NBER WORKING PAPER SERIES

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Working Paper 35464
http://www.nber.org/papers/w35464

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
July 2026

We acknowledge financial help from Agencia Estatal de Investigación project PID2023-147602OB-I00. Analía Viola acknowledges the Agencia Estatal de Investigación for financial support JDC2022-049212-I. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

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NBER Working Paper No. 35464
July 2026
JEL No. I18, I38, J14

ABSTRACT

The growing prevalence of cognitive impairment (CI) is one of the main drivers of age-related demand for health and long-term care (LTC). In Spain, CI is estimated to affect 18.5% of Spaniards over 65, and 45.3% in those aged 85 and above. This paper draws on a pooled pre-COVID data from a longitudinal sample of individuals aged 65+ to examine the effect of CI and physical limitations on health and long-term care utilisation, estimates its costs, and financial burden. We report four sets of findings. First, we find that socioeconomic status at older age to be the strongest predictor of CI. Second, while both CI and physical limitations increase health and care adult care use, physical impairment is a stronger predictor of overall care utilisation (73% versus 55% for CI alone) and nursing home residence (2.0% versus 0.9%). Third, informal caregiving constitutes the overwhelming majority of dementia costs, accounting for 69–81% of the total. Finally, we estimate that the replacement cost of informal care would exhaust the full budget of Spain's LTC system (SAAD).

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1. Introduction

Population ageing is reshaping demand for health and long-term care (LTC) across Europe, posing significant challenges to the sustainability of welfare programs. However, its impact on health and LTC expenditure remains debated, as much of the increase in care needs reflects proximity to death, morbidity, and technological change rather than ageing itself (Zweifel et al., 1999, 2022; Breyer et al., 2010; Costa-Font and Vilaplana, 2020). Among the key drivers of age-related care demand is the growing prevalence of cognitive impairment (CI) and neurodegenerative diseases.

Estimating the exact number of people living with CI and neurodegenerative diseases is challenging, largely because of persistent under-diagnosis; even though conservative estimates suggest that between one and one and a half million people in Spain may be affected by some form of neurodegenerative condition, with cognitive impairment present in most cases. Within this broader picture, dementia represents a particularly pressing public health challenge in Spain, with figures indicating that somewhere between 734,000 and 937,000 people currently live with the condition. Hence, understanding the scale of the problem – including the diverse needs of people with dementia - is crucial to design a sustainable care model for the future. Contributing to this question is the main purpose of this paper.

Alzheimer's disease accounts for approximately 60–80% of all dementia cases, according to the Comprehensive Plan for Alzheimer's Disease, and the prevalence of cognitive impairment is estimated to be about 18.5%.(Vega Alonso, 2018) However, prevalence rates vary by gender - women exhibit higher adjusted rates, education level, marital status and age – as the prevalence was 45.3% in people aged 85 and older (Vega Alonso, 2018).

The growing prevalence of dementia is placing increasing pressure on healthcare and long-term care support systems, pointing to the urgent need for further adaptation to meet the demands of an ageing population. The Spanish Ministry of Health has developed two strategies, namely the so-called "Strategy on neurodegenerative disorders"[2] and the "Comprehensive plan for Alzheimer's and other dementias"[3]. Among the principal challenges include the need for an effective diagnosis, early intervention, and access to comprehensive care, all of which are essential to managing dementia effectively[4]. This includes psychological support, social integration, and the creation of dementia-friendly environments[5] which can help maintaining a better quality of life while easing the burden placed on families and communities.

This paper draws in the best available evidence to study the prevalence, drivers and costs of dementia and neurodegenerative disorders in Spain. To provide some context, we provide a brief description of the health and long-term care system and reforms in place. We report for sets of findings. First, we find that socioeconomic status at older age to be the strongest predictor of CI. Second, while both CI and physical limitations increase health and care adult care use, physical impairment is a stronger predictor of overall care utilisation (73% versus 55% for CI alone) and nursing home residence (2.0% versus 0.9%). Third, informal caregiving constitutes the overwhelming majority of dementia costs, accounting for 69–81% of the total. Finally, we report a monetary valuation of informal care using the Proxy Good method, which estimates the cost of

[2] Ministerio de Sanidad, Servicios Sociales e Igualdad. Estrategia en enfermedades neurodegenerativas del Sistema Nacional de Salud (2016): https://www.sanidad.gob.es/areas/calidadAsistencial/estrategias/enfermedadesNeurodegenerativas/docs/Est_Neurodegenerativas_APROBADA_C_INTERTERRITORIAL.pdf

[3] Ministerio de Sanidad, Consumo y Bienestar Social. Plan integral de Alzheimer y otras demencias. 2019-2023 (2019): https://www.sanidad.gob.es/profesionales/saludPublica/docs/Plan_Integral_Alhzeimer_Octubre_2019.pdf

[4] Addressing these challenges, however, entail a closer collaboration between medical professionals, caregivers, and policymakers to raise awareness, improve diagnostic tools, and require funding available for both individuals living with dementia and their families.

[5] Such environments might include adapting public spaces and homes to better accommodate people with cognitive impairments, as well as training caregivers and healthcare providers in specialized dementia care

replacing informal caregiving with formal home care services. Our estimates results that fully substituting informal care with formal care would exhaust the entire budget of the Spanish System for Autonomy and Care for Dependency, known under the acronym SAAD in Spain.

The remainder of the paper is organized as follows. The next section reviews the evidence on the drivers and costs of dementia and neurodegenerative disorders. Section three discusses the policy and institutional environment, Section four describes the data sources used, and Section five presents the results of our estimates. A final section concludes.

2. The Drivers and Costs of Dementia

Ageing effects. Age acts as a predisposing rather than a need factor in the demand for care services (de Meijer et al., 2013), and while it plays a comparatively minor role in driving overall healthcare spending (Zweifel et al., 1999; Seshamani and Gray, 2004; Carreras et al., 2018; Costa-Font and Vilaplana, 2020; Breyer and Lorenz, 2021; Zweifel, 2022), its influence on LTC expenditure remains consistently significant, even after controlling for proximity to death (Karlsson and Klohn, 2014; Hashimoto et al., 2010). Consequently, we anticipate substantial growth in the demand for LTC services across Europe over the coming decades (European Commission, 2024). One of the key forces behind this rise in LTC spending is the increasing prevalence of neurodegenerative diseases, particularly those associated with cognitive impairment (Oficina de Ciencia y Tecnología, 2023).

Prevalence. Identifying the exact number of people living with neurodegenerative diseases is difficult, largely due to persistent under-diagnosis and largely because often individuals—

especially in early stages—do not seek or receive an accurate diagnosis[6]. However, existing lower bound estimates suggest that between one and one and a half million people in Spain may be affected, most with associated cognitive impairment. Within this group, dementia is a particularly pressing public health challenge, affecting an estimated 734,000 to 937,000 people. Dementia is not a single disease but an umbrella term for disorders that progressively erode memory, reasoning, and daily functioning. Alzheimer's disease is the leading cause, though vascular dementia and Lewy body dementia also contribute significantly.

Costs of dementia. Cost of illness studies have estimated large social costs that compare to the costs of professional care (Kosaner et al, 2021; Wimo et al, 2023). A recent study (Gomez Maldonado et al, 2024) estimates that the average annual cost of care for patients with Alzheimer's disease (AD) in 2021 to range from €42,336 to €70,445, with the cost rising as cognitive impairment worsened—doubling from moderate to severe impairment. Among the total cost, healthcare expenses accounted for 5.2% to 8.6%. Formal long-term care (LTC) services, provided by professionals, represented between 7.7% and 12.8% of the overall cost. However, the cost of informal care, typically provided by family members or unpaid caregivers, was significantly higher, ranging from 69.0% to 81.4% of the total cost. These figures illustrate not only the considerable financial burden of dementia on healthcare systems but also the critical role played by informal caregivers. Indeed, the heavy reliance on unpaid care underscores the need for policy

[6] This gap reflects persistent stigma around cognitive decline, the subtle onset of symptoms, and the common misconception that memory loss is simply a normal part of ageing. As a result, the actual number of people living with dementia is likely higher than current estimates suggest.

measures that support family caregivers, including financial assistance, respite services, and improved training to help them manage the demands of caregiving[7].

Non-healthcare costs associated with brain damage—including stroke and traumatic brain injury—rise significantly with the severity of functional impairment (Mar et al, 2011). These costs increased from €16,484 for individuals with mild physical or cognitive impairment to €44,550 for those with severe impairment (base year 2008). Mar et al, (2011) shows that the composition of this cost also shifts with severity. At mild levels of impairment, informal care—typically provided by family members or friends—accounts for a larger share of the total cost, reflecting greater reliance on unpaid caregivers at this stage. As impairment worsens, however, formal care provided by professional services becomes the dominant cost factor, pointing to a growing need for structured, professional support as functional decline progresses and underscoring the mounting financial strain placed on both families and healthcare systems.

This pattern of rising informal care burden is further illustrated by Vilaplana-Prieto and Oliva-Moreno (2024), who estimated the time spent on informal care for individuals with Alzheimer's disease (AD) living at home, along with its economic value, comparing 2021 with 2008. Despite the relatively short time span, they found that the number of people with AD living at home had increased by 43%, accompanied by a corresponding rise in the number of individuals receiving informal care. While several factors likely contribute to this increase, the authors point to the ageing of the Spanish population as a key driver: between 2008 and 2021, the population aged 65 and over grew by 24.2%, with an especially marked rise—74.4%—among those aged 85 and over.

[7] The differences between the total cost figures and the weight of the items are due to the shadow price applied to the valuation of the informal care time (home employee vs. home help service).

3. Health and Care system

Dementia care in Spain is delivered through a combination of healthcare and social care services, reflecting the broader institutional separation between the National Health System (NHS) and the long term care (LTC) system. Diagnosis, clinical management and treatment are primarily provided through the health system, involving primary care physicians, neurologists, geriatricians and memory clinics, although access and availability vary substantially across Autonomous Communities. As dementia progresses and functional dependency increases, care needs increasingly fall within the remit of tghe long term care system, which provides access to home care, day centres, residential facilities and caregiver support according to assessed dependency levels. However, coordination between health and social care remains uneven, with fragmented responsibilities across administrative levels often creating difficulties in continuity of care, particularly for people with complex and evolving needs. Consequently, families continue to play a central role in dementia care, providing substantial amounts of unpaid support and acting as the main coordinators of services across health and social care sectors.

While the NHS in Spain provides comprehensive medical care, LTC has historically developed outside the health system and has been organised as a separate pillar of social protection. Responsibility for LTC has traditionally been shared between central and regional governments, with services delivered by a mix of public, private and non-profit providers. Like most Southern European countries, Spain has historically exhibited relatively low levels of formal long-term care (LTC) provision compared with other Western European nations. Instead, families have traditionally remained the primary providers of care, reflecting the country's strongly familialistic welfare model (Costa-Font, 2010; Costa-Font and Vilaplana-

Prieto, 2010; Costa-Font et al., 2025). This model has long placed the responsibility for supporting dependent individuals on household networks rather than public institutions.

A major shift occurred with the enactment of the Promotion of Personal Autonomy and Care for Dependent Persons Act (Sistema para la Autonomía y Atención a la Dependencia, SAAD), which came into force on 1 January 2007. The reform established a nationwide LTC system based on three core principles: the universal and public nature of the right to receive LTC benefits, equal access according to assessed need, and shared responsibility across different levels of government, while allowing private providers to participate in service delivery (Costa-Font et al., 2025). The reform represented one of the most ambitious expansions of the Spanish welfare state, aiming to reduce reliance on informal family care and create a comprehensive system of publicly supported LTC.

Under SAAD, eligibility is determined through a standardised national assessment of dependency, and beneficiaries are entitled to a package of services or cash benefits according to the severity of their care needs. Benefits include residential care, home care, day-care centres, telecare, and cash allowances for family caregivers or for purchasing care services. Financing is shared between the central government, the Autonomous Communities and, for some services, users through income-related co-payments.

However, the implementation of SAAD coincided with the severe economic crisis that affected Spain between 2008 and 2014, substantially constraining public finances and delaying the expansion of the new system (Peña-Longobardo et al., 2016). Consequently, long waiting lists emerged, whereby individuals who had been assessed as eligible waited extended periods before receiving services. Faced with these implementation challenges,

policymakers increasingly relied on cash benefits supporting informal family care rather than expanding professional care services (Costa-Font et al., 2018; Costa-Font et al., 2025)[8].

By the end of 2024, almost 1.5 million individuals were receiving either supports of cash subsidies. This includes supports aimed at preventing dependency and promoting personal autonomy, such as telecare, home care, day and night care centres, and residential nursing care. Eligibility for SAAD is universal but conditional on needs tests. Applicants undergo an evaluation using the official Dependency Assessment Scale, which classifies individuals into three levels of dependency: Moderate (Degree I), Severe (Degree II), and High Dependency (Degree III), reflecting the intensity of support required for activities of daily living. The assessment also considers cognitive impairment, particularly where limitations affect decision-making and independent functioning, and includes adaptations for individuals with health conditions affecting cognitive capacity.

SAAD is financed through a combination of central government funding, regional government contributions, and user co-payments. Since its introduction, public expenditure on LTC has expanded substantially and now exceeds 1% of GDP (Jiménez-Martín and Viola, 2022). User contributions account for approximately 22% of total SAAD expenditure on average (Codorniu, 2024). Recent reforms have focused on strengthening quality standards, increasing minimum staffing requirements for both public and private providers, and reducing waiting times. At the same time, policy has increasingly prioritised ageing in place by expanding home- and community-based care while improving the quality of both domiciliary and residential services. This strategic reorientation towards home-based care is consistent with broader evidence

[8] These challenges were further compounded by Spain's highly decentralized governance structure, under which regional governments are responsible for implementing LTC policy, contributing to persistent territorial variation in access, service availability, and quality (Costa-Font, 2010).

highlighting the importance of supporting informal caregivers while delaying or avoiding institutionalisation.

4. Data and Definitions

Sample. Our primary data source is the Survey of Health, Ageing and Retirement in Europe (SHARE). We pool data from Waves 1 (2004/05), 2 (2006/07), 4 (2010/11), 5 (2012/13), 6 (2014/15), and 7 (2016/17), covering the pre-COVID period. Although SHARE surveys individuals aged 50 and over, our analysis is restricted to respondents aged 65 years and older.

Cognitive impairment. We define cognitive impairment using a threshold score of 6 or below, following the approach of Crimmins et al. (2011) and Langa et al. (2017). The cognitive indicator combines performance across four domains:

- **10-word immediate recall:** immediate recall of a list of 10 words, measuring short-term memory.
- **10-word delayed recall:** recall of the same list after a delay, assessing memory consolidation.
- **Serial 7s:** sequential subtraction of seven from 100, measuring attention and working memory.
- **Date naming:** correct identification of the current date, capturing temporal orientation.

The maximum possible score is 29 points, although observed scores in our sample range from 0 to 24. Individuals scoring 6 or below are classified as cognitively impaired.

To minimise selection bias arising from severe cognitive impairment, we additionally classify as cognitively impaired individuals whose interview was completed by a proxy respondent because

they were unable to participate due to cognitive limitations. Proxy interviews are identified using the SHARE question indicating whether the survey was answered on behalf of the respondent.

5. Results

*Cognitive Score and limitations***.** We begin our analysis examining the distribution of cognitive scores is presented in Figure 1a, where a score of 6 or below is used as the threshold for cognitive impairment. The dashed vertical lines denote the quintiles of the distribution, providing a visual representation of how cognitive performance is distributed across the study population. The distribution is skewed towards higher scores, indicating that most respondents retain relatively good cognitive functioning. Hence, only a small proportion of individuals are concentrated in the upper quintiles of the distribution. An important feature of the distribution is that the second quintile spans scores from 4 to 6, accounting for 21.1% of individuals aged 65 years and over. Since this interval includes the threshold for cognitive impairment, it suggests that a sizeable share of the older population exhibits relatively low levels of cognitive functioning and may be at increased risk of cognitive decline.

Next, Figure 1b further illustrates the distribution of cognitive scores separately for two age groups: individuals aged 65–84 and those aged 85 years and over. The comparison reveals a pronounced age gradient in cognitive performance, with the distribution shifting systematically towards lower scores among the oldest respondents. Specifically, 96.5% of individuals aged 85 years and over obtain a cognitive score of 12 or less, compared with 76.5% of those aged 65–84. Conversely, higher cognitive scores are considerably more common among the younger elderly group, while they become increasingly rare among those aged 85 and above. These findings are

consistent with the well-established association between advancing age and declining cognitive function, reflecting the cumulative effects of ageing on memory, orientation, and other cognitive abilities. Overall, the figure highlights a substantial deterioration in cognitive performance at advanced ages, with the oldest-old exhibiting markedly lower cognitive scores and a greater concentration around the lower end of the distribution.

[Insert Figures 1a and 1b about here]

Physical Limitations: The measure of physical limitations used in this study is based on difficulties in performing activities of daily living (ADLs), a standard indicator of functional capacity among older adults. The ADLs considered include dressing, bathing or showering, walking across a room, getting in and out of bed, and using the toilet. Following the clinical literature, an individual is classified as having a physical limitation if they report difficulty performing two or more of these activities independently. This threshold captures moderate to severe functional impairment that is likely to require assistance with everyday living.

Figure 2a presents the distribution of ADL limitations in the SHARE sample. The distribution is heavily concentrated at zero, indicating that most respondents aged 65 years and over report no difficulties with basic daily activities. As the number of reported limitations increases, the proportion of respondents declines steadily, suggesting that severe physical disability remains relatively uncommon in the overall older population. Nevertheless, a non-negligible minority experience multiple limitations, reflecting the substantial burden of disability among the most vulnerable older adults.

Figure 2b compares the distribution of ADL limitations between respondents aged 65–84 and those aged 85 years and over, revealing a pronounced age gradient in functional ability. While approximately 85% of individuals aged 65–84 report no physical limitations, this share falls to around 56% among those aged 85 and over. Correspondingly, the prevalence of functional impairment increases sharply with age. Among respondents aged 65–84, only 8.3% report difficulties with two or more ADLs, whereas this proportion rises almost fourfold to 32.2% among those aged 85 years and older.

[Insert Figures 2a and 2b about here]

The distributions therefore highlight the substantial deterioration in physical functioning that accompanies advanced age. Although most individuals entering older age remain physically independent, the likelihood of experiencing limitations in essential daily activities rises markedly among the oldest-old. These findings are consistent with the well-established age-related increase in frailty and disability and underscore the growing need for long-term care and support services as populations age. They also illustrate the importance of considering functional limitations alongside cognitive impairment when assessing dependency and the demand for long-term care.

Care Utilization and Outcomes: Figure 3 displays the proportion of individuals aged 65 years and over receiving long-term care (LTC), disaggregated by quintiles of the cognitive score distribution. We distinguish between three mutually non-exclusive forms of care: informal care provided at home, formal care delivered at home, and residential care in a nursing home. This breakdown allows us to examine how the use of different types of LTC varies across levels of cognitive functioning.

Our estimates suggest that informal care is the most common form of support, with approximately 19% of older adults receiving assistance from family members, friends, or other unpaid caregivers within the home. Formal home care, provided by professional caregivers or care agencies, is used by 15.5% of respondents. Residential care remains comparatively uncommon, with only 2.3% of the sample residing in a nursing home. A clear gradient emerges across cognitive quintiles. As cognitive functioning deteriorates, the likelihood of receiving any form of long-term care increases, although the magnitude of this increase differs by type of care. Individuals in the lowest cognitive quintiles are substantially more likely to receive both informal and formal home care than those with better cognitive functioning, reflecting the greater support needs associated with cognitive decline. Nursing home residence, while relatively rare overall, also becomes progressively more common among individuals with lower cognitive scores, suggesting that severe cognitive impairment is an important determinant of institutional care.

These descriptive patterns are suggestive of a clear pattern, namely, that *declining cognitive function is associated with a higher probability of receiving long-term care, particularly care provided in the community*. At the same time, the much higher prevalence of home-based care relative to institutional care point to the central role of ageing in place (Costa-Font and Vilaplana 2022, Costa-Font et al, 2009) and the continued importance of family caregiving in meeting the care needs of older adults.

[Insert Figures 3 about here]

When we turn to the effect of CI on nursing home care, it's worth mentioning that the SHARE survey data does not provide a complete cross-sectional picture of all older adults in

nursing homes[9]. Although our captures only a subset of institutional care users and is likely to underestimate the overall prevalence of nursing home residence[10], the longitudinal structure of SHARE offers valuable information on transitions into institutional care and, importantly, on barriers to accessing nursing homes. Among respondents who transitioned to residential care, individuals with cognitive impairment report substantially greater unmet need than those with physical limitations. Specifically, 33.3% of respondents with CI report being unable to access a nursing home because of financial constraints, compared with only 7.6% of those with physical impairment. Likewise, 50.0% of individuals with CI report difficulties due to the lack of available places, compared with just 5.2% among those with physical limitations. These findings suggest that cognitive impairment is associated with considerably greater barriers to obtaining institutional care, both in terms of affordability and service availability.

Taken together, the descriptive evidence provides important insights into how long-term care use varies with cognitive functioning. Individuals with lower cognitive scores are substantially more likely to receive both informal and formal care, reflecting the greater support needs associated with cognitive decline. Conversely, those in the highest cognitive quintiles make considerably less use of LTC services. The evidence on nursing home access further suggests that, despite having greater care needs, older adults with cognitive impairment face significant obstacles in accessing residential care, reinforcing the importance of expanding both the availability and affordability of formal long-term care services.

[9] We identify two main groups of nursing home users: (i) individuals reporting temporary stays in a nursing home, and (ii) permanent residents who were interviewed while living in the community in a previous SHARE wave but subsequently moved into a nursing home.

[10] We identify two main groups of nursing home users: (i) individuals reporting temporary stays in a nursing home, and (ii) permanent residents who were interviewed while living in the community in a previous SHARE wave but subsequently moved into a nursing home.

The interaction between cognitive score and limitations. Table 1 reports the joint distribution of physical limitations and CI among individuals aged 65 years and over. Overall, 80.5% of respondents report no physical limitations, defined as having fewer than two limitations in activities of daily living (ADLs). Consistently, more than half of the sample (53.4%) experience neither physical nor cognitive impairment, indicating that most older adults remain relatively independent. Approximately 12% of respondents report physical limitations (two or more ADL difficulties), while around 9% experience both cognitive impairment and physical limitations, highlighting the substantial overlap between declines in physical and cognitive functioning at older ages.

[Insert Tables 1, 2a and 2b about here]

Table 2a compares the sociodemographic characteristics of three mutually exclusive groups: (i) individuals with no impairment (0–1 ADL limitations and a cognitive score of 7 or above); (ii) individuals with physical impairment only (two or more ADL limitations and a cognitive score of 7 or above); and (iii) individuals with cognitive impairment (cognitive score of 6 or below, irrespective of physical limitations). Several clear patterns emerge.

First, there is a *pronounced age gradient across the three groups*. Individuals without impairments are, on average, 73 years old, compared with 77 years among those with physical impairments and 79 years among those with cognitive impairment. This pattern is consistent with the descriptive evidence presented earlier, indicating that both forms of impairment become increasingly prevalent with advancing age.

Second, the groups *differ markedly in their socioeconomic characteristics*. Older adults without impairments are more likely to be married or living with a partner and have substantially higher levels of educational attainment. For example, they are around five percentage points more likely to have completed tertiary education than individuals with physical impairments and eight percentage points more likely than those with cognitive impairment. These differences are consistent with a growing body of evidence linking educational attainment to healthier ageing and greater cognitive reserve.

Socio-economic status also differs substantially across groups. *Individuals without impairments exhibit considerably higher income and wealth than those experiencing cognitive impairment*. Average annual income per capita is €14,553 among the non-impaired group, compared with €10,564 for individuals with cognitive impairment. Similarly, differences in accumulated wealth are even more pronounced: average per capita wealth is €204,906 among individuals without impairment but only €144,099 among those with cognitive impairment, a gap of more than €60,000. These findings point to a strong socioeconomic gradient in both physical and cognitive health at older ages.

Next, Table 2b compares health status, care needs, and long-term care utilisation across the same three groups. As expected, cognitive functioning differs sharply across these categories. The average cognitive score is 11.32 among individuals without impairments and 9.56 among those with physical impairments only but falls to just 3.43 among the cognitively impaired group.

Functional limitations also vary considerably. Respondents with physical impairments report substantially more limitations in both ADLs and instrumental activities of daily living (IADLs) than those with cognitive impairment alone, with the difference being particularly pronounced for ADL limitations. This reflects the fact that the physical impairment group is

explicitly defined by significant functional disability, whereas cognitive impairment may occur in the absence of severe physical limitations.

These differences translate directly into patterns of care utilisation. The proportion of individuals receiving any type of long-term care increases markedly with the severity of impairment. Only 13% of respondents without impairments receive any form of care, compared with 38% of those with cognitive impairment and 71% of those with physical impairments. Thus, although both conditions substantially increase the need for support, physical limitations are associated with considerably higher rates of care use.

The type and intensity of care received also differ across groups. Nursing home care access remains relatively uncommon regardless of impairment status, although it is highest among individuals with physical impairments (3.5%), followed by those with cognitive impairment (2.0%). As expected, institutional care is least common among respondents without impairments. Similarly, individuals with physical impairments receive substantially more care at home. They use an average of 84 hours of informal care, compared with 65 hours among those with cognitive impairment, while average formal home care amounts to 32 hours and 27 hours, respectively.

Overall, *these descriptive results indicate that both cognitive and physical impairments substantially increase the demand for long-term care*, but their effects differ in important ways. Physical limitations are associated with considerably higher levels of formal and informal care utilisation, reflecting the greater assistance required to perform basic activities of daily living. In contrast, individuals with cognitive impairment make comparatively less use of both home-based and institutional care despite exhibiting substantial care needs. This pattern may reflect differences in care required by individuals with cognitive decline, but it may also indicate unmet need and

barriers to accessing appropriate formal services, particularly residential care, as suggested by the descriptive evidence presented above.

*Examining Long-Term Care Use and Determinants***.** We begin by examining the determinants of receiving any long-term care (LTC) before distinguishing between its main components: formal home care, informal home care, and nursing home care. To capture both the extensive and intensive margins of care use, we estimate models for the probability of receiving each type of care and, conditional on receipt, the number of hours of formal and informal care received during the previous month. All regression specifications control for a rich set of demographic and socioeconomic characteristics. In addition to indicators for physical and cognitive impairment, the specifications include age and age squared, marital status, gender, an interaction between gender and marital status, whether the respondent has children and the number of children, educational attainment, and measures of income and wealth. This specification allows us to isolate the association between impairment status and care utilization while accounting for observable differences in family structure and socioeconomic resources that are also likely to influence access to care.

Table 3 linear probability estimates of the effect of the impact of both physical and cognitive impairments on the receipt of any type of long-term care. The unconditional estimates in Column (1) show that both *physical and cognitive impairments are associated with a substantially higher probability of receiving care*, with the association being considerably larger for individuals with physical limitations. Adding age and age squared in Column (2) reduces the magnitude of both coefficients, indicating that part of the observed relationship reflects the higher prevalence of impairment among older individuals. Nevertheless, impairment remains a

strong predictor of care receipt, suggesting that the relationship is not driven solely by age differences.

[Insert Table 3 about here]

The fully adjusted specification in Column (3) confirms these findings after controlling for socioeconomic and family characteristics. Marital status emerges as an important determinant of care utilization. Being married is associated with a reduction of approximately 10 percentage points (pp) in the probability of receiving care, while married women are around 5.5 pp more likely to receive care than married men. These results are consistent with gender differences in caregiving arrangements and household support networks. Educational attainment also plays a role. Compared with individuals who did not complete primary education, those with primary education are approximately 3.3 pp less likely to receive care, whereas the difference for individuals with tertiary education is small and statistically insignificant. Overall, the results indicate that although demographic and socioeconomic characteristics explain part of the variation in care use, impairment status remains the dominant predictor of receiving long-term care.

Tables 4a and 4b examine the use of formal home care. Across all specifications, both cognitive and physical impairments are positively and significantly associated with the probability of receiving professional home care. Consistently with Table 3, the estimated coefficients decline somewhat after progressively adding controls, suggesting that part of the raw association reflects differences in age and socioeconomic characteristics. However, the effects remain sizeable and statistically significant throughout.

[Insert Tables 4a and 4b about here]

The results also reveal important socioeconomic differences in access to formal care. Married women are significantly less likely to receive professional home care than other respondents, pointing to the continuing importance of spouses as informal caregivers. In contrast, educational attainment is positively associated with the use of formal services. Relative to respondents with less than primary education, individuals with a high school education are approximately 4.6 pp more likely to receive formal home care, while those with tertiary education are around 5.1 pp more likely to have access to formal care. These findings suggest that more educated individuals may be better able to navigate the LTC system or have greater resources to complement publicly funded services.

Conditional on receiving formal care, both physical and cognitive impairments are associated with a significantly greater number of care hours. The estimated effects are substantially larger for individuals with physical limitations, indicating that functional disability is a particularly important determinant of care intensity. Age also displays a nonlinear relationship with formal care use: while the linear age term is negative, the positive coefficient on age squared suggests that the probability of receiving formal care increases again at very advanced ages.

To complete the picture, Table 5 focuses on informal home care. Consistently, both physical and cognitive impairments substantially increase the probability of receiving unpaid assistance from relatives or friends. Although the estimated effects become smaller after controlling for demographic and socioeconomic characteristics, they remain highly significant, indicating that impairment independently predicts informal caregiving.

Family characteristics appear to play a more prominent role in informal than in formal care arrangements. *Married women are significantly more likely to receive informal care, consistent with the availability of family support within the household* (Costa-Font et al, 2025). In contrast to formal care, educational attainment is negatively associated with informal care use, suggesting that individuals with lower levels of education rely more heavily on family caregivers, possibly reflecting differences in financial resources or access to formal services.

[Insert Table 5 about here]

Conditional on receiving any informal care, *both physically and cognitively impaired respondents receive substantially more hours of care than individuals without impairments*. Once again, the effects are considerably larger for those with physical limitations, highlighting the greater time demands associated with assisting individuals experiencing functional disability. These findings reinforce the central role played by family caregivers in supporting older adults with physical impairments.

Finally, Table 6 examines the impact of cognitive and physical impairment in nursing home care access[11]. Our estimates indicate that physical limitations are more strongly associated with nursing home use than cognitive impairment. Individuals with *physical impairments are approximately two percentage points more likely to reside in a nursing home, whereas the corresponding increase associated with cognitive impairment is only around 0.6 percentage points*. Although these probabilities remain relatively small, they are consistent with the descriptive evidence showing that institutional care is comparatively uncommon in Spain and

[11] Because SHARE identifies only a subset of institutionalized individuals, the estimation sample is considerably smaller, and the results should therefore be interpreted with caution

that most long-term care continues to be provided in the community. Together with the earlier findings on unmet need, these results suggest that barriers to accessing residential care may be particularly important for older adults with cognitive impairment, who appear to rely disproportionately on home-based and family care despite having substantial care needs.

[Insert Table 6 about here]

Cost Estimation. Table 7 reports the estimated costs of long-term care at both the individual and aggregate levels. The costing methodology follows the approach developed in Costa-Font et al. (2025), combining information on service utilization with unit costs to estimate the economic value of formal and informal care across different impairment groups.

[Insert Table 7 about here]

The results reveal substantial variation in the cost of care according to individuals' health status. Average annual long-term care costs per user amount to €2,860 for individuals with no significant impairments (0–1 ADL limitations and a cognitive score of 7 or above), €11,113 for those with physical impairment only (two or more ADL limitations and a cognitive score of 7 or above), and €83,507 for individuals with cognitive impairment (cognitive score between 0 and 6, irrespective of ADL limitations). Thus, the average cost of caring for an individual with cognitive impairment is almost thirty times higher than that for an older adult without significant impairments and more than seven times higher than the cost associated with physical impairment alone.

Disaggregating these estimates by type of care highlights the different sources of expenditure. Average annual expenditure on formal home care amounts to €906 per user in the

non-impaired group, €2,213 among individuals with physical impairments, and €23,756 for those with cognitive impairment. A similar pattern emerges for informal care, although the differences are even more pronounced. The estimated value of informal care reaches €3,174, €7,747, and €83,153 per user, respectively, indicating that unpaid family care constitutes the largest component of total care costs, particularly for individuals with cognitive impairment. Estimated annual costs associated with nursing home care are €5,087 for the non-impaired group, €12,418 for individuals with physical impairments, and €133,287 for those with cognitive impairment, reflecting the high resource intensity of institutional care among the relatively small number of users.

At the aggregate level, the estimated annual cost of long-term care in Spain amounts to €21.2 billion. Informal care accounts for the largest share of expenditure, representing €11.6 billion, or approximately 55% of total LTC costs. This finding point to the central role played by unpaid family caregivers within the Spanish long-term care system. *Despite the expansion of publicly funded LTC after SAAD, the economic burden of caring for older adults continues to fall predominantly on families.* The particularly high costs associated with cognitive impairment further suggest that population ageing and the expected increase in dementia prevalence are likely to place growing pressure on both households and the long-term care system in the coming decades.

6. Conclusions

Although population ageing is rapidly increasing the demand for health and long-term care (LTC) in Spain, cognitive impairment rather than ageing is increasingly becoming one of its main drivers. Using pooled pre-pandemic SHARE data (2004–2017), this paper estimates the prevalence of cognitive impairment (CI), alongside its interaction with physical limitations, patterns of LTC utilization, and the associated economic costs.

Our findings suggest that cognitive impairment affects *18.5%* of Spaniards aged 65 and over, rising to *45.3%* among those aged 85 and above. Physical limitations also increase sharply with age, and approximately *9%* of older adults experience both cognitive and physical impairments. Although both conditions increase the demand for care, we find that physical limitations are associated with substantially greater use of both formal and informal home care. Individuals with physical impairments are *71 percentage points* (pp) more likely to receive care than those without impairments, compared with 38 pp for those with cognitive impairment. At the same time, individuals with cognitive impairment face greater barriers to accessing nursing home care, suggesting important unmet needs despite the expansion of SAAD.

The analysis also reveals a marked socioeconomic gradient. Older adults with cognitive impairment are more likely to exhibit lower levels of education, income, and wealth compared to those without impairments, highlighting the close relationship between dependency and socioeconomic disadvantage. Our cost estimates suggest that while the average annual LTC costs per user amounts to **€2,860** for individuals without significant impairments, such estimates increase to **€11,113** for those with physical limitations, and **€83,507** for individuals with cognitive impairment. At the national level, total LTC expenditure is estimated at **€21.2 billion**, of which **€11.6 billion (55%)** corresponds to informal care. Finally, using the Proxy Good method, we further estimate that replacing all informal care with equivalent formal home care services would require resources broadly equivalent to the entire annual budget of the SAAD, the main long term care public program in place today after 2007, illustrating the extent to which the Spanish LTC system continues to depend on unpaid family caregivers.

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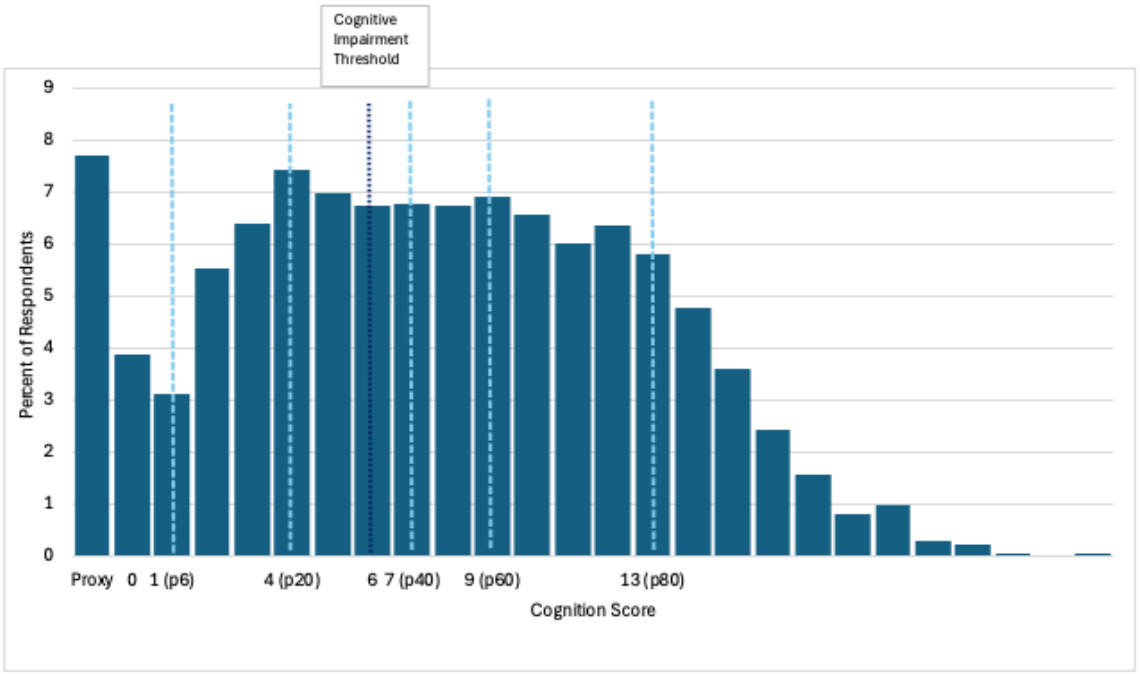
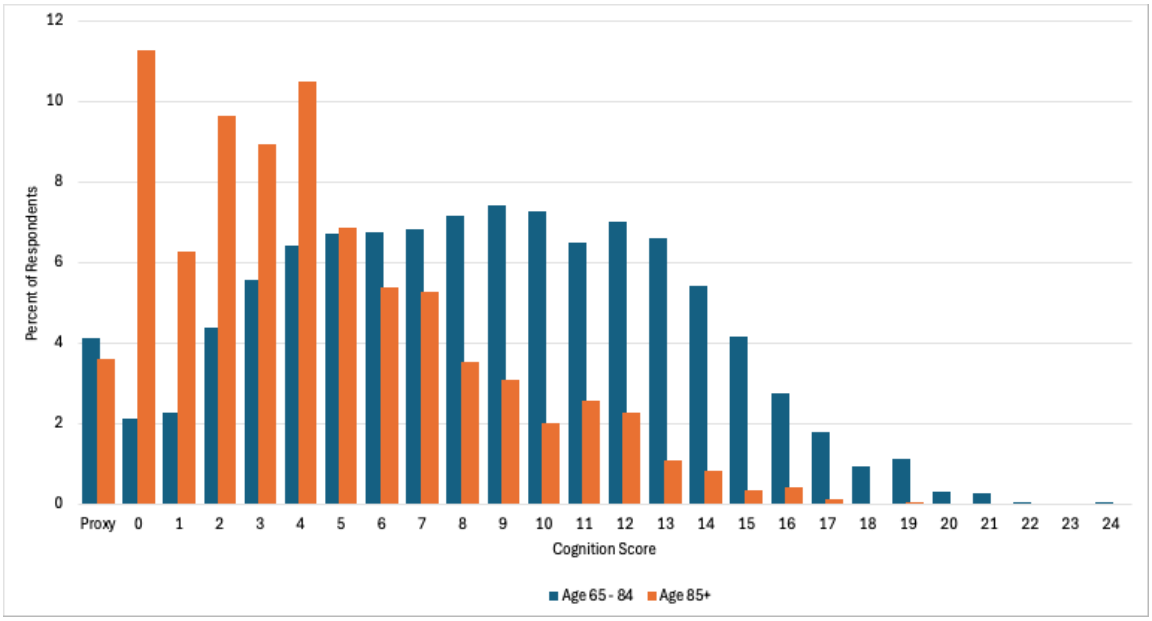
Tables and Figures

Figure 1a. Histogram of cognition scores (including proxies).



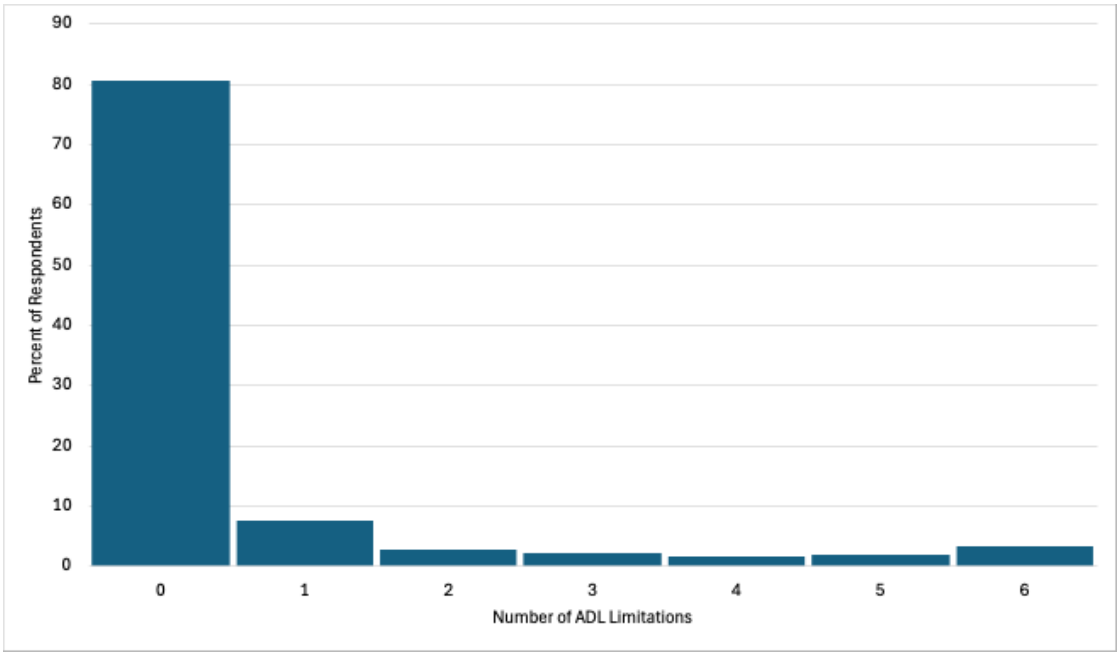
Source: SHARE (waves 1, 2, 4, 5, 6 y 7).

Figure 1b. Histogram of cognition scores by age categories



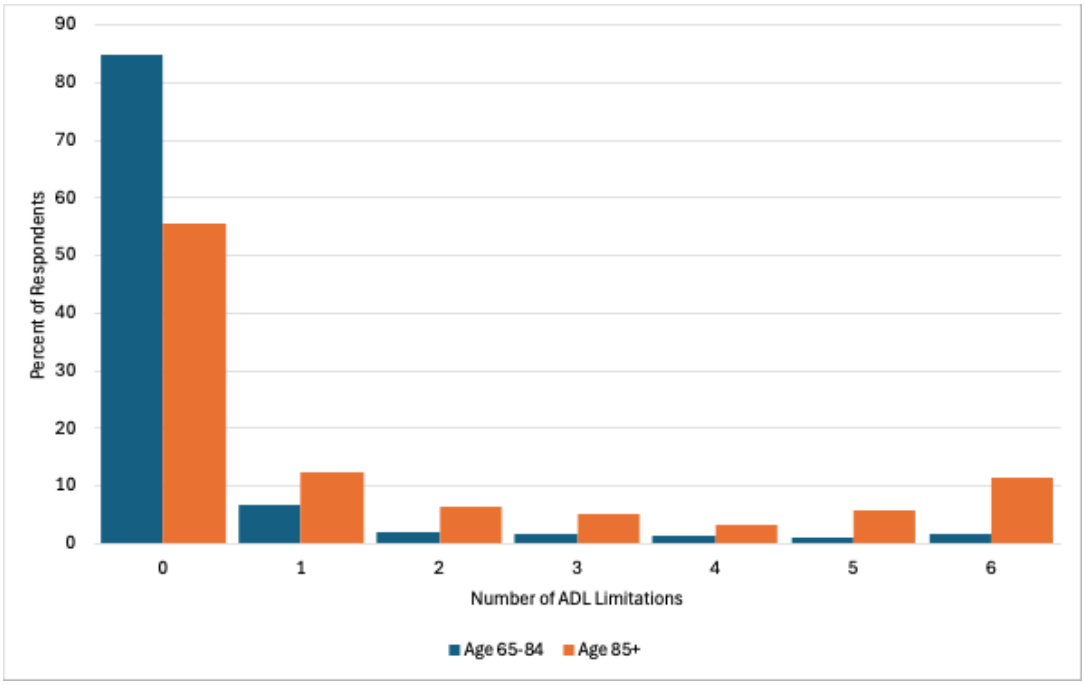
Source: SHARE (waves 1, 2, 4, 5, 6 y 7).

Figure 2a. Histogram of ADL limitations



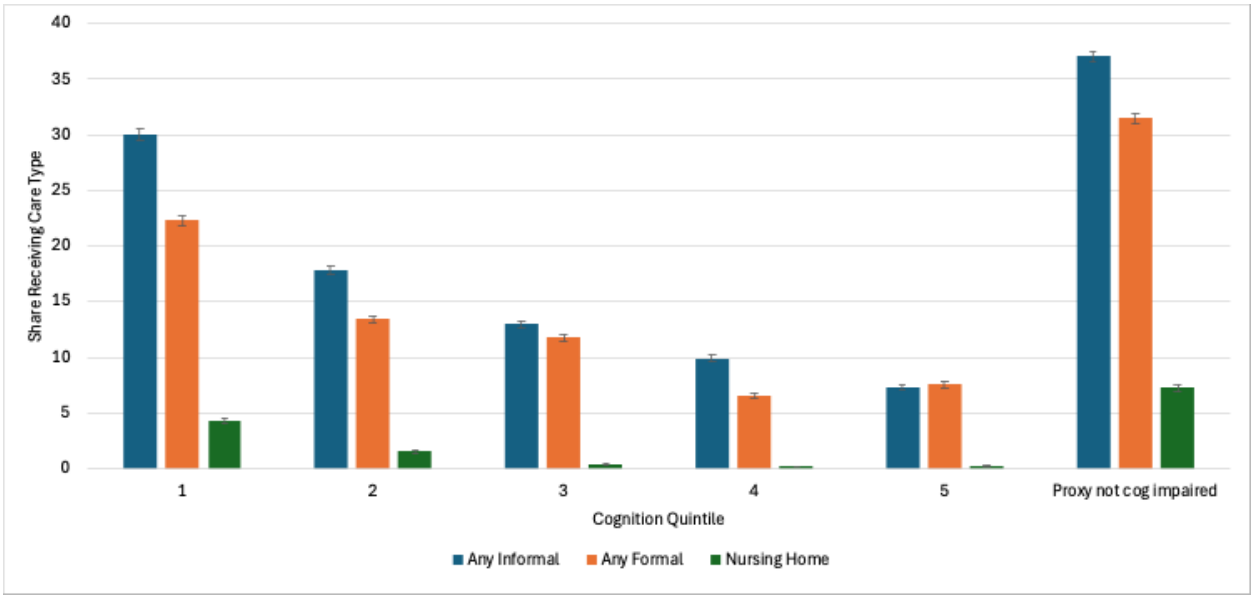
Source: SHARE (waves 1, 2, 4, 5, 6 y 7).

Figure 2b. Histogram of ADL limitations by age categories



Source: SHARE (waves 1, 2, 4, 5, 6 y 7).

Figure 3. Share Receiving Care Type by Cognition Quintile



Source: SHARE (waves 1, 2, 4, 5, 6 y 7).

Table 1: Joint distribution cognition score and ADL limitations

Limitations	Cognition score 0–6	Cognition Score 7+	Total
0 ADLs	27.06%	53.48%	80.54%
1 ADL	4.03%	3.53%	7.56%
2+ ADL	8.99%	2.91%	11.90%
Total	40.08%	59.92%	100.00%

Source: SHARE (waves 1, 2, 4, 5, 6 y 7). Proxy respondents identified as cognitively impairment are grouped with respondents who scored 0–6 on the cognitive assessment. Weighted percent.

Table 2a: Joint distribution cognition score and ADL limitations by sociodemographic characteristics

Means	0 – 1 ADLs & Score 7+	2+ ADLs & Score 7+	Score 0 – 6 (All ADLs)	Total
Age	73.323	77.739**	79.450**	75.877
	6.377	*7.819*	*7.456*	*7.488*
Female (0 or 1)	0.478	0.590**	0.628**	0.541
	0.500	*0.493*	*0.483*	*0.498*
Married (0 or 1)	0.796	0.652**	0.636**	0.728
	0.403	*0.477*	*0.481*	*0.445*
Any children (0 or 1)	0.647	0.628	0.674*	0.657
	0.478	*0.484*	*0.469*	*0.475*
Number of children	1.708	1.972**	1.991**	1.828
	1.661	*2.092*	*1.951*	*1.800*
Primary education (0 or 1)	0.630	0.541**	0.510**	0.580
	0.483	*0.499*	*0.500*	*0.494*
High school (0 or 1)	0.081	0.052**	0.017**	0.055
	0.273	*0.223*	*0.132*	*0.229*
College + (0 or 1)	0.100	0.052**	0.017**	0.065
	0.300	*0.223*	*0.128*	*0.247*
Work for pay (0 or 1)	0.034	0.028	0.008**	0.024
	0.182	*0.165*	*0.092*	*0.153*
Income per capita (mean)	14,553.69	12,219.44*	10,564.47**	12,904.11
	14,225.34	*8,504.54*	*10,475.13*	*12,875.45*
Income per capita (median)	11,821.63	10,384.59	9,333.59	10,630.26
Wealth per capita (mean)	204,906.80	145,921.7*	144,099.9**	179,141.50
	368,029.90	*203,644.20*	*317,886.60*	*346,622.50*
Wealth per capita (median)	116,294.30	91,972.63	97,711.21	116,486.30
N	5,936	288	4,094	10,318

Source: SHARE (waves 1, 2, 4, 5, 6 y 7). Notes: Standard errors are in italics. Standard errors are clustered at the respondent level. Stars correspond to the null hypothesis that the mean is different from the mean of 0 - 1 ADLs & Score 7+. *: Significant at the 95% confidence level **: Significant at the 99% confidence level.

Table 2b: Care needs and care usage across cognition score and ADL limitations

Means	0 – 1 ADLs & Score 7+	2+ ADLs & Score 7+	Score 0 – 6 (All ADLs)	Total
Limited score (out of 29)	11.318	9.565**	3.439**	8.143
	3.108	*2.622*	*1.925*	*4.675*
Number of ADLs	0.048	3.635**	0.970**	0.514
	0.214	*1.466*	*1.801*	*1.361*
Number of IADLs	0.194	3.850**	1.821**	0.942
	0.670	*2.664*	*2.543*	*1.971*
Any care (0 or 1)	0.133	0.708**	0.379**	0.247
	0.340	*0.455*	*0.485*	*0.431*
Any Unpaid care (0 or 1)	0.080	0.538**	0.265**	0.167
	0.272	*0.499*	*0.442*	*0.373*
Any Paid care (0 or 1)	0.067	0.361**	0.193**	0.126
	0.251	*0.481*	*0.395*	*0.331*
Any Nursing home (0 or 1)	0.002	0.035**	0.020**	0.010
	0.043	*0.183*	*0.140*	*0.099*
Unpaid care hours per month (conditional on unpaid care)	42.158	83.950**	65.071**	60.412
	8.335	*17.314*	*25.902*	*24.801*
Paid care hours per month (conditional on paid care)	17.027	32.401**	27.194**	24.472
	3.279	*6.993*	*10.063*	*9.785*
NH LOS days per year (conditional on nursing home stay)	0.050	2.941**	0.356*	0.252
	1.766	*30.960*	*6.270*	*6.654*
N	5,936	288	4,094	10,318

Source: SHARE (waves 1, 2, 4, 5, 6 y 7). Notes: Standard errors are in italics. Standard errors are clustered at the respondent level. Stars correspond to the null hypothesis that the mean is different from the mean of 0 - 1 ADLs & Score 7+. *: Significant at the 95% confidence level **: Significant at the 99% confidence level.

Table 3: Probability of receiving any care

	(1) Any personal care R1 b/se	(2) Any personal care R2 b/se	(3) Any personal care R3 b/se
2+ ADLs and Score 7+	0.575***	0.508***	0.494***
	(0.025)	(0.024)	(0.026)
Score 0 – 6	0.246***	0.154***	0.136***
	(0.008)	(0.009)	(0.010)
Age – 65		-0.065***	-0.063***
		(0.010)	(0.010)
(Age – 65) Squared		0.001***	0.000***
		(0.000)	(0.000)
Female			0.002
			(0.018)
Married			-0.098***
			(0.017)
Female * Married			0.055***
			(0.020)
Number of children			0.006*
			(0.003)
Any children			-0.005
			(0.013)
Income (Inverse Hyperbolic Sine)			0.000*
			(0.000)
Wealth (Inverse Hyperbolic Sine)			-0.000
			(0.000)
Primary education			-0.033***
			(0.009)
High school			0.000
			(0.020)
College or more			-0.003
			(0.019)
Constant	0.133***	2.101***	2.121***
	(0.005)	(0.371)	(0.392)
N	10,318	10,318	9,234
F	631.458	532.774	139.925
p	0	0	0
R2	0.109	0.171	0.175

Source: SHARE (waves 1, 2, 4, 5, 6 y 7). Notes: Standard errors in parentheses. Standard errors are clustered at the respondent level="* p<0.05, ** p<0.01, *** p<0.001"**.** Proxies who are identified as cognitively impaired are placed into groups "Score 0 - 6 Only" and "2+ ADLs and Score 0 - 6", depending on the number of ADL limitations.

Table 4a and 4b: Use of formal care on the extensive and intensive margin

	Extensive Margin: Any paid care			Intensive Margin: Hours paid care conditional on receiving any paid care		
	R1	**R2**	**R3**	**R4**	**R5**	**R6**
	b/se	**b/se**	**b/se**	**b/se**	**b/se**	**b/se**
2+ ADLs and Score 7+	0.294***	0.242***	0.243***	15.374***	14.434***	14.793***
	(0.020)	(0.019)	(0.020)	(0.915)	(0.810)	(0.884)
Score 0 – 6	0.126***	0.055***	0.055***	10.167***	7.475***	7.629***
	(0.007)	(0.007)	(0.008)	(0.510)	(0.477)	(0.542)
Age – 65		-0.061***	-0.056***		-1.499***	-1.466***
		(0.008)	(0.008)		(0.486)	(0.521)
(Age – 65) Squared		0.000***	0.000***		0.013***	0.012***
		(0.000)	(0.000)		(0.003)	(0.003)
Female			0.027*			1.553*
			(0.014)			(0.835)
Married			-0.050***			2.348***
			(0.013)			(0.872)
Female * Married			0.026			-2.087**
			(0.016)			(1.025)
Number of children			0.002			0.262
			(0.003)			(0.160)
Any children			0.006			-1.310**
			(0.010)			(0.656)
Income (Inverse Hyperbolic Sine)			0.000**			-0.000
			(0.000)			(0.000)
Wealth (Inverse Hyperbolic Sine)			0.000**			-0.000
			(0.000)			(0.000)
Primary education			0.003			0.390
			(0.007)			(0.476)
High school			0.046***			0.638
			(0.016)			(1.105)
College or more			0.051***			0.793
			(0.015)			(0.969)
Constant	0.067***	1.992***	1.837***	17.027***	56.483***	53.398**
	(0.004)	(0.295)	(0.312)	(0.416)	(19.594)	(20.991)
N	10,318	10,318	9,234	1,295	1,295	1,147
F	262	325	92	250	253	64
p	0	0	0	0	0	0
R2	0.048	0.112	0.123	0.279	0.439	0.444

Source: SHARE (waves 1, 2, 4, 5, 6 y 7) and EDAD (2020). Notes: Standard errors in parentheses. Standard errors are clustered at the respondent level="* p<0.05, ** p<0.01, *** p<0.001"**.** Proxies who are identified as cognitively impaired are placed into groups "Score 0 - 6 Only" and "2+ ADLs and Score 0 - 6", depending on the number of ADL limitations.

Table 5a and 5b: Use of informal care on the extensive and intensive margin

	Extensive Margin: Any unpaid care			Intensive Margin: Hours unpaid care conditional on receiving any unpaid care		
	R1	**R2**	**R3**	**R4**	**R5**	**R6**
	b/se	**b/se**	**b/se**	**b/se**	**b/se**	**b/se**
2+ ADLs and Score 7+	0.46***	0.42***	0.41***	39.90***	39.98***	40.44***
	(0.02)	(0.02)	(0.02)	(3.77)	(3.70)	(3.99)
Score 0 – 6	0.18***	0.14***	0.12***	27.56***	26.75***	26.83***
	(0.01)	(0.01)	(0.01)	(2.61)	(2.70)	(3.02)
Age – 65		-0.03***	-0.03***		-10.90***	-10.98***
		(0.01)	(0.01)		(2.57)	(2.77)
(Age – 65) Squared		0.00***	0.00***		0.07***	0.07***
		(0.00)	(0.00)		(0.02)	(0.02)
Female			-0.00			7.16*
			(0.02)			(4.18)
Married			-0.04***			13.45***
			(0.02)			(4.39)
Female * Married			0.03*			-10.05**
			(0.02)			(5.04)
Number of children			0.01***			1.69**
			(0.00)			(0.71)
Any children			0.00			-9.42***
			(0.01)			(3.08)
Income (Inverse Hyperbolic Sine)			0.00			0.00
			(0.00)			(0.00)
Wealth (Inverse Hyperbolic Sine)			-0.00**			-0.00
			(0.00)			(0.00)
Primary school			-0.04***			3.33
			(0.01)			(2.22)
Some college			-0.03*			6.44
			(0.02)			(5.66)
College or more			-0.05***			1.81
			(0.02)			(5.61)
Constant	0.08***	0.90***	1.18***	42.92***	464.66***	453.88***
	(0.00)	(0.33)	(0.35)	(2.32)	(104.07)	(111.86)
N	10,318	10,318	9,234	516	516	448
F	488	311	82	72	45	14
p	0	0	0	0	0	0
R2	0.09	0.11	0.11	0.22	0.26	0.31

Source: SHARE (waves 1, 2, 4, 5, 6 y 7) and EDAD (2020). Notes: Standard errors in parentheses. Standard errors are clustered at the respondent level="* p<0.05, ** p<0.01, *** p<0.001". Proxies who are identified as cognitively impaired are placed into groups "Score 0 - 6 Only" and "2+ ADLs and Score 0 - 6", depending on the number of ADL limitations.

Table 6: Use of nursing home on the extensive margin

	(1) Reside in Nursing Home >= 100 days R1 b/se	(2) Reside in Nursing Home >= 100 days R2 b/se	(3) Reside in Nursing Home >= 100 days R3 b/se
2+ ADLs and Score 7+	0.019***	0.017***	0.012***
	(0.004)	(0.004)	(0.004)
Score 0 – 6	0.006***	0.003**	0.002
	(0.001)	(0.001)	(0.002)
Age – 65		0.002	0.002
		(0.002)	(0.002)
(Age – 65) Squared		0.000	0.000
		(0.000)	(0.000)
Female			0.005
			(0.003)
Married			0.001
			(0.003)
Female * Married			0.004
			(0.003)
Number of children			0.001*
			(0.001)
Any children			-0.005**
			(0.002)
Income (Inverse Hyperbolic Sine)			0.000
			(0.000)
Wealth (Inverse Hyperbolic Sine)			0.000
			(0.000)
Less than high school			0.000
			(0.002)
Some college			0.002
			(0.003)
College or more			0.003
			(0.003)
Constant	0.001	0.057	0.049
	(0.001)	(0.063)	(0.067)
N	10,318	10,318	9,234
F	20	18	5
p	0	0	0
R2	0.004	0.007	0.007

Source: SHARE (waves 1, 2, 4, 5, 6 y 7). Notes: Standard errors in parentheses. Standard errors are clustered at the respondent level="* p<0.05, ** p<0.01, *** p<0.001"**.** Proxies who are identified as cognitively impaired are placed into groups "Score 0 - 6 Only" and "2+ ADLs and Score 0 - 6", depending on the number of ADL limitations.

Table 7: Total cost of long-term care by cognitive score and ADL limitations

		0 – 1 ADLs & Score 7+	2+ ADLs & Score 7+	Score 0 – 6 (All ADLs)	Total
	N	730	58	296	1,084
	Population (millions)	2.94	0.16	0.23	3.33
Formal Care	National total (Million €)	1,007.56	310.14	1,263.12	2,240.00
	Per user (€)	906.86	2,213.43	23,756.42	1,717.35
	Per capita (€)	113.87	33.83	131.83	247.04
	% of GDP	0.08%	0.02%	0.10%	0.18%
Informal Care	National total (Million €)	5,366.93	1,594.58	6,213.01	11,643.00
	Per user (€)	3,174.24	7,747.61	83,153.80	5,906.22
	Per capita (€)	21.38	6.58	26.80	47.53
	% of GDP	0.43%	0.13%	0.50%	0.93%
Nursing Home	National total (Million €)	1,720.36	2,096.05	3,379.79	7,321.00
	Per user (€)	5,087.99	12,418.65	133,287.38	13,754.51
	Per capita (€)	36.50	44.47	71.71	155.34
	% of GDP	0.14%	0.17%	0.27%	0.58%
Total Cost	National total (Million €)	8,094.85	4,000.77	10,855.93	21,204.00
	Per user (€)	2,860.37	11,113.26	83,507.13	6,386.75
	Per capita (€)	171.76	84.89	230.34	449.90
	% of GDP	0.65%	0.32%	0.87%	1.69%

Source: SHARE wave 7. Notes: in euros 2019. See Costa-Font et al. (2025) for clarifications of the calculations.