RESEARCH PAPER

Why is living alone in older age related to increased mortality risk? A longitudinal cohort study

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Abstract

Background: Living alone has been associated with increased mortality risk, but it is unclear whether this is a result of a selection effect or the impact of stressful life changes such as widowhood or divorce leading to changes in living arrangements. We therefore examined the association between living alone, transitions in living arrangements and all-cause mortality.
Method: We analysed data from 4,888 individuals who participated in both wave 2 (2004–2005) and wave 4 (2008–2009) of the English Longitudinal Study of Ageing. Transitions in living arrangements over this period were identified. Mortality status was ascertained from linked national mortality registers. Cox proportional hazards analysis was used to examine the association between living alone and mortality over an average 8.5 year follow-up period.
Results: An association was found between living alone at wave 4 and mortality (hazard ratio (HR): 1.20, 95% CI 1.04–1.38) in a model adjusted for multiple factors including socioeconomic status, physical health, health behaviours and loneliness. We also found that participants who moved to living alone after divorce or bereavement had a higher risk of mortality compared with those who lived with others at both time points (HR: 1.34, 95% CI 1.01–1.79), while those who moved to living alone for other reasons did not show an increased mortality risk.
Conclusions: The relationship between living alone and mortality is complicated by the reasons underlying not living with others. A greater understanding of these dynamics will help to identify the individuals who are at particular health risk because of their living arrangements.

Keywords: living alone, marital transitions, loneliness, ageing, mortality, older people

Key Points

- Living alone at older ages is associated with increased mortality risk.
- People who move from living with others to living alone because of divorce or widowhood are especially vulnerable.
- Depression, loneliness and mobility impairment partly explain these relationships, but the mechanisms are poorly understood.

Introduction

The number of single person households in the UK is rising, particularly among older age groups. Between 1997 and 2017, the proportion of adults living alone grew by 16%, but with an increase of 53% among people aged 45–64 years [1]. Some 3.8 million people aged 65 and older now live alone. This reflects wider trends across the European Union where 32% of people aged 65 and older live alone [2]. Social relationships, reflected both in objective measures of social integration and subjective experiences of social support, are thought to be health protective, whereas isolation and loneliness are associated with increased risk of morbidity and mortality [3, 4]. However, the overlapping concepts of social isolation, partnership status and living arrangements make it difficult to assess the independent impact of living alone on mortality.

People who live alone in later life may do so for a variety of reasons. For some, this reflects a personal choice, preferring the independence that solo living affords. But for others, circumstances such as death of a spouse, divorce or children leaving home, might have prompted this transition. An additional possibility is that people who are in poorer physical or mental health may be less likely to sustain shared living arrangements, resulting in negative health selection [5].

Several studies of general population samples have found that living alone is a risk factor for mortality, although evidence has often been drawn from studies with relatively short follow-up periods [6–9]. But a recent study using data from The Copenhagen Male Study with over three decades of follow-up found that living alone was an independent risk factor for all-cause and cardiovascular mortality [10]. Living alone at older ages is also associated with increased risk of hospital admissions for falls and respiratory disease [11, 12], and with prognosis of people with pre-existing health conditions [13, 14]. However, these studies have examined the impact of living alone at one time point, and transitions may be equally important. For example, there is evidence that marital dissolution in later life is associated with a higher risk of mortality [15–17]; since marital dissolution often leads to living alone, this could be an explanation for the higher levels of mortality among non-partnered individuals [15]. The contribution of living arrangements to the associations between social relationships and mortality is poorly understood.

The present study took advantage of detailed information about household composition collected repeatedly in the English Longitudinal Study of Ageing (ELSA). We compared people who consistently lived alone or with others, and those who moved from one living arrangement to the other over a 4-year period, assessing mortality over the subsequent 8.5 years. A range of socioeconomic, health, behavioural and emotional factors such as depression and loneliness were taken into account, together with reasons for transitioning to living alone. We hypothesised that consistent living alone, and transitioning to living alone because of divorce or death of spouse, would be associated with increased mortality risk, compared with living with others.

Methods

Study design

The ELSA is a nationally representative study of individuals aged 50 and older living in England [18]. The study began in 2002–2003 (wave 1) and assessments are repeated every 2 years. The primary form of data collection in ELSA is a computer-assisted personal interview (CAPI), which takes place in the participant's home. About 8,780 core respondents took part in wave 2 (2004–2005), and were eligible for this study if they also took part in 2008–2009 (wave 4), were linked to mortality data, and had complete data on covariates. The final analytic sample included 4,888 participants, as detailed in Supplementary Figure S1. For the current analysis, the baseline was defined as the date of the wave 4 interview. A comparison of the analytic sample with people who completed wave 2 but were not included is summarised in Supplementary Table S1.

Outcome measure: mortality

Mortality status was ascertained from linked Office for National Statistics mortality registers. We analysed data on all-cause mortality until March 2018. Length of follow-up was defined as the number of months between the baseline (wave 4) interview date between 2008 and 2009 and date of death up to 31 March 2018.

Exposure: living arrangements

Living arrangements at each wave was assessed through the number of people recorded in each household. If only one household member (the participant) was recorded in the household, then they were defined as living alone. To examine change in living arrangements between waves, we identified four main categories: (1) Alone wave 2/Alone wave 4; (2) Alone wave 2/Not Alone wave 4; (3) Not Alone wave 2/Alone wave 4 and (4) Not Alone wave 2/Not Alone wave 4. For those who experienced a change in living arrangements, the characteristics of the household they left or joined was examined to identify factors related to the change. Using additional measures concerning relationship status, household size and household type, five categories described the type of household: [1] Lives alone, [2] Lives with partner only, [3] Single but lives with children, [4] Lives with partner plus children and [5] Lives with others. We used this information to create two categories for those who moved from living with others to living alone, as detailed in Supplementary Table S2: (a) Not Alone/Alone (widowed/divorced) and (b) Not Alone/Alone (children or others left). Numbers were too small to subcategorise the group moving from living alone to living with others.

Covariates

Baseline covariates measured at wave 4 (2008–2009) were selected for their relevance to living circumstances and mortality risk. Education was classified as whether or not the person had basic qualifications (GCSE, O level). Household wealth includes savings, investments and value of property or business assets but excludes pension assets [19]. Depressive symptoms were measured using the eight item Centre for Epidemiologic Studies Depression Scale (CES-D), with a score of at least four indicating high depressive symptoms [20]. Physical health was measured by physician diagnoses of coronary heart disease, diabetes, stroke, arthritis and limiting long-standing illness. Physical activity was measured using detailed questions from which we derived a binary variable to indicate sedentary behaviour [21]. Alcohol intake was coded into a binary variable depending on whether the participant drank almost daily (5/7 days week) or less than daily (<5 days a week). Smoking status was defined as current smoking. Mobility was assessed using 10 items concerning difficulties with a range of tasks and impairment was defined as two or more difficulties. Loneliness was measured using three items of the UCLA loneliness scale (lack companionship, feeling left out, feeling isolated) [22]. Scores could ranges from 3 to 9, with higher scores indicating greater loneliness.

Statistical analysis

To examine baseline (wave 4) differences between those who lived alone and those who lived with others, *t*-tests and chi-squared tests were used. The association between living alone at wave 4 and mortality was analysed using Cox proportional hazards, adjusting for age, sex, education and wealth in the base model (Model 1). Results are presented as adjusted HR with 95% CI, with living with others as the reference group. A series of models additionally adjusted for factors that might contribute to the association, including depression (Model 2), chronic disease/limiting long term illness (Model 3), health behaviours (Model 4), mobility impairment (Model 5) and loneliness (Model 6), with a final model adjusted for all factors (Model 7). We examined the extent to which baseline risk factors explained the association between living alone and mortality by calculating the percentage of excess risk explained (PERE) [23].

The association between living alone transitions (wave 2/wave 4) and mortality was also analysed with Cox proportional hazards, tested with the same set of potential explanatory variables entered into the models in a step-wise fashion. Gender interactions were examined for the association between living alone at waves 2 and 4 and mortality and were not-significant. As a sensitivity analysis, we tested the association between living alone and mortality using wave 2 (2004/2005) instead of wave 4 (2008/2009) as the baseline. The assumption of proportional hazards was tested using tests and graphs based on the Schoenfeld residuals. The main analyses were carried out with unweighted data, so we conducted a sensitivity analysis using inverse probability weights to match population estimates for age, gender, housing tenure and other characteristics. All statistical analyses were conducted using Stata version 15.0.

Results

The average length of follow-up was 8.5 years, by which time 1,091 deaths (22.3%) had occurred. At baseline (wave 4) 27% of the sample (*n* = 1,301 participants) was living alone. Table 1 shows those who lived alone were more likely to be older, female and have lower levels of wealth and education than those who lived with others. They were also more likely to report poor physical and mental health. They were more likely to be current smokers and not engage in any physical activity, but were less likely to drink alcohol daily. They reported greater loneliness than those who lived with others.

Table 2 shows the association between living alone at wave 4 (2008/2009) and all-cause mortality. The hazard ratio for living alone compared to living with others was 1.29 (95% CI 1.12–1.48) in the model adjusted for socio-demographic factors (age, sex, education and wealth). This decreased by 24% after adjusting for depressive symptoms, 7% for health behaviours, 24% for mobility impairment and 28% for loneliness. The overall attenuation after adjustment for all these factors (Model 7) was 31% (hazard ratio 1.20, 95% CI 1.04–1.38), indicating that around one third of the association between living alone and mortality was explained by these factors.

We also examined the association between living alone and mortality using wave 2 (2004/2005) as the baseline. The basic model indicated an adjusted HR of 1.20 (95% CI 1.06–1.16), as detailed in Supplementary Table S3 (Appendix). There were similar patterns in the variance explained by the different factors such as depressive symptoms (15%), health behaviours (10%), mobility impairment (25%) and loneliness (30%), as in the primary analysis. The HR in the full model was 1.12 (95% CI 0.98–1.27), with around 40% of the association explained by the variables included in the models.

Mortality and transitions in living arrangements

Table 3 shows the association between living arrangement transitions between wave 2 and wave 4 and all-cause mortality. In analyses adjusted for age, sex, education and wealth, living alone at both time points was associated with higher risk of death than living with others at waves 2 and 4 (HR = 1.26; 95% CI 1.10–1.46). This association was slightly attenuated after adjustment for baseline depressive symptoms, chronic disease, mobility impairment, health behaviours and loneliness, but the fully adjusted model remained significant (HR = 1.19; 95% CI 1.02–1.38).

The HR ratio for those who transitioned from living with others to living alone was 1.44 (95% CI 1.12–1.86) (results not shown). We subsequently divided this group according to the type of household they had lived in at wave 2. Those who had previously lived with a partner and then lived alone

Table 1. Baseline characteristics (wave 4) of people who do and do not live alone

Characteristics	Total n = 4,888 N (%)	Alone n = 1,301 N (%)	Not alone n = 3,587 N (%)	P-difference
Age; mean (SD)	68.6 (8.7)	73.1 (9.3)	67.0 (7.9)	<0.001
Female	2,712 (55.5)	917 (70.5)	1,795 (50.0)	<0.001
Education (below GCSE)	1,978 (40.5)	667 (51.3)	1,311 (36.6)	<0.001
Wealth (lowest quintile)	729 (14.9)	369 (28.4)	360 (10.0)	<0.001
Significant depressive symptoms	616 (12.6)	285 (21.9)	331 (9.2)	<0.001
Coronary heart disease	589 (12.1)	212 (16.3)	377 (10.5)	<0.001
Diabetes	534 (10.9)	168 (12.9)	366 (10.2)	0.007
Stroke	238 (4.9)	81 (6.2)	157 (4.4)	0.008
Arthritis	2,012 (41.2)	638 (49.0)	1,374 (38.3)	<0.001
Limiting long-term condition	1,663 (34.0)	546 (42.0)	1,117 (31.1)	<0.001
Smoking (current)	565 (11.6)	199 (15.3)	366 (10.2)	<0.001
Physical activity (sedentary)	788 (16.1)	330 (25.4)	458 (12.8)	<0.001
Alcohol (daily)	1,130 (23.1)	257 (19.8)	873 (24.3)	0.001
Mobility (≥2 impairments)	2,030 (41.5)	718 (55.2)	1,312 (36.6)	<0.001
Loneliness; mean (SD)	4.2 (1.5)	5.0 (1.8)	3.9 (1.3)	<0.001

Table 2. Association between living alone status (wave 4) and subsequent mortality

	Adjusted hazard ratio for living alone (95% CI)	P value	PERE[b]
Basic model[a]	1.29 (1.12, 1.48)	< 0001	
+ Depressive symptoms	1.22 (1.07, 1.40)	< 0001	24%
+ Chronic disease/limiting long term illness	1.31 (1.14, 1.51)	< 0001	0%
+ Health behaviour [c]	1.22 (1.06, 1.40)	0.005	7%
+ Mobility impairment	1.27 (1.11, 1.46)	0.001	24%
+ Loneliness	1.21 (1.05, 1.39)	0.010	28%
+ Full model	1.20 (1.04, 1.38)	0.012	31%

[a]Adjusted for age, sex, education, wealth (wave 4). [b]PERE, percentage of excess risk explained. [c]Health behaviour indicators are current smoking, physical activity, alcohol consumption.

Table 3. Association between living alone transitions (wave 2/wave 4) and mortality

Wave 2/Wave 4 living status	Model 1 HR (95% CI)	Model 2 HR (95% CI)	Model 3 HR (95% CI)	Model 4 HR (95% CI)	Model 5 HR (95% CI)
Not alone/Not alone	1.00	1.00	1.00	1.00	1.00
Alone/Not alone	1.16 (0.58, 2.33)	1.14 (0.57, 2.29)	1.10 (0.55, 2.21)	1.04 (0.52, 2.10)	1.04 (0.52, 2.09)
Not alone/Alone (widow/divorced)	1.48 (1.12, 1.95)	1.28 (0.96, 1.69)	1.40 (1.05, 1.85)	1.38 (1.04, 1.82)	1.34 (1.01, 1.79)
Not alone/Alone (children left)	1.28 (0.70, 2.33)	1.22 (0.67, 2.22)	1.15 (0.63, 2.10)	1.11 (0.61, 2.03)	1.10 (0.61, 2.01)
Alone/Alone	1.26 (1.10, 1.46)	1.22 (1.05, 1.41)	1.25 (1.08, 1.45)	1.20 (1.04, 1.39)	1.19 (1.02, 1.38)

Model 1: Age/sex/education/wealth. Model 2: Model 1 + depression. Model 3: Model 2 + chronic disease/limiting long-term illness/mobility. Model 4: Model 3 + health behaviour (current smoking, physical activity, alcohol consumption). Model 5: Model 4 + loneliness.

(widowed/divorced) (n = 57) had an elevated mortality risk (HR = 1.34; 95% CI 1.01–1.79) in the fully adjusted model, compared with those who continuously lived with others. By contrast, people who had previously lived with children or others and then lived alone (children left) showed no greater mortality risk than individuals who lived with others at both time points (HR = 1.10; 95% CI 0.61–2.01). Similarly, there was no excess risk for people who transitioned from living alone to living with others (HR = 1.04; 95% CI 0.52–2.09).

The proportional hazards assumption was tested for all models and significant (<0.05) or borderline significant (<0.10), and violations were found for age, wealth, diabetes, arthritis and mobility status. These were examined graphically and further models were estimated with these

covariates interacting with time. The hazard ratios for the main exposure were similar to those in the original models.

The sensitivity analyses involving weighted data are summarised in Supplementary Tables S4 and S5. The results are comparable with those of the main analyses, and there were no changes in the statistical significance of associations.

Discussion

This study explored the relationship between living alone and mortality over an 8.5 year period in a large population sample. We found that living alone was associated with increased mortality, and this was explained in part by factors

such as depression, loneliness and reduced mobility. We also found that compared with people who continued living with others across the 4-year period from 2004 to 2008, those who transitioned into living alone had a higher risk of mortality. Within this group, those who had previously lived with a partner and subsequently lived alone had the highest risk of mortality, while participants who transitioned from living with children or others to living alone experienced no increased mortality risk.

Our findings confirm the association between living arrangements and increased mortality risk that has been observed in previous studies of younger and older populations [6, 7, 10, 13]. These differences have generally been interpreted in terms of the social isolation and stress accompanying living alone. However, because this work has typically examined living arrangements at one time point, it was not possible completely to rule out negative health selection, or the impact of loss of close emotional ties. By definition, people living alone were not living with a spouse or partner. By studying the participants who transitioned from living with others to living alone, we were able to demonstrate that people who began to live alone because of the loss of a partner through divorce or bereavement had an increased risk of mortality, but this was not the case for those who had previously lived with other people (including children) and now lived alone. This suggests that older people who are exposed to the stress and loss of support from their closest relationship are at greater risk of mortality even after taking account of factors such as age and socioeconomic position. This is consistent with the evidence that marital dissolution results in an increased risk of all-cause mortality [16, 17].

We attempted to tease out the mechanisms contributing to the association between living alone and all-cause mortality by examining the proportion of the risk explained by different factors using the PERE method that has been increasingly adopted in epidemiology [23, 24]. Depressive symptoms explained around one quarter of the association (Table 2), as did loneliness. This suggests that the greater depression and loneliness experienced by people living alone contributed to their heightened mortality risk [25, 26]. Impaired mobility was another important factor accounting in part for the links between living alone and mortality risk [27]. Unexpectedly, the presence of specific chronic illnesses, long-term conditions and adverse health behaviour profiles did not contribute independently to explaining the relationship. This is despite evidence that people living with others typically show healthier behavioural profiles, that loneliness is correlated with less prudent behaviours, and that changes in health behaviour partly explain associations between marital dissolution and mortality risk [28, 29]. In the present study, long-term conditions, smoking and physical inactivity were all more common among people living alone (Table 1). The finding that they played a limited role in explaining the links between living alone and mortality is likely because

they are also associated with the factors included in the base model (age, sex and socioeconomic position), so had little independent explanatory power.

It is notable that in combination, the factors considered in Table 2 only explained around one third of the association between living alone and mortality, indicating that other unmeasured factors are relevant. These could include the quality of housing of people living alone, their local environments, pollution and access to services and facilities within their neighbourhoods. Other health behaviours that were not measured may be relevant, including level of self-care, and adherence to recommendations such as influenza vaccination and national cancer screening programmes. It is also possible that living alone means that people fail to act on early signs that would prevent rapid progression of disease, or respond promptly to acute symptoms [5].

This study broadens understanding of the relevance of living arrangements to mortality risk among older people by studying transitions. We were able to take account of a wide range of covariates in order to identify factors contributing to the links between living alone and mortality that are potentially modifiable, pointing to ways of reducing risk. Vital status was assessed using linked registry data rather than reported mortality. The study has a number of limitations. Participants in ELSA are predominantly of white European origin, and results may not generalise to other cultures in which multigenerational living arrangements are more common. The number of fatal outcomes and relatively small proportion of transitions made it difficult to carry out more fine grained analysis. For example, an analysis from the National Social Life Health and Aging Project has shown that the impact of widowhood on mortality is moderated by the strength of other relationships [30]. There are other factors potentially relevant to stability of living arrangements and mortality that were not considered in these analyses. We could not differentiate between reasons for changes from living alone to living with others; some associations could be potentially protective such as moving in with a new partner, others could be less positive, including moving to live with children who provide care. We do now know whether the participants who lived alone at both time points had also experienced relationship changes in the past, or had lived alone throughout their adult lives. We were also unable to study different causes of death, but confined analysis to all-cause mortality.

In conclusion, this study brings together two strands of research on the association between social connectivity and mortality, namely work on living alone and studies of the impact of separation, divorce and bereavement. It suggests that the association between living alone and mortality is complicated by the duration of these circumstances and by the reasons underlying not living with others. A greater understanding of these dynamics will help to identify the individuals who are at particular health risk because of their living arrangements.

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