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Association of area deprivation index with adherence to proposed regimen in patients with sarcoidosis in Detroit, Michigan

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Abstract. *Background and aim:* Social predictors affect severity of sarcoidosis, with Black patients, older individuals, those with lower income, and those without insurance having greater severity. This study aimed to explore potential disparities affecting access to care in sarcoidosis patients with a primary focus on metrics such as area deprivation index (ADI) and its association with adherence to the proposed regimen. *Methods:* A retrospective chart review study of all patients seen in pulmonary clinics at a large urban tertiary care center over 2 years with sarcoidosis patients identified with International Classification of Diseases diagnosis code D86. Data collected included age, race, sex, ADI, insurance, online patient portal usage, chest x-rays, pulmonary function tests, missed visits, hospitalizations, positive biopsy, communication and visits around bronchoscopy. Categorical variables were described using frequency and percentage. Numerical variables were described using median, mean and standard deviation. Statistical analysis included chi-square test, two-sample T-test and Wilcoxon rank sum test. Multivariate logistic regression analysis was performed to model independent association with 12 month no-show occurrence as a metric of adherence to the proposed regimen. *Results:* Among sarcoidosis patients (N = 788), univariate models showed the presence of active online patient portal use among younger patients (58.6 years with portal vs. 65.1 years without portal, $p < 0.001$), those with lower ADI (73 with portal vs. 92 without portal, $p < 0.001$) and with commercial insurance (48.5% with portal vs. 20.7% without portal, $p < 0.001$); more x-rays (45.6% with x-rays vs. 36.6% without x-rays, $p = 0.018$) and hospitalizations (50.3% with hospitalizations vs. 36.2% without hospitalizations, $p < 0.001$) in Medicare patients. Sarcoidosis patients with positive biopsies on file from 2013-2023 were more likely to be male (44.19% with positive biopsy vs. 33.91% without positive biopsy, $p = 0.006$), White (36.29% with positive biopsy vs. 22.9% without positive biopsy, $p < 0.001$) or other races (3.23% with positive biopsy vs. 2.25% without positive biopsy, $p < 0.001$), younger (55.8 years with positive biopsy vs. 61.7 years without positive biopsy, $p < 0.001$) and belonged to lower national ADI ranks (73 with positive biopsy vs. 80 without biopsy, $p = 0.041$). A multivariate analysis was done with those variables found to be significant in the univariate analyses, which revealed that higher ADI national was associated with failure to adhere to the proposed regimen. *Conclusions:* We identified intricate patterns of sociodemographic variables affecting access to care in sarcoidosis patients, especially higher ADI national associated with failure to adhere to the proposed regimen, raising concerns for potential healthcare barriers. Understanding these barriers is vital for equitable high-quality care, assisting in timely and efficient management of the patient's disease.

Key words: Healthcare inequalities, health services accessibility, lung diseases

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Introduction

There is immense ongoing research in the domains of epidemiology, natural history of disease, and management of sarcoidosis. The ACCESS study in 2004 assessed the role of social predictors on disease severity at the time of presentation and found Black patients, older individuals, those with lower income, and absence of private or Medicare insurance to have more severe disease at the time of presentation (1) with age-adjusted mortality rate 12 times higher in Blacks than for Caucasians (2). Patients from low-income zip codes perceived more concerns about discrimination based on race and income (3), with a multivariate analysis in the United States revealing low-income patients to have significantly higher rates of new sarcoidosis-related and new steroid-related comorbidities (4). The United States reported the incidence rate of sarcoidosis to range from 7.6-8.8 per 100,000 people per year (5) with a reported higher incidence and prevalence in Black than other races, with women twice as likely as men, and highest prevalence noted in Black women (6). The city of Detroit, Michigan (when compared to the United States) had 5 times greater Black population (77.1% vs. 13.6%), with almost half the median household income from 2016-2020 ($32,498 vs. $64,994), and almost thrice persons in poverty (33.2% vs. 11.6%) placing this population at greater risk of disparities (7). As higher ADI has been found to be associated with worse baseline lung function and rapid decline (8), we aimed to study metrics such as ADI and explore its association with adherence to the proposed regimen in patients with sarcoidosis. In addition, we aimed to explore potential disparities affecting access to care including office visits, chest x-rays, pulmonary function tests (PFTs), bronchoscopies, and number of hospitalizations to understand essential information to incorporate into future practice at provider, patient and healthcare system levels.

Methods

This is a retrospective chart review of records for patients 18 years and older scheduled for office and virtual visits in the pulmonary clinics at the health system between January 1, 2020, and December 31, 2022. This study was approved by the Institutional Review Board. Sarcoidosis patients (identified as those with International Classification of Diseases Tenth Revision diagnosis code D86: Sarcoidosis) have been seen by our clinics for years; however, a formal Sarcoid Clinic was started in January 2020. Those included in our study are from all pulmonary clinics, including the Sarcoid Clinic, for the time frame stated.

Data collected included date of office visit(s), age, race (Black, White, or races other than Black or White), sex, socioeconomic status utilizing area deprivation index (ADI), income, insurance type (Medicare, Medicaid, or Commercial), online patient portal, chest x-rays, PFTs, missed clinic visits (for all patients in the pulmonary clinics), number of hospitalizations and mortality. Additional data included positive biopsy on file, bronchoscopy on file, communication of results after bronchoscopy and visits around the time of bronchoscopy. The ADI was developed by the University of Wisconsin-Madison and ranks neighborhoods by socioeconomic status disadvantage using census block groups and includes factors such as income, house quality, employment, and education level. Areas with a higher ADI represent higher deprivation or more socioeconomic disadvantage and vice versa.

Initially, analysis was done using univariate models. Categorical variables such as presence of sarcoidosis, insurance type, race, sex, deceased status, active online patient portal, presence of biopsy, and biopsy result were described using frequency. Numerical variables such as age, ADI national and state ranks, no-show appointments, number of hospitalizations, chest x-rays, PFTs, days to communication of biopsy result and days to appointment after biopsy were described using medians, means and standard deviations. Statistical analysis was done using chi-square test, two-sample T-test, Wilcoxon rank sum test, Kruskal-Wallis test and Spearman correlation analysis, and a p-value of < 0.05 was considered statistically significant.

Subsequently, a multivariate logistic regression analysis was performed. The outcomes of 6 month and 12 month no-shows were similar therefore comparisons based on 12 month no-show occurrence were first analyzed by univariate analysis. We selected variables for multivariate analysis that were found to be significant in univariate analyses, which included five variables including age, ADI national, ADI state, Medicare insurance and Medicaid insurance. We found ADI national and state to be collinear therefore ADI national was used in the

analysis due to clinical significance. Multivariate logistic regression was performed to model independent association between the remaining 4 variables and 12 month no-show occurrence. A p value < 0.05 was considered statistically significant and odds ratios with confidence intervals were reported. Statistical analysis was performed using SPSS 27 (IBM, Armonk, NY).

Results

There were 13,824 patients seen in various locations of pulmonary clinics across the health system that were included in this chart review. Results described below include multiple univariate models followed by a multivariate logistic regression analysis.

Among all the patients seen in pulmonary clinics during our study period (Table 1), more than half (55.9%) had Medicare as their primary insurance, were more likely to be White, more likely female, had a mean age of 65.7 years, ADI state rank of 5 and ADI national rank of 66. The majority, greater than 75%, had active online patient portal and PFTs, while about 50% had x-rays on file. A third (33%) of these patients had no-show appointments within the

Table 1. Sociodemographic features among patients with sarcoidosis compared to patients seen for other pulmonary diseases

		Sarcoidosis		Comparison P-value
		No (N=13036)	Yes (N=788)	
Insurance type	Medicare	7242 (56.7%)	320 (41.5%)	<0.001 (C)*
	Medicaid	1363 (10.7%)	109 (14.1%)	
	Commercial	4161 (32.6%)	342 (44.4%)	
Age, years		64.2 ± 15.2 (66.1)	58.9 ± 11.7 (59.4)	<0.001 (T)*
Race	White	7293 (58.4%)	215 (28.6%)	<0.001 (C)*
	Black	4426 (35.5%)	519 (69.0%)	
	Other	763 (6.1%)	18 (2.4%)	
Sex	Male	5234 (40.2%)	299 (37.9%)	0.220 (C)
	Female	7802 (59.8%)	489 (62.1%)	
Deceased		1304 (10.0%)	40 (5.1%)	<0.001 (C)*
Active online patient portal		10023 (77.1%)	671 (85.2%)	<0.001 (C)*
Any no-show appointments within 6 months of the first visit		4259 (32.7%)	303 (38.5%)	<0.001 (C)*
Any no-show appointments within 12 of the first visit		4912 (37.7%)	373 (47.3%)	<0.001 (C)*
Any hospitalizations		4992 (38.3%)	294 (37.3%)	0.581 (C)
Any x-rays		7002 (53.7%)	432 (54.8%)	0.544 (C)
Any PFTs		10123 (77.7%)	669 (84.9%)	<0.001 (C)*
Number of no-show appointments within 6 months of the first visit		0.5 ± 0.8 (0.0)	0.6 ± 0.9 (0.0)	<0.001 (W)*
Number of no-show appointments within 12 months of the first visit		0.6 ± 1.0 (0.0)	0.8 ± 1.2 (0.0)	<0.001 (W)*
Number of hospitalizations		2.9 ± 7.6 (0.0)	2.9 ± 7.5 (0.0)	0.621 (W)
Number of x-rays		1.4 ± 2.4 (1.0)	1.3 ± 2.0 (1.0)	0.665 (W)
Number of PFTs		1.2 ± 1.3 (1.0)	1.5 ± 1.3 (1.0)	<0.001 (W)*
ADI national rank		63.4 ± 27.6 (65.0)	69.8 ± 26.9 (77.0)	<0.001 (W)*
ADI state rank		5.3 ± 3.2 (5.0)	6.0 ± 3.2 (7.0)	<0.001 (W)*

ADI, area deprivation index; C, chi-square test; PFTs, pulmonary function tests; T, two-sample t-test; W, Wilcoxon rank sum test. *Used to indicate significant P value < 0.05.

6 and 12 months following the first visit along with hospitalizations during the study period.

Among these patients, 788 were found to have sarcoidosis as identified by primary diagnosis International Classification of Diseases code of D86, accounting for 5.7% of all patients seen in the pulmonary clinics. There were notable findings when comparing patients seen in the pulmonary clinics for sarcoidosis as their primary diagnosis to those seen for other pulmonary conditions (Table 1). In sarcoidosis patients compared to the rest of the population, there was higher use of a commercial insurance (44.4% vs. 32.6%) and Medicaid (14.1% vs. 10.7%) compared to Medicare (41.5% vs. 56.7%), they were typically slightly younger (59.4 vs. 66.1 years), more likely to be Black, more likely to be female (although not statistically significant), along with belonging to areas of higher deprivation based on national (77 vs. 65) and state rankings (7 vs. 5). Sarcoidosis patients compared to non-sarcoidosis counterparts were more likely to have active online patient portal (85.2% vs. 77.1%), more PFTs on file (84.9% vs. 77.7%) and interestingly have more no-show appointments (6-month 38.5% vs. 32.7% and 12-month 47.3% vs. 37.7%). Both groups had similar rates of hospitalizations and x-rays, which were not statistically significant. Of the sarcoidosis patients, 5.1% are deceased, although this does not accurately represent mortality.

Comparison of sociodemographic variables including age, race, sex, insurance type, ADI, and their interactions with various measures of access to care were initially analyzed in those patients with sarcoidosis with univariate models as noted in Table 2. In addition, among the sarcoidosis patients who had biopsies on file from 2013-2023, the interactions of age, race, sex, ADI with presence of biopsy, type of biopsy (bronchoscopy or not), presence of pre-bronchoscopy pulmonary office visit, days to communicate the biopsy result, days to first appointment (including no-show appointments) and days to starting medication were analyzed. Of the 788 patients with sarcoidosis, 624 had information regarding biopsy on file in our electronic medical record system, dating back to 2013. Of these 624, 158 had a positive biopsy indicating a biopsy that was diagnostic for sarcoidosis while 466 had a nondiagnostic bronchoscopy. Those with a "positive biopsy" on file include 158 with a diagnostic biopsy.

When studying the interactions of median age with various outcomes as seen in Figure 1 and Table 2, it appeared that older individuals were more likely to be deceased (69.2 years deceased vs. 58.8 years not deceased, $p < 0.001$), and have more hospitalizations (61.7 years with hospitalizations vs. 57.9 years without hospitalizations, $p < 0.001$). On the contrary, younger patients were found to have more 6 month no-shows (57.4 years with no-shows vs. 60.2 years without no-shows, $p = 0.002$), more likely to have more active patient portals (58.6 years with portal vs. 65.1 years without portal, $p < 0.001$). The patients with a positive biopsy on file were slightly younger (55.8 years with positive biopsy vs. 61.7 years without positive biopsy, $p < 0.001$) and a younger age was significantly associated with a greater number of appointments made and cancelled/no-showed before the post-bronchoscopy visit ($p = 0.021$).

Race appeared to interact with outcomes of access to care including active patient portal, x-rays on file and positive biopsies on file, as seen in Figure 2 and Table 2. White patients were more likely to have active patient portal (31% with portal vs. 14.5% without portal, $p < 0.001$), and Black patients were less likely to have active patient portal (66.4% with portal vs. 84.5% without portal, $p < 0.001$). It appeared that Black patients had more x-rays on file (74.8% with x-rays vs. 61.9% without x-rays, $p < 0.001$). Black patients were significantly less likely (60.48% with positive biopsy vs. 74.83% without positive biopsy, $p < 0.001$) to have a positive biopsy on file when compared to White (36.29% with positive biopsy vs. 22.9% without positive biopsy, $p < 0.001$) and other races (3.23% with positive biopsy vs. 2.25% without positive biopsy, $p < 0.001$), significantly less likely to have been diagnosed with bronchoscopy rather than non-bronchoscopic (74.6% vs. 25.4%, $p = 0.015$) biopsies and it took almost double the time to be started on medication than White patients (41 days vs. 22 days, $p = 0.038$).

Sex did not seem to significantly affect having an active patient portal, records of chest x-rays, pulmonary function tests, no-show rates or hospitalizations. (Table 2) Females were significantly less likely (55.81% with positive biopsy vs. 66.09% without positive biopsy, $p = 0.006$) to have a positive biopsy on file when compared to the males (44.19% with positive biopsy vs. 33.91% without positive biopsy, $p = 0.006$). Sex did not appear to affect type of biopsy or presence of pre-bronchoscopy visits; however, it appeared that male patients took longer to schedule visits and make it to their first appointment, although not statistically significant.

Table 2. Interaction of sociodemographic variables with outcomes in sarcoidosis patients

		Insurance			Age	Race			Sex		ADI	
		Medicare	Medicaid	Commercial		White	Black	Other	Female	Male	ADI National	ADI State
Deceased	No (N=748)	291 (39.8%)	107 (14.6%)	334 (45.6%)	58.5 ± 11.6 (58.8)	206 (28.9%)	488 (68.5%)	18 (2.5%)	464 (62.0%)	284 (38.0%)	69.5 ± 27.1 (76)	6.0 ± 3.2 (7)
	Yes (N=40)	29 (74.4%)	2 (5.1%)	8 (20.5%)	66.2 ± 12.5 (69.2)	9 (22.5%)	31 (77.5%)	0 (0.0%)	25 (62.5%)	15 (37.5%)	76.6 ± 22.8 (81.5)	6.8 ± 3.0 (7)
	P-value	<0.001 (C) *			<0.001 (T) *	0.368 (C)			0.953 (C)		0.087 (W)	0.082 (W)
Active Patient Portal	No (N=117)	76 (65.5%)	16 (13.8%)	24 (20.7%)	63.8 ± 11.9 (65.1)	16 (14.5%)	93 (84.5%)	1 (0.9%)	68 (58.1%)	49 (41.9%)	81.5 ± 21.8 (92)	7.4 ± 2.8 (9)
	Yes (N-671)	244 (37.3%)	93 (14.2%)	318 (48.5%)	58.0 ± 11.5 (58.6)	199 (31.0%)	426 (66.4%)	17 (2.6%)	421 (62.7%)	250 (37.3%)	67.8 ± 27.2 (73)	5.8 ± 3.2 (6)
	P-value	<0.001 (C) *			<0.001 (T) *	<0.001 (C) *			0.342 (C)		<0.001 (W) *	<0.001 (W) *
Any X-ray on file	No (N=356)	128 (36.6%)	48 (13.7%)	174 (49.7%)	58.1 ± 11.4 (58)	120 (35.7%)	208 (61.9%)	8 (2.4%)	219 (61.5%)	137 (38.5%)	67.7 ± 27.8 (74)	5.8 ± 3.3 (6)
	Yes (N=432)	192 (45.6%)	61 (14.5%)	168 (39.9%)	59.5 ± 12.0 (60.1)	95 (22.8%)	311 (74.8%)	10 (2.4%)	270 (62.5%)	162 (37.5%)	71.6 ± 26.1 (79)	6.2 ± 3.2 (7)
	P-value	0.018 (C) *			0.076 (T)	<0.001 (C) *			0.777 (C)		0.045 (W) *	0.052 (W)
Any PFT on file	No (N=119)	59 (50.9%)	7 (6.0%)	50 (43.1%)	60.0 ± 11.1 (61)	31 (27.2%)	80 (70.2%)	3 (2.6%)	77 (64.7%)	42 (35.3%)	68.3 ± 28.4 (77)	5.9 ± 3.3 (7)
	Yes (N=669)	261 (39.8%)	102 (15.6%)	292 (44.6%)	58.7 ± 11.8 (59.2)	184 (28.8%)	439 (68.8%)	15 (2.4%)	412 (61.6%)	257 (38.4%)	70.1 ± 26.7 (76)	6.1 ± 3.2 (7)
	P-value	0.010 (C) *			0.263 (T)	0.928 (C)			0.518 (C)		0.353 (W)	0.543 (W)
Any No Show within 6 Months of the First Visit	No (N=485)	196 (40.7%)	59 (12.3%)	226 (47.0%)	59.9 ± 11.3 (60.2)	129 (28.2%)	320 (69.9%)	9 (2.0%)	305 (62.9%)	180 (37.1%)	68.1 ± 27.5 (73)	5.8 ± 3.3 (6)
	Yes (N=303)	124 (42.8%)	50 (17.2%)	116 (40.0%)	57.3 ± 12.2 (57.4)	86 (29.3%)	199 (67.7%)	9 (3.1%)	184 (60.7%)	119 (39.3%)	72.6 ± 25.7 (81.5)	6.3 ± 3.2 (7)
	P-value	0.069 (C)			0.002 (T) *	0.578 (C)			0.543 (C)		0.063 (W)	0.049 (W) *
Any No Show within 12 Months of the First Visit	No (N=415)	156 (38.0%)	53 (12.9%)	202 (49.1%)	59.6 ± 11.6 (59.8)	114 (29.3%)	268 (68.9%)	7 (1.8%)	257 (61.9%)	158 (38.1%)	67.7 ± 27.7 (73)	5.8 ± 3.3 (6)
	Yes (N=373)	164 (45.6%)	56 (15.6%)	140 (38.9%)	58.1 ± 11.9 (58.6)	101 (27.8%)	251 (69.1%)	11 (3.0%)	232 (62.2%)	141 (37.8%)	72.2 ± 25.9 (81)	6.3 ± 3.2 (7)
	P-value	0.017 (C) *			0.067 (T)	0.513 (C)			0.938 (C)		0.046 (W) *	0.041 (W) *
Hospitalizations	No (N=494)	174 (36.2%)	71 (14.8%)	236 (49.1%)	57.4 ± 11.8 (57.9)	142 (30.5%)	310 (66.5%)	14 (3.0%)	296 (59.9%)	198 (40.1%)	69.6 ± 27.2 (75)	6.0 ± 3.2 (6)
	Yes (N=294)	146 (50.3%)	38 (13.1%)	106 (36.6%)	61.3 ± 11.3 (61.7)	73 (25.5%)	209 (73.1%)	4 (1.4%)	193 (65.6%)	101 (34.4%)	70.2 ± 26.4 (78)	6.1 ± 3.2 (7)
	P-value	<0.001 (C)*			<0.001 (T)*	0.104 (C)			0.109 (C)		0.742 (W)	0.722 (W)
Positive biospy on file	No (N=466)	not analyzed			61.1 ± 11.3 (61.7)	102 (22.9%)	333 (74.8%)	10 (2.3%)	308 (66.1%)	158 (33.9%)	71.9 ± 26.1 (80)	6.3 ± 3.1 (7)
	Yes (N=158)				55.2 ± 11.6 (55.8)	90 (36.3%)	150 (60.5%)	8 (3.2%)	144 (55.8%)	114 (44.2%)	67.6 ± 27.8 (73)	5.8 ± 3.3 (6)
	P-value				< 0.001*	< 0.001 (C)*			0.006 (C)*		0.041 (T) *	0.056 (T)

ADI, area deprivation index; C, chi-square test; PFTs, pulmonary function tests; T, two-sample t-test; W, Wilcoxon rank sum test. *Used to indicate significant P value < 0.05.

Type of insurance was classified as Medicare, Medicaid and commercial and were found to have significant interactions with various outcomes, as noted in Figure 3 and Table 2. There was a higher percentage of deceased patients among sarcoidosis patients with Medicare insurance (74.4% deceased vs. 39.8% not deceased, p < 0.001). Having an active patient portal was associated with use of commercial insurance (48.5% with portal vs. 20.7% without portal, p < 0.001) rather than Medicare. While chest x-rays were significantly seen more in those with Medicare (45.6% with x-rays vs. 36.6% without x-rays, p = 0.018), it was seen less in those with commercial insurance (39.9% with x-rays vs. 49.7% without x-rays, p = 0.018). It was also noted that presence of PFTs on file was more prevalent in dose with Medicaid insurance (15.6% with PFTs vs. 6% without PFTs, p = 0.010). Patients with

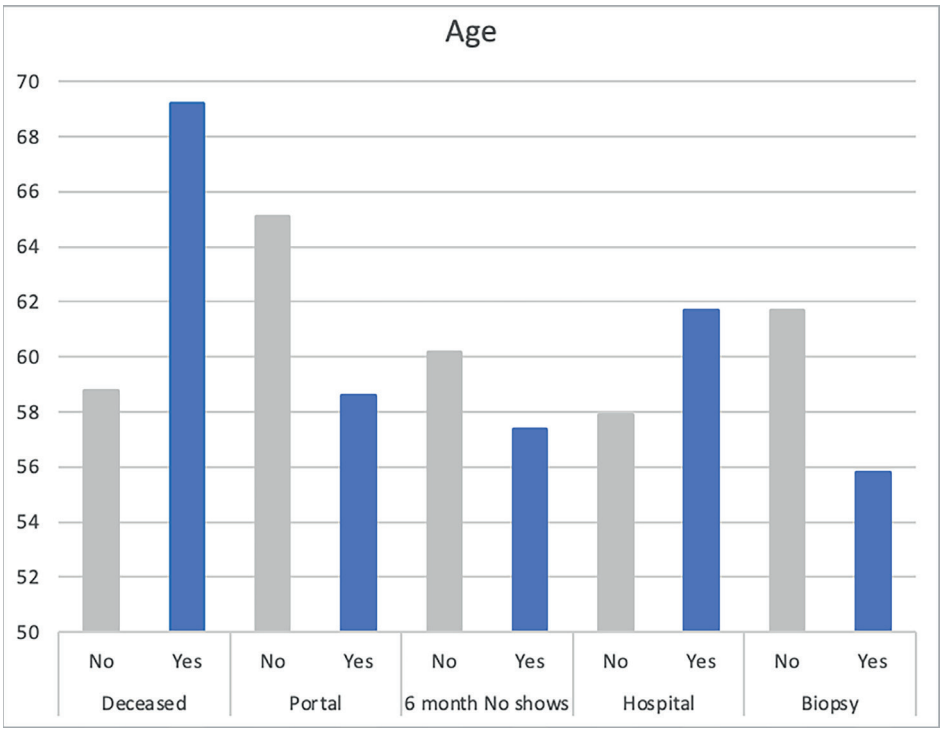

Figure 1. Significant interactions ($p < 0.05$) of median age with outcomes related to access to care. Y axis represents median age in years, X axis represents outcomes including deceased state, active patient portal, no-show rates within 6 months from initial visit, hospitalizations, and positive biopsies on file.

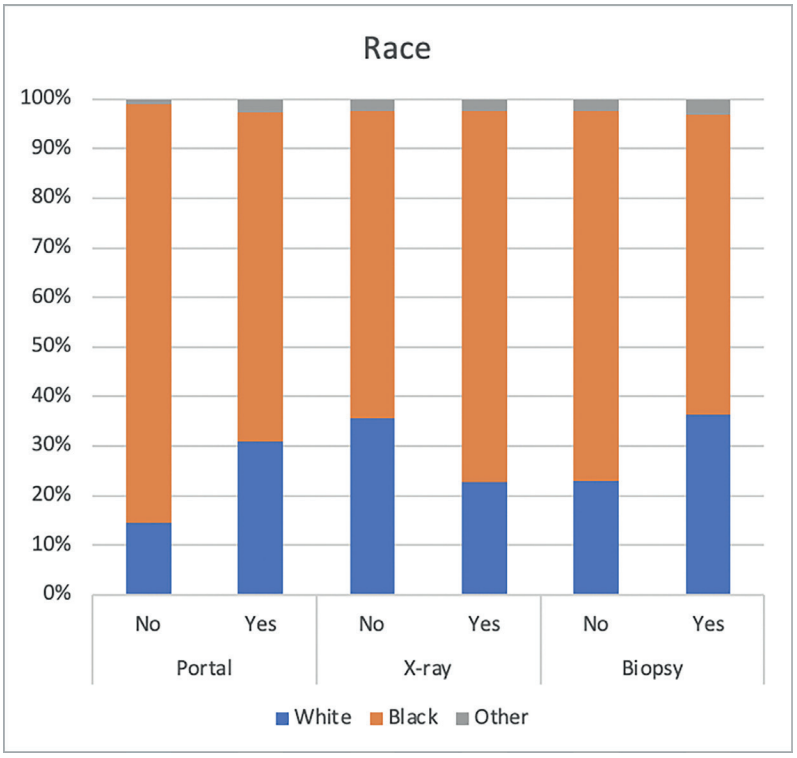

Figure 2. Significant interactions ($p < 0.05$) of race categories with outcomes related to access to care. Y axis represents percentage, X axis represents outcomes including active patient portal, chest x-rays on file, and positive biopsies on file.

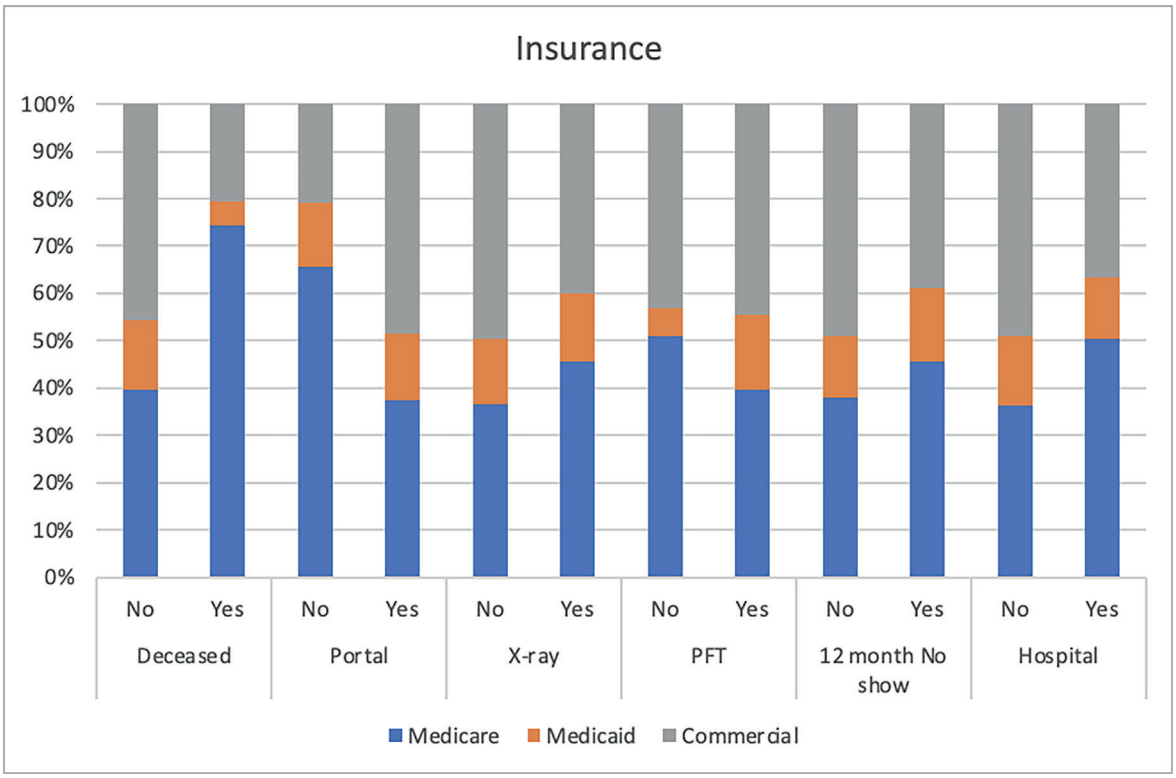

Figure 3. Significant interactions ($p < 0.05$) of insurance categories with outcomes related to access to care. Y axis represents percentage, X axis represents outcomes including deceased status, active patient portal, chest x-rays on file, PFTs on file, no-show rates within 12 months from initial visit, and hospitalizations.

no-show appointments were more likely to be covered by government insurance including Medicare (6-month no-shows 42.8% vs. 40.7% without no-shows, 12-month no-shows 45.6% vs. 38% without no-shows, $p = 0.01$) and Medicaid (6-month no-shows 17.2% vs. 12.3% without no-shows, 12-month no-shows 15.6% vs. 12.9% without no-shows, $p = 0.01$). Patients who were hospitalized were more likely to be covered by Medicare (50.3% with hospitalizations vs. 36.2% without hospitalizations, $p < 0.001$).

The interaction between area deprivation index and access to care revealed significant associations, and this included state (Figure 4 and Table 2) and national ADI (Figure 5 and Table 2). A lower national ADI was associated with active patient portal (73 with portal vs. 92 without portal, $p < 0.001$) and positive biopsy on file (73 with positive biopsy vs. 80 without biopsy, $p = 0.041$). Whereas a higher national ADI was associated with chest x-rays on file (79 with x-rays vs. 74 without x-rays, $p = 0.045$) and 12 month no shows (81 with no-shows vs. 73 without no-shows, $p = 0.046$). Similarly, a lower state ADI was associated with active patient portal (6 with portal vs. 9 without portal, $p < 0.001$) and a higher state ADI was associated with higher rate of 6 month (7 with no-shows vs. 6 without no-shows, $p = 0.049$) and 12 month no shows (7 with no-shoes vs. 6 without no-shows, $p = 0.041$).

Finally, a multivariate logistic regression analysis was done as represented in Table 3. Based on this analysis, lower ADI national was found to be associated with lower 12 month no-show occurrences or adherence to proposed regimen and higher ADI national was found to be independently associated with higher 12 month no-show occurrences or failure to adhere to the proposed regimen. (OR 0.994, CI 0.989-0.099, p-value = 0.025) Having Medicare insurance shows a trend towards higher 12 month no-show occurrences or failure to adhere to the proposed regimen (OR 1.381), however the p-value slightly crosses that of significance (0.066) and the confidence interval crosses unity (0.979-1.948).

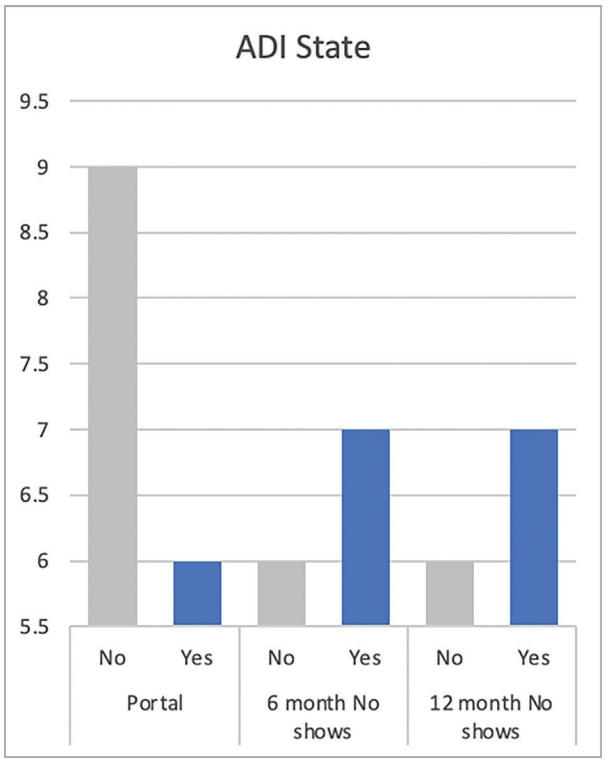

Figure 4. Significant interactions ($p < 0.05$) of median ADI state with outcomes related to access to care. Y axis represents median ADI state, X axis represents outcomes including active patient portal, no-show rates within 6 and 12 months from initial visit.

Table 3. Multivariate logistic regression analysis of comparison of 12 month no-show occurrences and independent variables.

	OR	CI	p-value
Age	1.002	0.990-1.014	0.776
ADI N	0.994	0.989-0.999	0.025
Medicaid	0.833	0.540-1.285	0.409
Medicare	1.381	0.979-1.948	0.066

ADI N, area deprivation index national; OR, odds ratio; CI, confidence interval; p-value < 0.05 is considered statistically significant.

Discussion

The most noteworthy finding of this retrospective study was the association of ADI with adherence to the proposed regimen. The no-show rate is an important indicator of adherence to therapy because it implicates availability of appointments, transportation, medical literacy, and effective treatment, and adversely impacts those persons from demographic groups impacted by disparity. A higher ADI national, indicating higher socioeconomic deprivation was associated with failure to adhere to the proposed regimen in patients with sarcoidosis, measured with 12 month no-show occurrences, both in univariate and multivariate analyses. Greater sociodemographic

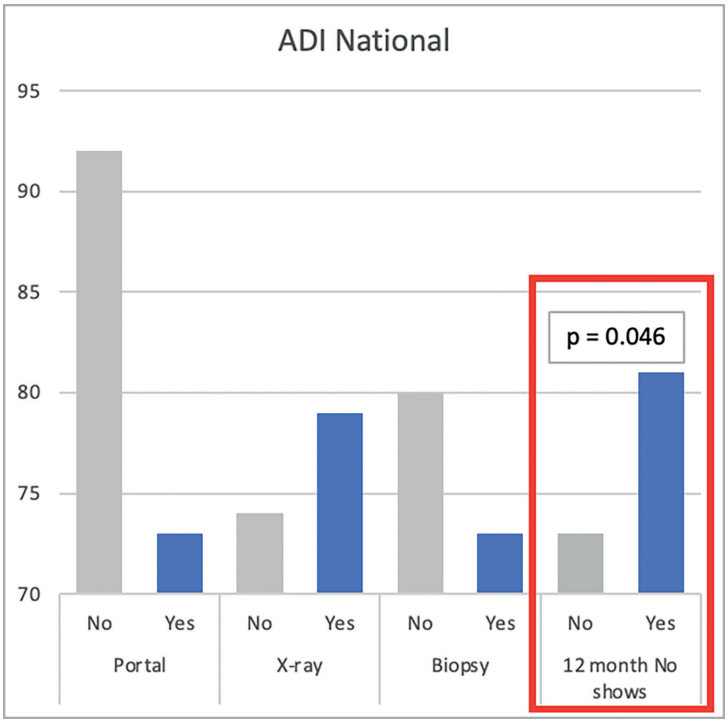

Figure 5. Significant interactions ($p < 0.05$) of median ADI national with outcomes related to access to care. Y axis represents median ADI national, X axis represents outcomes including active patient portal, chest x-rays on file, no-show rates within 12 months from initial visit, and positive biopsies on file. Red box is used to denote significant association on multivariate analysis.

deprivation has been found to be associated with worse baseline lung function and rapid decline (8), likely due to disparities in access to care as noted in our study. This highlights the clinical significance of ADI as it takes into consideration multiple factors such as income, house quality, employment, and educational level, leading to an intricate pattern of disparities.

This study also identified various patterns of socioeconomic and demographic variables affecting care. Previous studies have shown that among those with sarcoidosis, those who are uninsured or with public insurance are known to have worse outcomes secondary to healthcare barriers (1), while Black patients and females tend to have multiple organ involvement, and likely poor outcomes (9) and hospitalizations (10). Studies suggest that mortality in patients with sarcoidosis could indicate healthcare disparities (11). While potential contributors to health disparities have been described including the financial strain associated with the diagnosis of sarcoidosis (12), further studies are needed to explore causative mechanisms at play.

In our study, the overall population demographic comprised more than half of the patients insured by Medicare, more likely to be White females, and had a mean age of 65.7 years. Interestingly, this was not the typical distribution of characteristics studied in the Detroit population (7), which may reflect increased access to care in Medicare beneficiaries and White patients. The sarcoidosis group itself was insured by commercial insurance and Medicaid more than Medicare, likely due to being younger, more likely Black, females and belonged to lower socioeconomic classes when compared to the rest of the population, a trend seen in other studies (6, 7) that described the natural disease process of sarcoidosis. A notable finding among sarcoidosis patients when compared to the rest of the population seen in pulmonary clinic was higher percentage of active online patient portal status, with surprisingly more no-show appointments, which may indicate a barrier in access to care despite an active mode of communication via the patient portal or lack of timely transportation.

We then assessed certain measures including deceased status, online patient portal usage, presence of chest x-rays and PFTs, no-show appointments and hospitalizations and their interaction with insurance, age, race, sex and ADI in sarcoidosis patients, initially using univariate models followed by multivariate logistic regression analysis.

Additional findings were noted in the univariate models. Although not an accurate measure of mortality, older patients had a higher percentage of **deceased** status. This was not further explored by our study but could be due to increased comorbidities. **Online patient portals** are a vital mode of communication that healthcare systems have turned to and as expected, the online patient portal was used by younger patients with commercial insurance. While sarcoidosis patients seemed to have an active account more than their non-sarcoidosis counterparts, this did not translate into less no-show appointments as one would expect. Understanding the pattern among this group may aid us in utilizing this platform more efficiently. The presence of **chest x-rays** and **PFTs** on record were considered outcomes of importance given their use in monitoring the sarcoidosis disease status and progression. Medicare beneficiaries and White patients had more chest x-rays on file; Medicaid beneficiaries had more PFTs. This may reflect increased access to care in Medicare beneficiaries and White patients. Patients who were **hospitalized** were more likely to be older and covered by Medicare, showing that older lower income patients are sicker. Surprisingly, there was no association of deprivation or neighborhood disadvantage on hospitalizations; however, this may be limited by the lack of access to outside hospital records. Finally, we explored potential interactions of sociodemographic variables with presence of **positive biopsy on file**, type of biopsy and care surrounding the bronchoscopy. It was interesting to note that sarcoidosis patients with positive biopsies on file from 2013-2023 were more likely to be male, White or other races, younger and belonged to lower national ADI ranks, in contrast to the typical demographic of sarcoidosis patients in our study, who were younger, female, Black and belonging to higher ADI. This highlights disparate access to obtaining biopsies for diagnosis, higher testing in a demographic group thought to be less likely to have the disease; however, this may also be a limited assessment due to lack of prior records and outside hospital records at the time of analysis. Additionally, we sought to understand the role of these sociodemographic variables on care surrounding the bronchoscopy and found no significant associations other than increased time to be started on medication in Black patients, which was almost double the time to start

medications in White patients although our study did not account for necessity of starting treatment based on symptoms at the time of diagnosis. There is limited literature on these interactions, warranting further studies, likely in a larger population to discover any underlying patterns.

In conclusion, a higher ADI national or greater socioeconomic deprivation was associated with failure to adhere to the proposed regimen as measured by 12 month no-show occurrences, a noteworthy disparity as those with greater neighborhood disadvantage are known to have a poor clinical course (8). In addition, sarcoidosis patients were more likely to be younger, females, and Black living in areas of more deprivation or a lower socioeconomic class and are typically insured by commercial insurances and Medicaid when compared to the rest of the pulmonary clinic population. The online patient portal is used mostly by younger patients and those with commercial insurance and efforts to identify patterns in use may bridge disparities in care. Those with higher ADI national and Medicare insurance had higher rates of 12 month no-show occurrences. Along these lines, those with government insurance such as Medicare and Medicaid had more hospitalizations despite having more chest x-rays and PFTs on file. This raises concerns for the presence of additional barriers to healthcare and comorbidities. Sarcoidosis patients with positive biopsies on file were more likely to be male, White or other races, younger and belonged to lower national ADI ranks, in contrast to the typical demographic, highlighting the need for further research. Limitations of this study included lack of access to outside hospital records and records prior to 2013, incorrect usage of the sarcoidosis diagnosis code and patients who may have been lost to follow-up. Furthermore, understanding these baseline characteristics and the associated disparities present is important in providing equitable high-quality care. It will also assist in timely and efficient management of the patient's disease. Multidisciplinary clinics and sarcoidosis centers have been studied to tackle disparities (13) and should be established to focus on specific health care needs and disparities of this population, and the role of telemedicine can be explored but may bring with it a unique pattern of barriers, and finally, policy-level interventions should be considered.

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Conflicts of Interest: Medha R. Cherabuddi is a sub-investigator for Novartis Pharmaceutical: CMK389 versus placebo in chronic sarcoidosis, ATYR Pharmaceutical: ATYR1923 versus placebo in pulmonary sarcoidosis and DOMPE Pharmaceutical: Reparixin versus placebo in ARDS with all funds being given to the institution. Benjamin D. Goodman is a sub-investigator for Novartis Pharmaceutical: CMK389 versus placebo in chronic sarcoidosis and ATYR Pharmaceutical: ATYR1923 versus placebo in pulmonary sarcoidosis with all funds being given to the institution. Asem Ayyad has no known conflicts of interest. Dina A. Almajali has no known conflicts of interest. Owais Nadeem is a sub-investigator for Novartis Pharmaceutical: CMK389 versus placebo in chronic sarcoidosis and ATYR Pharmaceutical: ATYR1923 versus placebo in pulmonary sarcoidosis with all funds being given to the institution. Patrick Bradley is a sub-investigator for Novartis Pharmaceutical: CMK389 versus placebo in chronic sarcoidosis and ATYR Pharmaceutical: ATYR1923 versus placebo in pulmonary sarcoidosis with all funds being given to the institution. Cori Russell has no known conflicts of interest. Daniel R. Ouellette is the site investigator for Novartis Pharmaceutical: CMK389 versus placebo in chronic sarcoidosis, ATYR Pharmaceutical: ATYR1923 versus placebo in pulmonary sarcoidosis, DOMPE Pharmaceutical: Reparixin versus placebo in ARDS, PICORI grant federal) for RELIANCE (Azithromycin versus Roflumilast to prevent COPD Exacerbations), Sanofi, Itepekimab versus placebo to prevent COPD exacerbations and Sanofi, Dupilumab versus placebo to prevent COPD exacerbations with all funds being given to the institution, and has received payment fo expert testimony in VTE, critical illness, COPD.

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Appendix
Supplementary files

Supplemental Table 1. An Overall Summarization

		All Patients (N=13824)
Presence of sarcoidosis		788 (5.7%)
Insurance type	Medicare	7562 (55.9%)
	Medicaid	1472 (10.9%)
	Commercial	4503 (33.3%)
Age, years		63.9 ± 15.1 (65.7)
Race	White	7508 (56.7%)
	Black	4945 (37.4%)
	Other	781 (5.9%)
Sex	Male	5533 (40.0%)
	Female	8291 (60.0%)
Deceased		1344 (9.7%)
Active online patient portal		10694 (77.5%)
Any no-show appointments within 6 months of the first visit		4562 (33.0%)
Any no-show appointments within 12 months of the first visit		5285 (38.2%)
Any hospitalizations		5286 (38.2%)
Any x-rays		7434 (53.8%)
Any PFTs		10792 (78.1%)
Number of no-show appointments within 6 months of the first visit		0.5 ± 0.8 (0.0)
Number of no-show appointments within 12 months of the first visit		0.6 ± 1.0 (0.0)
Number of hospitalizations		2.9 ± 7.6 (0.0)
Number of x-rays		1.4 ± 2.3 (1.0)
Number of PFTs		1.2 ± 1.3 (1.0)
ADI national rank		63.8 ± 27.6 (66.0)
ADI state rank		5.3 ± 3.2 (5.0)

ADI, area deprivation index; PFTs, pulmonary function tests.
Categorical variables are given as frequency (total percent). Numerical variables are given as mean ± standard deviation (median).
*Used to indicate significant P value < 0.05.