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Yale University

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Yale University and IZA

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IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

Long-Term Services and Supports and Disease Management among Older Chinese Adults in Different Stages of Cognitive Impairment

Rapid population aging elevates burden of chronic and non-communicable diseases among older adults. Despite the critical role of self-management in disease prevention and control, effective management of diseases can be cognitively demanding and may require additional supports from family and social services. Using nationally representative data from China, this paper reveals great challenges in disease management and characterizes the differential effects of long-term care services and supports (LTSS) on disease management among older adults in different stages of cognitive impairment (CI). In specific, we use preventive care utilization and hypertension management as key indicators to assess the performance of disease management. We show that while access to LTSS from spouse or home-based services significantly facilitate active disease management behaviors, the effects are only evident among older adults with no CI. By contrast, access to LTSS has very modest effect for cognitively impaired individuals. In addition, older adults in more severe stages of CI perform worse in disease prevention, hypertension awareness and management. These findings reveal the vulnerability of older adults with CI in disease management and point to the importance of promoting targeted interventions to reduce barriers of accessing LTSS, especially among cognitively impaired population.

JEL Classification: J14, I18, I38, D10, H41

Keywords: aging, long-term services and supports, chronic disease management, cognitive impairment, preventive care utilization, disease awareness, hypertension

Corresponding author:
Xi Chen
Department of Health Policy and Management
Department of Economics
Yale University
60 College St
New Haven CT, 06520
USA

E-mail: xi.chen@yale.edu

1. Introduction

The world population is aging rapidly with a rising burden of chronic and non-communicable diseases (NCDs) (Bennett et al., 2018). Faced with enormous challenges in supporting older population, disease prevention and control are of crucial importance for individuals, families, and society. However, the performance of chronic disease management is far from satisfactory. The overall diagnosis, treatment and control rates of hypertension, for instance, are low in some developed countries; and the rates are even worse in developing countries, including China (World Health Organization, 2019). Moreover, as the population ages, a growing size of population is living with cognitive impairment (CI) including dementia, which makes disease management even more difficult and demanding (Livingston et al., 2020; Winblad et al., 2016). Declining cognitive function may interfere with patients' ability to detect health changes and adhere to disease management strategies, engendering new barriers for effective disease management and control, thereby increasing the risk of CI and leading to a vicious cycle (Feil et al., 2012).

The challenges are particularly acute in China, where a huge number of older adults are living with NCDs, and cognitive impairment with or without dementia (Chan et al., 2013; Jia et al., 2020; Yang et al., 2013; Zhou et al., 2019, 2016). Amid the escalating long-term care needs and the rapid aging trend, long-term services and supports (LTSS) are expected to play pivotal roles in China, especially given its potential for disease management (Disler et al., 2012; Tan et al., 2019). However, there is limited evidence assessing the impacts of LTSS in developing contexts. In China, the long-term care for older adults relies primarily on family members and informal caregivers, with increasing demands for formal LTSS including home-based and community-based services (Feng et al., 2020). Nevertheless, the capacity of the long-term care system is still concerning and the effectiveness of the LTSS remains to be examined. Notably, with reduced fertility in the past decades coupled with rapid urbanization and increased labor mobility, informal caregiving and support provided by family members and relatives is being increasingly strained (Feng et al., 2020, 2012). Meanwhile, despite recent efforts to reform long-term care system, formal LTSS, such as home and community-based services, are still underdeveloped (Feng et al., 2020; Wang et al., 2018). Facing the marked demographic shifts and system changes, it is very important to evaluate the availability of informal and formal LTSS in China, as well as their effectiveness in facilitating disease prevention and control. The assessment is particularly critical among people with cognitive

impairment, who have special needs in long-term care but face increased difficulties in obtaining services and supports (Wang et al., 2018).

Using nationally representative physical examination and survey data from the China Health and Retirement Longitudinal Study (CHARLS), this paper assesses the availability of LTSS among Chinese older adults and evaluates their impacts on preventive care utilization, hypertension awareness and management. In particular, we investigate the heterogeneity across older adults in different stages of CI.

We find that, LTSS are generally inadequate among Chinese older adults, particularly for those with CI. The overall utilization rates of home- and community-based services are quite low among all older adults; and older adults with more severe stages of CI are less likely to have access to spousal supports. Besides, the performance of disease management is consistently poorer among cognitive impaired older adults. Specifically, we find older adults with mild CI or severe CI have lower chance of receiving physical examination, become less aware of own hypertension status, and tend not to monitor blood pressure (BP) regularly or even annually as compared to those without CI. Severe CI, for example, leads to 42% lower odds of annual physical examination, 51% lower odds of hypertension awareness, 49% lower odds of annual BP examination, and 52% lower odds of regular BP examination relative to no CI.

We show that overall, access to LTSS can benefit older adults' disease management, with informal supports being more impactful than formal services. In particular, the effects of spousal supports are large and significant for disease prevention, hypertension awareness and monitoring; whereas formal home-based services only have significant positive effect on regular and annual BP examination. Moreover, the effects of LTSS seem to differ between older adults with and without CI. Some LTSS, such as spousal and home-based services, only have strong and significant impact for cognitively normal individuals. By contrast, no significant effect of LTSS on disease management are found for cognitively impaired individuals, despite some modest evidence suggesting the potential role of community-based services in equalizing the gaps of health education between individuals with and without CI.

These findings may contribute to the existing literature in several ways. First of all, we are one of the first to document the cognitive gradients in a broad range of disease management outcomes, both in prevention care utilization and hypertension management. We also show differences in access to LTSS across older adults in different stages of CI. Previous studies largely focus on the relationship between cognitive ability and self-management of a particular disease, usually with small sample size (Feil et al., 2012; Hajduk et al., 2013; Kiza and Cong, 2021; Lovell et al., 2019; Sinclair et al., 2000), while less attention is paid to disease prevention. Studies in China, on the other hand, mostly focus on the socioeconomic differences in disease management, neglecting the potential heterogeneity by cognitive ability (Feng et al., 2014; Li and Lumey, 2019; Lu et al., 2017; Zhao et al., 2016). Our study thus fills the gap by highlighting the high vulnerability of cognitively impaired individuals in utilizing preventive care and managing chronic diseases.

Second, we provide novel evidence on the impacts of informal and formal LTSS on the performance of disease management. While there is a growing body of studies showing the health impacts of LTSS, such as their impacts on physical function, mental health, harms, and mortality, evidence on disease prevention or chronic disease management is limited, especially in developing contexts (Disler et al., 2012; Sohn et al., 2020; Tan et al., 2019; Wysocki et al., 2015). This study enriches our understanding of the effects of access to LTSS on both preventive care utilization and the management of hypertension among Chinese older adults. Our results suggest that informal care still plays a critical role, while formal care only has modest impact on disease management. Continuous efforts, therefore, should be devoted to developing accessible, high-quality, and well-targeted home- and community-based services.

Finally, we reveal the differential effects of LTSS on disease management among older adults in different stages of CI. To our best knowledge, no study to date has shown the heterogenous effect of LTSS on disease management by stage of CI. In our study, we demonstrate that cognitively impaired older adults in China tend to benefit less from LTSS compared to those without CI. Our findings thus emphasize the increased vulnerability of older adults with CI in disease management, especially with weakening informal care; and point to the importance of promoting targeted interventions to reduce their barriers of receiving and utilizing LTSS.

2. Methods

2.1 Data Source

Data are obtained from China Health and Retirement Longitudinal Study (CHARLS), a nationally representative survey of Chinese older adults age 45 years or older. The national baseline was conducted in 2011, and the respondents were longitudinally followed up in 2013, 2015, and 2018. In each wave, comprehensive data on participants' demographic characteristics, family, health status and health care utilization, cognition, and work and economic conditions were collected (Zhao et al., 2014). Additionally, physical measurements, such as BP, were taken in 2011, 2013, and 2015. Each participant's systolic BP and diastolic BP were recorded three times by a trained nurse in 2015, and his or her medication usages were interviewed, which can be used to assess hypertension status. Yet, these biomarkers are not available for wave 2018 due to a revised survey design (Zhao et al., 2020).

In the first 3 waves, cognitive ability was assessed with a reduced form of the Telephone Interview for Cognitive Status (TICS) as well as the HRS version of CERAD immediate and delayed word recall. Starting in 2018, CHARLS took an expanded set of cognitive tests for older adults age 60 years and over, which includes Mini-Mental State Exam (MMSE), brief community screening instrument for dementia CSI-D, and other cognitive instruments (Zhao et al., 2020). These tests are well established and have been widely used to assess individuals' status of CI (Borenstein and Mortimer, 2016). Besides, as compared to previous three waves, 2018 survey additionally collected data on long-term care utilization, thereby allowing us to examine the LTSS. Therefore, our analysis primarily use cognition, disease management and LTSS data in 2018, with the additional use of BP biomarkers data in 2015 (for hypertension).

2.2 Cognitive Status

In our study, cognition of older adults is assessed with the Mini-Mental State Examination (MMSE), a 30-score scale that is designed to evaluate major domains of cognitive status, including orientation, attention, calculation, memory and language abilities (Folstein et al., 1975). As a validated cognitive instrument, the MMSE is widely used in clinical practice to screen for CI. According to an established classification criteria, participants are classified with the following

cut-off scores: no CI, 24-30; mild CI, 18-23; and severe CI, 0-17 (Tombaugh and McIntyre, 1992). The MMSE is only measured among older adults age 60 years and over in CHARLS 2018.

2.3 Long term Services and Supports

We measure both access to informal LTSS and formal LTSS in our analysis using 2018 data. Informal LTSS represent support from informal caregivers, such as children and spouse, friends, and other relatives. In this study, we measure the participants' access to supports from their children and spouse.[1] Access to children's support is assessed by adding up the total number of days the respondents have in-person contact with each children. Individuals whose children visiting them more often than sample median are considered having good access to children's support. Access to spousal support is measured by individuals' marital and co-residence status. Individuals who were married and living with spouses are considered having spousal support.[2]

Formal LTSS reflect the support and care obtained through professional agencies. In China, formal LTSS encompass two important components, including home-based services and community-based services (Feng et al., 2020; Li and Song, 2019).[3] In this study, we consider services that can be clearly classified into these two categories. For home-based services, we include the onsite visits and family beds; while for community-based services, we include day care centers and community nursing. Participants are asked to report if they have ever received each service.[4] Older

[1] While friends' support is also an important dimension to understand, the data largely impede the investigation. In CHARLS, friends' support can only be meaningfully measured by individuals' interaction with friends. However, the measure may suffer from serious endogeneity problem as interacting with friends are highly dependent on individuals' cognitive state and disease status. Therefore, we only consider it as a control rather than a key independent variable.

[2] It is difficult to find direct measures of informal care in CHARLS. The questions on care received are only asked for individuals who have functional limitations (e.g., activity of daily living), which would limit our sample size (by excluding more than 70% of the sample) and likely bias our sample. Therefore, we use indirect measures as a proxy for informal care and support. Note that, the measures only reflect individuals' potential access to LTSS, but not necessarily capture the actual utilization of these informal LTSS. Hence, we use "access to" rather than "utilization" throughout the paper.

[3] According to the literature, formal LTSS can be classified into three different categories: "(1) home-based care; (2) community-based care (such as daycare centers with trained staff); and (3) residential care in the form of nursing homes" (Feng et al., 2020; Li and Song, 2019). While the institutional-based services are also an important component of formal LTSS, the utilization of institutional care is extremely low in CHARLS (around 0.3%, i.e., 52 individuals). Hence, we can only meaningfully evaluate the first two components of formal care, i.e., home-based and community-based services, using CHARLS. Future studies need to evaluate the long-term care for institutional residents as well, probably using other more specialized data sources.

[4] In our sample, only a small proportion of people have ever received these services.

adults are considered to have good access to the services if any participants in their local area have ever used these services.[5] The local area is defined at the county level, stratified by rural and urban areas to account for the potential large variations in the policies and practices. Detailed variable definitions and construction can be found in Appendix B Table B1.

2.4 Disease Management

In this study, we focus on the utilization of preventive care, as well as the management of hypertension, a highly prevalent but inadequately controlled chronic disease in China. Disease prevention is measured by preventive care utilization. Participants were asked to report the time of their last physical examination (CHARLS physical examination in 2015 excluded). According to the reported exam date and interview date, we evaluate whether the participants took any physical examination within 1 year, within 3 years, or not. This is intended to measure the extent to which individuals actively monitor their overall health conditions, regardless of their illnesses.

The performance of hypertension management is evaluated based on hypertension awareness, health education, and monitoring. Participant's hypertension status is determined primarily based on biomarkers collected in 2015. An individual is considered hypertensive if he or she had an average systolic blood pressure (SBP) of $\geq$ 140 mm Hg, an average diastolic blood pressure (DBP) of $\geq$ 90 mm Hg, or self-reported use of antihypertensive medication (Feng et al., 2014; Lu et al., 2017). Participants with identified hypertension are deemed aware of their conditions if they reported they had ever been diagnosed by a doctor by 2018.[6] Besides, in 2018 survey, participants were asked if they have ever received any medical advice or health education regarding hypertension management, including weight control, exercise, diet, smoking control; and how they monitored their BP in the past 12 months. Specifically, participants were asked if they had at least

[5] To avoid self-selection problem, we measure whether individuals had access to home and community-based services in the local area rather than individuals' utilization of the services themselves.

[6] The awareness is defined as whether individuals have "ever" been diagnosed with hypertension by 2018. We do not assume that the participants still had hypertension in 2018 as their hypertension status might have changed by then. In other words, conditional on having hypertension in 2015, our awareness measure allows people to take 3 years to be aware of their condition (identified in 2015). People who tend to manage their chronic conditions well should be aware of their hypertension status sooner. The awareness gap between people with and without CI thus may narrow during the 3-year period. Nevertheless, its influence on the effects of LTSS can be less certain. As our estimates identify more of longer-term effects of LTSS on disease awareness and control than shorter-term effects, the effects of LTSS may not be conservative since we allow LTSS to have more time to kick in and take effect.

one BP test annually, and if they had regular BP examination.[7] Participants who reported hypertension diagnosis in 2018, in addition to the hypertensive cases identified in 2015, are included to investigate their overall performance of hypertension education and monitoring. Detailed variable definitions and construction are presented in Appendix B Table B2.

2.5 Sample Construction and Missing Data

Sample inclusion criteria are illustrated in Figure 1. Our sample are constructed primarily based on CHARLS 2018 survey as it has comprehensive cognitive assessment and detailed long-term care measures. Among 9,989 participants age 60 or older who participated in the cognition survey, 909 are excluded because they have incomplete measures of disease management, LTSS and sociodemographic characteristics. Of the remaining 9,080 participants, less than 40% complete all 30 items of MMSE tests, with the remaining 60% have at least some MMSE items missing. To account for the item-level missing data and alleviate the sample attrition, we follow the prior literature to prorate scale the non-missing cognitive scores among participants who completed at least 80% of the MMSE items (≥ 24 of the 30 items) (Andrew and Rockwood, 2010; Craft et al., 2020; Crowe et al., 2021; Ramirez et al., 2022; White et al., 2011; Zheng et al., 2018). For each individual, the prorating involves calculating his/her non-missing item scores, dividing by the number of non-missing items, and multiplying by the total number of MMSE items (i.e., 30 items). By rescaling the non-missing scores to 30, we are able to classify the stages of CI, without changing the relative scale for individuals with partial missing items. We exclude 1,379 samples who completed less than 80% non-missing items to ensure the accuracy of proration and cognitive measurements. This overall results in 7,701 samples with valid MMSE assessments.

The distribution of MMSE and cognitive status for these sample is illustrated in Appendix Figure A1, where we identify 3,757 with no CI, 2,500 with mild CI, and 1,444 with severe CI. Nevertheless, as we can see in the figure, many of the people with severe CI receive no proxy assistance when they answer the disease management questions, which challenges the reliability

[7] CHARLS does allow proxy respondent to help answer these questions. Despite the increased chance of recall bias among people with cognitive impairment, older adults in more severe stages of CI tend to receive more help from proxy respondents to answer these disease management questions. Hence, their frequent use of proxy respondents may alleviate the concerns of recall bias associated with cognitive impairment.

of their survey responses. Therefore, to ensure the accuracy of our outcome measures, we further exclude 934 samples with severe CI but no proxy from the analysis.

Finally, a total of 6,767 participants with valid measures of cognitive assessment (i.e., MMSE), LTSS, and basic individual sociodemographic characteristics from 2018 survey are included in the analysis. These sample are primarily used to examine the effects of LTSS and cognition on preventive care utilization (as illustrated in the left branch of Figure 1). Moreover, to assess the management of hypertension, we identify a group of 2,776 participants who has underlying risks of hypertension based on BP biomarkers collected in 2015 to examine their awareness of the condition as of 2018 survey.[8] Then, we identify a group of 3,479 participants who has hypertension either based on biomarkers or self-reported diagnosis to investigate their health education and monitoring of hypertension (as illustrated in the right branch of Figure 1).

[Figure 1 about here]

2.6 Statistical Analysis

As descriptive analyses, we examine the differences in sociodemographic characteristics, access to LTSS, and disease management across older adults in different stages of CI (i.e., no CI, mild CI, and severe CI). Chi-square test is employed for categorical variables and one-way ANOVA is employed for continuous variables.

To estimate the effects of LTSS on various binary disease management outcomes, logistic regressions are employed in this study. The model used can be specified as,

$$logit\ (p_i) = ln\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 LTSS_i + \beta_2 X_i + \alpha_p + \epsilon_i$$

where p_i is the conditional probability of the binary disease management outcome ($Y_i = 1$), given the explanatory variables included on the right-hand side of the equation, i.e., $p_i = \Pr\ (Y_i = 1|\mathbf{X_i})$.

[8] As the explanatory variables (i.e., cognition and LTSS) are only available in 2018, we evaluate the hypertension diagnosis/awareness and management also using the self-reported information collected in 2018.

$LTSS_i$ are the primary variables of interest, which consists of a series of dummy variables indicating whether individual i have access to informal care (i.e., children's support and spousal support) and formal care (i.e., home-based services, and community-based services). X_i are a set of individual sociodemographic and health attributes measured as of 2018 survey, including age, gender, years of schooling, rural/urban hukou status, number of chronic diseases, activities of daily living (ADL), instrumental activities of daily living (IADL), number of living children, social interaction, health insurance, and stages of CI.[9] These variables are included to control for heterogeneity in individual characteristics. In particular, CI is included in X_i to control for the variations in cognitive status and test its effects on disease management outcomes, consisting of two dummies indicating whether the individual has mild CI or severe CI (reference: no CI). Lastly, province fixed-effects, α_p, are included to account for geographical differences across provinces.

Moreover, to explore the heterogeneous effects of LTSS, we stratify our sample by cognitive status and estimate the models respectively for individuals with and without CI.[10] All the analyses are performed in Stata 17.0. Standard errors are clustered at county level.[11]

3. Results

3.1 Descriptive Findings

Table 1 shows the sociodemographic characteristics of our sample. Of the 6,767 older adults included, 3,757 have no CI, 2,500 have mild CI, and 510 have severe CI as measured in 2018. Older adults who are female, older aged, less educated, having rural hukou status or rural medical insurance, having more living children or more functional limitations are more likely to be in more severe stages of CI.

[9] We choose not to include household income and wealth due to a large number of missingness in income and asset variables (with about 25-30% of our sample having missing problems), which may bias our sample composition and greatly reduce statistical power given the limited sample size in our study. Education (years of schooling), rural/urban status thus are instead used as proxy measures of socioeconomic conditions. As a robustness check, we rerun the analyses by further controlling for income/wealth measures, and the findings are fairly consistent.
[10] We do the stratifying analysis because it has less assumptions on functional forms as compared to interactions. The sample size is not enough to further stratify cognitively impaired individuals into mild CI and severe CI.
[11] As a robustness check, we also run the analyses by clustering the standard errors at the community level, to address the potential concern of strong correlation within communities. The results are fairly robust to the community-level clustering.

[Table 1 about here]

As indicated in Figures 2 and 3, the performance of disease management is consistently poorer among people in more severe stages of CI, with the most salient difference in disease prevention. Overall, only 48% of the older adults have had physical examination within one year. Stratified by cognitive status, about 52% of older adults with no CI have taken physical examination in the past year, followed by 45% among mild CI, and 42% among severe CI (Figure 2). Notably, on average 41% of the older adults have never taken any physical examination within 3 years, where the difference between CI and non-CI is even larger as compared to their corresponding gap within 1 year. Around 48% of persons with CI, either mild or severe CI, did not take any physical examination within 3 years, while the percentage is comparatively lower among persons without CI (36%).

[Figure 2 about here]

Similar pattern is observed for hypertension management (Figure 3). We show that for individuals with hypertension, those in more severe stages of CI are significantly less likely to be aware of hypertension, receive health education, and monitor their BP annually or regularly. Overall, older adults perform poorly in hypertension management, with significantly worse performance among older adults with CI. The difference between individuals with and without CI is about 5-10% for each outcome.

[Figure 3 about here]

As for access to LTSS, we demonstrate that older adults with CI lack both formal and informal supports (Figure 4). In particular, individuals in more severe stages of CI tend to have less access to supports from spouse though with more access to children's support. Although cognitively impaired adults have greater access to home-based and community-based services, the actual utilization rates are still quite low, at less than 5%. These results, overall, point to the high vulnerability of older adults with CI.

[Figure 4 about here]

3.2 Effects of LTSS on Disease Management

Adjusting for sociodemographic characteristics and geographical differences, significant protective effects of LTSS are found for a set of disease management outcomes. People with spousal support are more likely to have physical examination in the past year [OR=1.20, 95%CI=1.04-1.38] than those without. In contrast, we find no significant association of access to children's support, and home-based and community-based services with physical examination (Table 2).

[Table 2 about here]

With regard to hypertension management, we show that access to spousal support has large and significant impact on hypertension awareness, health education and annual BP examination. In particular, as presented in Table 3 and Table 4, people with spouse present have 33% increased odds of being aware of hypertension, 43% increased odds of doing annual BP examination, and 37% increased odds of having regular BP examination than those without. On the other hand, older adults with local access to home-based services have 33% higher odds of annual BP examination and 46% higher odds of regular BP examination than those without the access. Besides, access to community-based services has marginally significant positive effect on health education [OR=1.22, 95%CI=0.99-1.51].

[Table 3 & 4 about here]

In addition, the regression analysis corroborates the observed gradient relationship between CI and disease management. Relative to older adults with no CI, individuals with mild CI or severe CI have significantly lower odds of taking physical examination, being aware of hypertension, and getting annual and regular BP tests. Gaps are even greater for older adults with severe CI as compared to those with mild CI (Appendix Figure A2).

3.3 Effects of LTSS on Disease Management by Stage of Cognitive Impairment

As CI greatly worsens individuals' ability to manage their diseases by themselves, the LTSS are potentially of crucial importance for cognitive impaired individuals and may have greater impact on this population than others. Meanwhile, CI may also create barriers for effectively seeking and utilizing the services, which can make it difficult for cognitively impaired individuals to benefit from LTSS. Therefore, it is an empirical question whether the effects of LTSS are larger or lower among people with CI as compared to those without CI. To examine the potential heterogeneous effects of LTSS, we separately run the regressions for older adults with and without CI. The results are illustrated in Figures 5-7.

Consistent with the baseline estimates, Figure 5 visualizes our estimates that cognitively intact older adults with children's support and spousal support are more likely to have physical examination in the past year, while no significant association is found for cognitively impaired individuals. Notably, despite the overall effect of children's support being insignificant, it has significant effect for older adults with no CI, though the effect size is relatively small compared to others.

[Figure 5 about here]

For hypertension management, the effects of informal LTSS are generally larger and more significant for older adults without CI than for those with CI (Figures 6-7). In particular, access to spousal support only has positive and significant association with disease awareness, health education, annual BP examination and regular BP examination among cognitively intact individuals, but not among impaired older adults. With regard to formal LTSS, the findings are relatively mixed. We find access to home-based services has larger and more significant effect on annual and regular BP examination among people without CI, while access to community-based services has larger and positive effect on health education for those with CI compared to others. Overall, these findings suggest that LTSS are more likely to have larger effects among older adults without CI and those with CI.

[Figure 6 & 7 about here]

3.4 Robustness of the Effects of LTSS

Above we have shown the positive effects of LTSS on disease management and its heterogeneity across people with and without CI. However, a few concerns may challenge the validity of our findings. In this section, we discuss the issues in detail and further validate our results through a set of sensitivity analyses and robustness checks.

One of the leading concerns is the sample selection. In our study, we include participants who have at least 24 non-missing items of MMSE and prorate the non-missing scores to alleviate the issue of sample attrition and item-level missingness. Nevertheless, the accuracy of cognitive measurements might be lower as we allow people to have more missing items. To alleviate the concern, we further restrict the samples to those who have less missing MMSE items. We obtain very similar results. In columns 1-6 of Appendix Tables A1-A5, we show that the results are fairly consistent when we restrict samples to those who have at least 26 or 28 of the non-missing items of MMSE.[12] On the other hand, the sample attrition might still be a threat since we impose such restriction on MMSE non-missing items. Hence, we relax such restriction to have more samples with partial missing items to be included, [13] and the findings are very consistent.[14] The sensitivity analyses overall largely alleviate the concerns of sample selection.

Another concern related to sample selection is the exclusion of samples with severe CI. In our main specification, to ensure the reliability of survey responses, we exclude samples who have severe CI but receive no proxy assistance in answering the disease management questions. Nevertheless, recall bias could still be an issue especially for people with severe CI. In columns 7-9 of Appendix Tables A1-A5, we show that the findings are the same even when we fully exclude samples with severe CI, either with or without proxy assistance.

[12] In fact, the results are similar for any values between 25 to 30 as the lower bounds of non-missing items. We use 26, 28 as two leading examples. Other results will be readily available upon request.
[13] For example, we may relax such restriction to allow people with >15 or 20 non-missing items to be included.
[14] The results are available upon request.

Third, while we use one of the most commonly used approaches to address item-level missingness, people may still have concerns about the proration since it assumes the missing items to have similar distributions as non-missing items. To address this issue, we employ an alternative imputation approach to show that our results are not sensitive to the specific imputation methods used. As CHARLS is a comparable family study of the Health and Retirement Study (HRS) in the US, we strictly follow a multivariate, regression-based procedure adopted and validated in the HRS to impute the missing cognitive items, which creates imputations through a sequence of multiple regressions (Raghunathan et al., 2020; Ryan J McCammon et al., 2022). Specifically, the approach uses a combination of relevant demographic (e.g., birth dates, age, gender, education, parental education), health (e.g., self-rated health, past health, morbidities, vision), and economic variables (e.g., household income, net wealth), as well as prior and current wave cognitive variables in the regressions to perform the imputations. More details of the approach can be found in the Appendix C and elsewhere (Raghunathan et al., 2020; Ryan J McCammon et al., 2022). Following the HRS imputation procedure, we obtain very similar results as shown in columns 10-12 of Appendix Tables A1-A5. Notably, our results are very consistent using different combinations of samples and approaches, which further consolidate the findings.[15]

The endogeneity of informal LTSS might also be an issue. In specific, more vulnerable older adults may need more help in disease management, and their access to informal support may also change accordingly. For example, the frequency of children's visits, a measure of intensive margin, might be affected by incremental changes in health needs. While it is difficult to leverage an exogenous change to directly identify the causal effect of informal LTSS on disease management, we mitigate this concern through two different ways. First, we use an alternative measure of children's support mainly reflects the support at an extensive margin, i.e., whether an individual co-resides with children. In response to worsening health status, living arrangement is less prone to change compared to the frequency of children visiting parents.[16] The results in columns 1-3 of Appendix Tables A6-A10 indicate that our findings are robust to the specification. Second, the endogeneity

[15] For example, the results are pretty similar when we perform the HRS imputation procedure for participants who completed at least 50% 60% 70%...90% of the MMSE items.

[16] The using of intergenerational living arrangement measure may lose some variation of children's support. As for other informal support (e.g., spousal support), unfortunately, there is no alternative measure of better quality in CHARLS.

problem might also be alleviated if we could better control for individuals' health status. Hence, in addition to the ADL, IADL functional limitations and number of chronic diseases controlled for in our main specification, we further control for individuals' self-related health and childhood health conditions and present the results in the columns 4-6 of Appendix Tables A6-A10. The results are consistent with our baseline estimates. Moreover, the results are also robust to the further control of depressive symptoms (i.e., measured by CES-D).[17] Although the analysis may not fully address the endogeneity problem, the robustness of the results to a large extent strengthens the validity of our findings.

Besides, it is also possible that the effects of children's support might depend on individuals' access to spousal support. In other words, there might be some interactive effects between these two types of informal supports. In Appendix Table A11, we construct a set of measures to capture individuals' access to an interaction of spousal and children's support. However, consistent with baseline results, there is no evidence showing the effect of children's support for older adults with no spousal support.

Finally, as our study primarily focus on older adults with different stages of CI, it is important to know whether our findings are sensitive to the classifications of CI. In the columns 7-12 of Appendix Tables A6-A10, we show that our results are not sensitive to either the cutoffs of MMSE and or the use of cognitive measurements for classifications. With regard to cutoffs, we employ an alternative cutoffs of MMSE that has been used and validated in China (An and Liu, 2016; Yao et al., 2021). Particularly, it uses 25 as the cutoffs for CI, rather than 24 as what we have in the main specification. The results are pretty similar as shown in columns 7-9. We also find that the results are not sensitive to varying the cutoffs up or down by 1-2 points, which further consolidate our findings.[18] With regard to cognitive measurements, we use some other cognitive tests (TICS and CERAD word recall) collected in CHARLS to assess cognitive abilities and show that the findings are robust to alternative cognitive measurements. Specifically, following prior literature (Lin and Chen, 2021; Xu et al., 2015), we use global cognitive score to evaluate individuals' cognitive abilities, which is a summary score of immediate word recall, delayed word recall, serial 7 tests,

[17] The results including depressive symptoms as controls will be available upon request.
[18] Due to space limit, these results are readily available upon request.

date naming, and picture drawing (ranging 0-30).[19] Individuals are classified into no CI, mild CI and severe CI using the tertiles of the global cognitive scores to be comparable with the CI classifications using MMSE. The findings are fairly consistent with the main results as shown in columns 10-12, indicating the robustness of the results to the cognitive measurements.

These analyses overall demonstrate that our findings are very consistent and robust to different sample selections as well as alternative measurements and specifications.

4. Discussion and Conclusion

Amid rapid population aging and rising burden of non-communicable diseases (NCDs), a sizable and still growing share of Chinese older adults live with mild-CI or dementia. Consequently, the demand for services and supports will grow substantially as effective disease prevention and control can be cognitively demanding. Using nationally representative physical examination and survey data from waves 2015 and 2018 of the China Health and Retirement Longitudinal Study (CHARLS), this paper is among the first to document the cognitive gradients in disease management and characterize the differential effects of long-term care services and supports (LTSS) on disease management among older adults by stage of CI. In particular, we examine a rich set of disease management outcomes from preventive care utilization to hypertension management, highlighting the potential challenges in supporting cognitively impaired older adults.

Several findings warrant further discussion. First of all, we find that older adults in more severe stages of CI are facing greater vulnerability in disease management while having insufficient access to formal and informal supports. Compared to cognitively intact individuals, those with CI are 10-15% less likely to utilize physical examinations, and about 10% less likely to be aware of hypertension, receive health advice, or effectively monitor their BP. A lack of disease prevention and control will inevitably elevate disease risks, accelerating the progression of cognitive aging and widening the health gaps across population groups. While LTSS may provide supports to these individuals, cognitively impaired adults are less likely to have spousal support than those without CI. Moreover, the overall utilization rate of home-based and community-based services are quite

[19] The measure can better reflect the overall cognitive abilities than disorders.

low, even though they have access to these services. Therefore, given the weakening informal care under the changing demographic structure, more efforts should be devoted to improving the provision of formal long-term care and services and encouraging the effective utilization of the services, especially among cognitively impaired individuals.

Second, we demonstrate that LTSS play a critical role in facilitating disease management. In particular, access to informal spousal support can greatly increase preventive care use and help older adults manage and monitor their health and chronic conditions, such as hypertension. As for formal LTSS, we find that home-based services may augment the likelihood of having annual and regular BP examination, and community-based services may slightly increase the likelihood of receiving health education. The smaller effects observed for formal LTSS compared to informal LTSS are not that surprising as home-based and community-based services in China are still underdeveloped and unequally distributed. Despite recent efforts of Chinese government in promoting long-term care systems, Chinese long-term care and services are still facing the problems of low availability, weak quality assurance, severe workforce shortage, and limited public financing (Feng et al., 2020). These policy issues may largely restrict the effectiveness of formal LTSS. Besides, limited utilization of formal LTSS from the demand side may also explain the lack of effect. As family values are highly regarded among Chinese population, older adults may prefer informal care provided by family members over that by formal caregivers, especially when the quality of formal LTSS is still unsatisfactory (Feng et al., 2012). Our findings thus re-emphasize the importance and necessity of continuing promoting long-term care systems formal LTSS, particularly given the declining supply of informal family support. Specifically, more high-quality and well-accessible provision of formal LTSS from the supply side may motivate more effective utilization from the demand side to achieve the full potential in promoting disease management (Feng et al., 2020, 2012).

Third, we show that individuals with CI are less likely to benefit from informal LTSS than those without CI. The effects of spousal support on disease management are consistently lower and weaker among older adults with CI as compared to those without CI. This pattern is broadly observed for physical examination as well as hypertension awareness, health education, and monitoring, which implies the challenges cognitively impaired older adults face in benefiting from

informal care. Older adults with CI, especially those with dementia, often need comprehensive and continuous support from caregivers; however, the co-occurred behavioral and psychological symptoms can make it extremely hard for informal caregivers to understand their actual demands and feelings, thereby imposing large barriers for caregivers to offering appropriate care and support (Savva et al., 2009). Moreover, the caregivers of people with CI may have poor physical and mental health due to the great burden and stress of caregiving, restricting their capacity of providing persistent and high-quality long-term care (Nam and Park, 2017). Therefore, publicly-funded training and supporting programs should be provided to help informal caregivers possess professional skills and knowledge and alleviates their burden of caregiving, thereby ensuring the quality of care received by older adults with CI (Wang et al., 2018). With regard to formal LTSS, home-based services are found to have less effect for people with CI than those without CI, similar to the patterns of informal LTSS. Although formal LTSS can facilitate disease management, people with CI may face increased difficulties and barriers in seeking for or utilizing proper long-term care and services due to their impaired cognitive function (Wang et al., 2019, 2018). The problem can be particularly salient in China, where the LTC for dementia are still inadequate and underdeveloped. While we do find some evidence that community-based services may somewhat equalize the differences in disease management between people with and without CI in health education,[20] the effects are not evident in other dimensions of disease management. More public financing and well-trained professionals are thus needed to ensure the quality and effectiveness of formal long-term care services, especially for cognitively impaired or demented older adults.

Our analysis has some limitations and weaknesses. First, our reliance on individual-level survey data to investigate LTSS is subject to recall biases and inaccuracies. It might be of interest for future studies to use administrative data or community-level survey data to more accurately measure the provision of LTSS. Second, our measures of informal care only capture the access but may not fully reflect the actual supports individuals received or utilized. CHARLS did not collect adequately rich information on informal caregiving for all participants, which hinders us from holistically assessing the supports individuals receive. Besides, our study only assesses two major components of formal LTSS, including home- and community-based services, but do not examine the effects of institutional care. More research is thus needed to evaluate the effects of informal

[20] This is probably due to the exposure to the extensive health educational campaigns in the community.

care utilization as well as the effects of institutional care among older adults. Third, information on biomarkers were collected three years before our measures of hypertension management, therefore our estimates should identify more of longer term effects on disease awareness and control than shorter term effects, since individuals have about 3 years to be aware of their conditions.[21] Fourth, only a snapshot measure of MMSE is collected, which does not allow us to examine how the transition from no-CI to mild-CI or severe-CI would interfere with preventive care utilization and chronic disease management. Follow-up surveys are needed to understand the temporal relationship. Finally, to ensure the accuracy of measurements, we exclude a portion of samples with missing items or samples with severe CI but no proxy from the analysis. The findings thus may not be generalized to the whole population given the differences.[22]

Despite these limitations, this study provides novel evidence on the impact of LTSS on disease management, and reveals the difficulties and challenges for older adults with CI to manage their diseases and to benefit from LTSS. Our findings may inspire future research to identify the exact barriers in existing practice as well as effective strategies to support vulnerable populations.

[21] Based on the survey data, we cannot capture the change in hypertension status. Nevertheless, our focus is whether people have ever realized the fact that they ever had hypertension status in 2015 (with at least 3 years learning periods), which do not assume their hypertension status to be unchanged. In fact, identification of shorter-term effects on disease awareness and control can be subject to more measurement errors, given the instant timing and delayed learning effect.

[22] As shown in Appendix Table 12, the samples included are more likely to have more advantaged sociodemographic characteristics. Specifically, people who are male, younger aged, higher educated, and people who have urban hukou, less functional limitations are more likely to be included in the analysis. Nevertheless, gaps in the characteristics between included samples and all participants are small in magnitude, which may alleviate some of the concerns over representativeness.

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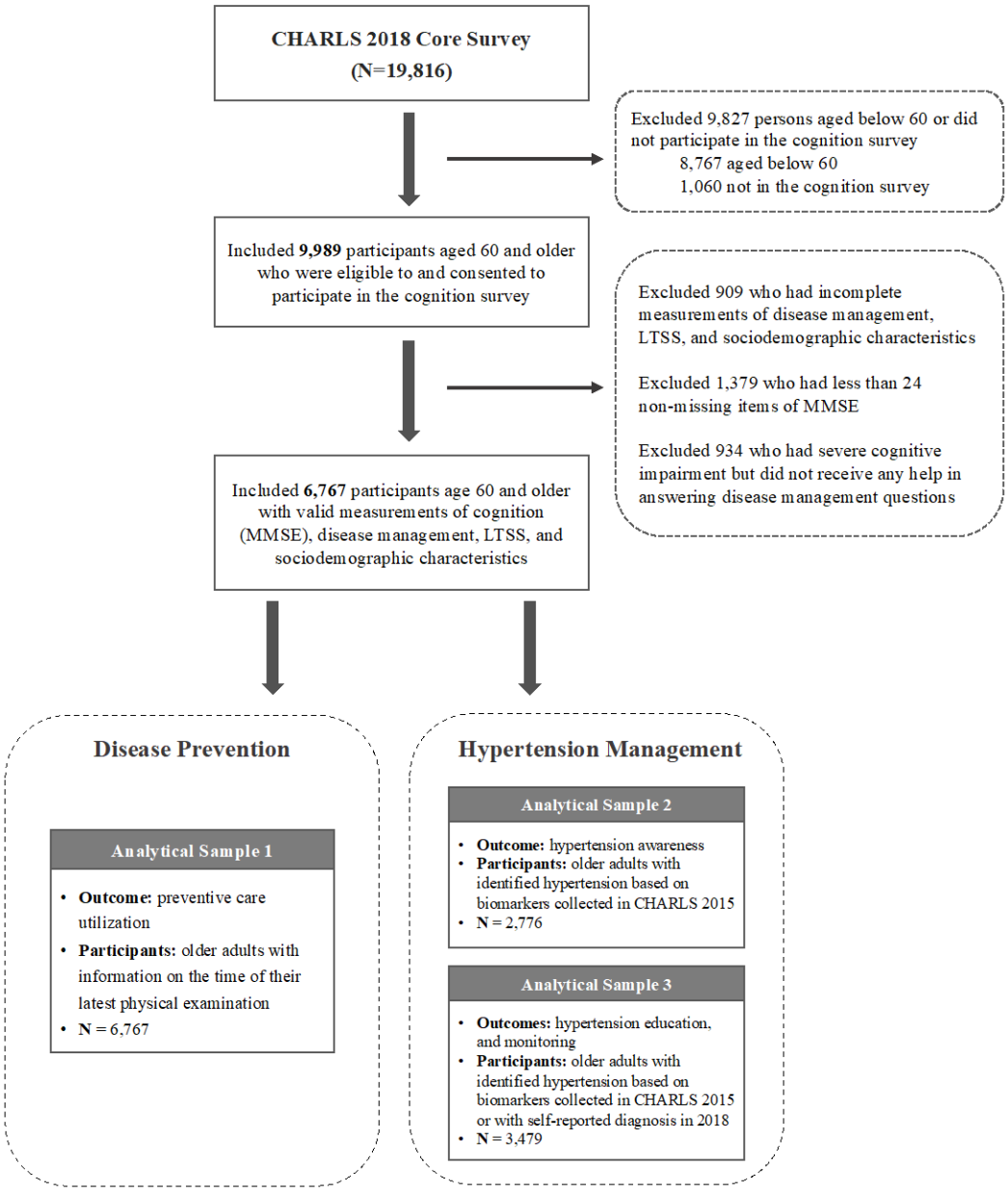
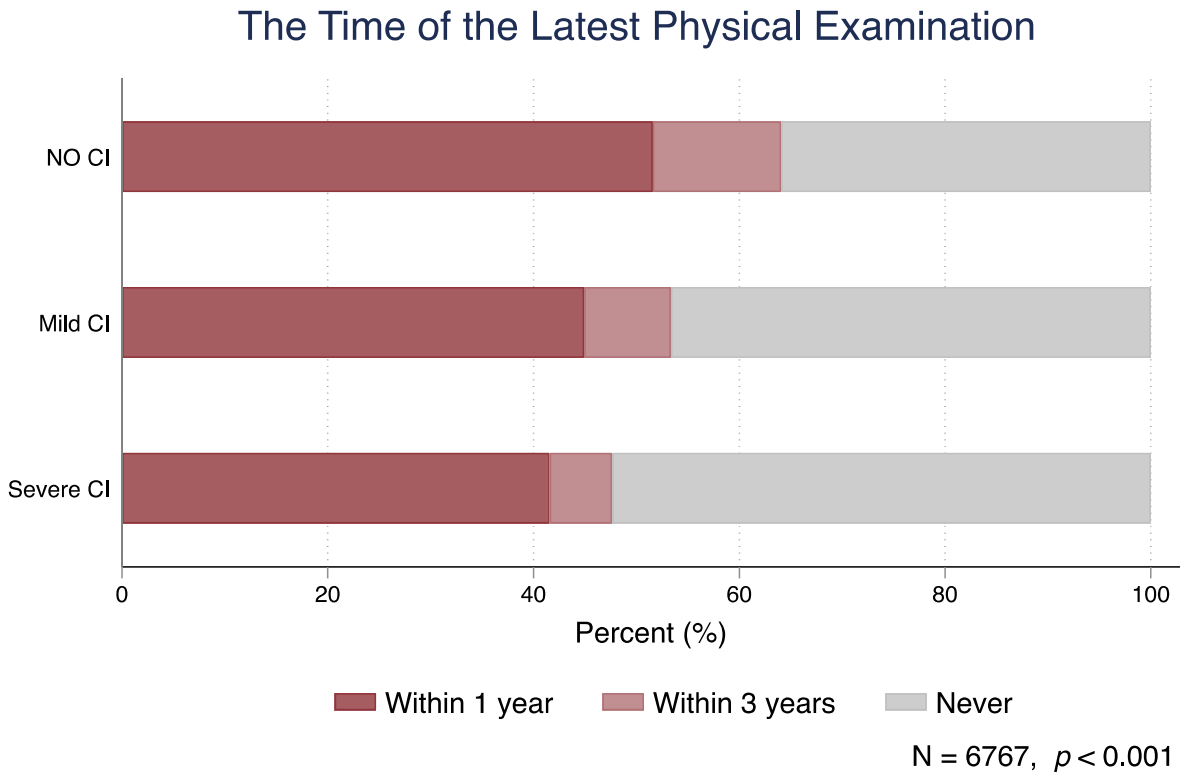
Figures and Tables

Figure 1. Flow chart of sample inclusion and study participants



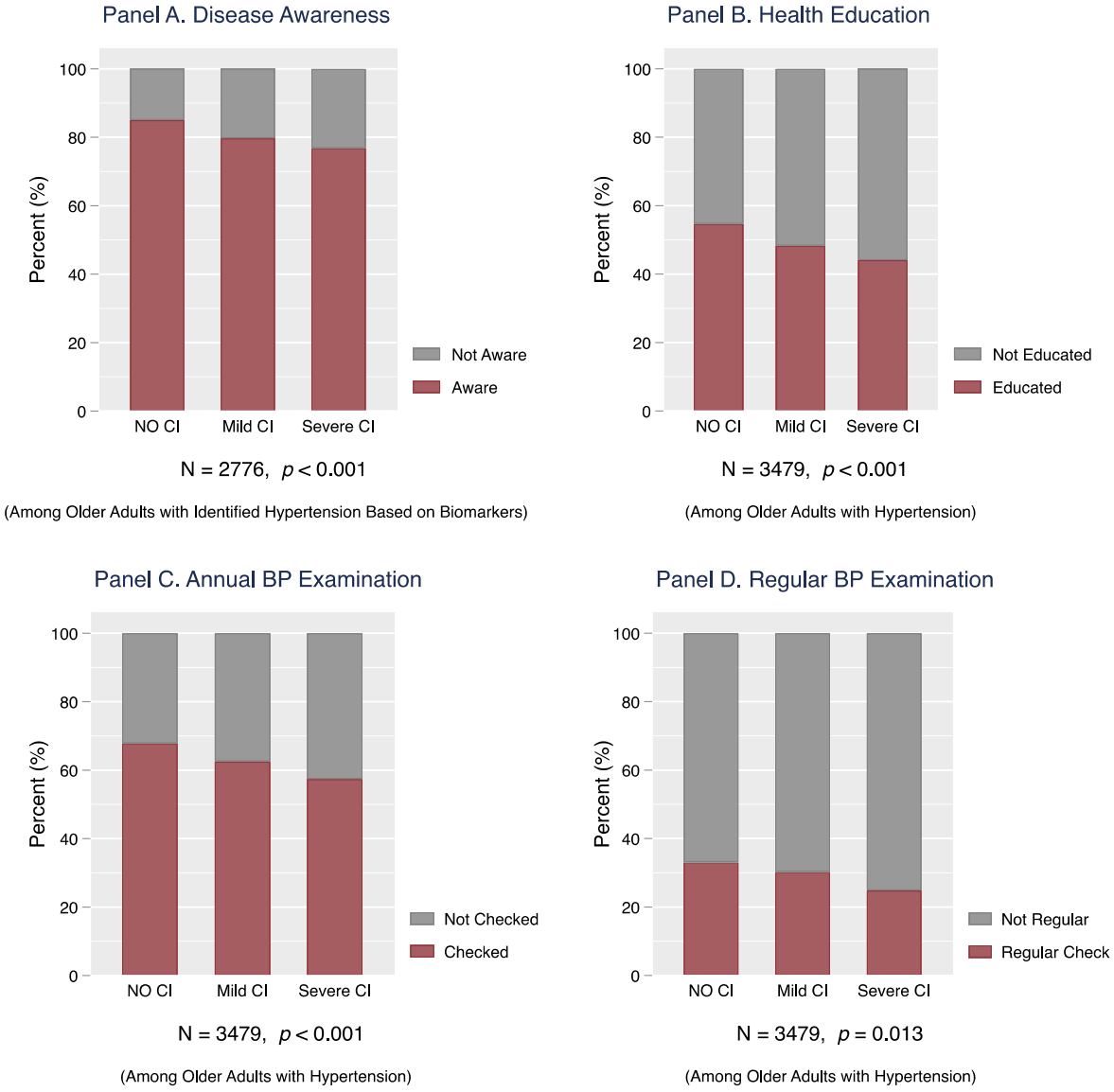
Notes: CHARLS = China Health and Retirement Longitudinal Study; MMSE = Mini-Mental States Examination; LTSS = Long-term Services and Supports. Biomarkers, including systolic and diastolic blood pressure, were collected by a trained nurse in CHARLS 2015 wave.

Figure 2. Physical examination among older adults in different stages of cognitive impairment (CI)



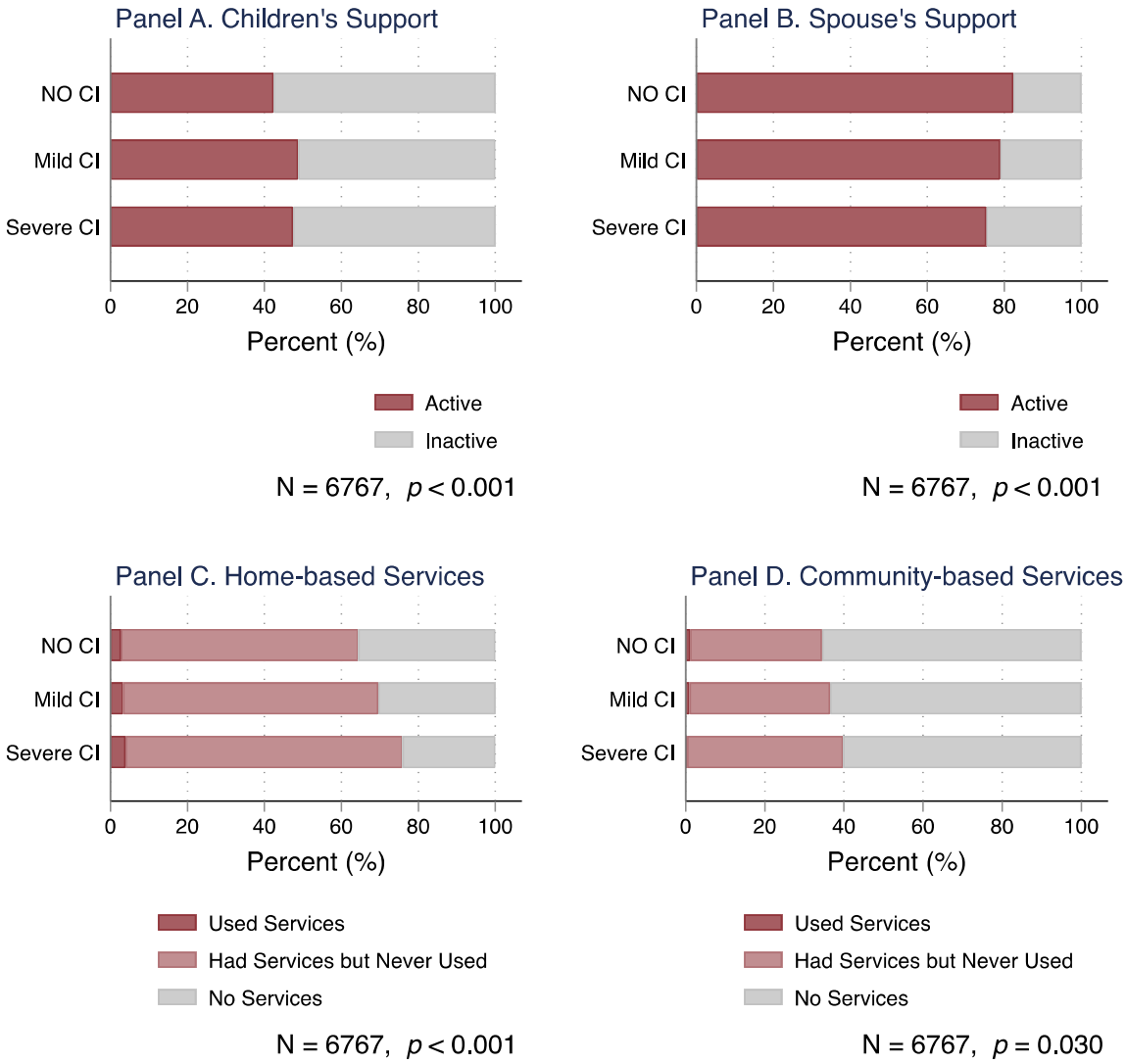
Notes: "Never" means that individuals have never had any physical examination in the past 3 years. P-value is calculated using Chi-square test.

Figure 3. Awareness, education, and monitoring of hypertension among older adults in different stages of cognitive impairment (CI)



Notes: Disease awareness denotes whether individuals with hypertension identified by biomarkers in the wave of 2015, have ever been diagnosed with hypertension by a doctor by the wave of 2018. Health education denotes whether individuals have ever been given health education/advice by doctors to control their hypertension, including weight control, exercise, diet and/or smoking control. Annual blood pressure (BP) examination denotes whether individuals have BP examination in the past year. Regular BP examination denotes whether individuals have had BP examination by community/village doctors regularly. Health education, annual BP examination, and regular BP examination are examined among individuals either have identified hypertension in the wave of 2015 or know they have hypertension as of the wave of 2018, i.e., with hypertension. P-values are calculated using Chi-square test.

Figure 4. Access to various types of long-term services and supports (LTSS) among older adults in different stages of cognitive impairment (CI)



Notes: Children's support measures whether individuals have children's visits more than median (active) or below (inactive). Spousal support measures whether individuals have spouse present (active) or not (inactive). Home-based services encompass family beds and onsite visit, and community-based services encompass day care centers and community nursing. For each service, access (i.e., having services or not) is measured at the county level, stratified by rural/urban areas; whereas the utilization of service is assessed at the individual level. P-values are calculated using Chi-square test.

Figure 5. Effects of LTSS on physical examination among older adults with and without cognitive impairment (CI)

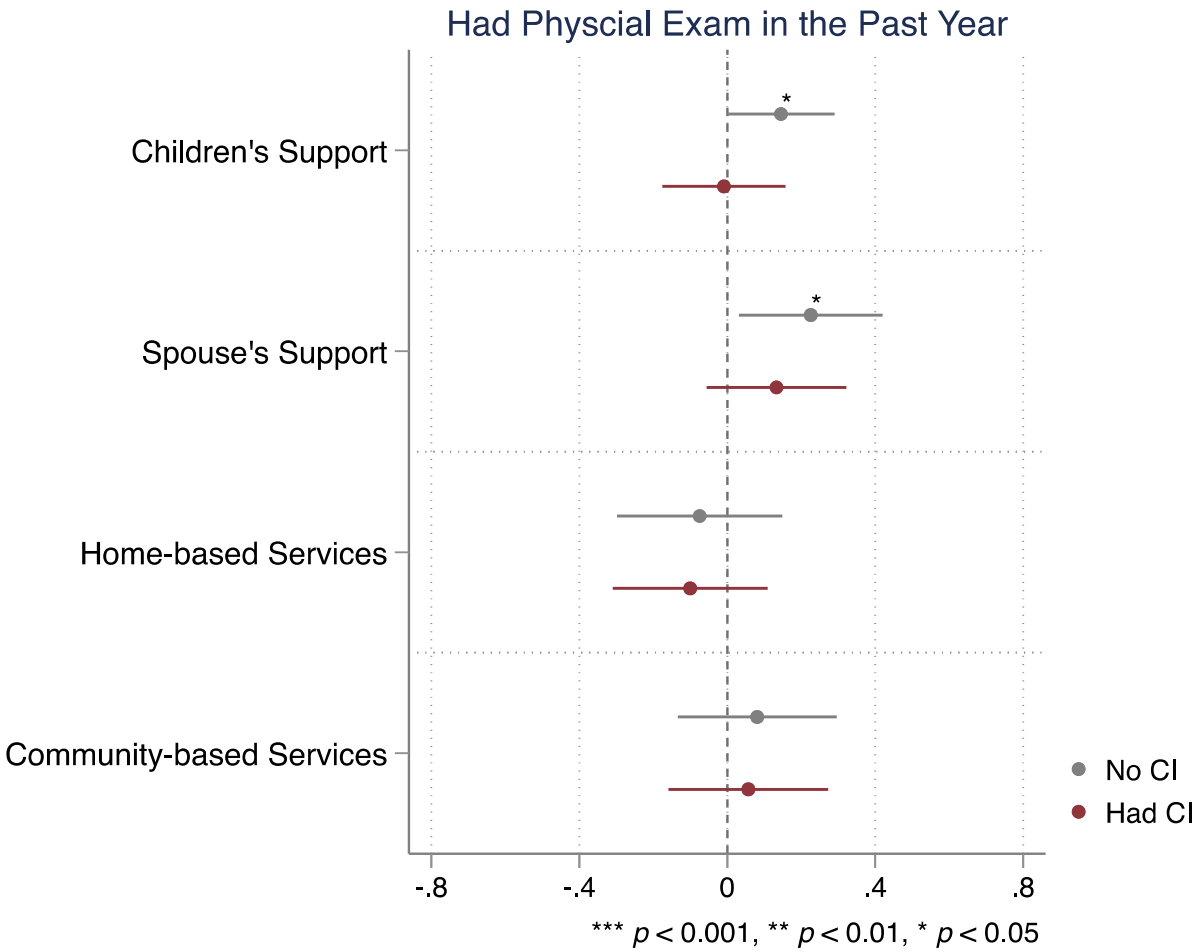
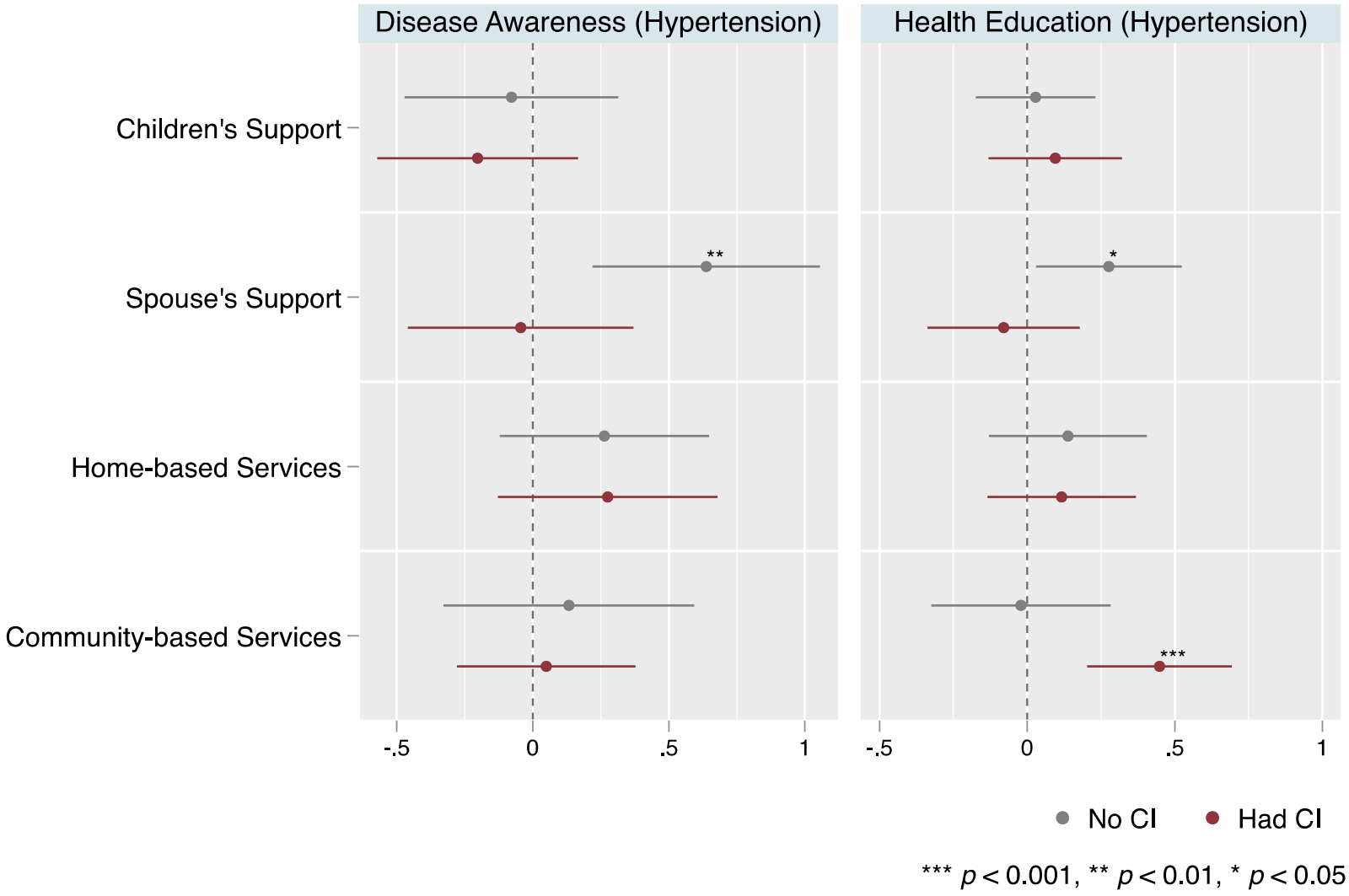
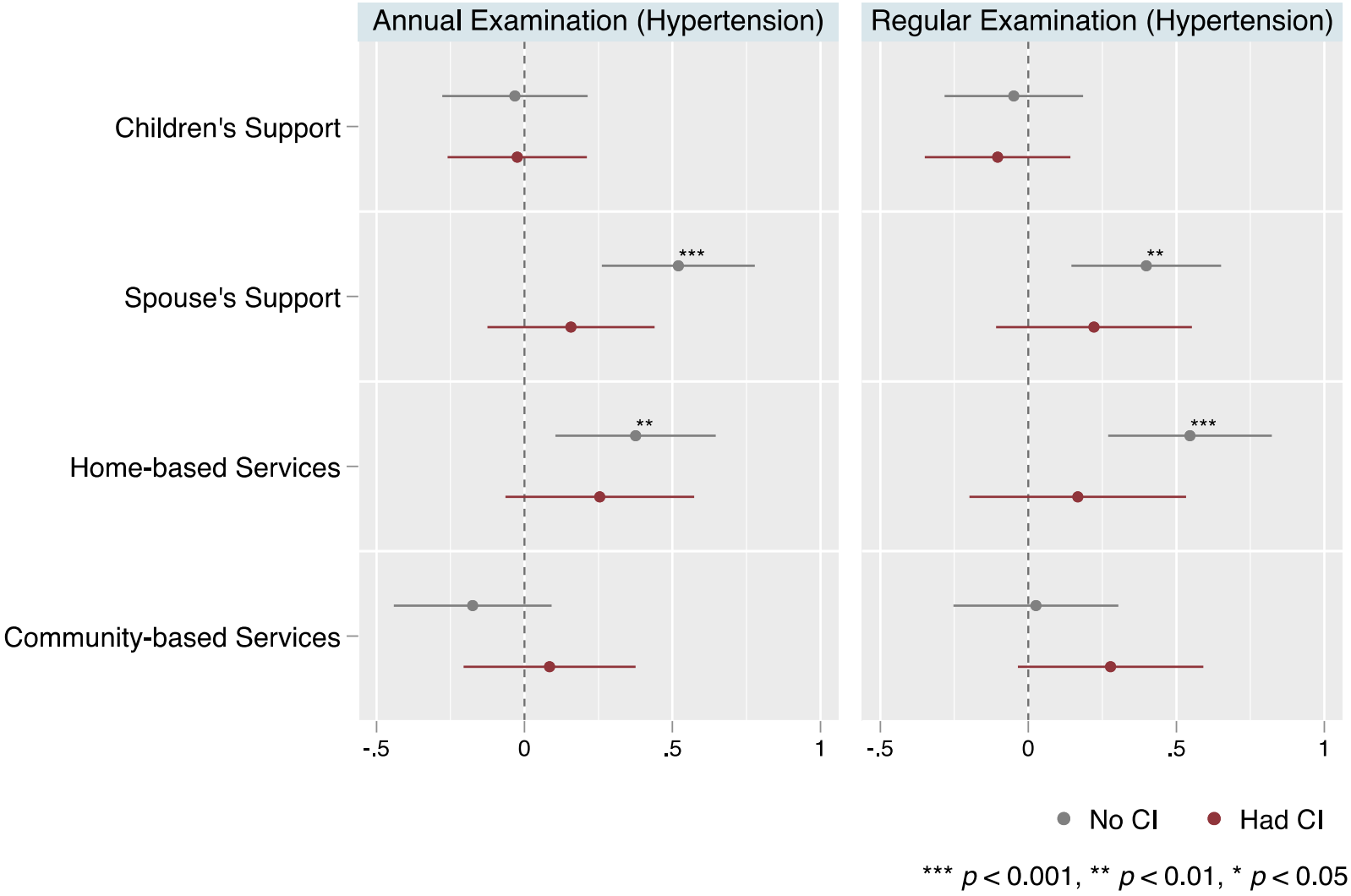


Figure 6. Effects of LTSS on the awareness and education of hypertension among older adults with and without cognitive impairment (CI)



Notes: The left panel shows the logistic regression estimates for the awareness of hypertension, while the right panel shows the results for the health education of hypertension. Hypertension awareness denotes whether individuals with hypertension identified by biomarkers in the wave of 2015, have ever been diagnosed with hypertension by a doctor by the wave of 2018. It is assessed among older adults with identified hypertension according to the biomarkers of wave 2015. Health education denotes whether individuals have ever been given health education/advice by their doctors to control their hypertension, including weight control, exercise, diet and/or smoking control. It is assessed among older adults either have identified hypertension in the wave of 2015 or know they have hypertension as of the wave of 2018. Logistic regressions are respectively conducted among sample without CI (shown in gray color; N = 1,498 for awareness and N = 1,928 for education) and sample with CI (shown in red color; N = 1,243 for awareness and N = 1,549 for education) to examine the association between LTSS and hypertension awareness and education. Plotted points represent the regression coefficients, and the horizontal lines represent the 95% confidence intervals. Standard errors are clustered at county level. All the regression models control for age, gender, education, rural/urban status, number of chronic diseases, ADL, IADL, number of living children, social interaction, and health insurance. Detailed estimates are available upon request.

Figure 7. Effects of LTSS on the monitoring of hypertension among older adults with and without cognitive impairment (CI)



Notes: The left panel shows the logistic regression estimates for annual blood pressure (BP) examination, while the right panel shows the results for regular BP examination. Annual BP examination denotes whether individuals have BP examination in the past year. Regular BP examination denotes whether individuals have had blood pressure examination by community/village doctors regularly. Both variables are assessed among older adults who either have identified hypertension in the wave of 2015 or know they have hypertension as of the wave of 2018 (i.e., with hypertension). Logistic regressions are respectively conducted among sample without CI (shown in gray color; N = 1,928 annual BP examination and N=1,921 for regular BP examination) and sample with CI (shown in red color; N = 1,549 for both variables) to examine the association between LTSS and hypertension monitoring. Plotted points represent the regression coefficients, and the horizontal lines represent the 95% confidence intervals. Standard errors are clustered at county level. All the regression models control for age, gender, education, rural/urban status, number of chronic diseases, ADL, IADL, number of living children, social interaction, and health insurance. Province fixed effects are included. Detailed estimates are available upon request.

Table 1. Characteristics of older adults in different stages of cognitive impairment (CI)

	(1) Total (N=6767)	(2) No CI (N=3757)	(3) Mild CI (N=2500)	(4) Severe CI (N=510)	(4) *p*-value
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Female	0.442 (0.497)	0.372 (0.483)	0.489 (0.500)	0.727 (0.446)	<0.001
Age	67.935 (6.042)	67.581 (5.720)	67.996 (6.124)	70.249 (7.312)	<0.001
Years of Schooling	5.113 (4.625)	6.859 (4.383)	3.382 (4.066)	0.735 (2.234)	<0.001
Rural Status	0.711 (0.453)	0.609 (0.488)	0.820 (0.384)	0.925 (0.263)	<0.001
Number of Chronic Diseases	2.545 (1.972)	2.533 (1.944)	2.542 (2.007)	2.653 (1.999)	0.477
IADL (0-5)	0.424 (0.940)	0.244 (0.684)	0.508 (1.005)	1.341 (1.493)	<0.001
ADL (0-5)	0.354 (0.892)	0.242 (0.718)	0.432 (0.973)	0.800 (1.346)	<0.001
Number of Living Children	3.043 (1.560)	2.801 (1.476)	3.220 (1.518)	3.955 (1.882)	<0.001
Urban employee MI	0.194 (0.395)	0.284 (0.451)	0.094 (0.292)	0.022 (0.145)	<0.001
Urban-rural residence MI	0.124 (0.329)	0.119 (0.323)	0.132 (0.339)	0.120 (0.325)	0.261
Urban-residence MI	0.049 (0.215)	0.059 (0.235)	0.040 (0.197)	0.018 (0.132)	<0.001
New rural cooperative MI	0.586 (0.493)	0.488 (0.500)	0.694 (0.461)	0.782 (0.413)	<0.001
Governmental MI	0.022 (0.148)	0.033 (0.179)	0.009 (0.093)	0.010 (0.099)	<0.001

Notes: *p*-values are calculated based on Chi-square test for categorical variables, and one-way ANOVA for continuous variables. Abbreviations: CI, cognitive impairment; SD, standard deviation; ADL, activities of daily living; IADL, instrumental activities of daily living; MI, medical insurance.

Table 2. Effects of LTSS on physical examination

VARIABLES	(1)	(2)
	Physical Examination in the Past Year	
	β (SE)	OR [95% CI]
Children's Support	0.073	1.08
	(0.059)	[0.96 - 1.21]
Spousal Support	0.179*	1.20
	(0.073)	[1.04 - 1.38]
Home-based Services	-0.093	0.91
	(0.090)	[0.76 - 1.09]
Community-based Services	0.077	1.08
	(0.091)	[0.90 - 1.29]
Observations	6,767	
Covariates	YES	
Province FE	YES	
Pseudo R-squared	0.069	

Notes: Logistic regression is conducted for disease prevention. Standard errors are clustered at county level. Preventive care utilization is assessed among all older adults. Stage of cognitive impairment status is controlled (see Figure A2 for the estimates) and the regression model also controls for age, gender, education, rural/urban status, number of chronic diseases, ADL, IADL, number of living children, social interaction, and health insurance. Province fixed effects are included. Abbreviations: OR, odds ratio; SE, standard errors; CI, cognitive impairment; FE, fixed effects. Statistical significance: *** p<0.001, ** p<0.01, * p<0.05.

Table 3. Effects of LTSS on the awareness and education of hypertension

VARIABLES	(1)	(2)	(3)	(4)
	Disease Awareness (Hypertension)		Health Education (Hypertension)	
	β (SE)	OR [95% CI]	β (SE)	OR [95% CI]
Children's Support	-0.147	0.86	0.058	1.06
	(0.129)	[0.67 - 1.11]	(0.074)	[0.92 - 1.23]
Spousal Support	0.285*	1.33	0.122	1.13
	(0.143)	[1.00 - 1.76]	(0.096)	[0.94 - 1.36]
Home-based Services	0.258	1.29	0.144	1.16
	(0.137)	[0.99 - 1.69]	(0.106)	[0.94 - 1.42]
Community-based Services	0.072	1.07	0.200	1.22
	(0.137)	[0.82 - 1.41]	(0.108)	[0.99 - 1.51]
Observations	2,760		3,479	
Covariates	YES		YES	
Province FE	YES		YES	
Pseudo R-squared	0.290		0.093	

Notes: Logistic regression is conducted for each of the two outcome variables. Standard errors are clustered at county level. Hypertension awareness denotes whether individuals with hypertension identified by biomarkers in the wave of 2015 have ever been diagnosed with hypertension by a doctor by the wave of 2018. It is assessed among older adults with identified hypertension according to CHARLS biomarkers collected in 2015 wave. Health education denotes whether individuals have ever been given health education/advice by doctors to control their hypertension, including weight control, exercise, diet and/or smoking control. It is assessed among older adults either have identified hypertension in the wave of 2015 or know they have hypertension as of the wave of 2018 (i.e., with hypertension). Stage of cognitive impairment status is controlled (see Figure A2 for the estimates) and the regression models also control for age, gender, education, rural/urban status, number of chronic diseases, ADL, IADL, number of living children, social interaction, and health insurance. Province fixed effects are included. Abbreviations: OR, odds ratio; SE, standard errors; CI, cognitive impairment; FE, fixed effects. Statistical significance: *** p<0.001, ** p<0.01, * p<0.05.

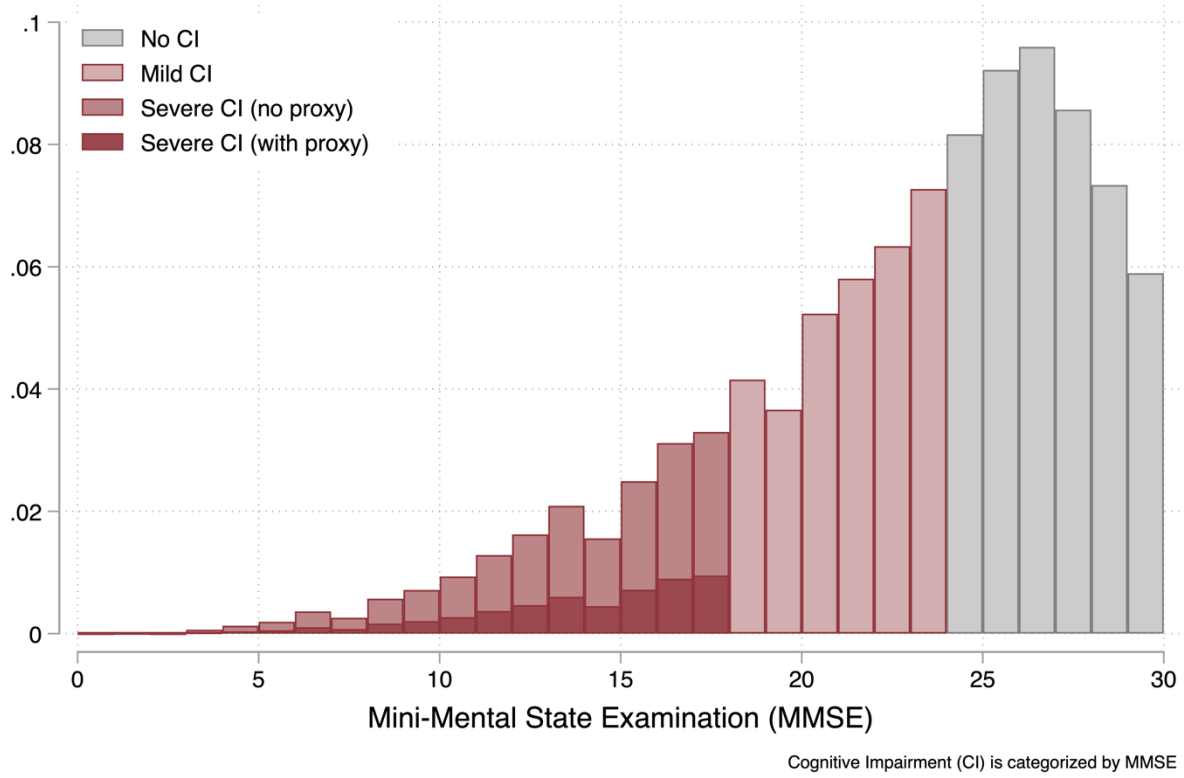
Table 4. Effects of LTSS on the monitoring of hypertension

VARIABLES	(1)	(2)	(3)	(4)
	Annual BP Examination (Hypertension)		Regular BP Examination (Hypertension)	
	β (SE)	OR [95% CI]	β (SE)	OR [95% CI]
Children's Support	-0.036	0.96	-0.077	0.93
	(0.084)	[0.82 - 1.14]	(0.084)	[0.79 - 1.09]
Spousal Support	0.358***	1.43	0.312**	1.37
	(0.100)	[1.17 - 1.74]	(0.113)	[1.10 - 1.70]
Home-based Services	0.283*	1.33	0.379**	1.46
	(0.116)	[1.06 - 1.67]	(0.137)	[1.12 - 1.91]
Community-based Services	-0.041	0.96	0.159	1.17
	(0.116)	[0.76 - 1.21]	(0.118)	[0.93 - 1.48]
Observations	3,479		3,479	
Covariates	YES		YES	
Province FE	YES		YES	
Pseudo R-squared	0.094		0.077	

Notes: Logistic regression is conducted for each of the two outcome variables. Standard errors are clustered at county level. Annual BP examination denotes whether individuals have BP examination in the past year. Regular BP examination denotes whether individuals have had blood pressure examination by community/village doctors regularly. Both variables are assessed among older adults who either have identified hypertension in the wave of 2015 or know they have hypertension as of the wave of 2018 (i.e., with hypertension). Stage of cognitive impairment is controlled (see Figure A2 for the estimates) and the regression models also control for age, gender, education, rural/urban status, number of chronic diseases, ADL, IADL, number of living children, social interaction, and health insurance. Province fixed effects are included. Abbreviations: OR, odds ratio; SE, standard errors; CI, cognitive impairment; FE, fixed effects. Statistical significance: *** p<0.001, ** p<0.01, * p<0.05.

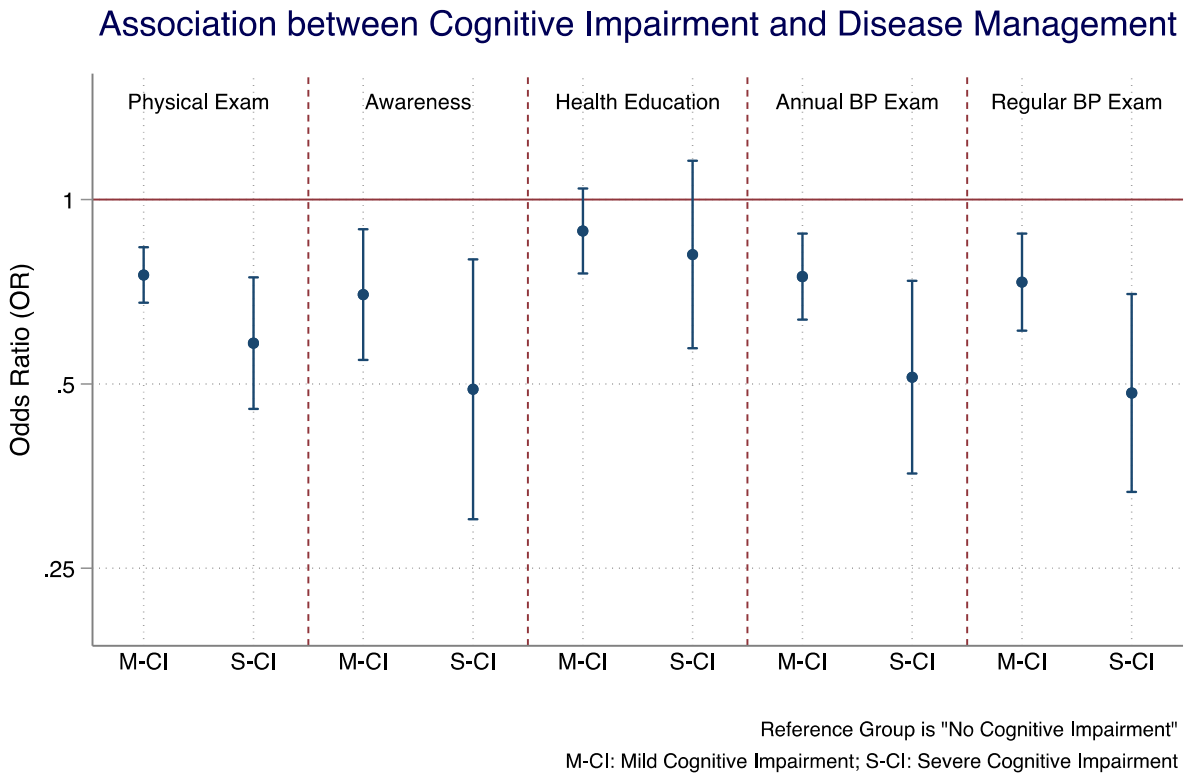
Appendix A. Supplementary Figures and Tables

Figure A1. Distribution of Mini-Mental State Examination (MMSE) and different stages of cognitive impairment (CI)



Notes: Cognitive impairment (CI) is categorized by the score of MMSE (0-30), with a score of 24-30 as "No CI", a score of 18-23 as "Mild CI", and a score of 0-17 as "Severe CI". For people with severe CI, we estimate the density separately for those with and without assistance from proxy respondent. People with no CI, mild CI, or severe CI (with proxy) are included in our main analysis (severe CI with no proxy are excluded because severe CI may affect the reliability of self-responses to disease management questions). Among our study sample (N=6,767), the mean value of MMSE is 23.62; the standard deviation is 4.32; the minimum value is 0; and the maximum value is 30.

Figure A2. Effects of cognitive impairment on disease management



Notes: Logistic regression is conducted to examine the association of cognitive impairment with each disease management outcomes, including physical examination, hypertension awareness, health education, annual BP examination, and regular BP examination. The plotted points represent adjusted odds ratios; the vertical lines represent the 95% confidence intervals; and the Y axis is displayed on log scale. Standard errors are clustered at county level. Long-term services and supports are controlled in the regression models with the adjustment of age, gender, education, rural/urban status, number of chronic diseases, ADL, IADL, number of living children, and health insurance. Province fixed effects are included. Abbreviations: OR, odds ratio; BP, blood pressure; CI, cognitive impairment; Statistical significance: *** $p<0.001$, ** $p<0.01$, * $p<0.05$.

Table A1. Robustness to sample selection and construction: effects on physical examination

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Physical Examination in the Past Year											
	Total	No CI	CI	Total	No CI	CI	Total	No CI	CI	Total	No CI	CI
Children's Support	0.06	0.15*	-0.04	0.06	0.16*	-0.06	0.08	0.15*	0.00	0.07	0.17*	-0.04
	(0.06)	(0.07)	(0.10)	(0.06)	(0.08)	(0.10)	(0.06)	(0.07)	(0.09)	(0.06)	(0.07)	(0.09)
Spouse's Support	0.20*	0.22*	0.18	0.19*	0.21	0.19	0.19*	0.23*	0.16	0.18*	0.24*	0.11
	(0.08)	(0.11)	(0.11)	(0.09)	(0.11)	(0.11)	(0.08)	(0.10)	(0.11)	(0.07)	(0.10)	(0.10)
Home-based Services	-0.09	-0.04	-0.12	-0.10	-0.05	-0.15	-0.08	-0.07	-0.07	-0.09	-0.04	-0.14
	(0.09)	(0.12)	(0.11)	(0.09)	(0.12)	(0.12)	(0.09)	(0.11)	(0.12)	(0.09)	(0.11)	(0.11)
Community-based Services	0.12	0.09	0.13	0.13	0.10	0.15	0.10	0.08	0.12	0.08	0.04	0.09
	(0.09)	(0.12)	(0.12)	(0.09)	(0.12)	(0.11)	(0.09)	(0.11)	(0.11)	(0.09)	(0.11)	(0.11)
Observations	6,170	3,535	2,635	5,638	3,356	2,282	6,257	3,757	2,500	6,767	3,810	2,957
Covariates and Province FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Prorated with ≥26 complete items	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO
Prorated with ≥28 complete items	NO	NO	NO	YES	YES	YES	NO	NO	NO	NO	NO	NO
Prorated sample excluding severe CI	NO	NO	NO	NO	NO	NO	YES	YES	YES	NO	NO	NO
Imputed following HRS guideline	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES

Notes: Logistic regressions are respectively conducted among entire sample (column 1, 4, 7, 10), sample without CI (column 2, 5, 8, 11) and sample with CI (column 3, 6, 9, 12). Estimated coefficient (standard error) is shown in each cell, and odds ratio (95% CI) is readily available upon request. Standard errors are robust and clustered at county level. All the regression models control for age, gender, education, rural/urban status, number of chronic diseases, ADL, IADL, number of living children, social interaction, and health insurance. Province fixed effects are included. Columns 1-3 and columns 4-6 respectively display the estimates using the sample with at least 26 or 28 non-missing items of the total 30 MMSE items to address the potential concerns of sample selection and measurement accuracy. Similar to the main specification, we prorate the non-missing items for the cognitive classifications. Columns 7-9 display the estimates using samples that fully exclude individuals with severe CI (either with or without proxy) to address the potential concern with regard to the reliability of survey responses. Columns 10-12 employ an alternative multivariate, regression-based imputation procedure used in the Health and Retirement Study (HRS) to impute the cognitive items and address the item-level missingness. The sample used are the same as the main specification. The results are fairly consistent when using different combinations of samples and approaches. Abbreviations: CI, cognitive impairment; FE, fixed effects. Statistical significance: *** p<0.001, ** p<0.01, * p<0.05.

Table A2. Robustness to sample selection and construction: effects on hypertension awareness

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Hypertension Awareness											
	Total	No CI	CI	Total	No CI	CI	Total	No CI	CI	Total	No CI	CI
Children's Support	-0.12	-0.07	-0.17	-0.13	-0.14	-0.13	-0.20	-0.08	-0.35	-0.14	-0.07	-0.17
	(0.13)	(0.20)	(0.20)	(0.15)	(0.21)	(0.23)	(0.13)	(0.20)	(0.21)	(0.13)	(0.19)	(0.18)
Spouse's Support	0.32*	0.67**	-0.03	0.38*	0.73**	0.01	0.42**	0.64**	0.19	0.28*	0.57**	-0.02
	(0.16)	(0.22)	(0.24)	(0.17)	(0.24)	(0.25)	(0.15)	(0.21)	(0.23)	(0.14)	(0.22)	(0.20)
Home-based Services	0.25	0.19	0.32	0.25	0.13	0.35	0.29*	0.26	0.41	0.25	0.27	0.23
	(0.14)	(0.20)	(0.24)	(0.15)	(0.21)	(0.25)	(0.14)	(0.20)	(0.22)	(0.14)	(0.19)	(0.23)
Community-based Services	0.06	0.22	-0.09	0.03	0.16	-0.11	0.08	0.13	-0.04	0.07	0.09	0.10
	(0.14)	(0.24)	(0.19)	(0.15)	(0.26)	(0.20)	(0.16)	(0.24)	(0.22)	(0.14)	(0.23)	(0.18)
Observations	2,524	1,403	1,077	2,289	1,312	937	2,540	1,498	1,013	2,760	1,521	1,210
Covariates and Province FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Prorated with ≥26 complete items	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO
Prorated with ≥28 complete items	NO	NO	NO	YES	YES	YES	NO	NO	NO	NO	NO	NO
Prorated sample excluding severe CI	NO	NO	NO	NO	NO	NO	YES	YES	YES	NO	NO	NO
Imputed following HRS guideline	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES

Notes: Logistic regressions are respectively conducted among entire sample (column 1, 4, 7, 10), sample without CI (column 2, 5, 8, 11) and sample with CI (column 3, 6, 9, 12). Estimated coefficient (standard error) is shown in each cell, and odds ratio (95% CI) is readily available upon request. Standard errors are robust and clustered at county level. All the regression models control for age, gender, education, rural/urban status, number of chronic diseases, ADL, IADL, number of living children, social interaction, and health insurance. Province fixed effects are included. Columns 1-3 and columns 4-6 respectively display the estimates using the sample with at least 26 or 28 non-missing items of the total 30 MMSE items to address the potential concerns of sample selection and measurement accuracy. Similar to the main specification, we prorate the non-missing items for the cognitive classifications. Columns 7-9 display the estimates using samples that fully exclude individuals with severe CI (either with or without proxy) to address the potential concern with regard to the reliability of survey responses. Columns 10-12 employ an alternative multivariate, regression-based imputation procedure used in the Health and Retirement Study (HRS) to impute the cognitive items and address the item-level missingness. The sample used are the same as the main specification. The results are fairly consistent when using different combinations of samples and approaches. Abbreviations: CI, cognitive impairment; FE, fixed effects. Statistical significance: *** p<0.001, ** p<0.01, * p<0.05.

Table A3. Robustness to sample selection and construction: effects on hypertension education

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Hypertension Education											
	Total	No CI	CI	Total	No CI	CI	Total	No CI	CI	Total	No CI	CI
Children's Support	0.07	0.05	0.08	0.09	0.05	0.14	0.03	0.03	0.01	0.06	0.03	0.10
	(0.08)	(0.11)	(0.13)	(0.09)	(0.11)	(0.14)	(0.08)	(0.10)	(0.13)	(0.07)	(0.10)	(0.12)
Spouse's Support	0.11	0.24	-0.07	0.14	0.27	-0.04	0.18	0.28*	0.00	0.12	0.26*	-0.05
	(0.10)	(0.14)	(0.14)	(0.10)	(0.14)	(0.14)	(0.10)	(0.13)	(0.15)	(0.10)	(0.12)	(0.14)
Home-based Services	0.10	0.13	0.03	0.06	0.15	-0.09	0.16	0.14	0.15	0.14	0.14	0.15
	(0.11)	(0.14)	(0.14)	(0.11)	(0.14)	(0.15)	(0.11)	(0.14)	(0.14)	(0.11)	(0.13)	(0.14)
Community-based Services	0.18	-0.05	0.45***	0.19	-0.03	0.45**	0.17	-0.02	0.42**	0.20	-0.04	0.45***
	(0.11)	(0.16)	(0.13)	(0.12)	(0.16)	(0.14)	(0.11)	(0.16)	(0.14)	(0.11)	(0.15)	(0.13)
Observations	3,172	1,812	1,358	2,890	1,712	1,176	3,209	1,928	1,279	3,479	1,972	1,505
Covariates and Province FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Prorated with ≥26 complete items	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO
Prorated with ≥28 complete items	NO	NO	NO	YES	YES	YES	NO	NO	NO	NO	NO	NO
Prorated sample excluding severe CI	NO	NO	NO	NO	NO	NO	YES	YES	YES	NO	NO	NO
Imputed following HRS guideline	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES

Notes: Logistic regressions are respectively conducted among entire sample (column 1, 4, 7, 10), sample without CI (column 2, 5, 8, 11) and sample with CI (column 3, 6, 9, 12). Estimated coefficient (standard error) is shown in each cell, and odds ratio (95% CI) is readily available upon request. Standard errors are robust and clustered at county level. All the regression models control for age, gender, education, rural/urban status, number of chronic diseases, ADL, IADL, number of living children, social interaction, and health insurance. Province fixed effects are included. Columns 1-3 and columns 4-6 respectively display the estimates using the sample with at least 26 or 28 non-missing items of the total 30 MMSE items to address the potential concerns of sample selection and measurement accuracy. Similar to the main specification, we prorate the non-missing items for the cognitive classifications. Columns 7-9 display the estimates using samples that fully exclude individuals with severe CI (either with or without proxy) to address the potential concern with regard to the reliability of survey responses. Columns 10-12 employ an alternative multivariate, regression-based imputation procedure used in the Health and Retirement Study (HRS) to impute the cognitive items and address the item-level missingness. The sample used are the same as the main specification. The results are fairly consistent when using different combinations of samples and approaches. Abbreviations: CI, cognitive impairment; FE, fixed effects. Statistical significance: *** p<0.001, ** p<0.01, * p<0.05.

Table A4. Robustness to sample selection and construction: effects on annual blood pressure examination

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Annual Blood Pressure Examination											
	Total	No CI	CI	Total	No CI	CI	Total	No CI	CI	Total	No CI	CI
Children's Support	-0.01	-0.01	-0.00	-0.04	-0.02	-0.05	-0.05	-0.03	-0.03	-0.03	-0.03	-0.01
	(0.09)	(0.13)	(0.14)	(0.09)	(0.13)	(0.15)	(0.08)	(0.13)	(0.12)	(0.08)	(0.12)	(0.12)
Spouse's Support	0.36***	0.54***	0.14	0.40***	0.49**	0.29	0.41***	0.52***	0.25	0.35***	0.55***	0.13
	(0.11)	(0.15)	(0.15)	(0.11)	(0.15)	(0.17)	(0.11)	(0.13)	(0.17)	(0.10)	(0.13)	(0.14)
Home-based Services	0.28*	0.33*	0.29	0.29*	0.32*	0.28	0.28*	0.38**	0.23	0.28*	0.39**	0.23
	(0.12)	(0.15)	(0.16)	(0.12)	(0.16)	(0.17)	(0.12)	(0.14)	(0.17)	(0.12)	(0.14)	(0.16)
Community-based Services	-0.03	-0.15	0.13	-0.05	-0.17	0.14	-0.01	-0.18	0.17	-0.04	-0.24	0.16
	(0.12)	(0.14)	(0.15)	(0.12)	(0.15)	(0.16)	(0.12)	(0.14)	(0.17)	(0.12)	(0.14)	(0.15)
Observations	3,172	1,797	1,358	2,890	1,697	1,162	3,209	1,928	1,277	3,479	1,955	1,505
Covariates and Province FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Prorated with ≥26 complete items	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO
Prorated with ≥28 complete items	NO	NO	NO	YES	YES	YES	NO	NO	NO	NO	NO	NO
Prorated sample excluding severe CI	NO	NO	NO	NO	NO	NO	YES	YES	YES	NO	NO	NO
Imputed following HRS guideline	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES

Notes: Logistic regressions are respectively conducted among entire sample (column 1, 4, 7, 10), sample without CI (column 2, 5, 8, 11) and sample with CI (column 3, 6, 9, 12). Estimated coefficient (standard error) is shown in each cell, and odds ratio (95% CI) is readily available upon request. Standard errors are robust and clustered at county level. All the regression models control for age, gender, education, rural/urban status, number of chronic diseases, ADL, IADL, number of living children, social interaction, and health insurance. Province fixed effects are included. Columns 1-3 and columns 4-6 respectively display the estimates using the sample with at least 26 or 28 non-missing items of the total 30 MMSE items to address the potential concerns of sample selection and measurement accuracy. Similar to the main specification, we prorate the non-missing items for the cognitive classifications. Columns 7-9 display the estimates using samples that fully exclude individuals with severe CI (either with or without proxy) to address the potential concern with regard to the reliability of survey responses. Columns 10-12 employ an alternative multivariate, regression-based imputation procedure used in the Health and Retirement Study (HRS) to impute the cognitive items and address the item-level missingness. The sample used are the same as the main specification. The results are fairly consistent when using different combinations of samples and approaches. Abbreviations: CI, cognitive impairment; FE, fixed effects. Statistical significance: *** p<0.001, ** p<0.01, * p<0.05.

Table A5. Robustness to sample selection and construction: effects on regular blood pressure examination

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Regular Blood Pressure Examination											
	Total	No CI	CI	Total	No CI	CI	Total	No CI	CI	Total	No CI	CI
Children's Support	-0.04	-0.02	-0.06	-0.06	-0.05	-0.06	-0.09	-0.05	-0.12	-0.08	-0.09	-0.04
	(0.08)	(0.12)	(0.13)	(0.09)	(0.13)	(0.14)	(0.08)	(0.12)	(0.13)	(0.08)	(0.12)	(0.14)
Spouse's Support	0.33**	0.39**	0.29	0.32**	0.39**	0.26	0.31**	0.40**	0.18	0.31**	0.39**	0.23
	(0.12)	(0.14)	(0.18)	(0.12)	(0.14)	(0.19)	(0.11)	(0.13)	(0.18)	(0.11)	(0.13)	(0.17)
Home-based Services	0.41**	0.60***	0.15	0.42**	0.58***	0.16	0.41**	0.55***	0.17	0.38**	0.58***	0.10
	(0.14)	(0.14)	(0.20)	(0.14)	(0.14)	(0.20)	(0.14)	(0.14)	(0.19)	(0.14)	(0.14)	(0.19)
Community-based Services	0.16	0.03	0.30	0.16	0.05	0.29	0.15	0.03	0.30	0.16	0.01	0.28
	(0.12)	(0.15)	(0.18)	(0.13)	(0.16)	(0.18)	(0.13)	(0.14)	(0.17)	(0.12)	(0.14)	(0.16)
Observations	3,172	1,805	1,358	2,890	1,706	1,176	3,209	1,921	1,271	3,479	1,965	1,505
Covariates and Province FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Prorated with ≥26 complete items	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO
Prorated with ≥28 complete items	NO	NO	NO	YES	YES	YES	NO	NO	NO	NO	NO	NO
Prorated sample excluding severe CI	NO	NO	NO	NO	NO	NO	YES	YES	YES	NO	NO	NO
Imputed following HRS guideline	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES

Notes: Logistic regressions are respectively conducted among entire sample (column 1, 4, 7, 10), sample without CI (column 2, 5, 8, 11) and sample with CI (column 3, 6, 9, 12). Estimated coefficient (standard error) is shown in each cell, and odds ratio (95% CI) is readily available upon request. Standard errors are robust and clustered at county level. All the regression models control for age, gender, education, rural/urban status, number of chronic diseases, ADL, IADL, number of living children, social interaction, and health insurance. Province fixed effects are included. Columns 1-3 and columns 4-6 respectively display the estimates using the sample with at least 26 or 28 non-missing items of the total 30 MMSE items to address the potential concerns of sample selection and measurement accuracy. Similar to the main specification, we prorate the non-missing items for the cognitive classifications. Columns 7-9 display the estimates using samples that fully exclude individuals with severe CI (either with or without proxy) to address the potential concern with regard to the reliability of survey responses. Columns 10-12 employ an alternative multivariate, regression-based imputation procedure used in the Health and Retirement Study (HRS) to impute the cognitive items and address the item-level missingness. The sample used are the same as the main specification. The results are fairly consistent when using different combinations of samples and approaches. Abbreviations: CI, cognitive impairment; FE, fixed effects. Statistical significance: *** p<0.001, ** p<0.01, * p<0.05.

Table A6. Robustness to alternative measurements and specifications: effects on physical examination

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Physical Examination in the Past Year											
	Total	No CI	CI	Total	No CI	CI	Total	No CI	CI	Total	No CI	CI
Children's Support	0.06	0.06	0.04	0.07	0.15*	-0.02	0.07	0.18*	0.00	0.08	0.13	0.04
	(0.06)	(0.09)	(0.08)	(0.06)	(0.07)	(0.08)	(0.06)	(0.08)	(0.08)	(0.06)	(0.08)	(0.07)
Spouse's Support	0.18*	0.23*	0.14	0.18*	0.23*	0.12	0.18*	0.25*	0.12	0.16*	0.32**	0.06
	(0.07)	(0.10)	(0.10)	(0.07)	(0.10)	(0.10)	(0.07)	(0.11)	(0.09)	(0.07)	(0.12)	(0.09)
Home-based Services	-0.09	-0.08	-0.10	-0.09	-0.08	-0.09	-0.10	-0.09	-0.10	-0.10	-0.07	-0.13
	(0.09)	(0.11)	(0.11)	(0.09)	(0.11)	(0.11)	(0.09)	(0.12)	(0.10)	(0.09)	(0.12)	(0.11)
Community-based Services	0.08	0.08	0.06	0.07	0.08	0.05	0.08	0.09	0.09	0.09	0.11	0.07
	(0.09)	(0.11)	(0.11)	(0.09)	(0.11)	(0.11)	(0.09)	(0.12)	(0.10)	(0.09)	(0.12)	(0.10)
Observations	6,767	3,757	3,010	6,725	3,740	2,985	6,767	3,128	3,639	6,767	2,915	3,852
Covariates and Province FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Alt. measures of children's support	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO
More health control	NO	NO	NO	YES	YES	YES	NO	NO	NO	NO	NO	NO
Alt. cutoffs of MMSE and CI	NO	NO	NO	NO	NO	NO	YES	YES	YES	NO	NO	NO
Alt. measures of cognition and CI	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES

Notes: Logistic regressions are respectively conducted among entire sample (column 1, 4, 7, 10), sample without CI (column 2, 5, 8, 11) and sample with CI (column 3, 6, 9, 12). Estimated coefficient (standard error) is shown in each cell, and odds ratio (95% CI) will be readily available upon request. Standard errors are robust and clustered at county level. All the regression models control for age, gender, education, rural/urban status, number of chronic diseases, ADL, IADL, number of living children, and health insurance. Province fixed effects are included. Columns 1-3 display the estimates using alternative measure of children's support to address endogeneity problems, where we measure access to children's support as whether individual has any co-resident children. Columns 4-6 further control additional measures of health status, including self-related health and childhood health conditions. The results are fairly robust when we further control depressive symptoms, though sample size would be smaller. Columns 7-9 display the estimates using alternative cutoffs of MMSE for CI (25 as the cutoff for CI rather than 24) and indicate the robustness of the results to the CI classification. The results are also insensitive to varying the cutoffs up or down by 1-2 points. Columns 10-12 display the estimates using alternative cognitive measurements in CHARLS to assess cognitive abilities and CI (i.e., 30-point global cognitive score using TICS and CERAD word recall). Individuals are classified into no CI, mild CI and severe CI using the tertiles of the global cognitive scores. Abbreviations: CI, cognitive impairment; FE, fixed effects. Statistical significance: *** p<0.001, ** p<0.01, * p<0.05.

Table A7. Robustness to alternative measurements and specifications: effects on hypertension awareness

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Hypertension Awareness											
	Total	No CI	CI	Total	No CI	CI	Total	No CI	CI	Total	No CI	CI
Children's Support	-0.01	-0.11	0.16	-0.14	-0.09	-0.17	-0.14	-0.13	-0.17	-0.13	0.06	-0.15
	(0.13)	(0.19)	(0.19)	(0.13)	(0.20)	(0.19)	(0.13)	(0.22)	(0.17)	(0.13)	(0.21)	(0.17)
Spouse's Support	0.28	0.63**	-0.04	0.30*	0.65**	-0.05	0.28	0.72**	0.02	0.27	0.70*	0.01
	(0.14)	(0.21)	(0.21)	(0.14)	(0.22)	(0.21)	(0.14)	(0.26)	(0.19)	(0.14)	(0.28)	(0.16)
Home-based Services	0.27*	0.26	0.29	0.25	0.27	0.25	0.26	0.34	0.20	0.25	0.08	0.30
	(0.14)	(0.20)	(0.21)	(0.14)	(0.20)	(0.21)	(0.14)	(0.21)	(0.17)	(0.14)	(0.20)	(0.18)
Community-based Services	0.08	0.14	0.06	0.07	0.13	0.05	0.08	0.04	0.12	0.09	0.21	0.03
	(0.14)	(0.23)	(0.17)	(0.14)	(0.24)	(0.17)	(0.14)	(0.26)	(0.16)	(0.14)	(0.25)	(0.16)
Observations	2,760	1,498	1,243	2,745	1,491	1,236	2,760	1,233	1,507	2,760	1,136	1,590
Covariates and Province FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Alt. measures of children's support	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO
More health control	NO	NO	NO	YES	YES	YES	NO	NO	NO	NO	NO	NO
Alt. cutoffs of MMSE and CI	NO	NO	NO	NO	NO	NO	YES	YES	YES	NO	NO	NO
Alt. measures of cognition and CI	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES

Notes: Logistic regressions are respectively conducted among entire sample (column 1, 4, 7, 10), sample without CI (column 2, 5, 8, 11) and sample with CI (column 3, 6, 9, 12). Estimated coefficient (standard error) is shown in each cell, and odds ratio (95% CI) will be readily available upon request. Standard errors are robust and clustered at county level. All the regression models control for age, gender, education, rural/urban status, number of chronic diseases, ADL, IADL, number of living children, and health insurance. Province fixed effects are included. Columns 1-3 display the estimates using alternative measure of children's support to address endogeneity problems, where we measure access to children's support as whether individual has any co-resident children. Columns 4-6 further control additional measures of health status, including self-related health and childhood health conditions. The results are fairly robust when we further control depressive symptoms, though sample size would be smaller. Columns 7-9 display the estimates using alternative cutoffs of MMSE for CI (25 as the cutoff for CI rather than 24) and indicate the robustness of the results to the CI classification. The results are also insensitive to varying the cutoffs up or down by 1-2 points. Columns 10-12 display the estimates using alternative cognitive measurements in CHARLS to assess cognitive abilities and CI (i.e., 30-point global cognitive score using TICS and CERAD word recall). Individuals are classified into no CI, mild CI and severe CI using the tertiles of the global cognitive scores. Abbreviations: CI, cognitive impairment; FE, fixed effects. Statistical significance: *** p<0.001, ** p<0.01, * p<0.05.

Table A8. Robustness to alternative measurements and specifications: effects on hypertension education

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Hypertension Education											
	Total	No CI	CI	Total	No CI	CI	Total	No CI	CI	Total	No CI	CI
Children's Support	-0.05	-0.05	-0.05	0.04	0.01	0.07	0.06	0.05	0.08	0.06	0.03	0.07
	(0.08)	(0.10)	(0.12)	(0.07)	(0.10)	(0.12)	(0.07)	(0.12)	(0.10)	(0.07)	(0.13)	(0.10)
Spouse's Support	0.12	0.27*	-0.09	0.12	0.26*	-0.08	0.12	0.36*	-0.05	0.12	0.37**	-0.08
	(0.10)	(0.13)	(0.13)	(0.10)	(0.13)	(0.13)	(0.10)	(0.15)	(0.12)	(0.10)	(0.14)	(0.11)
Home-based Services	0.14	0.13	0.11	0.17	0.16	0.15	0.14	0.20	0.10	0.14	0.05	0.18
	(0.11)	(0.14)	(0.13)	(0.11)	(0.14)	(0.13)	(0.11)	(0.15)	(0.12)	(0.11)	(0.15)	(0.13)
Community-based Services	0.20	-0.02	0.45***	0.20	-0.02	0.45***	0.20	-0.11	0.42***	0.21	0.07	0.30*
	(0.11)	(0.15)	(0.13)	(0.11)	(0.16)	(0.13)	(0.11)	(0.18)	(0.12)	(0.11)	(0.16)	(0.12)
Observations	3,479	1,928	1,549	3,460	1,920	1,538	3,479	1,588	1,891	3,479	1,486	1,989
Covariates and Province FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Alt. measures of children's support	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO
More health control	NO	NO	NO	YES	YES	YES	NO	NO	NO	NO	NO	NO
Alt. cutoffs of MMSE and CI	NO	NO	NO	NO	NO	NO	YES	YES	YES	NO	NO	NO
Alt. measures of cognition and CI	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES

Notes: Logistic regressions are respectively conducted among entire sample (column 1, 4, 7, 10), sample without CI (column 2, 5, 8, 11) and sample with CI (column 3, 6, 9, 12). Estimated coefficient (standard error) is shown in each cell, and odds ratio (95% CI) will be readily available upon request. Standard errors are robust and clustered at county level. All the regression models control for age, gender, education, rural/urban status, number of chronic diseases, ADL, IADL, number of living children, and health insurance. Province fixed effects are included. Columns 1-3 display the estimates using alternative measure of children's support to address endogeneity problems, where we measure access to children's support as whether individual has any co-resident children. Columns 4-6 further control additional measures of health status, including self-related health and childhood health conditions. The results are fairly robust when we further control depressive symptoms, though sample size would be smaller. Columns 7-9 display the estimates using alternative cutoffs of MMSE for CI (25 as the cutoff for CI rather than 24) and indicate the robustness of the results to the CI classification. The results are also insensitive to varying the cutoffs up or down by 1-2 points. Columns 10-12 display the estimates using alternative cognitive measurements in CHARLS to assess cognitive abilities and CI (i.e., 30-point global cognitive score using TICS and CERAD word recall). Individuals are classified into no CI, mild CI and severe CI using the tertiles of the global cognitive scores. Abbreviations: CI, cognitive impairment; FE, fixed effects. Statistical significance: *** p<0.001, ** p<0.01, * p<0.05.

Table A9. Robustness to alternative measurements and specifications: effects on annual blood pressure examination

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Annual Blood Pressure Examination											
	Total	No CI	CI	Total	No CI	CI	Total	No CI	CI	Total	No CI	CI
Children's Support	-0.08	-0.17	0.04	-0.04	-0.03	-0.01	-0.04	-0.02	-0.03	-0.03	0.05	-0.08
	(0.08)	(0.11)	(0.11)	(0.09)	(0.13)	(0.12)	(0.08)	(0.14)	(0.11)	(0.08)	(0.13)	(0.10)
Spouse's Support	0.35***	0.51***	0.16	0.36***	0.51***	0.17	0.35***	0.58***	0.19	0.34***	0.58***	0.18
	(0.10)	(0.13)	(0.14)	(0.10)	(0.13)	(0.14)	(0.10)	(0.15)	(0.13)	(0.10)	(0.16)	(0.13)
Home-based Services	0.28*	0.37**	0.26	0.30*	0.39**	0.27	0.28*	0.40*	0.25	0.27*	0.42**	0.17
	(0.12)	(0.14)	(0.16)	(0.12)	(0.14)	(0.17)	(0.12)	(0.16)	(0.14)	(0.12)	(0.16)	(0.15)
Community-based Services	-0.04	-0.18	0.08	-0.03	-0.17	0.10	-0.04	-0.23	0.09	-0.02	-0.23	0.13
	(0.12)	(0.14)	(0.15)	(0.12)	(0.14)	(0.15)	(0.12)	(0.17)	(0.14)	(0.12)	(0.16)	(0.13)
Observations	3,479	1,928	1,549	3,460	1,920	1,538	3,479	1,588	1,891	3,479	1,478	1,993
Covariates and Province FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Alt. measures of children's support	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO
More health control	NO	NO	NO	YES	YES	YES	NO	NO	NO	NO	NO	NO
Alt. cutoffs of MMSE and CI	NO	NO	NO	NO	NO	NO	YES	YES	YES	NO	NO	NO
Alt. measures of cognition and CI	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES

Notes: Logistic regressions are respectively conducted among entire sample (column 1, 4, 7, 10), sample without CI (column 2, 5, 8, 11) and sample with CI (column 3, 6, 9, 12). Estimated coefficient (standard error) is shown in each cell, and odds ratio (95% CI) will be readily available upon request. Standard errors are robust and clustered at county level. All the regression models control for age, gender, education, rural/urban status, number of chronic diseases, ADL, IADL, number of living children, and health insurance. Province fixed effects are included. Columns 1-3 display the estimates using alternative measure of children's support to address endogeneity problems, where we measure access to children's support as whether individual has any co-resident children. Columns 4-6 further control additional measures of health status, including self-related health and childhood health conditions. The results are fairly robust when we further control depressive symptoms, though sample size would be smaller. Columns 7-9 display the estimates using alternative cutoffs of MMSE for CI (25 as the cutoff for CI rather than 24) and indicate the robustness of the results to the CI classification. The results are also insensitive to varying the cutoffs up or down by 1-2 points. Columns 10-12 display the estimates using alternative cognitive measurements in CHARLS to assess cognitive abilities and CI (i.e., 30-point global cognitive score using TICS and CERAD word recall). Individuals are classified into no CI, mild CI and severe CI using the tertiles of the global cognitive scores. Abbreviations: CI, cognitive impairment; FE, fixed effects. Statistical significance: *** $p<0.001$, ** $p<0.01$, * $p<0.05$.

Table A10. Robustness to alternative measurements and specifications: effects on regular blood pressure examination

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Regular Blood Pressure Examination											
	Total	No CI	CI	Total	No CI	CI	Total	No CI	CI	Total	No CI	CI
Children's Support	-0.01	-0.12	0.11	-0.09	-0.06	-0.11	-0.08	-0.01	-0.10	-0.07	-0.09	-0.06
	(0.08)	(0.11)	(0.12)	(0.08)	(0.12)	(0.13)	(0.08)	(0.14)	(0.11)	(0.08)	(0.13)	(0.11)
Spouse's Support	0.31**	0.39**	0.23	0.30**	0.40**	0.20	0.30**	0.47**	0.21	0.30**	0.51**	0.16
	(0.11)	(0.13)	(0.17)	(0.11)	(0.13)	(0.17)	(0.11)	(0.14)	(0.16)	(0.11)	(0.17)	(0.15)
Home-based Services	0.38**	0.54***	0.17	0.38**	0.55***	0.18	0.37**	0.65***	0.15	0.37**	0.64***	0.17
	(0.14)	(0.14)	(0.19)	(0.14)	(0.14)	(0.19)	(0.14)	(0.15)	(0.17)	(0.14)	(0.15)	(0.17)
Community-based Services	0.16	0.02	0.27	0.15	0.02	0.27	0.17	0.03	0.28	0.18	0.04	0.32*
	(0.12)	(0.14)	(0.16)	(0.12)	(0.14)	(0.16)	(0.12)	(0.16)	(0.15)	(0.12)	(0.16)	(0.14)
Observations	3,479	1,921	1,549	3,460	1,913	1,538	3,479	1,582	1,885	3,479	1,486	1,989
Covariates and Province FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Alt. measures of children's support	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO
More health control	NO	NO	NO	YES	YES	YES	NO	NO	NO	NO	NO	NO
Alt. cutoffs of MMSE and CI	NO	NO	NO	NO	NO	NO	YES	YES	YES	NO	NO	NO
Alt. measures of cognition and CI	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES

Notes: Logistic regressions are respectively conducted among entire sample (column 1, 4, 7, 10), sample without CI (column 2, 5, 8, 11) and sample with CI (column 3, 6, 9, 12). Estimated coefficient (standard error) is shown in each cell, and odds ratio (95% CI) will be readily available upon request. Standard errors are robust and clustered at county level. All the regression models control for age, gender, education, rural/urban status, number of chronic diseases, ADL, IADL, number of living children, and health insurance. Province fixed effects are included. Columns 1-3 display the estimates using alternative measure of children's support to address endogeneity problems, where we measure access to children's support as whether individual has any co-resident children. Columns 4-6 further control additional measures of health status, including self-related health and childhood health conditions. The results are fairly robust when we further control depressive symptoms, though sample size would be smaller. Columns 7-9 display the estimates using alternative cutoffs of MMSE for CI (25 as the cutoff for CI rather than 24) and indicate the robustness of the results to the CI classification. The results are also insensitive to varying the cutoffs up or down by 1-2 points. Columns 10-12 display the estimates using alternative cognitive measurements in CHARLS to assess cognitive abilities and CI (i.e., 30-point global cognitive score using TICS and CERAD word recall). Individuals are classified into no CI, mild CI and severe CI using the tertiles of the global cognitive scores. Abbreviations: CI, cognitive impairment; FE, fixed effects. Statistical significance: *** p<0.001, ** p<0.01, * p<0.05.

Table A11. Interactive effects of access to spousal and children's support

VARIABLES	(1) Physical Examination	(2) Hypertension Awareness	(3) Hypertension Education	(4) Annual BP Examination	(5) Regular BP Examination
Access to Spousal and Children's Support (Ref. None)					
Only Spousal Support	0.30**	0.38*	0.16	0.37**	0.12
	(0.10)	(0.18)	(0.13)	(0.13)	(0.14)
Only Children's Support	0.06	0.02	0.18	0.16	-0.31
	(0.11)	(0.24)	(0.14)	(0.17)	(0.16)
Both Spousal and Children's Support	0.37***	0.21	0.24	0.33*	0.18
	(0.10)	(0.19)	(0.13)	(0.13)	(0.13)
Access to Home-based Services	-0.04	0.20	0.11	0.21	0.36**
	(0.09)	(0.13)	(0.11)	(0.11)	(0.13)
Access to Community-based Services	0.11	0.12	0.12	0.03	0.23
	(0.09)	(0.13)	(0.11)	(0.12)	(0.12)
Observations	6,865	2,814	3,579	3,578	3,579
Covariates	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES
Pseudo R-squared	0.06	0.29	0.09	0.09	0.07

Notes: Logistic regression is respectively performed for each disease management outcome. Estimated coefficient (standard error) is shown in each cell, and odds ratio (95% CI) will be readily available upon request. Standard errors are clustered at county level. All the regression models control for age, gender, education, rural/urban status, number of chronic diseases, ADL, IADL, number of living children, stages of cognitive impairment, social interaction and health insurance. Province fixed effects are included. Abbreviations: CI, cognitive impairment; FE, fixed effects. Statistical significance: *** $p<0.001$, ** $p<0.01$, * $p<0.05$.

Table A12. Characteristics of all participated sample and included sample

	(1) All Participated Sample	(2) Included Sample	(4) *p*-value
	Mean (SD)	Mean (SD)	
Female	0.496 (0.500)	0.442 (0.497)	<0.001
Age	68.411 (6.393)	67.935 (6.042)	<0.001
Years of Schooling	4.119 (4.569)	5.113 (4.625)	<0.001
Rural Status	0.760 (0.427)	0.711 (0.453)	<0.001
Number of Chronic Diseases	2.528 (1.973)	2.545 (1.972)	0.996
IADL (0-5)	0.558 (1.086)	0.424 (0.940)	<0.001
ADL (0-5)	0.425 (0.995)	0.354 (0.892)	0.001

Notes: *p*-values are calculated based on Chi-square test for categorical variables, and one-way ANOVA for continuous variables. The samples are required to have complete data of sociodemographic characteristics to enable the comparisons (i.e., 9080 vs. 6767). Abbreviations: CI, cognitive impairment; SD, standard deviation; ADL, activities of daily living; IADL, instrumental activities of daily living; MMSE, mini-mental state exam.

Appendix B. Variables

Table B1. The construction and conceptualization of variables for long-term services and supports (LTSS)

Variables	Questions in the Survey	Construction of Variables	Conceptualization
Access to Children's Support (Frequency of In-person contact with children)	During last year, how long had your child i lived with you and your spouse? (In month) ___Months When the child i is not living with you, how often do you have in-person contact/visit with the child? 1. Almost every day 2. 2-3 times a week 3. Once a week 4. Every two weeks 5. Once a month 6. Once every three months 7. Once every six months 8. Once a year 9. Almost never 10. Other	These two questions were asked for each child i that the participants have. We added up the total number of days (days per month) the participants had in-person contact/visit with their children (i.e., $\sum Child_i$). Particularly, children who co-resided with the participants were considered to have "daily" in-person contact with the participants (30 days/month). Hence, both co-resident and non-co-resident children were included. We constructed a dummy variable to denote whether individuals had in-person contact with their children more often than sample median or not (0/1).	Children's Support (Informal LTSS)
Access to Spousal Support (Married and living with spouse)	What is your marital status? [IWER: common-law marriage is considered as married] 1. Married and live with spouse 2. Married but don't living with spouse temporarily for reasons such as work 3. Separated, don't live together as a couple anymore 4. Divorced 5. Widowed 6. Never married	Spousal support was measured by individuals' marital and co-residence status. We constructed a dummy variable to denote whether individuals were married and living with spouses or not (0/1).	Spousal Support (Informal LTSS)
Access to Home-based Services	Have you ever received the following home and community care services? - Onsite visit - Family beds	Older adults were considered to have good access to the home-based services if any participants in the local area (defined at county level, stratified by rural/urban area) had ever used these services. We constructed a dummy variable to denote if individuals had access to the services (0/1) in local area (county by rural/urban). The results are also robust to other alternative specifications.	Home-based Services (Formal LTSS)

Access to Community-based Services	Have you ever received the following home and community care services? - Day care centers, nursing homes, senior dining tables, etc. - Community nursing	Older adults were considered to have good access to the community-based services if any participants in the local area (defined at county level, stratified by rural/urban area) had ever used these services. We constructed a dummy variable to denote if individuals had access to the services (0/1) in local area (county by rural/urban). The results are also robust to other alternative specifications.	Community-based Services (Formal LTSS)

Notes: The classification of formal and informal LTSS are based on existing literature (Feng et al., 2020; Li and Song, 2019).

Table B2. The construction and conceptualization of variables for disease management

Variables	Questions in the Survey	Construction of Variables	Conceptualization
Physical Examination (For all participants)	When did you take the last physical examination? (Not including CHARLS physical examination) 1. ___1900-2018 Year ___0...12 Month 2. Have never taken physical examination yet/since last survey	We calculated the time gap between the reported exam date and interview date in 2018, and created two dummy variables to indicate whether the time of the last physical exam were within 1 year (0/1), within 3 years (0/1), relative to the interview. Individuals who had never taken any physical examination were treated as 0.	Preventive care utilization
Hypertension Awareness (For participants with hypertension identified by biomarkers)	Have you [ever] been diagnosed with Hypertension by a doctor? 1. Yes 2. No	For participants who had identified hypertension based on biomarkers, we constructed a dummy variable to denote if they were ever aware of their underlying hypertension (0/1).	Hypertension awareness (chronic disease awareness)
Hypertension Education (For participants with identified or diagnosed hypertension)	Have your care providers ever given you any health education/advice on the following [for hypertension control] (check all that apply)? 1. Weight control 2. Exercise 3. Diet 4. Smoking control 5. None of the above	For participants with identified or diagnosed hypertension, we constructed a dummy variable to denote if they have ever been given health education/advice by their doctors to control their hypertension, including weight control, exercise, diet and/or smoking control (0/1).	Hypertension education (chronic disease management)
Annual Blood Pressure Examination (For participants with identified or diagnosed hypertension)	During last year (last 12 months), how many times have you had blood pressure examination? ___ [0…999] Times	For participants with identified or diagnosed hypertension, we constructed a dummy variable to denote if they had any blood pressure examination in the past year (0/1).	Hypertension monitoring (chronic disease management)
Regular Blood Pressure Examination (For participants with identified or diagnosed hypertension)	During the last year (last 12 months), have you had blood pressure examination by community/village doctors regularly? 1. Yes 2. No	For participants with identified or diagnosed hypertension, we constructed a dummy variable to denote if they had regular blood pressure examination by doctors in the past year (0/1).	Hypertension monitoring (chronic disease management)

Notes: Survey questions are derived from CHARLS 2018 survey. Some questions may have soft check or preloaded questions to determine the status of participants (e.g., new interview vs. re-interview), and we have taken all these into account when constructing the variables.

Appendix C. Imputation of Missing Item-Level MMSE Data

As we discussed in the main text, over 60% of the people who participate in the cognition survey have partial missing items of MMSE; and a majority of these samples complete most MMSE items. To address the issue of sample attrition and item-level missingness, we employ two approaches to impute the cognitive items.

In the main specification, following prior literature, we prorate scale the non-missing MMSE items for participants who respond to at least 80% of the MMSE items (i.e., at least 24 of the 30 items) (Andrew and Rockwood, 2010; Craft et al., 2020; Crowe et al., 2021; Ramirez et al., 2022; White et al., 2011; Zheng et al., 2018). For each individual, the prorating involves calculating his/her non-missing item scores, dividing by the number of non-missing items, and multiplying by the total number of MMSE items (i.e., 30 items). In other words, it calculates the average value of non-missing item scores for each individual and replace the missing items with that value. Therefore, it does not change the relative scale and distributions of cognitive performance for individuals with partial missing items.

In the robustness check, we use an alternative strategy to impute missing data. As CHARLS is a comparable family study of the Health and Retirement Study (HRS) in the US, we strictly follow a multivariate, regression-based procedure adopted and validated in the HRS to impute the missing cognitive items, which creates imputations through a sequence of multiple regressions. The approach uses a combination of relevant demographic, health, and economic as well as prior and current wave cognitive variables in the regressions to perform the imputations (Raghunathan et al., 2020; Ryan J McCammon et al., 2022). Using Imputation and Variance Estimation (IVEware) software (Raghunathan et al., 2020), the imputation procedure consists of three steps. First, we assemble and clean the baseline non-varying demographic variables, including year of birth, month of birth, years of education, respondents' highest degree earned, gender, father's years of education, mother's years of education, and indicator for college degree, and impute the missing values of baseline characteristics using IVEware when necessary. Second, we assemble and clean the wave-specific variables, including age, age^2, age^3, self vs. proxy status, interview language, coupleness, nursing home status, household income and net wealth, and impute the missing values when

necessary. Finally, we assemble and clean the cognitive measurements of current and previous waves and impute the cognitive and MMSE missing items with other non-changing and wave-specific variables as predictors in the IVEware models. More details of the procedure can be found in the HRS documentation and software guideline (Raghunathan et al., 2020; Ryan J McCammon et al., 2022).