1 Friendships, loneliness and psychological well-being in older adults: A limit to the benefit
2 of the number of friends

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Abstract

Objectives: To examine the relationship between number of friends and loneliness, depression, anxiety and stress in older adults. *Methods:* Data were obtained from 335 older adults via completion of an online survey. Measures included loneliness (UCLA Version 3), depression, stress and anxiety (DASS-21). Participants also reported their number of close friends. *Results:* Regression analysis revealed an inverse curvilinear relationship between number of friends and each of the measures tested. Breakpoint analysis demonstrated a threshold for the effect of number of friends on each of the measures (loneliness = 4, depression = 2, anxiety = 3, stress = 2). *Discussion:* The results suggest that there is a limit to the benefit of increasing the number of friends in older adults for each of these measures. Elucidating these thresholds can enable loneliness and psychological well-being interventions to be more targeted.

Keywords: Loneliness; Friendships; Older Adults; Psychological Well-being

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Introduction

Loneliness has been defined as an unpleasant or distressing experience resulting from a perceived qualitative or quantitative deficiency in one's social relationships (Peplau and Perlman 1982; Russell, Peplau and Cutrona 1980). As such loneliness can be emotional or social. Emotional loneliness is derived from a perception of inadequate intimacy in relationships, whereas social loneliness is due to deficits in the quantity of social relationships (Hawkley and Cacioppo 2010).

Transient experiences of loneliness are believed to be adaptive in that they provide motivation to form and maintain social connections in order to promote the survival of genes (Cacioppo and Hawkley 2009; Cacioppo *et al.* 2006; Hawkley and Cacioppo 2010). However, sustained loneliness has been repeatedly linked to many negative psychological and physiological health outcomes across age groups. These outcomes include anxiety and depression (Age UK South Lakeland 2018; Barg *et al.* 2006; Cacioppo, Hawkley and Thisted 2010; Lee *et al.* 2021), suicidality (Stravynski and Boyer 2001; Van Orden *et al.* 2010), maladaptive stress responses (Adam *et al.* 2006; Steptoe *et al.* 2004), cognitive decline and Alzheimer's Disease (Boss, Kang and Branson 2015; Donovan *et al.* 2017; Wilson *et al.* 2007) cardiovascular disease (Momtaz *et al.* 2012; Valtorta *et al.* 2018; Valtorta *et al.* 2016), malnutrition (Ramic *et al.* 2011), sleep quality (Yu *et al.* 2018), functional decline (Perissinotto, Stijacic Cenzer and Covinsky 2012) as well as increased risk of mortality (Holt-Lunstad *et al.* 2015; Holt-Lunstad, Smith and Layton 2010).

These negative impacts have associated economic costs. The cost of loneliness to UK employers has been estimated as being £2.5 billion due to increased staff turnover, reduced productivity, the impact of caring responsibilities and sickness absence related to ill health (New Economics Foundation and Co-op 2017). The monetised impact of severe loneliness

has been estimated as £9,900 per person due to its impact on well-being, health and productivity (Peytrignet, Garforth-ble and Way 2020).

Further, loneliness is becoming increasingly prevalent in later life with in excess of 1 million UK residents over the age of 50 reporting that they are chronically lonely (Abrahams 2018). This figure is expected to increase to 2 million by 2025 (Abrahams 2018). Importantly, as the worldwide population is ageing (UN DESA's Population Division 2019), the negative health correlates of loneliness are linked to increased strain on the National Health Service usage in the UK. For example, loneliness in older adults was consistently and positively associated with the number of General Practitioner visits in both cross-sectional and longitudinal analysis as well as with Emergency Department visits for women (Burns *et al.* 2020).

Due to the multiple negative impacts demonstrated above, the UK government has implemented, or is planning to implement a number of initiatives with the goal of reducing loneliness in this age group. This includes strengthening their "Tackling Loneliness" charity network, the awarding of £31.3 million of funding to charities supporting people who experience loneliness and the announcement of an additional £7.5 million to tackle loneliness during winter (Sport 2021)

Clearly loneliness has a negative impact on both individuals and a society as a whole. Therefore, it is important to fully understand contributors to this experience in order to reduce its deleterious impact.

Friendships in later life

At its core, loneliness relates to a perceived lack of meaningful social connections and interactions (Cacioppo and Patrick 2008; Reichmann 1959; Townsend 1968). Friendships are a type of social connection which appear to be particularly important to older adults with evidence indicating that this age group are more satisfied with their friendships than

their younger counterparts (Nicolaisen and Thorsen 2017). Additionally, research has shown that a preference for emotionally close social partners increases with age (Carstensen 1992).

Socioemotional selectivity theory (Carstensen, Isaacowitz and Charles 1999) provides a framework for this observation. This theory posits that the perception of time causes individuals to prioritise particular social goals which are in competition with one another. Younger individuals who perceive time to be expansive focus on the pursuit of future oriented knowledge based goals. In contrast, those that perceive time as limited, such as older adults, become more focussed on present oriented goals. These present focussed goals include the aim of emotional satisfaction. As such, selectivity of social partners in this age group is increased with a preference for high quality relationships emerging. Older adults are thought to construct their social world to match these social goals. This leads to a reduction in social network size beginning in early adulthood and results in a network which excludes novel social partners and maintains those that are already emotionally close (English and Carstensen 2014). Thus, highlighting the notion that existing close friendships become more important with age.

Friendships and loneliness in older adults

Studies have repeatedly shown that in older adults, friendships are a greater determinant of loneliness than relationships with family members (e.g., Shiovitz-Ezra and Leitsch 2010). For example, it has been shown that interactions with friends reduce loneliness to a greater extent than interactions with close relatives including children, grandchildren and neighbours (Lee and Ishii-Kuntz 1987; Mullins, Johnson and Andersson 1987; Pinquart and Sörensen 2001; Steed *et al.* 2007). Having close friends who reside in close proximity is more important than having relatives that do (Eshbaugh 2009) and those with networks composed mainly of kin appear to be more vulnerable to loneliness and negative psychological well-being (Silverstein, Chen and Heller 1996). Additionally, 50% of

those who report having no friends also report feeling lonely (Holmén *et al.* 1992) suggesting that social connections which are not friendships, such as kinship, may be less important in terms of loneliness in some cases.

As pointed out by Pinquart and Sörensen (2001), an explanation for a stronger association between friendships and loneliness in comparison to familial relationships and loneliness may lie in the quality of those relationships. Friendships tend to be of higher quality than familial relationships, as the latter are more likely based on obligation and may also involve caregiving responsibilities (Bengtson *et al.* 1985). Given the importance of shared experiences, interests, attitudes and lifestyle for friendships, these relationships may offer more insight into understanding loneliness than family relationships (Rawlins 1995).

Further evidence for the importance of friendships in relation to loneliness has been demonstrated. For example, Eshbaugh and colleagues (2009) found that in older women living alone, having close friends who reside within 50 miles was a significant negative predictor of loneliness. A similar finding was evident in work by Mullins and associates (1990) in older adults living in independent living facilities. Further, a lack of friends was reported as a reason for feeling lonely in Finnish older adults (Savikko *et al.* 2005). Additionally, frequency of contact with friends has been evidenced as having a negative relationship with loneliness in older adults across marital statuses (Pinquart 2003).

Quantity of friends and loneliness

As outlined above, friendships are clearly important in terms of reducing loneliness. In this context it is important to note that research has consistently demonstrated that the quantity of friends has a negative association with loneliness. This has been found in adolescents (Lodder *et al.* 2017), children (Nangle *et al.* 2003), sophomore high school students (Russell *et al.* 2012) and older adults (Shiovitz-Ezra and Leitsch 2010). The association between this objective parameter and subjective loneliness has repeatedly been

found despite the consensus being that loneliness is a subjective experience. Despite this association, there has been limited investigation of the ways in which the number of friends contributes to this. One notable exception is research exploring the discrepancy between an individual's ideal and actual number of friends (Russell *et al.* 2012) which finds a curvilinear relationship between this discrepancy and loneliness in college students. Here, loneliness decreases as the number of actual friendships rises towards the number of ideal friendships. Once the ideal number of friendships is passed, loneliness begins to increase again. The authors explain this non-linear relationship in relation to the cognitive-discrepancy model of loneliness (Thibaut and Kelley 2017). Here a loss or gain of a friend when the number of friendships is close to an individual's ideal number may be especially important for determining loneliness. However, a loss or gain may be less important when the number is far above or below this ideal number.

Studies, apart from that of Russell and colleagues (2012), have overlooked the possibility that the relationship between the quantity of friends and loneliness may be curvilinear. The presence of a non-linear relationship may be indicative of a limit to the effect of increasing friends on loneliness. Work by Brummet and colleagues (2001) suggests that the link between the number of social contacts and risk of mortality in coronary patients is non-linear. Here, the mortality rate was highest in those with three or fewer social contacts. When four social contacts were present, the risk was reduced by more than half and remained at a similar level with further additions of social contacts. It is possible that a similar relationship may be present between the number of friends and loneliness, given the previously established links between loneliness and coronary heart disease (Valtorta *et al.* 2016). The presence of a limit makes theoretical sense as it has previously been established that there is a constraint on the number of emotionally close relationships an individual can maintain within their social network with an increase in emotional closeness linked to a reduction in network size (Roberts *et al.* 2009). Additionally, studies have shown that intimacy in friendships differentiates between those who are lonely and

those who are not (Drageset, Kirkevold and Espehaug 2011; Hamid 1989; Williams and Solano 1983) although not in all cases (Mullins and Mushel 1992). It is therefore plausible that, as more friends are added to a person's network, the emotional closeness within the network is decreased, which in turn impacts on how lonely the individual feels. Thus, creating a natural limit. It is also possible that individuals experiencing loneliness may surround themselves with acquaintances as a coping strategy which could suggest a curved association between number of friends and loneliness.

As mentioned above, there are a variety of negative psychological outcomes associated with loneliness. Similarly to loneliness, previous research has shown that friendships have been linked to improved mental health. Quantity of friends is related to reduced levels of depression in older adults (Potts 1997). Friendship support has been linked to better affect balance in the same age group (Montpetit, Nelson and Tiberio 2017). Subjective isolation from friends is linked to a greater increase in both depression and psychological distress than subjective isolation from family (Taylor *et al.* 2018). An increase in the number of friends is linked to a reduction in stress (Horst and Coffé 2012). Older adult friendships are linked to better psychological well-being in comparison to family relationships (Nussbaum 1994). Similarly, friendship networks have been shown to have a stronger relationship with psychological well-being than kin based networks (Cable *et al.* 2013). Finally, a lower number of social relationships has been linked to the maintenance of low negative affect and high negative affect (Huxhold *et al.* 2020).

Of note, friendship closeness has also been associated with reduced levels of depression in both older adults (Bishop 2008) and adults (Taylor *et al.* 2015). As outlined previously, increasing a person's number of friendships may reduce levels of this closeness within their social network. This reduction in closeness to network contacts may in turn lessen the impact of the number of friends on depression creating a natural limit. However, as with loneliness, there has been little exploration of whether the number of friends relates to psychological health outcomes and there has been no exploration of what an optimal

number of friends may be in terms of these outcomes in this age group.

Quantity vs Quality

It is important to note here that quality of friendships has often been indicated as being important in terms of loneliness. Higher quality friendships are related to lower levels of loneliness. This association has been found in the oldest old (Long and Martin 2000), during adolescence (Lodder *et al.* 2017) and in children (Parker and Asher 1993). This relationship has also been found for social relationships more generally in older adults; with higher quality social relationships predicting lower levels of loneliness (Pinquart and Sörensen 2001).

Quality within friendships is therefore clearly important with regards to loneliness. As it is known that relationship closeness is correlated with relationship quality (e.g., Crespo *et al.* 2008), we argue that it is more appropriate to focus on the ways in which close, and therefore high quality, friendships impact loneliness rather than more peripheral, low quality, friendships. This allows the exploration of the impact of these arguably more important friendships in relation to loneliness in older adults. Further, this encompasses both the theoretical quantitative social and qualitative emotional aspects of loneliness as highlighted above.

The present study

As illustrated, a closer inspection of the relationship between number of close friends and loneliness and its psychological health correlates is warranted. To this end, the present study aimed to extend previous findings in the following key ways. First, the study aimed to determine the relationship between the number of close friends and loneliness along with three of its associated psychological health outcomes: depression, anxiety and stress. Crucially, the existence of a non-linear relationship was explored. A further aim was to

determine the optimal number of close friends for each of these parameters. As outlined above, a negative relationship between number of close friends and loneliness and each of the associated psychological well-being measures has previously been established. Here, we expected to replicate those findings. However, no hypothesis was made in relation to a potential curvilinear relationship. Instead we posed the research question, Is there a curvilinear relationship between number of close friends and loneliness in older adults. As the second aim was exploratory no hypothesis was made in this regard either. Again, a research question was posed of what is the optimal number of close friends in terms of loneliness in this age group?

Method

Design

The present study was an exploratory, cross-sectional and correlational investigation into the relationship between number of close friends and loneliness, depression, anxiety and stress in older adults.

Participants

A target sample size of 400 was pre-registered, this was primarily determined by cost. Due to time constraints this number fell somewhat short of the target. However, this number is still sufficient to perform the analysis (1 predictor per 25 cases, Harrell 2015; Austin and Steyerberg 2015; Roscoe 1975; Schmidt 1971; Tabachnik and Fidell 2009). A total of 350 residents of the United Kingdom aged 65 or over responded to an online questionnaire. This was advertised via the recruitment platform Prolific (Palan and Schitter 2018), Facebook adverts and via word of mouth. The Facebook and Prolific adverts were targeted specifically to UK residents aged 65 plus. Those that completed the questionnaire via Prolific were paid £2 upon completion. To be eligible to take part in the

study participants were required to not have had a current clinical diagnosis of depression or anxiety. The initial sample consisted of 350 respondents (138 male, 211 female and one participant did not specify).

Measures

Key Dependent Variables. *Loneliness.* There were four dependent variables examined in this study. The first was loneliness as measured by the University of California, Los Angeles, Loneliness Scale-Version 3 (UCLA-3) (Russell 1996). The UCLA-3 is a 20-item self-report scale designed to measure an individual's subjective feelings of loneliness. Participants are asked how often each statement is descriptive of them (e.g., How often do you feel that you lack companionship?). Items are on a scale ranging from 1 (Never) to 4 (Often) and nine items are reverse scored. All items are summed to give one loneliness score; a higher score represents greater levels of loneliness. Version 3 of this scale has demonstrated good internal reliability (Cronbach's $\alpha = .96$) (e.g., Russell 1996), with the reliability for the present study being .94, and has demonstrated a unidimensional factor structure (Russell 1996).

Psychological Well-being. The three psychological well-being measures were all assessed via the short version of the Depression Anxiety and Stress Scale (DASS-21) (Lovibond and Lovibond 1995). The DASS-21 consists of 21 items and consists of three 7-item subscales measuring depression, anxiety and stress separately. Participants are asked how much each statement has applied to them over the past week (e.g. I found it hard to wind down). Items are on a scale ranging from 0 (Never) to 3 (Almost Always). Items are summed for each scale separately and multiplied by two to allow comparison to the original 42-item DASS scale. No items are reverse scored. A higher score in a subscale represents a greater level of that particular psychological state. The separate depression, anxiety and stress scales have all repeatedly demonstrated good internal reliability (all Cronbach's $\alpha > .80$) (e.g., Osman *et al.* 2012). Reliability for the present study is as

follows: Anxiety (Cronbach's $\alpha = .80$), Stress (Cronbach's $\alpha = .88$) and Depression (Cronbach's $\alpha = .90$). The DASS-21 scale has repeatedly demonstrated a three factor structure representing the three separate scales (e.g., Norton 2007; Crawford and Henry 2003; Scholten *et al.* 2017; Sinclair *et al.* 2012). Table 1 contains the descriptive statistics for each of the dependent variables.

Key Independent variable. The main independent variable of interest was the number of friends participants reported having. This variable was elicited by asking participants to "Please indicate how many close friends you currently have". The question eliciting the number of close friends was modelled after Russell and colleagues (2012). However, instead of asking participants to indicate this number on a 7-point likert scale ranging from "none" to "11+", we asked participants to provide the actual number, as the number of friends is better operationalised as a count variable than a 7-point likert scale. The definition of a close friend was left to the interpretation of the participant based on previous findings that friendships are not easily defined in older adults (Adams, Blieszner and DeVries 2000).

Covariates. Four demographic covariates were included in this study as they have previously been linked to one or more of the dependent variables. Age was included as a continuous variable. Gender was included as a categorical variable with female being the reference category. Marital status was included as a categorical variable with response options being "In a relationship", "Married/Registered civil partnership", "Separated but still married or in a registered civil partnership", "Divorced" and "Widowed". The reference category for this variable was "Single, never married or in a civil partnership". Highest attained level of education was also included as a categorical variable with response options being "Some secondary school", "GCSE or equivalent", "A level or equivalent", "Undergraduate degree". The reference category for this variable was "Primary School".

Other measures were collected as part of a separate study, (the ideal number of friends, the Satisfaction with Life Scale (Diener, Emmons and Larsen 1985), as well as

three other measures of loneliness - the short De Jong Gierveld Scale (Jong-Gierveld and Tilburg 1999), the short Social and Emotional Loneliness Scale for Adults (DiTommaso, Brannen and Best 2004) and a direct measure of loneliness) but are not reported on here. Please see the following link for a study containing this information https://osf.io/5f2ph/?view_only=6617265f58804de9b0145806375bb6a6.

Procedure

Ethical approval was granted by the local ethics committee. Data were collected between May and July 2019. Once informed consent was obtained, participants completed all measures via an online questionnaire hosted by Qualtrics (Anon 2020) available at <https://www.qualtrics.com>. The demographic measures were completed first followed by each of the scales. The order these were presented in were randomised. The questions relating to the number of ideal and actual friends were completed last. The whole questionnaire took no longer than 20 minutes to complete.

Analytical Approach

All analyses were performed using R version 3.6.1 (R Core Team 2017). Observations which contained missing data for the independent variable and dependent variables were removed (13 cases) as were two outliers where the number of friends was listed as 105 (30 *SD* away from mean) and age as 66,123 years. Finally, due to the presence of extreme values and asymmetry (skewness = -1.37), the data were winsorized to 3 standard deviations for the number of friends (12 friends) variable (12 cases). This resulted in a final sample of 335 participants; 290 of which were recruited via Prolific and 45 via social media.

The data met the assumptions of non-multicollinearity, homoscedasticity and non-autocorrelation. The loneliness data met the assumption of normally distributed residuals. The three DASS variables all exhibited some skew in the distribution of

residuals. However, this is to be expected given that the majority of respondents were not currently experiencing high levels of depression, anxiety or stress. However, regression is relatively robust, therefore we used this technique (Berry 1993) and we further assessed the robustness of these models with other techniques (e.g., segmented regression).

Prior to performing regression analyses, some demographic factor levels were grouped to result in a more equal n per cell. For marital status, single and undisclosed were combined into one level. As were separated and divorced. For education, primary and secondary school were combined. Based on a visual inspection of the data and a plot of residuals, the fit of polynomial regression models were assessed for all dependent variables. It was found that a quadratic model had the best fit to the data in each case. This was based on the model with a statistically significant reduction in residual sum of squares as indicated by a Chi-Squared difference test. A Davies test was then employed to test for a non-constant regression parameter in the predictor. This was followed by segmented regression via the segmented package (Muggeo 2008) and multivariate adaptive regression spline analysis (“mars”) via the earth package (Milborrow, Hastie and Tibshirani 2011) to determine and confirm a breakpoint in the data. The segmented package utilises an algorithm which determines the breakpoint iteratively. Similarly, the earth package uses an algorithmic approach to examine breakpoints in the data. We also performed additional analyses including robustness checks - these can be found at https://osf.io/5f2ph/?view_only=6617265f58804de9b0145806375bb6a6 .

Results

Sample Characteristics

Sample characteristics and descriptive statistics are presented in Table 1. In the final sample 60% of participants were female and 40% were male. The mean age of participants was 69 years ($SD = 4.29$). Most participants reported being married or in a civil

330 partnership (62%) and having completed an undergraduate degree (35%).The average
331 number of close friends reported was four. All were residents of the United Kingdom.

Main Analysis

Correlations.

The bivariate correlations are presented in Table 2. Number of friends was significantly negatively associated with each of the dependent variables. Loneliness was significantly positively associated with each of the psychological well-being variables.

Table 1

Sample Characteristics (n = 335)

Characteristic	Statistic (Mean (SD) or n (%))
Age	69.36 (4.29)
Gender	
Female	201 (60)
Male	134 (40)
Marital Status	
Single	19 (6)
In a relationship	26 (8)
Married/ Civil Partnership	207 (62)
Separated	4 (1)
Divorced	50 (15)
Widowed	28 (8)
Undisclosed	1 (0)
Education	
Primary school	2 (1)
Some secondary school	28 (8)
GCSE's or equivalent	66 (20)
A level or equivalent	67 (20)
Undergraduate degree	116 (35)
Postgraduate degree	56 (17)
Number of Friends	4.26 (4.11)
Loneliness	40.22 (11.64)
Depression	6.99 (8.01)
Anxiety	3.68 (5.42)
Stress	8.23 (8.12)

Table 2

Zero-order correlations for study variables (n=335)

	No. of Friends	UCLA_Total	DASS_Depression	DASS_Anxiety
No. of Friends				
UCLA_Total	-0.50***			
DASS_Depression	-0.25***	0.59***		
DASS_Anxiety	-0.16**	0.37***	0.56***	
DASS_Stress	-0.13*	0.44***	0.72***	0.62***

Regressions.

Hierarchical OLS regression analysis with the inclusion of a quadratic term was performed for each of the outcome measures to test for a curvilinear relationship.

Loneliness After adjusting for all demographic information the final model was significant ($F(12,322) = 15.09, p < .001$). In this model both the linear term for number of close friends ($B = -4.78, p < .001$) and the quadratic term ($B = .27, p < .001$) remained significant. As quadratic relationships are difficult to interpret from coefficients alone, please see Figure 1.

Of the demographic covariates, only being married or in a civil partnership, in comparison to being single, was a significant predictor of loneliness ($B = -6.29, p = .006$). Those with this particular marital status reported less loneliness than those who were single. This final model explained 34% of the variance in loneliness scores (Table 3).

As suggested by the plot, there appears to be a point at which the effect of the number of close friends on loneliness is greatly reduced. A Davies Test indicated that there was a significant difference between the slopes when segmenting the regression line at 3.90 friends ($p < .001$). Breakpoint analysis via the “segmented” package further supported that a breakpoint could be elicited at this point ($\psi = 3.86, 95\%CI [2.77, 4.94]$). Multivariate adaptive regression spline analysis further suggested a knot at 4 close friends. This analysis suggests that the effect of additional close friends on loneliness is diminished once around four close friends are reached.

Table 3

	Loneliness				
	Model 1	Model 2	Model 3	Model 4	Model 5
Number of friends	−4.591*** (0.499)	−4.725*** (0.496)	−4.757*** (0.498)	−4.705*** (0.501)	−4.783*** (0.500)
Number of friends ²	0.253*** (0.044)	0.268*** (0.044)	0.272*** (0.044)	0.266*** (0.045)	0.274*** (0.045)
Marital Status: In a Relationship		−6.151* (2.858)	−6.235* (2.862)	−6.401* (2.867)	−5.243 [†] (2.899)
Marital Status: Married/ Registered Civil Partnership		−6.946** (2.243)	−6.896** (2.245)	−7.139** (2.259)	−6.290** (2.285)
Marital Status: Separated or Divorced		−3.958 (2.505)	−3.882 (2.508)	−3.738 (2.513)	−3.198 (2.520)
Marital Status: Widowed		−4.347 (2.814)	−3.953 (2.863)	−3.861 (2.865)	−3.022 (2.871)
Age			−0.096 (0.127)	−0.115 (0.128)	−0.090 (0.131)
Gender (Female→Male)				1.123 (1.138)	0.622 (1.158)
Education: GCSE or Equivalent					−1.938 (2.133)
Education: A Level or Equivalent					1.734 (2.151)
Education: Undergraduate Degree					1.849 (2.026)
Education: Postgraduate Degree					0.636 (2.228)
Constant	52.212*** (1.156)	58.144*** (2.467)	64.784*** (9.088)	65.734*** (9.139)	62.786*** (9.917)
<i>N</i>	335	335	335	335	335
R ²	0.316	0.342	0.343	0.345	0.360
Adjusted R ²	0.312	0.330	0.329	0.329	0.336
Residual Std. Error	9.656 (df = 332)	9.528 (df = 328)	9.534 (df = 327)	9.535 (df = 326)	9.486 (df = 322)
F Statistic	76.766*** (df = 2; 332)	28.443*** (df = 6; 328)	24.430*** (df = 7; 327)	21.497*** (df = 8; 326)	15.091*** (df = 12; 322)

[†] p<0.1; * p<0.05; ** p<0.01; *** p<0.001: Reference categories: marital status = single or undisclosed, gender = female, education = primary or some secondary school

Figure 1. Loneliness as a function of the number of friendships (curvilinear fit with 95%CI).

Breakpoint is determined by segmented regression

Depression After adjusting for all demographic information the final model was significant, ($F(12,322) = 4.43, p < .001$). In this model both the linear term for number of close friends ($B = -2.16, p < .001$) and the quadratic term ($B = .15, p < .001$) remained significant. The plot in Figure 2 demonstrates this relationship.

Table 4 summarises all models on depression. Of the demographic covariates, gender was a significant predictor of depression ($B = -2.72, p < .01$), with men reporting less depression than women. Educational attainment was also a significant predictor of depression (Table 4: all dummy variables $p < .01$). Those who reported that they had received an education past primary school level reported less depression than those that

366 had not. This model explained 11% of the variance in depression scores.

367 Similar to the effect for loneliness, there appeared to be a point at which the effect of
368 number of close friends on depression is greatly reduced. A Davies Test indicated that
369 there was a significant difference between the slopes when segmenting the regression line at
370 2.16 friends ($p < .001$). Breakpoint analysis via the “segmented” package in R confirmed
371 that a breakpoint could be elicited at this point ($\psi = 2.17$, $SE = .491$, 95%CI [1.19, 3.12]).
372 Multivariate adaptive regression spline analysis further suggested a knot at 2 close friends.
373 This analysis suggests that the effect of additional close friends on depression is diminished
374 once a cut-off of around two close friends is reached.

Table 4

Hierarchical OLS regression analysis to predict depression (+/- SE).

	Depression				
	Model 1	Model 2	Model 3	Model 4	Model 5
Number of friends	-2.096*** (0.393)	-2.066*** (0.397)	-2.016*** (0.397)	-2.136*** (0.395)	-2.162*** (0.399)
Number of friends ²	0.135*** (0.035)	0.135*** (0.035)	0.130*** (0.035)	0.143*** (0.035)	0.146*** (0.035)
Marital Status: In a Relationship		1.973 (2.287)	2.105 (2.284)	2.490 (2.262)	2.809 (2.309)
Marital Status: Married/ Registered Civil Partnership		0.132 (1.794)	0.053 (1.792)	0.617 (1.782)	0.822 (1.820)
Marital Status: Separated or Divorced		-0.195 (2.004)	-0.314 (2.002)	-0.649 (1.983)	-0.501 (2.008)
Marital Status: Widowed		1.164 (2.252)	0.543 (2.285)	0.328 (2.261)	0.600 (2.287)
Age			0.152 (0.101)	0.196 ⁺ (0.101)	0.196 ⁺ (0.104)
Gender (Female→Male)				-2.606** (0.898)	-2.721** (0.922)
Education: GCSE or Equivalent					-1.142 (1.699)
Education: A Level or Equivalent					-0.059 (1.713)
Education: Undergraduate Degree					0.088 (1.614)
Education: Postgraduate Degree					-0.357 (1.775)
Constant	11.982*** (0.910)	11.564*** (1.974)	1.083 (7.252)	-1.120 (7.211)	-0.940 (7.900)
<i>N</i>	335	335	335	335	335
R ²	0.105	0.110	0.116	0.139	0.142
Adjusted R ²	0.100	0.094	0.097	0.117	0.110
Residual Std. Error	7.599 (df = 332)	7.623 (df = 328)	7.609 (df = 327)	7.524 (df = 326)	7.556 (df = 322)
F Statistic	19.488*** (df = 2; 332)	6.776*** (df = 6; 328)	6.153*** (df = 7; 327)	6.559*** (df = 8; 326)	4.434*** (df = 12; 322)

† p<0.1; * p<0.05; ** p<0.01; *** p<0.001: Reference categories: marital status = single or undisclosed, gender = female, education = primary or some secondary school

Figure 2. Depression as a function of the number of friendships (curvilinear fit with 95%CI). Breakpoint is determined by segmented regression.

Anxiety After adjusting for all demographic information the final model was significant, ($F(15,319) = 1.74, p = .043$). In the final model, both the linear term for number of close friends ($B = -.74, p = .001$) and the quadratic term ($B = .04, p = .014$) remained significant. This quadratic relationship is illustrated in Figure 3. None of the demographic covariates were significant predictors of anxiety. This model explained 3.2% of the variance in anxiety scores. See Table 5 for all coefficients.

Figure 3 suggests a breakpoint after which there is no additional reduction from adding close friends. A Davies Test indicated that there was a significant difference between the slopes when segmenting the regression line at 2.51 friends ($p < .01$). Breakpoint analysis confirmed that a breakpoint could be elicited at this point ($\psi = 2.51$,

385 95%CI [1.02, 4.0]). Multivariate adaptive regression spline analysis further suggested a
386 knot at 3 close friends. This analysis suggests that the effect of additional close friends on
387 anxiety is diminished once a threshold of approximately three close friends is reached.

Table 5

Hierarchical OLS regression analysis to predict anxiety (+/- SE).

	Anxiety				
	Model 1	Model 2	Model 3	Model 4	Model 5
Number of friends ²	-0.980*** (0.275)	-0.944*** (0.276)	-0.941*** (0.278)	-0.976*** (0.279)	-0.970*** (0.280)
Number of friends2	0.066** (0.024)	0.064** (0.024)	0.064** (0.025)	0.068** (0.025)	0.067** (0.025)
Marital Status: In a Relationship		3.207* (1.591)	3.213* (1.595)	3.322* (1.597)	2.905 [†] (1.620)
Marital Status: Married/ Registered Civil Partnership		1.400 (1.249)	1.397 (1.251)	1.558 (1.258)	1.185 (1.277)
Marital Status: Separated or Divorced		0.988 (1.394)	0.983 (1.398)	0.887 (1.399)	0.720 (1.408)
Marital Status: Widowed		0.749 (1.567)	0.723 (1.596)	0.662 (1.596)	0.444 (1.604)
Age			0.006 (0.071)	0.019 (0.071)	-0.015 (0.073)
Gender (Female→Male)				-0.745 (0.634)	-0.469 (0.647)
Education: GCSE or Equivalent					-1.230 (1.192)
Education: A Level or Equivalent					-2.142 [†] (1.201)
Education: Undergraduate Degree					-2.305* (1.132)
Education: Postgraduate Degree					-1.397 (1.245)
Constant	5.943*** (0.636)	4.508** (1.373)	4.069 (5.064)	3.440 (5.089)	7.716 (5.540)
<i>N</i>	335	335	335	335	335
R ²	0.046	0.061	0.061	0.065	0.080
Adjusted R ²	0.040	0.043	0.041	0.042	0.045
Residual Std. Error	5.313 (df = 332)	5.305 (df = 328)	5.313 (df = 327)	5.310 (df = 326)	5.299 (df = 322)
F Statistic	8.026*** (df = 2; 332)	3.529** (df = 6; 328)	3.017** (df = 7; 327)	2.815** (df = 8; 326)	2.327** (df = 12; 322)

[†] p<0.1; * p<0.05; ** p<0.01; *** p<0.001: Reference categories: marital status = single or undisclosed, gender = female, education = primary or some secondary school

Figure 3. Anxiety as a function of the number of friendships (curvilinear fit with 95%CI). Breakpoint is determined by segmented regression.

Stress After adjusting for all demographic information, the final model was significant, ($F(12,322) = 2.448, p < .001$). In this model both the linear term for number of close friends ($B = -1.51, p < .01$) and the quadratic term ($B = .11, p < .05$) remained significant. This relationship is illustrated in Figure 4.

Of the demographic covariates, being in a relationship was a significant predictor of stress ($B = 6.15, p < .05$). Those who were in a relationship reported more stress than those who were single. This model explained 4.9% of the variance in stress scores. See Table 6 for all coefficients.

Figure 4 suggests the presence of a threshold above which there is no further reduction in stress with a further increase of reported close friends. A Davies Test

indicated that there was a significant difference between the slopes when segmenting the regression line at 2.05 friends ($p < .05$). Breakpoint analysis confirmed that a breakpoint could be elicited at this point ($\psi = 2.05$, $SE = .64$, 95%CI [0 .80, 3.30]). Multivariate adaptive regression spline analysis further suggested a knot at 2 friends. This analysis suggests that the effect of additional close friends on stress is diminished once around two friends are reached.

Table 6

Hierarchical OLS regression analysis to predict stress (+/- SE).

	Stress				
	Model 1	Model 2	Model 3	Model 4	Model 5
Number of friends	-1.462*** (0.412)	-1.396*** (0.413)	-1.374** (0.415)	-1.454*** (0.416)	-1.511*** (0.418)
Number of friends ²	0.104** (0.037)	0.103** (0.037)	0.100** (0.037)	0.109** (0.037)	0.112** (0.037)
Marital Status: In a Relationship		5.440* (2.380)	5.499* (2.384)	5.754* (2.380)	6.148* (2.421)
Marital Status: Married/ Registered Civil Partnership		1.607 (1.868)	1.571 (1.871)	1.946 (1.875)	2.249 (1.908)
Marital Status: Separated or Divorced		0.726 (2.086)	0.672 (2.089)	0.450 (2.086)	0.741 (2.104)
Marital Status: Widowed		1.760 (2.344)	1.482 (2.385)	1.339 (2.378)	1.563 (2.397)
Age			0.068 (0.105)	0.097 (0.106)	0.089 (0.109)
Gender (Female→Male)				-1.732 [†] (0.945)	-1.797 [†] (0.967)
Education: GCSE or Equivalent					-1.582 (1.781)
Education: A Level or Equivalent					-0.132 (1.796)
Education: Undergraduate Degree					-0.909 (1.691)
Education: Postgraduate Degree					0.935 (1.860)
Constant	11.449*** (0.955)	9.555*** (2.055)	4.858 (7.571)	3.394 (7.586)	4.349 (8.280)
<i>N</i>	335	335	335	335	335
R ²	0.042	0.063	0.064	0.074	0.084
Adjusted R ²	0.036	0.046	0.044	0.051	0.049
Residual Std. Error	7.976 (df = 332)	7.936 (df = 328)	7.943 (df = 327)	7.914 (df = 326)	7.920 (df = 322)
F Statistic	7.194*** (df = 2; 332)	3.661** (df = 6; 328)	3.192** (df = 7; 327)	3.233** (df = 8; 326)	2.448** (df = 12; 322)

[†] p<0.1; * p<0.05; ** p<0.01; *** p<0.001: Reference categories: marital status = single or undisclosed, gender = female, education = primary or some secondary school

Figure 4. Stress as a function of the number of friendships (curvilinear fit with 95%CI). Breakpoint is determined by segmented regression.

Discussion

The purpose of this study was to explore the relationship between the reported number of close friends and loneliness, depression, anxiety, and stress in older adults. Our findings demonstrated significant inverse curvilinear relationships between the number of close friends and each of these parameters. These findings support those of previous studies which demonstrated a negative relationship between the quantity of friends and loneliness (Lodder *et al.* 2017; Mullins and Dugan 1990; Nangle *et al.* 2003; Russell *et al.* 2012; Shiovitz-Ezra and Leitsch 2010). The present findings are also in line with previous work demonstrating that having a greater quantity of friends is associated with better

self-reported mental health (Bishop 2008; Cable *et al.* 2013; Horst and Coffé 2012; Huxhold *et al.* 2020; Montpetit, Nelson and Tiberio 2017; Nussbaum 1994; Potts 1997; Taylor *et al.* 2018). Russell and colleagues (2012) have previously demonstrated that there is an inverse curvilinear relationship between the discrepancy between the number of actual and ideal friendships and loneliness in college students. However, we believe a curvilinear relationship for the effect of close friends on each outcome measure has gone previously untested.

Inspection of the plots for each of the outcome measures shows that there are relatively few individuals who report having many friends whilst simultaneously experiencing high levels of loneliness, depression, anxiety or stress. We have discussed the notion that having a large social network may reduce emotional closeness across the relationships within it (Roberts *et al.* 2009) and in turn this lack of emotional closeness may increase feelings of loneliness (Drageset, Kirkevold and Espehaug 2011; Hamid 1989; Williams and Solano 1983). It may be that whilst these individuals report having many close friends, these relationships are not actually providing the closeness, connection, and understanding needed to stave off loneliness and its maladaptive correlates due to the size of their networks. However, further work, ideally of a longitudinal nature, is needed to corroborate this.

It is therefore possible that a small cluster of observations could be driving the quadratic fit. However, we believe that this is unlikely to be the case. Bootstrapping, which reduces the weight of extreme cases, further supported the curvilinear relationship (see supplementary materials). Further, we conducted segmented regression using both the “segmented” and “earth” packages to determine break-points in the data. These approaches reduce the effect of outliers and consistently detected break-points in the data (please see https://osf.io/5f2ph/?view_only=6617265f58804de9b0145806375bb6a6).

Thus, each of our mental health related variables demonstrated that there was a point past which the addition of more close friends no longer has a substantial beneficial

effect. An increase of close friends was associated with a decrease in loneliness until four close friends were reached, for depression this number was found to be two close friends, for anxiety three close friends and for stress the threshold was two close friends. A slightly larger threshold value for loneliness in comparison to the other mental health variables is to be expected, as loneliness is more directly related to social connections and interactions than the other psychological well-being outcomes. The presence of a friendship threshold in terms of loneliness could be due to a reduction in emotional closeness to network members as network size is increased (Roberts *et al.* 2009).

It is encouraging that the threshold for the number of close friends in each instance appears to be relatively low. Making and maintaining meaningful social connections takes time and effort (Lang *et al.* 2013). However, given that on average a person's closest group of contacts, known as their support group, has been found to include around five members (Dunbar and Spoors 1995), it is possible that many older adults will already have met this number, or be close to it. The elucidation of these thresholds for close friendships is important as they can allow those involved in loneliness and mental health interventions to focus their limited resources on increasing social interaction opportunities for those with few or no close friends. This would be with the ultimate aim of reducing the negative physical and psychological impacts of loneliness as well as reducing the economic cost and strain on health services associated with loneliness. As research has previously shown that perceived quality of relationships has a protective effect against loneliness (Hawkley *et al.* 2008; Pinquart 2003), those with more friendships than a threshold could be encouraged to improve the quality and closeness of their friendships, rather than increase the number of friends they have.

A successful intervention to reduce loneliness could include elements of the previously successful "Friendship Program" (Hamid 1989). This program encourages reflection on one's own aspirations for friendships as well as reflection on current friendships. It also incorporates education around attitudes and experiences in the process of building

friendship. This includes actively utilising those already established but lesser used connections for support and by encouraging a proactive approach to maintaining and deepening friendships. The program has been found to both improve the quality of current friendships as well to increase the number of friendships. Further benefits of improving the quality of these relationships include this having increased resilience to adversity (Graber, Turner and Madill 2016) and a more adaptive stress response (Calhoun *et al.* 2014).

Alternatively, these individuals could be included in interventions with the aim of improving the other contributing factors to loneliness and psychological well-being such as health status and mobility (Theeke 2009). These could include cognitive based interventions to improve mobility (Marusic, Verghese and Mahoney 2018) and physical activity interventions to improve mobility (Yeom, Keller and Fleury 2009) and health status (Hwang and Braun 2015). As well as directly targeting psychological well-being with the aim of reducing loneliness in tandem. In this regard, a variety of interventions have been shown to be successful including psychotherapy and behavioural interventions (Pinquart, Duberstein and Lyness 2007). In particular, reminiscence therapy has repeatedly demonstrated a positive outcome in relation to depressive symptoms and subjective wellbeing (for a review see Yen and Lin 2018). This type of therapy involves recalling events from the past and sharing them with an observer or group who listen without making comment.

The present study has a number of strengths. To our knowledge, it is the first to explore the possibility of a curvilinear relationship between the quantity of close friends and loneliness, as well as its associated psychological well-being outcomes in an older adult population. It is also the first to assess the presence of break-points within this relationship. As mentioned previously, for both of these analyses robust techniques were employed to increase confidence in our findings.

We also explicitly focussed on close friendships and did not include any peripheral

friendships. This is because emotional closeness has repeatedly been shown to be more important than network size and frequency and contact with friends in terms of loneliness (Drageset, Kirkevold and Espehaug 2011; Hamid 1989; Williams and Solano 1983). Close friends also appear to be more important than less close friends in regards to subjective well-being (Horst and Coffé 2012). We asked participants specifically to include only friends that they thought of as close, although the interpretation of a close friend was left to the participant, this reduced any confusion about who to include in this number. This clarity has not always been present in previous studies (e.g., Pinquart 2003; Savikko *et al.* 2005; Steed *et al.* 2007).

However, the current study is not without its limitations. Firstly, the present research was an online study only available to those with access to the internet. Many older adults do not have this access (Yu *et al.* 2016) and/or autonomy with internet use (Hargittai, Piper and Morris 2019) and so the current findings are not representative of the UK population. Second, the definition of a close friend was left to each participant's own interpretation. Respondents were able to decide what a close friend meant to them, and to allocate their personal contacts accordingly. Although in previous studies, similar to ours, no definition for friendships has been given (e.g., Mullins and Dugan 1990; Russell *et al.* 2012), individual interpretations may differ between participants and providing an explicit definition, such as in Williams and Solano's study (Williams and Solano 1983), may have resulted in different findings. However, we believe that leaving this concept open to interpretation allows for more accurate inclusion of those whom respondents feel close to, rather than forcing them to exclude contacts based on a definition which may be incompatible with respondents' own views. This is something that has been cautioned against previously by Adams and colleagues (2000) who outline that it is not suitable to assign a definition of friendship to individuals as many do not share the same criteria for this type of relationship. Therefore, future research may benefit from repeating the study to include face-to-face data collection for those without access to the internet and

potentially the incorporation of an established definition of a close friend and comparing if this differs from a respondent's definition.

As mentioned previously we focussed on only close friendships. Doing so allowed the determination of the number of high quality and rewarding friendships that individuals should focus on to reduce loneliness and improve psychological well-being. This is important as these emotionally close friendships require bilateral effort, time and other resources to initiate and maintain and as such are more costly in comparison to less emotionally close relationships (Roberts and Dunbar 2011). However, despite the importance of these close relationships in terms of loneliness, more peripheral friendships could still be having an impact on our outcome measures. It may be beneficial for future work to take into account these friendships also.

Further, the present study did not explicitly take into account the impact of the quality of friendships on loneliness and mental health. Although we have mentioned the minority of participants who may have been experiencing low levels of closeness in the friendships they reported, as participants were asked *specifically* about close friends, it is likely that many of these contacts represent high quality relationships. Regardless, as the quality of friendships has been linked to loneliness and mental health (e.g., Mullins and Dugan 1990; Wheeler, Reis and Nezlek 1983), future studies would benefit from also including the quality or emotional closeness of these friendships explicitly as a covariate to determine whether the effect of the number of friends remains after adjusting for this.

Similarly, the present study did not account for the types of support that can be exchanged within friendships. Both emotional and instrumental support within social networks have been shown to predict levels of loneliness (e.g., Sanchez, Gierveld and Delgado 2012). Including the type support both given and received within close friendships in future analyses could assist in unpicking the aspects of these friendships which are most optimal in preventing loneliness in this age group.

It is important to note that the number of close friendships is not the only aspect of an individual's social network with implications for loneliness within this age group. Structural and compositional aspects of this network can also explain loneliness and its associated negative outcomes. For example, it has been demonstrated that social network size as well as brokerage and embeddedness can predict loneliness in older adults (Kim *et al.* 2021). Compositionally, the presence of a romantic partner is protective against loneliness (Martina 2021). This could potentially be due to the increased opportunity for accruing additional friends within a social network. The inclusion of such parameters in the above analyses would provide a deeper understanding of the effect of the number of close friendships on loneliness in older adults after controlling for these aspects.

In terms of additional future directions, as well as a replication, and taking into account the aforementioned issues, future research should establish who these close friends are. We know that these are emotionally close relationships but is there a difference in the impact on loneliness and psychological well-being in terms of the length of the relationship and whether these contacts belong to a dense network? Is it preferable to have contact with these friends in a certain way for a certain length of time or at a particular frequency? Or is the content of the interactions more important? Previous research suggests that network density is important in terms of happiness and subjective well-being (Huang *et al.* 2019) and that frequency of contact has a differential effect on subjective well-being dependent on the mode utilised (Horst and Coffé 2012). Therefore these nuances are possible and should be explored in order to further inform interventions. Importantly, the current investigation was cross-sectional in nature. It may well be possible that there is a limit to the benefit of increasing the number of friendships over time. It also may be possible that having a larger number of friends leads to improved well-being. However, we cannot rule out the possibility of reverse causation. A longitudinal design would be necessary to determine this in future.

For now we conclude that there is a nonlinear relationship between the reported number of friends and loneliness, depression, anxiety and stress in older adults. We further

572 conclude that based on the present data there appears to be a limit to the beneficial effect
573 of increasing the number of friends in this population. The findings are in need of
574 corroboration incorporating a more representative sample of this population and future
575 work is necessary to further qualify the nature of these friendships. However, these findings
576 have important implications in the development and provision of loneliness and
577 psychological well-being interventions.

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The Authors declare that there is no conflict of interest

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