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Why Is Dementia Diagnosed Later for Racial and Ethnic Minorities? The Role of Individual and Neighborhood Factors

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Abstract

Racial and ethnic minorities with dementia are substantially less likely to receive timely diagnoses, yet the factors underlying these gaps remain poorly quantified. Using nationally representative Health and Retirement Study (HRS) data linked to Medicare claims (1998–2021) and National Neighborhood Data Archive, we examine racial and ethnic disparities in timely dementia diagnosis among U.S. older adults and decompose these gaps using causal mediation analysis. Timely diagnosis is defined as a clinical dementia diagnosis recorded in Medicare claims within three years before or one year after the HRS survey wave at which dementia was first identified. After controlling for demographics and health conditions, non-Hispanic Black and Hispanic individuals are significantly less likely than non-Hispanic White individuals to receive a timely diagnosis. Educational attainment is the dominant mediator, explaining 48% of the Black–White disparity and 62% of the Hispanic–White disparity, followed by neighborhood affluence (27% and 18%, respectively) and the density of non-physician health practitioner offices (16% and 15%) and physician offices (10% and 12%). Dementia specialist evaluation accounts for a further 7% and 6%, respectively. These findings identify educational attainment and neighborhood-level healthcare infrastructure as the primary structural determinants of racial and ethnic gaps in dementia detection, pointing to targeted policy interventions to advance diagnostic equity.

JEL classification

I14, J15, J14, I11, I18, C35, R23

Keywords

timely dementia diagnosis, disparities, education, neighborhood socioeconomic factors, health care access

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Introduction

Alzheimer's disease and related dementias (ADRD), neurodegenerative conditions characterized by progressive cognitive decline, are a leading cause of disability and dependency among older adults and are among the most expensive diseases in the United States (U.S.)[1-3]. High-quality care for individuals with dementia begins with a timely diagnosis, a crucial first step that allows providers to identify reversible causes, optimize treatment, coordinate medical care, and help individuals and families plan for the future[4,5]. However, up to 60% of dementia cases go undiagnosed in the U.S. primary care[6]. Although underdiagnosis is a critical public health concern across all populations, it disproportionately affects racial and ethnic minority groups, with non-Hispanic Black and Hispanic individuals less likely than non-Hispanic White individuals to receive a timely diagnosis[7-11], despite having a higher risk of developing dementia[12-15].

Recent advancements in dementia care, including a new class of disease-modifying treatments for early-stage Alzheimer's disease and the Centers for Medicare & Medicaid Services' (CMS) adoption of an alternative payment model for comprehensive dementia care, represent a turning point for patients with dementia[16,17]. However, racial and ethnic disparities in the timely diagnosis of dementia may hinder equitable access to these novel treatments and care models. Ensuring equitable, timely detection of dementia is therefore critical for improving patient outcomes across all communities.

Prior studies have documented racial and ethnic differences in factors conceptually linked to delayed dementia diagnosis, including fewer socioeconomic resources[18], lower levels of patient

education and knowledge about dementia[18-20], and mistrust of health care providers among minority populations[21]. Disparities in access to detection-related care have also been reported[22], with minority groups less likely to discuss memory concerns with clinicians[23], receive cognitive screening[24,25], or access dementia specialists[26-28]. Separately, socioeconomic factors associated with the timeliness of dementia diagnosis in the general population[8-10,29-31], including neighborhood socioeconomic conditions, have also been found to contribute to racial and ethnic differences in diagnosis and treatment for other conditions[32-34]. However, direct quantitative evidence on which factors drive racial and ethnic disparities in timely dementia diagnosis, and the magnitude of their contributions, remains limited.

A deeper understanding of these mechanisms is needed to inform interventions and advance health equity. Building on prior studies that have hypothesized socioeconomic and access-related differences as potential contributors but have not quantified their roles, this study examined the extent to which individual- and neighborhood-level factors, including sociodemographic factors and access to health care services, are associated with racial and ethnic differences in the timely diagnosis of dementia among older U.S. adults.

Methods

Data Source

We used data from the 1998-2020 Health and Retirement Study (HRS), linked to Medicare claims from 1995 to 2021. The HRS is a nationally representative biennial survey of U.S. older adults with detailed information on demographics, socioeconomic status, and cognitive and physical functioning. By linking HRS data to Medicare claims, we could track both cognitive

status and diagnosis records over time. Additionally, we merged the HRS-Medicare linked data with the National Neighborhood Data Archive (NaNDA), a public archival resource containing composite index measures of sociodemographic status and health care service availability at the neighborhood level across the U.S. that has been used in recent studies[35-37].

Study Population

We included HRS participants from 1998 to 2020 who were classified as having dementia in HRS (defined below), consented to Medicare records linkage, and were enrolled in Medicare fee-for-service (FFS) during the three years preceding and one year following the HRS interview at which dementia was first observed (i.e., dementia onset). This four-year window was used to define our outcome (see *Outcomes* section). We excluded beneficiaries enrolled in Medicare Advantage (MA) at any point during the four-year window because complete claims data are not consistently available for MA enrollees. Enrollment status was ascertained from the Medicare Beneficiary Summary File. Individuals with missing covariate or mediator data (≈3%) were excluded (**Figure 1**). Individuals with claims-based diagnoses who did not meet the HRS algorithmic criteria for dementia were not eligible for the analytic sample, as the study focuses on diagnostic timing relative to the onset of symptomatic dementia (**Table S1**).

We assigned dementia status to all person-wave observations using the predicted cognition and dementia measures developed by Hudomiet et al[38], a validated algorithm that provides more accurate estimates of dementia prevalence by race and ethnicity and is better suited for examining racial and ethnic disparities than existing HRS-based methods [38,39]. Hudomiet et al.'s estimates span 2000-2016; we applied their published algorithms[40] to extend estimates to

additional years (1998, 2018-2020), with replicated estimates closely aligning with the originals. Details on the dementia classification algorithm, replication, and comparisons are provided in the Online Supplement (**Methods S1**).

Outcome Measures

Our primary outcome was a binary indicator of receiving a timely dementia diagnosis (versus not). Participants were categorized based on the timing of a clinical dementia diagnosis in Medicare claims relative to dementia onset as defined in the HRS, which served as a standardized, symptom-based reference point. Timely diagnosis was defined as a clinical diagnosis of dementia recorded in Medicare claims within 3 years before or 1 year after dementia onset. Individuals without a diagnosis within this 4-year window were classified as not timely diagnosed, including those whose first diagnosis occurred more than 1 year after onset (delayed diagnosis) and those who never received a diagnosis in claims through December 31, 2021, or prior to death (missed diagnosis). Those without a timely diagnosis whose first clinical dementia diagnosis preceded the 4-year window were excluded to avoid misclassification (**Figure 1**).

Although no consensus exists on the operational definition of a timeliness window, our approach aligns with prior studies informed by Medicare claims-based dementia identification periods and clinical judgment[7,41]. Dementia diagnoses were identified using the *International Classification of Diseases, Ninth or Tenth Revision, Clinical Modification* codes widely used in prior studies[9,42,43] (**Table S2**).

Race and Ethnicity

Race and ethnicity were self-reported by HRS participants using fixed categories provided by the survey instrument. For analysis, participants were classified into mutually exclusive groups: non-Hispanic White, non-Hispanic Black, Hispanic, and non-Hispanic other. Analysis focused on the first three groups due to the small sample size of the non-Hispanic other category.

Covariates

Following the Institute of Medicine (IOM) definition of a health care disparity (a difference in health services between racial and ethnic groups not justified by differences in health status or clinical need)[44,45], widely used in prior studies[46-49], we adjusted for non-modifiable demographics and health conditions to ensure comparisons of timely diagnosis were made across clinically comparable groups. These included age, gender, comorbid conditions, cognition score (algorithm-estimated latent cognition by Hudomiet et al.), and number of limitations in activities of daily living (ADLs) and instrumental activities of daily living (IADLs) (**Table S3**). Health conditions were measured at the wave of dementia onset, as individuals' clinical profiles at onset are most proximate to and most likely to shape the likelihood of timely diagnosis.

Potential Mediators

We evaluated mediators across three domains: individual-level socioeconomic status (income and educational attainment), neighborhood-level socioeconomic factors (neighborhood disadvantage and affluence), and health care access factors, including any pre-diagnosis visit to a dementia specialist and the density of physician and non-physician health practitioner offices and clinics at the neighborhood level. Dementia specialties included neurology, psychiatry, neuropsychiatry, geriatrics, and geriatric psychiatry[50]. Neighborhood-level factors were

measured at the census tract level using composite index variables. Details of variable definitions and operationalization are provided in **Table S4**. All mediators were measured in the year of dementia onset.

Statistical Analysis

We estimated racial and ethnic disparities in timely dementia diagnosis using multivariable logistic regression in Model A, adjusted for IOM-defined covariates. Models B, C, and D sequentially added individual-level socioeconomic, neighborhood-level socioeconomic, and health care access factors as potential mediators in a stepwise manner to assess how the magnitude of disparities changed. We also estimated the unadjusted time to first diagnosis among those with delayed diagnosis and the proportion of undiagnosed across racial and ethnic groups.

To quantify the contributions of each potential mediator to the racial and ethnic disparities observed in Model A, we used the general mediation approach by Imai et al[51]. Specifically, we estimated the association between race and ethnicity and timely dementia diagnosis, and the association between race and ethnicity and each potential mediator, using logistic regression adjusted for the aforementioned covariates. We then estimated mediation effects (i.e., the indirect effect, representing the portion of the association of race and ethnicity with the outcome that operates through the mediator variable) and the proportion mediated by each factor (**Methods S2**). A directed acyclic graph (DAG) depicting the mediation framework is presented in **Figure S1**. All analyses incorporated HRS sampling weights to account for unequal probability of inclusion in the sample.

We performed several sensitivity analyses. First, to assess the robustness of our findings to the choice of mediation method, we conducted a regression-based mediation analysis using the product-of-coefficients method by Cheng et al[52]. Second, we excluded individuals whose dementia status in HRS reverted to non-dementia after onset. Third, we restricted the sample to 2000-2016, the period for which Hudomiet et al's original dementia measures were fully available. Fourth, we excluded dual-eligible beneficiaries to avoid undercounting dementia diagnoses captured only in Medicaid claims.

All analyses were conducted using Stata, version 18 (StataCorp LLC) and R, version 4.3.0 (R Project for Statistical Computing). $P < .05$ (2-sided) was considered statistically significant. The institutional review board of Yale University reviewed and approved this study. Informed consent was waived because of minimal risk and the impracticality of obtaining consent from participants.

Results

Sample Characteristics

The final sample included 3,429 HRS participants (**Figure 1**), representing an estimated 11,002,244 U.S. adults aged 65 or older nationwide after applying HRS sampling weights (**Table S5**). Just over half (53.4%) received a timely diagnosis (**Table 1**). Among them, the most frequently recorded codes were "Other persistent mental disorders due to conditions classified elsewhere" (23%), "Alzheimer's disease" (22%), and "Senile dementia, uncomplicated" (15%) (**Table S6**).

Of the participants, 74.0% self-identified as non-Hispanic White, 16.3% as non-Hispanic Black, and 7.4% as Hispanic (**Table 2**). Compared with individuals who self-identified as non-Hispanic White, individuals who were non-Hispanic Black or Hispanic were less likely to receive a timely diagnosis (55.7% vs 49.1% and 46.1%). Weighted estimates (**Table S5** and **Table S7**) were consistent with unweighted statistics. Among those with a delayed diagnosis, the mean time from dementia onset to first recorded clinical diagnosis was 39 months overall (**Figure S2**), and longer for non-Hispanic Black (44 months) and Hispanic individuals (55 months) than non-Hispanic White individuals (37 months).

Racial and Ethnic Disparities in Timely Dementia Diagnosis

After adjusting for IOM-defined covariates, non-Hispanic Black and Hispanic individuals had significantly lower odds of receiving a timely diagnosis than non-Hispanic White individuals (OR=0.71; 95% CI, 0.57-0.89 and OR=0.61; 95% CI, 0.44-0.85, respectively; $P < .01$ for both) (**Table 3**). These disparities were substantially attenuated after sequentially adjusting for individual-level socioeconomic status (Model B), neighborhood-level socioeconomic factors (Model C), and health care access factors (Model D), with odds of timely diagnosis no longer statistically significantly different across racial and ethnic groups in Models B through D. In Model D, adjusted ORs were 0.92 (95% CI, 0.72-1.17) for non-Hispanic Black individuals and 0.90 (95% CI, 0.64-1.26) for Hispanic individuals, compared with non-Hispanic White individuals.

Mediators of Timely Diagnosis

In the mediation analysis, educational attainment was the strongest mediator, explaining 48.4% (indirect effect, -0.04 [95% CI, -0.06 to -0.02]) of the disparity in timely diagnosis between non-Hispanic Black and non-Hispanic White individuals and 61.9% (indirect effect, -0.07 [95% CI, -0.10 to -0.04]) between Hispanic and non-Hispanic White individuals (**Figure 2**). Neighborhood affluence was the second largest mediator, accounting for 27.3% (indirect effect, -0.02 [95% CI, -0.04 to -0.01]) and 17.8% (indirect effect, -0.02 [95% CI, -0.04 to -0.01]) of the disparities for non-Hispanic Black and Hispanic individuals, respectively. The density of health practitioner offices also explained meaningful shares of the disparities, at 15.8% (indirect effect, -0.013 [95% CI, -0.024 to -0.003]) for non-Hispanic Black individuals and 14.6% (indirect effect, -0.016 [95% CI, -0.031 to -0.003]) for Hispanic individuals, followed by the density of physician offices, at 9.6% (indirect effect, -0.008 [95% CI, -0.016 to -0.002]) for non-Hispanic Black individuals and 12.4% (indirect effect, -0.014 [95% CI, -0.026 to -0.003]) for Hispanic individuals, respectively.

Specialist evaluation also accounted for a statistically significant but modest proportion of disparities: 6.6% for non-Hispanic Black individuals (indirect effect, -0.006 [95% CI, -0.013 to -0.001]) and 5.5% for Hispanic individuals (indirect effect, -0.006 [95% CI, -0.015 to -0.000]), compared with non-Hispanic White individuals. Income and neighborhood disadvantage were not significant mediators of racial and ethnic disparities in timely dementia diagnosis.

Sensitivity and Additional Analyses

Sensitivity analyses using the product method for mediation (**Table S8**), excluding individuals whose dementia status reverted after onset (**Table S9**; **Figure S3**), and restricting the sample to

2000-2016 (**Table S10**; **Figure S4**) yielded results consistent with the main findings. Excluding dual-eligible beneficiaries produced similar results, though specialist evaluation and neighborhood affluence were not significant when comparing Hispanic versus non-Hispanic White individuals (**Figure S5**), likely due to the reduced sample size (**Table S11**) and exclusion of more socioeconomically disadvantaged individuals.

Discussion

A growing body of literature has conceptualized multiple factors as potential contributors to racial and ethnic disparities in timely dementia diagnosis, including lower educational level[18-20], linguistic disparities[29], fewer socioeconomic resources[18], limited access to care[26-28], mistrust of health care providers[21], and physician training and concerns about misdiagnosis[53,54]. While not all such factors could be empirically examined due to data limitations, this study is the first, to our knowledge, to leverage survey-linked claims data to quantify the contributions of individual- and neighborhood-level socioeconomic and health care access factors – commonly hypothesized drivers of disparities – within a unified mediation framework.

Consistent with existing evidence, we found that non-Hispanic Black and Hispanic individuals with dementia were less likely to receive a timely diagnosis than non-Hispanic White individuals[8-10]. Educational attainment was the most prominent mediator of the observed disparities, while neighborhood affluence, the density of health practitioner offices, and the density of physician offices accounted for a non-trivial portion. In contrast, income and neighborhood disadvantage were not significant mediators, suggesting that differential financial resources alone do not drive diagnostic disparities.

Educational attainment of high school or above explained the largest share of disparities in timely dementia diagnosis. Non-Hispanic Black and Hispanic individuals with dementia had considerably lower proportions of high school completion than non-Hispanic White individuals. Low educational attainment is a key correlate of limited health literacy and poor dementia knowledge[55,56]. This deficiency often impairs perception of cognitive decline, awareness of dementia and treatments[57], hindering individuals' ability to recognize early symptoms and effectively navigate the healthcare system, ultimately reducing the likelihood of seeking timely medical evaluation. Although racial and ethnic disparities in educational attainment are deeply rooted in historical and structural inequities that cannot be addressed through resource redistribution alone[58,59], our findings highlight the potential relevance of dementia care interventions targeting demand-side barriers related to low educational attainment, such as dementia education programs and care navigation initiatives, to improve timely detection among minority populations.

Prior research has demonstrated that neighborhood disadvantage and rurality are associated with timely dementia diagnosis[9], but relies on broad contextual measures such as the Area Deprivation Index, a multidimensional evaluation of neighborhood socioeconomic conditions. Our study adds new evidence by distinguishing distinct neighborhood dimensions and examining their role in diagnosis disparities. The finding that neighborhood affluence, but not disadvantage, was a significant mediator likely reflects their distinct constructs: affluent neighborhoods are characterized by concentrations of high-income, highly educated professionals; these areas often exert greater social control and leverage over local institutions to facilitate health-promoting

environments[60,61] – advantages that extend beyond the mere absence of deprivation found in typical non-disadvantaged neighborhoods. Racial and ethnic differences in exposure to affluent neighborhoods may therefore contribute to differences in dementia awareness and care-seeking behavior, underscoring the potential of place-based and community-level approaches to address disparities in timely diagnosis.

Although specialist evaluation was a significant mediator of timely diagnosis disparities, consistent with prior hypotheses regarding differential access to specialty care[22,26], its mediating role was notably smaller than that of non-physician health practitioner and physician office density. Moreover, fewer than 40% of patients across racial and ethnic groups had received a specialist evaluation. These findings highlight the critical role of broader clinical settings in dementia detection. Prior literature documents primary care physicians as the first point of contact for cognitive symptoms and non-physician clinicians as key contributors to early symptom recognition through sustained patient engagement[62,63]. Given their broader geographic distribution relative to dementia specialist practices and the rapidly growing supply of non-physician primary care clinicians such as nurse practitioners[64], policy efforts may consider supporting these providers in underserved communities and strengthening referral pathways into specialty care.

This study had several limitations. First, we used an HRS-based prediction algorithm to determine dementia status due to the lack of clinical ascertainment of dementia onset. Any non-differential misclassification, as well as the omission of individuals identified by claims diagnoses alone, would likely attenuate estimated disparities toward the null. Second, our sample

was limited to Medicare FFS beneficiaries. MA enrollees may differ systematically from FFS beneficiaries in socioeconomic status, health literacy, and care-seeking behavior, and MA plans differ from FFS in care access, delivery, and financing; our findings may therefore not generalize to MA enrollees. Third, our sample excluded other racial and ethnic groups (e.g., Asian or Pacific Islander) due to small sample sizes; findings may not generalize to these populations given potential differences in socioeconomic characteristics and health care access. Fourth, although census tract-level measures of health care access are granular, they may not fully reflect individual access circumstances or experiences within larger geographic areas. Finally, although our analysis used the statistical framework of mediation analysis, causal interpretation requires strong assumptions (described in Methods S2), including known timing of mediator measurement, that may not hold in our data. Our findings therefore identify factors that statistically account for disparities rather than causal mechanisms through which they operate.

Without a universal cognitive screening recommendation in the U.S. and given disproportionately high dementia incidence among non-Hispanic Black and Hispanic older adults, our findings point to important directions for targeted intervention to improve timely dementia detection and advance equity in dementia care.

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Author Contribution: Y.Q., F.L., and X.C. conceived and designed the study. Y.Q. collected the data, performed the analysis, and drafted the manuscript. F.L. and X.C. provided critical revisions, and both supervised the analysis. X.C. contributed as the senior author.

Conflicts of Interest Statement: The authors have no conflicts of interest to declare.

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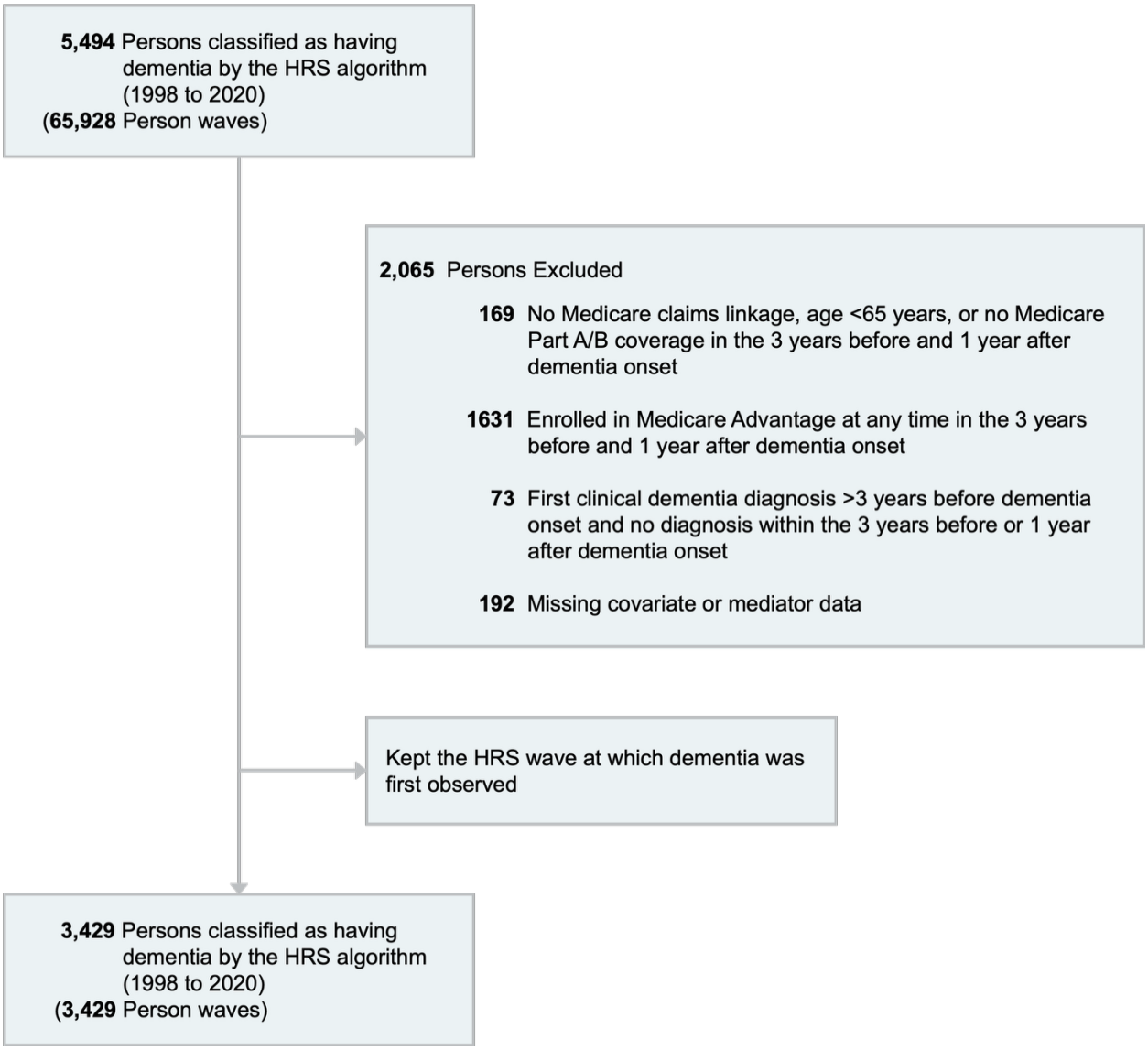
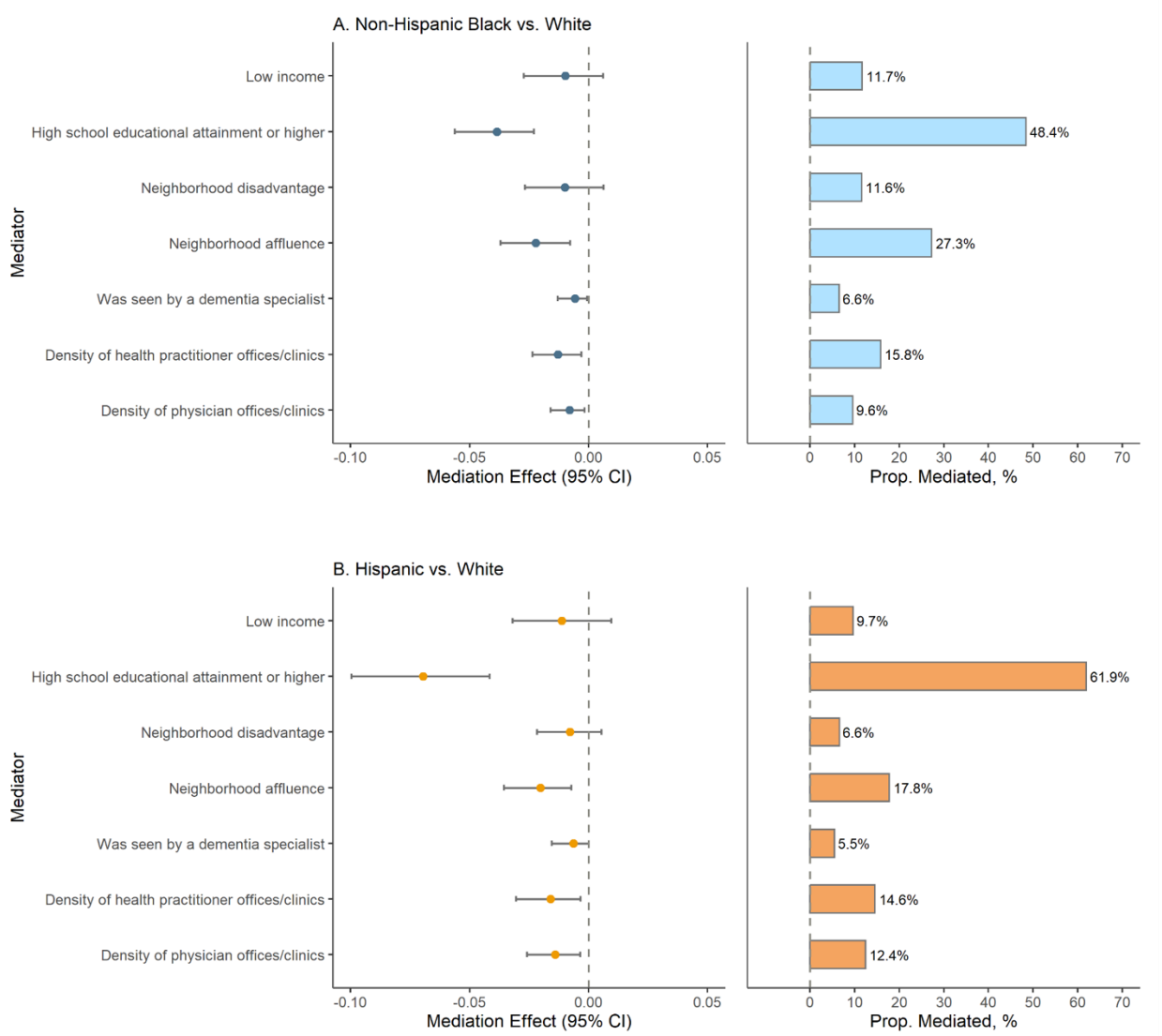
FIGURES

Figure 1. Generation of the Analytic Sample



Abbreviations: HRS, Health and Retirement Study.
Notes: The figure illustrates the sample selection process. "HRS algorithm" refers to the predicted cognition and dementia measures developed by Hudomiet et al. (2022). Dementia onset refers to the HRS interview at which dementia was first observed.

Figure 2. Relative Effects From Mediation Analysis for the Timely Diagnosis of Dementia



Notes: All mediator variables were operationalized as binary indicators. Low income was defined as a family income-to-poverty ratio below 1. Neighborhood disadvantage and affluence were coded as one for individuals in the least disadvantaged (disadvantage index deciles 1-2) and most affluent (affluence index deciles 8-10) neighborhoods, respectively. "Was seen by a dementia specialist" was coded as one if the individual had any office visit to a specialist prior to diagnosis. Health practitioner (not physician) and physician office/clinic density were each coded as one for individuals in neighborhoods with a density index in deciles 8-10. The x-axis displays indirect effects and the proportion mediated by each factor, estimated using the general mediation approach of Imai et al. (Supplementary Methods S2).

TABLES

Table 1. Characteristics of the Study Sample, by Timely versus Delayed or Missed Diagnosis

Characteristic	Patients, No (%)		
	Timely diagnosis*	Delayed/Missed diagnosis†	Full sample
All observations, No.	1,831 (53.4)	1,598 (46.6)	3,429
Individual level			
Age, y			
65-69	87 (4.8)	170 (10.6)	257 (7.5)
70-74	137 (7.5)	153 (9.6)	290 (8.5)
75-79	292 (15.9)	256 (16.0)	548 (16.0)
80-84	423 (23.1)	362 (22.7)	785 (22.9)
>=85	892 (48.7)	657 (41.1)	1,549 (45.2)
Race and Ethnicity			
Non-Hispanic White	1,414 (77.2)	1,123 (70.3)	2,537 (74.0)
Non-Hispanic Black	275 (15.0)	285 (17.8)	560 (16.3)
Hispanic	117 (6.4)	137 (8.6)	254 (7.4)
Non-Hispanic Other	25 (1.4)	53 (3.3)	78 (2.3)
Male	590 (32.2)	626 (39.2)	1,216 (35.5)
High school educational attainment or higher	1,100 (60.1)	825 (51.6)	1,925 (56.1)
Ratio of family income to poverty threshold			
Less than 1	311 (17.0)	321 (20.1)	632 (18.4)
Between 1 and 4	1,104 (60.3)	955 (59.8)	2,059 (60.0)
Greater than or equal to 4	416 (22.7)	322 (20.2)	738 (21.5)
Number of chronic conditions‡, mean (SD)	2.5 (1.5)	2.4 (1.5)	2.5 (1.5)
Number of activities of daily living (ADL), mean (SD)	2.3 (2.3)	1.8 (2.0)	2.1 (2.2)
Number of instrumental activities of daily living (IADL), mean (SD)	2.7 (1.9)	1.8 (1.7)	2.3 (1.8)
Predicted latent cognition, mean (SD)	-0.6 (0.6)	-0.3 (0.4)	-0.5 (0.5)
Was seen by a dementia specialist§	756 (41.3)	527 (33.0)	1,283 (37.4)
Neighborhood level¶			
Density of physician offices/clinics			
Low density (deciles 1-2)	529 (28.9)	574 (35.9)	1,103 (32.2)
Medium density (deciles 3-7)	656 (35.8)	576 (36.0)	1,232 (35.9)
High density (deciles 8-10)	646 (35.3)	448 (28.0)	1,094 (31.9)

Density of health practitioner offices/clinics			
Low density (deciles 1-2)	596 (32.6)	678 (42.4)	1,274 (37.2)
Medium density (deciles 3-7)	589 (32.2)	488 (30.5)	1,077 (31.4)
High density (deciles 8-10)	646 (35.3)	432 (27.0)	1,078 (31.4)
Neighborhood disadvantage			
Least disadvantage (deciles 1-2)	431 (23.5)	301 (18.8)	732 (21.3)
Intermediate disadvantage (deciles 3-7)	936 (51.1)	825 (51.6)	1,761 (51.4)
Most disadvantage (deciles 8-10)	464 (25.3)	472 (29.5)	936 (27.3)
Neighborhood affluence			
Least affluent (deciles 1-2)	288 (15.7)	390 (24.4)	678 (19.8)
Intermediate affluent (deciles 3-7)	909 (49.6)	803 (50.3)	1,712 (49.9)
Most affluent (deciles 8-10)	634 (34.6)	405 (25.3)	1,039 (30.3)

* Timely diagnosis was defined as the presence of a clinical diagnosis of dementia, identified by an ICD-9-CM or ICD-10-CM code in Medicare claims, recorded up to 3 years prior to or 1 year following the HRS interview at which dementia was first observed.
† Delayed/Missed diagnosis was defined as the absence of a timely diagnosis, including individuals who received their first clinical dementia diagnosis more than 1 year after the HRS interview at which dementia was first observed or who never received a dementia diagnosis in Medicare claims.
‡ Details on chronic conditions are provided in Supplementary Table S3.
§ Dementia specialties included neurology, psychiatry, neuropsychiatry, geriatrics, and geriatric psychiatry.
¶ Details on neighborhood-level characteristics are provided in Supplementary Table S4.

Table 2. Characteristics of the Study Sample, by Race and Ethnicity

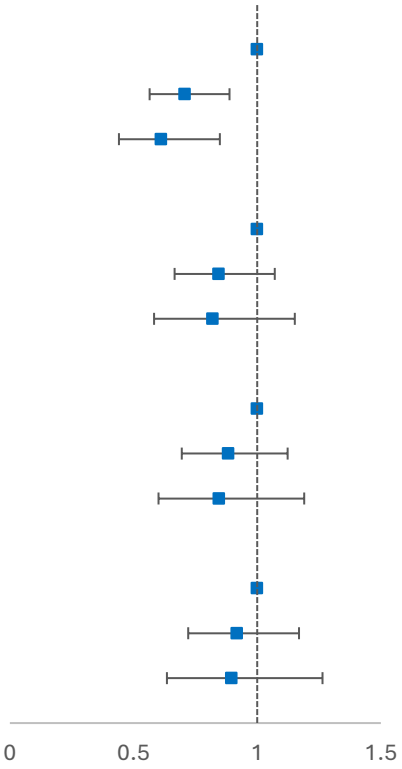
Characteristic	Patients, No (%)		
	Non-Hispanic White	Non-Hispanic Black	Hispanic
All observations, No.	2,537 (74.0)	560 (16.3)	254 (7.4)
Timely diagnosis[*]	1,414 (55.7)	275 (49.1)	117 (46.1)
Individual level			
Age, y			
65-69	138 (5.4)	74 (13.2)	35 (13.8)
70-74	196 (7.7)	57 (10.2)	25 (9.8)
75-79	372 (14.7)	112 (20.0)	52 (20.5)
80-84	601 (23.7)	115 (20.5)	50 (19.7)
>=85	1,230 (48.5)	202 (36.1)	92 (36.2)
Male	889 (35.0)	210 (37.5)	83 (32.7)
High school educational attainment or higher	1,663 (65.5)	190 (33.9)	37 (14.6)
Ratio of family income to poverty threshold			
Less than 1	298 (11.7)	192 (34.3)	109 (42.9)
Between 1 and 4	1,601 (63.1)	300 (53.6)	124 (48.8)
Greater than or equal to 4	638 (25.1)	68 (12.1)	21 (8.3)
Number of Chronic Conditions[†], mean (SD)	2.4 (1.4)	2.7 (1.5)	3.0 (1.4)
Number of activities of daily living (ADL), mean (SD)	2.0 (2.2)	2.2 (2.3)	2.8 (2.3)
Number of instrumental activities of daily living (IADL), mean (SD)	2.2 (1.8)	2.3 (1.8)	2.8 (1.8)
Predicted latent cognition, mean (SD)	-0.5 (0.5)	-0.6 (0.6)	-0.5 (0.5)
Was seen by a dementia specialist[‡]	973 (38.4)	193 (34.5)	89 (35.0)
Neighborhood level[§]			
Density of physician offices/clinics			
Low density (deciles 1-2)	747 (29.4)	234 (41.8)	101 (39.8)
Medium density (deciles 3-7)	899 (35.4)	193 (34.5)	104 (40.9)
High density (deciles 8-10)	891 (35.1)	133 (23.8)	49 (19.3)
Density of health practitioner offices/clinics			
Low density (deciles 1-2)	794 (31.3)	314 (56.1)	134 (52.8)
Medium density (deciles 3-7)	822 (32.4)	146 (26.1)	83 (32.7)
High density (deciles 8-10)	921 (36.3)	100 (17.9)	37 (14.6)
Neighborhood disadvantage			

Least disadvantage (deciles 1-2)	690 (27.2)	22 (3.9)	13 (5.1)
Intermediate disadvantage (deciles 3-7)	1,462 (57.6)	187 (33.4)	80 (31.5)
Most disadvantage (deciles 8-10)	385 (15.2)	351 (62.7)	161 (63.4)
Neighborhood affluence			
Least affluent (deciles 1-2)	297 (11.7)	236 (42.1)	118 (46.5)
Intermediate affluent (deciles 3-7)	1,313 (51.8)	260 (46.4)	105 (41.3)
Most affluent (deciles 8-10)	927 (36.5)	64 (11.4)	31 (12.2)

[*] Timely diagnosis was defined as the presence of a clinical diagnosis of dementia, identified by an ICD-9-CM or ICD-10-CM code in Medicare claims, recorded up to 3 years prior to or 1 year following the HRS interview at which dementia was first observed.
[†] Details on chronic conditions are provided in Supplementary Table S3.
[‡] Dementia specialties included neurology, psychiatry, neuropsychiatry, geriatrics, and geriatric psychiatry.
[§] Details on neighborhood-level characteristics are provided in Supplementary Table S4.

Table 3. Adjusted Associations Between Race and Ethnicity and Timely Diagnosis of Dementia

Model	The timely diagnosis of dementia, OR (95% CI)
Model A	
White	1 [Reference]
Black	0.708** (0.565 - 0.888)
Hispanic	0.612** (0.441 - 0.849)
Model B	
White	1 [Reference]
Black	0.845 (0.666 - 1.071)
Hispanic	0.820 (0.583 - 1.152)
Model C	
White	1 [Reference]
Black	0.883 (0.695 - 1.123)
Hispanic	0.846 (0.601 - 1.190)
Model D	
White	1 [Reference]
Black	0.918 (0.721 - 1.169)
Hispanic	0.896 (0.635 - 1.264)



** p<0.01, * p<0.05

Model A: Adjusted for IOM-defined covariates
Model B: Adjusted for IOM-defined covariates + individual-level socioeconomic status
Model C: Adjusted for IOM-defined covariates + individual-level socioeconomic status + neighborhood-level socioeconomic factors
Model D: Adjusted for IOM-defined covariates + individual-level socioeconomic status + neighborhood-level socioeconomic factors + health care access factors

Abbreviations: IOM, Institute of Medicine.
Notes: Multivariable logistic regression was used to estimate racial and ethnic disparities in timely dementia diagnosis. IOM-defined covariates included unmodifiable demographics and health conditions, as described in the *Covariates* section. Individual-level socioeconomic status, neighborhood-level socioeconomic factors, and health care access factors are described in the *Potential Mediators* section.

ONLINE SUPPLEMENTARY APPENDIX

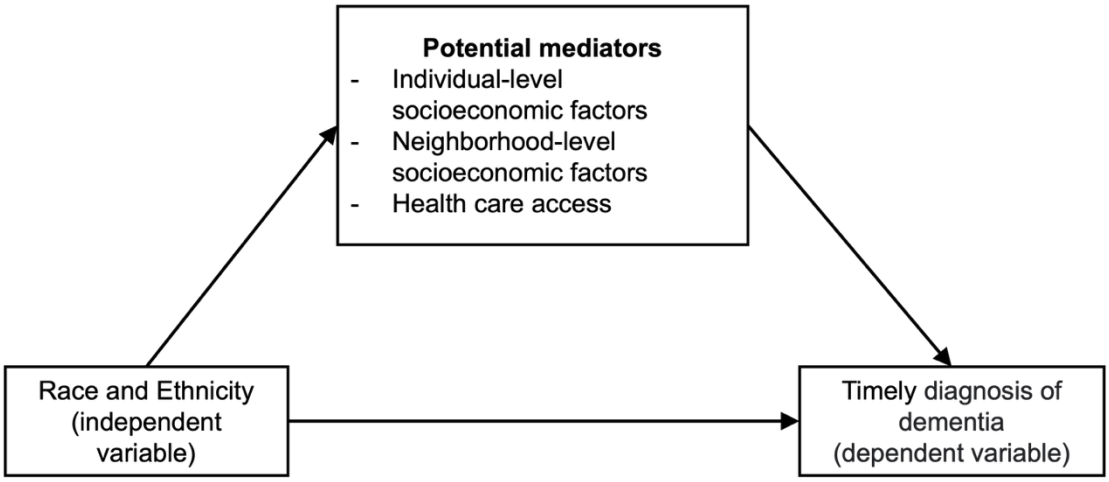
Associations of Individual- and Neighborhood-Level Factors With Racial and Ethnic Disparities in Timely Dementia Diagnosis

Methods S1: Replication of Predicted Cognition and Dementia Measures and Application to 1998-2020

Methods S2: Additional Details on Mediation Analysis

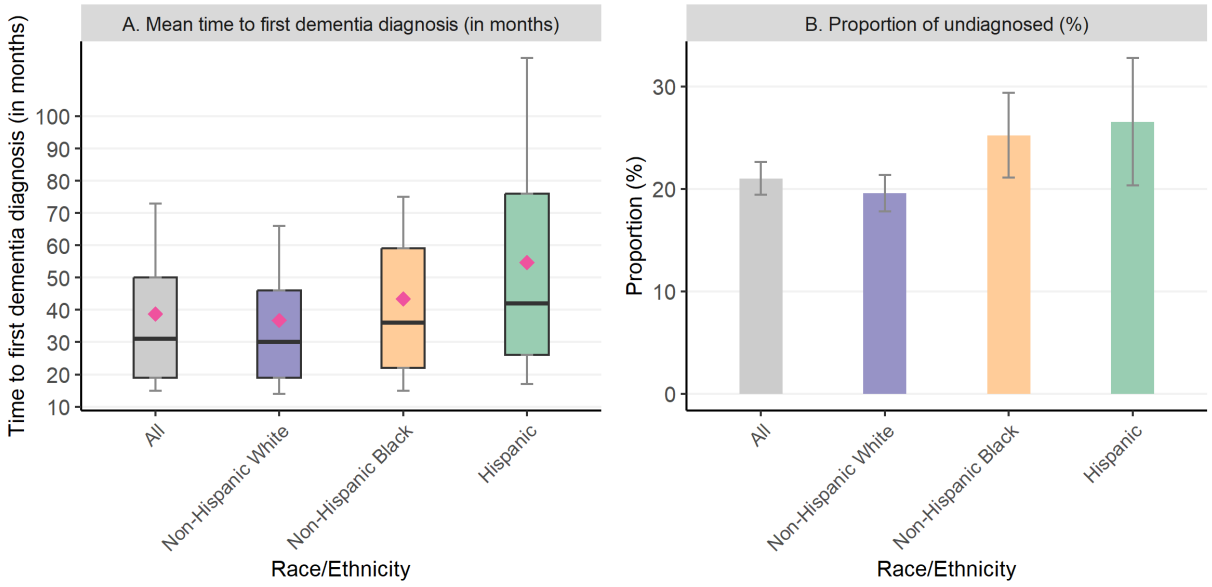
References S1

Figure S1: Directed Acyclic Graph for the Mediation Analysis of Racial and Ethnic Disparities in Timely Dementia Diagnosis



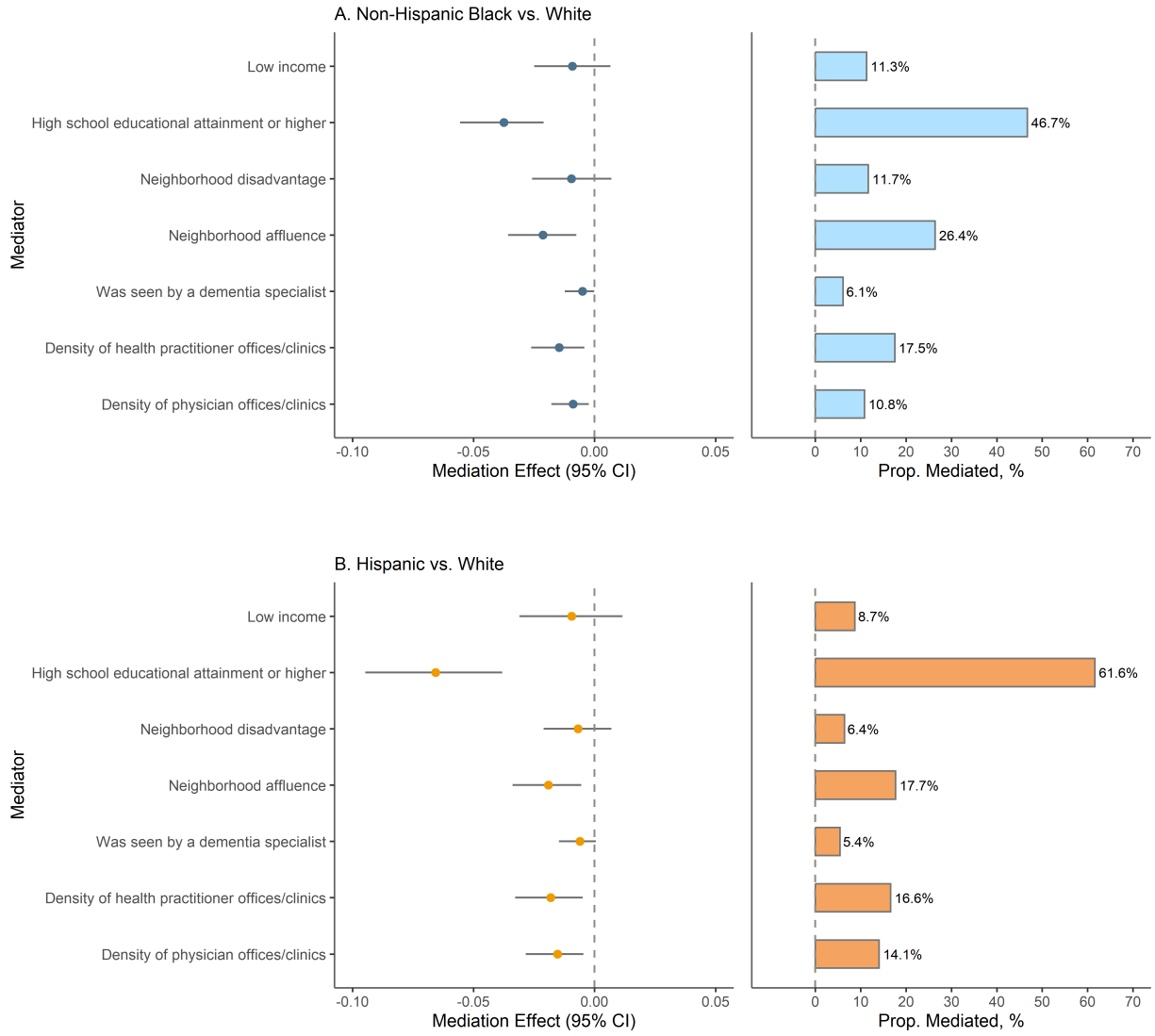
Notes: In this directed acyclic graph (DAG), race and ethnicity is the exposure and timely dementia diagnosis is the outcome. Following the Institute of Medicine (IOM) framework described in the Covariates section of the Methods, non-modifiable demographic characteristics (age, gender) and health conditions (comorbid medical conditions, ADLs/IADLs, cognition score) are treated as confounders. The mediation analysis estimated the total effect of race and ethnicity on timely dementia diagnosis, decomposing it into a direct effect and indirect effects operating through each mediator, while holding confounders constant. Each mediator was examined separately while adjusting for confounders.

Figure S2: Average Delay in Dementia Diagnosis and Proportion of Undiagnosed Individuals by Race and Ethnicity



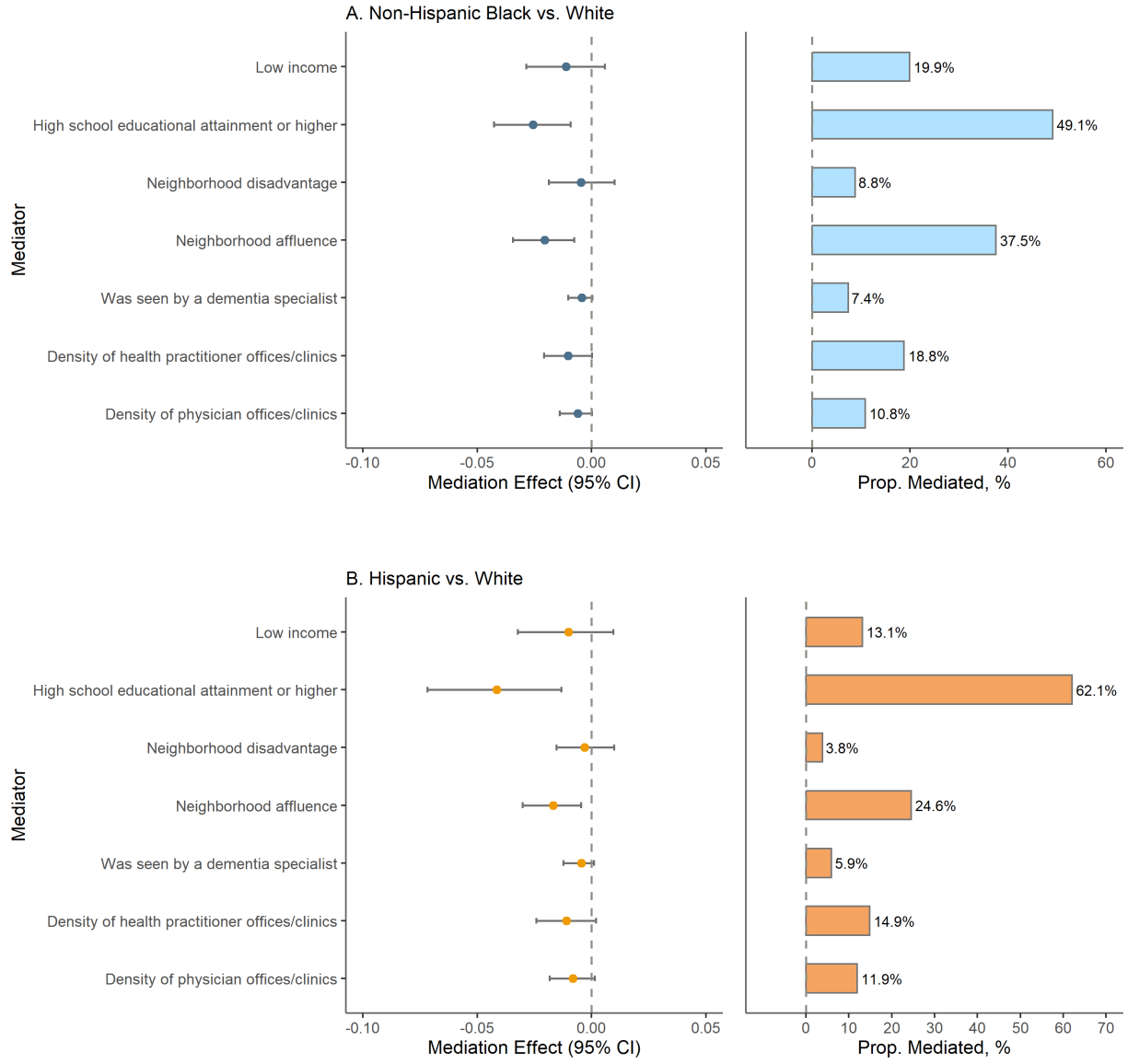
Notes: Panel A presents the unadjusted time from dementia onset (as defined by HRS) to the first recorded clinical diagnosis of dementia among individuals with a delayed diagnosis, stratified by race and ethnicity. Box boundaries indicate the 25th and 75th percentiles; whiskers, the 10th and 90th percentiles; horizontal lines, the median; and diamonds, the mean. Panel B presents the proportion of individuals with dementia who never received a diagnosis, stratified by race and ethnicity. In Panel B, whiskers represent 95% confidence intervals. All estimates were weighted using HRS analytic weights to represent U.S. adults aged 65 or older.

Figure S3: Relative Effects from Mediation Analysis for Timely Dementia Diagnosis, Excluding Individuals with Reverted Dementia Status



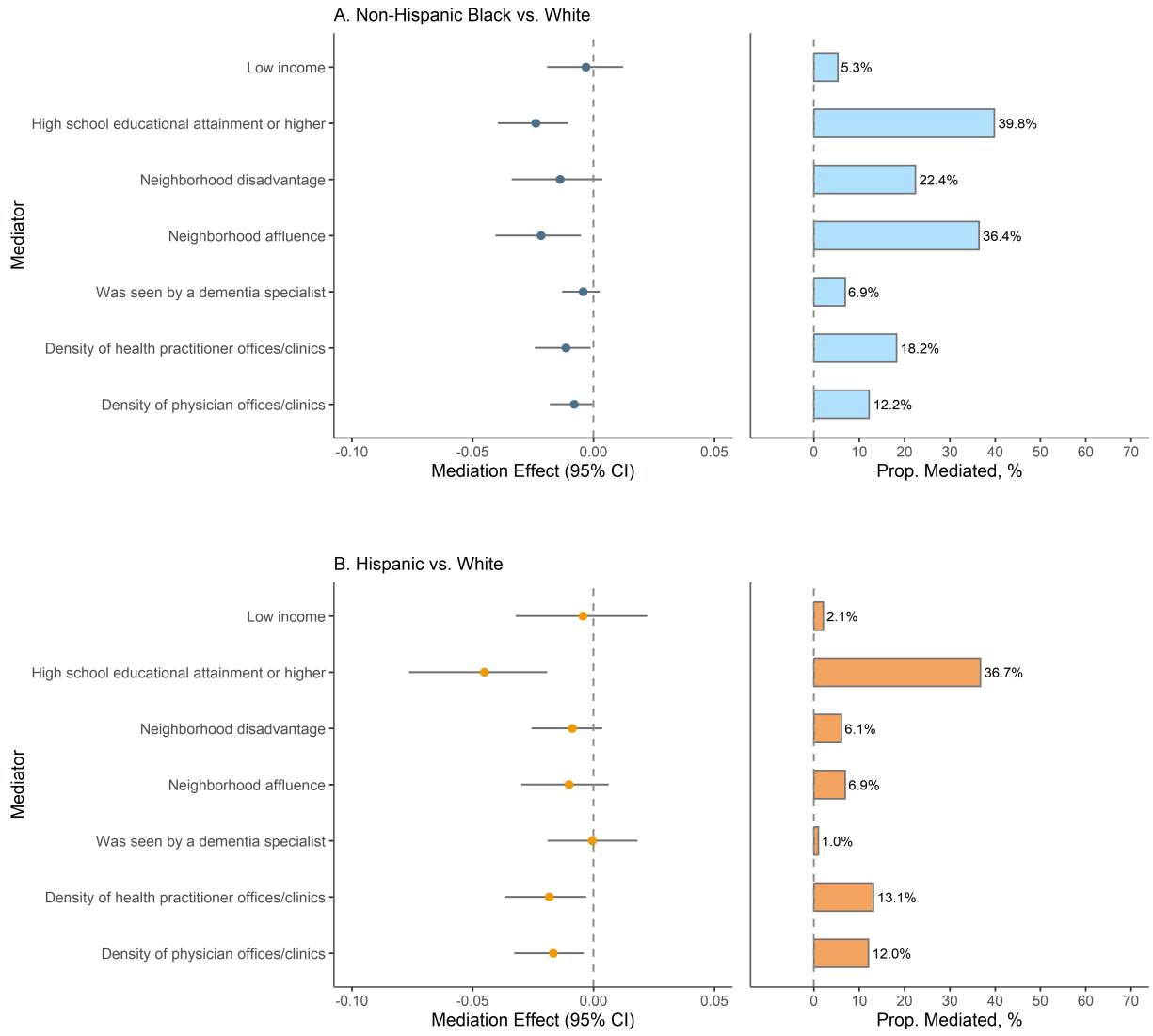
Notes: Estimates are from mediation analyses excluding individuals whose dementia status reverted to non-dementia after onset. All mediator variables were operationalized as binary indicators. Low income was defined as a family income-to-poverty ratio below 1. Neighborhood disadvantage and affluence were coded as one for individuals in the least disadvantaged (disadvantage index deciles 1-2) and most affluent (affluence index deciles 8-10) neighborhoods, respectively. "Was seen by a dementia specialist" was coded as one if the individual had any office visit to a specialist prior to diagnosis. Health practitioner (not physician) and physician office/clinic density were each coded as one for individuals in neighborhoods with a density index in deciles 8-10. The x-axis displays indirect effects and the proportion mediated by each factor, estimated using the general mediation approach of Imai et al. (Supplementary Methods S2).

Figure S4. Relative Effects From Mediation Analysis for the Timely Diagnosis of Dementia Using the 2000-2016 Sample



Notes: Estimates are from mediation analyses restricting the Health and Retirement Study (HRS) sample to 2000-2016. All mediator variables were operationalized as binary indicators. Low income was defined as a family income-to-poverty ratio below 1. Neighborhood disadvantage and affluence were coded as one for individuals in the least disadvantaged (disadvantage index deciles 1-2) and most affluent (affluence index deciles 8-10) neighborhoods, respectively. "Was seen by a dementia specialist" was coded as one if the individual had any office visit to a specialist prior to diagnosis. Health practitioner (not physician) and physician office/clinic density were each coded as one for individuals in neighborhoods with a density index in deciles 8-10. The x-axis displays indirect effects and the proportion mediated by each factor, estimated using the general mediation approach of Imai et al. (Supplementary Methods S2).

Figure S5: Relative Effects From Mediation Analysis for the Timely Diagnosis of Dementia, Excluding Dual-Eligible Beneficiaries



Notes: Estimates are from mediation analyses excluding dual-eligible beneficiaries. All mediator variables were operationalized as binary indicators. Low income was defined as a family income-to-poverty ratio below 1. Neighborhood disadvantage and affluence were coded as one for individuals in the least disadvantaged (disadvantage index deciles 1-2) and most affluent (affluence index deciles 8-10) neighborhoods, respectively. "Was seen by a dementia specialist" was coded as one if the individual had any office visit to a specialist prior to diagnosis. Health practitioner (not physician) and physician office/clinic density were each coded as one for individuals in neighborhoods with a density index in deciles 8-10. The x-axis displays indirect effects and the proportion mediated by each factor, estimated using the general mediation approach of Imai et al. (Supplementary Methods S2).

Table S1: Individuals with Claims-Based Dementia Diagnosis Not Classified As Having Dementia by the HRS Algorithm

Claims-based dementia identification metrics	Not classified as having dementia by the HRS algorithm		Total person-waves	Total persons
	N (%), Person-waves	N (%), Persons		
Any claims-based dementia diagnosis	3,219 (36.37)	1,613 (33.08)	8,851	4,876
≥1 inpatient, SNF, home health, or hospice claim for dementia, or ≥2 carrier/outpatient claims that are ≥7 days apart	2,007 (29.11)	985 (25.47)	6,895	3,867
Dementia claims from ≥2 distinct health care settings	1,113 (23.63)	563 (19.73)	4,710	2,854

Notes: This table is based on HRS respondents aged 65 years or older with Medicare claims linkage. It reports the number and percentage of person-waves and individuals for whom claims data indicated a dementia diagnosis but who were not classified as having dementia by the HRS algorithm (Hudomiet et al., 2022), across different claims-based identification metrics. Individuals with claims-based diagnoses who did not meet the HRS algorithmic criteria for dementia were not eligible for the analytic sample.

Table S2: ICD-9-CM and ICD-10-CM Codes Utilized for Identifying Dementia Diagnoses

Dementia			
ICD-9-CM Code	**Description**	**ICD-10-CM Code**	**Description**
290.0	Senile dementia, uncomplicated	F01.50	Vascular dementia without behavioral disturbance
290.10	Presenile dementia, uncomplicated	F01.51	Vascular dementia with behavioral disturbance
290.11	Presenile dementia with delirium	F02.80	Dementia in other diseases classified elsewhere without behavioral disturbance
290.12	Presenile dementia with delusional features	F02.81	Dementia in other diseases classified elsewhere with behavioral disturbance
290.13	Presenile dementia with depressive features	F03.90	Unspecified dementia without behavioral disturbance
290.20	Senile dementia with delusional features	F03.91	Unspecified dementia with behavioral disturbance
290.21	Senile dementia with depressive features	F04	Amnestic disorder due to known physiological condition
290.3	Senile dementia with delirium	F05	Delirium due to known physiological condition
290.40	Vascular dementia, uncomplicated	F06.1	Catatonic disorder due to known physiological condition
290.41	Vascular dementia with delirium	F06.8	Other specified mental disorders due to known physiological condition
290.42	Vascular dementia with delusions	G13.8	Other systemic atrophies primarily affecting the central nervous system
290.43	Vascular dementia with depressed mood	G30.0	Alzheimer's disease with early onset
294.0	Amnestic disorder in conditions classified elsewhere	G30.1	Alzheimer's disease with late onset
294.10	Dementia in conditions classified elsewhere without behavioral disturbance	G30.8	Other Alzheimer's disease
294.11	Dementia in conditions classified elsewhere with behavioral disturbance	G30.9	Alzheimer's disease, unspecified
294.20	Dementia, unspecified, without behavioral disturbance	G31.01	Pick's disease
294.21	Dementia, unspecified, with behavioral disturbance	G31.09	Other frontotemporal dementia
294.8	Other persistent mental disorders due to conditions classified elsewhere	G31.1	Senile degeneration of the brain, not elsewhere classified
331.0	Alzheimer’s disease	G31.2	Degeneration of nervous system due to alcohol
331.11	Pick’s disease	G94	Other disorders of brain in diseases classified elsewhere
331.19	Other frontotemporal dementia	R54	Senility without mention of psychosis
331.2	Senile degeneration of brain		

331.7	Cerebral degeneration in diseases classified elsewhere		
797	Senility without mention of psychosis		

Table S3: Specification of Health Condition Covariates

Variable	Definition	Source
Comorbid medical conditions	Chronic conditions were obtained from the Chronic Condition Warehouse (CCW) linked to the Health and Retirement Study (HRS) survey year at which dementia was first observed. Conditions were categorized in alignment with the HRS survey and included seven categories: hypertension, diabetes, cancer, lung disease, heart disease, stroke, and arthritis.	HRS and CCW
Latent cognition	Cognitive status was assessed using the algorithm-estimated latent cognition score developed by Hudomiet et al. (2022). Latent cognition score is a continuous measure derived from cognitive and functional assessments collected in the HRS. A detailed description of the algorithm is provided in Methods S1.	HRS
Number of ADLs	ADLs include dressing, walking across a room, bathing, eating, getting in and out of bed, and using the toilet.	HRS
Number of IADLs	IADLs include preparing meals, grocery shopping, making phone calls, taking medications, and managing money.	HRS

Notes: This table describes the health condition variables included as covariates in assessing racial and ethnic differences in timely dementia diagnosis.

Table S4: Definitions and Operationalization of Potential Mediator Measures

Measure	Definition	Source	Operationalization in mediation analysis
Income	Total household income for the last calendar year, summed across respondent and spouse earnings, pensions and annuities, SSI and Social Security Disability, Social Security retirement, unemployment and workers' compensation, other government transfers, household capital income, and other income.	Health and Retirement Study (HRS)	Binary indicator of low income, defined as a family income-to-poverty ratio below 1, derived from HRS data.
Education	Educational level, categorized as: less than high school, General Educational Development (GED), high school graduate, some college, and college or above.	Health and Retirement Study (HRS)	Binary indicator of high school graduate or higher.
Was seen by a dementia specialist	Specialist evaluation was defined as having at least one visit to a dementia specialist, including neurology, psychiatry, neuropsychiatry, geriatrics, or geriatric psychiatry, prior to diagnosis within the timely diagnosis window for those with a timely diagnosis, or within the same window for those with a delayed or missed diagnosis.	Medicare claims	A binary indicator coded as 1 if the participant had at least one visit to a dementia specialist prior to diagnosis, and 0 otherwise.
Neighborhood disadvantage	The average of four census indicators (proportion of female-headed families with children, proportion of households receiving public assistance income or food stamps, proportion of families with income below the federal poverty level, and proportion of the population aged 16 years or older who were unemployed) ranging from 0 to 1.0.	National Neighborhood Data Archive (NaNDA): Neighborhood Socioeconomic and Demographic Characteristics by Tract, United States, 2000-2020	Binary indicator coded as 1 for individuals residing in the least disadvantaged neighborhoods (disadvantage index deciles 1-2).

Neighborhood affluence	The average of three census indicators (proportion of households with income exceeding $75,000, proportion of the population aged 16 years or older employed in professional or managerial occupations, and proportion of adults with a bachelor's degree or higher) ranging from 0 to 1.0.	National Neighborhood Data Archive (NaNDA): Neighborhood Socioeconomic and Demographic Characteristics by Tract, United States, 2000-2020	Binary indicator coded as 1 for individuals residing in the most affluent neighborhoods (affluence index deciles 8-10).
Density of physician offices/clinics	The number of physician offices/clinics per 1,000 people. Physician offices and clinics were defined as establishments of licensed practitioners having the degree of M.D. (doctor of medicine) or D.O. (doctor of osteopathy) engaged in the practice of general or specialized medicine and surgery.	National Neighborhood Data Archive (NaNDA) Health Care Services by Census Tract and ZCTA, United States, 1990-2021	Binary indicator coded as 1 for individuals residing in neighborhoods with a density index in deciles 8-10.
Density of health practitioner offices/clinics	The number of health practitioner offices/clinics per 1,000 people. Health practitioner offices and clinics were defined as offices and clinics of non-physician health practitioners, including physical therapists, occupational therapists, speech pathologists, clinical psychologists, psychotherapists, registered nurses, chiropractors, podiatrists, acupuncturists, massage therapists, and other non-physician health practitioners.	National Neighborhood Data Archive (NaNDA) Health Care Services by Census Tract and ZCTA, United States, 1990-2021	Binary indicator coded as 1 for individuals residing in neighborhoods with a density index in deciles 8-10.

Notes: All measures are available during the study period (1998-2020), except for neighborhood disadvantage and affluence in 1998, which were proxied using 2000 census data given the relative stability of neighborhood-level socioeconomic characteristics over short periods.

Table S5: Weighted Sample Characteristics, by Timely versus Delayed or Missed Diagnosis

	Patients, Weighted* N (%)		
Characteristic	**Timely diagnosis†**	**Delayed/Missed diagnosis‡**	**Full sample**
All observations, No.	5,889,626 (53.5)	5,112,618 (46.5)	11,002,244
Individual level			
Age, y			
65-69	315,337 (5.4)	535,607 (10.5)	850,944 (7.7)
70-74	441,075 (7.5)	523,709 (10.2)	964,784 (8.8)
75-79	956,676 (16.2)	827,401 (16.2)	1,784,077 (16.2)
80-84	1,403,435 (23.8)	1,172,391 (22.9)	2,575,826 (23.4)
>=85	2,773,103 (47.1)	2,053,510 (40.2)	4,826,613 (43.9)
Race and Ethnicity			
Non-Hispanic White	4,946,273 (84.0)	3,977,921 (77.8)	8,924,194 (81.1)
Non-Hispanic Black	574,567 (9.8)	613,459 (12.0)	1,188,026 (10.8)
Hispanic	283,212 (4.8)	334,732 (6.5)	617,944 (5.6)
Non-Hispanic Other	85,574 (1.5)	186,506 (3.6)	272,080 (2.5)
Male	1,934,468 (32.8)	1,963,949 (38.4)	3,898,417 (35.4)
High school educational attainment or higher	3,918,252 (66.5)	2,884,668 (56.4)	6,802,920 (61.8)
Ratio of family income to poverty threshold			
Less than 1	820,234 (13.9)	907,653 (17.8)	1,727,887 (15.7)
Between 1 and 4	3,591,658 (61.0)	3,117,226 (61.0)	6,708,884 (61.0)
Greater than or equal to 4	1,477,734 (25.1)	1,087,739 (21.3)	2,565,473 (23.3)
Number of chronic conditions§, mean (SD)	2.5 (1.4)	2.4 (1.5)	2.5 (1.5)
Number of activities of daily living (ADL), mean (SD)	2.1 (2.2)	1.8 (2.0)	1.9 (2.1)
Number of instrumental activities of daily living (IADL), mean (SD)	2.5 (1.9)	1.7 (1.6)	2.1 (1.8)
Predicted latent cognition, mean (SD)	-0.5 (0.5)	-0.3 (0.3)	-0.4 (0.4)
Was seen by a dementia specialist¶	2,447,899 (41.6)	1,724,613 (33.7)	4,172,512 (37.9)
Neighborhood level#			
Density of physician offices/clinics			
Low density (deciles 1-2)	1,614,705 (27.4)	1,722,729 (33.7)	3,337,434 (30.3)
Medium density (deciles 3-7)	2,148,647 (36.5)	1,890,261 (37.0)	4,038,908 (36.7)
High density (deciles 8-10)	2,126,274 (36.1)	1,499,628 (29.3)	3,625,902 (33.0)
Density of health practitioner offices/clinics			
Low density (deciles 1-2)	1,779,424 (30.2)	1,946,133 (38.1)	3,725,557 (33.9)

Medium density (deciles 3-7)	1,857,986 (31.5)	1,613,549 (31.6)	3,471,535 (31.6)
High density (deciles 8-10)	2,252,216 (38.2)	1,552,936 (30.4)	3,805,152 (34.6)
Neighborhood disadvantage			
Least disadvantage (deciles 1-2)	1,476,517 (25.1)	1,076,321 (21.1)	2,552,838 (23.2)
Intermediate disadvantage (deciles 3-7)	3,145,792 (53.4)	2,794,353 (54.7)	5,940,145 (54.0)
Most disadvantage (deciles 8-10)	1,267,317 (21.5)	1,241,944 (24.3)	2,509,261 (22.8)
Neighborhood affluence			
Least affluent (deciles 1-2)	694,767 (11.8)	994,490 (19.5)	1,689,257 (15.4)
Intermediate affluent (deciles 3-7)	2,993,717 (50.8)	2,648,358 (51.8)	5,642,075 (51.3)
Most affluent (deciles 8-10)	2,201,142 (37.4)	1,469,770 (28.7)	3,670,912 (33.4)

* Summary statistics were weighted by HRS analytic weights to represent US adults aged 65 or older.
† Timely diagnosis was defined as the presence of a clinical diagnosis of dementia, identified by an ICD-9-CM or ICD-10-CM code in Medicare claims, recorded up to 3 years prior to or 1 year following the HRS interview at which dementia was first observed.
‡ Delayed/Missed diagnosis was defined as the absence of a timely diagnosis, including individuals who received their first clinical dementia diagnosis more than 1 year after the HRS interview at which dementia was first observed or who never received a dementia diagnosis in Medicare claims.
§ Details on chronic conditions are provided in Table S3.
¶ Specialties classified as dementia specialties were neurology, psychiatry, neuropsychiatry, geriatrics, and geriatric psychiatry.
# Details on neighborhood-level characteristics are provided in Table S4.

Table S6: Distribution of Dementia Diagnosis Codes Among Patients with a Timely Diagnosis

Initial Dementia Diagnosis Codes (ICD-9-CM and ICD-10-CM)	Description	Percent of Total Frequency (%)
294.8	Other persistent mental disorders due to conditions classified elsewhere	22.99
331.0	Alzheimer's disease	22.06
290.0	Senile dementia, uncomplicated	15.02
F03.90	Unspecified dementia without behavioral disturbance	5.35
290.20	Senile dementia with delusional features	4.70
290.40	Vascular dementia, uncomplicated	4.15
294.10	Dementia in conditions classified elsewhere without behavioral disturbance	2.84
290.10	Presenile dementia, uncomplicated	2.35
290.21	Senile dementia with depressive features	1.86
331.2	Senile degeneration of brain	1.80
G30.9	Alzheimer's disease, unspecified	1.80
797	Senility without mention of psychosis	1.64
290.20	Senile dementia with delusional features	1.42
290.3	Senile dementia with delirium	1.31
G30.1	Alzheimer's disease with late onset	1.09
294.11	Dementia in conditions classified elsewhere with behavioral disturbance	0.98
290.43	Vascular dementia with depressed mood	0.87
F03.91	Unspecified dementia with behavioral disturbance	0.87
R54	Senility without mention of psychosis	0.82
290.41	Vascular dementia with delirium	0.76
F01.50	Vascular dementia without behavioral disturbance	0.71
F02.80	Dementia in other diseases classified elsewhere without behavioral disturbance	0.71
294.21	Dementia, unspecified, with behavioral disturbance	0.55
F05	Delirium due to known physiological condition	0.44
290.42	Vascular dementia with delusions	0.38
294.0	Amnestic disorder in conditions classified elsewhere	0.38

G31.1	Senile degeneration of the brain, not elsewhere classified	0.38
290.11	Presenile dementia with delirium	0.27
F01.51	Vascular dementia with behavioral disturbance	0.27
F02.81	Dementia in other diseases classified elsewhere with behavioral disturbance	0.27
290.13	Presenile dementia with depressive features	0.22
290.12	Presenile dementia with delusional features	0.16
G30.8	Other Alzheimer's disease	0.16
331.7	Cerebral degeneration in diseases classified elsewhere	0.11
331.11	Pick’s disease	0.05
F04	Amnestic disorder due to known physiological condition	0.05
G30.0	Alzheimer's disease with early onset	0.05
G31.09	Other frontotemporal dementia	0.05
G94	Other disorders of brain in diseases classified elsewhere	0.05

Notes: For each individual, the most recent Medicare claim containing a dementia diagnosis code within the timely diagnosis window (3 years pre- to 1 year post-dementia onset as defined in the HRS) was used for this frequency table. When multiple dementia codes were present within that claim, the first listed code was used.

Table S7: Weighted Sample Characteristics, by Race and Ethnicity

Characteristic	Patients, Weighted N* (%)		
	Non-Hispanic White	Non-Hispanic Black	Hispanic
All observations, No.	8,924,194 (81.1)	1,188,026 (10.8)	617,944 (5.6)
Timely diagnosis†	4,946,273 (55.4)	574,567 (48.4)	283,212 (45.8)
Individual level			
Age, y			
65-69	551,013 (6.2)	179,411 (15.1)	94,083 (15.2)
70-74	733,216 (8.2)	141,702 (11.9)	55,289 (8.9)
75-79	1,380,128 (15.5)	236,495 (19.9)	124,647 (20.2)
80-84	2,155,506 (24.2)	216,584 (18.2)	121,017 (19.6)
>=85	4,104,331 (46.0)	413,834 (34.8)	222,908 (36.1)
Male	3,108,485 (34.8)	471,978 (39.7)	196,465 (31.8)
High school educational attainment or higher	6,151,746 (68.9)	437,541 (36.8)	82,175 (13.3)
Ratio of family income to poverty threshold			
Less than 1	983,208 (11.0)	396,206 (33.3)	242,443 (39.2)
Between 1 and 4	5,636,233 (63.2)	638,062 (53.7)	309,101 (50.0)
Greater than or equal to 4	2,304,753 (25.8)	153,758 (12.9)	66,400 (10.7)
Number of Chronic Conditions‡, mean (SD)	2.386 (1.440)	2.620 (1.514)	2.994 (1.346)
Number of activities of daily living (ADL)	1.879 (2.121)	1.999 (2.194)	2.724 (2.296)
Number of instrumental activities of daily living (IADL)	2.092 (1.801)	2.135 (1.806)	2.777 (1.779)
Predicted latent cognition	-0.380 (0.401)	-0.463 (0.486)	-0.421 (0.510)
Was seen by a dementia specialist¶	3,449,155 (38.6)	408,116 (34.4)	216,790 (35.1)
Neighborhood level#			
Density of physician offices/clinics			
Low density (deciles 1-2)	2,533,361 (28.4)	484,189 (40.8)	252,492 (40.9)
Medium density (deciles 3-7)	3,243,707 (36.3)	407,905 (34.3)	258,001 (41.8)
High density (deciles 8-10)	3,147,126 (35.3)	295,932 (24.9)	107,451 (17.4)
Density of health practitioner offices/clinics			
Low density (deciles 1-2)	2,656,162 (29.8)	659,322 (55.5)	302,599 (49.0)
Medium density (deciles 3-7)	2,855,065 (32.0)	303,207 (25.5)	224,157 (36.3)
High density (deciles 8-10)	3,412,967 (38.2)	225,497 (19.0)	91,188 (14.8)
Neighborhood disadvantage			
Least disadvantage (deciles 1-2)	2,450,089 (27.5)	41,441 (3.5)	33,493 (5.4)

Intermediate disadvantage (deciles 3-7)	5,219,889 (58.5)	391,710 (33.0)	214,317 (34.7)
Most disadvantage (deciles 8-10)	1,254,216 (14.1)	754,875 (63.5)	370,134 (59.9)
Neighborhood affluence			
Least affluent (deciles 1-2)	879,317 (9.9)	462,753 (39.0)	267,468 (43.3)
Intermediate affluent (deciles 3-7)	4,661,561 (52.2)	581,563 (49.0)	268,086 (43.4)
Most affluent (deciles 8-10)	3,383,316 (37.9)	143,710 (12.1)	82,390 (13.3)

* Summary statistics were weighted by HRS analytic weights to represent US adults aged 65 or older.
† Timely diagnosis was defined as the presence of a clinical diagnosis of dementia, identified by an ICD-9-CM or ICD-10-CM code in Medicare claims, recorded up to 3 years prior to or 1 year following the HRS interview at which dementia was first observed.
‡ Details on chronic conditions are provided in Table S3.
¶ Specialties classified as dementia specialties were neurology, psychiatry, neuropsychiatry, geriatrics, and geriatric psychiatry.
# Details on neighborhood-level characteristics are provided in Table S4.

Table S8: Mediation Analysis Using Product Methods

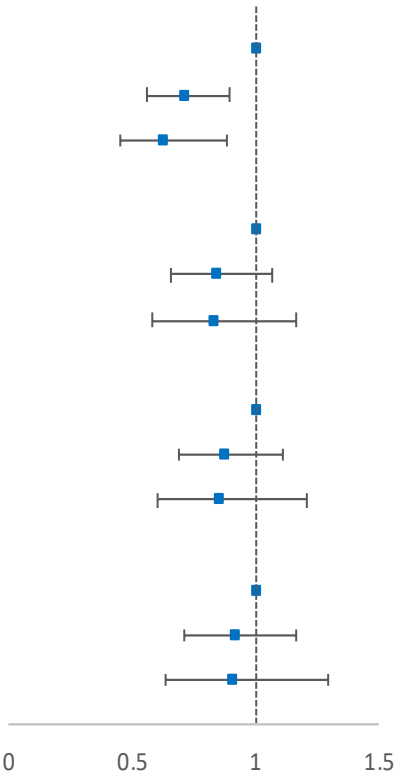
	Black vs White		Hispanic vs White	
Mediators	**Natural indirect effect, (95% CI)**	**Mediation proportion (%)**	**Natural indirect effect, (95% CI)**	**Mediation proportion (%)**
Low income	-0.03 (-0.08, 0.02)	9.60	-0.04 (-0.11, 0.03)	8.00
High school educational attainment or higher	-0.15 (-0.2, -0.1)	43.19	-0.25 (-0.34, -0.16)	49.34
Neighborhood disadvantage	-0.05 (-0.1, -0.01)	14.57	-0.04 (-0.09, 0)	8.44
Neighborhood affluence	-0.12 (-0.17, -0.08)	34.66	-0.1 (-0.16, -0.05)	20.77
Was seen by a dementia specialist	-0.01 (-0.04, 0)	4.54	-0.01 (-0.03, 0.01)	2.43
Density of health practitioner offices/clinics	-0.07 (-0.11, -0.04)	19.77	-0.09 (-0.13, -0.05)	17.43
Density of physician offices/clinics	-0.04 (-0.07, -0.02)	11.72	-0.06 (-0.1, -0.03)	12.46

Notes: The table presents the mediation analysis results using the *Product Method* by Cheng, Spiegelman, and Li[1], based on our main analysis sample. All mediator variables were operationalized as binary indicators. Low income was defined as a family income-to-poverty ratio below 1. Neighborhood disadvantage and affluence were coded as one for individuals in the least disadvantaged (disadvantage index deciles 1-2) and most affluent (affluence index deciles 8-10) neighborhoods, respectively. “Was seen by a dementia specialist” was coded as one if the individual had any office visit to a specialist prior to diagnosis. Health practitioner (not physician) and physician office/clinic density were each coded as one for individuals in neighborhoods with a density index in deciles 8-10. The x-axis displays indirect effects and the proportion mediated by each factor, estimated using the general mediation approach of Imai et al. (Supplementary Methods S2).

Table S9: Association between Race and Ethnicity and the Timely Diagnosis of Dementia, Excluding Individuals with Reverted Dementia Status

Panel A: Proportion of individuals receiving timely diagnosis of dementia*		
Race and Ethnicity	**Unadjusted, N (%)**	**Adjusted, Weighted N (%)**
Total sample	3,370	10,812,856
White	1,405 (56.2)	4,912,097 (55.9)
Black	271 (49.5)	568,424 (49.0)
Hispanic	115 (47.5)	279,134 (47.4)

Panel B: Adjusted association of race and ethnicity with the timely diagnosis of dementia†	
Adjusted Model	**OR (95% CI)**
Model A	
White	1 [Reference]
Black	0.707** (0.563–0.889)
Hispanic	0.628** (0.449–0.879)
Model B	
White	1 [Reference]
Black	0.837 (0.658–1.064)
Hispanic	0.825 (0.583–1.168)
Model C	
White	1 [Reference]
Black	0.874 (0.685–1.115)
Hispanic	0.850 (0.600–1.205)
Model D	
White	1 [Reference]
Black	0.912 (0.714–1.165)
Hispanic	0.907 (0.638–1.289)



** p<0.01, * p<0.05, † 0<0.1

Model A: Adjusted for IOM-defined covariates
Model B: Adjusted for IOM-defined covariates + individual-level socioeconomic status
Model C: Adjusted for IOM-defined covariates + individual-level socioeconomic status + neighborhood-level socioeconomic factors
Model D: Adjusted for IOM-defined covariates + individual-level socioeconomic status + neighborhood-level socioeconomic factors + health care access factors

Notes: Estimates are from sensitivity analyses excluding individuals whose dementia status reverted to non-dementia after onset. Weighted numbers reflect the estimated number of U.S. older adults represented by the HRS participants after applying survey weights.

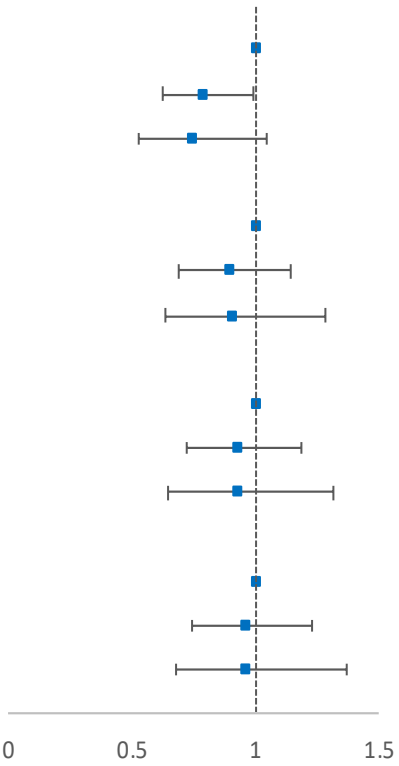
[*] Panel A presents both unadjusted and adjusted proportions of individuals receiving a timely dementia diagnosis in the overall population and by race and ethnicity. Adjusted proportions were estimated using predictive margins from Model A.

[†] Panel B presents the adjusted association between race and ethnicity and timely dementia diagnosis from multivariable logistic regression models, sequentially adjusting for additional variables from model A through model D. IOM-defined covariates included unmodifiable demographics and health conditions, as described in the *Covariates* section. Individual-level socioeconomic status, neighborhood-level socioeconomic factors, and health care access factors are described in the *Potential Mediators* section.

Table S10: Association between Race and Ethnicity and the Timely Diagnosis of Dementia Using the 2000-2016 Sample

Panel A: Proportion of individuals receiving timely diagnosis of dementia*		
Race and Ethnicity	**Unadjusted, N (%)**	**Adjusted, Weighted N (%)**
Total sample	2,989	10,123,382
White	1,251 (56.8)	4,660,687 (57.1)
Black	257 (53.2)	584,427 (51.7)
Hispanic	117 (50.4)	296,139 (50.6)

Panel B: Adjusted association of race and ethnicity with the timely diagnosis of dementia†	
Adjusted Model	**OR (95% CI)**
Model A	
White	1 [Reference]
Black	0.785* (0.619 - 0.996)
Hispanic	0.747† (0.532 - 1.049)
Model B	
White	1 [Reference]
Black	0.890 (0.694 - 1.142)
Hispanic	0.904 (0.635 - 1.286)
Model C	
White	1 [Reference]
Black	0.923 (0.717 - 1.188)
Hispanic	0.923 (0.647 - 1.317)
Model D	
White	1 [Reference]
Black	0.956 (0.742 - 1.231)
Hispanic	0.962 (0.675 - 1.371)



The timely diagnosis of dementia, OR (95% CI)

** p<0.01, * p<0.05, † 0<0.1

Model A: Adjusted for IOM-defined covariates
Model B: Adjusted for IOM-defined covariates + individual-level socioeconomic status
Model C: Adjusted for IOM-defined covariates + individual-level socioeconomic status + neighborhood-level socioeconomic factors
Model D: Adjusted for IOM-defined covariates + individual-level socioeconomic status + neighborhood-level socioeconomic factors + health care access factors

Notes: Estimates are from sensitivity analyses restricting the Health and Retirement Study (HRS) sample to 2000-2016. Weighted numbers reflect the estimated number of U.S. older adults represented by the HRS participants after applying survey weights.

[*] Panel A presents both unadjusted and adjusted proportions of individuals receiving a timely dementia diagnosis in the overall population and by race and ethnicity. Adjusted proportions were estimated using predictive margins from Model A.

[†] Panel B presents the adjusted association between race and ethnicity and timely dementia diagnosis from multivariable logistic regression models, sequentially adjusting for additional variables from model A through model D. IOM-defined covariates included unmodifiable demographics and health conditions, as described in the *Covariates* section. Individual-level socioeconomic status, neighborhood-level socioeconomic factors, and health care access factors are described in the *Potential Mediators* section.

Table S11: Sample Characteristics by Race and Ethnicity, Excluding Dual-Eligible Beneficiaries

Characteristic	Patients, No (%)		
	Non-Hispanic White	Non-Hispanic Black	Hispanic
All observations, No.	2,032 (84.9)	268 (11.2)	56 (2.3)
Timely diagnosis*	1,102 (54.2)	133 (49.6)	24 (42.9)
Individual level			
Age, mean (SD)	83.9 (7.5)	80.8 (8.1)	78.3 (9.3)
Male	766 (37.7)	121 (45.1)	27 (48.2)
High school educational attainment or higher	1,426 (70.2)	133 (49.6)	21 (37.5)
Ratio of family income to poverty threshold			
Less than 1	144 (7.1)	51 (19.0)	17 (30.4)
Between 1 and 4	1,284 (63.2)	164 (61.2)	28 (50.0)
Greater than or equal to 4	604 (29.7)	53 (19.8)	11 (19.6)
Number of Chronic Conditions†, mean (SD)	2.274 (1.414)	2.489 (1.505)	2.482 (1.501)
Number of activities of daily living (ADL), mean (SD)	1.782 (2.079)	1.735 (2.092)	1.804 (2.178)
Number of instrumental activities of daily living (IADL), mean (SD)	2.077 (1.831)	2.037 (1.832)	2.018 (1.773)
Predicted latent cognition, mean (SD)	-0.447 (0.508)	-0.499 (0.539)	-0.412 (0.583)
Was seen by a dementia specialist‡	767 (37.7)	99 (36.9)	22 (39.3)
Neighborhood level§			
Density of physician offices/clinics			
Low density (deciles 1-2)	591 (29.1)	112 (41.8)	22 (39.3)
Density of health practitioner offices/clinics			
Low density (deciles 1-2)	608 (29.9)	163 (60.8)	31 (55.4)
Neighborhood disadvantage			
Most disadvantage (deciles 8-10)	273 (13.4)	179 (66.8)	21 (37.5)
Neighborhood affluence			
Least affluent (deciles 1-2)	212 (10.4)	117 (43.7)	15 (26.8)

* Timely diagnosis was defined as the presence of a clinical diagnosis of dementia, identified by an ICD-9-CM or ICD-10-CM code in Medicare claims, recorded up to 3 years prior to or 1 year following the HRS interview at which dementia was first observed.
† Details on chronic conditions are provided in Supplementary Table S3.
‡ Dementia specialties included neurology, psychiatry, neuropsychiatry, geriatrics, and geriatric psychiatry.
§ To comply with Medicare data use agreements regarding minimum cell sizes, certain age and neighborhood-level subcategories could not be reported separately in this restricted sample.

Methods S1: Replication of Predicted Cognition and Dementia Measures and Application to 1998-2020

We replicated the methodology developed by Hudomiet et al. for creating predicted cognition and dementia measures, closely following their statistical approach and implementing their replication package[2]. This allowed us to extend these measures to 1998-2020, as the original study only covered 2000-2016.

The algorithm incorporated participants' performance on seven aggregated HRS cognitive measures into its prediction model for cognition. These measures included subjective limitations (the sum of self-rated memory, instrumental activities of daily living [IADLs], and self-rated health), immediate and delayed word recall, serial 7 subtraction, a mental status composite (backward counting, date naming, naming the president, cactus, and scissors), interviewer-rated cognitive limitations, and proxy-reported cognitive problems (e.g., getting lost, wandering, inability to be left alone, or seeing or hearing things).

These composite measures entered a longitudinal latent-variable model in which observed cognitive test performance is modeled as a function of an unobserved, person-wave–specific latent cognition that evolves with observed covariates and person-specific random effects. The clinical diagnosis of dementia in the Aging, Demographics and Memory Study (ADAMS) sample is used to calibrate the HRS cognitive tests to measure dementia. In ADAMS, a subsample of HRS respondents underwent a 3- to 4-hour in-home clinical assessment for dementia, and the final diagnosis was determined by an expert panel. The model was estimated using the Markov Chain Monte Carlo method using 2,000,000 simulation draws, and the first 10% burn-in draws were discarded.

After estimation, dementia classification for each person-wave observation was determined based on the latent cognition scale. Individuals were classified as having dementia if latent cognition fell below 0, cognitively impaired but not demented (CIND) if latent cognition was between 0 and 1, and cognitively normal if latent cognition exceeded 1. These cutoff values are normalizations within the latent cognition scale. The data and methodological details are described in their original paper, *Trends in inequalities in the prevalence of dementia in the United States.* (Hudomiet et al., 2022)[3].

All variables required for replication were available from 1998 to 2020, except for interviewers' assessments of cognitive limitations in proxy interviews, which were not collected in 1998. To address this, we used the 2000 assessment as a proxy measure for 1998. In addition, beginning in 2018, the HRS introduced web-based cognitive interviews, with 2016 respondents randomly assigned to phone or web-based modes. Some cognitive measures collected through web interviews differed in implementation, measurement, or elicitation. This change in data collection methods may have introduced bias in dementia prevalence estimates for 2018 and 2020. As a sensitivity analysis, we restricted the sample to 2000-2016, when the original measures were fully available, and repeated our primary analysis.

Regardless of the potential interview mode effects described above, the age-adjusted dementia prevalence shows a consistent declining trend between 1998 and 2020, a pattern consistent with

prior studies documenting declining dementia incidence and prevalence[4-6]. Birth cohort effects may play a role, as earlier cohorts experienced major social and economic disruptions that may have increased dementia risk[4]. Reductions in smoking, improved access to education, advances in nutrition, and better management of cardiovascular risk factors have been associated with lower dementia prevalence in more recent cohorts[5-8].

Below, we present our re-created dementia prevalence estimates in comparison with the originally released estimates for the comparable years 2000–2016. Overall, our re-created estimates closely tracked the original estimates.

Age-adjusted prevalence of dementia from 1998 to 2020 for total population, Age 65+

	Estimates by Hudomiet et al.		Re-created Estimates	
	Mean	95% CI	Mean	95% CI
1998	NA	NA	0.100	0.1 [0.094, 0.105]
2000	0.122	[0.117, 0.127]	0.117	0.117 [0.112, 0.122]
2002	0.109	[0.104, 0.114]	0.106	0.106 [0.101, 0.111]
2004	0.102	[0.097, 0.106]	0.101	0.101 [0.096, 0.106]
2006	0.098	[0.093, 0.103]	0.098	0.098 [0.093, 0.103]
2008	0.095	[0.09, 0.1]	0.094	0.094 [0.09, 0.099]
2010	0.093	[0.087, 0.098]	0.091	0.091 [0.086, 0.096]
2012	0.091	[0.086, 0.096]	0.089	0.089 [0.083, 0.094]
2014	0.087	[0.082, 0.093]	0.086	0.086 [0.08, 0.091]
2016	0.085	[0.079, 0.091]	0.084	0.084 [0.078, 0.089]
2018	NA	NA	0.077	0.077 [0.072, 0.082]
2020	NA	NA	0.070	0.07 [0.065, 0.075]

* Sample: Health and Retirement Study, Age 65+. The estimates by Hudomiet et al. (2000–2016) included 97,629 person-year observations; the replicated estimates (1998-2020) included 126,428 person-year observations.

Methods S2: Additional Details on Mediation Analysis

To quantify the relative contributions of individual- and neighborhood-level factors in explaining the racial and ethnic disparities observed in Model A, we constructed a series of mediation models. The mediation was conducted using a model-based approach proposed by Imai et al[9].

First, we fit a mediator model in which each potential mediator was regressed on race and ethnicity and covariates, including unmodifiable demographics and health conditions. Each mediator was modeled separately. We then fit an outcome model for receipt of a timely dementia diagnosis, with explanatory variables including the mediator, race and ethnicity, and the same covariates as those used in the mediator model. Logistic regression was used for both the mediator and outcome models. Race and ethnicity was modeled as two separate binary indicators: one comparing non-Hispanic White with non-Hispanic Black individuals, and the other comparing non-Hispanic White with Hispanic individuals, each analyzed in a separate mediation model.

When comparing non-Hispanic Black and non-Hispanic White individuals, we first generated two sets of predicted mediator values for each observation from the mediator model: one under the condition of being non-Hispanic Black and one under the condition of being non-Hispanic White. In the outcome model, we then generated two sets of outcome predictions for each observation from fixing race and ethnicity: first using the mediator value predicted under the non-Hispanic Black condition, and second using the mediator value predicted under the non-Hispanic White condition. The indirect effect was calculated as the average difference across observations between these two outcome predictions. The same approach was applied when comparing Hispanic and non-Hispanic White individuals.

Confidence intervals were calculated using heteroskedasticity-consistent standard errors. The proportion mediated by each mediator was then computed as the percentage of the total effect (i.e., the overall association between race and ethnicity and timely dementia diagnosis, adjusted for the covariates) explained by the corresponding indirect effect. All mediation analyses were implemented in R using the mediation package[10].

The identification assumption for the causal mediation analysis is sequential ignorability, which requires (1) that exposure is statistically independent of potential outcomes and potential mediators, conditional on a set of baseline covariates gathered before the exposure; and (2) that there are no unmeasured variables that confound the relationship between the mediator and the outcome. These are strong assumptions and might not be strictly met in the observational study, where exposure is not randomized, and unobserved mediator-outcome confounders may exist. Thus, we do not pursue a strong causal interpretation of our results and keep the interpretation associational.

References S1

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