern Institutional Review Board approved the minimal risk medical records study with a waiver of individual informed consent.

ADI. The ADI, refined and validated in 2018, is composed of 17 education, employment, housing characteristics, and poverty measures[23,24] and is published through the Neighborhood Atlas.[25] ADI values are available as national percentile ranks or state decile ranks. Each nine-digit zip code corresponds to both a national and state ADI rank. The national ADI rank ranges from 1 to 100, with 100 representing the highest disadvantage. Similarly, state ADI rank ranges from 1 to 10 for each respective state, with 10 indicating the highest disadvantage decile within that state. Each patient was assigned a state and national ADI rank based on their nine-digit zip code, obtained via SmartyStreets. Both hospitals provide care to patients residing in areas of high and low ADI (Supplemental Figure 2).

Outcome measures and statistics. In the first analysis, the exposure of interest was ADI deciles. The lower state ADI deciles (≤3 state, less deprivation) were compared against the upper state ADI deciles (≥8 state, most deprivation) in both the academic and safety net cohorts. Primary outcome variables

included CVD, CDAI and RAPID3 disease activity scores, and RA functional impairment as measured by MDHAQ and HAQ-II. Secondary outcome variables included patient portal use, primary care physician presence, primary language, smoking status, RA medication history, and number of emergency department visits and hospitalizations during the five-year period. In the hospital comparison analysis, the exposure of interest was the hospital system. Primary outcome variables included CVD and the CDAI disease activity score. Secondary outcome variables included number of emergency department visits and hospitalizations during the five-year period, primary language, patient portal use, smoking status, and primary care physician presence. The two-sample *t*-test, Fisher's exact test, and the chi-square test were conducted for the relevant group comparisons.

Propensity score matching. Propensity score matching analysis was performed with SAS 9.4 (SAS Institute Inc) and conducted 1:1 matching with the optimal matching approach under the PSMATCH procedure. In the first analysis, the matching variables included age, sex, race, ethnicity, insurance class, and CCI score. In the hospital comparison analysis, the matching variables included age, sex, race, ethnicity, insurance class, CCI score, and state ADI score.

RESULTS

There were 1,467 patients from the academic practice and 939 patients from the safety net institution pulled for initial analysis. Using state ADI scores, 542 patients from the academic cohort and

Table 1. Characteristics of patients at academic institution before and after propensity score matching*

Variable	Low ADI (≤3)	High ADI (≥8)	Total	*P* value
Before matching				
Cohort size, n	1,123	344	1,467	
Age, mean ± SD, y	60.2 ± 14.8	61.4 ± 14.2	60.5 ± 14.7	0.18[a]
Female, n (%)	882 (78.5)	292 (84.9)	1,174 (80)	**0.01**
Ethnicity, n (%)				
Hispanic	81 (7.2)	62 (18)	143 (9.8)	**<0.0001**
Non-Hispanic	941 (83.8)	262 (76.2)	1,203 (82)	
Unknown	101 (9)	20 (5.8)	121 (8.3)	
Race, n (%)				
White	914 (81.4)	182 (52.9)	1,096 (74.7)	**<0.0001**
Black	128 (11.4)	158 (45.9)	286 (19.5)	
Asian	71 (6.3)	1 (0.3)	72 (4.9)	
Other	10 (0.9)	3 (0.9)	13 (0.9)	
Charlson Comorbidity Index, mean ± SD, au	4.8 ± 3.6	5.6 ± 3.7	5 ± 3.6	**0.0005**[a]
Insurance class, n (%)				
Medicaid/charity	16 (1.4)	31 (9)	47 (3.2)	**<0.0001**
Medicare/similar	1,097 (97.7)	303 (88.1)	1,400 (95.4)	
Unknown	10 (0.9)	10 (2.9)	20 (1.4)	
Rheumatoid factor positive, n (%)	176 (38.2)	94 (52.8)	270 (42.3)	**0.0008**
Cyclic citrullinated peptide positive, n (%)	212 (47.2)	100 (56.5)	312 (49.8)	**0.04**
After matching				
Cohort size, n	271	271	542	
Age, mean ± SD, y	60.3 ± 13.7	60.3 ± 13.9	60.3 ± 13.8	0.99[a]
Female sex, n (%)	225 (83)	221 (81.6)	446 (82.3)	0.65
Ethnicity, n (%)				
Hispanic	48 (17.7)	50 (18.5)	98 (18.1)	0.98
Non-Hispanic	208 (76.8)	206 (76)	414 (76.4)	
Unknown	15 (5.5)	15 (5.5)	30 (5.5)	
Race, n (%)				
White	166 (61.3)	164 (60.5)	330 (60.9)	0.98[b]
Black	102 (37.6)	103 (38)	205 (37.8)	
Asian	1 (0.4)	1 (0.4)	2 (0.4)	
Other	2 (0.7)	3 (1.1)	5 (0.9)	
Charlson Comorbidity Index, mean ± SD, au	5.140 ± 3.4	5 ± 3.7	5.1 ± 3.5	0.59[a]
Insurance class, n (%)				
Medicaid/charity	8 (3)	8 (3)	16 (3)	0.7
Medicare/commercial	255 (94.1)	258 (95.2)	513 (94.7)	
Unknown	8 (3)	5 (1.9)	13 (2.4)	
Rheumatoid factor positive, n (%)	68 (48.2)	58 (47.2)	126 (47.7)	0.86
Cyclic citrullinated peptide positive, n (%)	75 (53.2)	66 (57.4)	141 (55.1)	0.5

**P* values are by chi-square test, unless indicated by footnote. Bold values are statistically significant results. ADI, Area Deprivation Index; au, arbitrary units.
[a]By *t*-test.
[b]By Fisher's exact test.

496 patients from the safety net cohort were analyzed after propensity score matching (Supplemental Figure 1). The academic cohort was 76% non-Hispanic, 61% White, and 82% female and had a mean age of 60.3 years (Table 1). The safety net cohort differed in that it was 52% non-Hispanic, 60% White, and 83% female and had a mean age of 57.5 years (Table 2). The first and third state ADI groups for the individual cohort analysis corresponded to state ADI decile scores of 1 to 3 and 8 to 10, respectively.

Within the academic cohort, those with high state ADI scores (≥8, more deprivation) compared to low state ADI scores (≤3) had greater RA disease activity (RAPID3 mean ± SD: 13.8 ± 7.1 vs 10.6 ± 7.4, $P < 0.0001$; CDAI mean ± SD: 12 ± 11.7 vs 9.4 ± 8, $P < 0.05$), worse RA functional impairment (MDHAQ mean ± SD 0.93 ± 0.68 vs 0.72 ± 0.67, $P < 0.001$), and lower patient health portal engagement ($P < 0.001$). There was a statistically significant relationship between state ADI scores and smoking status ($P < 0.01$). CVD prevalence was not different between the two groups (Table 3). When using national ADI scores to analyze the cohort, these conclusions persisted with the addition of lower targeted synthetic DMARD administration ($P < 0.05$), and there was a statistically significant relationship between national ADI scores and primary language ($P < 0.05$) (Supplemental Table 3).

Within the safety net cohort, the only statistically significant difference was in smoking status ($P < 0.01$). There was no significant difference in RA disease activity or functional impairment or CVD prevalence (Table 4). When using national ADI scores to analyze the cohort, there was lower RA disease activity ($P < 0.05$) and

Table 2. Characteristics of patients at safety net hospital before and after propensity score matching*

Variable	Low ADI (≤3)	High ADI (≥8)	Total	*P* value
Before matching				
Cohort size, n	298	641	939	
Age, mean ± SD, y	58.2 ± 12.9	57.6 ± 13.6	57.8 ± 13.4	0.55[a]
Female, n (%)	241 (80.9)	531 (82.8)	772 (82.2)	0.46
Ethnicity, n (%)				
Hispanic	122 (40.9)	355 (55.4)	477 (50.8)	**<0.0001**[b]
Non-Hispanic	174 (58.4)	285 (44.5)	459 (48.9)	
Unknown	174 (58.4)	1 (0.2)	3 (0.3)	
Race, n (%)				
White	171 (57.4)	403 (62.9)	574 (61.1)	**<0.0001**
Black	86 (28.9)	226 (35.3)	312 (33.2)	
Asian	34 (11.4)	12 (1.9)	46 (4.9)	
Other	7 (2.4)	0 (0)	7 (0.8)	
Charlson Comorbidity Index, mean ± SD, au	4.7 ± 3.4	5 ± 3.6	4.9 ± 3.6	0.27[a]
Insurance class, n (%)				
Medicaid/charity	199 (66.8)	416 (64.9)	615 (65.5)	**0.04**
Medicare/commercial	85 (28.5)	212 (33.1)	297 (31.6)	
Unknown	14 (4.7)	13 (2)	27 (2.9)	
Rheumatoid factor positive, n (%)	180 (66.7)	425 (69.9)	605 (68.9)	0.34
Cyclic citrullinated peptide positive, n (%)	216 (79.1)	464 (77.9)	680 (78.3)	0.67
After matching				
Cohort size, n	248	248	496	
Age, mean ± SD, y	59.9 ± 12.5	57.2 ± 13.1	58.6 ± 12.8	**0.02**[a]
Female, n (%)	202 (81.5)	205 (82.7)	407 (82.1)	0.73
Ethnicity, n (%)				
Hispanic	110 (44.4)	120 (48.4)	230 (46.4)	0.71[b]
Non-Hispanic	137 (55.2)	127 (51.2)	264 (53.2)	
Unknown	1 (0.4)	1 (0.4)	2 (0.4)	
Race, n (%)				
White	147 (59.3)	154 (62.1)	301 (60.7)	0.8
Black	90 (36.3)	83 (33.5)	173 (34.9)	
Asian	11 (4.4)	11 (4.4)	22 (4.4)	
Other	0 (0)	0 (0)	0 (0)	
Charlson Comorbidity Index, mean ± SD, au	5.2 ± 3.7	4.6 ± 3.3	4.9 ± 3.5	0.08[a]
Insurance class, n (%)				
Medicaid/charity	166 (66.9)	166 (66.9)	332 (66.9)	0.65
Medicare/commercial	78 (31.5)	75 (30.2)	153 (30.9)	
Unknown	4 (1.6)	7 (2.8)	11 (2.2)	
Rheumatoid factor positive, n (%)	164 (70.4)	151 (67.7)	315 (69.1)	0.54
Cyclic citrullinated peptide positive, n (%)	177 (77)	177 (78.3)	354 (77.6)	0.73

**P* values are by chi-square test, unless indicated by footnote. Bold values are statistically significant. ADI, Area Deprivation Index; au, arbitrary units.
[a]By *t*-test.
[b]By Fisher's exact test.

Table 3. Primary and secondary outcomes in academic cohort after propensity score matching*

	RA with low ADI ≤3 (n = 271)	RA with high ADI ≥8 (n = 271)	*P* value
RAPID3 score, mean ± SD, au	11.2 ± 7.4	13.8 ± 6.9	**<0.0001**[a]
CDAI score, mean ± SD, au	9.4 ± 8	12 ± 11.7	**0.02**[a]
MDHAQ average, mean ± SD, au	2.34 ± 2.23	2.99 ± 2.29	**0.001**[a]
Cardiovascular disease, n (%)	87 (32.1)	103 (38)	0.15
Emergency department visits, mean ± SD	0.3 ± 1.2	0.7 ± 2.7	0.05[a]
Hospital visits, mean ± SD	0.4 ± 1.7	0.37 ± 1.2	0.67[a]
Language, n (%)			
English	262 (96.7)	258 (95.2)	0.13[b]
Spanish	5 (1.9)	12 (4.4)	
Other	4 (1.5)	1 (0.4)	
MyChart status active, n (%)	234 (86.4)	203 (74.9)	**0.0008**
Smoking history, n (%)			
Ever smoked	92 (34)	124 (45.8)	**0.005**[b]
Never smoked	178 (65.7)	144 (53.1)	
Unknown	1 (0.4)	3 (1.1)	
Has primary care provider, n (%)	242 (89.3)	245 (90.4)	0.67
Medication ever used, n (%)			
Prednisone	214 (79)	225 (83)	0.23
NSAID	221 (81.6)	210 (77.5)	0.24
CSDMARD	208 (76.8)	224 (82.7)	0.09
BDMARD	135 (49.8)	136 (50.2)	0.93
TSDMARD	47 (17.3)	33 (12.2)	0.09

**P* values are by chi-square test, unless indicated by footnote. Bold values are statistically significant. ADI, Area Deprivation Index; au, arbitrary units; BDMARD, biologic disease-modifying antirheumatic drug; CDAI, Clinical Disease Activity Index; CSDMARD, conventional synthetic disease-modifying antirheumatic drug; MDHAQ, Multidimensional Health Assessment Questionnaire; NSAID, nonsteroidal anti-inflammatory drug; RA, rheumatoid arthritis; RAPID3, Routine Assessment of Patient Index Data 3; TSDMARD, targeted synthetic disease-modifying antirheumatic drug.
[a]By *t*-test.
[b]By Fisher's exact test.

higher biologic DMARD administration ($P < 0.05$) in the high ADI score group (≥8, more deprivation) (Supplemental Table 4).

The discrepancy in outcomes seen at the academic practice compared to the safety net hospital raised concern about population-specific differences. Thus, the hospital cohort populations were directly compared. When comparing patients with RA of each hospital, 579 academic patients and 579 safety net patients were used after propensity score matching. Overall, the combined cohort was primarily non-Hispanic (66%), White (52%), and female (83%) and had a mean age of 62 years (Table 5).

After controlling for state ADI score, the safety net cohort compared to the academic practice had greater RA disease activity (CDAI mean ± SD 14.2 ± 11.4 vs 12.4 ± 10.3, $P < 0.05$), a greater number of emergency department visits (mean ± SD 2.4 ± 3.7 vs 0.9 ± 2.6, $P < 0.0001$), and lower patient health portal engagement ($P < 0.0001$) and was less likely to have a primary care provider ($P < 0.0001$). There were also statistically significant differences in primary language ($P < 0.0001$) and smoking status ($P < 0.0001$) (Table 6). RA functional impairment could not be directly compared because of the different measures used at each hospital.

DISCUSSION

To our knowledge, there have not been studies examining the ADI at the hospital level for RA. This study examined the effects of the ADI to see if the conclusions drawn from a US cohort of primarily private practices can be applied locally.[21] Patients with RA at the academic practice generally followed the expected trends seen with ADI scores correlating with higher disease activity and worse functional outcomes. Furthermore, the study showed correlations with other variables that may shed light on the disparity, including increased smoking and decreased MyChart engagement. Similar to the findings in the academic center, prior studies of patients with RA from lower socioeconomic strata based on factors such as education, income, and occupation found higher disease activity scores, higher functional disability scores, and more degenerative changes of the joints.[18,26]

However, patients with RA at the safety net clinic showed no significant differences in RA disease activity and functional impairment despite stratifying by ADI score. In the second analysis, in which patients from the academic practice were compared to the patients at the safety net hospital, the latter had increased RA disease activity, had more frequent emergency department visits, engaged less with the patient health portal, smoked more, were less likely to have a primary care physician, and were more likely to speak a language other than English. In addition, the distribution of patient ADI scores before propensity score matching demonstrates a left skew for the safety net cohort and a right skew for the academic cohort (Supplemental Figure 3). These

Table 4. Primary and secondary outcomes in safety net cohort after propensity score matching*

	RA with low ADI ≤3 (n = 248)	RA with high ADI ≥8 (n = 248)	*P* value
CDAI score, mean ± SD, au	15.3 ± 12.2	12.8 ± 10.2	0.1[a]
HAQ-II average, mean ± SD, au	1.23 ± 0.76	1.23 ± 0.8	0.98[a]
Cardiovascular disease, n (%)	79 (31.9)	90 (36.3)	0.3
Emergency department visits, mean ± SD	2.7 ± 3.7	2.3 ± 3.3	0.16[a]
Hospital visits, mean ± SD	0.7 ± 1.5	0.5 ± 1.2	0.1[a]
Language, n (%)			
English	159 (64.1)	153 (61.7)	0.8
Spanish	81 (32.7)	85 (34.3)	
Other	8 (3.2)	10 (4)	
MyChart status active, n (%)	156 (62.9)	148 (59.7)	0.46
Smoking history, n (%)			
Ever smoked	94 (37.9)	96 (38.7)	**0.012**
Never smoked	135 (54.4)	113 (45.6)	
Unknown	19 (7.7)	39 (15.7)	
Has primary care provider, n (%)	200 (80.7)	209 (84.3)	0.55
Medication ever used, n (%)			
Prednisone	142 (57.3)	144 (58.1)	0.86
NSAID	177 (71.4)	182 (73.4)	0.62
CSDMARD	182 (73.4)	197 (79.4)	0.11
BDMARD	95 (38.3)	116 (46.8)	0.06
TSDMARD	7 (2.8)	6 (2.4)	0.78

**P* values are by chi-square test, unless indicated by footnote. Bold values are statistically significant. ADI, Area Deprivation Index; au, arbitrary units; BDMARD, biologic disease-modifying antirheumatic drug; CDAI, Clinical Disease Activity Index; CSDMARD, conventional synthetic disease-modifying antirheumatic drug; HAQ-II, Health Assessment Questionnaire II; NSAID, nonsteroidal anti-inflammatory drug; RA, rheumatoid arthritis; TSDMARD, targeted synthetic disease-modifying antirheumatic drug.
[a]By *t*-test.

differences suggest that the patient populations or the two hospital systems themselves may account for the observed discrepancy. The ADI, although powerful in its ability to geographically identify areas of socioeconomic disparity, appears to have limitations when applied in the context of the safety net hospital system.

The inherent nature of the safety net hospital may be a potential major contributor for this observed discrepancy. Academic cohort patients from neighborhoods of significant deprivation may experience greater instability of insurance coverage over time that is missed by the cross-sectional analysis. However, safety net patients covered by the hospital's insurance plan may be more resilient to variability in employment status and subsequent health coverage. In addition, most patients at the safety net hospital were found to have either charity or Medicaid versus those at the academic practice, who primarily had Medicare or commercial insurance (Table 1). Studies have shown that Medicaid insurance in RA populations across the United States is associated with worse disease activity scores.[27] Thus, the nature of the patient's insurance may also be diminishing the role of the ADI to stratify disease activity outcomes in the safety net cohort. Another consideration is that the safety net population of patients may on average have more frequent address changes given financial difficulties, which may alter the long-term socioeconomic effects of a geographic region. These patients may also have greater use of post office boxes, which would not accurately capture a patient's true geographic neighborhood status and would further limit the utility of the ADI.

Another potential factor influencing the analysis is geographic clustering. A significant portion of the safety net cohort was clustered around a few regional blocks compared to the academic cohort, which may have also reduced the ability of the ADI to stratify the safety net cohort (Supplemental Figure 4). Although there are a variety of neighborhood resource and socioeconomic factors that may result in a low ADI score, because of geographic clustering, the safety net patient population may have limited exposure to the full spectrum of socioeconomic variables.

There was no appreciable difference in cardiovascular morbidity in either of the hospital systems when stratifying by ADI score. One possible explanation is that the ADI as a geographic based socioeconomic marker does not adequately capture the risk factors involved in cardiovascular morbidity in the RA population. The analysis was also limited by its ability to capture the severity of cardiovascular morbidity. Because of the design of the study, the chronology of the CVD diagnoses in relation to the RA diagnosis could not be determined. Thus, it was difficult to untangle causal associations about cardiovascular outcomes in patients with RA. When comparing the hospital cohorts directly against each other, there was also no significant difference in cardiovascular prevalence. Overall, the prevalence of CVD in both

Table 5. Characteristics of patients at academic and safety net hospitals before and after propensity score matching*

Variable	Safety net	Academic	Total	*P* value
Before matching				
Cohort size, n	1,832	2,216	4,048	
Age, mean ± SD, y	56.9 ± 13.4	60.5 ± 14.5	58.9 ± 14.1	**<0.0001**[a]
Female, n (%)	1,509 (82.4)	1,783 (80.5)	3,292 (81.3)	0.12
Ethnicity, n (%)				
Hispanic	1,035 (56.5)	253 (11.4)	1,288 (31.8)	**<0.0001**
Non-Hispanic	791 (43.2)	1,812 (81.8)	2,603 (64.3)	
Unknown	6 (0.3)	151 (6.8)	157 (3.9)	
Race, n (%)				
White	1,253 (68.4)	1,645 (74.2)	2,898 (71.6)	**<0.0001**
Black	506 (27.6)	454 (20.5)	960 (23.7)	
Asian	65 (3.6)	97 (4.4)	162 (4)	
Other	8 (0.4)	20 (0.9)	28 (0.7)	
Charlson Comorbidity Index, mean ± SD, au	4.8 ± 3.5	5.1 ± 3.7	5 ± 3.6	**0.009**[a]
Insurance class, n (%)				
Medicaid/charity	1,212 (66.2)	84 (3.8)	1,296 (32)	**0**
Medicare/commercial	547 (29.9)	2,097 (94.6)	2,644 (65.3)	
Unknown	73 (4)	35 (1.6)	108 (2.7)	
State ADI, mean ± SD	6.2 ± 2.5	4 ± 2.7	5 ± 2.8	**<0.0001**[a]
Rheumatoid factor positive, n (%)	1,215 (70.5)	456 (45)	1,671 (61.1)	**<0.0001**
Cyclic citrullinated peptide positive, n (%)	1,348 (78.7)	518 (51.8)	1,866 (68.8)	**<0.0001**
After matching				
Cohort size, n	579	579	1,158	
Age, mean ± SD	61.8 ± 13.6	62.3 ± 14.1	62 ± 13.8	0.51[a]
Female, n (%)	483 (83.4)	481 (83)	964 (83.3)	0.87
Ethnicity, n (%)				
Hispanic	187 (32.3)	198 (34.2)	385 (33.3)	0.66
Non-Hispanic	386 (66.7)	377 (65.1)	763 (65.9)	
Unknown	6 (1)	4 (0.7)	10 (0.9)	
Race, n (%)				
White	307 (53)	300 (51.8)	607 (52.4)	0.91[b]
Black	250 (43.2)	254 (43.9)	504 (43.5)	
Asian	19 (3.3)	20 (3.5)	39 (3.4)	
Other	3 (0.5)	5 (0.9)	8 (0.7)	
Charlson Comorbidity Index, mean ± SD, au	5.9 ± 3.7	6.2 ± 4.1	6 ± 3.9	0.17[a]
Insurance class, n (%)				
Medicaid/charity	102 (17.6)	84 (14.5)	186 (16.1)	0.34
Medicare/commercial	453 (78.2)	468 (80.8)	921 (79.5)	
Unknown	24 (4.2)	27 (4.7)	51 (4.4)	
State ADI, mean ± SD	5.8 ± 2.6	6 ± 2.7	5.9 ± 2.6	0.3[a]
Rheumatoid factor positive, n (%)	373 (69.9)	140 (53)	513 (64.3)	**<0.0001**
Cyclic citrullinated peptide positive, n (%)	420 (77.8)	154 (60.2)	574 (72.1)	**<0.0001**

**P* values are by chi-square test, unless indicated by footnote. Bold values are statisticall significant. ADI, Area Deprivation Index; au, arbitrary units.
[a]By *t*-test.
[b]By Fisher's exact test.

cohorts was within the upper end of what has been reported in the literature,[28,29] which ranges from 8% to nearly 50%.

There are limitations to our investigation. As a cross-sectional analysis, only a snapshot of the patient's home address was collected, missing information regarding a patient's duration at a given address or their moving history. However, studies have shown that the addresses reported in the EHR are accurate at representing the true environmental exposure of the patients.[30] In addition, only the primary insurance at the time of the clinic visit was able to be retrieved, which does not capture the full complexity of the patients' varying insurance plans. The use of the ADI also has potential drawbacks. The ADI may be limited when accounting for undocumented immigrant populations,[31] and there is risk of ecological bias when ascribing individual-level socioeconomic differentials to geographic regions.[32] There is potential to misrepresent individuals who are not properly captured by the ADI by using addresses in areas not covered by census data, including post office box and institutional addresses, for example, prisons.[24] Our analysis did not capture the average number of clinic visits, which may influence RA disease control, though a previous study has suggested that visits may not drive the outcome of functional status.[21] We were unable to calculate RA disease duration, which may impact cardiovascular comorbidity. In addition, given the limitations of data extraction, we

Table 6. Primary and secondary outcomes in combined cohort after propensity score matching*

	Safety net (n = 579)	Academic (n = 579)	*P* value
CDAI score, mean ± SD, au	14.2 ± 11.4	12.4 ± 10.3	0.03[a]
Cardiovascular disease, n (%)	257 (44.4)	266 (45.9)	0.6
Emergency department visits, mean ± SD	2.4 ± 3.7	0.9 ± 2.6	**<0.0001**[a]
Hospital visits, mean ± SD	0.7 ± 1.6	0.6 ± 1.9	0.55[a]
Language, n (%)			
English	447 (77.2)	527 (91)	**<0.0001**
Spanish	116 (20)	45 (7.8)	
Other	16 (2.8)	7 (1.2)	
MyChart status active, n (%)	369 (63.7)	439 (75.8)	**<0.0001**
Smoking history, n (%)			
Ever smoked	245 (42.3)	238 (41.1)	**<0.0001**
Never smoked	264 (45.6)	338 (58.4)	
Unknown	70 (12.1)	3 (0.5)	
Has primary care provider, n (%)	482 (83.3)	529 (91.4)	**<0.0001**

**P* values are by chi-square test, unless indicated by footnote. Bold values are statisticall significant. au, arbitrary units; CDAI, Clinical Disease Activity Index.
[a]By *t*-test.

captured our target population through the criteria of having a single visit diagnosis code for RA, which could impact the target population. However, these patients were selected specifically from our rheumatology practices within the institutions. We used the CCI, which includes some measures of CVD, in our propensity score matching, which could have obscured subtleties in cardiovascular differences.

The strength of our study strength lies in its ability to examine large cohorts from two diverse RA patient populations under different health systems while using propensity score matching to identify more causal associations. The analysis accounts for skewed demographic variables, such as race, ethnicity, and insurance class, as seen in the prematching cohort (Tables 1, 2, and 5). This, however, comes with the caveat of a significant loss of sample size. Although we saw trends in the academic practice similar to those in the RISE registry study, the lack of a difference seen in the safety net hospital raises questions regarding the use of the ADI for stratifying socioeconomic risk in this RA population.[21] Further studies that use the ADI in safety net versus academic or commercial hospitals will be needed.

Disparities in health care impact the morbidity and mortality outcomes of patients with RA. Allocating finite resources and triaging high-risk populations most in need of care for targeted interventions is crucial for improving the lives of patients with RA. Particular attention can be given to increasing awareness in targeted components of health for vulnerable populations. Applications of the ADI for quality improvement initiatives for patients with RA should be mindful of its limitation and allocate resources in a manner that is equitable and appropriate for the patient population in question.

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AUTHOR CONTRIBUTIONS

All authors contributed to at least one of the following manuscript preparation roles: conceptualization AND/OR methodology, software, investigation, formal analysis, data curation, visualization, and validation AND drafting or reviewing/editing the final draft. As corresponding author, Dr Kim confirms that all authors have provided the final approval of the version to be published, and takes responsibility for the affirmations regarding article submission (eg, not under consideration by another journal), the integrity of the data presented, and the statements regarding compliance with institutional review board/Helsinki Declaration requirements.

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