Living alone and cognitive function in later life

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Conflict of interest

The authors have no conflict of interest to declare.

Background: Living alone may be associated with greater risk for social isolation and loneliness. Living alone, social isolation, loneliness, and limited engagement in social activity have all been associated with poorer cognitive function in later life. Hence, if individuals who live alone are also at greater risk of isolation and loneliness, this may exacerbate poor cognitive function.

Objective: To determine whether people living alone are more at risk of social isolation, feelings of loneliness, and limited social activity, and to examine the associations between living alone and cognitive function in later life.

Method: Baseline (N = 2,197) and two-year follow-up (N = 1,498) data from community-dwelling participants, age ≥65 years, without cognitive impairment or depression at baseline from CFAS-Wales were used. Linear regression analyses were conducted to assess the association between living arrangement and cognitive function at baseline and two-year follow-up.

Results: People living alone were more isolated from family and experienced more emotional loneliness than those living with others, but were not more isolated from friends, did not experience more social loneliness, and were more likely to engage in regular social activity. Living alone was not associated with poorer cognitive function at baseline or two-year follow-up.

Discussion: These findings have positive implications and suggest that people who live alone in later life are not at greater risk of poor cognitive function at baseline or two-year follow-up. Social isolation may be more associated with poor cognitive function.

Keywords: social isolation, social activity, social network, loneliness, cognition, ageing

1. Introduction

The proportion of people living alone in later life continues to rise as a result of population ageing, decreased family sizes, and government policies that promote ageing in place (Genet et al. 2011; Hays, 2002; Murphy & Grundy, 2003). Ageing in place is defined as the ability of an individual to live in their home independently, safely, and comfortably, regardless of age, income, or level of ability (Centers for Disease Control and Prevention, 2014). Ageing at home as an alternative to institutional care enables people to maintain autonomy, independence, and connection with family, friends, and the wider community (Wiles, Leibing, Guberman, Reeve & Allen, 2012). Ageing in place is preferable to policy makers, healthcare providers, and older people and their families alike, as it avoids the costly alternative of institutional care and can provide a sense of attachment, security, and familiarity which contributes to positive wellbeing and quality of life (Sixsmith & Sixsmith, 2008; World Health Organization, 2007).

People who live alone in later life may be more vulnerable in terms of social, behavioural, functional, and socioeconomic factors (Bergland & Engedal, 2011; Haslbeck, McCorkle & Schaeffer, 2012; Hughes & Waite, 2002; Shaw, Fors, Fritzell, Lennartsoon & Agahi, 2017). Good social relationships are identified as an important aspect of successful ageing (Rowe & Khan, 1997) and having poor social relationships has been associated with a range of negative health outcomes (Holt-Lunstad & Smith, 2012; Scharf, Philipson & Smith, 2005; Steptoe, Shankar, Demakakos & Wardle, 2013; Tomaszewski, 2013; Umberson & Montez, 2010). Ageing in place may prolong good social relationships with friends, family, and engagement with the wider community. However, for people living alone, ageing in place may lead to some negative experiences including social isolation, loneliness, and poor social networks, which may limit an individuals ability to live alone successfully in later life.

Older people face changes in their social environments and as a result may be at greater risk of social isolation and feelings of loneliness (Finlay & Kobayashi, 2018; Klinenberg, 2016; Victor, Scambler, Bond & Bowling, 2000). Social isolation is objective and relates to the absence of social relationships and disengagement from the wider community (Nicholson Jr, 2009). Loneliness refers to subjective feelings of dissatisfaction with aspects of social relationships, due to a perceived lack of close social contacts or emotional ties (Victor et al. 2000). Loneliness can be further divided into social and emotional loneliness. Social loneliness relates to the negative feelings that arise as a result of the absence of meaningful relationships and social integration, whereas emotional loneliness refers to the perceived lack of an attachment figure or confidant (Dahlberg & McKee, 2014; Holmén, Ericsson & Winblad, 2000; Weiss, 1973). In later life, social networks are likely to reduce in size due

to the increasing independence of adult children, the death of close social contacts, and the increased selectivity of social interactions with age (Baltes & Baltes, 1990; Bordone & Weber, 2012; Carstensen, 1992; de Jong Gierveld & Havens, 2004; Fredrickson & Carstensen, 1990; Freund & Baltes, 1998; Victor et al. 2000). Older age, deterioration of mental and physical health, and limited mobility may also reduce capacity for engaging in social activity and contribute to decreased social network size and an increase family-focussed network types (Antonucci, Ajrouch & Manalel, 2017; Suanet & Antonucci, 2016). This may limit opportunities for social contact and hence people who live alone may be at risk of social isolation (Carstensen, 1992; de Jong Gierveld, 2003; de Jong Gierveld & Havens, 2004; Kobayashi, Cloutier-Fisher & Roth, 2009) and feelings of loneliness (Newall, Chipperfield & Bailis, 2014; Victor, Scambler, Bowling & Bond, 2005).

Living alone, social isolation, and loneliness are distinct concepts and living alone does not necessarily mean that an individual will be isolated, feel lonely, or engage in less social activity (Klinenberg, 2016; Victor et al. 2000). Although the prevalence of living alone increases with age, feelings of loneliness may decrease (Stepler, 2016). People may anticipate smaller social networks and increased isolation with age and may prepare for this (Achenbaum & Bengstom, 1994; Cornwell & Waite, 2009). Furthermore, an individual can be isolated but not feel lonely, or feel lonely but not be isolated. Although these concepts are related, they have only a weak-to-moderate correlation (Cornwell & Waite, 2009; Steptoe et al. 2013; Victor et al. 2000).

Social isolation, feelings of loneliness, low engagement in social activity, and living alone simultaneously confer risk for impaired health and poorer wellbeing (Kharicha et al. 2007; Klinenberg, 2016; Pimouguet et al. 2015; Udell et al. 2012). Living alone in later life may increase the risk of poor cognitive function (Gow, Pattie, Whiteman, Whalley & Deary, 2007; Gow, Corley, Starr & Deary, 2013; van Gelder et al. 2006; Yaffe et al. 2009) and dementia (Fratiglioni, Wang, Ericsson, Maytan & Winblad, 2000; Holwerda et al. 2012). Social isolation (DiNapoli, Wu & Scogin, 2014; Shankar, Hamer, McMunn & Steptoe, 2013), feelings of loneliness (Conroy, Golden, Jeffares, O'Neill & McGee, 2010; Ellwardt, Aartsen, Deeg & Steverink, 2013; Fung, Leung & Lam, 2011; Gerst-Emerson et al. 2014; Gow et al. 2013; O'Luanaigh et al. 2011; Shankar et al. 2013; Tilvis et al. 2004), and low engagement in social activity (Barnes, De Leon, Wilson, Bienias & Evans, 2004; Conroy et al. 2010; Glei et al. 2005; Golden, Conroy & Lawlor, 2009; Haslam, Cruwys & Haslam, 2014; Hughes, Flatt, Fu, Chang & Ganguli, 2013; James, Wilson, Barnes & Bennett, 2011; Paillard-Borg, Fratiglioni, Winblad & Wang, 2009; Yaffe et al. 2009; Zunzunegui, Alvarado, Del Ser & Otero, 2003) have each been associated with poor cognitive outcomes, although findings are mixed and not all studies report this association (DiNapoli et al. 2014; Holwerda et al. 2012; Hsu, 2007; Karp et al. 2005; Saczynski et al. 2006; Simning, Cornwell & van Wijngaarden, 2014). If older people living alone are at

more risk of isolation, loneliness, and lower engagement in social activities, this may exacerbate poor cognitive outcomes. However, findings from studies that assess the association between living alone and cognitive function are conflicting. Some studies have reported an association between living alone and poorer scores on tests of global cognitive function (van Gelder et al. 2006; Yaffe et al. 2009), immediate and delayed recall, orientation (Mazzuco, Meggiolaro, Ongaro & Toffolutti, 2016), processing speed (Gow et al. 2013), and IQ (Gow et al. 2007). Other studies have found no association between living alone and poorer scores on measures of global cognitive function (Conroy et al. 2010; Gow et al. 2013; Mahoney, Einser, Havinghurt, Gray & Palta, 2000; Wang, He & Dong, 2015; Yeh & Liu, 2003), memory, IQ (Gow et al. 2013), verbal fluency, and numeracy (Mazzuco et al. 2016). Most of these studies have been cross-sectional (Conroy et al. 2010; Gow et al. 2007; Gow et al. 2013; Wang et al. 2015; Yeh & Liu, 2003). Some are longitudinal and report the association between living alone and cognitive function over two (Mazzuco et al. 2016), eight (Yaffe et al. 2009), and ten (van Gelder et al. 2006) years, and one study had a follow-up of one month (Mahoney et al. 2000).

Cognitive reserve may account for some discrepancies in findings relating to living arrangement and cognitive function. Cognitive reserve theory suggests that individuals differ in their level of resilience against brain pathology and hence may exhibit differences in cognitive function despite equivalent levels of pathology (Stern, 2002, 2012). Reserve can be built through a range of experiences across the lifespan, such as educational level, occupational complexity, and social and cognitive activity (Stern, 2009). This reserve may protect against a decline in cognitive function by compensating for damage and recruiting alternative neural networks to maintain good cognitive function (Siedlecki et al. 2009).

From a cognitive reserve perspective, living with others may enhance cognitive function directly through the stimulation arising from regular social interaction with others (van Gelder et al. 2006). Social interactions are effortful and require the mobilisation of complex cognitive processes, and therefore may help to build reserve and maintain cognitive function (Barnes et al. 2004; Fratilgioni, Paillard-Borg & Winblad, 2004). Individuals who live alone may have less frequent opportunity for social contact, may be more isolated (Carstensen, 1992; de Jong Gierveld, 2003; de Jong Gierveld & Havens, 2004; Kobayashi et al. 2009), and may feel more lonely (Newall et al. 2014; Victor et al. 2005) than those who live with others, which may result in reduced cognitive stimulation and lower cognitive reserve (Gow et al. 2007).

We aimed to determine whether people who live alone in later life are at greater risk of social isolation, loneliness, or lower engagement in social activity. Given that people who live alone may be

at greater risk of social isolation, loneliness, and lower engagement in social activity, which have each been associated with poor cognitive function, we examined the association between living alone and cognitive function using baseline and two-year follow-up data from the Cognitive Function and Ageing Study–Wales (CFAS-Wales).

2. Method

2.1 Design

The study aims were addressed using data from CFAS-Wales, a longitudinal study of people age ≥65 years. The study was conducted in Wales across two locations, one rural (Gwynedd/ Ynys Môn) and one urban (Neath Port Talbot). The aim of CFAS-Wales was to investigate the physical and cognitive health of older people and to consider environmental factors that may influence activity and participation in community life. Ethical approval for data collection was granted by the NHS North Wales - West Research Ethics Committee (REC Ref No: 10/WNo01/37; IRAS Project No: 40092).

2.2 Study population

Participant recruitment was completed between 2011 and 2013. People aged ≥65 years were randomly selected from general practice registers and stratified into two age groups (65-74 and ≥75) to ensure a representative sample. Selected participants were sent information regarding the study and informed consent was obtained if they wished to take part. In-depth interviews were conducted by trained research assistants at the participants' homes. Baseline data were collected between 2011 and 2013 and participants were followed up two-years later between 2013 and 2015.

The present study uses baseline (N = 3,593) and follow-up (N = 2,236) data. To reduce the risk of reverse causation in analyses, participants with cognitive impairment (Mini-Mental State Examination: MMSE; score ≤25; N = 908) or an Automated Geriatric Examination Assisted Taxonomy (AGECAT) classification of dementia (N = 185) at baseline were excluded. The AGECAT is a diagnostic algorithm that assesses symptoms to determine whether a person has dementia, depression, anxiety, or no diagnosis (Copeland, Dewey & Griffiths-Jones, 1986). Participants with an AGECAT classification of depression (N = 333) at baseline were excluded as depression is known to be associated with poor cognitive function. We excluded people living in an institution (N = 95) as living with others in institutional care is different to living with others in the community. Finally, we excluded people with missing data for variables assessed in the present study at baseline (N = 463) and follow-up (N = 699). This gave a final sample of 2,197 participants for cross-sectional analyses and 1,498 participants for analyses at two-year follow-up. A comparison of participants that were included at both time points with those that were included in cross-sectional analyses but excluded from follow-up analyses due to missing data at follow-up is reported in Table 1. Those who were excluded at follow-up were older, more likely to have impairments in activities of daily living (ADLs), had fewer years of education, lower cognitive and cognitive reserve scores, lower occupational complexity, engaged in less cognitive activity, were more socially isolated, and were less likely to

engage in regular social activity, but were no more likely to be women, live alone, or experience greater feelings of loneliness, and there was no difference in marital status.

Table 1. *Comparison of participants assessed at baseline who were included at two-year follow-up with those who were included at baseline but excluded at two-year follow-up.*

Variable	Included participants (N = 1,498)	Excluded participants (N = 699)	*t*(df) or X^2(df) *p*
Age (years)[1]	73.22 (6.15)	73.97 (6.52)	*t*(1, 2195) = 2.63 *p* = .009
Gender[2]			
Men	747 (49.87)	338 (48.35)	$X^2(1) = .44$ *p* = .509
Women	751 (50.13)	361 (51.65)	
Living alone[2]	430 (28.70)	194 (27.75)	$X^2(1) = .21$ *p* = .645
Marital status[2]			
Married	1,033 (68.96)	455 (65.09)	
Cohabiting	20 (1.34)	15 (2.15)	
Single	55 (3.67)	27 (3.86)	$X^2(4) = 5.13$ *p* = .274
Widowed	300 (20.03)	161 (23.03)	
Divorced/ separated	90 (6.01)	41 (5.87)	
ADL Impairment[2]	371 (24.77)	241 (34.48)	$X^2(1) = 22.38$ *p* <.001
CAMCOG score[1]	94.16 (4.94)	92.03 (5.91)	*t*(1, 2195) = -8.85 *p* <.001
Educational level (years)[1]	12.20 (2.85)	11.77 (2.67)	*t*(1, 2195) = -3.38 *p* <.001
Cognitive activity[1]	21.54 (5.14)	20.83 (5.23)	*t*(1, 2195) = -3.00 *p* = .003
Occupational complexity[1]	8.35 (3.31)	7.60 (3.32)	*t*(1, 2195) = -4.91 *p* <.001
Cognitive reserve score[1]	61.66 (11.51)	58.90 (11.07)	*t*(1, 2195) = -5.30 *p* <.001
Social isolation[1]			
Overall	16.48 (5.77)	15.50 (5.58)	*t*(1, 2195) = -3.76 *p* <.001
Family	8.79 (3.31)	8.47 (3.30)	*t*(1, 2195) = -2.11 *p* = .035
Friends	8.69 (4.07)	7.03 (3.89)	*t*(1, 2195) = -3.61 *p* <.001
Loneliness[1]			
Overall	.82 (1.04)	.81 (1.05)	*t*(1, 2195) = -.08 *p* = .938
Social loneliness	.45 (.76)	.43 (.77)	*t*(1, 2195) = -.50 *p* = .616
Emotional loneliness	.37 (.61)	.39 (.64)	*t*(1, 2195) = .48 *p* = .628
Social activity[2]			
No	609 (40.65)	378 (54.08)	
Occasionally	98 (6.54)	37 (5.29)	$X^2(2) = 34.76$ *p* = <.001
Regularly	791 (52.80)	284 (40.63)	

Note: [1] *M* (SD); [2] *N* (%); ADL = Activities of Daily Living; CAMCOG = Cambridge Cognitive Examination

2.3 Measures

2.3.1 *Living alone*

Living alone was assessed by asking participants 'does anyone else live here?' (yes/ no).

2.3.2 *Social isolation*

Social isolation was assessed with the Lubben Social Network Scale–6 (LSNS-6; Lubben et al. 2006). The LSNS-6 is a standardised measure of social isolation and consists of three questions assessing isolation from family and three comparable questions assessing isolation from friends. The questions ask participants to report the number of relatives/ friends seen or heard from in the past month, that they feel at ease to talk with about private matters, and that they feel they could call on for help. Responses are coded along a six-item category response scale ranging from 0 (no relatives/ friends) to 5 (nine or more relatives/ friends). An overall score for isolation is calculated by summing responses to all questions. Scores range from 0-30 and lower scores indicate social isolation. Questions for family and friends can be scored separately, providing two subscale scores which range from 0-15 and lower scores indicate greater isolation.

2.3.3 *Loneliness*

Loneliness was assessed using the De Jong Gierveld scale (De Jong Gierveld & van Tilburg, 2006), which consists of three questions to assess social loneliness and a further three questions to assess emotional loneliness. Participants respond either yes, more or less, or no. Scores are summed to provide an overall loneliness score, which ranges from 0–6. Scores for the social and emotional subscale range from 0–3. Higher scores indicate greater feelings of loneliness.

2.3.4 *Social activity*

Social activity was assessed by asking participants 'do you attend any community or social groups?' (e.g. over 60s clubs, evening classes, but not including attendance to religious meetings). Participants respond as no (less than yearly), occasionally (less than monthly), or regularly (daily/ weekly).

2.3.5 *Cognitive function*

Cognitive function was assessed using the Cambridge Cognitive Examination (CAMCOG: Roth et al. 1986), a standardised measure of cognitive function. The measure consists of 67 items that assess cognitive function along eight subscales, including orientation, memory, praxis, attention, abstract thinking, perception, and calculation. Scores range from 0–107 and a lower score indicates poor

cognitive function. The CAMCOG has good inter-rater reliability (r = .97), high sensitivity (92%) and specificity (96%: Roth et al. 1986; Wouters, van Gool, Schmand, Zwinderman & Lindeboom, 2010).

2.3.6 *Cognitive reserve*

Cognitive reserve was assessed by combining three proxy measures to represent experiences that may build reserve across the lifespan: educational level, occupational complexity, and cognitive activity (Opdebeeck et al. 2018; Tucker & Stern, 2011; Valenzuela, Brayne, Sachdev, Wilcock & Matthews, 2011). Educational level was determined by the number of years in full time education. Occupational complexity was measured by the participant's social class and the complexity and social economic grouping of the participant's main employment. This gave a complexity score ranging from 1 (less complex occupations) to 14 (more complex occupations). Cognitive activity was assessed by asking the participant about engagement in seven cognitive activities (listening to the radio, reading a newspaper, magazine, or book, playing cards or chess, and completing crosswords or puzzles). Participants respond either once a year or less, several times a year, several times a month, several times a week, or everyday/ almost every day. Higher scores indicate greater cognitive activity.

Scores for each indicator were weighted based on the interquartile range to ensure that each proxy item contributed equally to determining the cognitive reserve score. This gave the following formula: cognitive reserve score = (2.33 × educational level) + (1.40 × occupational complexity) + (1 × cognitive activity). Higher scores indicate higher levels of cognitive reserve.

2.3.7 *Marital status*

Participants indicated their marital status at baseline as either married, cohabiting, single, widowed, or divorced/ separated.

2.3.8 *Activities of daily living*

Activities of daily living (ADLs) were measured as a dichotomous variable (impaired/ not impaired) based on five questions considered to capture ADL ability (Bond & Carstairs, 1982). At baseline, participants were asked about their ability to wash, prepare a hot meal, put on their own shoes, do the housework, and go shopping independently. If the participant indicated a need for help to complete any of these tasks, or was rated by the research assistant as being either housebound, chairfast, or bedfast, they were considered to be impaired in ADLs.

2.3.9 *Covariates*

Baseline age (years), gender, and educational level (years) are all well-established covariates of late-life cognitive function (Barnes et al. 2003; Tervo et al. 2004; Tilvis et al. 2004) and were controlled for in all analyses. Social isolation, loneliness, and social activity were also controlled for as these factors have been associated with living alone (Victor et al. 2000; Victor et al. 2005) and with cognitive function (DiNapoli et al. 2014; Ellwardt et al. 2013; Gerst-Emerson et al. 2014; Gow et al. 2013; Shankar et al. 2013; Zunzunegui et al. 2003). We also controlled for marital status as people who are unmarried in later life may be more likely to live alone (Victor et al. 2000) and for impairment in ADLs as people with ADL limitations may have reduced mobility which may limit ability to be socially engaged, and hence increase level of social isolation, feelings of loneliness, or reduce engagement in social activity (Mendes de Leon, Glass & Berkman, 2003).

2.4 Statistical analysis

Analyses were conducted in Stata version 15.0. Descriptive information is reported for the overall sample at baseline and separately for those who were living alone or with others. T-tests or chi squared tests were conducted to determine whether there were differences in social isolation, loneliness, social activity, and other demographic variables across these groups. Pearsons correlations were used to assess correlations between variables. A linear regression was conducted to assess the relationship between living arrangement and cognitive function at baseline. A second linear regression was conducted to determine the association between living arrangement and cognitive function at two-year follow-up, controlling for baseline cognitive scores. Adjusted R^2 values were reported for regression models to indicate the proportion of variance explained by variables in the model. Standardised regression coefficients were also reported, along with 95% confidence intervals. We used an attrition weight to account for the attrition of participants between baseline and follow-up and applied this to all prospective analyses. We derived this weight using the inverse probability of being included in follow-up analyses following a multivariable logistic regression model with in follow-up as the dependent variable and living arrangement, baseline CAMCOG score, age, gender, education, social isolation, loneliness, social activity, marital status, and ADL impairment as independent variables.

3. Results

The mean age of participants was 73 years and 51% were women. Scores on the CAMCOG at baseline ranged from 63–105 with a mean of 93.48, and at two-year follow-up ranged from 53–106 with a mean of 93.74. At baseline 624 people were living alone. Those living alone were significantly

older, more likely to be women, less likely to be married or cohabiting, more likely to be single, widowed, or divorced, were more likely to have impairments in ADLs, and had poorer CAMCOG scores. There was no difference in educational level, occupational complexity, cognitive activity, or cognitive reserve score (Table 2).

Table 2. *Summary of baseline characteristics of participants in CFAS-Wales.*

Variable	Total sample (N = 2,197)	Living alone (N = 624)	Living with others (N =1,573)	*t*(df) or X^2(df) *p*
Age (years)[1]	73.46 (6.28)	75.96 (6.91)	72.46 (5.71)	*t*(1, 2195) = 12.19 *p* <.001
Gender[2]				
Men	1,085 (49.39)	186 (29.81)	899 (57.15)	X^2(1) = 133.64 *p* <.001
Women	1,112 (50.61)	438 (70.19)	674 (42.85)	
Marital status[2]				
Married	1,488 (67.73)	62 (9.94)	1,426 (90.65)	
Cohabiting	35 (1.59)	2 (.32)	33 (2.10)	
Single	82 (3.73)	71 (11.38)	11 (.70)	X^2(4) = 6.81 *p* <.001
Widowed	461 (20.98)	393 (62.98)	68 (4.32)	
Divorced/ separated	131 (5.96)	96 (15.38)	35 (2.23)	
ADL Impairment[2]	612 (27.86)	215 (34.46)	397 (25.24)	X^2(1) = 18.89 *p* <.001
CAMCOG score[1]	93.48 (5.36)	92.49 (5.74)	93.88 (5.15)	*t*(1, 2195) = -5.51 *p* <.001
Educational level (years)[1]	12.07 (2.80)	12.09 (2.79)	12.05 (2.81)	*t*(1, 2195) = .31 *p* = .760
Cognitive activity[1]	21.31 (5.18)	21.12 (5.43)	21.39 (5.07)	*t*(1, 2195) = -1.08 *p* = .279
Occupational complexity[1]	8.11 (3.33)	8.17 (3.30)	8.09 (3.34)	*t*(1, 2195) = .52 *p* = .601
Cognitive reserve score[1]	60.78 (11.45)	60.74 (11.57)	60.79 (11.40)	*t*(1, 2195) = -.10 *p* = .919
Social isolation[1]				
Overall	16.17 (5.73)	15.75 (5.69)	16.33 (5.74)	*t*(1, 2195) = -2.14 *p* = .032
Family	8.69 (3.31)	8.31 (3.42)	8.83 (3.25)	*t*(1, 2195) = -3.34 *p* = <.001
Friends	7.48 (4.02)	7.44 (3.95)	7.50 (4.05)	*t*(1, 2195) = -.30 *p* = .762
Loneliness[1]				
Overall	.82 (1.04)	.99 (1.15)	.75 (.99)	*t*(1, 2195) = 4.86 *p* <.001
Social loneliness	.44 (.76)	.44 (.79)	.44 (.75)	*t*(1, 2195) = -.02 *p* = .982
Emotional loneliness	.38 (.62)	.55 (.74)	.31 (.55)	*t*(1, 2195) = 8.28 *p* <.001
Social activity[2]				
No	987 (44.92)	254 (40.71)	733 (46.60)	X^2(2) = 7.42 *p* = .025
Occasionally	135 (6.14)	36 (5.77)	99 (6.29)	
Regularly	1,075 (48.93)	334 (53.53)	741 (47.11)	

Note: [1] *M* (SD); [2] *N* (%); ADL = activities of daily living; CAMCOG = Cambridge Cognitive Examination

Table 3. Pearson correlations between variables.

		1	2	3	4	5	6	7	8	9	10	11	12	13
1.	**Age**	-												
2.	**Gender**	.03	-											
3.	**Living arrangement**	-.25***	-.25***	-										
4.	**Marital status**	.24***	.27***	-.78***	-									
5.	**ADL impairment**	.26***	.15***	-.09***	.11***	-								
6.	**Baseline CAMCOG score**	-.32***	-.08***	.12***	-.14***	-.19***	-							
7.	**Educational level (years)**	-.09***	-.01	-.01	-.01	-.10***	.24***	-						
8.	**Cognitive activity**	-.06***	.21***	.02	-.03	-.06***	.24***	.15***	-					
9.	**Occupational complexity**	.02	-.03	-.01	-.02	-.10***	.20***	.39***	.13***	-				
10.	**Cognitive reserve score**	-.07***	.07***	0	-.02	-.12***	.33***	.79***	.59***	.69***	-			
11.	**Social isolation**	-.12***	.06***	.05*	-.05*	-.07***	.13***	.09***	.18***	.03	.14***	-		
12.	**Loneliness**	.02	0	-.10***	.10***	.07***	.01*	.04*	-.04*	.07**	.03	-.31***	-	
13.	**Social activity**	0	.10***	-.05*	.03	-.06***	.12***	.12***	.17***	.11***	.19***	.24***	-.07**	-

Note: *p <.05 **p <.01 ***p <.001

3.1 Social relationships in older people living alone or with others

T-tests were conducted to compare social isolation and loneliness among people living alone and those living with others (Table 2). People living alone were more likely to be socially isolated overall and to be isolated from family than those living with others, but there was no difference in isolation from friends. People living alone reported significantly greater feelings of overall loneliness and emotional loneliness, but there was no difference in feelings of social loneliness. People living alone were slightly more likely to engage in regular social activity than those living with others.

Living arrangement and marital status were highly correlated. Social isolation was moderately correlated with loneliness and social activity (Table 3).

3.2 Association between living arrangement and cognitive function

3.2.1 *Baseline*

A linear regression was conducted to assess the relationship between living arrangement and cognitive function at baseline. Living alone was not significantly associated with poorer CAMCOG scores in the fully adjusted model adjusted (R^2 = .17, F(9, 2187) = 52.36, p <.001: Table 4).

Table 4. *Cross-sectional association between living alone and cognitive function (N = 2,197).*

CAMCOG score	**Model 1** *B* (95% CI) *p*	**Model 2** *B* (95% CI) *P*	**Model 3** *B* (95% CI) *p*
Living alone (no)	.15 (.09, .20) <.001	.04 (-.01, .09) .162	-.02 (-.09, .06) .641
Age	-	-.03 (-.03, -.02) <.001	-.02 (-.03, -.02) <.001
Gender	-	-.07 (-.11, -.02) .002	-.06 (-.11, -.02) .008
Education	-	.04 (.04, .05) <.001	.04 (.03, .05) <.001
Social isolation	-	-	.04 (.02, .06) <.001
Loneliness	-	-	.03 (0, .05) .040
Social activity (yes)	-	-	.09 (.05, .14) <.001
Marital status (not married)	-	-	-.08 (-.15, -.01) .036
ADL impairment (yes)	-	-	-.11 (-.16, -.06) <.001

Note: Model 1: unadjusted; Model 2: adjusted for age, gender, and years of education; Model 3 adjusted for age, gender, years of education, social isolation, loneliness, social activity, marital status, and ADL impairment.

Further regression analyses were conducted to determine whether living alone was more associated with any specific cognitive domain assessed by the CAMCOG (Table 5). Living alone was significantly associated with praxis (adjusted R^2 = .07, F(9, 2187) = 19.08, p <.001), but not orientation (adjusted R^2 = 0, F(9, 2187) = 1.49, p = .146), comprehension (adjusted R^2 = .02, F(9, 2187) = 5.64, p <.001), expression (adjusted R^2 = .11, F(9, 2187) = 31.89, p <.001), memory (adjusted R^2 = .04, F(9, 2187) = 11.21, p <.001), attention and calculation (adjusted R^2 = .03, F(9, 2187) = 7.38, p <.001), abstract thinking (adjusted R^2 = .04, F(9, 2187) = 10.51, p <.001), or perception (adjusted R^2 = .12, F(9, 2187) = 34.26, p <.001).

Table 5. *Cross-sectional association between living alone and sub-domains of cognition assessed by the CAMCOG (N = 2,197).*

	Orientation	**Comprehension**	**Expression**	**Memory**	**Attention and calculation**	**Praxis**	**Abstract thinking**	**Perception**
	B (95% CI) *P*	*B* (95% CI) *P*	*B* (95% CI) *p*	*B* (95% CI) *p*	*B* (95% CI) *P*	*B* (95% CI) *p*	*B* (95% CI) *p*	*B* (95% CI) *p*
Living alone (no)	-.05 (-.12, .02) .160	-.04 (-.09, 0) .068	.04 (-.01, .09) .127	-.04 (-.10, .01) .131	0 (-.06, .05) .869	.08 (.02, .14) .016	-.01 (-.11, .08) .758	-.05 (-.16, .07) .424
Age	0 (0, 0) .679	0 (-.01, 0) <.001	-.01 (-.02, -.01) <.001	-.01 (-.01, 0) <.001	0 (-.01, 0) .038	-.01 (-.01, 0) <.001	-.01 (-.02, -.01) <.001	-.04 (-.04, -.03) <.001
Gender	-.02 (-.07, .02) .225	.03 (0, .05) .054	.02 (-.01, .05) .278	-.07 (-.10, -.03) <.001	-.10 (-.13, -.06) <.001	-.04 (-.08, 0) .040	.06 (.01, .12) .025	-.06 (-.13, .01) .082
Education	.01 (0, .01) .072	.01 (0, .01) .002	.02 (.01, .02) <.001	.01 (.01, .02) <.001	.01 (.01, .02) <.001	.02 (.01, .02) <.001	.03 (.02, .04) <.001	02 (.01, .03) .003
Social isolation	.01 (-.01, .03) .447	0 (-.02, .01) .634	.02 (.01, .03) .044	.01 (0, .03) .119	.02 (0, .03) .091	.03 (.01, .05) .009	0 (-.03, .03) .867	.05 (.01, .08) .014
Loneliness	-.01 (-.03, .01) .414	0 (-.02, .01) .821	.02 (0, .03) .058	.01 (-.01, .03) .191	.02 (0, .04) .060	.01 (-.02, .03) .615	.01 (-.02, .04) .491	0 (-.03, .04) .802
Social activity (yes)	.02 (-.02, .06) .239	0 (-.02, .03) .731	.04 (.01, .07) .006	.05 (.01, .08) .005	.02 (-.01, .06) .207	.03 (-.01, .07) .099	.09 (.03, .14) .002	.07 (0, .13) .056
Marital status (not married)	.01 (-.06, .07) .886	-.06 (-.11, -.02) .008	-.01 (-.06, .04) .694	-.05 (-.10, .01) .102	-.02 (-.07, .04) .543	0 (-.06, .06) .949	-.04 (-.13, .05) .369	-.10 (-.21, .01) .075
ADL impairment (yes)	.02 (-.03, .06) .493	-.02 (-.05, .01) .114	-.06 (-.09, -.03) <.001	-.01 (-.05, .03) .598	.01 (-.03, .04) .750	-.11 (-.16, -.07) <.001	-.01 (-.07, .05) .700	-.13 (-.21, -.06) <.001

Note: adjusted for age, gender, years of education, social isolation, loneliness, social activity, marital status, and ADL impairment.

3.2.2 *Longitudinal*

A linear regression was conducted to assess the association between living arrangement and cognitive function at two-year follow-up. Living arrangement was not significantly associated with cognitive function at follow-up in the fully adjusted model (adjusted R^2 = .49, F(10, 1488) = 93.15, p <.001: Table 6).

Table 6. *Longitudinal association between living alone and cognitive function at two-year follow-up (N = 1,498).*

CAMCOG score at follow-up	**Model 1** *B* (95% CI) *p*	**Model 2** *B* (95% CI) *p*	**Model 3** *B* (95% CI) *p*
Living alone (no)	.19 (.09, .28) <.001	.05 (-.05, .14) .334	.03 (-.13, .18) .735
Baseline CAMCOG score	1.22 (.09, .28) <.001	1.04 (.95, 1.14) <.001	1.02 (.92, 1.11) <.001
Age	-	-.04 (-.05, -.03) <.001	-.04 (-.04, -.03) <.001
Gender	-	-.10 (-.18, -.02) .011	-.10 (-.17, -.02) .018
Education	-	.04 (.02, .05) <.001	.03 (.02, .04) <.001
Social isolation	-	-	.08 (.04, .12) <.001
Loneliness	-	-	.04 (-.01, .08) .090
Social activity (yes)	-	-	.04 (-.04, .13) .337
Marital status (not married)	-	-	-.03 (-.17, .12) .733
ADL impairment (yes)	-	-	-.16 (-.25, -.06) <.001

Note: Model 1: unadjusted; Model 2: adjusted for baseline CAMCOG score, age, gender, and years of education; Model 3 adjusted for age, gender, years of education, social isolation, loneliness, social activity, marital status, and ADL impairment.

Further regression analyses were conducted to determine whether living alone was more associated with cognitive change in any specific cognitive domain assessed by the CAMCOG (Table 7). Living alone was not significantly associated with two-year change in scores on any of the CAMCOG sub-domains: orientation (adjusted R^2 = .06, F(10, 1488) = 4.77, p <.001), comprehension (adjusted R^2 =

.07, F(10, 1488) = 9.35, p <.001), expression (adjusted R^2 = .27, F(10, 1488) = 34.60, p <.001), memory (adjusted R^2 = .36, F(10, 1488) = 53.00, p <.001), attention and calculation (adjusted R^2 = .16, F(10, 1488) = 17.48, p <.001), praxis (adjusted R^2 = .20, F(10, 1488) = 30.10, p <.001), abstract thinking (adjusted R^2 = .18, F(10, 1488) = 22.64, p <.001), or perception (adjusted R^2 = .27, F(10, 1488) = 43.36, p <.001).

Table 7. *Longitudinal association between living alone and sub-domains of cognition assessed by the CAMCOG (N = 1,498).*

	Orientation	**Comprehension**	**Expression**	**Memory**	**Attention and calculation**	**Praxis**	**Abstract thinking**	**Perception**
	B (95% CI) *P*	*B* (95% CI) *P*	*B* (95% CI) *p*	*B* (95% CI) *p*	*B* (95% CI) *P*	*B* (95% CI) *p*	*B* (95% CI) *p*	*B* (95% CI) *p*
Living alone (no)	-.07 (-.28, .13) .485	.17 (-.03, .36) .095	.05 (-.11, .22) .550	.03 (-.12, .19) .660	-.04 (-.26, .18) .750	-.06 (-.23, .11) .481	.03 (-.15, .21) .758	.05 (-.10, .20) .507
Baseline CAMCOG sub-domain score	.07 (-.03, .17) .182	.24 (.05, .42) .012	1.06 (.68, 1.43) <.001	1.44 (1.30, 1.58) <.001	.82 (.65, .99) <.001	.77 (.64, .90) <.001	.51 (.41, .61) <.001	.47 (.40, .54) <.001
Age	-.03 (-.04, -.02) <.001	-.02 (-.03, -.01) <.001	-.03 (-.04, -.02) <.001	-.03 (-.04, -.02) <.001	-.02 (-.03, -.01) <.001	-.03 (-.03, -.02) <.001	-.02 (-.03, -.02) <.001	-.03 (-.04, -.03) <.001
Gender	-.07 (-.17, .04) .212	.07 (-.03, .18) .169	.06 (-.04, .15) .221	-.06 (-.14, .03) .198	-.22 (-.32, -.12) <.001	-.15 (-.25, -.05) .002	.04 (-.06, .14) .473	-.08 (-.17, .01) .076
Education	.03 (.01, .05) .003	.02 (0, .04) .021	.04 (.02, .06) <.001	.02 (0, .03) .022	.03 (.02, .05) <.001	.04 (.02, .06) <.001	.05 (.03, .06) <.001	.01 (0, .03) .126
Social isolation	.05 (-.02, .11) .190	.06 (0, .12) .047	.11 (.05, .16) <.001	.06 (.01, .11) .012	.02 (-.03, .07) .444	.02 (-.04, .07) .527	.08 (.02, .13) .005	.04 (-.01, .09) .138
Loneliness	-.01 (-.08, .06) .714	.06 (0, .11) .059	.06 (.01, .11) .019	.02 (-.03, .07) .521	.03 (-.03, .08) .301	0 (-.06, .06) .966	.04 (-.02, .10) .208	.03 (-.03, .08) .376
Social activity (yes)	.08 (-.03, .19) .157	.04 (-.07, .14) .501	.01 (-.09, .10) .861	.03 (-.06, .12) .539	.08 (-.03, .18) .143	.08 (-.02, .18) .123	.01 (-.09, .12) .809	.01 (-.08, .11) .760
Marital status (not married)	-.05 (-.24, .14) .639	.04 (-.15, .22) .700	.07 (-.09, .23) .397	-.05 (-.20, .10) .481	-.06 (-.28, .16) .587	-.10 (-.27, .07) .256	-.02 (-.19, .15) .791	-.05 (-.19, .10) .526
ADL impairment (yes)	-.18 (-.31, -.05) .009	-.30 (-.42, -.17) <.001	-.07 (-.18, .03) .184	-.11 (-.22, -.01) .035	-.05 (-.17, .07) .400	-.05 (-.16, .07) .410	-.13 (-.25, -.01) .039	-.15 (-.26, -.04) .006

Note: adjusted for baseline CAMCOG sub-domain score, age, gender, years of education, social isolation, loneliness, social activity, marital status, and ADL impairment.

4. Discussion

Living alone is a common experience for many people in later life (Evandrou, Falkingham, Rake & Scott, 2001; Kharicha et al. 2007; Mazzuco et al. 2016; Victor et al. 2000). This study aimed to determine whether people living alone are at greater risk of social isolation, feelings of loneliness, and lower engagement in social activity. Consistent with previous work, we found that people living alone are more isolated (de Jong Gierveld, 2003; de Jong Gierveld & Havens, 2004; Gow et al. 2013; Kobayashi et al. 2009; Iliffe et al. 2007; Kharicha et al. 2007) and feel lonelier (de Jong Gierveld, 2003; de Jong Gierveld & Havens, 2004; Newall et al. 2014; Victor et al. 2005) than those living with others. More specifically, people living alone reported greater isolation from family and greater feelings of emotional loneliness than those living with others, but there was no difference in isolation from friends or feelings of social loneliness. Interestingly, people who lived alone engaged in slightly more frequent social activity than those living with others. This is consistent with previous work (Michael, Berkman, Colditz & Kawachi, 2001) which reflects that living alone is not synonymous with lower engagement in social activity within this cohort.

The finding that living alone is not significantly associated with cognitive function at baseline is consistent with most previous studies (Conroy et al. 2010; Gow et al. 2013; Mahoney et al. 2000; Wang et al. 2015; Yeh & Liu, 2003). The present findings are inconsistent with one study that reports an association between living alone and cognitive function determined by a measure of IQ at baseline (Gow et al. 2007). This difference may be accounted for by the differences in measures used to assess cognitive function. The measure of IQ used in Gow et al. (2007) assesses reasoning, arithmetic, following directions, and analogies. Previous studies that do not find an association assess cognitive function using measures of global cognitive function, such as the MMSE (Mahoney et al. 2000; Wang et al. 2015), the Abbreviated Mental Test (Conroy et al. 2010), the Short Portable Mental State Questionnaire (Yeh & Liu, 2003), and the CAMCOG in the present study. The measure of IQ used in Gow et al. (2007) assesses different cognitive abilities to those assessed by the CAMCOG and other global measures of cognitive function which may be more affected by ageing than a measure of IQ and hence may account for differences in findings. However, a study that also assessed the association between living alone and the same measure of IQ as in Gow et al. (2007) found no association (Gow et al. 2013). It is not clear why there were differences in the reported associations between living alone and IQ score in two relatively similar cohorts. One explanation could be that there were twice as many people living alone in Gow et al. (2007) compared to Gow et al. (2013) and so there may have been more statistical power in Gow et al. (2007) to detect an association. It has been suggested that crystallised cognitive abilities, such as those assessed in the measure of IQ may be less associated with cognitive ageing, whereas fluid cognitive domains such as

executive functions and memory may be more affected by ageing (Christensen, 2001; Deary et al. 2009; Hedden & Gabrieli, 2004; Mazzuco et al. 2016; Park & Reuter-Lorenz, 2009). Therefore, the findings from Gow et al. (2007) seem inconsistent with most previous literature and the present study which report nonsignificant findings in both crystallised and fluid cognitive abilities.

There was no association between living alone and global cognitive function at two-year follow-up. This is inconsistent with previous findings (van Gelder et al. 2006; Yaffe et al. 2009). These studies had a follow-up period of eight (Yaffe et al. 2009) and ten (van Gelder et al. 2006) years which is longer than the two-year follow-up in CFAS-Wales. It may be that the associations between living arrangement and cognitive function would manifest in longer term follow-up assessments. In addition, there was little cognitive change observed over two-years in the present sample and many people had improvements in their cognitive scores, which may account for the non-significant finding at follow-up. However, we did find that living alone was significantly associated with poorer scores in praxis at baseline and follow-up. The present findings are consistent with a study that reported findings from eight European countries and found that living alone was not associated with poorer scores in several cognitive domains, including orientation (no association in five countries), immediate recall (no association in six countries), delayed recall (no association in six countries), verbal fluency (no association in seven countries), or numeracy (no association in eight countries) over two-year follow-up (Mazzuco et al. 2016). The authors concluded that living with others may be protective in some countries and for some specific abilities, but there was mostly no protective effect of living with others on cognitive function.

In line with cognitive reserve theory, we predicted that people living alone may have less opportunity for social contact and hence may have lower levels of cognitive reserve and poorer cognitive function (de Jong Gierveld, 2003; de Jong Gierveld & Havens, 2004; Kobayashi et al. 2009; Stern, 2012). We found no difference in cognitive reserve scores at baseline between those living alone and with others.

Living alone and being unmarried were highly correlated. Unsurprisingly, people who were widowed, separated/ divorced, or single were more likely to live alone whereas those that were married continued to live with others. Previous research has suggested that being married is protective against poor cognitive function (Aartsen, van Tilburg, Smits, Comijs & Knipscheer, 2005; Gow et al. 2007; Håkansson et al. 2009; Paúl, Ribeiro & Santos, 2010; van Gelder et al. 2006; Yeh & Liu, 2003; Xu, Thomas & Umberson, 2015), and dementia (Håkansson et al. 2009; Holwerda et al. 2012). It is possible that living in a relationship as a couple provides a greater degree of emotional closeness and feelings of support which may help to reduce stress and protect against poor cognitive function

uniquely (Håkansson et al. 2009; Xu et al. 2015). Marital relationships may also protect against cognitive decline by influencing health and lifestyle choices that are known to influence cognitive function (Lee et al. 2010; Wilson, Schneider et al. 2007). Loss of a spouse can lead to adverse changes in mental and physical health and may exacerbate cognitive problems or poor social relationships (Kiecolt-Glaser & Newton, 2001). However, being unhappily married and experiencing frequent negative interactions with a spouse can be emotionally distressing and have detrimental effects on health and wellbeing (Xu et al. 2015). It is difficult to separate the effects of living arrangement and marital status in the present study given that these variables are so closely correlated.

The present findings seem to implicate that age, gender, educational level, social isolation, and impairments in ADLs may be more associated with cognitive function than living alone at baseline and two-year follow-up. Indeed, previous work suggests that people who are older (Hendrie et al. 2006; Lipnicki et al. 2013), have fewer years of education (Opdebeeck, Martyr & Clare, 2016; Plassman, Williams, Burke, Holsinger & Benjamin, 2010), are more isolated (DiNapoli et al. 2014; Evans et al. 2018; Holwerda et al. 2012; Shankar et al. 2013; Wilson, Krueger et al. 2007), or have impairments in ADLs or poorer mobility (Demnitz et al. 2017; Tolea & Galvin, 2016; Zhao, Tranovich & Wright, 2014) may be at greater risk of poor cognitive function in later life. It is interesting that social isolation predicted poor cognitive function at baseline and two-year follow-up, while loneliness and social activity predicted poor cognitive function at baseline, but not two-year follow-up, and living alone did not predict poor cognitive function at baseline or two-year follow-up in the fully adjusted model. Social isolation was measured using the LSNS-6 in the present study, which assesses the absence of social relationships and disengagement from the wider community. This is much more comprehensive than the single question which assesses living arrangement and provides an indication of the level of interaction with a range of people in the community. It is possible that this more complex level of integration better predicts cognitive function (Berkman, 2000). This further reinforces the importance of social isolation in later life and the benefits of having a wide social network and engagement in frequent social activity on cognitive function.

The present findings have several implications. There is an assumption that living alone may be less cognitively stimulating, yet it is possible that living alone has many benefits. People who live alone are often solely responsible for completing household tasks, such as paying the bills, shopping, cleaning, maintenance, and answering the telephone or door, which all require cognitive input (Jekel et al. 2015; Njegovan, Man-Son-Hing, Mitchell & Molnar, 2001). People living with others may have less responsibility for completing these tasks, and in some households and partnerships, one individual may take charge, leaving the other partner to take a more passive role. People who live

alone and are unable to complete household tasks due to poor cognitive function or health are unlikely to manage independently at home and may be more likely to move into a care home (Cornelis, Gorus, Beyer, Bautmans & De Vriendt, 2017; Wang et al. 2015). Those able to manage may gain cognitive stimulation from these tasks, along with stimulation from social interactions with others outside the home. Living arrangement is a basic structural assessment of social connections and does not consider the wider social context. Social interaction with the individual(s) with whom an older person resides are likely to be insufficient to build or maintain cognitive reserve alone (Berkman & Glass, 2000; Mazzuco et al. 2016). It is possibly the more complex web of social contacts and interactions the individual engages with that builds reserve and enhances cognitive function (Berkman, 2000). This may explain why no differences in cognitive function or cognitive change over two-years are found between those living alone and with others in the present study and is particularly relevant given our findings that social isolation may be more associated with cognitive function. There has been little focus on these possible benefits of living alone and how they may enhance health outcomes for older people. Living alone is not necessarily a risk factor in itself for people who are in good health and have sufficient social connections; it may be a positive state for many people and reflect the maintenance of functional independence (Kharicha et al. 2007; Mazzuco et al. 2016).

This study has a number of strengths. CFAS-Wales is a large population-based cohort that is representative of the general population. Participants were sampled from general practice registers and invited to participate. This ensures that individuals who were living alone and particularly isolated were more adequately represented in CFAS-Wales than in self-selected samples.

This study has several limitations. Limited cognitive decline was observed across the sample over the two-year follow-up, and some participants had significant improvements in their CAMCOG scores at follow-up. It is possible that a two-year follow-up period is insufficient to observe cognitive decline and hence an association with living alone could not be detected. People who dropped out between baseline and follow-up were more likely to be socially isolated and to experience feelings of loneliness, and had poorer scores on measures of cognitive function and cognitive reserve. Hence, the follow-up sample was to some degree a selective sample of higher-functioning individuals in terms of social and cognitive variables. This may account for the limited cognitive change observed over the two-years and for the non-significant association between living alone and cognitive function at follow-up. It was not possible to determine for how long people had been living alone in the present sample. Social situations are fluid and frequently change (van Gelder et al. 2006). People who are currently living alone may have previously lived with others, or may have started living alone only recently. It is possible that people who are used to living alone and have done so for

many years are able to compensate and adapt for subtle impairments in cognitive function, and hence impairments may not be detected by cognitive measures. Those who have been living alone for a shorter period of time may be less able to make such compromises and so impairment may be more apparent and the risk of experiencing negative health outcomes as a result may increase (Cacioppo & Hawkley, 2003). It is also possible that different circumstances for living alone may influence cognitive function. For example, people living alone who are recently bereaved may be at greater risk of poor cognitive function (Aartsen et al. 2005; Karlamangla et al. 2009; Mousavi-Nasab, Kormi-Nouri, Sundström & Nilsson, 2012; Shin, Kim & Park, 2018; van Gelder et al. 2006). Although findings relating to widowhood and cognitive function are mixed and may be attributed to experiences that precede widowhood (Vable, Subramanian, Rist & Glymour, 2015; Vidarsdottir et al. 2014; Woodruff et al. 2014). An additional limitation is that 'playing chess and cards' was included in the cognitive activity score but may also contribute to social activity. This reflects the difficulty of assessing lifestyle factors such as cognitive activity independently from other factors such as social or physical activity and determining the extent of contribution of cognitive demand within such activities (Aartsen, Smits, van Tilburg, Knipscheer & Deeg 2002; Toepoel, 2013).

Finally, most previous research, including the present study, focuses on global, person-level variables when assessing living arrangement. There is little research which considers the immediate experience of living alone and what that may be like for an older person (Larson, Zuzanek & Mannell, 1985; Pauly, Lay, Nater, Scott & Hoppmann, 2017). It would be interesting to gain a qualitative perspective and determine whether any specific aspects of living alone are more or less favourable. Likewise, the positive aspects of living alone in later life are frequently overlooked in research. These perspectives could be considered in future work to provide further insight into how living alone may benefit or hinder cognitive function and other health outcomes.

In summary, we report that people who live alone may be more isolated in terms of family networks but that their friendship networks are as strong as those of people living with others, which may mitigate the degree of isolation from family and feelings of loneliness and hence benefit cognitive function. We also find that people living alone in CFAS-Wales are no more vulnerable to poor cognitive function at baseline, or to cognitive decline at follow-up, at least over a relatively short follow-up of two-years, than those living with others. This finding provides a positive message for people living alone in later life, a time when transition to living alone may be more likely than at any other period in the lifespan.

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