

Social isolation and loneliness: Prospective associations with functional status in older adults

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Abstract

Objective: The present analysis aimed to examine the associations of isolation and loneliness, individually as well as simultaneously, with two measures of functional status (gait speed and difficulties in activities of daily living) in older adults over a 6-year period using data from the English Longitudinal Study of Ageing, and to assess if these associations differ by SES.

Methods: Loneliness was measured using the short form of the Revised UCLA scale and an index of social isolation was computed incorporating marital status; frequency of contact with friends, family, and children; and participation in social activities. Measures of functional status were assessed identically at baseline and 6 years later for 3070 participants (mean age 69 years). Wealth was used as an indicator of SES.

Results: In fully and mutually adjusted models, social isolation and loneliness were found to be associated with a decrease in gait speed at follow-up, with stronger effects among more disadvantaged individuals. Loneliness was associated with an increase in difficulties with activities of daily living.

Conclusions: Isolation and loneliness were adversely associated with different aspects of functional status. Interventions to reduce isolation and loneliness may be particularly beneficial for individuals in disadvantaged groups.

Key words: social isolation, loneliness, gait speed, older adults, English Longitudinal Study of Ageing

Introduction

There is a considerable body of research indicating the health benefits of a socially integrated lifestyle. Individuals who are isolated have been shown to have higher levels of morbidity and mortality when compared with those who are more socially integrated (Courtin & Knapp, 2015; Holt-Lunstad, Smith, & Layton, 2010). While these findings relate to the effects of objective social network characteristics such as contact with friends and family or participation in social activities, similar findings have been reported for ‘perceived isolation’ or loneliness (Courtin & Knapp, 2015; Holt-Lunstad, Smith, Baker, Harris, & Stephenson, 2015). The issue of isolation and loneliness is particularly important for older adults. In the UK, approximately 9% of older adults report being lonely often (Beaumont, 2013). Levels of isolation are harder to estimate as this construct has been defined and measured differently across studies. However, in the 2011 census, 31% of adults aged 65 years and over were living alone (Office for National Statistics, 2013). In 2010/2011, about half of older adults in England reported that they did not participate in any civic, leisure or cultural activities and around 5% reported having either no family, friends or children, or less than weekly contact with these groups (Jivraj, Nazroo, & Barnes, 2012).

Loss of muscle mass, reduced mobility and disability are common in older age (Brown & Flood, 2013; Cruz-Jentoft et al., 2010). These changes are not, however, inevitable (Christensen, McGue, Petersen, Jeune, & Vaupel, 2008). Hence it is important to identify factors that may help maintain physical function in older age. Studies assessing the association between social relationships and physical functioning in older age have largely mixed findings. Higher levels of loneliness were associated with an increase in self-reported difficulties with activities of daily living (ADLs) such as being able to dress oneself, bathe and eat, mobility problems and difficulty with climbing stairs over a 6-year period in a sample of US adults (Perissinotto, Stijacic, & Covinsky, 2012). In contrast, loneliness was not

associated with an increase in either difficulty or dependence in activities of daily living at a 7-year follow-up in the Jerusalem Longitudinal Cohort Study (Stessman, Rottenberg, Shimshilashvili, Ein-Mor, & Jacobs, 2013). Having a large number of social ties (Unger, McAvay, Bruce, Berkman, & Seeman, 1999) and participation in social activities have also been linked with less decline in physical function in some longitudinal studies (Buchman et al., 2009; Kanamori et al., 2014; Lee, 2000), with others reporting limited or no significant associations (Avlund et al., 2004; Green, Rebok, & Lyketsos, 2008). A later analysis by Buchman and colleagues that additionally examined the role of social network size and loneliness found that loneliness was associated with rate of decline in global motor function. Social network size was not, however, associated with either baseline motor function or rate of decline (Buchman et al., 2010). In a cross-sectional study examining the combined effect of marital status and living arrangements, married older adults living with children had the best functional status on measures including difficulties with ADLs and instrumental ADLs while older adults who were unmarried (including widowed/divorced) and living with children reported the worst outcomes (Wang, Chen, Pan, Jing, & Liu, 2013). Using prospective data from a birth cohort and objective assessments of functioning Guralnik et al. found that never married and married men who remained childless had significantly poorer physical function when compared with married men who had children (Guralnik, Butterworth, Patel, Mishra, & Kuh, 2009). These associations were not observed among women.

As is clear from above, studies have defined functional status in a range of different ways. Objective or performance-based measures include tests of walking speed, grip strength, and tests of balance, while subjective measures ask participants if they are able to perform certain activities such as bathing, dressing themselves and eating. While related, the two sets of measures capture different aspects of physical function. It has been suggested that most

performance-based measures reflect *functional limitations*, i.e. whether or not an individual has the capacity to carry out certain basic actions, with no reference to a specific task or situation. Subjective assessments in contrast, are largely indicative of *disability*, reflecting the individual's ability to carry out specific tasks considered important for daily living (Hoeymans, Feskens, van den Bos, & Kromhout, 1996). It has been suggested that these measures reflect different stages of physical decline with functional limitations foreshadowing the development of disability (Guralnik & Ferrucci, 2003; Nagi, 1976). Indeed physical performance tests may be indicative of subclinical disease (Cooper et al., 2011; Reuben et al., 2004) and they have been found to be predictive of a range of adverse health outcomes (Abellan Van Kan et al., 2010; Cooper et al., 2011; Studenski et al., 2011). It has been suggested that the two approaches cannot be regarded as being mutually exclusive, and hence a consideration of both may provide a more complete picture of an individual's functional status (Kivinen, Sulkava, Halonen, & Nissinen, 1998; Reuben et al., 2004).

Previous research has indicated that individuals who are depressed have slower gait speed, although there is some evidence that this association is bidirectional (Demakakos et al., 2013). Higher levels of depression have also been known to be associated with increased difficulties with ADLs and instrumental ADLs (Rozzini et al., 1997). Further, risky health behaviors such as smoking and physical inactivity may be associated with isolation and loneliness (Shankar et al., 2011), and are also associated with poorer functional status (Brach, FitzGerald, Newman, & et al., 2003; North et al., 2015). Indeed, measures of isolation may to some extent index levels of physical activity and this needs to be taken into consideration when examining the effect of isolation and loneliness on physical function.

The importance of socioeconomic status

Another important consideration is that of socioeconomic status (SES). Socioeconomic disadvantage has been associated with lower physical functioning and greater

disability. Social relationships may act as a buffer against the effects of low SES, in which case one would expect the effects of social relationships to be more pronounced amongst the socioeconomically disadvantaged. The Reserve Capacity Model (Gallo, de los Monteros, & Shivpuri, 2009; Gallo & Matthews, 2003) suggests that social and psychological resources may contribute to building up resilience among individuals of low SES, thereby attenuating inequalities in health. In testing this model, Schöllgen et al. found that greater social resources were associated with better self-rated health as well as a composite measure of physical health and functioning among individuals with low education but not amongst those with higher educational qualifications (Schöllgen, Huxhold, Schüz, & Tesch-Römer, 2011). On the other hand, Unger et al. (1999) did not find that the effect of social ties on functional decline was moderated by income. The current analysis examined wealth as a moderator of the effect of isolation and loneliness on gait speed and number of ADLs. Wealth was chosen as a measure of SES as it may better reflect resources available to older adults when compared with education which is fixed earlier in life, or income which may not be appropriate for participants who are no longer working.

In summary, the present study used data from a nationally representative panel study of older adults to examine the effect of both social isolation and loneliness simultaneously on gait speed and difficulties with ADLs. It was hypothesized that both social isolation and loneliness would be prospectively associated with worsening gait speed and increasing difficulties with ADLs. No specific hypotheses were made regarding the relative size of the effects. It was also hypothesized that the effects of isolation and loneliness on these measures would be greater amongst those with less wealth.

Method

Participants

Data were obtained from waves 2 (2004/5) and 5 (2009/10) of the English Longitudinal Study of Ageing (ELSA), a nationally representative panel study of individuals aged 50 years or over, with biennial follow-up. Participants for ELSA were selected from respondents to the Health Surveys for England in 1998, 1999 and 2001. Further details regarding the study sample, data collection procedures and the cohort profile are available elsewhere (Step toe, Breeze, Banks, & Nazroo, 2013). Ethical approval for the ELSA study was provided by the London Multicentre Research Ethics Committee.

Wave 2 was used as baseline for these analyses as this is the first wave of ELSA that includes a measure of loneliness. Participants who dropped out after wave 1 of ELSA were of lower SES, less educated, in poorer health, more likely to be non-White, and less socially connected (Scholes, Taylor, Cheshire, Cox, & Lessof, 2008; Shankar, McMunn, Banks, & Step toe, 2011). At each wave, the timed walk test was carried out only for participants aged 60 years and over. At baseline, complete data on gait speed were available for 5498 participants (89% of core sample members aged 60 years and over). Follow-up data on gait speed were available for 3070 participants who formed the analytic sample. When compared with participants who dropped out after the baseline wave, the analytic sample was younger, wealthier, better educated, healthier, more socially connected and less lonely. Participants who dropped out also had lower gait speed and reported more problems with activities of daily living.

Measures

Measures of physical function were obtained in an identical manner at baseline and follow-up.

Gait speed: A standard protocol was used where participants were required to walk a distance of 2.44 meters (8 feet) twice that was timed. The interviewer initially demonstrated the test. The participants were then instructed to walk at their usual pace and not race across the course. Participants were allowed to use a walking stick or a Zimmer frame if they normally used one. However, if the participant was unable to walk, required the support of another person to walk, did not feel it was safe to do the test or the interviewer judged that the test was unsafe for the participant, or if there was no suitable space to carry out the test, the timed walk test was not administered. The mean speed of the two walks (m/s) was taken as the measure of gait speed. If only a single valid value was available, this value was used.

Activities of daily living (ADL): Participants were asked to report if they had difficulty with any of 6 activities of daily living including *dressing, walking across a room, bathing or showering, eating, getting in or out of bed* and *using the toilet*, with response options *yes* or *no*. Participants were instructed not to consider any difficulties that they expected would last less than 3 months. Responses to the items were summed to provide the total number of activities of daily living with which the participant had difficulties.

Measures of isolation, loneliness, wealth and all covariates were obtained at baseline only.

Social isolation: An index of social isolation was computed based on not married or living with a partner (scored as 1), less than monthly contact with other family, friends and children (each scored as 1), and non-participation in any social activities (scored as 1) (Shankar et al., 2011). Score ranged from 0 to 5 with higher scores indicating greater social isolation.

Loneliness: Loneliness was measured by summing responses on the 3-item Revised UCLA Loneliness Scale (Hughes, Waite, Hawkley, & Cacioppo, 2004). Scores ranged from 3

to 9, with higher scores indicating greater loneliness. The scale was found to have acceptable internal reliability (Cronbach's $\alpha = 0.79$).

Wealth: This refers to total (non-pension) wealth which was calculated net of debt and included the total value of the participant's home, other property, financial assets, business assets, jewelry, etc. (Banks, Karlssen, & Oldfield, 2003).

Covariates: Details on age and gender were obtained from the core interview. Health status was measured using self-reports of doctor-diagnosed health conditions including cardiovascular disease (including arrhythmia, myocardial infarction, congestive heart failure, angina, heart murmur, diabetes, and stroke), cancer, chronic lung disease and arthritis. Depression was measured using the 8-item version of the Center for Epidemiologic Studies depression scale (Steffick, 2000). The item on loneliness was excluded (Cacioppo, Hawkley, & Thisted, 2010) and responses were summed. Scores ranged from 0 to 7, with higher scores indicating a greater number of depressive symptoms, and scores of 4 or higher indicate depressive caseness (Steffick, 2000). Educational level was coded as *low*, indicating participants with no formal qualifications (equivalent to no high school diploma in the United States) and *high*, including participants who had O-levels, A-levels or higher qualifications. The analysis additionally adjusted for health behaviors such as current smoking status and physical activity level. Current smoking status was measured by asking participants if they ever smoked. Participants who replied in the affirmative were then asked if they smoked at present. Responses to both questions were combined to form a current smoking status (yes/no) measure. A leisure-time physical activity measure asked participants about the frequency with which they took part in vigorous, moderate, or mild physical activity. In addition, individuals who were currently employed were asked whether their job was mainly *sedentary standing*, *physical work* or *heavy manual work*. Participants who reported moderate or vigorous leisure-time physical activity only once a week or less and if currently employed,

were in a primarily sedentary occupation were classified as not meeting physical activity criteria. Participants reporting high levels of occupational physical activity and/or greater than once a week moderate/vigorous leisure time physical activity were classified as being physically active (Shankar, McMunn, & Steptoe, 2010).

Statistical analysis

Missing data on predictors and covariates (for items imputed: median percentage missing = 0.26%, mean = 1.9%, maximum = 6.5%) were imputed using the multiple imputation procedure in SAS (PROC MI). Five complete data sets were created and analyzed. Results for the analyses carried out on a sample where values were not imputed did not differ substantively from the analyses for the imputed data set, with the exception of the test for the interaction effects which were non-significant in the complete case analysis. The results of the analysis using the complete (imputed) data set are reported here.

As the wealth variable was skewed, it was log-transformed prior to analysis. Associations between isolation, loneliness and covariates were examined using bivariate regression analyses and results are presented as standardized regression coefficients (β) with corresponding p-values. Linear regression analysis was used to examine the association between social isolation and loneliness at baseline and gait speed at follow-up. Results are presented using unstandardized regression coefficients (B) with corresponding standard errors (S.E.) and standardized regression coefficients (β). As ADL scores represent count data, with some evidence of over-dispersion, we used a negative binomial regression with a log-link to predict ADL values at follow-up. Results are presented as incidence rate ratios (IRR) with corresponding 95% confidence intervals.

Four models were run for each outcome. Model 1 included all covariates and baseline levels of the outcome under consideration. Isolation and loneliness were added in Model 2. Model 3(a) included the addition of the isolation*wealth interaction to Model 2, while Model 3(b) included the addition of the loneliness*wealth interaction to Model 2. To aid the interpretation of significant interactions, MODPROBE was used to obtain predicted values of the outcome variable at different levels of the moderator (median, 25th percentile and 75th percentile). Analyses were carried out using SPSS 22.0 and SAS v 9.4 (SAS Institute, Cary, NC).

Results

The mean age of participants included in these analyses was 69 years, over half were women and just over a third reported having no formal educational qualifications (see Table 1). Approximately 8% of participants reported ever having cancer. Diagnosed CVD was reported by 29.1% of the participants and just under 40% had arthritis. Chronic lung disease was reported by over 6% of participants. Nearly 11% of individuals identified themselves as current smokers and a quarter reported low levels of physical activity. About 10% of participants had a score of 4 and higher on the CESD which is indicative of depression. Only a small proportion of participants reported the highest possible scores on either the loneliness or the isolation measure. Gait speed declined significantly over the 6-year period ($p < 0.001$), while the number of individuals reporting more than 1 difficulty with ADLs increased ($p < 0.001$).

Relationship with covariates

Age was positively associated with isolation ($\beta = 0.11, p < 0.001$) and loneliness ($\beta = 0.09, p < 0.001$). Gender was not significantly associated with isolation ($\beta = -0.01, p = 0.48$), but women reported higher levels of loneliness when compared with men ($\beta = 0.11, p < 0.001$). Higher levels of isolation and loneliness were reported by individuals with diagnosed CVD ($\beta = 0.05, p = 0.005$ for isolation; $\beta = 0.07, p < 0.001$ for loneliness), lung disease ($\beta = 0.04, p < 0.05$ for isolation; $\beta = 0.09, p < 0.001$ for loneliness), and with CESD scores of 4 or higher ($\beta = 0.13, p < 0.001$ for isolation; $\beta = 0.35, p < 0.001$ for loneliness). Arthritis was associated with higher levels of loneliness ($\beta = 0.14, p < 0.001$) but not isolation ($\beta = 0.04, p = 0.052$). However, diagnosis of cancer was not associated with greater isolation or loneliness ($\beta = 0.002, p = 0.92$ for isolation; $\beta = 0.01, p = 0.69$ for loneliness). Having no formal educational qualifications ($\beta = 0.17, p < 0.001$) and decreasing wealth ($\beta = -0.26, p < 0.001$) were also associated with higher levels of isolation. A similar pattern was found for loneliness ($\beta = 0.12, p < 0.001$ for education; $\beta = -0.21, p < 0.001$ for wealth). Being a smoker and reporting low levels of physical activity were both associated with greater isolation ($\beta = 0.13, p < 0.001$ for smoking; $\beta = 0.10, p < 0.001$ for physical activity) and loneliness ($\beta = 0.08, p < 0.001$ for smoking; $\beta = 0.14, p < 0.001$ for physical activity).

Relationship between social isolation and loneliness

Being isolated was associated with higher levels of loneliness ($B = 0.34, 95\% \text{ CI: } 0.30$ to $0.38, \beta = 0.31$). After adjustment for age, gender, health conditions, wealth, education and depression this association was partially attenuated, although still significant ($B = 0.27, 95\% \text{ CI: } 0.24$ to $0.31; \beta = 0.24$).

Social isolation, loneliness and gait speed at follow-up

In a model including only covariates and baseline gait speed, all covariates except for diagnosed cancer and current smoking status were significantly associated with change in gait speed. Isolation and loneliness were added in Model 2, but neither was significantly associated with gait speed at follow-up.

Social isolation, loneliness and difficulties with ADLs at follow-up

In the covariate only model (Table 3, Model 1) all covariates with the exception of gender, educational level, cancer diagnosis, and current smoking status were associated with change in the number of difficulties with ADLs over time. Isolation and loneliness were added in the following model. A unit increase in loneliness score was associated with a 1.08 times increase in the incidence rate of number of ADLs. Isolation was not associated with change in number of ADLs.

Moderation by wealth

Both the isolation*wealth (Table 2, Model 3(a)) and the loneliness*wealth (Table 2, Model 3(b)) interactions were found to be significant in the analysis for gait speed. As seen in Figure 1, panels A and B, baseline isolation and loneliness had little effect on gait speed among the wealthiest participants. As levels of disadvantage increased, however, the effect of isolation and loneliness grew stronger such that individuals who were most disadvantaged showed the most marked decreases in gait speed with increasing levels of isolation and loneliness.

Wealth did not significantly moderate the effect of loneliness and isolation on difficulties with ADLs.

Discussion

This one of few studies to examine the association of both structural and functional aspects of social relationships with measures of functional status. The analysis also assessed both an objective and a subjective measure of functional status, enabling us to examine the differential association of isolation and loneliness on these measures. Our findings show that both isolation and loneliness were important for declines in gait speed over the 6-year period, particularly as levels of socioeconomic disadvantage increased. Loneliness, but not isolation, was associated with an increase in reported difficulties with activities of daily living over a 6-year period. These effects were independent of depression and other health related factors.

The Reserve Capacity Model suggests that social and psychological variables are particularly important among individuals who are more disadvantaged as they may help buffer the effects of a lack of material resources (Gallo, de los Monteros & Shivpuri, 2009). As objective tests such as gait speed may reveal declines in health before the participant actually experiences difficulties in daily activities (Rozzini, Frisoni, Bianchetti, Zanetti, & Trabucchi, 1993), it is possible that early intervention and better healthcare might have an important role to play in preventing such decline. Wealthy individuals are better able to access health care and other preventive measures, and hence may be less reliant on informal sources of support. In contrast, social networks might represent an important or even the main source of information and help for those who have fewer material resources. This also relates to the 'added value' hypothesis, such that social relationships may be more important to, and hence represent greater value for more disadvantaged groups (Vitaliano et al., 2001). [At low](#)

levels of isolation and loneliness, wealthier participants report faster gait speed than poorer individuals (0.85 m/s for the 75th percentile vs 0.83 m/s for the 25th percentile), and this gap widened with increasing levels of isolation and loneliness. At the highest scores of isolation and loneliness, there was virtually no change in gait speed for the wealthy participants (0.85 m/s for the 75th percentile), while poorer participants showed marked decreases (0.80 m/s for the 25th percentile). A gait speed of less than 0.80 m/s may be associated with a reduced ability to move about freely in the community (Fritz & Lusardi, 2009). Further, among community dwelling adults, a change 0.03-0.05 m/s in walking speed would be regarded as clinically meaningful (Kwon et al., 2009; Perera, Mody, Woodman, & Studenski, 2006). Thus, reducing isolation and loneliness among the most socioeconomically deprived older adults may have important implications for functional status.

Loneliness was also associated with self-reported disability. Previous research has indicated that variables such as neuroticism, low self-efficacy and low sense of control that are closely associated with loneliness (Cohen-Mansfield, Hazan, Lerman, & Shalom, 2015; Mund & Neyer, 2015; Newall et al., 2009), are also associated with subjective measures of functional status (Clarke & Smith, 2011; Duberstein et al., 2003; Jang, Mortimer, Haley, & Graves, 2002; Kempen, Sonderen, & Ormel, 1999) over time. Feelings of loneliness may serve to exacerbate existing vulnerabilities in health leading to disability, either through poor health behaviors or through the inflammatory or cardiovascular pathway (Cacioppo & Hawkey, 2003; Cacioppo et al., 2002; Hawkey & Cacioppo, 2003). Findings in this area are, however, equivocal and more research is required to determine the precise mechanisms through which loneliness may affect health.

Study strengths and limitations

The current analyses used data from a large, nationally representative, multidisciplinary panel study of older adults. Hence, it was possible to obtain not only objective assessments of physical function which were measured using a standardized protocol by trained professionals, but also subjective assessments of disability and detailed information on individuals' financial circumstances. The analyses were adjusted for a variety of confounding health, socioeconomic and psychosocial factors. Notwithstanding, these are observational data and causation cannot be inferred. Further, measures of health behaviors were self-reported and hence may have been incorrectly estimated. At baseline 55.2% of the sample reported the lowest possible scores on loneliness, while 45.4% reported the lowest possible scores on the 7-item depression measure, suggesting floor effects. The present analysis used the short form of the CES-D and a different measure may have provided a more comprehensive assessment of depression in this population. One of the main limitations in this study is that of drop out. The sample analyzed here was healthier, wealthier, more socially connected and less lonely when compared with those who had dropped out. Further, measures of gait speed were not obtained for participants who were very frail or those for whom it was judged unsafe. Thus these findings may represent a conservative estimate of the true associations and as such be generalizable to relatively healthy older adults.

Conclusions

These findings indicate differences in determinants of objective and subjective disability and further illustrate the need to examine both isolation and loneliness as distinct risk factors for poor health outcomes. The findings highlight the need to address issues of isolation and loneliness among older adults to help them maintain physical functioning as they age. It may be useful to direct intervention efforts at individuals from disadvantaged

backgrounds who are also at high risk of being isolated or lonely (e.g. those who are recently bereaved) or those who may be particularly vulnerable to functional decline.

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Table 1. Characteristics of the study sample (N = 3070)

Variable	Analytic sample
Age in years – Mean (SD)	69.0 (6.6)
Male (%)	44.2
Diagnosed CVD (%)	29.1
Diagnosed chronic lung disease (%)	6.5
Diagnosed cancer (%)	8.1
Diagnosed arthritis (%)	38.8
Depression	
Mean (SD)	1.2 (1.6)
Caseness - scores > 3 (%)	10.1
No educational qualifications (%)	36.4
Wealth (GBP) – Median (Min-Max)	213930 (120850-360010)
Current smoker (%)	10.6
Inactive (%)	25.7
Isolation (range: 0 to 5)	
Mean (SD)	1.3 (1.2)
Reporting highest possible score (%)	3.4
Loneliness (range: 3 to 9)	
Mean (SD)	4.0 (1.4)
Reporting highest possible score (%)	1.2
Gait speed (m/s)	
Baseline	0.92 (0.27)
Follow-up	0.83 (0.27)

Problems with 1 or more ADLS (%)

Baseline 15.5

Follow-up 18.8

Table 2. Linear regression of gait speed at follow-up (N = 3070)

	Model 1		Model 2		Model 3(a)		Model 3(b)	
	B (SE)	β	B (SE)	β	B (SE)	β	B (SE)	β
Age	-0.01 (0.001) [†]	-0.23	-0.01 (0.001) [†]	-0.23	-0.01 (0.001) [†]	-0.23	-0.01 (0.001)	-0.23
Male	0.03 (0.01) [†]	0.05	0.03 (0.01) ^{**}	0.05	0.03 (0.01) ^{**}	0.05	0.03 (0.01)	0.05
CVD	-0.03 (0.01) [†]	-0.05	-0.03 (0.01) [†]	-0.05	-0.03 (0.01) [†]	-0.05	-0.03 (0.01)	-0.05
Chronic lung disease	-0.04 (0.01) [*]	-0.04	-0.04 (0.01) ^{**}	-0.04	-0.04 (0.01) ^{**}	-0.04	-0.04 (0.02)	-0.04
Arthritis	-0.03 (0.01) [†]	-0.06	-0.03 (0.01) [†]	-0.06	-0.01 (0.01) [†]	-0.06	-0.03 (0.01)	-0.06
Cancer	-0.01 (0.01)	-0.01	-0.01 (0.01)	-0.01	-0.03 (0.01)	-0.01	-0.01 (0.01)	-0.01
Low educational level	-0.03 (0.01) [†]	-0.01	-0.03 (0.01) [†]	-0.05	-0.03 (0.01) [†]	-0.05	-0.03 (0.01)	-0.05
Wealth [‡]	0.07 (0.01) [†]	0.10	0.07 (0.01) [†]	0.09	0.05 (0.02) ^{**}	0.06	0.01 (0.03)	0.02
Depression	-0.03 (0.01) [*]	-0.03	-0.02 (0.01)	-0.02	-0.02 (0.01)	-0.02	-0.02 (0.01)	-0.02
Current smoker	-0.02 (0.01)	-0.02	-0.02 (0.01)	-0.01	-0.02 (0.01)	-0.02	-0.02 (0.01)	-0.02
Inactive	-0.04 (0.01) [†]	-0.07	-0.04 (0.01) [†]	-0.06	-0.04 (0.01) [†]	-0.06	-0.04 (0.01)	-0.06
Baseline gait speed	0.47 (0.02) [†]	0.46	0.47 (0.02) [†]	0.46	0.47 (0.02) [†]	0.46	0.47 (0.01)	0.46
Isolation			-0.01 (0.003)	-0.02	-0.08 (0.04) [*]	-0.40	-0.01 (0.003)	-0.02

Loneliness		-0.004 (0.003)	-0.02	-0.004 (0.003)	-0.02	-0.08 (0.04)*	-0.39
Isolation x Wealth [‡]				0.02 (0.01)*	0.38		
Loneliness x Wealth [‡]						0.01 (0.01)*	0.36
R ²	0.492	0.493		0.493		0.493	
ΔR ²		0.001		0.001		0.001	
ΔF	246.39 [‡]	3.08*		4.43*		4.08*	

[‡]Log-transformed

[‡]p < 0.001; ** p < 0.01; * p < 0.05

Table 3. Negative binomial regression of number of difficulties with Activities of Daily Living at follow-up (N = 3070)

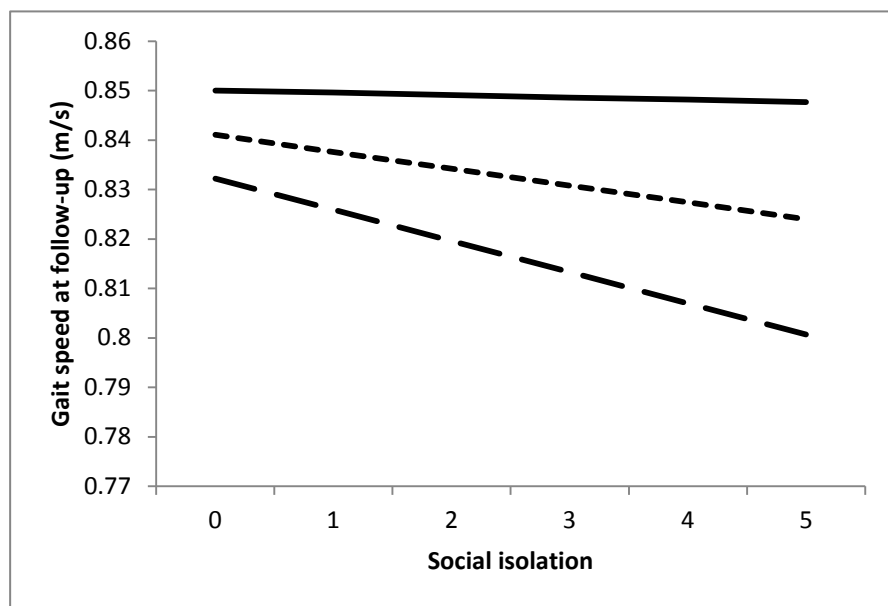
	Model 1	Model 2	Model 3(a)	Model 3(b)
	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)
Age	1.04 (1.03 – 1.06) [†]	1.04 (1.03 – 1.05) [†]	1.04 (1.03 – 1.05) [†]	1.04 (1.03 – 1.05) [†]
Male	0.98 (0.82 – 1.17)	0.96 (0.81 – 1.15)	0.96 (0.81 – 1.15)	0.96 (0.81 – 1.15)
CVD	1.28 (1.07 – 1.53) ^{**}	1.28 (1.07 – 1.53) ^{**}	1.28 (1.07 – 1.53) ^{**}	1.28 (1.07 – 1.53) ^{**}
Chronic lung disease	1.52 (1.14 – 2.02) ^{**}	1.48 (1.11 – 1.96) ^{**}	1.47 (1.11 – 1.96) ^{**}	1.48 (1.11 – 1.97) ^{**}
Arthritis	1.84 (1.54 – 2.19) [†]	1.81 (1.51 – 2.16) [†]	1.81 (1.51 – 2.16) [†]	1.81 (1.51 – 2.16) [†]
Cancer	1.19 (0.89 – 1.59)	1.19 (0.89 – 1.60)	1.19 (0.89 – 1.60)	1.19 (0.89 – 1.60)
Low educational level	0.92 (0.77 – 1.11)	0.94 (0.79 – 1.13)	0.94 (0.79 – 1.13)	0.94 (0.79 – 1.13)
Wealth [‡]	0.76 (0.59 – 0.96) [*]	0.76 (0.59 – 0.97) [*]	0.73 (0.51 – 1.05)	0.75 (0.39 – 1.42)
Depression	1.59 (1.26 – 2.01) [†]	1.44 (1.13 – 1.85) ^{**}	1.44 (1.13 – 1.85) ^{**}	1.44 (1.13 – 1.85) ^{**}
Current smoker	1.14 (0.88 – 1.49)	1.14 (0.88 – 1.48)	1.14 (0.87 – 1.48)	1.14 (0.87 – 1.48)
Inactive	1.38 (1.15 – 1.66) [†]	1.37 (1.15 – 1.66) [†]	1.38 (1.15 – 1.66) [†]	1.38 (1.15 – 1.66) [†]
Baseline difficulties	1.72 (1.55 – 1.89) [†]	1.70 (1.54 – 1.88) [†]	1.71 (1.55 – 1.88) [†]	1.71 (1.54 – 1.88) [†]
with ADLs				

Isolation	0.95 (0.88 – 1.02)	0.83 (0.34 – 2.06)	0.96 (0.88 – 1.02)
Loneliness	1.08 (1.01 – 1.15)*	1.08 (1.02 – 1.15)*	1.06 (0.52 – 2.15)
Isolation x Wealth [‡]		1.03 (0.86 – 1.22)	
Loneliness x Wealth [‡]			1.00 (0.88 – 1.15)

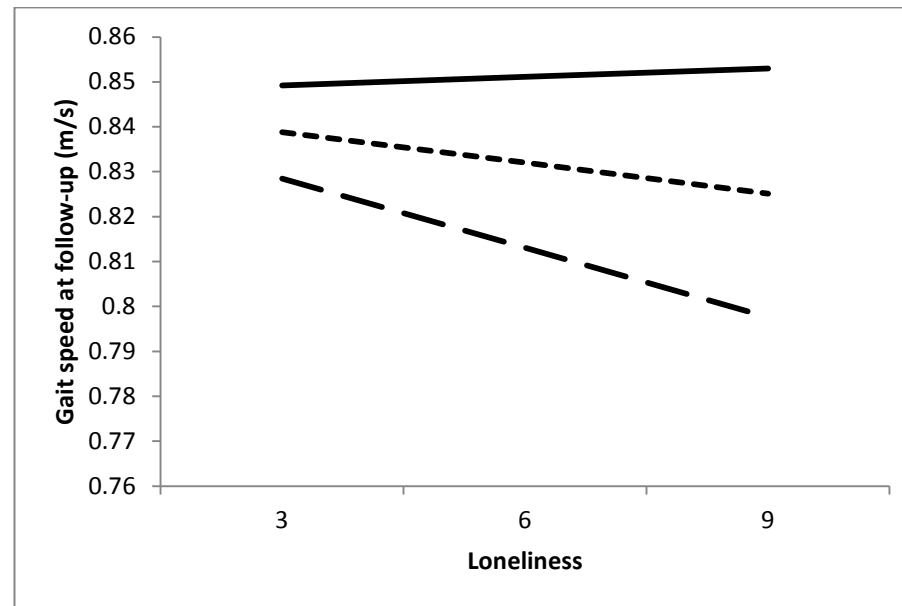
[‡]Log-transformed

[†]p < 0.001; ** p < 0.01; * p < 0.05

Figure 1. Follow-up gait speed by levels of isolation and wealth (A) and loneliness and wealth (B)



(A)



(B)

25th percentile of wealth
 50th percentile of wealth (median)
 75th percentile of wealth

Values adjusted for age, gender, diagnosed CVD, diagnosed cancer, diagnosed chronic lung disease, diagnosed arthritis, CESD caseness, educational level, current smoking status, physical activity and baseline gait speed.