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Risk factors and mediating pathways of loneliness and social support in community-dwelling older adults

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Objectives: To develop biopsychosocial models of loneliness and social support thereby identifying their key risk factors in an Irish sample of community-dwelling older adults. Additionally, to investigate indirect effects of social support on loneliness through mediating risk factors.

Methods: A total of 579 participants (400 females; 179 males) were given a battery of biopsychosocial assessments with the primary measures being the De Jong Gierveld Loneliness Scale and the Lubben Social Network Scale along with a broad range of secondary measures.

Analysis: Bivariate correlation analyses identified items to be included in separate psychosocial, cognitive, biological and demographic multiple regression analyses. The resulting model items were then entered into further multiple regression analyses to obtain overall models. Following this, bootstrapping mediation analyses was conducted to examine indirect effects of social support on the subtypes (emotional and social) of loneliness.

Results: The overall model for (1) emotional loneliness included depression, neuroticism, perceived stress, living alone and accommodation type, (2) social loneliness included neuroticism, perceived stress, animal naming and number of grandchildren and (3) social support included extraversion, executive functioning (Trail Making Test B-time), history of falls, age and whether the participant drives or not. Social support influenced emotional loneliness predominantly through indirect means, while its effect on social loneliness was more direct.

Conclusions: These results characterise the biopsychosocial risk factors of emotional loneliness, social loneliness and social support and identify key pathways by which social support influences emotional and social loneliness. These findings highlight issues with the potential for consideration in the development of targeted interventions.

Keywords: mental health measures; loss/bereavement/life events; physical health measures; psychological and social aspects; personality

Introduction

Loneliness is a pervasive issue among the elderly with strong links to social support, both mental and physical health as well as cognition. When examining loneliness in older adults, it is important to consider it as a subjective experience distinct from social isolation and social support. Cognitive theories of loneliness suggest it arises through a mismatch of the actual quantity and quality of social networks and the desired levels (de Jong Gierveld, van Tilburg, & Dykstra, 2006; Perlman & Peplau, 1981). For many older adults their social groups will have decreased in size due to their own illness or frailty, the illness or frailty of a loved one for whom they are a carer, or the illness, frailty or death of individuals in their own social groups. However, not all individuals who are socially isolated or who have small social support networks are lonely. Additionally, it is possible to feel lonely even when socially integrated and possessing large support networks. Significantly, according to the cognitive perspective (Perlman & Peplau, 1981), a discrepancy between actual and desired social relations is not necessarily sufficient for feelings of loneliness to occur but is itself modulated by cognitive processes such as

causal attributions, social comparisons and perceived control. Regardless, it is apparent that there is a strong relationship between social support networks and loneliness (Cacioppo, Fowler, & Christakis, 2009; Golden et al., 2009; Stokes, 1985).

When considering the different pathways to loneliness, it is particularly vital to distinguish between different forms of loneliness. Weiss (1973) identified two primary forms of loneliness: emotional loneliness, which involves the lack or loss of a close attachment relationship; and social loneliness, which stems from the lack of a satisfying and engaging social network. Making a distinction between emotional loneliness and social loneliness can be beneficial, when considering the evolution of loneliness within individuals (van Baarsen, Snijders, Smit, & van Duijn, 2001) and also in the development of interventions.

In an investigation into loneliness in Ireland, Drennan et al. (2008) examined the sociodemographic predictors of family, romantic and social loneliness. Family and romantic loneliness were included under the general heading of emotional loneliness, and the risk factors were identified as; being widowed, divorced or separated as well as living in a rural setting, gender,

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infrequent access to children and relatives and caring for a spouse or relative at home. In comparison, risk factors for social loneliness included living in a rural area, greater age, poorer health and lack of contact with a friend. The evidence is contradictory regarding the specific effect of contact with children on loneliness; however, contact with grandchildren has consistently been noted as a significant risk factor for loneliness (Heylen, 2010; Routasalo, Savikko, Tilvis, Strandberg, & Pitkälä Kaisu, 2006; Savikko, 2008). Perceived social support levels have been shown not to fluctuate greatly over the life span (Gurung, Taylor, & Seeman, 2003), instead it is the type of support which may change. Lansford, Sherman and Antonucci (1998) suggest smaller close-knit groups become predominant as individuals age.

The links between mental health and loneliness in older adults are well established. Depression in particular has been found to have a strong association with loneliness (Barg et al., 2006; Cacioppo, Hughes, Waite, Hawkley, & Thisted, 2006; Savikko, 2008; Stek et al., 2005); although emotional loneliness and social loneliness are seldom considered separately. Similarly, Russell and Cutrona (1991) identified initial levels of social support as a predictor of levels of depression 1 year later. The relationship between loneliness and anxiety is less clear although evidence of such an association does exist. Fees, Martin and Poon (1999) found the effects of anxiety to be mediated by perceived loneliness in older adults. Similarly, in a study of the oldest old and their adult children, individuals with anxious personalities and who were less extraverted were found to be more likely to be lonely (Long & Martin, 2000). While a strong association between neuroticism and loneliness has previously been identified, research in this area has been primarily conducted on college students (Stokes, 1985) and adolescents (Lasgaard & Elklit, 2009) and therefore cannot be fully generalised to older adult populations.

Associations between cognition, loneliness and social support have been reported, although the precise nature of this relationship is in need of further clarification. Both loneliness (Tilvis et al., 2004; Wilson et al., 2007) and social network (Fratiglioni, Wang, Ericsson, Maytan, & Winblad, 2000) have been identified as risk factors for dementia. More generally, in a 10-year longitudinal follow-up of older adults, Tilvis et al. (2004) identified loneliness as an independent predictor of cognitive decline. More recently, Wilson et al. (2007) examined loneliness as a risk factor for developing Alzheimer disease in a longitudinal follow-up of 823 older adults. Loneliness was associated with poorer cognitive performance at baseline and with faster cognitive decline. Additionally, the risk of Alzheimer disease was more than doubled in lonely individuals compared to those who were not lonely. With regard to social network, Fratiglioni et al. (2000) found a 60% increased risk of dementia in individuals with poor or limited social network in a follow-up of

individuals who had good cognition at baseline. With relation to semantic fluency, Gilmour (2011) has recently reported a relationship between the animal naming task and general loneliness, although this relationship did not persist following multivariate analysis.

The specific nature of the relationship between health and loneliness, while not well defined, is well documented. Loneliness has been associated with poor subjective health (Savikko, 2008), hearing impairments and lung disease (Kramer, Kapteyn, Kuik, & Deeg, 2002; Penninx et al., 1999), an increased risk of heart conditions and disrupted autonomic regulation (Hawkley, Masi, Berry, & Cacioppo, 2006; Sorkin, Rook, & Lu, 2002; Steptoe, Owen, Kunz-Ebrecht, & Brydon, 2004), obesity (Lauder, Mummery, Jones, & Caperchione, 2006), osteoarthritis and rheumatoid arthritis (Penninx et al., 1999), poorer sleep quality and larger age-related blood pressure increases (Cacioppo et al., 2002). With regard to physical illness, functional incapacitation may influence an individual's ability to maintain pre-existing, and develop new, social relationships and may also affect their desire to engage in outside activities due to either an embarrassment over their condition or a fear of injuring themselves. This limiting of social contacts may result in a diminishing social support and/or to feelings of loneliness developing (Penninx et al. 1999). Mortality is another issue affected by loneliness. Patterson and Veenstra (2010) identified significantly higher chances of all-cause mortality among individuals who report feeling lonely compared to those who report never feeling lonely. In particular, mortality rates from cardiovascular diseases other than ischemic disease were more than doubled for individuals reporting themselves as often being lonely; this is even when age and gender were controlled for. Patterson and Veenstra suggest that this association between loneliness and mortality may be mediated to some extent by physical activity and depression although further research is needed to elucidate this.

The primary aim of this study is to identify the biopsychosocial and cognitive risk factors of emotional loneliness, social loneliness and social support. An initial broad approach will be taken including a wide array of psychosocial, cognitive, biological and demographic variables. This initial array will be screened for inclusion in follow-up analyses, which will allow for very specific models of loneliness and social support to be created. A secondary aim is to examine mediating effects in the relationship between social support and outcomes of emotional and social loneliness. By investigating direct factors affecting loneliness and social support, and also mediating factors in the relationship between loneliness and social support, it is hoped that this will aid in identifying those at risk of developing loneliness or low levels of social support and also in determining how social support impacts on loneliness. This may help explain why certain individuals are lonely or lack adequate social support.

The identification of these pathways may also aid in the development of targeted interventions aimed at preventing or ameliorating loneliness and increasing levels of social support.

Method

Sample

The study involved the participation of 624 community-dwelling participants attending the Technology Research for Independent Living (TRIL) clinic at St James's Hospital, Dublin. For a more comprehensive description of the TRIL clinic please refer to Romero-Ortuno, Cogan, Fan and Kenny (2010). Local Research Ethics Committee approval was obtained (SJH/AMNCH Research Ethics Committee approval reference number 2007/06/13). Of the 624 participants, 45 were excluded due to impaired cognition (Mini-Mental State Examination (MMSE) < 23) leaving a total of 579 participants. All participants gave their informed consent prior to their inclusion in the study.

Primary measures

De Jong-Gierveld scale for loneliness

Emotional and social loneliness were assessed using the six-item de Jong-Gierveld Loneliness Scale (de Jong Gierveld & van Tilburg, 2006). In all, three items assessed emotional loneliness and three items assessed social loneliness. Both emotional and social loneliness are therefore given separate total scores from 0 to 3, with increasing scores indicating increasing levels of loneliness.

The Lubben Social Network Scale

The 18-item Lubben Social Network Scale (LSNS-18; Lubben & Gironde, 2004) examines perceived family, friendship and neighbourhood social support and, from this, gauges levels of social isolation. Individual scores for these aspects ranging from 0 to 30 are provided, as well as a total network score ranging from 0 to 90. Higher scores indicate greater social support.

Secondary measures

A total of 82 measures from a battery of psychosocial, physiological, cognitive and demographic assessments and questionnaires were selected for inclusion in the initial bivariate comparisons with loneliness and social support (for a full list see Appendix 1, Table 1A). This initial screening process identified factors for inclusion in the multiple regression analyses and mediation analyses.

Methods of analyses

Data were analysed using SPSS 16.0. Spearman's Rank Correlation Coefficient was used to conduct bivariate correlations of selected psychosocial, biological, cognitive and demographic variables with scores of emotional loneliness, social loneliness and social support. Bonferroni adjusted levels were used to assess significance of the correlations. Variables found to be significantly correlated with one of these measures of loneliness or social network were then entered into separate (psychosocial, biological, cognitive and demographic) backward multiple linear regression analyses with the relevant measure (emotional loneliness, social loneliness and social support). Age and gender were included in all multiple regression analyses. Following this, the variables found to be significant risk factors in each model were collated and entered into a final multiple regression analysis with the relevant measure as the dependent variable (emotional loneliness, social loneliness and social support). Collinearity was assessed for all regression analyses and found not to be an issue. Supplementary analyses, utilising a bootstrapping approach was used to examine possible mediation effects of selected variables.

Path models demonstrating direct effects and indirect effects through a mediator are shown in Figure 1. A bootstrapping approach to mediation analyses has been recommended as one of the more valid and powerful methods currently available (Hayes, 2009; Shrout & Bolger, 2002). Bootstrapping is a nonparametric resampling procedure, which makes no assumptions about the sampling distribution of the indirect effect. Bootstrapping involves the generation of a large number of datasets each of which is obtained through random sampling observations with replacement from the original dataset. The indirect effect is then calculated in each sample and results in the construction of a probability distribution from all of the resampled estimates. From these confidence intervals bootstrap-estimated standard errors of the mediated effects can be determined (Preacher & Hayes, 2008; Shrout & Bolger, 2002). Based on a SPSS macro (Preacher & Hayes, 2008), this type of analysis was conducted to estimate bootstrap standard errors and bias-corrected confidence intervals (BC CI) around the mediated effect, based on $k = 5000$ bootstrap samples. The significance level of $p < 0.05$ was set for all regression and bootstrapping statistical procedures.

Results

Bivariate correlations

A total of 82 measures (for a full list see Appendix 1, Table 1A) were correlated in a bivariate analysis with scores of emotional loneliness, social loneliness and total social support network. Due to the large number of included measures a full list of the bivariate analysis results and the Bonferroni adjusted significance levels can be found in Appendix 1, Table 2A.

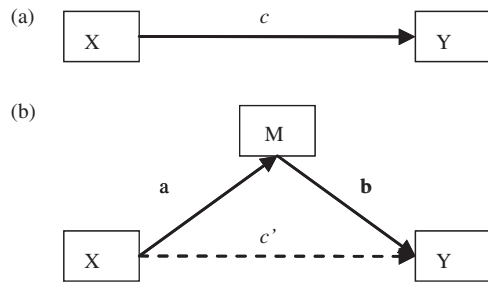


Figure 1. Path models showing (a) total effect and (b) mediated effect and direct effect. Mediation is indicated when the c' path is smaller than the c path.

Multiple linear regression analyses

Variables significantly correlated with emotional loneliness, social loneliness or social support were entered into separate multiple regression psychosocial, biological, cognitive and demographic analyses. The emerging factors in each of these models were then entered into an overall multiple regression analyses with the relevant outcome.

Emotional loneliness

Using the backward method, a significant model emerged for emotional loneliness with respect to psychosocial variables ($F_{4,310} = 41.995$, $p < 0.001$), biological variables ($F_{2,444} = 7.930$, $p < 0.001$), cognitive variables ($F_{2,349} = 7.337$, $p < 0.01$) and demographic variables ($F_{3,502} = 12.151$, $p < 0.001$). Following this, the significant risk factors of these models were combined and entered into a multiple linear regression with emotional loneliness as the dependent variable. A significant model emerged ($F_{6,268} = 26.182$, $p < 0.001$) and accounted for 36.1% of the variance. Depression ($\beta = 0.148$, $p < 0.05$), neuroticism ($\beta = 0.302$, $p < 0.001$), perceived stress ($\beta = 0.248$, $p < 0.001$), living alone ($\beta = 0.160$, $p < 0.01$) and type of accommodation ($\beta = 0.116$, $p < 0.05$) were significant risk factors in this model. The levels of significance of these models along with the risk factors in each model can be seen in Table 1.

Social loneliness

With respect to psychosocial variables ($F_{2,315} = 16.010$, $p < 0.001$), cognitive variables ($F_{1,490} = 9.075$, $p < 0.01$) and demographic variables ($F_{1,523} = 12.903$, $p < 0.001$), significant models emerged for social loneliness. No biological model was computed as none of these variables reached significance in the preliminary correlation analyses following Bonferroni adjustment of the significance levels. When the significant risk factors of the models were combined and entered into a multiple regression analysis with social loneliness as the dependent variable, a significant model emerged ($F_{5,407} = 12.388$, $p < 0.001$) and accounted for 12.3% of the variance. Neuroticism ($\beta = 0.115$, $p < 0.05$), perceived stress ($\beta = 0.232$, $p < 0.001$), verbal fluency as measured by animal naming ($\beta = 0.167$, $p < 0.01$) and the number of alive grandchildren ($\beta = -0.134$,

$p < 0.01$) were significant risk factors in this final overall model. The levels of significance and the risk factors of the categorised models as well as the final overall model can be seen in Table 2.

Social support network

Significant multiple regression models emerged for social support with respect to psychosocial variables ($F_{6,382} = 19.681$, $p < 0.001$), biological variables ($F_{2,368} = 9.503$, $p < 0.001$), cognitive variables ($F_{2,131} = 10.673$, $p < 0.001$) and demographic variables ($F_{4,498} = 22.892$, $p < 0.001$). Following this, the significant risk factors of these models were combined and entered into a multiple linear regression with social support as the dependent variable. A significant model emerged ($F_{7,389} = 16.299$, $p < 0.001$) and accounted for 21.6% of the variance. Extraversion ($\beta = 0.260$, $p < 0.001$), executive functioning as measured by the Trail Making Test (TMT) B time ($\beta = -0.157$, $p < 0.01$), history of falls ($\beta = -0.147$, $p < 0.01$), drives ($\beta = 0.094$, $p < 0.05$), age ($\beta = -0.136$, $p < 0.01$) and the Geriatric Adverse Life Events Scale (GALES) item 'difficulty getting access to adequate professional services' ($\beta = -0.100$, $p < 0.05$) were significant risk factors in this model. The levels of significance of these models along with the risk factors in each model can be seen in Table 3.

Supplementary mediation analyses

Given the results of these multiple regression analyses, where final models of the strongest risk factors for emotional loneliness and social loneliness emerged, we conducted a mediation analysis to supplement the above analyses. Strong links between social support and loneliness have previously been found, however, the precise nature of these links is unclear. A bootstrapping approach to mediation analyses was used and due to the nature of this analysis no dichotomous variables could be included as potential mediators. Therefore, the current analysis aims to investigate whether any of the nondichotomous final items in the models for emotional and social loneliness mediate the effects of social support. That is, are there indirect effects of social support on emotional loneliness through depression, neuroticism, perceived stress or accommodation type? Additionally, are there indirect effects of social support on social loneliness through neuroticism, perceived stress, animal naming and the number of grandchildren an individual has? In these analyses, the independent variable was social support and the outcome variable was either emotional loneliness or social loneliness.

Indirect effects of social support on emotional loneliness and social loneliness

Path models conceptualising the results of the multiple mediation analyses can be seen in Figure 2.

Table 1. The psychosocial, biological, cognitive, demographic and final overall multiple regression models for emotional loneliness.

Model	β	p	F	Model significance	R^2 adjusted
Psychosocial			41.995	0.000	0.346
Depression	0.138	0.016			
Neuroticism	0.247	0.000			
Perceived stress	0.240	0.000			
Biological			7.930	0.000	0.030
Pain	0.121	0.016			
Berg Balance Scale	-0.106	0.034			
Cognitive			7.337	0.004	0.035
CFQ	0.147	0.006			
TMT A time	0.133	0.012			
Demographic			12.151	0.000	0.062
Lives alone	0.163	0.000			
Type of Accommodation	0.090	0.048			
Drives	-0.134	0.003			
Overall			26.182	0.000	0.361
Depression	0.148	0.015			
Neuroticism	0.302	0.000			
Perceived stress	0.248	0.000			
Lives alone	0.160	0.002			
Type of accommodation	0.116	0.025			

Table 2. The psychosocial, biological, cognitive, demographic and final overall multiple regression models for social loneliness.

Model	β	p	F	Model significance	R^2 adjusted
Psychosocial			16.010	0.000	0.087
Neuroticism	0.147	0.018			
Perceived stress	0.203	0.001			
Cognitive			9.075	0.003	0.016
Animal naming (verbal fluency)	0.135	0.003			
Demographic			12.903	0.000	0.022
Number of alive grandchildren	-0.155	0.000			
Overall			12.388	0.000	0.123
Neuroticism	0.115	0.028			
Perceived stress	0.232	0.000			
Animal naming	0.167	0.001			
Number of alive grandchildren	-0.134	0.006			

Social support had significant total effects on both emotional loneliness ($B_{5,430} = -0.0115$, $p < 0.01$) and social loneliness ($B_{5,400} = -0.0222$, $p < 0.001$). As can be seen in Table 4, an examination of the indirect effects indicates that a set depression, neuroticism, perceived stress and accommodation type do mediate the effect of social support on emotional loneliness. The difference between the total and direct effects is the total indirect effect through the four mediators. This total indirect effect has a point estimate of -0.0076 and a 95% BC bootstrap CI of -0.0122 to -0.0036 . An examination of the specific indirect effects indicates that there are significant indirect effects of social support on emotional loneliness through depression, perceived stress and accommodation type, since the 95% BC CIs do not contain zero for any of these mediators. Additionally, neuroticism was a marginally

significant mediator as its 95% BC CIs included zero at the upper limit.

For the output social loneliness, the total indirect effect through the four mediators is not significant indicating that a set perceived stress, neuroticism, animal naming and the number of grandchildren do not mediate the effect of social support on social loneliness (point estimate = -0.0011 , 95% BC CIs = -0.0037 to 0.0009). In comparison to emotional loneliness; an examination of the specific indirect effects of social support on social loneliness indicates that both neuroticism and perceived stress are marginally significant mediators as their BC CIs include zero at the upper limit. Animal naming and number of grandchildren do not contribute the indirect effect above and beyond perceived stress and neuroticism.

Table 3. The psychosocial, biological, cognitive, demographic and final overall multiple regression models for social support.

Model	β	p	F	Model significance	R^2 adjusted
Psychosocial			19.681	0.000	0.227
Extraversion	0.299	0.000			
Accident/injury	-0.097	0.042			
Age	-0.228	0.000			
Gender	0.099	0.030			
Biological			9.503	0.000	0.120
ADL (self-rated)	0.127	0.013			
History of falls	-0.133	0.013			
Pain	-0.102	0.045			
Age	-0.172	0.001			
Gender	0.107	0.038			
Cognitive			10.673	0.000	0.129
Trail Making Test B time	-0.210	0.025			
Age	-0.200	0.028			
Demographic			22.892	0.000	0.150
Voluntary work in the past year	0.104	0.014			
Drives	0.195	0.000			
Age	-0.258	0.000			
Overall			16.299	0.000	0.216
Extraversion	0.260	0.000			
History of falls	-0.147	0.003			
Trail Making Test B time	-0.157	0.002			
Drives	0.100	0.037			
Age	-0.130	0.010			

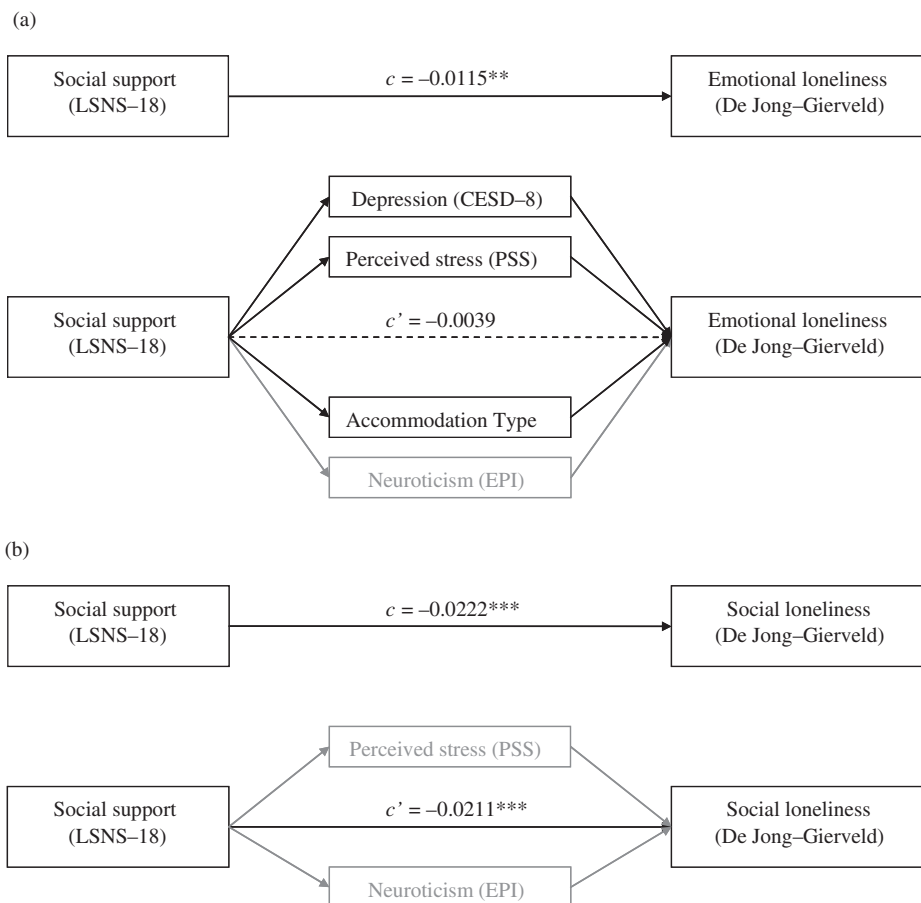


Figure 2. Conceptual diagram showing the multiple mediation models for total, direct and indirect effects of social support on (a) emotional loneliness and (b) social loneliness. Marginally significant mediators are indicated by greyscale. Significance levels: *** $p < 0.001$, ** $p < 0.01$.

Table 4. Point estimates, standard error, z-values and 95% bias-corrected confidence intervals for indirect effects of social support on emotional loneliness and social loneliness.

	Indirect effects	Point estimate	Product of coefficients		Bootstrap 95% BC ^a CI	
			SE	z	Lower	Upper
Emotional loneliness (<i>N</i> = 436)	Total	-0.0076	0.0021	-3.6797	-0.0122	-0.0036
	Depression	-0.0024	0.0009	-2.6322	-0.0049	-0.0008
	Neuroticism	-0.0017	0.0010	-1.7543	-0.0042	0.0000
	Perceived stress	-0.0023	0.0010	-2.4317	-0.0050	-0.0007
	Type of accommodation	-0.0011	0.0006	-1.1508	-0.0027	-0.0001
Social loneliness (<i>N</i> = 406)	Total	-0.0011	0.0011	-1.0435	-0.0037	0.0009
	Perceived stress	-0.0012	0.0007	-1.7187	-0.0033	0.0000
	Neuroticism	-0.0005	0.0004	-1.2671	-0.0018	0.0000
	Animal naming	0.0002	0.0005	0.5024	-0.0006	0.0015
	Number of alive grandchildren	0.0003	0.0004	0.8021	-0.0004	0.0014

Notes: ^aBC = bias-corrected; 5000 bootstrap samples.

Significance at < .05 (if confidence intervals do not cross zero, then the relationship is significant).

Discussion

The current study identified comprehensive models of emotional loneliness, social loneliness and social support from an exploration of a range of biopsychosocial, cognitive and demographic assessments in a sample of community-dwelling older adults in Ireland. The differing nature of these models confirms the importance of distinguishing between different types of loneliness and also between a lack of social support and loneliness. Additionally, a representation of the direct and indirect effects of social support on emotional and social loneliness through their identified risk factors has been constructed. Social support was found to affect emotional loneliness indirectly through several factors. In contrast, the effect of social support on social loneliness was primarily direct. This has important implications in the development of interventions targeting loneliness.

Multiple regression analyses

According to the overall multiple regression model constructed following individual psychosocial, biological, cognitive and demographic analyses, the psychosocial variables were the most likely to appear in the final model for emotional loneliness with no cognitive or biological variables emerging. Higher levels of neuroticism, depression and perceived stress were all significant indicators of increased emotional loneliness, as was living alone and the type of accommodation lived in. Risk factors of social loneliness are slightly more varied. Both neuroticism and perceived stress are still found to be important in the overall model, however, animal naming, a measure of semantic fluency, is also found to be a risk factor. Additionally, the number of grandchildren an individual has also appears in the final model for social loneliness, with individuals with fewer grandchildren being more likely to be socially lonely.

The final model for social support is entirely different from those for the different forms of loneliness. Lower levels of extraversion was the strongest indicator of decreased social support although higher scores on the TMT B time, indicating greater impairment in executive functioning, and having a history of falling were also strong indicators. Other risk factors for lower levels of social support included increasing age and not being able to drive.

The differing models for emotional loneliness, social loneliness and social support confirm the usefulness of distinguishing between these outcomes. The predominance of mood and personality factors in both loneliness models indicates that they do share some similar characteristics and confirms previous research in these areas (Barg et al., 2006; Cacioppo et al., 2006; Fees et al., 1999; Lasgaard & Elklit, 2009; Savikko, 2008; Stek et al., 2005; Stokes, 1985). Living arrangements, principally living alone, were identified as particularly important for emotional loneliness in line with Weiss' (1973) original definition involving the lack or loss of a close attachment relationship. Interestingly, social support was the only outcome in which a biological variable, falls history, emerged in the final model; this may indicate the relative importance of health factors compared to psychosocial factors in the loneliness models. The presence of a cognitive variable in both of the overall models for social loneliness and social support, but not emotional loneliness, reflects the relative importance of cognition to each of these outcomes and may be a sign of the importance of cognition to engaging in social activities and in instigating and maintaining social relationships. Specifically, animal naming, a measure of semantic fluency, was identified as a major indicator of social loneliness in the current analysis and this corresponds with previous research by Gilmour (2011) identifying a relationship between low levels of semantic fluency and general loneliness. It is possible that deficits in semantic fluency may discourage conversations with friends and

family leading to an increased perception of loneliness. In contrast, social support was indicated by the TMT B time, a measure of executive functioning, which relates to previous findings identifying a limited social network as increasing risk of dementia by 60% (Fratiglioni et al., 2000). Difficulties in the maintenance of social networks may be a key issue here.

Mediation analyses

A secondary aim was to investigate mediating effects in the relationship between social support and the outcomes of emotional and social loneliness. Strong links between levels of social support and loneliness are evident. Social support was identified as a risk factor of both emotional loneliness and social loneliness; however, distinct models for these relationships emerge once potential mediators are considered. Interestingly, the significant effect of social support on emotional loneliness no longer reached significance following the addition of the mediators; that is, the total effect (*c* path) was much greater than the direct effect (*c'* path). This indicates a large proportion of the effect of social support on emotional loneliness is not direct but is instead indirect through depression, perceived stress and living arrangements, although marginal effects through neuroticism were also indicated.

In comparison, little change occurred in the effect of social support on social loneliness following the inclusion of potential mediators; both the total effect (*c* path) and the direct effect (*c'* path) of social support on social loneliness were significant. This is in stark contrast to the effect of social support on emotional loneliness. The effects of smaller levels of social support on feelings of social loneliness were almost entirely direct in nature; although marginally significant indirect effects did occur through increasing levels of perceived stress and neuroticism.

These results highlight the differences in the manner by which social support influences the levels of emotional loneliness and social loneliness. Social support predominantly affects emotional loneliness indirectly, while its effects on social loneliness are nearly exclusively direct. Interventions aimed at targeting loneliness should therefore tailor their approach depending on the type of loneliness present. Our findings suggest that interventions targeting depression, perceived stress, living arrangements and neuroticism may be valuable in buffering the relationship between social support and emotional loneliness. In contrast, directly targeting social support may be the most effective method of ameliorating feelings of social loneliness, although interventions aimed at perceived stress and neuroticism may also be beneficial in buffering this relationship.

Methodological issues and future research

An array of standardised and validated biopsychosocial assessments were employed in the current study. It

is hoped this inclusion of a broad range of assessments allowed for a more accurate and in-depth appraisal of the risk factors of emotional loneliness, social loneliness and social support. However, the possibility that our initial broad approach has led to false positive findings should be considered. It is hoped that the conservative nature of the analysis, utilising Bonferroni corrected significance levels at the screening stage followed by conservative backwards linear regression analyses has helped to reduce this possibility. It should also be considered that this methodological approach was overly conservative, resulting in very few variables in the final overall models.

The cross-sectional nature of the study limits the degree to which we can interpret direct and indirect causality with regard to loneliness and social support. This issue is to be addressed in a longitudinal follow-up of participants currently taking place at the TRIL clinic. Additionally, all participants in the current study were community-dwelling adults in Ireland, aged over 60 and therefore the resulting models of emotional loneliness, social loneliness and social support, as well as the indirect effects discussed previously are specific to this population and may not be generalised to other populations. It is likely that these individuals are better functioning than people in support living environments and this should be taken into account when considering the results. Additionally, there may be cultural differences in the development of loneliness and social support. Future research will focus on a more comprehensive investigation of indirect effects with regard to biopsychosocial factors and emotional and social loneliness.

An important aspect of loneliness not considered in the current analysis is an exploration of the risk factors of being both emotionally and socially lonely. The current analysis focused on emotional and social loneliness as separate entities. However, it is possible to be both socially and emotionally lonely and therefore modelling the simultaneous occurrence of these two types of loneliness is of clinical significance. Additionally, the possibility of additive and superadditive effects exists and is needful for investigation, when both emotional and social loneliness are present.

The analyses of the indirect pathways by which social support can affect loneliness were based on the primary risk factors identified. A more comprehensive investigation of these pathways could have included a large number of other potential mediators based on the earlier individual demographic, psychosocial, cognitive and biological risk factor models developed. Such a complex and extensive analyses may be better examined through a process such as structural equation modelling and is a topic which should be considered for future research.

In conclusion, the present study identified the main risk factors of developing emotional loneliness, social loneliness or a decreased perception of available social support. It also determined both the direct and indirect pathways by which social support can affect loneliness.

These findings are of crucial importance in the development of a broader representation of who is vulnerable to becoming lonely and why. Interventions aimed at preventing or ameliorating loneliness should tailor their approaches depending on the nature and the direction of these direct and indirect pathways.

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Appendix 1

Table 1A. The psychosocial, biological, cognitive and demographic variables for inclusion in the bivariate Spearman's Rank Correlation Coefficient analyses with emotional loneliness, social loneliness and social support.

Variables for inclusion			
Psychosocial	CESD-7 (depression) HADS (anxiety) Pittsburg sleep index (perceived sleep quality) Neuroticism Extraversion Perceived Stress Scale Modified falls efficacy scale GALES items: Financial difficulties Retirement Sudden loss of employment New major physical illness Other major physical illness Physical illness of close family member	GALES items continued: Accident/injury Marital separation/divorce Other marital difficulties Major family problems other than with spouse Major problems with friends/ neighbours Break-up of a long-term relationship (not marriage) Separation from other close friend/relative Death of spouse Death of child Death of parent Death of a brother/sister	GALES items continued: Death of other relative/close friend Death of a pet Forced to leave/lose home Voluntarily changed place of residence Individual moved out of household Individual moved into household Difficulty getting adequate professional services Victim of crime Became caretaker for relative/friend
Biological	Fried Frailty Index Timed get up and go (walking speed) Berg Balance Scale Charlson Comorbidity Index Falls history MNA (nutrition)	Visual acuity Hearing test Activities of daily living (self-rated physical functioning) Instrumental activities of daily living (self-rated physical functioning)	Pain score Baseline systolic blood pressure Nadir systolic blood pressure Delta systolic blood pressure Recoverer type (blood pressure) Maximum systolic blood pressure
Cognitive	MMSE Cognitive Failures Questionnaire Prospective memory: hidden belongings Prospective memory: questions Initial word recall Delayed word recall	Animal naming (verbal fluency) Digit span backwards Intelligence quotient – cognition CAMCOG: recognition CAMCOG: similarities CAMCOG: draw	CAMCOG: recall CAMCOG: naming TMT A time (sec) TMT B time (sec) TMT B minus A Praxis
Demographic	Marital status Educational level Working status Voluntary work in the past year	Childless Number of alive children Number of alive grandchildren Type of accommodation	Lives alone Drives Urban vs. rural

Table 2A. Bivariate Spearman's Rank Correlation Coefficient comparisons of emotional loneliness, social loneliness and social support scores with 82 psychosocial, cognitive, physiological and demographic variables.

Variable		Emotional loneliness	Social loneliness	Social support
Psychosocial	Depression (CESD-7)	0.374*	0.165*	-0.189*
	Anxiety (HADS-A)	0.429*	0.194*	-0.191*
	Pittsburgh sleep index	0.184*	0.103	-0.114
	Neuroticism	0.427*	0.186*	-0.126
	Extraversion	0.033	-0.136	0.320*
	Perceived Stress Scale	0.415*	0.180*	-0.105
	Modified falls efficacy scale	-0.200*	-0.161*	0.246*
	GALES items			
	Financial difficulties	0.017	0.090	0.018
	Retirement	0.031	0.018	-0.008
	Sudden loss of employment	0.033	-0.011	0.062
	New major physical illness	-0.006	0.005	-0.030
	Other major physical illness	0.122	-0.008	-0.079
	Physical illness of close family member	0.089	-0.050	0.103
	Accident/injury	0.074	0.031	-0.188*
	Marital separation/divorce	0.073	0.021	-0.061
	Other marital difficulties	0.086	0.052	-0.039
	Major family problems other than with spouse	0.040	0.107	-0.035
	Major problems with friends/neighbours	0.079	0.019	-0.060
	Break-up of a long-term relationship other than marriage	0.062	0.049	-0.053
	Separation from other close friend/relative	0.104	0.039	0.017
	Death of spouse	0.080	-0.065	0.033
	Death of child	0.052	-0.043	0.061
	Death of parent	0.072	-0.022	0.032
	Death of a brother/sister	0.012	-0.023	0.022
	Death of other relative/close friend	-0.029	-0.019	0.059
	Death of a pet	-0.036	-0.016	0.049
	Forced to leave/lose home	0.003	0.014	-0.010
	Voluntarily changed place of residence	0.058	0.048	0.012
	Individual moved out of household	-0.024	0.007	-0.034
	Individual moved into household	-0.122	-0.057	0.085
	Difficulty getting adequate professional services	0.137*	0.078	-0.091
	Victim of crime	0.025	-0.036	-0.035
Became caretaker for relative/friend	0.093	0.004	0.050	
Biological	Timed get up and go	0.207*	0.017	-0.325*
	Fried Frailty Index	0.153*	-0.012	-0.195*
	Berg Balance Score	-0.248*	-0.059	0.310*
	Activities of daily living (self-rated)	-0.130*	-0.071	0.149*
	Instrumental activities of daily living (self-rated)	-0.179*	-0.072	0.296*
	Charlson Comorbidity Index	0.094	0.051	-0.219*
	History of falls	0.134*	0.090	-0.247*
	MNA (nutrition)	0.133*	0.080	-0.160*
	Pain score (VRS)	0.170*	0.087	-0.173*
	Visual acuity – binocular	0.119	0.032	-0.147*
	Hearing test	0.122	0.004	-0.193*
	Baseline SBP	-0.069	-0.026	-0.053
	Maximum SBP	-0.043	0.002	-0.057
	Nadir SBP	-0.016	0.005	-0.020
	Delta SBP	-0.071	-0.045	-0.041
	Type of recoverer (fast or slow)	-0.073	-0.064	-0.048
	Cognitive	Word recall initial	-0.024	0.058
Delayed word recall		-0.098	0.040	0.219*
Animal naming (verbal fluency)		-0.015	0.137*	0.033
Digit backwards		-0.062	0.046	0.152*
Camcog similarities		-0.106	0.056	0.119
Prospective memory: hidden belongings		-0.076	0.079	0.210*
Prospective memory: questions		-0.124	-0.021	0.152
TMT A time (sec)		0.148*	-0.047	-0.207*
TMT B time (sec)		0.119	-0.002	-0.287*
TMT B minus A		0.081	0.025	-0.281*
CAMCOG: naming		-0.008	-0.056	0.072
CAMCOG: draw		-0.070	-0.036	0.191*
CAMCOG: recall	0.016	-0.092	0.187	

(continued)

Table 2A. Continued.

	Variable	Emotional loneliness	Social loneliness	Social support
	CAMCOG: recognition	-0.037	-0.014	0.055
	Praxis	-0.090	-0.034	0.143*
	Intelligence quotient – cognition	-0.080	0.033	0.059
	Cognitive Failures Questionnaire Score	0.185*	0.026	-0.155*
	MMSE score	-0.085	-0.005	0.203*
Demographic	Marital status	0.087	0.013	-0.062
	Educational level	-0.080	0.061	0.137*
	Working status	-0.041	0.017	0.099
	Voluntary work in the past year	0.006	-0.025	0.162*
	Childless	0.007	0.063	-0.102
	Number of alive children	-0.022	-0.099	0.099
	Number of alive grandchildren	0.028	-0.165*	0.046
	Lives alone	0.181*	0.109	-0.106
	Drives	-0.146*	-0.046	0.248*
	Type of accommodation	0.134*	0.084	-0.126
	Urban vs. rural living	-0.058	-0.093	-0.007
	Age	0.068	-0.017	-0.283*
	Gender	0.089	0.007	0.033

Note: *Bonferroni adjusted significance levels: psychosocial, $p < 0.001389$; biological, $p < 0.002632$; cognitive, $p < 0.002381$ and demographic, $p < 0.003125$.