# How Do Health Care Use, Spending, and Patient Outcomes Respond to a Timely Dementia Diagnosis? Evidence from HRS-Medicare Linked Data

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**KEY POINTS**

**Question:** What is the association of health care use, spending, and patient outcomes with receiving a timely dementia diagnosis among older adults living with dementia?

**Findings:** In this cohort study of 1,554 Medicare beneficiaries (7,661 person-waves) with dementia, receiving a timely diagnosis was associated with lower mortality, increased formal care receipt, greater use of home health and nursing home care, and informed decision-making in health plan enrollment. The changes in care use were accompanied by higher Medicare spending. However, no significant differences were observed in several aspects of outpatient disease management, including ACS admissions, physician visits, or preventive care.

**Meaning:** These findings suggest that while timely dementia diagnosis could enhance care planning and improve certain patient outcomes, policies are needed to improve disease management and care quality post-diagnosis while addressing health care system demands.

**ABSTRACT**

Early detection of dementia can be critical to the quality of care and life for millions of older adults. However, limited evidence exists on the impact of receiving a timely diagnosis. This study fills the gap in our understanding of how health care use, spending, and patient outcomes for people living with dementia may respond to a timely dementia diagnosis, in comparison to those who remained undiagnosed. We implement a difference-in-differences approach to U.S. adults aged 65 and older with incident dementia in the Health and Retirement Study, linked to Medicare claims from 1998 to 2020. We find that individuals diagnosed at dementia onset had 7.0 percentage points (95% CI, -13.0 to -2.0) lower mortality, 22.0 percentage points (95% CI, 13.0-30.0) greater formal care receipt, and 11.0 percentage points (95% CI, -18.0 to -4.0) lower Medicare Advantage (MA) enrollment, compared with those who remained undiagnosed. They also had greater use of skilled nursing facility care (17.0 percentage points [95% CI, 10.0-24.0]) and home health care (17.0 percentage points [95% CI, 11.0-22.0]) and 74.0% (95% CI, 21.9%-148.4%) higher Medicare spending after dementia onset. No significant association is found between timely diagnosis and depressive symptoms, ambulatory care-sensitive admissions for chronic conditions, or preventive care use. The initial increase in problem-based evaluation and management visits also diminished over time (2.0 percentage points [95% CI, -4.0 to 9.0]). These results suggest that receiving a timely diagnosis may generate meaningful improvements in some key patient outcomes, which provides insights into recent policy initiatives aimed at improving early dementia detection. However, it may also place strains on the health care system, highlighting the need for capacity building to meet growing care demands.

## Introduction

Over 6 million older adults in the U.S. live with Alzheimer's disease or related dementias (ADRD), with a prevalence of about 11% that increases with age[1]. The progression of ADRD results in not only memory issues but also physical disabilities and medical complications, such as pneumonia and cardiovascular disease[2, 3], ultimately leading to death. Dementia imposes significant burdens on families and society, including increased healthcare needs and economic strain. 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]. However, families and physicians often do not detect the condition until later in the course of the disease, with up to 60% of cases going undiagnosed in U.S. primary care settings[5].

Although the potential benefits of an early dementia diagnosis have been widely advocated, prior evidence on dementia diagnosis has found mixed results on its impact[6-15]. Some studies have reported elevated anxiety, increased depression, and diminished quality of life following an early diagnosis[6-9, 16], whereas others have demonstrated no such association or even improvements in these domains[10-13]. However, most of the existing studies did not distinguish the effect of receiving a dementia diagnosis from that of the disease itself or account for the timing of the diagnosis, which may in part explain the lack of consensus in the findings. Only a few recent studies, to our knowledge, have explored this distinction. One study compared spending associated with a new ADRD diagnosis to spending changes around the initial detection of cognitive impairment but did not evaluate patient outcomes[15]. Another study used multivariable-adjusted models to compare hospitalization outcomes by dementia diagnosis status among

persons with dementia but did not account for diagnosis timing[17]. To date, there has been scant evidence to examine the impact of receiving a timely diagnosis on broad health care utilization, decision-making, and overall patient outcomes for individuals living with dementia.

Addressing this evidence gap is particularly important in the context of recent policy changes aimed at improving cognitive assessments and dementia detection. Specifically, the Centers for Medicare and Medicaid Services (CMS) introduced new codes in 2017 to reimburse cognitive assessment and care planning services for Medicare beneficiaries[18], along with two new dementia condition categories in its risk-adjustment models for 2020 Medicare Advantage (MA) plan payments[19]. In addition, the recent FDA approval of a new class of disease-modifying treatments for early-stage Alzheimer's disease further emphasizes the necessity of early diagnosis to facilitate timely intervention.

To assess the impact of receiving a timely dementia diagnosis on broad outcomes, including care use, health outcomes, and spending, we leveraged the timing of dementia symptom onset and diagnosis using Health and Retirement Study–Medicare linked claims data to analyze changes in outcomes before versus after diagnosis at dementia onset, compared with similar changes among dementia patients who remain undiagnosed. Our findings provide the first evidence quantifying the impacts of receiving a timely dementia diagnosis and build on existing work in literature that evaluates the impact of diagnoses and subsequent care on health[20-22].

## Methods

### *Data Source and Study Population*

This study used data from the Health and Retirement Study (HRS) linked with Medicare claims. The HRS is a nationally representative biennial survey of older adults in the U.S. that collects detailed information on demographics, socioeconomic status, and cognitive and physical functioning. By linking HRS data with Medicare claims, we could track both cognitive status and the timing of diagnoses over time. We included HRS respondents from 1998 to 2020 who had incident dementia, consented to Medicare records linkage, and were enrolled in Medicare during the study period. We then limited the study sample to individuals who received their initial dementia diagnosis at the HRS interview when dementia was first observed (i.e., dementia onset), as well as those who remained undiagnosed. The primary analysis included data for up to 6 years prior to and following the year of dementia onset (**eFigure 1** presents a flowchart of the sample selection process). The institutional review board of Yale University reviewed and approved this study.

*Identification of Dementia Onset and Diagnosis*

We assigned dementia status to all person-wave observations using the predicted cognition and dementia measures developed by Hudomiet et al[23]., a validated algorithm that improves classification precision by leveraging the longitudinal dimension of HRS data[23, 24]. Dementia was defined as a latent cognitive function score below 0 for HRS respondents aged 65 years or older. Hudomiet et al.'s measures are available for the years 2000-2016. In our study, we replicated their algorithms to extend the measures to additional years (1998, 2018-2020) and supplemented the original measures with replicated estimates[25]. Our replicated estimates closely align with the original measures. A detailed description of the algorithm, replication methods, and comparisons are provided in the Online Supplement (**eMethods 1** in the Supplement).

The study's main exposure was the receipt of a timely dementia diagnosis, defined as having the initial dementia diagnosis recorded in Medicare claims during the HRS survey wave when dementia was first observed. Respondents who remained undiagnosed throughout the study period were included in the control group. The diagnoses of dementia were determined based on the *International Classification of Diseases, Ninth or Tenth Revision, Clinical Modification* diagnosis codes widely used in prior studies[26-28] (**eTable 1** in the Supplement). We used data from all available claim types, including carrier, durable medical equipment, home health agency, hospice, inpatient, outpatient, and skilled nursing facility. To ensure that we could observe the period immediately preceding dementia onset, we required that each respondent show no indication of dementia in the survey wave prior to the onset wave.

*Outcome Measures*

To provide broad implications of timely dementia diagnosis and to explore the potential mechanisms through which diagnosis may affect patient outcomes, we examined several measures of health outcomes (mortality and depressive symptoms), care receipt (informal and formal care receipt), health care utilization (MA enrollment, use of home health care and skilled nursing facility, ambulatory care-sensitive admissions, evaluation and management visits, and influenza vaccination), and costs of care (total spending and beneficiary spending).

Mortality was assessed using the Medicare Beneficiary Summary File (MBSF). Depressive symptoms were measured using the modified eight-item Center for Epidemiologic Studies Depression Scale (CES-D) available among HRS self-respondents, with a cut-off of three or

more indicating the presence of depression. Care receipt outcomes included receiving any informal or formal assistance with activities of daily living (ADLs) or instrumental activities of daily living (IADLs) among respondents experiencing difficulties in ADLs or IADLs.

MA enrollment was determined from MBSF, which captures individuals' decisions regarding enrollment in traditional Medicare versus an MA plan. Home health care and SNF care were defined as separate binary indicators based on the presence of at least one Medicare-reimbursed episode recorded in Medicare Part A claims. To assess care management and quality, we generated three additional health care use indicators related to clinical outcome and process measures. These included an indicator for ambulatory care–sensitive admissions for chronic conditions (chronic conditions ACS admissions)[29], identified using a validated algorithm defined by the Agency for Healthcare Research and Quality (AHRQ), as these admissions are potentially preventable with good outpatient care. We also examined the use of problem-based evaluation and management visits and receipt of influenza vaccinations (the CPT and Healthcare Common Procedure Coding System codes are listed in **eTable 2** in the Supplement)[30, 31].

Finally, we measured the cost of care using total allowed charges and beneficiaries' out-of-pocket costs from Medicare Parts A and B claims. These cost measures were inflation-adjusted to 2010 dollars, winsorized at the top and bottom 1%, and transformed using the inverse hyperbolic sine function. All outcomes were assessed over the two-year period between the last HRS interview and the current interview for each patient at each survey wave. SNF and home health care use at dementia onset were measured after the initial diagnosis, with prior use included as covariates (described below).

*Covariates*

We constructed individual-level covariate indicators reflecting patient demographic and socioeconomic characteristics, health status, and health care utilization. Specifically, demographic and socioeconomic variables included age, gender, race and ethnicity (non-Hispanic White vs other), education (above vs. below high school), partner status, and family income (below vs above the poverty threshold). For health status, we included the number of ADL and IADL limitations, as well as indicators for chronic conditions (stroke, cancer) that differed significantly at dementia onset between individuals who received a timely diagnosis and those in the control group. Health care utilization variables were derived from Medicare claims and included any hospitalization, emergency department (ED) visits, home health care use, and SNF stays. These variables were measured during the survey wave of dementia onset, before the initial diagnosis, to avoid the potential for incorporating post-treatment covariates, as they could be affected by the diagnosis.

All covariates were measured during the survey wave of dementia onset to better account for confounders affecting the probability of receiving a diagnosis at dementia onset and the outcomes of interest. Patients with missing characteristics were excluded.

*Statistical Analysis*

We first compared the characteristics of individuals who received a timely dementia diagnosis and those who remained undiagnosed in the survey wave before and at dementia onset. We then visualized unadjusted outcome trends by event time (years relative to dementia onset) and used a

nonparametric event study approach to compare outcome patterns between the two groups using a matched sample. In the nonparametric event study analysis, we first applied propensity score reweighting to the control group (undiagnosed individuals) to match on the covariates described above. We then estimated outcomes as a function of time relative to the survey wave preceding dementia onset separately for individuals who received a diagnosis at onset and their matched undiagnosed counterparts (see **eMethods 2** in the Supplement for more details on the propensity score reweighting and nonparametric event study approach).

To examine the association between timely dementia diagnosis and patient outcomes, we conducted a difference-in-differences (DiD) analysis using an adapted DiD design developed by Callaway and Sant'Anna[32]. This estimator extends the strict parallel trends assumption in traditional DiD methods to include covariates, allowing the parallel trend assumption to hold potentially only after conditioning on observed covariates. We employed this method to estimate the mean differential change in the outcome for individuals who received a diagnosis at dementia onset relative to those who remained undiagnosed, relative to the survey wave immediately preceding dementia onset. All covariates described in the *Covariates* section above were included in the model. Further details, including the estimation equation, are provided in **eMethods 3** in the Supplement.

The key assumption of the Callaway and Sant'Anna DiD estimator is that patients who received a timely dementia diagnosis and those who remained undiagnosed would have followed similar outcome trends in the absence of a diagnosis after conditioning on observed covariates. This

assumption cannot be directly tested, but potential violations can be assessed by examining the DiD event study estimates for the pre-dementia onset years.

*Sensitivity Analyses*

We conducted additional analyses to provide supporting evidence and assess the robustness of our findings. First, we repeated our analysis of patient mortality outcomes stratified by ED visit status to identify population subgroups driving the observed mortality results. We further examined the association between timely diagnosis and in-hospital or 30-day mortality following ED visits and explored the sites of death for individuals with a timely dementia diagnosis versus those who remained undiagnosed. Second, to address potential bias due to attrition, we reestimated the main analysis on a balanced panel of individuals whom we observed in all years from -4 to 2 relative to dementia onset. This specification allowed us to examine outcome trends over time without concerns about compositional changes. Attrition is mechanically zero in the survey wave at dementia onset since one must survive to be observed for dementia. Finally, we repeated the main analysis excluding MA beneficiaries, as claims data do not fully capture diagnosis and care utilization across all study years for MA enrollees (available only from 2015 to 2019). Statistical analyses were performed using R software, version 4.0.3 (R Foundation for Statistical Computing). The statistical significance threshold was 2-tailed $P < .05$.

**Results**

*Study Sample*

Our study sample included 7,661 person-waves from 1,554 individuals living with dementia, consisting of 3,672 person-waves from 843 individuals who received a timely diagnosis and 3,989 person-waves from 711 individuals who remained undiagnosed during the study period. These individuals accounted for nearly half (45.6%) of all individuals with dementia in the study cohort, with 20.8% receiving a timely diagnosis and 24.8% remaining undiagnosed (**eFigure 2**).

Compared with the wave preceding dementia onset, individuals diagnosed at onset had poorer overall health and greater health care utilization at the onset wave than those who remained undiagnosed (**Table 1**). For instance, before dementia onset, diagnosed individuals had fewer ADL limitations (0.80 vs. 1.11, $P<.001$) and similar hospitalization rates (35.3% vs. 33.5%, $P=.45$) compared with undiagnosed individuals. However, at dementia onset, diagnosed individuals had more ADL limitations (2.35 vs. 1.94, $P<.001$) and a higher hospitalization rate (50.1% vs. 24.4%, $P<.001$). Additionally, diagnosed individuals were less likely to be male (35.0% vs. 43.5%, $P<.001$), have a partner (31.9% vs. 38.3%, $P=0.009$), and live below the poverty threshold (14.9% vs. 18.3%, $P=.074$), but were more likely to have at least a high school education (62.6% vs. 56.7%, $P=.019$).

*Changes in Health Outcomes After Timely Dementia Diagnosis*

In the first two years after dementia onset, mortality was significantly lower among individuals diagnosed at onset compared with those who remained undiagnosed (**Figure 1,** Panel A). However, this difference became less pronounced over time (i.e., four to six years post-dementia onset), with timely diagnosis associated with a 7-percentage point reduction in mortality after dementia onset (95% CI, -13.0 to -2.0) (**Table 2**). There was no significant change in the

probability of having depressive symptoms after dementia onset among those receiving a diagnosis at onset compared with those who remained undiagnosed (mean treatment effect, 0 percentage points [95% CI, -10.0 to 10.0]) (**Figure 1**, Panel B; **Table 2**).

Additionally, in-hospital and 30-day mortality following an ED visit significantly decreased among individuals diagnosed at dementia onset compared with those who remained undiagnosed across all post-dementia onset periods (**Figure 5**, Panel A), with an overall reduction of 11.0 percentage points (95% CI, -17.0 to -6.0) (**Table 2**). A similar pattern was observed for overall mortality among those with ED visits, which decreased by 14.0 percentage points (95% CI, -19.0 to -9.0). In contrast, no significant differential change in mortality was found among those without an ED visit (-2.0 [95% CI, -9.0 to 5.0] percentage points). Results from additional analyses also showed that individuals who received a timely diagnosis were more likely to die while receiving hospice services (54.5% vs. 41.1%) and less likely to die in an acute care hospital (15.7% vs. 25.4%) compared with undiagnosed individuals (**eTable 4**).

*Changes in Patterns of Care Receipt After Timely Dementia Diagnosis*

There was a statistically significant and large increase in the probability of receiving formal care among individuals diagnosed at dementia onset compared with those who remained undiagnosed after dementia onset (22 percentage points increase [95% CI, 13.0 to 30.0]). However, no significant association was found between receiving a timely dementia diagnosis and the probability of receiving informal care after dementia onset (7 percentage point increase [95% CI, -2.0 to 16.0]) (**Figure 2, Table 2**).

*Changes in Health Care Use and Spending After Timely Dementia Diagnosis*

The probability of enrolling in an MA plan significantly declined in all years post-dementia onset among those receiving a diagnosis at onset compared with individuals who remained undiagnosed (**Figure 3**, Panel A), with an aggregated DiD estimate showing an 11.0 percentage point decrease in MA enrollment associated with a timely diagnosis (95% CI, -18.0 to -4.0) (**Table 2**). In addition, a significant increase in the use of home health care and SNF care was observed in all years after receiving a diagnosis at dementia onset (**Figure 3**, Panels B and C), with timely diagnosis associated with a 17.0 percentage point increase in the probability of using home health care (95% CI, 10.0 to 24.0) and a 17.0 percentage point increase in the probability of using SNF care (95% CI, 11.0 to 22.0) (**Table 2**).

No significant association was found between timely dementia diagnosis and the probability of having chronic conditions ACS admissions (mean treatment effect, 2.0 [95% CI, -3.0 to 7.0] percentage points) or receiving an influenza vaccination (mean treatment effect, 7.0 [95% CI, -1.0 to 15.0] percentage points) (**Figure 3**, Panels D and F). In the year of dementia onset, the probability of having problem-based evaluation and management visits increased among those who received a diagnosis compared with those who remained undiagnosed. However, this effect gradually diminished over time (**Figure 3**, Panel E), and the aggregated DiD estimate was not significant (mean treatment effect, 2.0 [95% CI, -4.0 to 9.0] percentage points) (**Table 2**).

Changes in health care use corresponded to an increase in Medicare spending, with timely dementia diagnosis associated with a 74% increase in total Medicare spending (95% CI, 21.9% to 148.4%) and a 59.6% increase in beneficiary spending (95% CI, 19.9% to 112.3%) after

dementia onset (**Table 2**). This increase in Medicare spending was observed across all years post-dementia onset (**Figure 4**).

*Robustness and Sensitivity Analysis*

Unadjusted trends in outcomes and adjusted estimates from the nonparametric event study analysis reflected the same pattern of results as the DiD estimates (**eFigures 3-7** in the Supplement). There was no evidence of differential trends in outcomes before dementia onset, except for influenza vaccination. The results of the sensitivity analyses using the sample restricted to the balanced panel or fee-for-service (FFS) beneficiaries were consistent with the main findings (**Table 2**).

## Discussion

By leveraging the timing of dementia symptom onset and receipt of a diagnosis in a covariate-adjusted difference-in-differences analysis, this study provides important counterfactual evidence on the association between receiving a timely dementia diagnosis and broad aspects of patient outcomes, care use, and costs after dementia onset. Among older adults who received a diagnosis at dementia onset, we found lower mortality, increased receipt of formal care, decreased enrollment in MA, greater use of post-acute care (i.e., SNF care) and long-term care (i.e., home health care), and higher Medicare spending after dementia onset compared with those who had similar health conditions, sociodemographic characteristics, and care use at dementia onset but remained undiagnosed during the follow-up period. However, no significant association was found between timely diagnosis and the probability of having ACS admissions for chronic conditions or receiving preventive care services, including influenza vaccination, and the initial

increase in problem-based evaluation and management visits diminished over time. Additionally, we found no significant changes in depressive symptoms associated with timely diagnosis.

Our subgroup analysis on mortality suggests that the reduced mortality risk associated with timely dementia diagnosis was primarily driven by individuals with ED visits and those in acute care settings. Several factors may explain this pattern. A documented dementia diagnosis may play a critical role in shaping care pathways during acute episodes, guiding clinical decision-making, care transitions, and medical interventions. Individuals with ED visits are likely more medically and functionally vulnerable, making the ED a crucial setting where a timely dementia diagnosis can be particularly meaningful. Recognition of dementia among these high-risk patients may also facilitate access to supportive services, including formal caregiving, post-acute care, and long-term care, which may be associated with improved survival.

Our findings on the lack of association between timely diagnosis and ACS admissions for chronic conditions, physician office visits, and preventive care may suggest limited patient engagement in disease management following diagnosis. This may also reflect structural barriers in health care delivery, such as fragmented care coordination across providers and the lack of integrated chronic disease management within dementia care. Without a structured, multidisciplinary approach to dementia care, the benefits of timely diagnosis may not be fully realized in improving care quality for individuals living with dementia.

In addition, the observed enrollment transition from MA to FFS after a dementia diagnosis suggests that timely diagnosis may support informed decision-making, enabling patients to select

a health plan that better aligns with their care needs. This finding is particularly relevant in the context of the Centers for Medicare & Medicaid Services' newly launched Guiding an Improved Dementia Experience (GUIDE) model, an alternative payment model aimed at improving comprehensive dementia care for FFS beneficiaries[33]. Given the potential benefits of timely diagnosis on care planning and access to appropriate services, ensuring early detection of dementia is critical to improving outcomes and supporting the needs of individuals living with dementia. However, widespread early detection may also place a substantial strain on the health care system due to increased use of health services and higher Medicare spending associated with timely diagnosis. These challenges highlight the need for strategies to ensure that the health care system is equipped to meet the increasing demand for comprehensive dementia care and support services following a timely diagnosis.[34]

*Limitations*

Interpretation of our findings is subject to several limitations. First, although we used a rigorous study design to construct comparable groups and demonstrated robustness across multiple sensitivity analyses, we cannot definitively rule out the possibility that the estimated associations could be explained by unobserved confounding. Second, the findings may not be generalizable to other insured populations besides individuals insured by Medicare. Third, the MA enrollment outcome is not applicable to the robustness analysis restricted to FFS beneficiaries. Incomplete claims data for MA enrollees may have led to some misclassification in the undiagnosed control group. However, this bias is likely small, as MA beneficiaries accounted for about 30% of the sample, and their claims are fully captured from 2015 to 2019, as well as for hospice care and select MA plans for which CMS processes provider claims. Fourth, this study focused on the

impact of timely dementia diagnosis (i.e., diagnosis at the time of dementia onset), and thus, the results may not be generalizable to individuals diagnosed at other stages, including those diagnosed before symptom onset or at later stages of disease progression.

## Conclusion

Among older adults living with dementia, receiving a timely diagnosis was associated with meaningful improvements in certain patient outcomes, including lower mortality, increased formal care receipt, improved access to post-acute and long-term care, and informed decision-making. However, no significant changes were observed in several aspects of outpatient disease management, including ACS admissions, physician visits, or preventive care. The observed benefits were also accompanied by higher Medicare spending. These findings suggest that while timely diagnosis may facilitate care planning and improve patient outcomes, it may also place a potential strain on the health care system, underscoring the need for policies that support dementia care post-diagnosis and ensure the system can meet growing care demands.

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**Table 1. Characteristics of Older Adults with Probable Dementia Before and at Dementia Onset**

| Characteristic | No. (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Before dementia onset[a] | | | At dementia onset[b] | | | |
| | Diagnosed at dementia onset[c] (n=711) | Undiagnosed[d] (n=842) | *P* value | Diagnosed at dementia onset (n=711) | Undiagnosed (n=841) | *P* value | Full dementia sample (n=7,661) |
| **Demographic and Socioeconomic Status** | | | | | | | |
| Age, y.o. | | | | | | | |
| 65-74 | 114 (16.0) | 183 (21.7) | 0.016 | 76 (10.7) | 112 (13.3) | 0.072 | 1,324 (17.3) |
| 75-84 | 326 (45.9) | 352 (41.8) | | 285 (40.1) | 360 (42.8) | | 3,249 (42.4) |
| >=85 | 271 (38.1) | 307 (36.5) | | 350 (49.2) | 369 (43.9) | | 3,088 (40.3) |
| Male | 249 (35.0) | 367 (43.6) | <0.001 | 249 (35.0) | 366 (43.5) | <0.001 | 3,002 (39.2) |
| Race and ethnicity | | | | | | | |
| Non-Hispanic White | 542 (76.2) | 580 (68.9) | <0.001 | 542 (76.2) | 580 (69.0) | <0.001 | 5,512 (71.9) |
| Non-Hispanic Black | 107 (15.0) | 132 (15.7) | | 107 (15.0) | 132 (15.7) | | 1,189 (15.5) |
| Hispanic | 54 (7.6) | 104 (12.4) | | 54 (7.6) | 104 (12.4) | | 798 (10.4) |
| High school and above | 445 (62.6) | 478 (56.8) | 0.020 | 445 (62.6) | 477 (56.7) | 0.019 | 4,559 (59.5) |
| With partner | 291 (40.9) | 367 (43.6) | 0.29 | 227 (31.9) | 322 (38.3) | 0.009 | 2,958 (38.6) |
| Below poverty thresholds | 103 (14.5) | 127 (15.1) | 0.74 | 106 (14.9) | 154 (18.3) | 0.074 | 1,055 (15.5) |
| **Health Status[e]** | | | | | | | |
| Number of ADL difficulties | 0.80 (1.40) | 1.11 (1.59) | <0.001 | 2.35 (2.30) | 1.94 (2.07) | <0.001 | 1.460 (1.963) |
| Number of IADL difficulties | 0.67 (1.08) | 0.96 (1.27) | <0.001 | 2.64 (1.88) | 1.88 (1.65) | <0.001 | 1.452 (1.751) |
| Hypertension | 466 (65.9) | 553 (66.1) | 0.95 | 529 (74.4) | 595 (70.7) | 0.11 | 4,777 (68.3) |
| Diabetes | 198 (27.8) | 288 (34.2) | 0.007 | 231 (32.5) | 309 (36.7) | 0.083 | 2,283 (32.6) |
| Lung disease | 121 (17.0) | 189 (22.5) | 0.008 | 166 (23.4) | 232 (27.7) | 0.055 | 1,542 (22.4) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Stroke | 70 (9.8) | 106 (12.6) | 0.088 | 163 (22.9) | 158 (18.8) | 0.045 | 960 (13.7) |
| Heart disease | 319 (44.9) | 415 (49.5) | 0.071 | 420 (59.1) | 461 (54.8) | 0.092 | 3,493 (49.8) |
| Rheumatoid arthritis | 350 (49.3) | 450 (53.6) | 0.089 | 384 (54.0) | 442 (52.6) | 0.57 | 3,573 (51.2) |
| Cancer | 89 (12.5) | 132 (15.7) | 0.073 | 90 (12.7) | 148 (17.6) | 0.007 | 967 (13.8) |
| **Health Care Utilization[f]** | | | | | | | |
| Any hospitalization | 251 (35.3) | 282 (33.5) | 0.45 | 356 (50.1) | 205 (24.4) | <0.001 | 3,070 (40.1) |
| Any ED visit | 357 (50.2) | 350 (41.6) | <0.001 | 581 (81.7) | 429 (51.0) | <0.001 | 3,874 (50.6) |
| Any home health care | 129 (18.1) | 147 (17.5) | 0.73 | 344 (48.4) | 216 (25.7) | <0.001 | 1,718 (22.4) |
| Any SNF episode | 61 (8.6) | 60 (7.1) | 0.29 | 274 (38.5) | 134 (15.9) | <0.001 | 1,118 (14.6) |

Abbreviations: ADL, activities of daily living; IADL, instrumental ADL; ED, emergency department; SNF, skilled nursing facility.

[a] Before dementia onset refers to the survey wave immediately preceding the wave when dementia was first observed.

[b] At dementia onset refers to the survey wave when dementia was first observed.

[c] Individuals diagnosed at dementia onset included those who received their initial dementia diagnosis during the survey wave when dementia was first observed.

[d] Undiagnosed individuals included those who did not receive a dementia diagnosis at any point during the study period.

[e] Chronic condition variables were obtained from the Chronic Condition Warehouse (CCW). Conditions were categorized in alignment with the Health and Retirement Study (HRS) survey and included seven categories: high blood pressure, diabetes, cancer, lung disease, heart disease, stroke, and arthritis. HRS self-reported doctor diagnoses were used to supplement any conditions missing in the CCW.

[f] Health care utilization variables were derived from Medicare claims data.

**Table 2. Changes in Health, Care Utilization, and Spending Associated with Timely Dementia Diagnosis Among Older Adults with Probable Dementia**

| | Adjusted difference-in-differences estimates (95% CI) | | |
|---|---|---|---|
| **Outcome** | **(1) [Baseline][a]** | **(2) Balanced Panel[b]** | **(3) Excluding MA Beneficiaries[c]** |
| ***Panel A. Health Outcomes*** | | | |
| Mortality | -0.07 (-0.13, -0.02)*** | NA | -0.09 (-0.14, -0.04)*** |
| In-hospital or 30-day mortality following ED visits[d] | -0.11 (-0.17, -0.06)*** | NA | -0.13 (-0.19, -0.07)*** |
| Mortality among those with ED visits[d] | -0.14 (-0.19, -0.09)*** | NA | -0.16 (-0.21, -0.1)*** |
| Mortality among those without ED visits[d] | -0.02 (-0.09, 0.05) | NA | 0.04 (-0.03, 0.11) |
| Depressive symptoms[e] | 0 (-0.10, 0.10) | -0.05 (-0.16, 0.06) | -0.02 (-0.14, 0.09) |
| ***Panel B. Care Receipt*** | | | |
| Informal care receipt[f] | 0.07 (-0.02, 0.16) | 0.03 (-0.12 0.18) | 0.03 (-0.06, 0.13) |
| Formal care receipt[f] | 0.22 (0.13, 0.30)*** | 0.13 (0.01, 0.25)** | 0.11 (0.03, 0.2)*** |
| ***Part C. Health Care Utilization*** | | | |
| Enrollment in Medicare Advantage | -0.11 (-0.18, -0.04)*** | -0.08 (-0.15, -0.01)** | NA |
| Any use of home health care | 0.17 (0.10, 0.24)*** | 0.13 (-0.01, 0.26)* | 0.14 (0.06, 0.22)*** |
| Any use of SNF care | 0.17 (0.11, 0.22)*** | 0.12 (0.05, 0.2)*** | 0.14 (0.07, 0.2)*** |
| Chronic conditions ACS admissions[g] | 0.02 (-0.03, 0.07) | 0 .02 (-0.05, 0.08) | 0.01 (-0.04, 0.06) |
| Problem oriented E/M visits | 0.02 (-0.04, 0.09) | 0.07 (0.01 0.13)** | -0.03 (-0.08, 0.02) |
| Influenza vaccination | 0.07 (-0.01, 0.15)* | 0.1 (-0.01, 0.22)* | 0.03 (-0.06, 0.11) |
| ***Panel D. Spending*** | | | |
| Medicare spending[h], % difference | 74.01 (21.88, 148.43)*** | 105.58 (28.09, 229.95)*** | 74.01 (21.88, 148.43)*** |
| Beneficiary spending[h], % difference | 59.56 (19.93, 112.27)*** | 76.84 (24.20, 151.79)*** | 59.56 (19.93, 112.27)*** |
| Number of individuals | 1,554 | 631 | 1,219 |

| | | | |
|---|---|---|---|
| Observations | 7,661 | 2,524 | 4,985 |

Abbreviations: SNF, skilled nursing facility; ED, emergency department; MA, Medicare Advantage; ACS, ambulatory care sensitive; E/M, evaluation and management; NA, not applicable;

[a] Column 1 presents aggregated effects from estimating the difference-in-differences estimator developed by Callaway and Sant'Anna. Details on model specifications and covariates are provided in the Methods section of the manuscript and in eMethods 3 of the Supplement.

[b] Column 2 re-estimates the model restring the sample to a balanced panel of individuals who are observed in years -4 through 2 relative to dementia onset.

[c] Column 3 restricts the sample to Medicare Fee-for-Service (FFS) beneficiaries and includes person waves up to four years following dementia onset, due to the relatively small sample sizes observed at six years post-dementia onset after sample restriction.

[d] Subgroup analysis for mortality outcomes (those with ED visits vs. those without ED visits) were restricted to person waves up to four years after dementia onset, due to the relatively small sample sizes observed at six years post-dementia onset in each subgroup.

[e] Depressive symptoms were assessed using the modified eight-item Center for Epidemiologic Studies Depression Scale (CES-D) available in the HRS, with a cut-off three or more indicating the presence of depression. Since the measure is only available for self-respondents, the analysis was limited to person waves within four years of dementia onset, due to the small sample sizes at six years post-dementia onset.

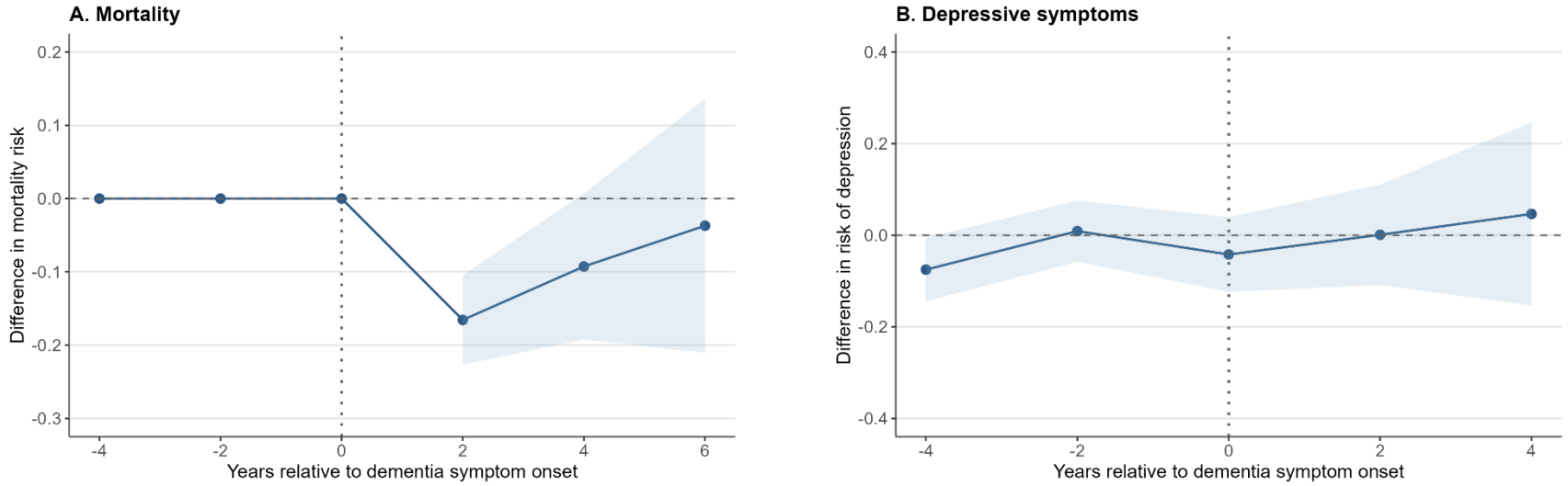
[f] Informal and formal care receipt refer to the assistance with activities of daily living (ADL) or instrumental activities of daily living (IADL), and analyses of these outcomes were restricted to individuals with ADL/IADL limitations.

[g] Analysis of chronic conditions ACS admissions was restricted to patients with diabetes, chronic obstructive pulmonary disease, asthma, hypertension or congestive heart failure.

[h] Spending outcomes were derived from Medicare claims and are available only for Medicare FFS beneficiaries.

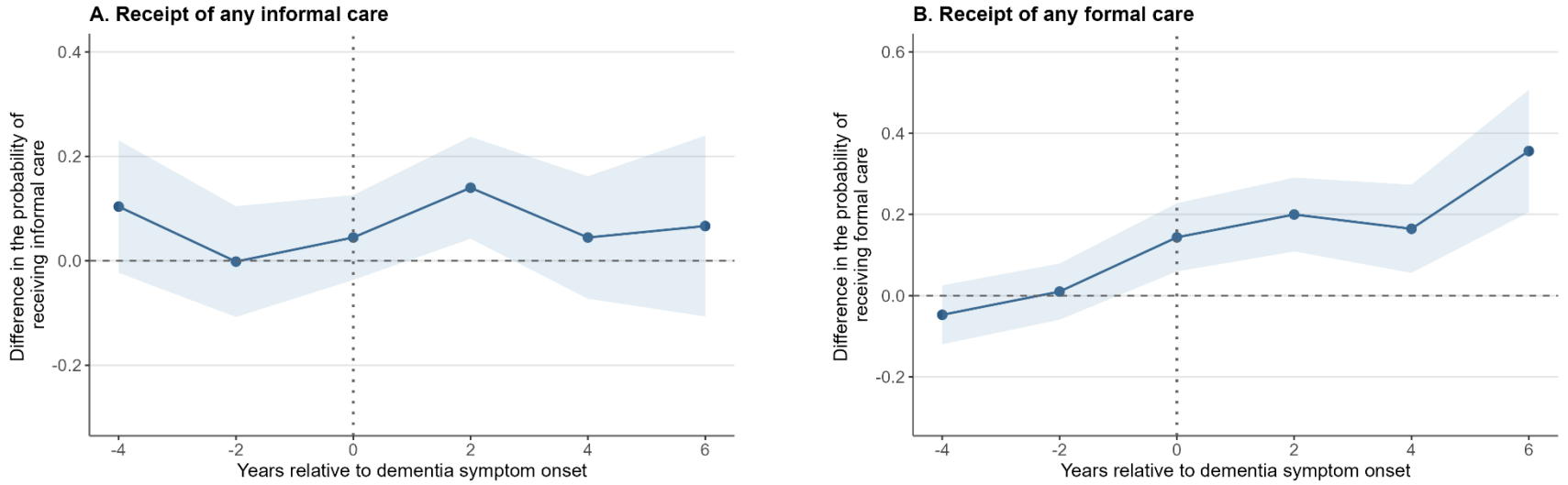
Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Figure 1. Difference-in-Differences Estimates of the Association Between Timely Dementia Diagnosis and Health Outcomes Among Older Adults With Probable Dementia**



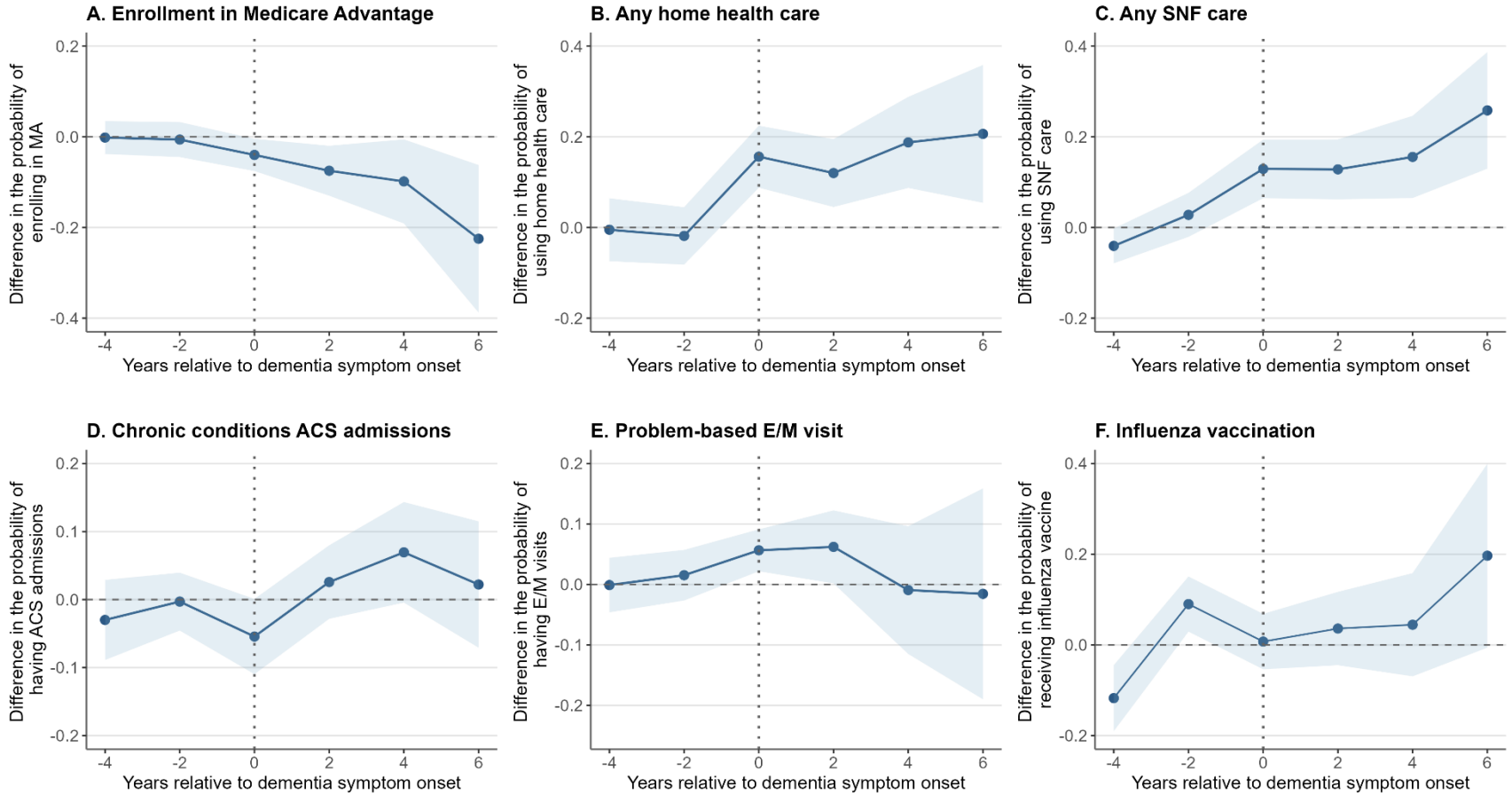

*Notes*: Plots show adjusted differences (difference-in-differences estimates) in the risk of mortality and depressive symptoms between individuals with probable dementia who received a diagnosis at dementia onset and those with probable dementia who remained undiagnosed, relative to the two years before dementia onset. The shaded areas represent 95% CIs for the point estimates in each year relative to dementia symptom onset. The difference-in-differences estimates were estimated using the estimator proposed by Callaway and Sant'Anna, as described in the Methods section. The base period for post-dementia onset estimates is the period immediately before dementia onset (i.e., two years prior); the base period for pre-dementia onset estimates is the period immediately preceding each time point. Depressive symptoms were assessed using the modified eight-item Center for Epidemiologic Studies Depression Scale (CES-D) available in the HRS, with a cut-off of three or more indicating the presence of depression. Since the measure is only available for self-respondents, the analysis was limited to person waves within four years of dementia onset, due to the small sample sizes at six years post-dementia onset.

**Figure 2. Difference-in-Differences Estimates of the Association Between Timely Dementia Diagnosis and Care Receipt Among Older Adults With Probable Dementia**




*Notes*: Plots show adjusted differences (difference-in-differences estimates) in the probability of receiving informal and formal care between individuals with probable dementia who received a diagnosis at dementia onset and those with probable dementia who remained undiagnosed, relative to the two years before dementia onset. Informal and formal care receipt refer to the assistance with activities of daily living (ADL) or instrumental activities of daily living (IADL), and analyses are restricted to individuals with ADL/IADL limitations. The shaded areas represent 95% CIs for the point estimates in each year relative to dementia symptom onset. The difference-in-differences estimates were estimated using the estimator proposed by Callaway and Sant'Anna, as described in the Methods section. The base period for post-dementia onset estimates is the period immediately before dementia onset (i.e., two years prior); the base period for pre-dementia onset estimates is the period immediately preceding each time point.

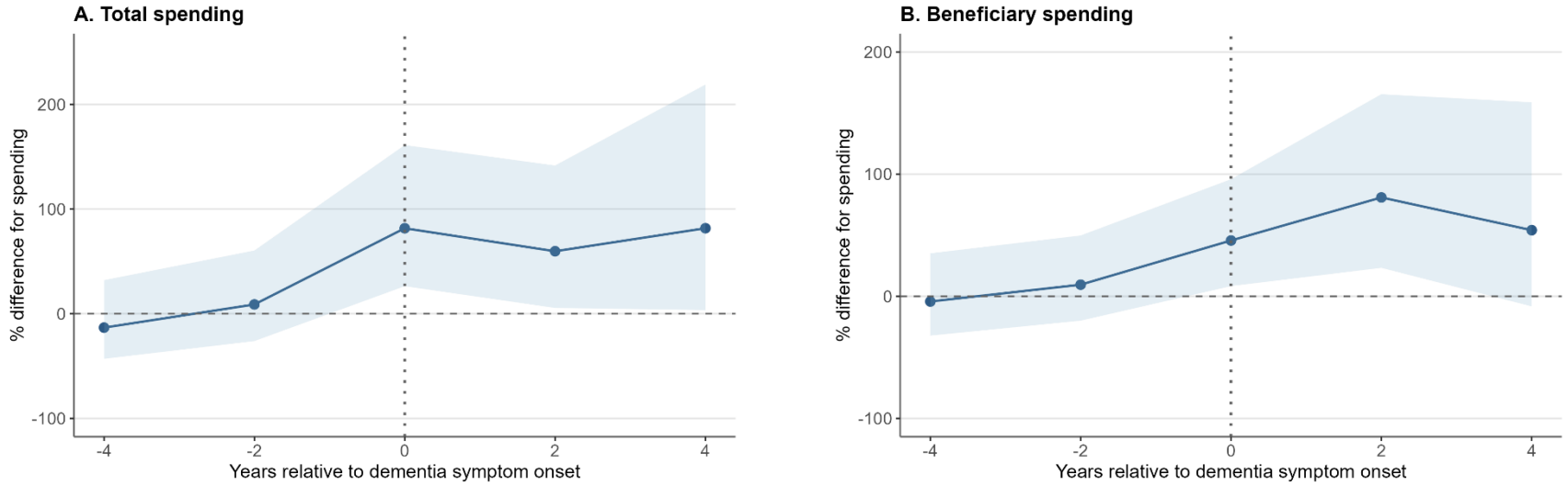
**Figure 3. Difference-in-Differences Estimates of the Association Between Timely Dementia Diagnosis and Health Care Utilization Among Older Adults With Probable Dementia**




*Notes*: Plots show adjusted differences (difference-in-differences estimates) in the health plan choice (Panel A) and health care utilization (Panels B-F) between individuals with probable dementia who received a diagnosis at symptom onset and those with probable dementia who remained undiagnosed, relative to the two years before dementia onset. Analysis of chronic conditions ACS admissions was restricted to patients with diabetes, chronic obstructive pulmonary disease, asthma, hypertension or congestive heart failure. The shaded areas represent 95% CIs for the

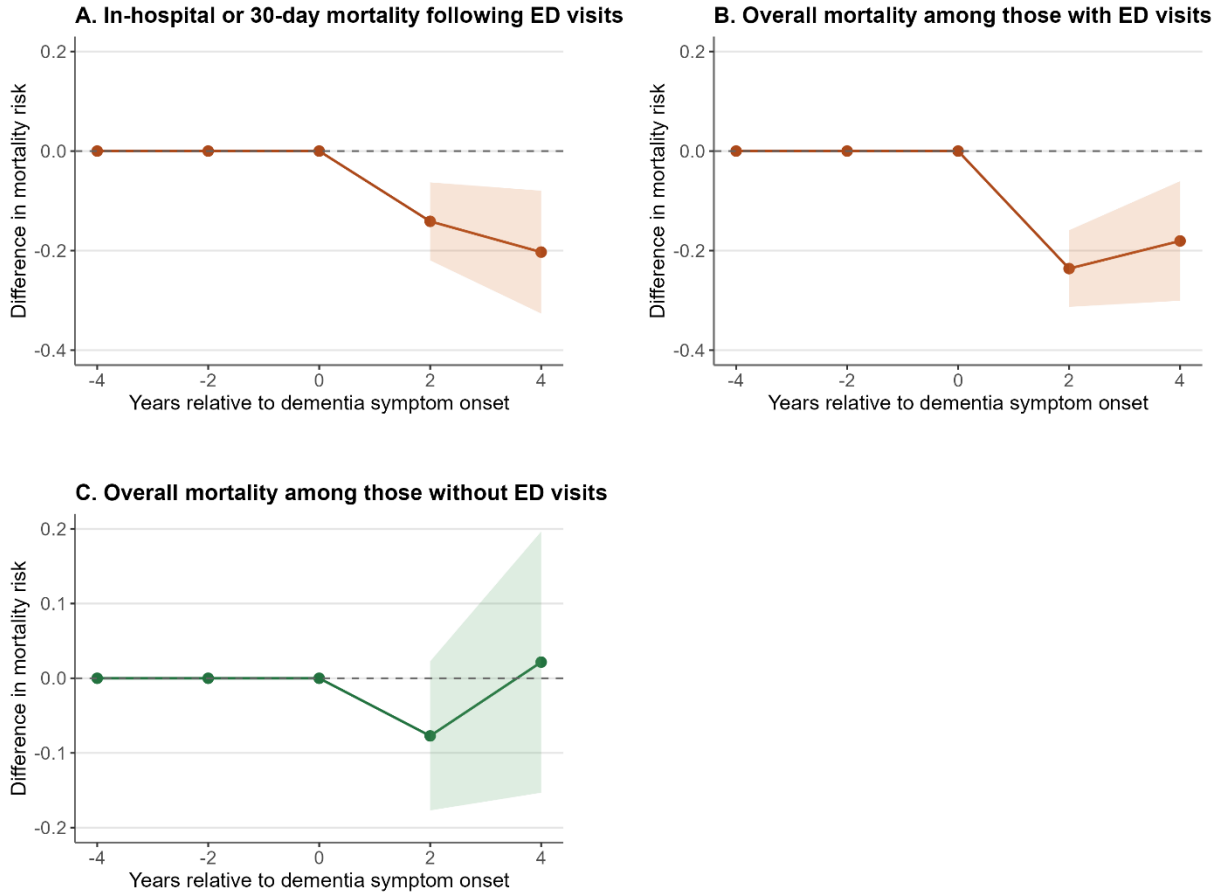
point estimates in each year relative to dementia symptom onset. The difference-in-differences estimates were estimated using the estimator proposed by Callaway and Sant'Anna, as described in the Methods section. The base period for post-dementia onset estimates is the period immediately before dementia onset (i.e., two years prior); the base period for pre-dementia onset estimates is the period immediately preceding each time point.

**Figure 4. Difference-in-Differences Estimates of the Association Between Timely Dementia Diagnosis and Cost of Care Among Older Adults With Probable Dementia**




*Notes*: Plots show adjusted differences (difference-in-differences estimates) in the cost of care between individuals with probable dementia who received a diagnosis at dementia onset and those with probable dementia who remained undiagnosed, relative to the two years before dementia onset. Cost of care outcomes were derived from Medicare claims and are available only for Medicare FFS beneficiaries. The sample includes person waves up to four years following dementia onset due to the relatively small sample sizes observed at six years post-dementia onset after restricting to Medicare FFS beneficiaries. Total spending was measured using total allowed charges for a beneficiary's care in Medicare Parts A and B claims. Beneficiary spending includes beneficiary deductible and coinsurance liability amount in Medicare Parts A and B claims. All spending measures were inflation-adjusted to 2010 dollars, winsorized at the top and bottom 1%, and transformed using inverse hyperbolic sine (HIS) function. The y-axis was rescaled to reflect relative percent differences. The shaded areas represent 95% CIs for the point estimates in each year relative to dementia symptom onset. The difference-in-differences estimates were estimated using the estimator proposed by Callaway and Sant'Anna, as described in the Methods section. The base period for post-dementia onset estimates is the period immediately before dementia onset (i.e., two years prior); the base period for pre-dementia onset estimates is the period immediately preceding each time point.

**Figure 5. Difference-in-Differences Estimates for In-Hospital and 30-day Mortality after ED Visits and Overall Mortality Among Individuals With and Without ED Visits**




*Notes*: Plots show adjusted differences (difference-in-differences estimates) in in-hospital and 30-day mortality after ED visits (Panel A), and overall mortality among those with (Panel B) and without ED visits (Panel C) between individuals with probable dementia who received a diagnosis at dementia onset and those with probable dementia who remained undiagnosed, relative to the two years before dementia onset. The shaded areas represent 95% CIs for the point estimates in each year relative to dementia symptom onset. The difference-in-differences estimates were estimated using the estimator proposed by Callaway and Sant'Anna (2021), as described in the Methods section. The sample was restricted to person waves up to four years after dementia onset due to the relatively small sample sizes observed at six years post-dementia onset in each subgroup (i.e., those with ED visits vs. those without ED visits).

**Supplementary Material**

# How Do Health Care Use, Spending, and Patient Outcomes Respond to a Timely Dementia Diagnosis? Evidence from HRS-Medicare Linked Data


eFigure 1: Generation of the Analytic Sample

eFigure 2: Distribution of Diagnosis Timing Among Individuals With Probable Dementia

eFigure 3: Covariate Balance Before and After Propensity Score Reweighting in the Nonparametric Event Study

eFigure 4: Unadjusted Trends and Adjusted Changes in Health Outcomes Following Timely Dementia Diagnosis Among Older Adults With Probable Dementia

eFigure 5: Unadjusted Trends and Adjusted Changes in Care Receipt Following Timely Dementia Diagnosis Among Older Adults With Probable Dementia

eFigure 6: Unadjusted Trends and Adjusted Changes in Health Care Utilization Following Timely Dementia Diagnosis Among Older Adults With Probable Dementia

eFigure 7. Unadjusted Trends and Adjusted Changes in Cost of Care Following Timely Dementia Diagnosis Among Older Adults With Probable Dementia

eTable 1: ICD-9-CM and ICD-10-CM Codes Utilized for Identifying Dementia Diagnoses

eTable 2: Identification of Problem-Based Visits and Influenza Vaccination in Claims

eTable 3: Sample Sizes by Outcome and Subgroup

eTable 4: Site of Death by Dementia Diagnostic Status Among Older Adults With Probable Dementia

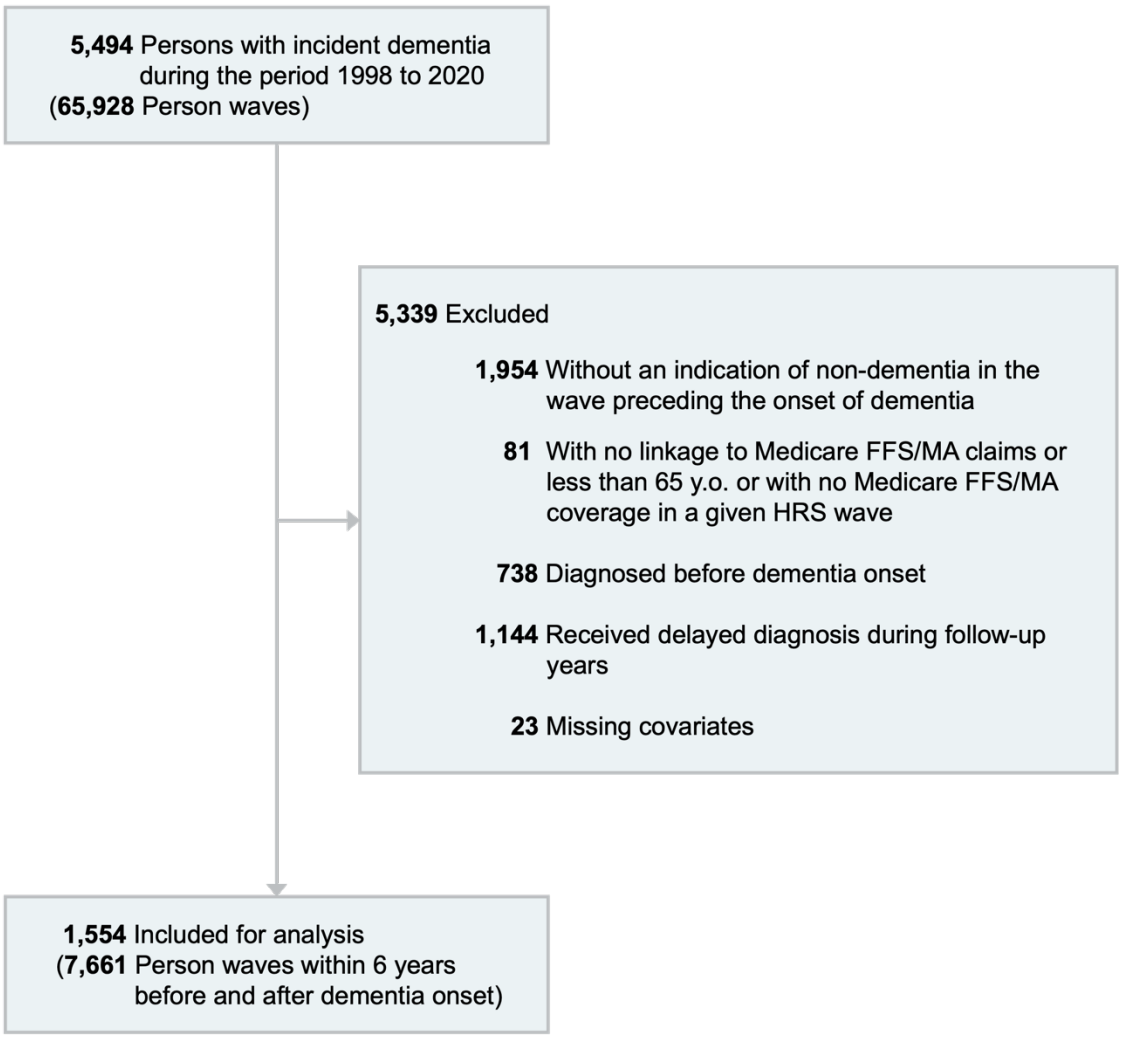
eMethods1: Replication of Predicted Cognition and Dementia Measures and Application to 1998–2020

eMethods2: Propensity Score Weighting and Nonparametric Event Study Analysis

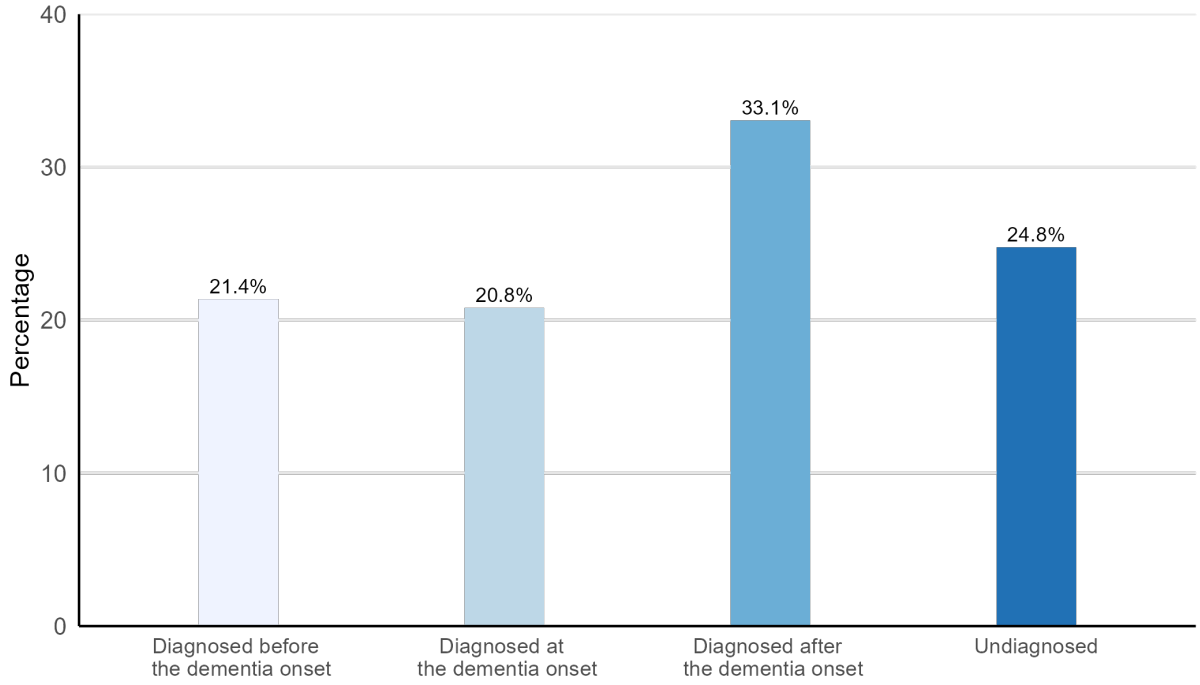
eMethods3: Callaway and Sant'Anna Difference-in-Differences Estimator

eReferences

**eFigure 1: Generation of the Analytic Sample**

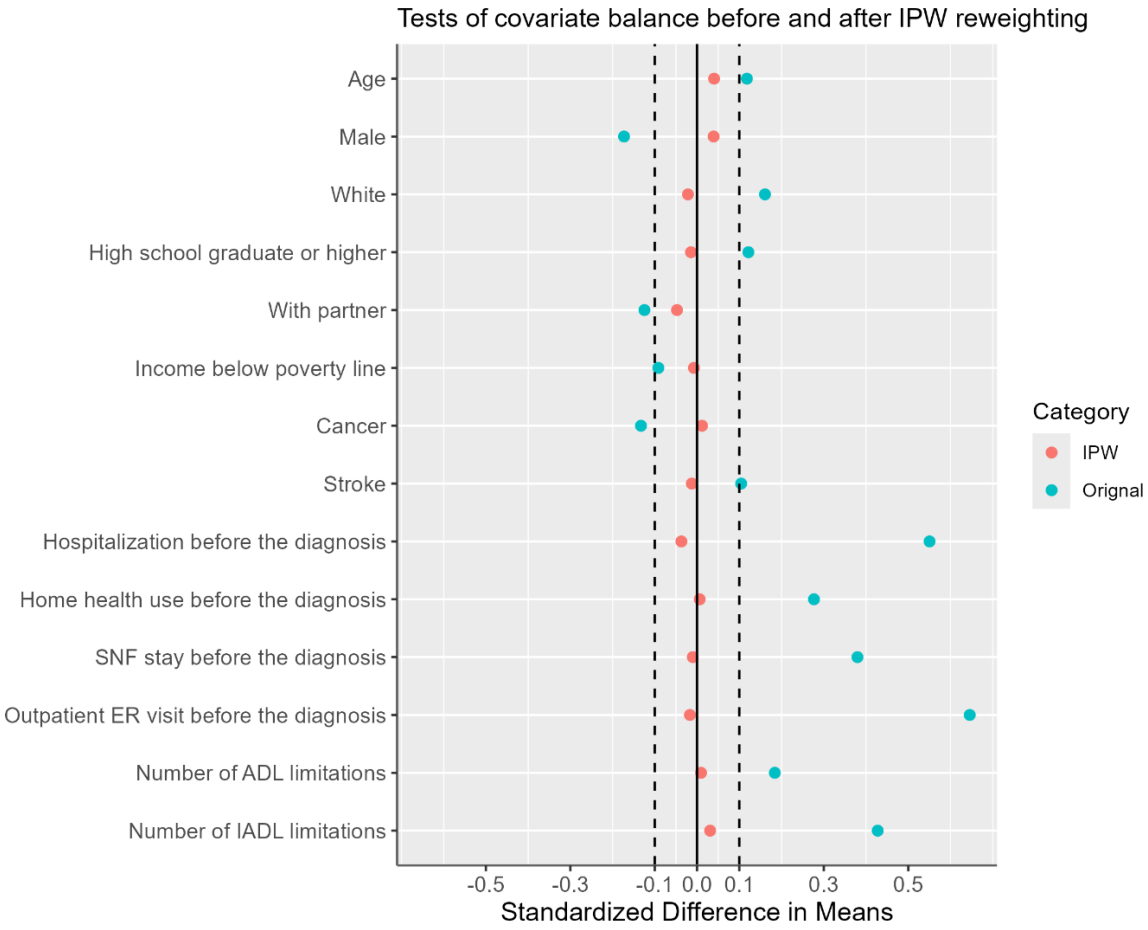


**eFigure 2: Distribution of Diagnosis Timing Among Individuals With Probable Dementia**



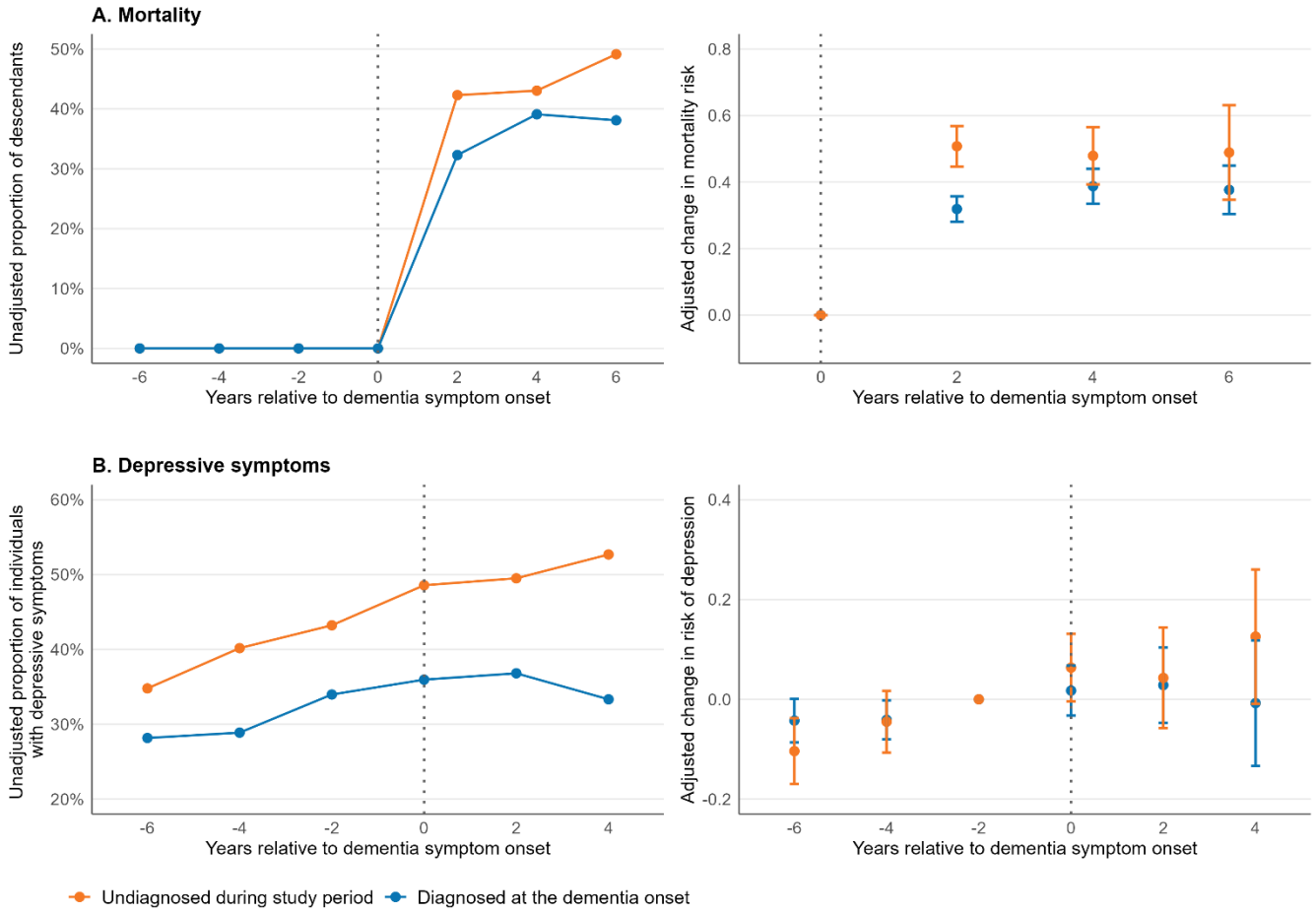

*Notes:* The figure shows the percentage distribution of Medicare beneficiaries with probable dementia (n=3,454) who were diagnosed before, at, or after the HRS interview when dementia was first observed, as well as those who remained undiagnosed during the study period. Individuals diagnosed at dementia onset and those who remained undiagnosed were included in the analysis.

**eFigure 3: Covariate Balance Before and After Propensity Score Reweighting in the Nonparametric Event Study**



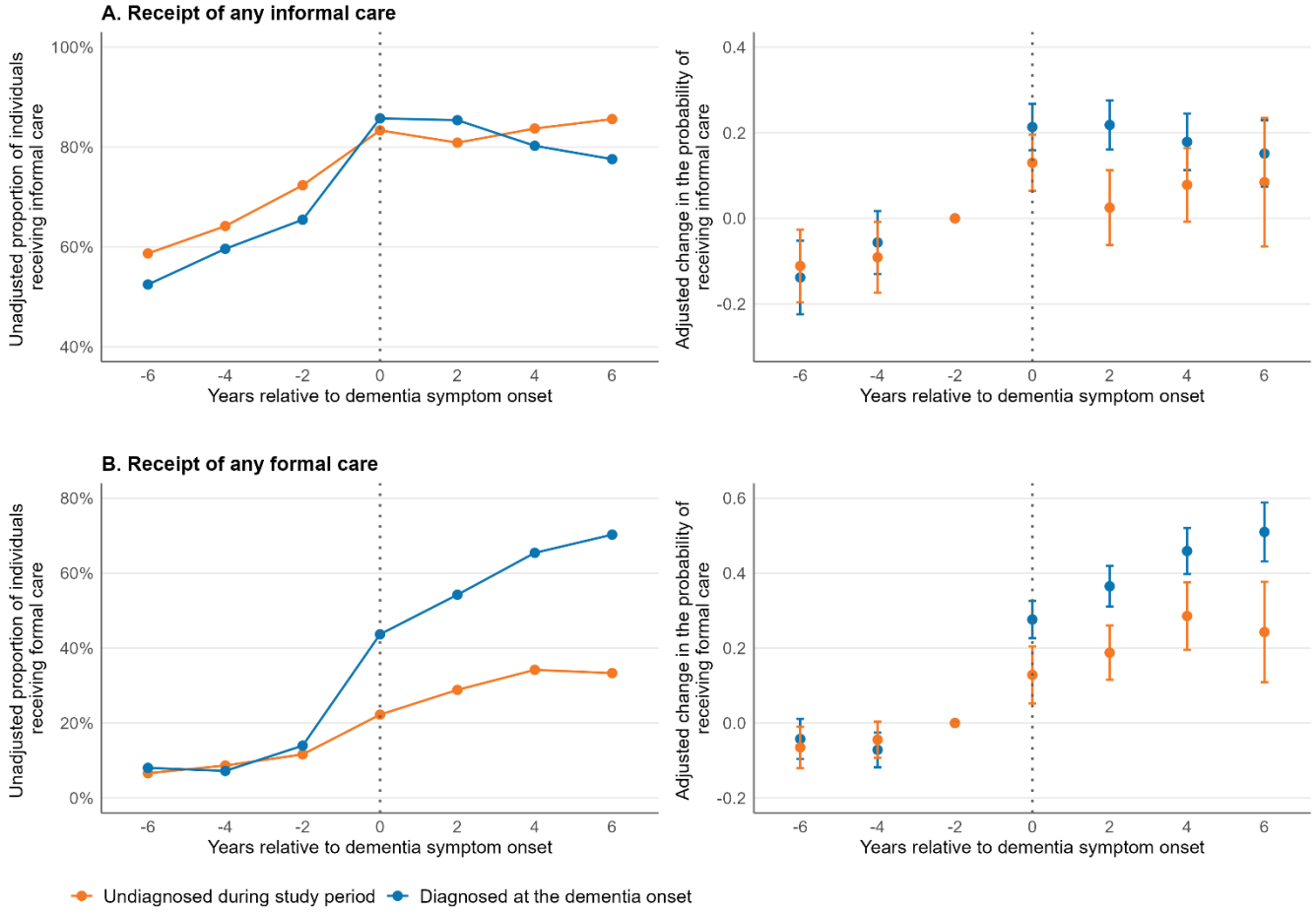

*Notes:* The figure shows standardized mean differences in covariates measured at dementia onset in the main analysis sample between individuals who received a diagnosis at onset and those who remained undiagnosed. The y-axis lists the variables used for propensity score reweighting in the nonparametric event study models. Propensity score reweighting was applied to controls (undiagnosed individuals) to match on the listed covariates. More details on covariates, propensity score reweighting, and nonparametric event study models are provided in the Methods section of the manuscript and in eMethods 2 of the Supplement.

**eFigure 4: Unadjusted Trends and Adjusted Changes in Health Outcomes Following Timely Dementia Diagnosis Among Older Adults With Probable Dementia**



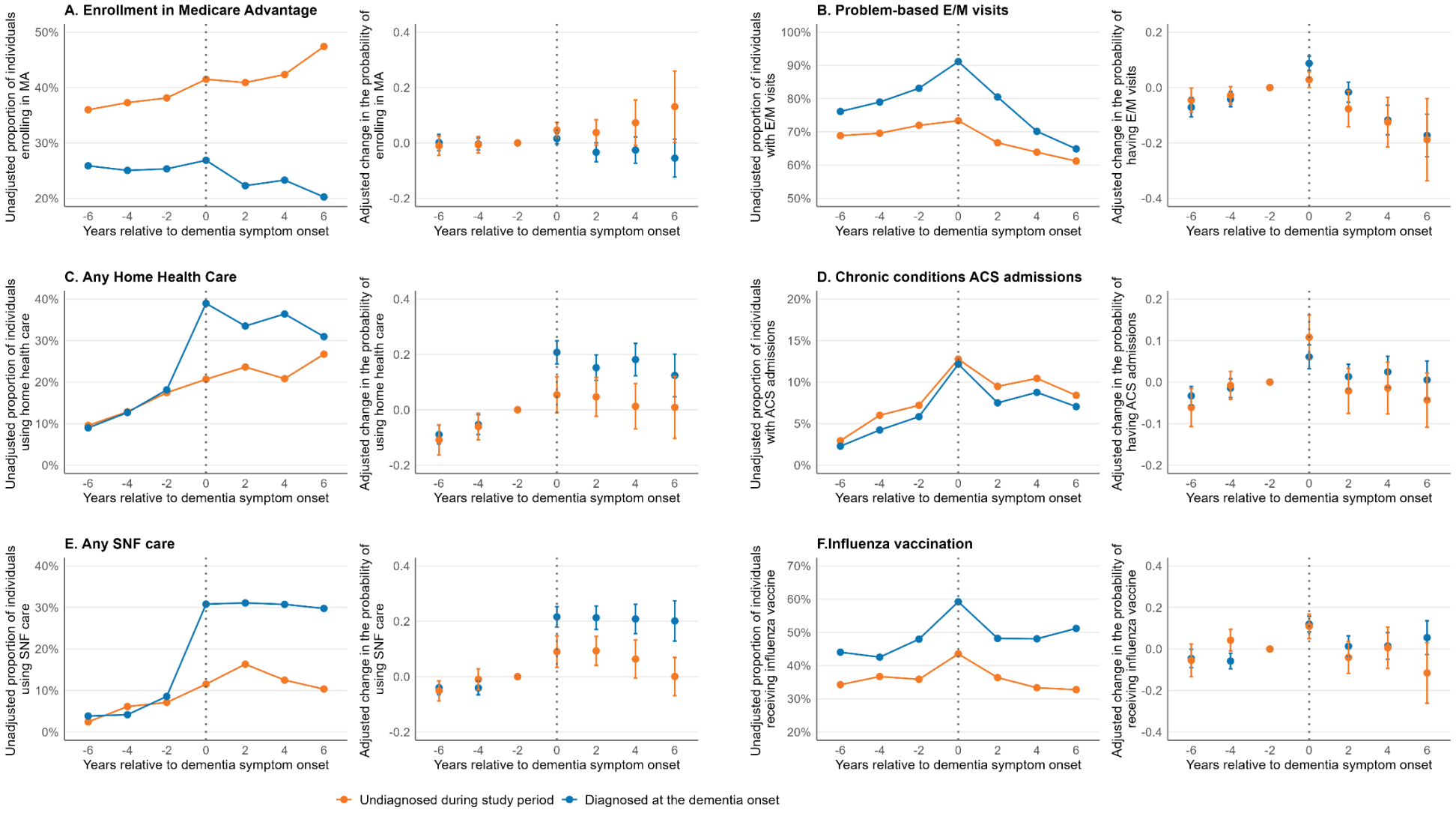

*Notes:* Plots show unadjusted trends in health outcomes and adjusted changes relative to two years before dementia onset among individuals with probable dementia who received a diagnosis at onset compared with those who remained undiagnosed. Adjusted changes were estimated using a nonparametric event study approach on a matched sample with propensity score reweighting applied to controls, as described in the Methods. Depressive symptoms were assessed using the modified eight-item Center for Epidemiologic Studies Depression Scale (CES-D) available in the HRS, with a cut-off of three or more indicating the presence of depression. Since the measure is only available for self-respondents, the analysis was limited to person waves within four years of dementia onset due to the small sample sizes at six years post-dementia onset.

**eFigure 5: Unadjusted Trends and Adjusted Changes in Care Receipt Following Timely Dementia Diagnosis Among Older Adults With Probable Dementia**



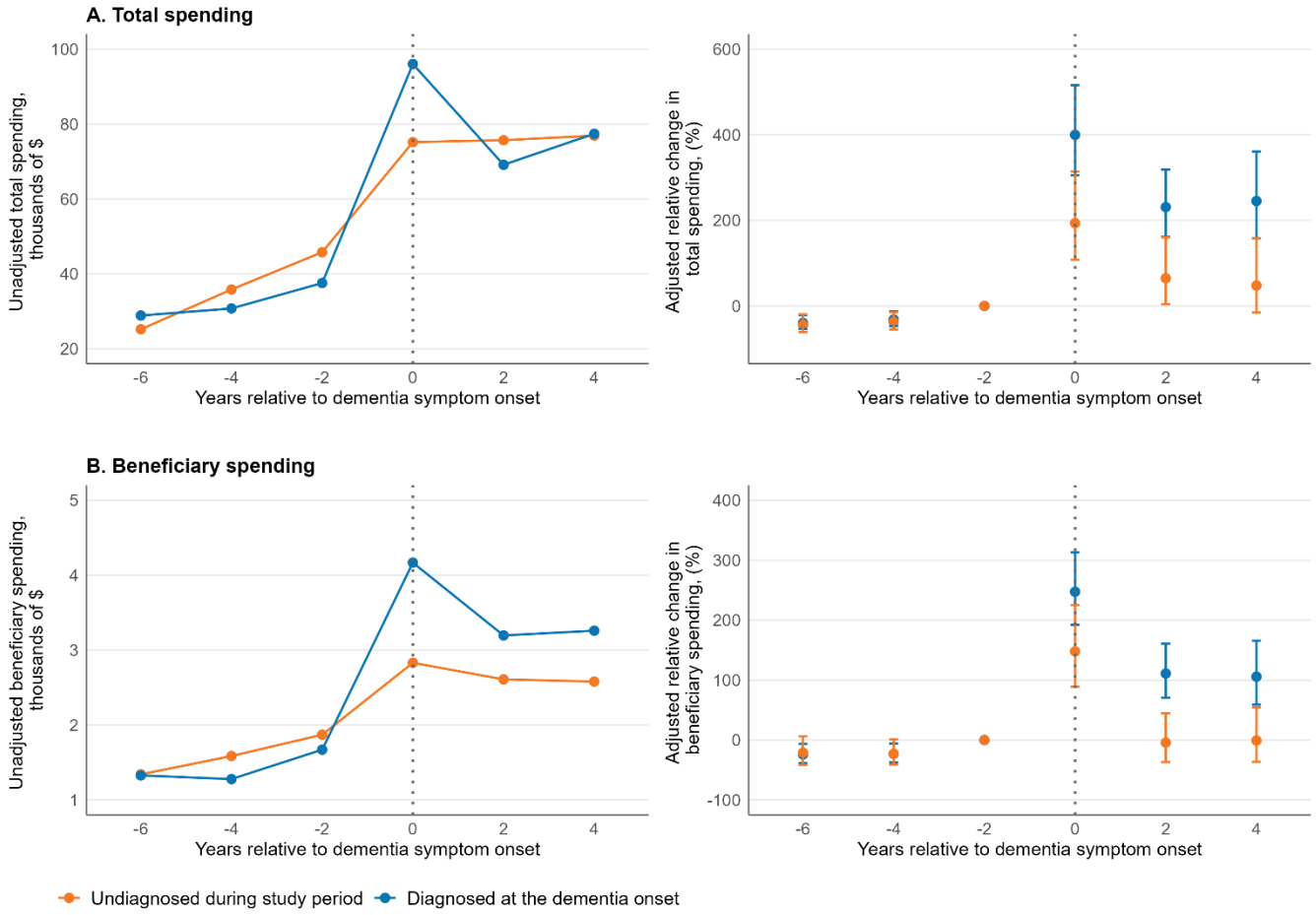

*Notes:* Plots show unadjusted trends in care receipt outcomes and adjusted changes relative to two years before dementia onset among individuals with probable dementia who received a diagnosis at onset compared with those who remained undiagnosed. Informal and formal care receipt refer to the assistance with activities of daily living (ADL) or instrumental activities of daily living (IADL), and analyses are restricted to individuals with ADL/IADL limitations. Adjusted changes were estimated using a nonparametric event study approach on a matched sample with propensity score reweighting applied to controls, as described in the Methods.

**eFigure 6: Unadjusted Trends and Adjusted Changes in Health Care Utilization Following Timely Dementia Diagnosis Among Older Adults With Probable Dementia**




*Notes:* Plots show unadjusted trends in health care utilization outcomes and adjusted changes relative to two years before dementia onset among individuals with probable dementia who received a diagnosis at onset compared with those who remained undiagnosed. Analysis of chronic conditions ACS admissions was restricted to patients with diabetes, chronic obstructive pulmonary disease, asthma, hypertension or congestive heart failure. Adjusted changes were estimated using a nonparametric event study approach on a matched sample with propensity score reweighting applied to controls, as described in the Methods.

**eFigure 7: Unadjusted Trends and Adjusted Changes in Cost of Care Following Timely Dementia Diagnosis Among Older Adults With Probable Dementia**




*Notes:* Plots show unadjusted trends in cost of care outcomes and adjusted changes relative to two years before dementia onset among individuals with probable dementia who received a diagnosis at onset compared with those who remained undiagnosed. Adjusted changes were estimated using a nonparametric event study approach on a matched sample with propensity score reweighting applied to controls, as described in the Methods. Cost of care outcomes (Medicare total allowed charges and beneficiary spending) were derived from Medicare claims and are available only for Medicare FFS beneficiaries. The sample includes person waves up to four years following dementia onset due to the relatively small sample sizes observed at six years post-dementia onset after restricting to Medicare FFS beneficiaries.

**eTable 1: 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 | R41.81 | Age-related cognitive decline |
| 331.2 | Senile degeneration of brain | R54 | Senility without mention of psychosis |

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

**eTable 2: Identification of Problem-Based Visits and Influenza Vaccination in Claims**

| Service Delivery | CPT codes | Healthcare Common Procedure Coding System codes |
|---|---|---|
| Problem-based evaluation and management visits | 99201-99215 | G0463 |
| Influenza vaccination | 90630, 90653, 90654, 90655, 90656, 90657, 90658, 90659, 90660, 90661, 90662, 90672, 90673, 90674, 90682, 90685, 90686, 90687, 90688, 90749, 90756, Q2033, Q2035, Q2036, Q2037, Q2038, Q2039 | |

**eTable 3: Sample Sizes by Outcome and Subgroup**

| | (1) Baseline[a] | | (2) Balanced panel[b] | | (3) Excluding MA Beneficiaries[c] | |
|---|---|---|---|---|---|---|
| | Total eligible, N | Obs., N | Total eligible, N | Obs., N | Total eligible, N | Obs., N |
| ***Panel A. Health Outcomes*** | | | | | | |
| Mortality | 7,661 | 7,661 | 2,286 | 2,286 | 4,985 | 4,985 |
| In-hospital or 30-day mortality following ED visits[d] | 3,710 | 3,710 | 1,207 | 1,207 | 2,908 | 2,908 |
| Mortality among those with ED visits[d] | 3,710 | 3,710 | 1,207 | 1,207 | 2,908 | 2,908 |
| Mortality among those without ED visits[d] | 3,667 | 3,667 | 1,079 | 1,079 | 2,077 | 2,077 |
| Depressive symptoms[e] | 5,078 | 5,071 | 1,571 | 1,569 | 3,404 | 3,400 |
| ***Panel B. Care Receipt*** | | | | | | |
| Informal care receipt[f] | 4,307 | 4,300 | 1,678 | 1,676 | 2,727 | 2,723 |
| Formal care receipt[f] | 4,307 | 4,290 | 1,678 | 1,673 | 2,727 | 2,716 |
| ***Part C. Health Care Utilization*** | | | | | | |
| Enrollment in Medicare Advantage | 7,661 | 7,661 | 2,286 | 2,286 | 4,985 | 4,985 |
| Any use of home health care | 7,661 | 7,661 | 2,286 | 2,286 | 4,985 | 4,985 |
| Any use of SNF care | 7,661 | 7,661 | 2,286 | 2,286 | 4,985 | 4,985 |
| Chronic conditions ACS admissions[g] | 6,781 | 6,781 | 2,001 | 2,001 | 4,134 | 4,134 |
| Problem oriented E/M visits | 7,661 | 7,661 | 2,286 | 2,286 | 4,985 | 4,985 |
| Influenza vaccination | 7,661 | 7,661 | 2,286 | 2,286 | 4,985 | 4,985 |
| ***Panel D. Spending*** | | | | | | |
| Medicare spending[h] | 4,985 | 4,985 | 1,509 | 1,509 | 4,985 | 4,985 |
| Beneficiary spending[h] | 4,985 | 4,985 | 1,509 | 1,509 | 4,985 | 4,985 |

Abbreviations: SNF, skilled nursing facility; ED, emergency department; MA, Medicare Advantage; ACS, ambulatory care sensitive; E/M, evaluation and management; NA, not applicable;

[a] Column 1 shows the sample size for the main analysis using all eligible person-waves.

[b] Column 2 shows the sample size for the robustness analysis restring the sample to a balanced panel of individuals who are observed in years -4 through 2 relative to dementia onset.

[c] Column 3 shows the sample size for the robustness analysis restring the sample to Medicare Fee-for-Service (FFS) beneficiaries and includes person waves up to four years following dementia onset, due to the relatively small sample sizes observed at six years post-dementia onset after sample restriction.

[d] Subgroup analysis for mortality outcomes (those with ED visits vs. those without ED visits) were restricted to person waves up to four years after dementia onset due to the relatively small sample sizes observed at six years post-dementia onset in each subgroup.
[e] Depressive symptoms were assessed using the modified eight-item Center for Epidemiologic Studies Depression Scale (CES-D) available in the HRS, with a cut-off of three or more indicating the presence of depression. Since the measure is only available for self-respondents, the analysis was limited to person waves within four years of dementia onset due to the small sample sizes at six years post-dementia onset.
[f] Informal and formal care receipt refer to the assistance with activities of daily living (ADL) or instrumental activities of daily living (IADL), and analyses are restricted to individuals with ADL/IADL limitations.
[g] Analysis of chronic conditions ACS admissions was restricted to patients with diabetes, chronic obstructive pulmonary disease, asthma, hypertension, or congestive heart failure.
[h] Spending outcomes were derived from Medicare claims and are available only for Medicare FFS beneficiaries.

**eTable 4: Site of Death by Dementia Diagnostic Status Among Older Adults With Probable Dementia**

| | Decedents, N (%) | | |
|---|---|---|---|
| **Site of Death[c]** | **Diagnosed at dementia onset[a] (No. of death=382)** | **Undiagnosed[b] (No. of death=453)** | **Total deaths (n=835)** |
| Home or inpatient with hospice[d] | 208 (54.5) | 186 (41.1) | 394 (47.2) |
| Home, no hospice | 35 (9.2) | 77 (17.0) | 112 (13.4) |
| Nursing home[e] | 79 (20.7) | 75 (16.6) | 154 (18.4) |
| Acute care hospital[f] | 60 (15.7) | 115 (25.4) | 175 (21.0) |

[a] Individuals diagnosed at dementia onset included those who received their initial dementia diagnosis during the survey wave when dementia was first observed.
[b] Undiagnosed individuals included those who did not receive a dementia diagnosis at any point during the study period.
[c] The Residential History File algorithm was used to define the site of death and has been widely used in previous studies[1, 2].
[d] Home or inpatient hospice death included persons who died in the home and community setting, or in an inpatient setting (i.e., in a free-standing hospice inpatient unit, an acute care hospital, or a nursing home) while receiving hospice services.
[e] Nursing home death was identified using Medicare Part A skilled nursing facility (SNF) data along with Minimum Data Set (MDS)[1].
[f] Acute care hospital death included individuals who died in an acute care hospital during an inpatient stay or in an outpatient hospital setting during emergency department visits.

**eMethods 1: 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[3]. This allowed us to extend these measures to 1998–2020, as the original study only covered 2000–2016.

Specifically, the algorithm developed a longitudinal, latent-variable model of cognitive status, which was estimated using the Markov Chain Monte Carlo method with 2,000,000 simulation draws, and the first 10% burn-in draws were discarded. 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)[4].

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 the dementia prevalence estimates for 2018 and 2020, potentially resulting in underidentification of dementia cases during those years.

Below, we present our re-created dementia prevalence estimates in comparison with the original 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.

**eMethods 2: Propensity Score Weighting and Nonparametric Event Study Analysis**

*Propensity Score Weighting*

In the nonparametric event study analysis, we began by implementing propensity score reweighting to adjust for potential selection bias.

First, we estimated a logistic regression model using observations at dementia onset for all individuals in our sample. The dependent variable was an indicator of whether the individual received their initial dementia diagnosis during the HRS survey wave when dementia was first observed (y = 1 if diagnosed, and y = 0 otherwise). The independent variables included all covariates specified in the "Covariates" section, including demographic and socioeconomic characteristics, health status, and health care utilization. This model yielded the predicted probability (i.e., the propensity score) of receiving a timely dementia diagnosis for each individual.

We then reweighted the sample by assigning control group individuals (those who remained undiagnosed) a weight of $\frac{p_i}{1-p_i}$, so that controls with higher propensity scores, and thus greater similarity to those receiving a timely diagnosis at the survey wave of dementia onset, received higher weights. Those who received a timely diagnosis were assigned a weight of 1.

*Nonparametric Event Study Analysis*

We then estimated outcomes as a function of time relative to the survey wave preceding dementia onset separately for individuals who received a diagnosis at onset and their matched undiagnosed counterparts. Similar methods have been used to study the economic consequences of health events[5]. The basic nonparametric event study specification takes the form:

$$y_{it} = \gamma_t + Z_i\delta + X_{it}\Gamma + \sum_{r=-4}^{-6} \mu_r + \sum_{r=0}^{6} \mu_r + \varepsilon_{it}$$

where $\gamma_t$ are coefficients on calendar-time fixed effects, $Z_i$ is a vector of time-invariant demographics described in the *Covariates* section (e.g., gender, education, race/ethnicity), $X_{it}$ represents time-varying demographics (e.g., age, partner status), and $\mu_r$ are coefficients on indicators for event time $r$ that refers to the years relative to the survey wave when dementia is first observed ($r = 0$). We analyze up to six years prior to the dementia onset, and six years after the dementia onset; the omitted category ($u_{-2}$) reflects the survey wave immediately preceding the dementia onset wave (i.e., 2 years prior or 1 wave prior).

The nonparametric event study approach allows us to visually compare the patterns of outcomes relative to the survey wave preceding dementia onset between individuals who received a timely dementia diagnosis and those who remained undiagnosed.

**eMethods 3: Callaway and Sant'Anna Difference-in-Differences Estimator**

We deploy the Callaway and Sant'Anna estimator to estimate the mean differential change in the outcome for individuals who received a diagnosis at dementia onset (i.e., treated group) relative to those who remained undiagnosed (i.e., control group), relative to the survey wave immediately preceding dementia onset.

We implemented the doubly robust estimator, which employs stabilized inverse propensity treatment weighting regression along with the outcome regression. In a doubly robust analysis, only one of these regressions needs to be correctly specified to yield unbiased estimates. As there is no staggered treatment timing and only one treated group, Callaway and Sant'Anna's doubly robust estimator has the following expression[6]:

$$ATT(D,t) = E\left[\left(\frac{D}{E[D]} - \frac{\frac{\hat{p}(X)C}{1-p(X)}}{E\left[\frac{\hat{p}(X)C}{1-p(X)}\right]}\right)(Y_t - Y_b - E[Y_t - Y_b|X, C=1])\right]$$

where $D$ is a dummy variable equalling one if the unit is in the treated group, $\hat{p}(X)$ indicates the probability of being treated, conditional on covariates $X$ described in the "Covariates" section of the manuscript and on either being a member of the treated group or a member of the control group. $C$ is a dummy variable equaling one for individuals in the control group. $Y_t$ is the individual's outcome in year $t$ and $Y_b$ is the individual's outcome in the survey wave immediately preceding the dementia onset wave (i.e., 2 years prior or 1 wave prior).

All inference procedures used clustered bootstrapped standard errors at the individual level. The analyses were performed using the *did* package developed by Callaway and Sant'Anna, and the reported confidence intervals are robust to multiple hypothesis testing.

Our main figures plot the average treatment effect on the treated (ATT) for different lengths of follow-up years, up to six years post-dementia onset. In Table 2, we aggregate these effects to obtain an overall ATT based on the Callaway and Sant'Anna event-study aggregation[6].

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