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Cognition in informal caregivers: evidence from an English population study

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ABSTRACT

Background and objectives: The relationship between caregiving and cognition remains unclear. We investigate this association comparing four cognitive tasks and exploring the role of potential explanatory pathways such as healthy behaviours (healthy caregiver hypothesis) and depression (stress process model).

Research design and methods: Respondents were from English Longitudinal Study of Ageing (ELSA) ($N = 8910$). Cognitive tasks included immediate and delayed word recall, verbal fluency and serial 7 subtraction. Series of hierarchical linear regressions were performed. Adjustments included socio-demographics, health related variables, health behaviours and depression.

Results: Being a caregiver was positively associated with immediate and delayed recall, verbal fluency but not with serial 7. For immediate and delayed recall, these associations were partially attenuated when adjusting for health behaviours, and depression. For verbal fluency, associations were partially attenuated when adjusting for depression but fully attenuated when adjusting for health behaviours. No associations were found for serial 7.

Discussion and implications: Our findings show that caregivers have higher level of memory and executive function compared to non-caregivers. For memory, we found that although health behaviours and depression can have a role in this association, they do not fully explain it. However, health behaviours seem to have a clear role in the association with executive function. Public health and policy do not need to target specifically cognitive function but other areas as the promotion of healthy behaviours and psychological adjustment such as preventing depression and promoting physical activity in caregivers.

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KEYWORDS

Verbal memory; executive function; caregiving duration; older adults

An informal caregiver can be defined as the responsible of providing unpaid help with the basic and daily instrumental activities of daily living of someone who is less able for different reasons (Badia-Llach, Lara-Suriñach, & Roset-Gamisans, 2004). Despite, provision of care can take different forms, such as to family members, friends, neighbours, or children, all forms of care can impact on the lives of caregivers in different ways (De-Vugt et al., 2006; Vlachantoni, 2010). However, providing care to an individual with chronic illness and disability is generally viewed as a major life stressor (Schulz & Tompkins, 2010). Following Schulz and Tompkins (2010), there are three different groups of informal caregivers, being defined by the age of the care recipient: (1) children with chronic illness and disability; (2) adult children with such conditions as mental illness; and (3) older adults. In United Kingdom, the Family Resources Survey estimated that in 2018/19 around 4.5 million people were providing informal care, what represents around 7% of the population, being adults aged 55–64 most likely to care for others (Powell et al., 2020). In the United State, it is estimated that in 2020 more than 1 in 5 Americans (21.3%) are caregivers, having provided care to an adult or child with special needs (National Alliance for Caregiving, 2020).

Providing care to others involves tasks that require optimal cognitive abilities such as problem solving, information recall or effective communication (Miller et al., 2006). Even minor cognitive impairments may have functional consequences when caregivers are decision makers for both themselves and the care recipient (Caswell et al., 2003; Vitaliano et al., 2005). In fact, care recipients whose caregivers had cognitive difficulties are more likely to use fewer community resources and to experience difficulties with medication compliance (Boucher, Renvall, & Jackson, 1996), leading to provide suboptimal care (Kurita et al., 2018; Miller et al., 2006) which may result with negative consequences for the care recipient (De-Vugt et al., 2006). When the cognitive status of informal caregivers is affected, their ability to provide adequate care is also affected. This does not have only a clear and direct impact on the care recipient well-being and health but also a wider impact on our society. Informal caregivers can save billions yearly for government or institutions (National Alliance for Caregiving, 2020). Given this and the fact that our ageing population will lead to an increasing number of individuals to become informal caregivers, further research focused on caregiver's health and functioning is needed.

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Previous research which examined cognitive function in caregivers provided contradictory results. On the one hand, some studies have found that caregivers are more likely to be cognitively impaired when compared to non-caregivers (De-Vugt et al., 2006; Mackenzie, Wiprzycka, Hasher, & Goldstein, 2009; Oken, Fonareva, & Wahbeh, 2011; Palma et al., 2011; Romero-Martínez et al., 2018; Vitaliano et al., 2005, Vitaliano et al., 2009). On the other hand, other studies have found some evidence of potential positive effects on cognitive performance, and caregivers have been found to be more likely to have better cognitive function than non-caregivers (Bertrand et al., 2012; Jütten, Mark, & Sitskoorn, 2020;; Leipold, Schacke, & Zank, 2008; O'Sullivan et al., 2019). Differences between studies might be associated to socio demographics characteristics such as age, education or socio-economic position which can be independently associated with the normative cognitive ageing process, especially for care recipient's spouses (Miller et al., 2006; Vlachantoni, 2010). Specifically, lower cognitive performance has been found in older adults as part of the normative ageing process (Davis et al., 2017; John & Montgomery, 2010; Patel & Singh, 2018; Wilson et al., 2013), whereas better cognitive performance has been found in higher educated individuals according to the cognitive reserve theory (Anstey & Christensen, 2000; Patel & Singh, 2018; Stern, 2003; Wilson et al., 2013).

On the other hand, the variability in the results could be also associated to the variability of cognitive domain examined in research to date. For example, De-Vugt et al. (2006) found greater impairment in verbal memory, processing speed and global cognitive functioning tasks but not for the Stroop Colour-Word Test (a measure of attention or cognitive flexibility). However, Oken et al. (2011) found that caregivers performed worse in the Stroop Colour-Word Test, but no differences were found in word list memory tasks. Vitaliano et al. (2005) found only impairment in the vocabulary subscale of the Shipley Institute of Living Scale but not in the abstract reasoning subscale. These differences could also be associated with the relatively small sample sizes, or their restriction to spouses of individuals with dementia. Further systematic research with larger and broader sample sizes is needed to further our understanding of this association. Moreover, the variability in these findings could be associated to the different theoretical frameworks adopted or the different potentially explanatory pathways tested. Some theoretical frameworks tend to focus on understanding the negative impact of caregiving and among these, stress process model (Pearlin, Mullan, Semple, & Skaff, 1990; Pearlin & Biermann, 2013) is one of the most widely and consistently used in caregiving research (e.g. Conde-Sala, Garre-Olmo, Turró-Gariga, Vilalta-Franch, & López-Pousa, 2010; García-Castro et al., 2020; Kim, Chang, Rose, & Kim, 2012); on the other hand, there is a growing body of research that highlight the positive impact of caregiving under the umbrella on the named the healthy caregiver hypothesis (e.g. Bertrand et al., 2012; Fredman et al., 2008, Fredman, Doros, Ensrud, Hochberg, & Cauley, 2009).

The stress process model (Pearlin et al., 1990; Pearlin & Biermann, 2013) suggested that caregivers could be more likely to show poor functioning outcomes linked their heightened stress exposure. Within the framework of this

model, negative consequences from caregiving, such as anxiety or depression, are explained by different kind of stressors, contextual variables, and mediating and moderating factors. Among stressors we find primary and secondary stressors. Primary stressors are those directly related to the disease and its symptoms, while secondary stressors are those which are not directly related with them but may have an impact on caregivers' health. Contextual variables as sociodemographic variables are included in this model, and also psychosocial factors, which could protect caregivers from the strain of their role (Pearlin et al., 1990; Pearlin & Biermann, 2013). The progressive loss of memory and autonomy, and the behavioural and psychological symptoms showed by patients with dementia supposes a significant burden on their caregivers (Palma et al., 2011). This implies a significative source of chronic stress that can affect caregiver's life, appearing negative consequences such as stress, anxiety, depression or burden, affecting caregiver well-being (Anum & Dasti, 2016; Delgado-Parada et al., 2014; Mausbach, Chattillion, Roepke, Patterson, & Grant, 2013; Papastavrou, Kalokerinou, Papacostas, Tsangari, & Sourtzi, 2007; Piersol et al., 2017; Romero-Martínez et al., 2018). Although many negative outcomes have received attention in caregiving studies, depression has been pointed out as the most important negative outcome of caregiving (Pinquart & Sörensen, 2003), and different studies have supported the association between stressors and depression (e.g. Haley, LaMonde, Han, Burton, & Schonwetter, 2003; Mausbach et al., 2012; Yates, Tennstedt, & Chang, 1999). Roth, Brown, Rhodes, and Haley (2018) also indicated caregiving was positively associated with depressive symptoms and perceived stress. The association between stress and depression with cognitive performance has been mainly investigated in caregivers of individuals with dementia, suggesting that higher levels of both of them are related with lower cognitive performance. For example, Caswell et al. (2003) suggested that higher levels of caregiver burden and lower levels of perceived positive experiences in different areas of caregivers' life were associated with lower cognitive performance. In the same line, Vitaliano et al. (2005) indicated that cognitive decline is influenced by chronic stress, whereas Vitaliano et al. (2009) pointed out that depression mediated the association between caregiver status and lower cognitive processing speed or attention in caregivers. Moreover, Mackenzie et al. (2009) suggested that distress is a mechanism which leads to disruptions on learning and memory.

Those studies in which caregivers are found to have a better cognitive function than non-caregivers are in line with the healthy caregiver hypothesis (Bertrand et al., 2012; Fredman et al., 2008, 2009). This hypothesis suggests that older adults become caregivers and are likely to remain caregivers because they are physically healthier than their non-caregiver counterparts of similar age. In addition, some factors related to the caregiving role are suggested to help to preserve the caregivers' physical and cognitive condition, for example, increased physical activity (Bertrand et al., 2012; Fredman et al., 2008). In fact, Bertrand et al. (2012) found that caregivers had higher performance in memory and processing speed than non-caregivers, and suggested two possible protective explanatory pathways: physical activity (caregivers are more physically active than

non-caregivers and their physical activity would act as a protective factor against cognitive impairment) and the cognitive demands of caregiving tasks (the task demands associated to the caregiving role would have a protective effect against cognitive impairment). Thus, those individuals who become caregivers may already have a health advantage over those who do not, and this advantage would widen because they tend to be more physically active than non-caregivers, and therefore, reducing the risks of functional and cognitive decline (Brown & Brown, 2014). Moreover, according to Fredman et al. (2009), caregivers would be more motivated to preserve their health. Furthermore, Leipold et al. (2008) and Yuan and Grünh (2018) findings also supported this hypothesis and highlighted caregiving duration as a key factor to understand these associations. Leipold et al. (2008) found that a longer duration of caregiving was positively associated with increases in cognitive complexity. Yuan and Grünh (2018) found that caregiving for 2–4 years was associated with better immediate and delayed recall in British older adults and suggested a U-shaped relation between caregiving duration and memory performance, but they did not explore the role of potential confounders or explanatory pathways.

To sum up, these two theoretical frameworks provide two possible explanatory pathways for the impact of caregiving role on the caregivers' cognitive condition, and furthermore, in their general health. The stress process model (Pearlin et al., 1990; Pearlin & Biermann, 2013) explains that caregiving role is going to have a negative effect on caregiver's health, whereas healthy caregiver hypothesis (Bertrand et al., 2012; Fredman et al., 2008, 2009) indicates that caregiving involves some requirements, physical and cognitive, which are going to preserve the caregivers' cognitive condition, by buffering the negative effects of caregiving.

Given this context, there is an ongoing debate on the potential positive or negative impact of caregiving on caregivers' cognitive function and there is a need of further research that goes beyond specific cognitive domains and uses larger, representative samples. Most research to our knowledge focused only on specific domains (e.g. Caswell et al., 2003; Leipold et al., 2008; Vitaliano et al., 2005; 2009) and those that tried to include a larger number of tasks used convenient, non-representative or small samples (e.g. De-Vugt et al., 2006; Mackenzie et al., 2009; Oken et al., 2011). Studies that explore the association between caregiving and different cognitive domains with large representative datasets are needed as these can contribute to further our understanding on the impact of caregiving on caregivers' cognitive performance, identify target areas for future intervention programs and consequently have relevant clinical and public health implications.

The present study aims to explore further how being a caregiver, and its duration, are associated with four different cognitive tasks that represent three different cognitive domains, in a large population cohort representative of British population which allows us to compare caregivers ($n=4117$) and non-caregivers ($n=4793$). In addition, we account for potential confounders (socio-demographics and health status) and test the role of potentially explanatory pathways such as increased engagement with healthy

behaviours (healthy caregiver hypothesis) and depressive symptomatology (stress process model) (Figure 1). Considering both the stress process model and the healthy caregiver hypothesis allow us to explore their proposed explanatory pathways for the association between caregiving and cognitive performance. According to the stress process model, we would expect to find that caregivers show lower cognitive performance compared to non-caregivers, with depression attenuating this relationship. According to the healthy caregiver hypothesis, we would expect the opposite, that caregivers show higher cognitive performance compared to non-caregivers, with healthy behaviors attenuating this association.

Design and methods

Setting and sample

Data are drawn from ELSA, which is a biannual, longitudinal, and nationally representative survey, which collects information from people aged over 50 to understand all aspects of ageing in England. More than 18,000 people have taken part in the study since it started in 2002, with the same people re-interviewed every two years. ELSA collects information on people's physical and mental health, wellbeing, finances, and attitudes around ageing and how these change over time. More details can be found in <https://www.elsa-project.ac.uk/> (Banks et al., 2019). Given that we aimed to compare different cognitive domains in caregivers and non-caregivers, cognitive data is drawn from wave 7 (2014). To account for temporality in caregiving, whether caregivers have provided care in previous waves, and duration of their caregiving, we also drew data about caregiving status (whether respondents were caregivers or not) from 6 years before (wave 4, 5 and 6) to facilitate comparisons with previous research (Yuan & Grünh, 2018). Our maximal sample ($N=8910$) included main respondents from ELSA who were 50 years old and over, had available data in caregiver status in wave 7, and available data for at least one of the four cognitive tasks included in the study (caregivers $n=4117$, non-caregivers $n=4793$). Included individuals in this study were more likely to have lower scores in cognitive tasks, be younger, female, have higher levels of education, employed, not single or white, less likely to report difficulties on activities of daily living, more likely to report a poor or fair self-reported health, and higher levels of mild and moderate physical activity compared to those that were excluded.

Measures

Cognitive performance

Different measures of cognitive performance were assessed in ELSA at wave 7 such as verbal memory (immediate and delayed recall), executive function (verbal fluency) and working memory (serial 7 subtraction tasks) (Huppert, Gardener, & McWilliams, 2004; Phillips, Lin, Wight, Chien, & Lee, 2017). All these measures were standardized to facilitate comparisons.

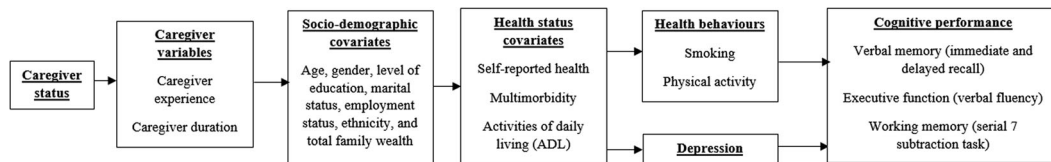


Figure 1. Variables involved in the study.

Immediate and delayed recall tasks

Ten common words were presented, and participants were asked to remember them immediately (immediate recall) and after a short delay (delayed recall). Both tasks provide a total score which ranges from 0 to 10. Higher scores indicate better verbal memory (Huppert et al., 2004; Phillips et al., 2017).

Verbal fluency task

Participants were asked to name members of a specific category of beings or objects within the limited time of one minute. Participants name as many animals as they can in one minute, classifying them in different categories, moving to a new category when no more animals come to mind from the previous one. The score of this task is the count of the number of acceptable animal names. This task is widely used to measure executive function (Daly, McMinn, & Allan, 2015; Jütten et al., 2020; O'Sullivan et al., 2019). Higher scores indicate higher levels of executive function, especially organization abilities, abstraction and mental flexibility (Huppert et al., 2004; Phillips et al., 2017).

Serial 7 subtraction task

The participants were asked to make a serial subtraction of seven, which begins with number 100. Individuals are asked to take 7 away from 100, to take 7 away from the answer, and so on. Correct subtractions are based on the prior number given, so if one subtraction is incorrect subsequent trials are evaluated on the given (perhaps wrong) answer. It stops after 5 answers and each correct response is one point, so the range of total scores goes from 0 to 5 (Phillips et al., 2017). Higher scores indicate better executive function (Lee, Strauss, Adams, & Redline, 1999) and higher levels of basic mathematical ability (Karczmark, 2000; Srygley, Mirelman, Herman, Giladi, & Hausdorff, 2009) and working memory (Bristow, Jih, Slabich, & Gunn, 2016; Srygley et al., 2009). It has also been used as a measure of processing speed (Williams et al., 1996) and attention (Bristow et al., 2016).

Caregiving

Respondent were asked whether they gave any informal care to anyone in the last month, and responses to this question from wave 7 were considered to know the *caregiver status* (caregiver at wave 7: 0 = No, 1 = Yes). Besides caregiver status at wave 7, several variables related to temporality were derived from caregiver status at previous waves in order to capture independently caregiver previous experience and duration. If a respondent was a caregiver in a previous wave, this caregiver has previous experience as caregiver. Caregiver duration was defined using a binary variable to summarize whether they were caregivers or not between wave 4 and 6. For example, being a caregiver

during wave 6 and 7 and not at wave 5 is coded as two years of caregiving duration while someone reporting being a caregiver from wave 5–7 is coded as 4 years of caregiving duration. Caregiver duration informs about how long the participants have been caregivers. Following Yuan and Grünh (2018) whose results suggest that we have to take into account at least 4 years of history of caregiving to capture the impact of caregiving in relevant outcomes, we extracted data from responses to caregiver status from waves 4 to wave 7 (6 years follow up) and derived three levels: 0–2 years, 2–4 years, and 4 or more years.

Potential explanatory pathways

The role of two explanatory pathways were investigated: health behaviours and depressive symptomatology (John & Montgomery, 2010; Sofi et al., 2011; Vitaliano et al., 2005, 2009). Each of them reflects the underlying healthy caregiver hypothesis (Bertrand et al., 2012; Fredman et al., 2008, 2009) and the stress process model, respectively (Pearlin et al., 1990; Pearlin & Biermann, 2013).

Regarding health behaviours, we included smoking and physical activity (Davis et al., 2017; Hamer, Terrera, & Demakakos, 2018; Zaninotto, Batty, Allerhand, & Deary, 2018). Smoking was assessed by asking if respondents have ever smoked and was coded as a binary variable (0 = never and 1 = ever smoked). Physical activity was derived using three variables indicating the frequency of vigorous, moderately or mild physical activity. Following other studies (Hamer, de Oliveira, & Demakakos, 2014; Smith, Gardner, Fisher, & Hamer, 2015), these three variables were used to create a new physical activity variable which had four categories (0 = inactive, 1 = mild physical activity, 2 = moderate physical activity, 3 = vigorous physical activity). To belong to a concrete category, individuals had to report their frequency in that category as more than once a week or once a week.

Depression, which has been found to be associated with caregiving (Roth et al., 2018; Vitaliano et al., 2009) was assessed using the 8-item Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977; Turvey, Wallace, & Herzog, 1999). To identify case level depression, we used the standard cut-off of four or more clinically significant symptoms (Mhaolain et al., 2012).

Covariates

Relevant covariates at wave 7 as socio-demographics and health status (Caswell et al., 2003; John & Montgomery, 2010; Luchsinger et al., 2007; Patel & Singh, 2018; Reitz, Tang, Manly, Mayeux, & Luchsinger, 2007; Vitaliano et al., 2005; Wilson et al., 2013). Socio-demographics included gender, age, education (i.e. 3 categories: less than secondary, upper secondary and vocational training; and tertiary) (Anstey & Christensen, 2000; Patel & Singh, 2018; Stern, 2003), marital status (0 = single/separated/divorced/widow

and 1 = married/in civil partnership), employment status (0 = unemployed/retired and 1 = employed), ethnicity (0 = white, 1 = non-white) (Fredman et al., 2008), and total family wealth (based on information collected from net value of primary residence, business, net non-housing financial wealth, secondary home residence, other property after paying all the debts, and total value of other physical assets for those reporting having other land, money owed by others, a trust, a covenant or inheritance, or other assets) (Patel & Singh, 2018).

Health status variables included self-reported health, multimorbidity and activities of daily living. Self-rated health was measured by an item which asked respondents to rate their health as poor, fair, good, very good, and excellent. Following previous research and in order to ease interpretation the categories were grouped as 0 = poor or fair, and 1 = good, very good or excellent (Bendayan, Piccinin, Hofer, & Muniz, 2017; Diehr, Thielke, Newman, Hirsch, & Tracy, 2013). Multimorbidity was defined as the co-occurrence of two or more chronic conditions (Navickas, Petric, Feigl, & Seychell, 2016). A binary variable was derived to capture multimorbidity (0 = no condition or one condition, and 1 = two or more conditions). The self-reported chronic conditions considered were: high blood pressure, diabetes, cancer, lungs' disease, heart problems, stroke, psychiatric problems, arthritis, asthma, cholesterol, cataracts, Parkinson's disease, hip fracture, memory problems, Alzheimer's Disease, and dementia. To assess difficulties with Activities of Daily Living (ADL; Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963) one point was given for each activity in which difficulties are reported. We derived a binary variable (0 = no difficulties, and 1 = at least one difficulty) to provide comparable results with previous research (Zaninotto et al., 2018).

Statistical procedure

Preliminary descriptive and exploratory analysis examined differences between caregivers and non-caregivers. Differences were examined using chi-square and Student t test for independent samples.

Series of hierarchical regression analysis were performed in order to explore the association between cognitive performance and being a caregiver. Being or not a caregiver was the independent variable, while the scores on different tasks for cognitive performance were used as dependent variables: immediate memory recall, delayed memory recall, verbal fluency, and serial 7 subtraction. For each cognitive domain, we conducted series of hierarchical regression models.

We used hierarchical regression as a framework for model comparison, in which we added different types of variables to the previous models at each step, in order to explore the potential explanatory pathways for the association between cognitive performance and caregiver status. First, we examined an unadjusted model including only caregiver status at wave 7 (model 1). In order to examine whether caregiver experience and/or duration are associated with cognitive performance, we included these variables in a second step (model 2). Then, after analysing the association between caregiver variables and cognitive performance in model 2, only significant caregiver predictors remained in subsequent models. To explore the role of

potential confounders, we included adjustments for socio-demographic covariates, and health status. Model 3 included adjustments for socio-demographic covariates, (gender, age, education, marital status, employment situation, ethnicity and total family wealth). Model 4 was additionally adjusted for health status (self-reported health, multimorbidity and difficulties for activities of daily living). In order to examine the two potential explanatory pathways, we included health behaviours and depression independently in the following models. Model 5 was model 4 additionally adjusted for health behaviour such as smoking and physical activity and model 6 was model 4 additionally adjusted for depression. Model 7 was a fully adjusted model including both health behaviours and depression.

When covariates were missing in more than 30% of the cases such as marital status (38.8%), total family wealth (40.4%) and employment situation (39.1%), we imputed using data from the previous wave. Remained missing data in marital status [$n = 2696$, 28.4%], total family wealth [$n = 2815$, 29.7%], and employment situation [$n = 2726$, 28.7%] were imputed via multiple imputation by chained equations. This procedure of multiple imputation was also followed for level of education [$n = 2099$, 22.1%], ethnicity [$n = 17$, 0.2%], ADL [$n = 2$, 0.0%], self-reported health [$n = 572$, 6%], health conditions [$n = 2090$, 22%], smoking [$n = 159$, 1.7%], physical activity [$n = 3$, < 0.1%], and depression [$n = 634$, 6.7%]. Analyses were performed across 30 imputed datasets and combined using Rubin's rules (Rubin, 1987).

Analyses were conducted using SPSS 25. Sensitivity analyses were performed for specific age ranges (50 to 64 and 65+ years old), comparing complete and imputed cases, comparing those who reported providing care to their grandchildren and those that did not. To ensure the robustness of the results with serial 7 subtraction given its coding, multinomial regression analysis was additionally performed.

Results

Exploratory analyses

Characteristics of the sample are described in Table 1, for both caregivers ($n = 4117$, 46.2%): and non-caregivers ($n = 4793$, 53.8%). For cognitive performance tasks, caregivers showed higher scores in immediate and delayed recall, and verbal fluency when compared to non-caregivers. Regarding caregiver temporality variables, caregivers at wave 7 were more likely to have previous experience, and for a longer duration. Moreover, caregivers were about 2 years younger, and more likely to be women, highly educated, married or in a partnership, employed, non-white, non-smokers, do more intense physical activity and have a better perception of their health than non-caregivers. They were also less likely to have any difficulties on ADL, multimorbidity or depression when compared to non-caregivers in wave 7.

Regression analyses

In general, results indicate that caregiver status at wave 7 was positively associated with immediate and delayed recall tasks, and the verbal fluency task. However, this

Table 1. Characteristics of the sample for both caregivers and non-caregivers. Sample sizes (n), percentages (%), means (M) and standard deviations (SD). Chi-square (χ^2) and Student-t (t) test and p values provided.

	Caregiver (N = 4117, 46.2%)		Non-caregiver (N = 4793, 53.8%)		
	n (%)	M (SD)	n (%)	M (SD)	
Caregiver experience	3356 (81.5%)		3888 (81.1%)		$\chi^2 (1) = 895.45, p < .001$
0-No	336 (10%)		1603 (41.2%)		
1-Yes	3020 (90%)		2285 (58.8%)		
Caregiver duration	3356 (81.5%)		3888 (81.1%)		$\chi^2 (2) = 3282.98, p < .001$
0-2 years	336 (10%)		2707 (69.6%)		
2-4 years	632 (18.8%)		792 (20.4%)		
4 or more years	2388 (71.2%)		389 (10%)		
Immediate recall	4107 (99.8%)	6.19 (1.76)	4786 (99.8%)	5.69 (1.92)	t(8855.99) = -12.76, p < .001
Delayed recall	4117 (100%)	4.92 (2.05)	4793 (100%)	4.30 (2.25)	t(8876.63) = -13.55, p < .001
Verbal Fluency	4116 (99.9%)	21.90 (6.93)	4793 (100%)	20.40 (7.60)	t(8875.51) = -9.73, p < .001
Serial7	3883 (94.3%)	3.76 (1.75)	4363 (91%)	3.78 (1.74)	t(8244) = 0.35, p = .730
Age	4117 (100%)	66.59 (8.87)	4793 (100%)	68.5 (10.15)	t(8905.16) = 9.49, p < .001
Gender	4117 (100%)		4793 (100%)		$\chi^2 (1) = 361.75, p < .001$
0-Female	2741 (66.6%)		2229 (46.5%)		
1-Male	1376 (33.4%)		2564 (53.5%)		
Marital status	3599 (87.42%)		2802 (58.5%)		$\chi^2 (1) = 5.05, p = .03$
0-Single / separated / divorced / widowed	1111 (30.9%)		939 (33.5%)		
1-Married / Civil Partnership	2488 (69.1%)		1863 (66.5%)		
Level of education	3206 (77.9%)		3713 (77.5%)		$\chi^2 (2) = 21.08, p < .001$
0-Less than secondary	921 (28.7%)		1253 (33.7%)		
1-Upper secondary and vocational training	1674 (52.2%)		1833 (49.4%)		
2-Tertiary	611 (19.1%)		627 (16.9%)		
Employment situation	3589 (87.2%)		2785 (58.1%)		$\chi^2 (1) = 165.25, p < .001$
0-Unemployed/Retired	1812 (50.5%)		1853 (66.5%)		
1-Employed	1777 (49.5%)		932 (33.5%)		
Total family wealth	3542 (86%)	407042.5 (1032432.75)	2749 (57.4%)	386940.7 (605769.26)	t(5886.63) = -.96, p = .335
Ethnicity	4105 (99.7%)		4789 (99.9%)		$\chi^2 (1) = 4.40, p = .04$
0-White	3882 (94.6%)		4575 (95.5%)		
1-Non-white	223 (5.4%)		214 (4.5%)		
Self-reported health	4116 (99.9%)		4791 (99.9%)		$\chi^2 (1) = 73.33, p < .001$
0-Poor or fair	904 (22%)		1436 (30%)		
1-Good, very good or excellent	3212 (78%)		3355 (70%)		
Difficulties for Activities of Daily Living (ADL)	4117 (100%)		4792 (99.9%)		$\chi^2 (1) = 60.81, p < .001$
0-No difficulties	3579 (86.9%)		3872 (80.8%)		
1-Any difficulties	538 (13.1%)		920 (19.2%)		
Multimorbidity	3172 (77.1%)		3782 (78.9%)		$\chi^2 (1) = 9.01, p = .003$
0-0 or 1 health conditions (no multimorbidity)	932 (29.4%)		989 (26.2%)		
2 or more health conditions (multimorbidity)	2240 (70.6%)		2793 (73.8%)		
Smoke ever	4116 (99.9%)		4790 (99.9%)		$\chi^2 (1) = 30.99, p < .001$
0-No	1677 (40.7%)		1677 (35%)		
1-Yes	2439 (59.3%)		3113 (65%)		
Physical activity	4116 (99.9%)		4792 (99.9%)		$\chi^2 (3) = 354.09, p < .001$
0-Inactive	110 (2.7%)		636 (13.3%)		
1-Mild physical activity	594 (14.4%)		804 (16.8%)		
2-Moderate physical activity	2103 (51.1%)		2041 (42.6%)		
3-Vigorous physical activity	1309 (31.8%)		1311 (27.4%)		
Depression	4098 (99.5%)		4758 (99.3%)		$\chi^2 (1) = 10.88, p = .001$
0-No depression	3609 (88.1%)		4077 (85.7%)		
1-Depression	489 (11.9%)		681 (14.3%)		

association was attenuated when adjusting for covariates. Although caregiver duration was significant for these variables and therefore remained in the subsequent models, its association with the cognitive tasks was fully attenuated when adjusting for covariates. No associations were found for Serial 7. The results from regression analyses are shown in Tables 2 and 3. Table 3 shows the predictors which were significant at least for one cognitive domain in model 7.

Immediate recall

Results showed a positive association between caregiver status and immediate recall (model 1) which remained significant when caregiver experience and duration were introduced in the model (model 2). Caregivers showed higher scores than non-caregivers. In addition, caregiving duration was also positively associated with immediate recall, and those who had been caregivers for 4 or more years presented higher scores in immediate recall compared with those that have been caregivers for less than

two years. Therefore, caregiving duration was included in the subsequent models. When additionally adjusting for sociodemographic variables (model 3) and health status (model 4), caregiver status remained significant and partially attenuated. When we explored the role of health behaviours (model 5), we found a substantial attenuation, and although when we examined the role of depression (model 6) we also found an attenuation this attenuation seemed to be minor. When both potential explanatory pathways were considered in a fully adjusted model (model 7), we found that the association remained significant. Caregiving duration did not present a significant association with immediate recall.

Delayed recall

Results showed a positive association between caregiver status and delayed recall (model 1) which remained significant when caregiver experience and duration were introduced in the model (model 2). Caregivers showed higher

Table 2. Regression coefficients (β) and 95% confident intervals (CI) for regression analysis with immediate recall, delayed recall, verbal fluency and serial 7 as dependent variables, and caregiver status, caregiver experience and caregiving duration as predictors.

	Immediate recall (N = 8893) β (CI 95%)	Delayed recall (N = 8910) β (CI 95%)	Verbal fluency (N = 8909) β (CI 95%)	Serial 7 (N = 8246) β (CI 95%)
Model 1	$R^2 = .018^{**}$	$R^2 = .020^{**}$	$R^2 = .010^{**}$	$R^2 = .000$
Caregiver W7 - Yes	.267** (.226, .308)	.283** (.241, .324)	.204** (.163, .246)	-.008 (-.051, .036)
Model 2	$R^2 = .023^{**}$	$R^2 = .028^{**}$	$R^2 = .013^{**}$	$R^2 = .001$
Caregiver W7 - Yes	.203** (.141, .266)	.204** (.141, .267)	.157** (.095, .220)	.040 (-.026, .105)
Caregiver experience - Yes	.025 (-.049, .099)	.033 (-.041, .107)	.049 (-.025, .123)	-.011 (-.090, .067)
Caregiver duration (reference: 0-2 years)				
2-4 years	.068 (-.015, .151)	.063 (-.020, .146)	.052 (-.030, .134)	.014 (-.073, .101)
4 or more years	.126** (.039, .214)	.163** (.076, .251)	.061 (-.027, .148)	-.084 (-.177, .008)

Model 1. Unadjusted. Model 2. Model 1 + caregiver temporality variables.

** $p < .01$; * $p < .05$.

Table 3. Regression coefficients (β) and confident intervals (CI) for regression analysis with immediate recall, delayed recall, verbal fluency and serial 7 as dependent variables, and caregiver status, caregiving duration as predictors, and sociodemographic variables, health status and behaviours, and depression as covariates.

	Immediate recall (N = 8893) β (CI 95%)	Delayed recall (N = 8910) β (CI 95%)	Verbal fluency (N = 8909) β (CI 95%)	Serial 7 (N = 8246) β (CI 95%)
Model 3	$R^2 = .217^{**}$	$R^2 = .226^{**}$	$R^2 = .152^{**}$	$R^2 = .048^{**}$
Caregiver wave 7-Yes	.123** (.066, .180)	.119** (.063, .175)	.092** (.034, .151)	.029 (-.035, .094)
Caregiver duration (reference: 0-2 years)				
2-4 years	.046 (-.014, .107)	.046 (-.014, .106)	.080* (.018, .141)	.029 (-.039, .097)
4 or more years	.039 (-.025, .103)	.076* (.012, .139)	.070* (.004, .136)	-.043 (-.116, .030)
Model 4	$R^2 = .248^{**}$	$R^2 = .254^{**}$	$R^2 = .188^{**}$	$R^2 = .050^{**}$
Caregiver wave 7-Yes	.099** (.043, .155)	.094** (.038, .149)	.068* (.010, .126)	.022 (-.043, .086)
Caregiver duration (reference: 0-2 years)				
2-4 years	.043 (-.016, .103)	.042 (-.017, .101)	.074* (.013, .135)	.029 (-.039, .097)
4 or more years	.042 (-.022, .106)	.079* (.016, .142)	.070* (.005, .136)	-.042 (-.115, .032)
Model 5	$R^2 = .257^{**}$	$R^2 = .264^{**}$	$R^2 = .200^{**}$	$R^2 = .052^{**}$
Caregiver wave 7-Yes	.083** (.027, .139)	.077** (.022, .133)	.048 (-.009, .106)	.016 (-.049, .080)
Caregiver duration (reference: 0-2 years)				
2-4 years	.025 (-.034, .085)	.024 (-.034, .083)	.053 (-.008, .114)	.023 (-.045, .092)
4 or more years	.024 (-.039, .088)	.061 (-.002, .124)	.050 (-.015, .115)	-.047 (-.120, .026)
Smoke ever	-.014 (-.057, .030)	-.002 (-.045, .041)	.037 (-.007, .082)	.002 (-.048, .052)
Physical activity	.129** (.102, .157)	.130** (.103, .157)	.155** (.127, .183)	.049** (.017, .080)
Model 6	$R^2 = .260^{**}$	$R^2 = .265^{**}$	$R^2 = .196^{**}$	$R^2 = .050^{**}$
Caregiver wave 7-Yes	.097** (.041, .153)	.092** (.036, .147)	.067* (.009, .124)	.021 (-.043, .086)
Caregiver duration (reference: 0-2 years)				
2-4 years	.046 (-.014, .105)	.045 (-.014, .103)	.076* (.015, .137)	.030 (-.038, .098)
4 or more years	.040 (-.023, .104)	.077* (.014, .139)	.069* (.004, .134)	-.042 (-.115, .031)
Depression	-.187** (-.254, -.119)	-.208** (-.274, -.141)	-.165** (-.234, -.096)	-.057 (-.136, .022)
Model 7	$R^2 = .267^{**}$	$R^2 = .274^{**}$	$R^2 = .207^{**}$	$R^2 = .053^{**}$
Caregiver wave 7-Yes	.082** (.026, .138)	.076** (.021, .132)	.048 (-.009, .105)	.016 (-.049, .080)
Caregiver duration (reference: 0-2 years)				
2-4 years	.028 (-.031, .087)	.027 (-.031, .086)	.055 (-.005, .116)	.024 (-.044, .093)
4 or more years	.024 (-.039, .087)	.060 (-.002, .123)	.049 (-.015, .114)	-.047 (-.120, .026)
Age	-.036** (-.038, -.033)	-.037** (-.040, -.035)	-.028** (-.031, -.026)	-.005** (-.009, -.002)
Gender	-.202** (-.246, -.158)	-.223** (-.267, -.179)	.005 (-.041, .050)	.180** (.129, .231)
Level of education	.232** (.198, .266)	.229** (.195, .263)	.208** (.174, .242)	.169** (.130, .208)
Self-reported health	.149** (.095, .204)	.159** (.105, .212)	.154** (.098, .209)	.054 (-.010, .117)
Multimorbidity	.026 (-.026, .077)	.016 (-.035, .067)	.064* (.010, .117)	.004 (-.057, .066)
Difficulties with Activities of Daily Living	-.061* (-.123, .000)	-.067* (-.128, -.006)	-.073* (-.136, -.010)	-.039 (-.122, .033)
Physical activity	.123** (.096, .151)	.123** (.096, .150)	.150** (.122, .178)	.047** (.015, .079)
Depression	-.159** (-.227, -.092)	-.181** (-.247, -.114)	-.133** (-.202, -.064)	-.046 (-.125, .033)

Model 3. Model caregiver W7 + caregiver duration + sociodemographics. Model 4. Model 3 + health status (self-reported health, multimorbidities, difficulties with Activities of Daily Living). Model 5. Model 4 + health behaviours (smoking, physical activity). Model 6. Model 4 + depression. Model 7. Fully adjusted model: Model 5 + depression.

** $p < .01$; * $p < .05$.

scores than non-caregivers. In addition, caregiving duration was also positively associated with delayed recall, and those who had been caregivers for 4 or more years presented higher scores in delayed recall when compared with those that have been caregivers for a shorter duration. Therefore, caregiving duration was included in the subsequent models. When additionally adjusting for sociodemographic variables (model 3) and health status (model 4), caregiver status remained significant and partially attenuated. When we explored the role of health behaviours (model 5), we found a substantial attenuation, and although when we examined the role of depression (model 6) we also found an attenuation this attenuation seemed

to be minor. When both potential explanatory pathways were considered in a fully adjusted model (model 7), we found that the association remained significant.

Caregiving duration remained significant and partially attenuated when adjusting for sociodemographic variables and health status (model 3 and 4), but it was fully attenuated when adjusting for health behaviours (model 5). However, when we included examined the independent role of depression (model 6) it was only partially attenuated, and fully attenuated when both health behaviours and depression were considered (model 7). As in the previous task, these results indicate that caregivers show higher scores than non-caregivers in delayed recall

task but the effect of duration of caregiver disappears when health behaviours are introduced in the model.

Verbal fluency

Results showed a positive association between caregiver status and scores on verbal fluency task (model 1) which remained significant when caregiver experience and duration were introduced in the model (model 2). Caregivers showed higher scores than non-caregivers. However, caregiver experience and caregiving duration were not significantly related to verbal fluency. When additionally adjusting for sociodemographic variables (model 3), and health status (model 4), caregiver status remained significant and partially attenuated. When we explored the role of health behaviours (model 5) we found that this association was fully attenuated. However, when depression was considered (model 6) the association between caregiving status and verbal fluency remained significant and only slightly attenuated compared to model 4. This association was fully attenuated for the final fully adjusted model (model 7). Caregiving duration was significantly associated with verbal fluency when we adjusted for socio-demographics (model 3) and health status (model 4) and this association was partially attenuated when investigating the role of depression (model 6). However, this association was fully attenuated when health behaviours were considered (model 5) and in the fully adjusted model (model 7).

Serial 7

Results showed there was no association between caregiver status and scores on serial 7 subtraction task.

Sensitivity analyses

When we performed sensitivity analyses for specific age ranges (50–64 and 65+ years old), we found that similar results were found for those aged 65 or over. For the younger group (50–64) we found that caregiving duration was no longer significant for immediate and delayed recall tasks. When we compared complete and imputed cases, similar trends were found but health status fully attenuated the association with caregiver status and cognitive performance in verbal fluency, immediate and delayed recall tasks. In general, similar results were found when comparing those that were grandparenting with those that did not. No differences were found when multinomial hierarchical regression analyses for serial 7 subtraction were performed.

Discussion and implications

The aim of this study was to explore the association between four cognitive tasks (immediate and delayed word recall, verbal fluency and serial 7) and caregiver status and duration in a large population cohort representative of British population, accounting for potential confounders such as socio-demographic variables. We also further investigated two potentially explanatory pathways such as increased likelihood of healthy behaviours (healthy caregiver hypothesis) and/or depressive symptomatology (stress process model).

In general, results showed that caregivers had higher scores in all the cognitive tasks (immediate and delayed recall tasks, and verbal fluency task) except for the serial 7 task. These results are consistent with previous research that found better cognitive performance in caregivers when compared to non-caregivers (Bertrand et al., 2012; Jütten et al., 2020; Leibold et al., 2008; O'Sullivan et al., 2019), specifically for memory tasks (Bertrand et al., 2012; Jütten et al., 2020). ; However, our results differ from those that found that caregivers have lower scores in performance (De-Vugt et al., 2006; Mackenzie et al., 2009; Oken et al., 2011; Palma et al., 2011; Romero-Martínez et al., 2018; Vitaliano et al., 2005, Vitaliano et al., 2009), which might be due to the different cognitive domains assessed (Vitaliano et al., 2005; 2009), different tasks (Mackenzie et al., 2009; Palma et al., 2011), different type of caregivers (i.e. spousal caregivers: De-Vugt et al., 2006; Mackenzie et al., 2009; Vitaliano et al., 2005; Vitaliano et al., 2009), or specific type of care recipient (i.e. dementia and Alzheimer caregivers: De-Vugt et al., 2006; Oken et al., 2011; Palma et al., 2011; Vitaliano et al., 2005; Vitaliano et al., 2009). It should be noted that most of the abovementioned studies used small or moderate sample sizes.

Regarding serial 7 task, no differences were found between caregivers and non-caregivers. This task has been used as a measure of processing speed (Williams et al., 1996), attention (Bristow et al., 2016) and working memory (Bristow et al., 2016; Srygley et al., 2009). The finding is partially consistent with previous research using different scales to measure these domains (Mackenzie, Smith, Hasher, Leach, & Behl, 2007; Mackenzie et al., 2009; O'Sullivan et al., 2019; Romero-Martínez et al., 2018). For example, Romero-Martínez et al. (2018) found that although caregivers had faster reactions because of their increased state of alertness, they were more likely to make mistakes leading to similar scores than non-caregivers. It is possible, in line with Mackenzie et al. (2009), that the task used here was not demanding enough to capture differences between groups.

The results regarding immediate and delayed recall tasks are in line with previous research which found that caregivers have better performance in memory tasks (Bertrand et al., 2012; Jütten et al., 2020; Mackenzie et al., 2007; Oken et al., 2011). Bertrand et al. (2012) suggested that this might be because daily tasks of caregiving contribute to preserving memory which is also supported by the fact that some authors have found that performance in verbal memory tasks can decline after care recipient's death (Mackenzie et al., 2007). For memory tasks, we found that although health behaviours and depression symptomatology play a role in this association (as both partially attenuated this association), none of these fully explained the association between being caregiver and memory in our sample. However, when we investigated the role of these potential explanatory mechanisms in the association between caregiver status and executive function (verbal fluency), we found that although the association was partially attenuated when depression was considered, it was actually the adjustments of health behaviours which fully attenuated the association.

According to the stress process model, we would expect to find that caregivers show lower cognitive performance

compared to non-caregivers, with depression attenuating this relationship. According to the healthy caregiver hypothesis, we would expect the opposite, that caregivers show higher cognitive performance compared to non-caregivers, with healthy behaviors attenuating this association. Our findings are more in line with the latter hypothesis since the caregivers' cognitive condition are preserved. However, our results may suggest that these two models are not mutually exclusive, and although we found some support for the healthy caregiver hypothesis we also found that a key component of the stress process model, such as depression, is still relevant to understand the association between being caregiver and cognitive performance. The fact that health behaviors such as physical activity attenuated this relationship supports further the well-known association between physical activity and cognitive performance and highlights its relevance for caregivers, for whom it also acts as a protective factor against cognitive impairment (Bertrand et al., 2012; Fredman et al., 2008). Furthermore, physical activity fully attenuated the relationships with executive function which suggests that this protective impact might vary across cognitive domains. Daly et al. (2015) studied the relationship between physical activity and executive function and observed that the improvement of executive abilities could promote physical activity, and vice versa. Thus, further research should explore the potential bidirectional associations between physical activity and caregiving activities. Additionally, physical activity fully attenuated the relationship between caregiver duration and cognitive performance which suggests that there could also be a strong association between caregiver duration and the likelihood to engage in healthy lifestyles. Future research in this line should be performed to further our understanding on the potentially dynamic association between health behaviours and caregiving over time.

As we mentioned earlier, our findings show that depression has also a key role explaining this association. Although moderately, depression also attenuated the relationship between being caregiver and cognitive performance. Individuals with clinically significant depressive symptomatology tend to have worse cognitive performance both in memory and executive function, which is consistent with previous research in general population studies (Bendayan, Kelly, Hofer, Piccinin, & Muniz-Terrera, 2020) and highlights its importance in caregivers as previous research in this population found (Mackenzie et al., 2009; Vitaliano et al., 2009). Accounting for and addressing depression in caregiving is essential as it might directly affect their ability to provide an adequate care.

Although we considered different cognitive measures to be able to compare the association between caregiving and different cognitive abilities, it seems that further research should include additional tasks to assess working memory or mathematical ability. ELSA provided us a unique opportunity to address our aim given the detailed data collected on caregiving status, experience and duration. However, we could not further investigate other interesting features of caregiving such as the health conditions or other characteristics of the care recipient, or the perception of the burden derived of their caregiving role. Future research should aim to include more details on the

experience of caregivers. In addition, our study drew data from a large population study moving beyond traditional studies on caregivers with reduced or convenient samples, we should acknowledge that our findings might represent healthy survivors, which is a common limitation of ageing studies (Hofer & Sliwinski, 2006). We also tried to go beyond caregiving status and included duration and previous experience of caregiving, however, the caregiving role is extremely heterogeneous, so the differences in types of care provided and relationship to the care-recipient are important to note so as the hours spent on care. Unfortunately, our data was limited for these and future studies with more granular data on these variables should be performed as the positive association found could be specific for those that have a moderate level of involvement in terms of hours spent caring. It should also be noted that data on potential covariates is mainly drawn from self-reports and thus recall bias cannot be excluded. Finally, this is an observational cross-sectional study and therefore no causal relationships can be assumed.

In conclusion, our results showed that caregivers show a better cognitive performance in different cognitive tasks than non-caregivers. This relationship between caregiver status and cognitive performance was attenuated when health behaviours and depression were included in the model. These results suggest that there is a potential positive impact of caregiving for memory in older age, which cannot be fully explained based on previous research suggesting healthier behaviours or depressive symptomatology as a result of the caregiving burden as potential explanatory pathways in this association. However, the role of a potential increased likelihood of engagement in healthy behaviours (healthy caregiver hypothesis) might be a key to understand the association between caregiver status and verbal fluency. Our findings can have clinical and public health implications as we found that caregiving does not have a negative impact on the cognitive functioning in older adults. Public health and policy do not need to target specifically cognitive function but other areas as the promotion of healthy behaviours and psychological adjustment. Moreover, our results suggest that preventing depression and promoting physical activity should be a core goal in public health interventions with caregivers as it cannot only improve their physical functioning but their cognitive one. Additionally, the positive cost-efficacy balance of caregiving already found in economic reports is increased exponentially if we consider the savings associated to improving the own caregivers' health.

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