The Journal of Rheumatology 2022;xx:xxxx
doi:10.3899/jrheum.220025
First Release October 1 2022

The Journal of Rheumatology

Age-Stratified 30-day Rehospitalization and Mortality and Predictors of Rehospitalization Among Patients With Systemic Lupus Erythematosus: A Medicare Cohort Study

Maria Schletzbaum[1], Amy J. Kind[2], Yi Chen[3], Brad C. Astor[1], Stacy P. Ardoin[4], Andrea Gilmore-Bykovskyi[5], Ann M. Sheehy[2], Farah A. Kaiksow[2], W. Ryan Powell[2], and Christie M. Bartels[2]

ABSTRACT. ***Objective.*** Recent studies suggest young adults with systemic lupus erythematosus (SLE) have high 30-day readmission rates, which may necessitate tailored readmission reduction strategies. To aid in risk stratification for future strategies, we measured 30-day rehospitalization and mortality rates among Medicare beneficiaries with SLE and determined rehospitalization predictors by age.

Methods. In a 2014 20% national Medicare sample of hospitalizations, rehospitalization risk and mortality within 30 days of discharge were calculated for young (aged 18-35 yrs), middle-aged (aged 36-64 yrs), and older (aged 65+ yrs) beneficiaries with and without SLE. Multivariable generalized estimating equation models were used to predict rehospitalization rates among patients with SLE by age group using patient, hospital, and geographic factors.

Results. Among 1.39 million Medicare hospitalizations, 10,868 involved beneficiaries with SLE. Hospitalized young adult beneficiaries with SLE were more racially diverse, were living in more disadvantaged areas, and had more comorbidities than older beneficiaries with SLE and those without SLE. Thirty-day rehospitalization was 36% among young adult beneficiaries with SLE—40% higher than peers without SLE and 85% higher than older beneficiaries with SLE. Longer length of stay and higher comorbidity risk score increased odds of rehospitalization in all age groups, whereas specific comorbid condition predictors and their effect varied. Our models, which incorporated neighborhood-level socioeconomic disadvantage, had moderate-to-good predictive value (C statistics 0.67-0.77), outperforming administrative data models lacking comprehensive social determinants in other conditions.

Conclusion. Young adults with SLE on Medicare had very high 30-day rehospitalization at 36%. Considering socioeconomic disadvantage and comorbidities provided good prediction of rehospitalization risk, particularly in young adults. Young beneficiaries with SLE with comorbidities should be a focus of programs aimed at reducing rehospitalizations.

Key Indexing Terms: age group, cohort study, health services research, hospital readmission, Medicare, systemic lupus erythematosus

Patients with systemic lupus erythematosus (SLE) experience high rates of hospital readmission (24-27%).[1,2] Medicare covers over a third of SLE hospitalizations in the United States,[2,3] and more than half of Medicare SLE hospitalizations occur in patients aged < 65 years who qualify for Medicare because of disability or endstage renal disease (ESRD).[2] In 2012, the Centers for Medicare & Medicaid Services (CMS) implemented a program that financially penalizes hospitals for unplanned

The primary source of funding for this study was provided by the National Institute on Minority Health and Health Disparities Research (NIMHD; award no. R01MD010243). Additional support was provided by NIMHD (award no. F30MD015211), the University of Wisconsin Medical Scientist Training Program (grant no. T32 GM140935), and the University of Wisconsin Clinical and Translational Science Award (National Institutes of Health CTSA grant 1UL1TR002373).

[1]M. Schletzbaum, PhD, B.C. Astor, PhD, MPH, Department of Population Health Sciences, and Department of Medicine, University of Wisconsin School of Medicine and Public Health, Madison, Wisconsin; [2]A.J. Kind, MD, PhD, A.M. Sheehy, MD, MS, F.A. Kaiksow MD, MPP, W. Ryan Powell, PhD, MA, C.M. Bartels, MD, MS, Department of Medicine, and Center for Health Disparities Research, University of Wisconsin School of Medicine and Public Health, Madison, Wisconsin; [3]Y. Chen, MS, Department of Biostatistics and Medical Informatics, University of Wisconsin School of Medicine and Public Health, Madison, Wisconsin; [4]S.P. Ardoin, MD, MS, Division of Pediatric Rheumatology, Nationwide Children's Hospital, Columbus, Ohio; [5]A. Gilmore-Bykovskyi, PhD, RN, Center for Health Disparities Research, University of Wisconsin School of Medicine and Public Health, and School of Nursing, University of Wisconsin, Madison, Wisconsin, USA.

CMB receives peer-reviewed institutional grant funding from Independent Grants for Learning and Change (Pfizer) for research unrelated to this study. All other authors declare no conflicts of interest relevant to this article.

Address correspondence to Dr. C.M. Bartels, University of Wisconsin Medical Foundation Centennial Building, 1685 Highland Ave #4132, Madison, WI 53705, USA. Email: cb4@medicine.wisc.edu.

Accepted for publication July 7, 2022.

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readmissions for 6 conditions as an indicator of poor inpatient care quality.[4] While readmissions related to SLE are not included in the program, rehospitalization within 30 days represents an important care quality marker. We previously reported higher 30-day readmissions in young adults compared to older age groups (27% vs 17%), yet drivers of readmission in young adults remain unclear.[2]

Many young adults with SLE were diagnosed before age 18. Making up 20% of SLE cases in the US,[5-7] early-onset vs adult-onset patients are more likely to identify as Black, Hispanic, Asian, or American Indian,[5,8] have lower socioeconomic status (SES),[7] and have greater organ damage.[8] Young adults with SLE also use emergency care more frequently than older patients with SLE.[9] Lower SES and greater disease activity further increase odds of emergency visits.[9] Disproportionately high acute care use and rehospitalizations might indicate suboptimal outpatient management, leading to increased healthcare costs and poor outcomes.[10,11] In other conditions, risk stratification to target high-risk patients has helped reduce rehospitalizations and healthcare costs.[12-16]

Our first objective was to assess rates of 30-day rehospitalization and mortality in young adults with SLE compared to those without SLE and to older Medicare beneficiaries with SLE. Then, for risk stratification, our second objective was to identify predictors of 30-day rehospitalization among young adults with SLE compared to older beneficiaries with SLE.

METHODS

Study population. We performed a cohort study using a geo-linked 20% random sample of Medicare beneficiaries. Hospitalizations of adult beneficiaries between January 1 and November 30, 2014, were eligible for inclusion; a beneficiary could contribute multiple hospitalizations. Inclusion required hospitalization with an SLE diagnosis code (International Classification of Diseases, 9th revision, Clinical Modification [ICD-9-CM] 710.0) and discharge before November 30, 2014 (Figure 1). At least 12 months of continuous Medicare A and B coverage with any claims before index hospitalization were required for baseline comorbidity assessment. Beneficiaries lacking at least 30 days of A/B coverage after discharge were excluded unless they died in the 30 days. As a result of alternative claims processing, beneficiaries with Health Maintenance Organization plans or Railroad Retirement Board benefits were excluded, as their Medicare data may have been incomplete. Consistent with standard rehospitalization metrics, long-term acute care facility, psychiatric, rehabilitation, cancer, children's hospitals, and drug treatment hospitalizations were excluded.[10] Beneficiaries were excluded from regression analysis if they were missing geographical residence.

SLE definition. Patients were defined as having SLE if the hospitalization was associated with an ICD-9-CM 710.0 (specificity of 99.4%) at any diagnosis level.[2,17,18]

Outcomes. The primary outcome for this study was all-cause readmission to a hospital setting within 30 days of discharge.[19] All-cause 30-day mortality (defined using the National Death Index) was evaluated as a secondary outcome.

Predictors. Potential 30-day readmission predictors included both individual and contextual factors to capture broad influences on rehospitalization[11,15,20]: demographic and SES variables, geographic area, comorbidities, and characteristics of the index hospital. Age was measured at index hospitalization. Age groups were young (aged 18-35 yrs), middle-aged (aged 36-64 yrs), and older adults (aged 65+ yrs). Medicare-reported race and ethnicity were included as a proxy for lived experiences of these groups, including structural and institutional racism. For analysis, race and ethnicity responses were consolidated to Asian, Black, American Indian, Hispanic, White, and other/unknown using the Research Triangle Institute (RTI) variable.[21-24] Medicaid status[25] was also included. The Area Deprivation Index (ADI) rank score was used to capture neighborhood-level socioeconomic disadvantage based on 9-digit ZIP codes.[26,27] The ADI includes 17 variables, reflecting census block-level income, education, employment, and housing quality. To account for geographical context, patients were classified into isolated, small rural, large rural, and urban areas based on Rural-Urban Commuting Area codes by ZIP code.[28,29]

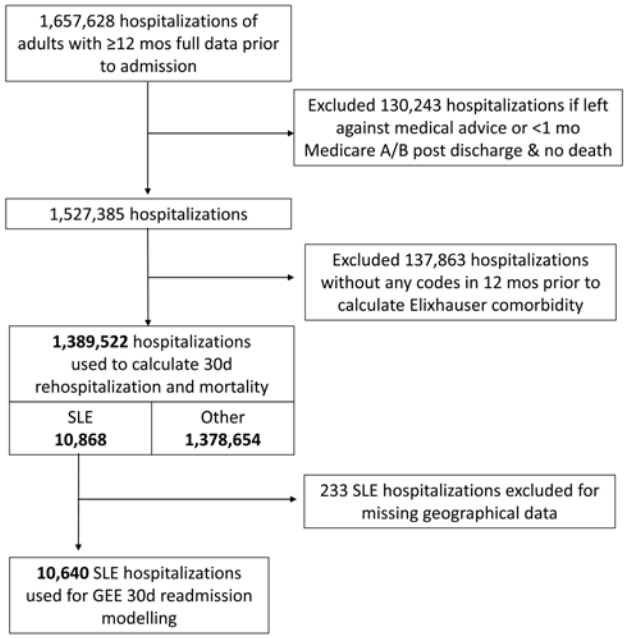

Figure 1. Flow diagram describing creation of study cohorts from a 20% national Medicare sample of index hospitalizations between January 1, 2014, and November 30, 2014. SLE: systemic lupus erythematosus.

The following health status variables were included: disability status, CMS hierarchical condition category (HCC) community risk score,[30] Elixhauser Comorbidity Index conditions,[31] and length of the index hospital stay. Disability was determined by original qualification for Medicare due to disability, regardless of subsequent eligibility (ie, ESRD, age 65 yrs).[25] The length of stay for the index hospitalization was included as a proxy for medical complexity.

Characteristics of the index treating hospital were evaluated, including affiliation with a medical school, tertile of discharge volume, and critical access hospital status.

Analysis. Descriptive summaries of patient and hospital characteristics for hospitalizations of beneficiaries with SLE and without SLE by age group are provided. The non-SLE group was composed of hospitalizations that were not associated with a SLE diagnosis code from the 20% random Medicare sample in the same period. This non-SLE group was used for comparison of observed 30-day rehospitalization and mortality risk but was not used in rehospitalization prediction models.

Observed risk of 30-day rehospitalization and 30-day mortality. Rehospitalization and mortality risk within 30 days of index hospitalization discharge with Clopper-Pearson 95% CI were calculated by age group among SLE and non-SLE hospitalizations.

Predictors of 30-day rehospitalization among SLE hospitalizations by beneficiary age group. We used generalized estimating equation (GEE) models with logistic link functions to predict 30-day odds of rehospitalization,

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clustering by beneficiary to account for multiple hospitalizations. A priori variables were selected based on the literature for their association with acute care use among patients with SLE; these variables were age, sex, race and ethnicity, disability, length of stay, ADI national rank, HCC community risk score, and renal failure status.[2,9,18,32-35] Other potential predictors, based on theoretical models of rehospitalization, were eligible for selection by least absolute shrinkage and selection operator (LASSO), which maximizes a model's predictive power while minimizing factors in the model for higher efficiency.[36]

Two modeling approaches were used. In the first, LASSO variable selection was performed across all SLE-associated hospitalizations, regardless of beneficiary age. These selected predictors, along with the a priori variables, were combined into 1 model to predict 30-day rehospitalization and applied separately to young, middle-aged, and older patient groups with SLE. This approach allows for quantitative comparisons of odds ratios (ORs) across age groups. In the second approach, 30-day rehospitalization predictors were selected separately within each beneficiary age group and then combined with the a priori variables, resulting in a unique set of predictors (and model) for each age group. This approach allows for a qualitative comparison of relevant predictors between SLE patient age groups. Model performance was assessed by C statistic.

Sensitivity analysis for obstetrical hospitalizations. Given the age and female predominance of the cohort, sensitivity analyses were performed to determine whether obstetrics-related hospitalizations influenced the findings. First, 30-day rehospitalization rates were calculated and compared for obstetrics-related index hospitalizations, based on having a primary Clinical Classification Software diagnostic code of 11.* (excluding 11.1.* [contraceptive care]), and nonobstetrical hospitalizations among SLE and non-SLE beneficiary hospitalizations. Second, LASSO variable selection and GEE models on the SLE cohort were re-performed excluding obstetrical hospitalizations. LASSO-selected variables and significant predictors of rehospitalization were compared for models including and excluding obstetrics-related hospitalizations. Analysis was conducted using SAS version 9.4 (SAS Institute).

Statement of ethics and consent. This study was approved by the Health Sciences Minimal Risk Institutional Review Board at the University of Wisconsin School of Medicine and Public Health, with a waiver of individual informed consent as a secondary analysis of administrative claims data (study ID: 2020-0438).

RESULTS

There were 10,868 SLE associated Medicare hospitalizations in the sample (Figure 1). Beneficiaries with SLE were significantly younger and more likely to be Black or Hispanic than those without SLE (Table 1). Disability, receipt of Medicaid, and multiple comorbid conditions were more frequent among young adults with SLE than among older adults with SLE or among the age-matched non-SLE Medicare population. Young adults with SLE tended to have a higher illness burden, as measured by HCC, and to live in more disadvantaged neighborhoods relative to both older beneficiaries with and without SLE.

Observed 30-day rehospitalization and mortality risk. Unadjusted 30-day rehospitalization risk was highest in young adult Medicare beneficiaries. In young adults, rehospitalization risk was 10% higher among SLE beneficiaries compared to non-SLE beneficiaries (36% vs 26%, $P < 0.001$). Older adults with SLE had a rehospitalization risk of 20% (Figure 2A). Thus, the rehospitalization risk for young adults with SLE was 40% higher than that of their peers without SLE and 85% higher relative to both older beneficiaris with SLE and those without SLE.

The unadjusted 30-day mortality risk for young adults with and without SLE was similar at 0.5% and 0.7% (Figure 2B). Mortality risk increased with age in beneficiaries with or without SLE, but was statistically lower for those with SLE compared to those without SLE in the middle-aged and older age groups.

Rehospitalization predictors across all ages. When examining predictors across all ages of beneficiaries with SLE, the variables selected by the LASSO procedure, after accounting for a priori variables, were all comorbid conditions: coagulopathy, congestive heart failure (CHF), drug use disorder, fluid and electrolyte disorders, and paralysis (Table 2).

When this model was applied separately to each SLE age group, length of index hospitalization and HCC risk score were significant predictors of rehospitalization in all ages. Longer index hospitalization showed a similar increase in odds in each age group (adjusted OR [aOR] ~1.03). Higher HCC risk scores were associated with higher odds of rehospitalization, with greater effect on middle-aged and older adults (young adult aOR 1.10, 95% CI 1.03-1.18; middle-aged aOR 1.18, 95% CI 1.14-1.23; older adults aOR 1.21, 95% CI 1.17-1.26). Within the young and middle-aged adult strata, but not among older adults, younger beneficiaries were at higher risk of rehospitalization. Each additional year of age was associated with a 6.4% decrease in odds of rehospitalization among young adults and a 2.1% decrease among middle-aged adults.

In young adults, fluid and electrolyte disorders (aOR 2.35, 95% CI 1.53-3.61), CHF (aOR 2.05, 1.44-2.91), drug use disorder (aOR 1.58, 1.10-2.27), and coagulopathy (aOR 1.46, 1.03- 2.06) substantially increased the odds of rehospitalization. Paralysis was associated with lower rehospitalization odds (aOR 0.23, 0.07-0.78). The effect of these comorbid conditions generally decreased in the older age groups. In middle-aged adults, only drug use disorder (aOR 1.73, 1.31-2.27) and fluid and electrolyte disorders (aOR 1.26, 1.05-1.52) remained significant. Among older adults, CHF (aOR 1.32, 1.08-1.61) was the only significant predictor beyond length of stay and HCC risk score (Table 2).

The C statistic for the model was 0.77 for young adults, 0.70 in middle-aged adults, and 0.67 in older adults.

Age-specific rehospitalization predictors. With the sample restricted to young adults with SLE, more variables were added by the LASSO procedure as predictors, including index hospital characteristics (index hospital medical school affiliation and discharge volume) and additional comorbid condition indicators (deficiency anemia, diabetes, hypertension with complications, and valvular disease; Table 3). With the addition of more comorbid condition variables, coagulopathy became nonsignificant (aOR 1.36, 95% CI 0.97-1.90), while valvular disease was associated with increased odds (aOR 1.74, 95% CI 1.14-2.65). Index hospitalization at a medical school–affiliated hospital was significantly protective for rehospitalization (aOR 0.68, 95% CI 0.50-0.92).

When LASSO variable selection was performed among middle-aged beneficiaries with SLE, additional variables selected as predictors included critical access status of the index hospital along with alcohol use disorder, liver disease, pulmonary

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Table 1. Characteristics of hospitalizations of Medicare beneficiaries.

	Non-SLE	SLE by Age Group		
		18-35 Years	36-64 Years	65+ Years
Patients, n	1,378,654	1133	4855	4880
Female sex	776,803 (56)	1037 (92)	4331 (89)	4355 (89)
Age, yrs, median (IQR)	75.0 (67.2-83.2)	29.8 (26.8-32.5)	52.5 (45.4-59.0)	73.4 (69.3-79.7)
Race/ethnicity				
Asian	14,920 (1)	24 (2)	52 (1)	37 (1)
Black	168,877 (12)	586 (52)	1880 (39)	687 (14)
Hispanic	27,180 (2)	170 (15)	297 (6)	71 (1)
American Indian	10,068 (1)	26 (2)	64 (1)	39 (1)
White	1,378,654 (83)	253 (22)	2493 (51)	3992 (82)
Other/unknown	19,022 (1)	74 (7)	69 (1)	54 (1)
ADI national rank, median (IQR)	51 (28-74)	66 (42-86)	63 (39-83)	50 (26-72)
Medical school–affiliated hospital	709,740 (52)	734 (65)	2809 (58)	2424 (50)
Critical access hospital	45,383 (3)	–[a]	51 (1)	104 (2)
Discharge volume: highest tertile	467,995 (34)	450 (40)	2023 (42)	1744 (36)
Middle tertile	454,667 (33)	427 (38)	1614 (33)	1701 (35)
Lowest tertile	455,992 (33)	256 (23)	1218 (25)	1435 (29)
Ever received Medicaid	411,694 (30)	1036 (91)	2912 (60)	1059 (22)
Disability on enrollment	440,957 (32)	898 (79)	4590 (95)	1559 (32)
Length of stay, days, median (IQR)	4 (2-6)	4 (2-6)	4 (2-6)	4 (2-6)
HCC risk score, median (IQR)	2.27 (1.26-3.89)	3.92 (2.24-6.07)	3.25 (1.90-5.32)	2.8 (1.70-4.42)
Renal failure	308,476 (22)	745 (66)	1839 (38)	1244 (25)
Coagulopathy	94,073 (7)	363 (32)	830 (17)	488 (10)
Congestive heart failure	291,295 (21)	345 (30)	1139 (23)	1134 (23)
Deficiency anemia	429,475 (31)	900 (79)	2547 (52)	1917 (39)
Fluid and electrolyte disorders	406,930 (30)	794 (70)	2234 (46)	1674 (34)
Hypertension with complications	983,804 (71)	895 (79)	3566 (73)	3601 (74)
Other neurological disorder	223,999 (16)	338 (30)	1104 (23)	823 (17)
Paralysis	50,851 (4)	23 (2)	196 (4)	124 (3)
Pulmonary circulation disorder	79,098 (6)	209 (18)	605 (12)	446 (9)
Valvular disease	159,653 (12)	145 (13)	629 (13)	678 (14)
Alcohol use disorder	49,741 (4)	36 (3)	164 (3)	22 (0)
Diabetes	495,115 (36)	209 (18)	1651 (34)	1403 (29)
Drug use disorder	55,168 (4)	308 (27)	630 (13)	78 (2)
Liver disease	64,096 (5)	75 (7)	441 (9)	227 (5)
Weight loss	106,444 (8)	210 (19)	572 (12)	436 (9)

Values are expressed as n (%) unless indicated otherwise. [a] Suppressed due to small cell size. ADI: Area Deprivation Index; HCC risk score: hierarchical condition category community risk score; SLE: systemic lupus erythematosus.

circulation disorders, and weight loss (Table 3). Coagulopathy, CHF, and paralysis were no longer selected for the model. Drug use disorder (aOR 1.67, 95% CI 1.23-2.18) and liver disease (aOR 1.32, 95% CI 1.03-1.68) conferred additional risk for rehospitalization, while hospitalization in a critical access hospital (aOR 0.30, 95% CI 0.10-0.95) and weight loss (aOR 0.71, 95% CI 0.55-0.92) were associated with decreased odds.

Among older adults with SLE, only 3 variables were selected as predictors by the LASSO procedure: CHF, other neurological conditions, and paralysis. CHF (aOR 1.35, 95% CI 1.11-1.64) and other neurological conditions (aOR 1.26, 95% CI 1.01-1.58) were significantly associated with increased odds of rehospitalization, while paralysis trended toward decreased odds (aOR 0.58, 95% CI 0.33-1.00).

The C statistic was 0.78 for the young adult model, 0.71 for the middle-aged adult model, and 0.67 for the older adult model.

Sensitivity analysis for obstetrical hospitalizations. Obstetrics-related hospitalizations made up 0.52% of SLE-related hospitalizations compared to 0.19% of non-SLE hospitalizations. Whereas rehospitalization rates were much lower for obstetric hospitalizations among young adults without SLE (9.8% vs 27.6% in nonobstetric, $P < 0.001$), rehospitalization rates for obstetric and nonobstetric hospitalizations among young adults with SLE were similarly high (31.7% vs 36.5%, $P = 0.53$). When obstetric hospitalizations were excluded, rehospitalization rates showed very minimal change and there were no changes in the significant predictors of rehospitalization (data not shown).

DISCUSSION

In this study, we found the 30-day rehospitalization risk among young adult Medicare beneficiaries with SLE to be 36%, which is 40% higher than young adult beneficiaries without SLE, and 85% higher than older beneficiaries with SLE. Young adult

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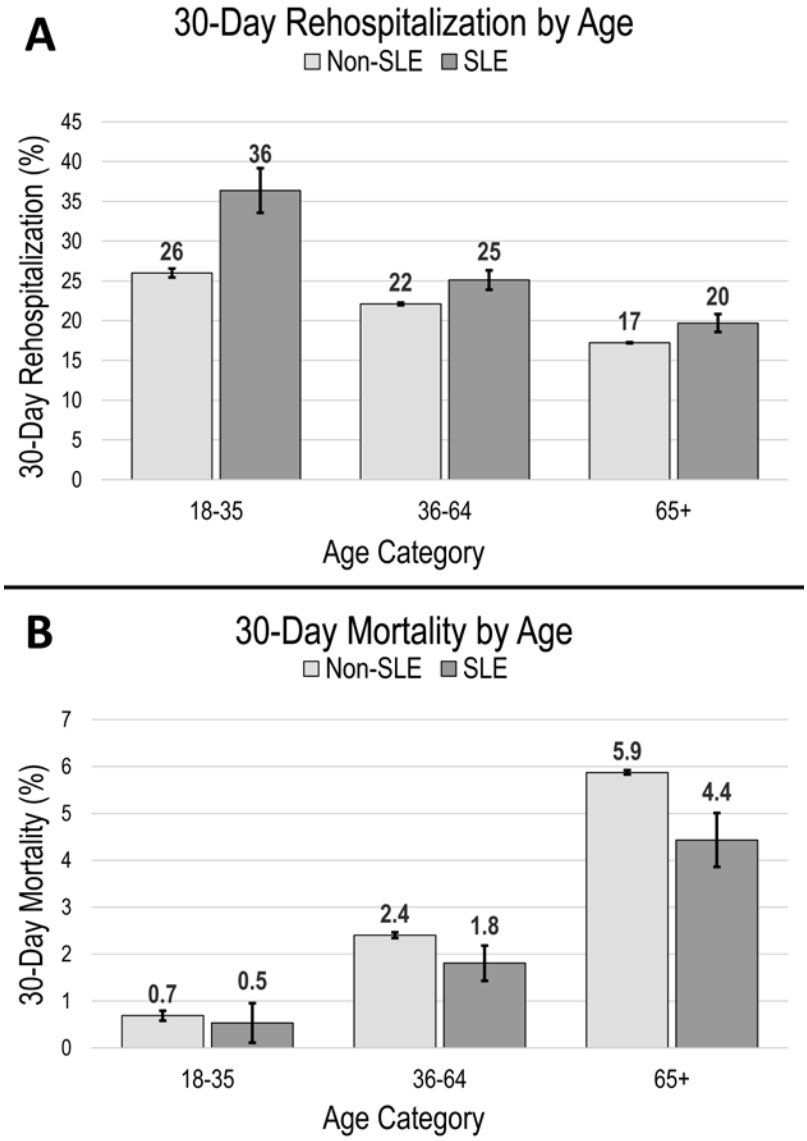

Figure 2. Observed (A) 30-day rehospitalization rates and (B) mortality rates among SLE and non-SLE Medicare beneficiaries by age category. Error bars represent 95% CI. SLE: systemic lupus erythematosus.

beneficiaries with SLE were more racially diverse, were from more disadvantaged neighborhoods, and had a higher burden of comorbidities than middle-aged and older adult beneficiaries with SLE. Our models had moderate-to-good predictive ability for 30-day rehospitalization among beneficiaries with SLE using geo-linked administrative data, demonstrating value for risk stratification. Medical school affiliation of the index hospital was protective for readmissions among young adults with SLE in this Medicare sample. This may indicate positive effects of programs or policies at medical school–affiliated hospitals and potential for wider dissemination efforts. To our knowledge, this is among the first studies to evaluate readmissions for young adults with SLE. It adds to findings from multipayor SLE cohorts that have reported associations of younger age with greater emergency department (ED) use[9] and direct healthcare costs.[37] Our findings underscore the high rehospitalization risk among young adult Medicare beneficiaries with SLE and suggest the need to include young adults with SLE in targeted efforts to reduce rehospitalization.

In Kangovi and Grande's framework for readmissions, rehospitalization is a result not only of inpatient care quality and patient health status but also outpatient care quality, access to care, and patient socioeconomic resources.[11] Uniquely, our models incorporated rich information on the social determinants of health: patient's neighborhood disadvantage (comprising 17 indicators of socioeconomic resources), Medicaid status, and rurality. We found that the highest risk group, young adult beneficiaries with SLE, lived in more disadvantaged socioeconomic contexts, with a median neighborhood disadvantage index 16 percentile points higher than the US median, and 91% qualified for Medicaid. Young adult Medicare beneficiaries with SLE were also highly diverse at 52% Black and 15% Hispanic. Reduced

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Table 2. Adjusted odds for 30-day rehospitalization across SLE age strata with LASSO-selected predictors from all SLE beneficiaries.

	SLE by Age Group, aOR (95% CI)		
	18-35 Years, n = 1103	36-64 Years, n = 4748	65+ Years, n = 4789
Age at index admission (per year)	**0.94 (0.90-0.98)**	**0.98 (0.97-0.99)**	0.99 (0.98-1.01)
Female sex	1.16 (0.70-1.93)	0.90 (0.69-1.17)	0.89 (0.68-1.16)
Race/ethnicity			
White	Ref	Ref	Ref
Asian	0.42 (0.16-1.12)	0.75 (0.35-1.57)	0.81 (0.37-1.78)
Black	0.79 (0.52-1.20)	1.13 (0.94-1.36)	1.07 (0.85-1.35)
Hispanic	0.61 (0.36-1.01)	0.98 (0.71-1.36)	0.83 (0.41-1.70)
American Indian	1.07 (0.48-2.36)	1.31 (0.76-2.26)	1.02 (0.55-1.92)
Other/Unknown	0.89 (0.47-1.67)	0.67 (0.35-1.25)	1.17 (0.56-2.46)
Ever received Medicaid	1.00 (0.58-1.73)	0.93 (0.78-1.11)	0.98 (0.79-1.22)
ADI national rank[a] (per decile increase)	1.00 (0.95-1.06)	1.02 (0.99-1.05)	0.98 (0.95-1.01)
Disability on enrollment	0.93 (0.61-1.42)	0.94 (0.67-1.31)	0.98 (0.82-1.18)
Length of stay (per day)	**1.04 (1.02-1.06)**	**1.04 (1.02-1.05)**	**1.03 (1.01-1.04)**
HCC community risk score[b] (per unit)	**1.10 (1.03-1.18)**	**1.18 (1.14-1.23)**	**1.21 (1.17-1.26)**
Renal failure	1.08 (0.74-1.58)	1.09 (0.89-1.34)	1.01 (0.84-1.23)
Coagulopathy[c]	**1.46 (1.03-2.06)**	1.09 (0.87-1.37)	1.15 (0.91-1.45)
CHF[c]	**2.05 (1.44-2.91)**	1.15 (0.93-1.42)	**1.32 (1.08-1.61)**
Fluid and electrolyte disorders[c]	**2.35 (1.53-3.61)**	**1.26 (1.05-1.52)**	1.17 (0.97-1.41)
Paralysis[c]	**0.23 (0.07-0.78)**	0.75 (0.49-1.15)	0.61 (0.37-1.02)
Drug use disorder[c]	**1.58 (1.10-2.27)**	**1.73 (1.31-2.27)**	1.25 (0.75-2.06)
C statistic	0.77	0.70	0.67

Values in bold are statistically significant. [a] ADI with higher values indicating greater disadvantage. [b] HCC community risk score is scaled to 1 for average risk, with higher values indicating greater comorbidities and healthcare usage. [c] Variables selected by LASSO variable selection performed on all participants with SLE. ADI: Area Deprivation Index; aOR: adjusted odds ratio; CHF: congestive heart failure; HCC: hierarchical condition category; LASSO: least absolute shrinkage and selection operator; SLE: systemic lupus erythematosus.

access to care for Black and Hispanic Americans compared to White Americans is well documented, and prior research has shown these groups may also receive lower-quality SLE care.[38,39]

An inverse relationship between age and rehospitalization rates has been observed in other early-onset chronic conditions, such as type 1 diabetes.[40] Young adults with SLE may disproportionately experience additional barriers to outpatient services (eg, childcare, transportation), potentially contributing to their higher rates of rehospitalization. In the general population, those aged 18 to 39 years were 10% more likely than adults aged ≥ 55 years to report nonfinancial barriers leading to delayed or unmet care[41].

To obtain Medicare coverage, individuals aged < 65 must have ESRD or have qualified for Social Security Disability Insurance benefits for ≥ 24 months.[42] The 5-step qualification process begins by confirming an income of < $1070/month. Young adults with SLE additionally had higher prevalence of many significant comorbid conditions than any other SLE age group (Table 1). In addition to HCC risk score and renal failure status, several other comorbidities potentially related to SLE pathophysiology (coagulopathy, CHF, fluid and electrolyte disorders, and paralysis) were selected for model inclusion. Notably, renal failure was not associated with odds of rehospitalization. Fluid and electrolyte disorders may have captured the sequalae of renal failure that predict rehospitalization. While obstetrical hospitalizations had significantly lower rehospitalization rates among beneficiaries without SLE, obstetrical hospitalizations of beneficiaries with SLE still had high levels of rehospitalization. This suggests readmission reduction efforts should extend to obstetrical care for patients with SLE.

Among young and middle-aged adults, drug use disorder was associated with increased rehospitalization odds. Patients with SLE often need chronic pain management as part of their SLE treatment and are 2 to 3 times more likely to be taking prescribed opioids than patients without SLE, with greater prevalence of previous opioid-related encounters among young adults with SLE.[43,44] Thus, these findings raise concerns about the contribution of substance use disorders, particularly in relation to prescribed opioids, to rehospitalization.

Among young adults with SLE, index hospitalization at a medical school–affiliated hospital was associated with lower odds of rehospitalization. This aligns with previous literature showing higher quality of care and lower 30-day postdischarge mortality for major teaching hospitals compared to nonacademic hospitals for many common inpatient conditions.[45,46] Our finding prompts interest in identifying practices at academic centers that may reduce rehospitalization for potential dissemination.

Our models outperformed prior US population-based studies on health condition-specific readmission risk prediction using retrospective administrative data, which reported moderately predictive models (C statistic range 0.55-0.65).[15] Our method, combining a priori and LASSO-selected variables, including a neighborhood-level social determinant of health index, performed better (C statistic range 0.67-0.77) than those in the literature. These results suggest the value of incorporating location-based metrics of SES, such as the ADI, in readmission

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Table 3. Adjusted odds for 30-day rehospitalization across SLE age groups using age strata-specific LASSO selected predictors.

	SLE by Age Group, aOR (95% CI)		
	18-35 Years, n = 1103	36-64 Years, n = 4748	65+ Years, n = 4789
Age at index admission (per year)	**0.93 (0.90-0.96)**	**0.98 (0.97-0.99)**	1.00 (0.98-1.01)
Female sex	1.13 (0.68-1.89)	0.93 (0.72-1.19)	0.89 (0.68-1.17)
Race/ethnicity			
White	Ref	Ref	Ref
Asian	**0.29 (0.10-0.81)**	0.76 (0.36-1.59)	0.86 (0.40-1.86)
Black	0.72 (0.48-1.08)	1.13 (0.94-1.35)	1.08 (0.85-1.36)
Hispanic	0.61 (0.36-1.03)	1.01 (0.72-1.40)	0.87 (0.43-1.75)
American Indian	1.08 (0.52-2.22)	1.19 (0.71-2.02)	1.02 (0.53-1.94)
Other/unknown	0.87 (0.46-1.65)	0.67 (0.26-1.23)	1.19 (0.57-2.51)
Ever received Medicaid	0.88 (0.50-1.54)	0.93 (0.78-1.11)	0.98 (0.79-1.21)
ADI national rank (per decile increase)[a]	1.00 (0.95-1.05)	1.02 (0.99-1.05)	0.98 (0.95-1.01)
Disability on enrollment	1.00 (0.69-1.46)	0.92 (0.66-1.29)	0.98 (0.81-1.18)
Length of stay (per day)	**1.03 (1.01-1.05)**	**1.04 (1.02-1.05)**	**1.03 (1.01-1.04)**
HCC community risk score (per unit)[b]	**1.09 (1.02-1.17)**	**1.19 (1.15-1.23)**	**1.22 (1.18-1.27)**
Renal failure	1.00 (0.69-1.44)	1.15 (0.95-1.39)	1.03 (0.85-1.24)
Medical school–affiliated hospital[c]	**0.68 (0.50-0.92)**	–	–
Discharge volume[c]			
Highest tertile	Ref	–	–
Middle tertile	0.73 (0.47-1.13)	–	–
Lowest tertile	0.95 (0.67-1.36)	–	–
Critical access hospital[c]	–	**0.30 (0.10-0.95)**	–
Deficiency anemia[c]	1.26 (0.76-2.10)	–	–
CHF[c]	**2.02 (1.46-2.81)**	–	**1.35 (1.11-1.64)**
Coagulopathy[c]	1.36 (0.97-1.90)	–	–
Hypertension with complications[c]	1.05 (0.65, 1.68)	–	–
Fluid and electrolyte disorders[c]	**2.30 (1.49-3.56)**	**1.29 (1.07-1.55)**	–
Other neurological conditions[c]	–	–	**1.26 (1.01-1.58)**
Paralysis[c]	**0.20 (0.06-0.63)**	–	0.58 (0.33-1.00)
Pulmonary circulation disorders[c]	–	1.27 (0.98-1.63)	–
Valvular disease[c]	**1.74 (1.14-2.65)**	–	–
Alcohol use disorder[c]	–	1.51 (0.97-2.36)	–
Diabetes[c]	1.37 (0.94-1.99)	–	–
Drug use disorder[c]	**1.57 (1.12-2.21)**	**1.67 (1.23-2.18)**	–
Liver disease[c]	–	**1.32 (1.03-1.68)**	–
Weight loss[c]	–	**0.71 (0.55-0.92)**	–
C statistic	0.78	0.71	0.67

Values in bold are statistically significant. [a] ADI with higher values indicating greater disadvantage. [b] HCC community risk score is scaled to 1 for average risk, with higher values indicating greater comorbidities and healthcare utilization. [c] Variables selected by LASSO variable selection procedure performed on the respective age stratum of beneficiaries with SLE. ADI: Area Deprivation Index; aOR: adjusted odds ratio; CHF: congestive heart failure; HCC: hierarchical condition category; LASSO: least absolute shrinkage and selection operator; SLE: systemic lupus erythematosus.

risk prediction models. Such metrics are now freely accessible and can be integrated into both retrospective administrative and real-time electronic health record data.[27,47] Notably, while the fit of age-specific models revealed some unique significant predictors in each age group, it had little effect on overall predictive value compared to the model developed with patients of all ages. The presented SLE-specific prediction models can aid healthcare and insurance systems in deciding where to focus resources to reduce rehospitalizations by risk-stratifying among the high-risk SLE patient population.

While there are many strengths of this study, including a large national cohort of patients with SLE, we acknowledge some limitations. Since this study used claims data, we do not have some patient health measures, such as functional status or current SLE disease activity. Individuals aged < 65 years must meet additional requirements to receive Medicare benefits. Thus, results for patients aged < 65 years may not generalize to the US population with SLE, particularly patients with better health status, lower prevalence of ESRD, or those unable to navigate disability qualification. However, one-third of individuals with SLE in the US have public insurance and one-half of SLE-related hospitalizations and ED visits are covered by Medicare or Medicaid,[10,48,49] making this cohort relevant to practice and policy. Higher rates of ED use among young adult patients with SLE in a multipayor SLE cohort[9] suggest that the higher risk of acute healthcare use in young adult patients with SLE is not unique to Medicare beneficiaries. Poor health status of Medicare beneficiaries also underscores the importance

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of developing interventions for this group. Reported race and ethnicity in Medicare data have known issues with misclassification.[22,23] While we used the more valid RTI measure, approximately 4% of patients may be misclassified. Native American and Asian patients are more likely to be misclassified,[22] which could affect comparisons involving these groups. As administrative data were used in this study, conditions and billing codes may not have been uniformly coded for all beneficiaries. However, previously validated, published algorithms for administrative data were used to define SLE and other comorbidities.[18,31] Coding bias may also have been reduced since all individuals in the cohort had the same insurance coverage.

While Medicare covers many patients with SLE, multipayor or Medicaid cohorts should be evaluated to compare rates and validate the rehospitalization predictors among young adults, including more patients without ESRD. Further research comparing rehospitalization reasons should be performed among young adults with SLE. Additional evaluations are needed of socioeconomic resource and access barriers for young adults with SLE and their relation to rehospitalization, ambulatory vs acute care use, and healthcare costs. For Medicare SLE-related hospitalizations, the administrative data-based predictive models had moderate-to-good predictive value and could be applied to prioritize patients with SLE for readmission interventions. These areas of inquiry can be leveraged to inform program and policy development to reduce rehospitalization and improve care for young adults with SLE.

Young adult Medicare beneficiaries with SLE were 40% more likely to be rehospitalized within 30 days compared to age matched beneficiaries without SLE and 85% more likely than older beneficiaries with SLE. This elevated rehospitalization rate among young adults with SLE in Medicare may be partially explained by higher neighborhood disadvantage and greater prevalence among Black and Hispanic patients, who generally have reduced access to healthcare and receive lower-quality SLE care than White patients.[38,39] Young adult beneficiaries with SLE also had more comorbidities, which increased their odds of rehospitalization. The presented SLE-specific prediction models had moderate-to-good prediction for 30-day rehospitalization, informing risk stratification. Together, these findings suggest a critical need to develop targeted interventions, alongside young adults with SLE, to provide greater outpatient support, address disease management barriers, and reduce costly rehospitalizations.

ACKNOWLEDGMENT

The authors would like to thank Monica Messina for manuscript formatting.

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