RESEARCH ARTICLE

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Accountable care organizations and Medicare payments for residents with ADRD in disadvantaged neighborhoods

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Abstract

INTRODUCTION: Accountable care organizations (ACOs) are well positioned to promote care coordination. However, robust evidence of ACOs' impact on Medicare payments for residents with Alzheimer's disease and related dementias (ADRD) in disadvantaged neighborhoods remains limited.

METHODS: Using a 2016 to 2020 longitudinal dataset, we examined the effects of ACO enrollment on Medicare payments for people newly diagnosed with ADRD, focusing on the neighborhood Social Vulnerability Index (SVI) and its subcategories. Multivariable generalized estimating equation (GEE) models were applied.

RESULTS: ACO enrollment was associated with significantly reduced total payments across all SVI subcategories. The highest cost savings were observed among ADRD patients living in neighborhoods with high proportions of racial and ethnic minorities. Results also showed that higher quality ACOs were associated with lower total payments.

DISCUSSION: ACOs have a great potential to save health-care costs for beneficiaries with ADRD living in socially vulnerable neighborhoods, particularly for those residing in areas with higher proportions of racial and ethnic minority populations.

KEYWORDS
accountable care organization, Alzheimer's disease and related dementias, cost disparities, neighborhood disadvantage, social vulnerability

Highlights

- Accountable care organizations (ACOs) reduced Medicare payments for Alzheimer's disease and related dementias across neighborhood disadvantage levels.
- The cost reductions varied by specific indicators of social vulnerability.
- Highest cost savings were found among residents living with high proportion of racial/ethnic minorities.
- Cost savings were the greatest among the highest quality ACOs.

1 | BACKGROUND

The number and the proportion of people with Alzheimer's disease and related dementias (ADRD) are projected to double and reach 13.8 million by 2060, increasing total annual payments for ADRD care from $360 billion in 2024 to nearly $1 trillion in 2050.[1] This sharp rise in costs reflects the growing number of individuals with ADRD and their complex care needs, which includes a variety of symptoms, from cognitive decline and behavioral changes to physical health problems.[1,2] Given these complexities, effective care coordination and continuity of care are particularly important in ADRD care management.[3–6]

Accountable care organizations (ACOs) are becoming Medicare's dominant care model and are well positioned to promote care coordination while reducing the costs of care for people with ADRD.[3,6–8] ACOs are virtually integrated networks of physicians, hospitals, and post-acute care providers that voluntarily partner to provide high-quality and coordinated care, improve health outcomes, and manage costs in return for receiving shared savings.[3,7–9] Approximately 13.7 million Medicare beneficiaries are affiliated with ACOs, serving nearly half of the people with traditional Medicare.[9] ACO enrollment has been associated with higher wellness visit rates,[6] lower preventable emergency department (ED) visits,[10] fewer hospitalizations, ED visits,[11] shorter skilled nursing facility (SNF) length of stay, and lower hospital readmission rates among people with ADRD.[12] The empirical evidence of ACO association and Medicare savings has been inconclusive.[6,13] Encouragingly, recent studies that examined Medicare payments among ADRD patients suggest ACOs' potential to reduce health-care costs among racial and ethnic minority groups and those living in socially disadvantaged areas.[3,7]

Despite the potential benefits of ACO enrollment, ACOs are inequitably distributed and are more likely to be located in affluent, urban areas.[14,15] Structural and social determinants of health (SDoH) adversely affect physical and mental health over the life course.[7,16,17] Neighborhood disadvantage has been associated with lower cognitive test scores and a high incidence of ADRD among non-Hispanic Whites.[18] In addition, living in areas with higher neighborhood disadvantages has been associated with increased risks of mortality, morbidity,[18,19] and adverse health outcomes among ADRD patients.[7,20,21] A recent study descriptively compared the Medicare payment for people with ADRD enrolled in ACOs by their level of neighborhood disadvantage, suggesting that further research is needed to confirm whether ACOs provide cost savings for people with ADRD living in highly disadvantaged areas.[3] Indeed, patients with complex health needs, including those with ADRD, are less likely to enroll in ACOs.[6,14,15] To better understand the potential cost-saving role of ACOs, it is important to account for patients' health needs. In this study, we used a longitudinal dataset and multiple robust econometric methods to minimize cost variations that may arise from ADRD patients' selection into ACOs.[6,14,15]

The objective of this study is to examine variations in total Medicare payments for patients with ADRD by neighborhood disadvantage and ACO enrollment status. We hypothesize that Medicare beneficiaries living in disadvantaged neighborhoods encounter higher costs and that

RESEARCH IN CONTEXT

1. **Systematic review**: Accountable care organizations (ACOs) are well positioned to promote care coordination while reducing the costs for people with Alzheimer's disease and related dementias (ADRD). However, this infrastructure is unevenly distributed. Robust analyses are needed to better understand the potential cost-saving role of ACOs for ADRD patients residing in areas with low social vulnerability.

2. **Interpretation**: Using the longitudinal ADRD cohort data, we demonstrated that ACO enrollment was associated with Medicare savings across all specific measures of social vulnerabilities. A more pronounced cost-saving effect of ACOs was observed among residents in neighborhoods with high proportions of racial and ethnic minorities, highlighting the need for encouraging ACO enrollment of these vulnerable populations.

3. **Future directions**: Our results emphasize the urgency of addressing racial and ethnic disparities in dementia care and highlight ACOs' potential to reduce these disparities among minority populations in socially vulnerable areas. We further suggest that the Social Vulnerability Index should incorporate local dementia care resources.

ACO enrollment serves as a protective factor, relatively reducing the costs compared to their non–ACO-enrolled counterparts. We focus on newly diagnosed ADRD enrollees in this study. Care coordination can play a critical role right after the diagnosis by helping patients and their family caregivers set long-term treatment plans, navigate care options and services, and plan for the future, all of which can delay disease progression and improve their quality of life.[22] Given the limited resources and greater burden of chronic conditions,[19] ACOs could lead to greater savings among residents in socially disadvantaged neighborhoods.

Neighborhood disadvantage encompasses a wide range of socioeconomic and environmental factors that, together, increase the health-care needs of residents and disparities associated with ADRD.[7,16,19–21,23] Hence, we further hypothesize that the associations between neighborhood disadvantage and Medicare payments vary by specific neighborhood measures, such as socioeconomic status and proportions of racial and minority populations. Finally, we investigate variations in Medicare payments by ACO quality among ADRD patients enrolled in ACOs, and among ACO enrollees, we examine whether those with continuous enrollment in higher quality ACOs for the entire study period (i.e., 5 years) encounter greater cost savings. Emerging evidence has documented that racial and ethnic minority patients, including ADRD patients, experience lower quality of care.[24] We hypothesize that higher ACO quality might result in greater cost

savings for ADRD residents in disadvantaged neighborhoods and that continuous enrollment in ACOs would lead to even greater savings.

2 | METHODS

2.1 | Data sources and study sample

We created the 2016 to 2020 longitudinal cohort dataset to examine Medicare payments for patients newly diagnosed with ADRD using the Medicare Beneficiary Summary file, Medicare Beneficiary Summary Cost and Use file, Medicare Shared Saving Program (MSSP) ACO file, the Social Vulnerability Index (SVI) from Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry (CDC/ATSDR), and the Area Health Resources File (AHRF). The combined dataset tracked Medicare payments of ADRD patients in the year preceding the diagnosis (2016) and the subsequent three years (2018–2020). Patients with ADRD were identified through the Centers for Medicare and Medicaid Services (CMS) Chronic Conditions Data Warehouse Algorithms as those having at least one inpatient, SNF, home health, Part B institutional, or Part B non-institutional claim with the following International Classification of Disease 10th Revision codes: F01.50, F01.51, F02.80, F02.81, F03.90, F03.91, F04, F05, F06.1, F06.8, G13.8, G30.0, G30.1, G30.8, G30.9, G31.01, G31.09, G31.1, G31.2, G94, R41.81, R54.[25] The development of these guidelines drew upon a review of validated algorithms in the research literature, and they have been widely used across numerous other studies.[26–28] Medicare beneficiaries who had an ADRD diagnosis in 2017 but no diagnosis in 2016 and no prior date of ADRD diagnosis were selected. The Medicare Beneficiary Summary Cost and Use file was used to calculate the total annual Medicare payments per beneficiary ≥ 65 who was continuously enrolled in fee for service (FFS) throughout the study period. We included FFS beneficiaries only as our study focused on MSSP ACOs, serving ≈ 11 million beneficiaries.[6]

Using beneficiary IDs and ACO identifiers, the 2016 to 2020 MSSP ACO beneficiary-level files and the MSSP ACO Performance Year Financial and Quality Results from the CMS were merged into the Medicare claims data to identify beneficiaries enrolled in ACO and ACO-specific overall quality scores, which determine whether the ACO qualifies for shared savings under MSSP. A higher score indicates better performance and can increase the percentage of savings the ACO is eligible to receive,[29] allowing us to capture variations of ACO quality in cost reduction after controlling for neighborhood social vulnerabilities and other individual differences among ACO enrollees.

Further, the combined Medicare claims and ACO data were merged with the 2020 county-level SVI using beneficiaries' Federal Information Processing System (FIPS) codes for states and counties.[30] The 2020 SVI was developed using the 2016 to 2020 US census-level variables from the American Community Survey (ACS).[30] Last, the 2016 to 2020 AHRF county-level data by the Bureau of Health Workforce was linked using beneficiaries' state and county FIPS codes to account for the availability of county-level health-care resources.

2.2 | Measures

2.2.1 | Total Medicare payments

The total Medicare payments include Medicare payments for major health-care services, including acute inpatient, SNF, hospice, home health, hospital outpatient, Part B physician, and Part D Medicare payments.[1] Total Medicare payments were adjusted to 2023 dollars using the gross domestic product price index.[31]

2.2.2 | Neighborhood disadvantage

Neighborhood disadvantage was measured by the 2020 SVI. The SVI used 16 US census demographic and socioeconomic risk factors to identify and quantify the relative vulnerability of communities and is grouped into four themes, covering four major areas of social vulnerability: racial and ethnic minority status, socioeconomic status, housing type and transportation, and household characteristics.[30] While the Area Deprivation Index (ADI) is also popularly used and derived from the same US Census Bureau ACS, SVI additionally incorporates measures of population demographics and is available as four separate themes.[32] We used the 2020 SVI, the most recent classification of vulnerabilities. The 2020 SVI added a housing cost burden to the socioeconomic status theme in the 2018 SVI and moved limited English speakers from the racial and ethnic minority status theme to the household characteristics theme.[30]

The four SVI themes include the following: (1) SVI racial and ethnic minority status measures the proportions of racial and ethnic minority groups and people with multiple races; (2) SVI socioeconomic status measures the proportions of people living below 150% poverty, unemployed, experiencing a housing cost burden, without a high school diploma, and uninsured; (3) SVI related to housing type and transportation measures the percentages of multi-unit housing, mobile homes, crowded housing, households without vehicles, and people living in group quarters; and (4) SVI related to household characteristics reflects the proportions of people aged ≥ 65, aged ≤ 17, with disabilities, living in single-parent households, and people with limited English. The above four themes are ranked and combined into a single measure of overall social vulnerability.[30] We categorized each SVI theme of social vulnerability and the overall SVI index into two neighborhood groups with low and high social vulnerability. Neighborhoods with low social vulnerability were defined as neighborhoods < 50th percentile of SVI, while neighborhoods with high social vulnerability were ≥ 50th percentile of the SVI. In the sensitivity analyses, we tested different cutoffs and measures of SVI.

2.2.3 | ACO enrollment status and quality

ACO enrollment status was defined as whether Medicare beneficiaries were enrolled in MSSP ACO for all four quarters (i.e., full year) or

not. The ACO enrollee group contains beneficiaries enrolled in ACOs for a full year, and the non-ACO group includes those never or partially enrolled in ACOs. When a beneficiary was enrolled in multiple ACOs for a year, the average ACO overall quality scores were used. The ACO overall quality scores are weighted average scores from 33 quality performance measures in four domains, including patient experience of care, care coordination and patient safety, prevention, and management of at-risk populations.[33] The quality scores of ACOs were categorized into four quantile groups, ranging from the lowest (quantile 1) to the highest (quantile 4) quality.

2.2.4 | Covariates

Other independent variables used in the study include age, sex, race (non-Hispanic White, Black, or Hispanic), insurance coverage (FFS only or any Medicare–Medicaid dually eligible month during a year), primary care provider shortage area (none, whole, or part), and presence of four common coexisting chronic conditions with ADRD (heart-related disease, diabetes, depression, and hypertension). These chronic conditions are common coexisting comorbidities in ADRD patients.[1,2,34] The primary care provider shortage area was used to account for overall access to primary care at the county level,[10] which plays a critical role in ADRD diagnosis and chronic condition management.[4,35] These covariates have been widely used in the literature to examine health-care costs, including people with ADRD.[7,36–39] We additionally added year fixed effects to control for macro changes across the study period.[23]

2.3 | Statistical analysis

We first compared the population characteristics among Medicare beneficiaries with ADRD stratified by their residence in neighborhoods with low (SVI < 50th percentile) or high (SVI ≥ 50th percentile) social vulnerability and further by ACO enrollment status. t tests and chi-squared tests were used to compare individual and neighborhood-level characteristics of the ACO enrollees and non-ACO enrollees.

To understand the effect of ACO enrollment status and the overall SVI on total Medicare payments, we used a multivariable generalized estimating equation (GEE) model with gamma distribution and log-link function on total Medicare payments controlling for individual and neighborhood-level characteristics listed above. We also included interaction terms between ACO enrollment status and the overall SVI to examine whether the effect of ACO enrollment on health-care expenditures differs by beneficiaries' residence in disadvantaged neighborhoods. GEE offers a flexible and robust approach to analyzing healthcare costs.[40–43] It allows specifications of different variance structures to control the clustering error within individuals while accounting for correlations between repeated measures in longitudinal data.[40,43] An unstructured covariance structure was chosen because

the correlation between repeated responses is complex or unknown.[40] Also, the implementation of the GEE model allowed accounting for the skewed healthcare cost data by incorporating gamma distribution and log-link function into the model.[40,42–44] We also tested the association between ACO enrollment and Medicare costs using a fixed-effects model, which allows for identifying the coefficient of time-variant ACO enrollment while accounting for omitted time-invariant variables correlated with ACO enrollment. Additionally, we implemented a propensity score matching analysis to account for patients' selection into ACOs. A logistic regression was used to calculate propensity scores, followed by one-to-one nearest-neighbor matching without replacement and a caliper of 0.2.[45,46] The results were consistent with those from the GEE model (see Tables S1 to S3 in supporting information).

Next, we used the same GEE model but replaced the neighborhood disadvantage measure using the overall SVI with four individual SVI themes to explore how individual themes of social vulnerability may affect health-care costs differently. We also included interaction terms of individual SVI themes and ACO enrollment status. We then estimated the average annual total Medicare payments per beneficiary for each social vulnerability theme by their ACO enrollment and disadvantaged neighborhood residence status. Our model of multiple SVI indicators passed the multicollinearity tests. Nevertheless, we tested our model with each individual SVI theme in each separate regression as a sensitivity analysis. Results were consistent (see Table S4 in supporting information).

Last, we conducted a subgroup analysis on the ADRD study cohort by including only the ACO full-year enrollees and examined total Medicare payments by their affiliated ACO quality after accounting for four themes of social vulnerabilities and the same covariates used in the previous analyses. We estimated the average annual payments per beneficiary by four quantiles of ACO quality to capture variations of cost savings among ACO enrollees depending on the qualities of ACOs. Among ACO enrollees, we further identified those who stayed in ACO throughout the study period (2016–2020) and examined whether their patterns of cost savings by ACO quality were similar.

We also conducted additional sensitivity analyses to ensure that our results were robust. We first tested different measurements. For example, we used the 75th percentile of the SVI as a cutoff to define neighborhood disadvantage; we used the 2018 SVI data, which included the proportion of limited English speakers in the racial and ethnic minority status theme and had no housing cost burden in the socioeconomic status theme. We also tested costs with and without the log of payment. Second, we justified comparison groups. We compared beneficiaries who were never enrolled in ACOs instead of non–full-year ACO enrollees, and among FFS beneficiaries only (i.e., excluding Medicare–Medicaid dually eligible individuals). Finally, we explored different model specifications using various sets of covariates, including prescription drug coverage and different county-level measures. The associations among ACO enrollment, SVI, and Medicare costs remained consistent and are available upon request. SAS 9.4 and Stata 18 were used to implement the study.

TABLE 1 Population characteristics of Medicare beneficiaries newly diagnosed with ADRD by SVI and ACO enrollment status in 2016.

	Low SVI			High SVI		
	ACO	Non-ACO		ACO	Non-ACO	
	n = 26,066	n = 89,188		n = 31,247	n = 146,672	
	Mean (SD)/no.(%)	Mean(SD)/no.(%)	p	Mean (SD)/no.(%)	Mean (SD)/no.(%)	p
Age (years)	79.2 (7.3)	78.2 (7.8)	<0.001	79.1 (7.4)	77.9 (7.8)	<0.001
Sex			<0.001			<0.001
Male	9575 (36.7)	34,185 (38.3)		11,000 (35.2)	55,256 (37.7)	
Female	16,491 (63.3)	55,003 (61.7)		20,247 (64.8)	91,416 (62.3)	
Race/ethnicity			<0.001			<0.001
Non-Hispanic White	24,693 (94.7)	83,500 (93.6)		26,579 (85.1)	119,240 (81.3)	
Black	884 (3.4)	3646 (4.1)		2984 (9.6)	15,762 (10.8)	
Hispanic	489 (1.9)	2042 (2.3)		1539 (5.4)	11,670 (8.0)	
Insurance coverage			<0.001			<0.001
Fee-for-service only	23,966 (91.9)	79,978 (89.7)		27,737 (88.8)	119,897 (81.7)	
Any dually eligible	2100 (8.1)	9210 (10.3)		3510 (11.2)	26,775 (18.3)	
Primary care shortage area			<0.001			<0.001
None	5880 (22.6)	17,072 (19.1)		1310 (4.2)	5619 (3.8)	
Whole	1235 (4.7)	5437 (6.1)		1430 (4.6)	9826 (6.7)	
Part	18,951 (72.7)	66,679 (74.8)		28,507 (91.2)	131,227 (89.5)	
Chronic comorbidities						
Have heart-related disease	12,057 (46.3)	36,989 (41.5)	<0.001	15,138 (48.5)	64,845 (44.2)	<0.001
Have diabetes	8154 (31.3)	24,321 (27.03)	<0.001	10,566 (33.8)	41,728 (31.2)	<0.001
Have depression	6320 (24.5)	19,393 (21.7)	<0.001	7451 (23.9)	31,197 (21.3)	<0.001
Have hypertension	19,273 (73.9)	56,509 (63.4)	<0.001	24,291 (77.7)	98,192 (67.0)	<0.001
ACO quality, if enrolled						
Quality < 25th p	8994 (34.5)			10,605 (33.9)		
25th p ≤ quality < 50th p	7917 (30.4)			8335 (26.7)		
50th p ≤ quality < 75th p	6262 (24.0)			8347 (26.7)		
75th p ≤ quality	2893 (11.1)			3960 (12.7)		

Note: Data for continuous variable, age, represents mean (standard deviation). Data for categorical variables represent frequencies (proportions). ACO group represents ACO enrollees for a full year. Non-ACO group includes beneficiaries who were not enrolled in ACO for a full year and those never enrolled in ACO. t tests and chi-squared tests were used to compare baseline differences between residents in low SVI and high SVI with and without ACO enrollment. Proportions may not sum to 100% because of rounding.

Abbreviations: ACO, accountable care organization; ADRD, Alzheimer's disease and related dementias; p, percentile; P, P value; SD, standard deviation; SVI, Social Vulnerability Index.

3 | RESULTS

Our study included 293,173 Medicare FFS beneficiaries with a new diagnosis of ADRD in 2017 who were continuously enrolled in Medicare throughout the study period. Table 1 describes the population characteristics of Medicare beneficiaries living in neighborhoods with low and high social vulnerability stratified by ACO enrollment status at the base year (2016). Beneficiaries living in neighborhoods with low social vulnerability had higher percentages of people enrolled in ACO than those living in neighborhoods with high social vulnerability (22.6% vs. 17.6%, respectively). Among those who lived in neighborhoods with low social vulnerability, ACO enrollees were generally

older (79.2 vs. 78.2 years), more likely to be female (63.3% vs. 61.7%), non-Hispanic White (94.7% vs. 93.6), enrolled in FFS only (91.9% vs. 89.7%), and live in neighborhoods with no primary care provider shortages (22.6% vs. 19.1%). ACO enrollees living in less socially vulnerable neighborhoods had higher morbidities in all four chronic comorbidities than non-ACO enrollees.

Similar patterns were shown among beneficiaries living in neighborhoods with high social vulnerability. However, residents in neighborhoods with high social vulnerability were more likely to be racial and ethnic minorities; dually eligible for Medicare and Medicaid; have higher rates of heart-related disease, diabetes, and hypertension; and less likely to live in neighborhoods without primary care shortage than
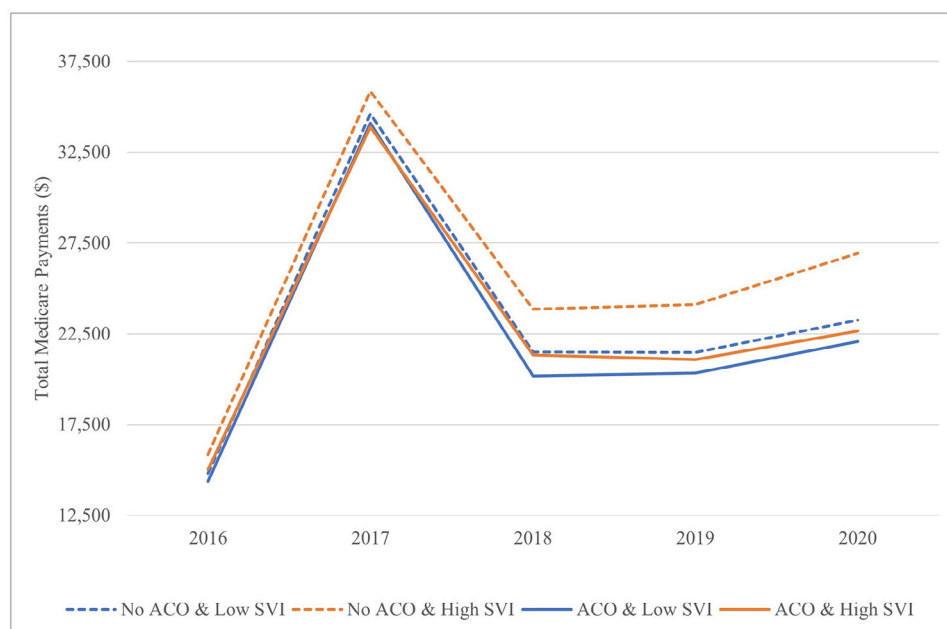
FIGURE 1 Trends of unadjusted total Medicare payments of newly diagnosed beneficiaries with ADRD by SVI and ACO enrollment status. Unadjusted total Medicare payments of newly diagnosed beneficiaries with ADRD were summarized by beneficiaries' ACO enrollment status and residence in low or high SVI neighborhoods. No ACO represents beneficiaries who were not enrolled in ACO for a full year and those who never enrolled in ACO. ACO represents ACO enrollees for a full year. Low SVI represents residents in neighborhoods with < 50th percentile of SVI, while high SVI represents those in neighborhoods with ≥ 50th percentile SVI. Unadjusted dollar amounts are available in Table S5 in supporting information. ACO, accountable care organization; ADRD, Alzheimer's disease and related dementias; SVI, Social Vulnerability Index.

those living in neighborhoods with low social vulnerability. ACO qualities among beneficiaries enrolled in ACOs were comparable between low and high SVI neighborhoods. However, once enrolled in ACOs, residents living in high SVI neighborhoods had relatively higher ACO quality measures.

Figure 1 describes the unadjusted total Medicare payment patterns of the ADRD cohort during the year before and 3 years after ADRD diagnosis by their residence in disadvantaged neighborhoods and enrollment in ACOs. Costs were similar between ACO enrollees in low SVI and high SVI neighborhoods, but differences were mainly observed among non-ACO enrollees by residence in socially disadvantaged neighborhoods. Throughout the study period, ACO enrollees consistently encountered lower total Medicare payments, and the cost savings from ACO enrollment widened after the ADRD diagnosis year (2017), regardless of their residence in disadvantaged neighborhoods. The cost savings were more pronounced among residents living in neighborhoods with high overall social vulnerability, with the highest cost difference reaching $4,290 ($26,937 among non-ACO enrollees vs. $22,647 among ACO enrollees) in 2020 (see Table S5 in supporting information for the unadjusted US dollar amounts).

Table 2 presents the associations between total health-care costs, ACO enrollment, and neighborhood disadvantage, adjusting for various individual- and neighborhood-level characteristics. While enrollment in ACOs was associated with a 4% decrease in the total Medicare payments (0.96, $P < 0.001$), living in socially disadvantaged neighborhoods was not significantly associated with total health-care costs ($P = 0.814$). The interaction term between ACO enrollment and neigh-

borhood disadvantage was associated with a 2% reduction in total costs (0.98, $P < 0.001$), indicating that the cost-saving effects of ACO were greater for disadvantaged neighborhood residents compared to those living in neighborhoods with low social vulnerability. Being Hispanic encountered lower total Medicare payments by 12% (0.88, $P < 0.001$), female by 3% (0.97, $P < 0.001$), older age by 1% (0.99, $P < 0.001$), and living in neighborhoods with primary care provider whole shortages by 5% (0.95, $P < 0.001$). On the other hand, being dually eligible for Medicare and Medicaid for 12 months increased total payments by 41% (1.41, $P < 0.001$), and living in neighborhoods with primary care provider partial shortage areas (1.04, $P < 0.001$) led to a 4% increase in total Medicare payments. Having other chronic conditions further increased total costs by 22% for diabetes (1.22, $P < 0.001$) to 89% for hypertension (1.89, $P < 0.001$; see Table S6 in supporting information for estimated marginal effects).

Figure 2 represents the estimated average annual total Medicare payments per beneficiary with ADRD after adjusting for individual and neighborhood characteristics in each area of social vulnerability stratified by ACO enrollment and residence in disadvantaged neighborhoods. In all areas of social vulnerability, ACO enrollees, regardless of their residence locations, exhibited significantly lower health-care costs throughout the study period ($P < 0.001$) compared to their non–ACO-enrolled counterparts.

In Figure 2, beneficiaries living in neighborhoods with high percentages of racial/ethnic minority groups had substantially higher costs ($P < 0.001$), and their cost savings from ACOs were significantly greater ($P < 0.001$). Figure 2 shows that residents living in neighborhoods

TABLE 2 Results of generalized estimating equation on total Medicare payments using overall SVI.

	Exp (Coef.)	95% CI		p value
ACO full year enrollment (ref: never/any quarter)	0.96	0.95	0.97	<0.001
SVI (ref: low SVI)				
High SVI	1.00	0.99	1.01	0.814
ACO × SVI (ref: no ACO & low SVI)				
ACO × High SVI	0.98	0.96	0.99	<0.001
Race/ethnicity (ref: non-Hispanic White)				
Black	0.99	0.98	1.01	0.298
Hispanic	0.88	0.87	0.90	<0.001
Sex (ref: male)				
Female	0.97	0.96	0.98	<0.001
Age (years)	0.99	0.99	0.99	<0.001
Insurance coverage (ref: FFS only)				
Any dually eligible	1.41	1.39	1.42	<0.001
Primary care shortage area (ref: none)				
Whole	0.95	0.93	0.97	<0.001
Part	1.04	1.02	1.05	<0.001
Heart-related disease (ref: none)	1.78	1.77	1.80	<0.001
Diabetes (ref: none)	1.22	1.22	1.23	<0.001
Depression (ref: none)	1.68	1.67	1.69	<0.001
Hypertension (ref: none)	1.89	1.87	1.91	<0.001
Year (ref: 2016)				
2017	1.94	1.93	1.95	<0.001
2018	1.27	1.26	1.27	<0.001
2019	1.29	1.28	1.30	<0.001
2020	1.42	1.41	1.43	<0.001

Note: Values represent results from generalized estimating equation model with log link and gamma distribution on total Medicare payments using overall SVI. Coefficients represent the log-transformed expected total costs after controlling for all other covariates. Coefficients were exponentiated for easier interpretation and represent the multiplicative effect on total Medicare payments. $N = 293,098$. Estimated marginal effects (i.e., annual total Medicare payments per beneficiary in US dollars) are available in Table S6 in supporting information.
Abbreviations: ACO, accountable care organization; CI, confidence interval; Exp (Coef.), exponentiated coefficient; FFS, fee-for-service; SVI, Social Vulnerability Index.

with high socioeconomic vulnerability spent slightly less than residents in neighborhoods with low socioeconomic vulnerability ($P = 0.012$), but the cost-saving effects of ACO enrollment were not significantly different between the two groups ($P = 0.562$). Regarding social vulnerability related to housing type and transportation (Figure 2), residents of neighborhoods with high vulnerability had slightly higher costs ($P < 0.001$), but ACO cost savings were minimal. Figure 2 shows that significantly lower Medicare payments were observed among beneficiaries living in neighborhoods with high vulnerability related to household characteristics than those living in neighborhoods with low vulnerability ($P < 0.001$), and the magnitudes of cost savings from ACO enrollment were similar (see Tables S7 in supporting information for detailed GEE results and S8 in supporting information for estimated US dollar amounts).

Table 3 presents the GEE regression results on total Medicare payments among ACO full-year enrollees. Compared to the lowest ACO quality group (i.e., overall quality score below the 25th percentile), beneficiaries enrolled in higher quality ACOs were associated with increasingly lower total payments after controlling for individual- and neighborhood-level differences ($P < 0.001$). Specifically, Medicare beneficiaries enrolled in ACOs with quality scores above the 75th percentile encountered a 7% reduction in total payments (0.93, $P < 0.001$).

Among ACO enrollees, we found that residents in neighborhoods with high vulnerability in racial/ethnic minority status faced 9% higher total payments (1.09, $P < 0.001$), high vulnerability in housing type and transportation with 2% higher total payments (1.02, $P = 0.004$), and high vulnerability in household characteristics with 7% lower total payments (0.93, $P < 0.001$). Socioeconomic vulnerability was not associated with total health-care costs ($P = 0.174$). Being racial/ethnic minorities (0.94, $P < 0.001$ for Black; 0.85, $P < 0.001$ for Hispanic), females (0.96, $P < 0.001$), and older age (0.99, $P < 0.001$)
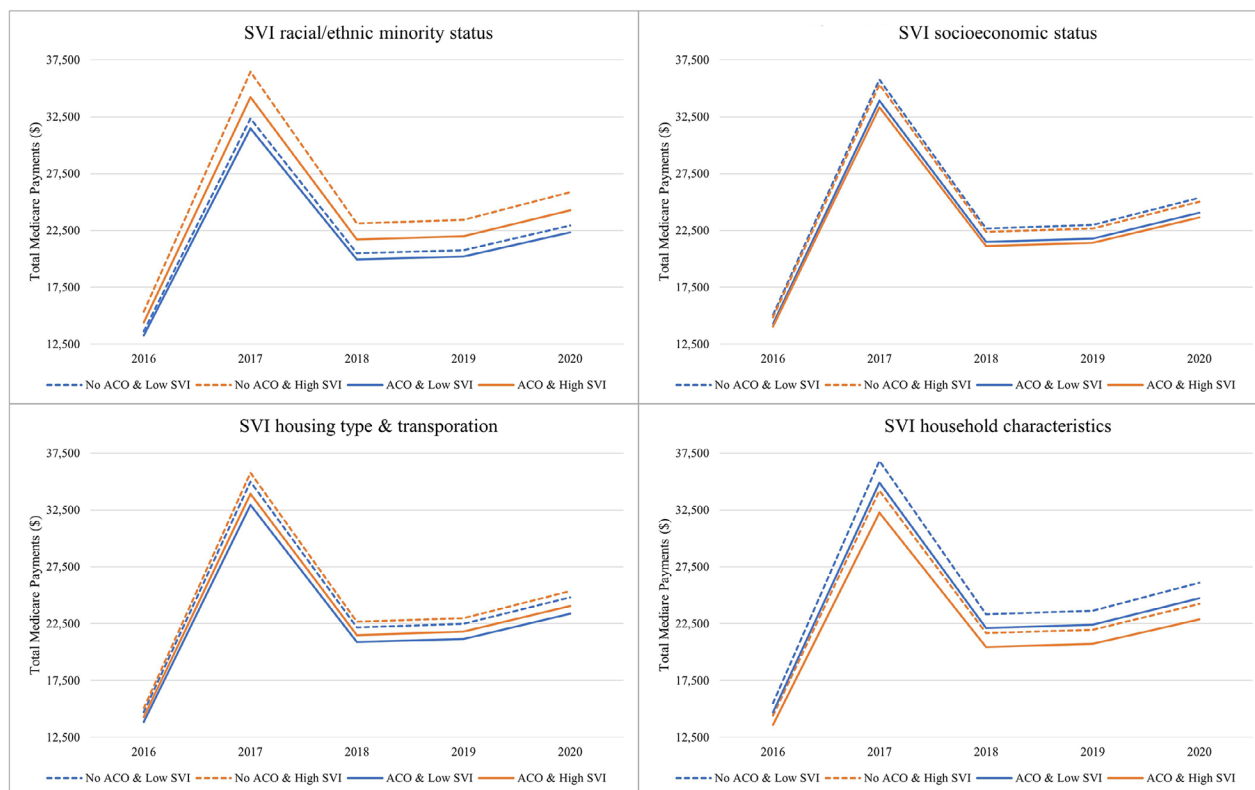
FIGURE 2 Total Medicare payments of newly diagnosed patients with ADRD by SVI and ACO enrollment status in different themes of neighborhood social vulnerabilities. Adjusted total Medicare payments were estimated using a GEE model in individual SVI themes to present variations in cost patterns by ACO enrollment status and residence in neighborhood vulnerability depending on specific measures of social vulnerability. The GEE results are available in Table S7 in supporting information and estimated US dollar amounts are available in Table S8 in supporting information. ACO enrollment status, individual SVI theme, interaction term between ACO and individual SVI, race/ethnicity, sex, age, insurance coverage, primary care provider shortage area, four common coexisting comorbidities, and year were included as covariates. No ACO includes beneficiaries who were not enrolled in ACO for a full year and those never enrolled in ACO. ACO represents ACO enrollees for a full year. Low SVI represents residents in neighborhoods with < 50th percentile of SVI, while high SVI represents those in neighborhoods with ≥ 50th percentile SVI. ACO, accountable care organization; ADRD, Alzheimer's disease and related dementias; GEE, generalized estimating equation; SVI, Social Vulnerability Index.

were associated with lower costs. Being dually eligible for Medicare and Medicaid (1.44, $P < 0.001$) and having other coexisting chronic conditions increased total payments from 24% for diabetes to 84% for heart-related disease ($P < 0.001$). Neighborhoods with a whole primary care provider shortage were associated with a 3% reduction in costs (0.97, $P = 0.033$), while those with a partial shortage were associated with a 3% increase in costs (1.03, $P = 0.007$; see Table S9 in supporting information for estimated marginal effects).

Figure 3 shows differences in total Medicare payments associated with ADRD by ACO-specific quality among ACO full-year enrollees who stayed in ACOs for 5 years. In 2016, ACO enrollees in the lowest quality ACOs had higher costs than beneficiaries who never enrolled in ACOs ($14,853 vs. $14,467, respectively). However, beginning from the diagnosis year (2017), beneficiaries who never enrolled in ACOs continued to incur the highest costs. The figure shows that newly diagnosed ADRD beneficiaries in the highest quality ACOs (i.e., overall quality ≥ 75th percentile) encountered the lowest spending throughout the study period, followed by those in the second and third ACO

quality groups (see Tables S10 in supporting information for detailed GEE results and S11 in supporting information for estimated US dollar amounts).

4 | DISCUSSION

Using the 2016 to 2020 integrated longitudinal dataset, we examined the effects of ACO enrollment on total Medicare payments of beneficiaries newly diagnosed with ADRD, focusing on neighborhood social vulnerability and its subcategories. Our analyses present several key findings.

4.1 | Medicare FFS payment and ACO enrollment by SVI

Our results consistently show that ACO enrollment was related to reduced total payments among newly diagnosed ADRD patients across all SVI-specific indicators.

TABLE 3 Results of generalized estimating equation on total Medicare payments among ACO full-year enrollees.

	Exp (Coef.)	95% CI		p value
ACO quality (ref: quality < 25th p)				
25th p ≤ quality < 50th p	0.95	0.93	0.96	<0.001
50th p ≤ quality < 75th p	0.93	0.92	0.95	<0.001
75th p ≤ quality	0.93	0.92	0.95	<0.001
SVI racial/ethnic minority (ref: low SVI)				
High SVI	1.09	1.07	1.11	<0.001
SVI socioeconomic status (ref: low SVI)				
High SVI	0.99	0.98	1.00	0.174
SVI housing type & transportation (ref: low SVI)				
High SVI	1.02	1.01	1.04	0.004
SVI household characteristics (ref: low SVI)				
High SVI	0.93	0.92	0.94	<0.001
Race/Ethnicity (ref: non-Hispanic White)				
Black	0.94	0.92	0.97	<0.001
Hispanic	0.85	0.83	0.88	<0.001
Sex (ref: male)				
Female	0.96	0.95	0.98	<0.001
Age (years)	0.99	0.99	0.99	<0.001
Insurance coverage (ref: FFS only)				
Any dually eligible	1.44	1.42	1.46	<0.001
Primary care shortage area (ref: none)				
Whole	0.97	0.94	1.00	0.033
Part	1.03	1.01	1.05	0.007
Heart-related disease (ref: none)	1.84	1.81	1.86	<0.001
Diabetes (ref: none)	1.24	1.22	1.25	<0.001
Depression (ref: none)	1.67	1.66	1.69	<0.001
Hypertension (ref: none)	1.77	1.74	1.80	<0.001
Year (ref: 2016)				
2017	1.94	1.92	1.97	<0.001
2018	1.26	1.24	1.28	<0.001
2019	1.28	1.26	1.30	<0.001
2020	1.36	1.34	1.39	<0.001

Note: Values represent results from generalized estimating equation model with log link and gamma distribution on total Medicare payments among ACO full-year enrollees, controlling for ACO-specific quality, individual SVI themes, and other covariates. Coefficients represent the log-transformed expected total costs after controlling for all other covariates. Coefficients were exponentiated for easier interpretation and represent the multiplicative effect on total Medicare payments. N = 153,019. Estimated marginal effects (i.e., annual total Medicare payments per beneficiary in US dollars) are available in Table S9 in supporting information.

Abbreviations: ACO, accountable care organization; CI, confidence interval; Exp (Coef.), exponentiated coefficient; FFS, fee-for-service; p, percentile; SVI, Social Vulnerability Index.

Prior research documented that residents in socially vulnerable neighborhoods are less likely to have a usual source of care and access preventive services, leading to increased use of acute care for ambulatory care–sensitive conditions, such as hypertension and diabetes.[23,47] Also, patients from disadvantaged neighborhoods may experience poorly coordinated care, leading to unnecessary healthcare use.[23] Through care coordination and effective man-

agement of other coexisting conditions, especially more prevalent among residents in disadvantaged neighborhoods, ACOs may have contributed to diminishing total cost differences.[23] Consistent with this, our study presents empirical findings showing that the cost-saving effects of ACO enrollment were significantly higher among residents living in neighborhoods with high overall social vulnerability.
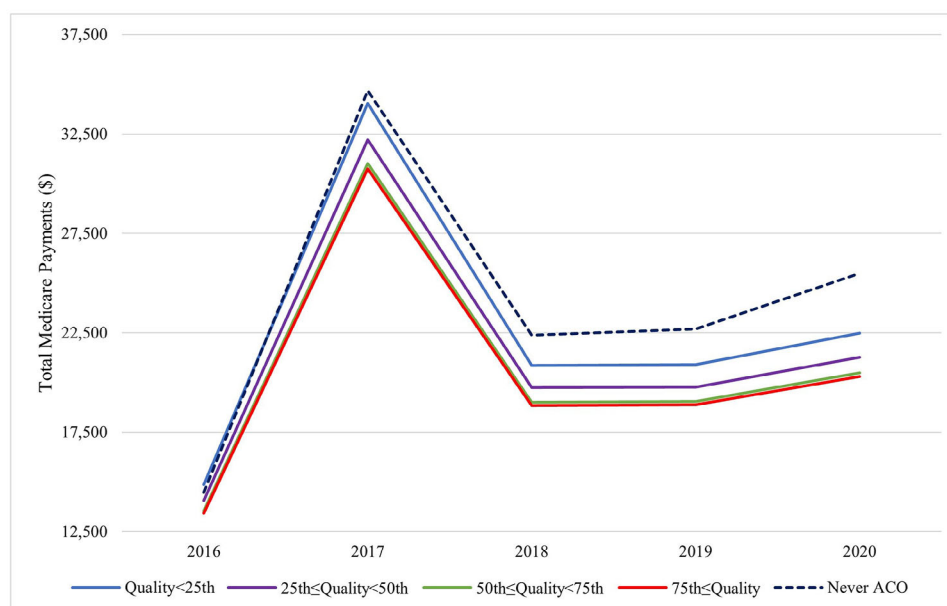
FIGURE 3 Total Medicare payments among continuous 5-year ACO enrollees by ACO-specific quality. Adjusted total Medicare payments among ACO enrollees continuously enrolled for 5 years by ACO-specific quality are presented. The MSSP ACO overall quality scores from CMS were categorized into four quantile groups, ranging from the lowest (i.e., < 25th percentile) to the highest (i.e., ≥ 75th percentile) quality. Never ACO represents beneficiaries who were never enrolled in ACO. The GEE results used to estimate adjusted total Medicare payments among continuous 5-year ACO enrollees are available in Table S10 and estimated US dollar amounts are available in Table S11. ACO, accountable care organization; CMS, Centers for Medicare and Medicaid Services; GEE, generalized estimating equation; MSSP, Medicare Shared Saving Program.

4.2 | Medicare FFS payment and ACO enrollment by the specific SVI measures

Our results showed that the highest cost savings from ACO enrollment were observed among residents in neighborhoods with high proportions of racial and ethnic minorities. Racial and ethnic minorities face significant challenges accessing health-care services.[48–50] In addition, racial and ethnic minoritized older adults often prefer to live close to their families and friends, forming social enclaves.[48,49] As a result, they are more likely to live in neighborhoods with a high concentration of minority groups in which distrust in the US healthcare system and social stigma about ADRD are more prevalent.[48,50] Older adults with ADRD living in these areas may rely on families or friends for help and often delay or avoid medical treatments due to cultural preference or affordability concerns. This increases the risks of preventable ED visits and hospitalizations.[50–52] Consequently, racial and ethnic minority older adults are often diagnosed with ADRD at more advanced stages, leading to more frequent and expensive treatments.[51,52] Our results suggest that racial and ethnic minorities benefit more from ACO enrollment, likely due to more effective management of ADRD and other coexisting conditions and potentially reducing health-care costs.[3,17]

Residents in neighborhoods with high social vulnerability related to housing type and transportation encountered consistently higher spending. Prior research has documented that poor housing conditions and living in crowded housing are associated with adverse health and mental health outcomes.[53,54] Also, inadequate access to reliable transportation limits access to needed health-care services.[55] Our finding supports the effectiveness of addressing non-medical needs,

such as transportation and housing, most commonly addressed by ACOs.[56,57]

The SVI household measure covers a heterogeneous population, including older adults, children, people with disabilities, and single-parent households. Nevertheless, our results showed that beneficiaries enrolled in ACOs still encountered lower Medicare costs than their counterparts. Though Medicare may not be a primary source of care for this heterogeneous group of populations in the area, our findings suggest that the MSSP ACO infrastructure may have a spillover effect to improve care coordination and reduce cost overall.

We found relatively comparable estimated total payments between ACO enrollees and non-ACO enrollees in high and low socioeconomic SVI neighborhoods after adjusting for patient demographic factors and health needs. This may be because ACOs are more likely to be homogeneously located in areas with lower poverty and uninsured rates.[15] As a result, populations in similar socioeconomic regions may have access to comparable health-care resources, and the marginal cost reduction attributed to ACO enrollment may be minimal after controlling for other neighborhood characteristics.

4.3 | Medicare FFS payment and ACO quality by SVI

We found that ACO quality played a significant role in reducing total Medicare payments among beneficiaries newly diagnosed with ADRD and that continuous enrollment in ACOs can make these cost savings sustainable.

ACOs are required to report their performance on quality metrics related to patient experience, care coordination, preventive care, and at-risk populations.[33,58] High-performing ACOs, based on these metrics, provide more preventive care services, manage chronic conditions more effectively, and reduce unplanned readmissions,[33,58,59] all of which can contribute to cost savings for ADRD patients. Our results suggest that high-quality ACOs can generate significant cost savings regardless of neighborhood social vulnerabilities and can be effective in vulnerable communities. This is particularly important given that neighborhood disadvantages are associated with adverse health outcomes and limited access,[18–21] potentially leading to higher health-care costs. Our study emphasizes the importance of continuous efforts to improve ACO quality and the need to encourage sustained enrollment among ACO enrollees to maximize their benefits.

4.4 | ACO and racial and ethnic disparities

Previous studies have found that neighborhood social vulnerability is often associated with negative health outcomes[7,17,21,56,57,60,61] and increased rates of readmissions and ED visits,[19,23] likely leading to increased health-care costs.[38,54] Our results also showed that the unadjusted total Medicare costs were higher among beneficiaries residing in neighborhoods with high social vulnerability. Further, after controlling for patient demographic characteristics and health needs, we found that the differences in overall SVI measures were no longer significant. By further examining specific social vulnerability measures, we found more pronounced reductions among residents living in neighborhoods with higher percentages of racial and ethnic minorities. Our study pointed out the urgency to focus on health and health care among ADRD patients living in areas with high proportions of racial and ethnic minority populations.

This evidence is further supported by our findings of the racial and ethnic disparities among ADRD patients fully enrolled in ACOs. Although, in general, Black and Hispanic ADRD patients encountered higher Medicare costs compared to their White counterparts, literature has shown that Black and Hispanic ADRD patients could benefit more from ACO enrollment.[3,7,17] Our results empirically demonstrated that the Medicare costs would be significantly lower if they were fully enrolled during a year. Our findings underscore the importance of encouraging ACO enrollment among beneficiaries in racial and ethnic minority groups to reduce disparities and improve both cost and health-related outcomes in the long term.

4.5 | Call for a comprehensive measure of neighborhood vulnerability for patients with ADRD

We advocate for improving the vulnerability measure specifically for people with dementia by incorporating healthcare resource availability. Our findings on the primary care shortage areas suggested the importance of considering the local health-care resources. More than 95% of residents in areas with high SVI experienced a primary care

provider shortage, compared to ≈ 80% of residents in areas with low SVI. The contrasting findings between whole and partial primary care shortage areas are intriguing. We speculate that the negative relationship between whole primary care shortage areas and costs may be due to individuals forgoing care, resulting in temporarily lower costs. In contrast, the positive association with costs in partial shortage areas could be due to delayed care, leading to higher health-care expenses. More research on the local availability of dementia care is particularly important for individuals newly diagnosed with ADRD and their caregivers. For newly diagnosed patients, a common challenge is identifying immediate assistance and locating professional care within their communities.[62] While the current SVI comprehensively measured social demographic and economic status, it did not fully capture the health-care resources.

A place-informed dementia care index could be useful in assessing local resources, from prevention and care management to navigating services, seeking timely diagnosis and care, delaying disease onset, and better care management through coordination.[63]

4.6 | Limitations and future directions

Our study has several limitations. First, while we tried to address the endogeneity of ACO selection, further robust analysis is needed. To minimize cost variations arising from ADRD patients' selection into ACOs, we used a longitudinal dataset and multiple econometric methods. In the sensitivity analyses, we further conducted individual-fixed longitudinal analyses, treating ACO enrollment as a time-variant variable, and applied the propensity score matching approach, with results presented in Tables S1 to S3. Both approaches showed results consistent with our main findings. Additionally, the observed cost trends by ACO quality indirectly support our conclusions regarding ACO enrollment and costs. However, we acknowledge that unobserved factors, such as disease severity and individual socioeconomic status, contributing to ACO selection may persist, even after controlling for covariates, such as individual demographic characteristics and health needs. Second, our study was limited to Medicare FFS beneficiaries as we focused on the MSSP ACOs. Future studies are needed to investigate the associations between Medicare payments and neighborhood social vulnerability among Medicare Advantage beneficiaries and Medicare–Medicaid dually eligible beneficiaries. Third, due to data unavailability, we used 5-year average SVI data instead of yearly SVI data, which limited our ability to capture timely variations of county-level SVI. Fourth, we tracked the total expenditures of newly diagnosed ADRD beneficiaries for 1 year prior and 3 years post-diagnosis. Future research may examine long-term costs and multiple years before diagnosis to understand ACOs' effectiveness in preventing ADRD. It would also be valuable to explore whether ACO enrollment is associated with the timing of ADRD diagnosis across low- and high-SVI regions. Additionally, examining subcategories of total Medicare payments in future studies could provide a deeper understanding of the pathways through which ACO enrollment contributes to cost reductions. Finally, this study did not account for other types of ACO models and organiza-

tional structures of ACOs, which may have different associations with total Medicare payments. Future studies are needed to test whether cost-reducing effects extend to other types of ACOs and what specific ACO features contribute to reducing costs.

In conclusion, our findings suggest that ACOs have a significant potential to reduce health-care costs for all residents in socially vulnerable neighborhoods across various areas of social vulnerabilities. ACOs show promise in meeting the non-medical needs of ADRD patients linked to these vulnerabilities, which are critical to advancing population health, improving quality of care, and lowering health-care costs.[56] Understanding these individual areas of neighborhood social vulnerabilities can help policymakers better identify vulnerable patients, develop targeted programs to address their needs, and expand ACO enrollment to underserved populations. Our results further indicate the urgency of addressing racial and ethnic disparities in dementia care and highlight ACOs' potential to reduce these disparities among minority populations of socially vulnerable areas.[3,7,9,56]

ACKNOWLEDGMENTS

CONFLICT OF INTEREST STATEMENT

Author disclosures are available in the supporting information.

CONSENT STATEMENT

The study was approved by the institutional review board at the University of Maryland.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.