Social isolation in mid-life: associations with psychological distress, life satisfaction and self-rated health in two successive British birth cohorts

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Abstract

Background and Objectives: Social isolation can be quantified using indicators across a range of social contexts e.g., household composition, friends and family, employment and community. Little is known about the way in which different forms of isolation differentially impact health, whether they produce a 'dose-response' effect, and whether different forms of isolation interact in an additive or multiplicative way to impact psychological distress, life satisfaction and general health. The current study focuses on social isolation in mid-life – a life stage often neglected by the field.

Research Design and Method: Data (N=32,391) were analysed from two successive British birth cohort studies: 1970 British Cohort Study (BCS) N=16,585 and the 1958 National Child Development Study (NCDS) N=15,806 focusing on participants' social isolation during mid-life (ages 42-46). Linear multivariable regression models were run to investigate the independent, 'dose-response' and interactive associations of social isolation indicators with psychological distress, life satisfaction and self-rated general health. Subsequently, all models were stratified to examine sex differences, and a cohort interaction was tested to assess cohort effects. An additional latent class analysis investigated whether different forms of isolation cluster in mid-life.

Results: Independent associations varied by form of isolation and specific health outcomes, for instance, being out of education and employment was associated with all outcomes, living alone was only associated with lower life satisfaction and a lack of frequent contact with friends and relatives, no labour market participation and limited community engagement were associated with lower life satisfaction and self-rated general health. There was a 'dose-response' relationship with higher social isolation scores associated with greater psychological distress, lower life satisfaction, and poorer self-reported general health. The effects of different combinations of social isolation on health appears to be additive, with no consistent sex and cohort differences observed.

Conclusions: Results support a multi-domain, multi-context approach to studying social isolation and provides justification for research that investigates the separate and combined effects of different forms of social isolation; and the relevance of investigating social isolation in relation to the complete state of physical, mental and social wellbeing. Overall, isolation in its various forms was found to be detrimental for health, in mid-life, and over time in Great Britain. In particular, social isolation was associated most consistently with lower levels of life satisfaction. Efforts to reduce social isolation and its negative health impacts must recognise the complexity of experience across contexts and for different populations.

Keywords: social isolation, mental health, psychological distress, life satisfaction, self-rated general health, subjective wellbeing, mid-life

Introduction

Social isolation can be quantified using indicators across multiple domains and relational contexts (Holt-Lunstad et al., 2015; Huisman & van Tilburg, 2021), for example, living alone or infrequent contact with friends, family and people in the community. An individual's objective social conditions are distinct from, although related to, their qualitative assessment of the meaning, value and function of social relationships (Hughes et al., 2004), and also how the circumstances arose e.g., chosen solitude. This is one reason why loneliness, the negative feeling arising from the perceived inadequacy of the quantity and quality of relationships (Zavaleta et al., 2017), is experienced by some individuals and not others (de Jong-Gierveld et al., 2006; Perlman & Peplau, 1984; Power et al., 2019). In fact, recent research suggests that isolation does not predict changes in loneliness at the within-person level (Luo & Li, 2023). Investigating social isolation as an objective condition helps to identify structural barriers leading to a lack of connectedness (d'Hombres et al., 2021; Huisman & van Tilburg, 2021). By analysing different experiences of social isolation across contexts, researchers can better understand specific conditions leading to poor health that are modifiable through policy (Klinenberg, 2016; Luo & Li, 2022). This paper primarily focuses on social isolation in mid-life and its association with psychological distress, life satisfaction and self-rated general health. We use health as an umbrella term in line with the World Health Organization's (WHO) definition i.e., health as a complete state of physical, mental and social wellbeing (WHO, 1948).

Before the Covid-19 pandemic, the European Social Survey revealed that 8.6 percent of the adult population frequently experienced loneliness whereas over double (20.8%) reported social isolation (d'Hombres et al., 2021). This finding was recently replicated across four British longitudinal, population-based studies, with higher rates of social isolation compared with loneliness in older age adults before and during the pandemic (Mansfield et al., 2023). Differences in prevalence point to the fact that social isolation and loneliness are only moderately associated (Hughes et al., 2004). During later life, social isolation predicts lower wellbeing and mortality independently from loneliness and explains more variance in poor health outcomes (Coyle & Dugan, 2012; Golden et al., 2009; Holt-Lunstad et al., 2015; Steptoe et al., 2013). Potential processes through which isolation and poor health are associated are reduced access to health resources and limited accountability for positive health behaviours due to a small social network (Berkman et al., 2000). Despite independent associations with health outcomes, social isolation and loneliness are often conflated in policy and research (Wigfield, 2020; Wigfield et al., 2022), and few studies focus primarily on social isolation (Holt-Lunstad & Steptoe, 2022; Loades et al., 2020). A range of individual indicators of social isolation have been identified as risk factors for poor health in later life (e.g., living alone); however, multiple types of isolation are rarely studied together (Cornwell & Waite, 2009).

During post-retirement age, people lack work networks, are less likely to have dependent children in the household or within close proximity and are more likely to experience spousal bereavement. It is understandable then, that there is a much larger evidence base relating to social isolation as a risk factor for poor health in this population compared to other life stages (Blazer, 2020). For example, Coyle and Dugan (2012) demonstrate the independent associations of loneliness and social isolation with mental and physical health in later life,

showing isolation to be more strongly associated with poorer self-rated health than loneliness. There is also a growing body of literature in childhood and adolescence showing that positive aspects of social contact, e.g. close friendships, spending time with and receiving social support from friends, and school attendance are protective factors for mental health (Myklestad et al., 2012; Patalay & Fitzsimons, 2016). Studies are also emerging that evidence the negative mental health impacts of social isolation independent from loneliness in this population (Christiansen et al., 2021). However, the significance of social isolation in mid-life has, until recently, been overlooked, despite being characterised by lower wellbeing (Blanchflower & Oswald, 2008), and diverse family networks, household compositions, labour market participation, and care responsibilities that bridge the gap between younger and older generations (Lachman, 2015).

Age stratified, cross-sectional analysis of the Swiss Health Survey found a negative association between social isolation and health outcomes across early, mid, and later life (Hämmig, 2019). However, more recent longitudinal analysis using the New Zealand birth cohort, provided better causal evidence for accelerated brain ageing and related negative health outcomes in individuals reporting social isolation in mid-life (Lay-Yee et al., 2023), emphasising the importance of this distinct life stage. Findings from the National Child Development Study, a British birth cohort born in 1958, demonstrated the function of social resources in reducing risk of mental health symptoms after exposure to stress in mid-life (Sehmi et al., 2020). An overall indicator of social resources was generated by combining objective social network data and qualitative assessments of perceived social support. Similarly, the English Longitudinal Study of Ageing (ELSA) was used to create typologies of loneliness, living alone and social isolation to examine their relationship with health (Smith & Victor, 2019). However, the combination of objective and subjective experiences did not permit investigations of the independent, interactive, and cumulative impact of different experiences of social isolation on health.

In the most comprehensive research to date, Luo and Li (2022) focused primarily on social isolation trajectories in mid and later-life and their associations with health in the United States (US) using the Health and Retirement Study (HRS). Using multiple social isolation indicators (e.g., social engagement, network composition and frequency of contact) as well as subjective assessments, the study identified four distinct patterns of isolation, with the most severely isolated participants showing greater functional limitations, depressive symptoms, memory deficits, and the lowest self-rated health. Interestingly, the group with the best health outcomes were characterised by the highest level of social engagement, suggesting that social activity may provide stronger health benefits than subjective experiences of social support. Investigating social isolation experiences independently and in combination provides a more nuanced picture, revealing the most toxic social conditions for health and potentially protective social connections. For example, the negative mental health impact of living alone in Ghana and Finland was found to be attenuated by physical activity and social circumstances and participation e.g., being in contact with family and friends (Gyasi et al., 2020; Pasanen et al., 2021).

Despite increased policy focus on social isolation and loneliness in the United Kingdom (UK), there is limited evidence from large scale, population-based studies on social isolation and its relationship to health. More research is needed that captures multiple indicators of social isolation across a range of relational contexts, to investigate the independent, cumulative and interactive associations. Understanding the patterning of social isolation in mid-life using a latent class framework could help to better understand the specific conditions leading to poor health that are modifiable through policy.

As noted above, there is an increasing evidence base for adolescents and older adults, but mid-life is often overlooked. The diversity of experience at this life stage, in addition to patterns of lower wellbeing, make this an important population for studying the impact of social isolation on health. By analysing two successive birth cohorts born in 1970 and 1958, the current study also offers cross-cohort perspectives to better understand if different social isolation experiences are associated with health consistently over time.

Analyses in the current study were stratified by sex given known differences in social isolation experiences between males and females (Mansfield et al., 2024). For example, males were found to be generally more socially isolated in a US longitudinal study based on items relating to romantic relations, friends, family and the community (Umberson et al., 2022). The extent of social isolation experienced by males in England has also been found to be more consistent across the lifecourse when compared to females (Read et al., 2020). Stratification of all analyses by sex, and analysis of cohort effects, provides the opportunity to consider social isolation within different time periods and increasingly diverse and complex life course trajectories with regards to family formation, care, and labour market participation (Roberson et al., 2017; Widmer & Ritschard, 2009). While we refer to literature relating to gendered patterns in social isolation, we must acknowledge that in the current study we stratify analyses by sex at birth as opposed to gender identity and are therefore only able to comment on sex differences.

Aims and Research Questions

The aim of the current study was to identify the independent, 'dose-response' and interactive associations of different forms of social isolation with psychological distress, life satisfaction and self-rated general health in mid-life, and to explore sex and cross-cohort differences. We set out to answer the following research questions:

(1) What are the independent associations between different forms of social isolation and health outcomes in mid-life, and are there sex and cohort differences?
(2) What is the 'dose-response' association between multiple forms of social isolation and health outcomes in mid-life, and are there sex and cohort differences?
(3) Is the effect of different combinations of social isolation on health outcomes additive or multiplicative, and are there sex and cohort differences?
(4) Do different forms of social isolation cluster in mid-life, and if so, how do these clusters associate differentially with health outcomes?

Method

Data Sources

Data were from two successive British birth cohort studies: the 1970 British Cohort Study (1970 BCS) (Elliott & Shepherd, 2006; Sullivan et al., 2022) and the 1958 National Child Development Study (1958 NCDS) (Power & Elliott, 2006). Cohort members were born in Great Britain (i.e., England, Wales & Scotland) in one week of 1970 and 1958 respectively, with regular follow-up surveys from birth. Social isolation was assessed during mid-life at age 42 (2012) (1970 BCS) and 46 (2004) (1958 NCDS) and data on health outcomes was taken at the next available sweep at age 46 (2016) (1970 BCS) and 50 (2008) (1958 NCDS).

Analytic sample

For both cohorts, the analytic sample was defined by the target population of the most recent sweep used in the analysis i.e., those alive and residing in Great Britian at age 46 in 1970 BCS (N=16,585) and age 50 in 1958 NCDS (N=15,806). For a summary of participants' demographic, socioeconomic, and health characteristics, both imputed and complete case, see Supplementary Tables S1 and S2.

Measures

Social isolation

Social isolation is a multi-dimensional construct measured in this study by a range of self-reported indicators across different relational contexts (e.g., household, community). Similar items across cohorts were identified indicating social isolation within the household (i.e., living alone), a lack of regular contact with friends and relatives outside of the household, education and employment status, and a lack of regular community engagement including community groups, religious activity, and volunteering. To ensure completeness of isolation indicators and consistency across cohorts, items were taken from sweeps between the ages of 42-46. For example, in the 1970 BCS, data were from the age 42 sweep except from information relating to cohort members' engagement with community groups or organisation which was taken at age 46. In the 1958 NCDS, data were from the age 46 sweep with the exception of frequency of contact with friends and relatives outside the household which was captured at age 44. Items were harmonised across cohorts to provide simple indicator variables where 1 = socially isolated e.g., living alone =1, being out of education and employment = 1. For connectedness to family and friends, participants were deemed isolated if they had no regular (at least monthly) contact with friends and relatives outside of the household. An isolation indicator was created for community engagement whereby a participant was deemed isolated if they satisfied two of the three criteria: did not engage in regular (at least monthly) religious activity, were not a volunteer and were not a member of a community group or organisation. To understand the 'dose-response' association i.e., the severity of outcomes according to the degree of isolation across contexts, a cumulative social isolation score was also generated. The total score was between 0-4 where 0 = no social isolation and 4 = high social isolation; however, due to small counts for social isolation scores of 4, scores of 3 and 4 were combined. Different combinations of indicators were examined using interaction terms to understand if any particular combination of isolation experiences was more strongly associated with health in mid-life compared to others. For more detail on the items and coding of social isolation variables, see Supplementary Table

S3. Table 1. presents the descriptive statistics for social isolation indicators and health outcomes.

Health Outcomes

Psychological distress

In the 1970 BCS at age 46 and in the 1958 NCDS at age 50, psychological distress was captured using the Malaise 9-item Questionnaire (Rodgers et al., 1999; Rutter et al., 1970). The 9-item version provides a reliable and valid assessment of psychological distress that is consistent within and between generations, suggesting that participants' understanding of the mental health items is comparable across these two cohorts (Ploubidis et al., 2019).

Subjective wellbeing – life satisfaction

Subjective wellbeing was captured in both the 1970 BCS and 1958 NCDS using a measure of life satisfaction. Cohort members were asked to indicate on a scale of 0-10 how satisfied or dissatisfied they were with the way their life had turned out so far, where 0 indicates "*completely dissatisfied*" and 10 indicates "*completely satisfied*".

Self-rated general health

Self-rated general health was measured in both cohorts with the item: 'In general, would you say your health is...1 "*excellent*" 2 "*very good*" 3 "*good*" 4 "*fair*" 5 "*poor*"?'. The item was recoded so that good self-rated health was indicated by higher scores.

Demographic, socioeconomic and health characteristics

Cohort members' sex was used to stratify analyses to understand possible differences in the impact of social isolation on health between males and females. Education (highest level of educational achievement (degree vs. no degree), was included as a covariate alongside socioeconomic variables: self-reported financial difficulties, occupational social class, and home ownership. Self-rated psychological distress and general health were also included as well as a binary indicator of limiting long-standing illness. Inclusion of a covariate set aimed to minimise possible confounding and socio-economic and health characteristics were taken from the most recent sweep available prior to mid-life in an attempt to avoid any reverse causality. For more detail on the items and coding of demographic, socioeconomic and health covariates, see Supplementary Table S3.

Analysis Strategy

Missing data strategy

Non-randomness in discontinued participation and item non-response can lead to biases in estimates. Therefore, it was important to retain as much data as possible from underrepresented groups and account for non-response biases in analyses. Predictors of non-response in 1970 BCS and 1958 NCDS have been identified in previous research, improving the plausibility of the missing at random (MAR) assumption (Mostafa & Wiggins, 2014; Mostafa et al., 2021). The selection of auxiliary variables in the current study i.e., variables known to predict missingness which therefore help estimate imputed values, were informed by this earlier work (Mustillo & Kwon, 2015). The selected auxiliary variables (e.g., birth weight, parents' social class and education level, home ownership, and childhood cognitive

ability) and all study variables were included in multiple imputation (MI) models using chained equations. Item non-response on study outcomes was low (<5%) however, due to lack of participation in the most recent data collection sweep, between 38-53% of cohort members were missing this information. MI is preferable to complete case analysis and produces less biased estimates, even with a relatively high percentage of missing data (Lee & Huber, 2021). Based on the overall proportions of missingness in the outcomes and standard recommendations, we chose to run 50 imputations (Sullivan et al., 2015; Lee & Huber, 2021) (see Supplementary Table S4. for more information on levels of missing data). For some auxiliary variables, response options were collapsed to reduce the number of categories to help imputation models converge. Due to working with two cohort studies, social isolation indicators were first recoded to ensure consistency across cohorts. Imputations were run using derived variables to ensure that the imputations and analyses were fully compatible. Sensitivity analyses were conducted for all models using an 'impute and delete' method (Von Hippel, 2007), analysing only those with data on study outcomes. This method can introduce biases in the presence of auxiliary variables associated with incomplete outcomes (Sullivan et al., 2015), it was therefore decided to include these models as supplementary as opposed to choosing this method for the main analyses. Results in a complete case sample are also presented as supplementary material.

Independent effects

All analyses were conducted using Stata 17 software (StataCorp, 2021). Linear multivariable regression models were run for each separate social isolation indicator with psychological distress, life satisfaction and self-rated general health as the outcomes. This determined the size of effect for different social isolation experiences across contexts. All models were stratified by sex and included the full covariate set and a cohort interaction term estimated to identify differences in association between social isolation and health across cohorts. Only the coefficient for the social isolation variable of interest was interpreted in each model to avoid table 2 fallacy (Westreich & Greenland, 2013).

'Dose-response' effects

The 'dose-response' effect of experiencing multiple forms of social isolation was explored by repeating the above models but replacing the independent social isolation indicator with a cumulative social isolation score between 0-4 where a higher score indicated greater social isolation. Due to low numbers of cohort members reporting 4 experiences of social isolation, those with a score of 3 or 4 were combined to give a scale between 0-3.

Additive and multiplicative effects

2-way interaction terms were created for all 6 combinations of the 4 social isolation experiences (e.g., living alone*out of education and employment), and included in linear multivariable regression models as outlined above. By identifying whether effects were additive or multiplicative, this analysis revealed which combinations of social isolation experiences were most toxic for health. Analyses were stratified by sex and an additional 3-way interaction term included for social isolation interaction term*cohort to understand any cohort differences. Significant interactions (p<.10) were visualised using margins plots.

Latent class analysis

To understand how different experiences of social isolation cluster in mid-life, latent class analysis was adopted to identify groups of individuals showing qualitatively similar patterns in their social conditions (Weller et al., 2020). First, latent class analysis generates probabilities for who belongs to which group or class. Then, the models describe the relationship between classes and the observed variables. To understand the optimal number of social isolation groups within the current data, models were run estimating an increasing number of classes between 1 and 5. When selecting the class solution, goodness-of-fit statistics were used in combination with a theoretical interpretation (Weller et al., 2020). The Bayesian information criteria (BIC) is the most commonly used criteria, with a lower BIC indicating better fit (Killian et al., 2019). We assessed both the BIC and the adjusted Bayesian information criteria (ABIC). The Akaike information criterion (AIC) indicated the adequacy of different non-nested models, where lower IC indicates a more adequate model (Wagenmakers & Farrell, 2004). In addition to these ICs, we calculated the entropy and posterior class-membership probabilities (Celeux & Soromenho, 1996) where an entropy value closer to 1 is preferable, and average latent posterior probabilities of greater than .90 are desirable (Muthén & Muthén, 2000). The Vuong-Lo-Mendell-Rubin adjusted likelihood ratio test also helped determine the final class solution (Lo et al., 2001; Vuong et al., 1989). Finally, we considered the general rule that classes should not contain less than 5% of the sample (Shanahan et al., 2013). Latent classes were assessed by sex and cohort. A Full Information Maximum Likelihood (FIML) approach to handling missing data was applied in Mplus eighth edition (Muthén & Muthén, 2017) for the latent class analyses.

Table 1. *Descriptive statistics for social isolation indicators and health outcomes using multiply imputed data m=50 (1970 BCS N = 16,585 and 1958 NCDS = 15,806)*

Variable	1970 BCS		1958 NCDS	
	Age (year)	%	Age (year)	%
Social Isolation Indicators				
Living alone (if yes)	42 (2012)	10.03	46 (2004)	9.71
				1.21
Lack of regular contact with friends and relatives outside of the household (if yes)	42 (2012)	3.74	44 (2002)	
Out of education and employment (if yes)	42 (2012)	15.22	46 (2004)	13.85
Lack of community engagement (if yes)	42 (2012)	76.53	46 (2004)	78.44
	46 (2016)			
Total social isolation score (0-3)*	42 (2012)		46 (2004)	
0		18.04		17.57
1		61.16		63.73
2		18.16		16.65
3		2.64		2.05
Health Outcomes				
Psychological distress (Mean(SE))	46 (2016)	1.89(.02)	50 (2008)	1.56(.02)
Subjective wellbeing - life satisfaction (Mean(SE))	46 (2016)	7.26(.02)	50 (2008)	7.22(.02)
Self-rated general health (Mean(SE))	46 (2016)	3.38(.01)	50 (2008)	3.42(.01)

Note: * *Due to small counts for social isolation scores of 4, scores of 3 and 4 were combined.*

Results

Independent effects

Figure 1. presents the standardised regression coefficients for the independent associations of social isolation indicators with psychological distress, life satisfaction and self-rated general health. A lack of frequent contact with friends and relatives, no labour market participation and limited community engagement were associated with lower life satisfaction and self-rated general health. However, living alone was only associated with lower life satisfaction. Being out of education and employment was the social isolation indicator most consistently associated with poorer mental health and wellbeing. Supplementary Table S5. includes all results from the linear multivariable regression models for each separate social isolation indicator to identify independent effects and cohort interaction effects on psychological distress, life satisfaction and self-rated general health using multiply imputed data.

The interaction between being out of education and employment and cohort was associated with life satisfaction and self-rated general health such that, the life satisfaction and general health of those born in 1958 was more negatively impacted by being out of education and employment when compared with those born in 1970. A similar cohort interaction was present for the association between living alone and self-rated general health such that there was a more negative health impact for those living alone in the 1958 birth cohort. The detrimental effects of some social isolation experiences in mid-life were therefore more pronounced for those born in 1958 (mid-life survey 2004) when compared to those born in 1970 (mid-life survey 2012) (see Supplementary Figure S1. a, b, c and d for marginal mean plots for the significant interaction effects). However, the opposite was found for the association between a lack of frequent contact with friends and relatives and psychological distress, with those born in 1970 experiencing higher psychological distress associated with a lack of frequent contact. No sex differences were found. Models were run with the full set of demographic, socioeconomic and health covariates.

Figure 1. *Standardized regression coefficients for the independent associations of social isolation indicators with psychological distress, life satisfaction and self-rated general health (N = 32,391)*

'Dose-response' effects

To understand the 'dose response' effect of experiencing multiple forms of social isolation on health outcomes, independent social isolation indicators were replaced with a cumulative social isolation score, where a higher score indicated greater social isolation. Scores ranged from 0-4; however, due to very low frequency of scores of 4, these scores were combined with scores of 3 resulting in a range of 0-3. Results from the multiply imputed linear multivariable regression models can be found in Table 4. Cumulative social isolation was associated with all health outcomes such that the greater the level of social isolation i.e., the more forms of social isolation experienced, the higher the psychological distress and the lower the life satisfaction and self-rated general health. However, results from the independent models indicate that the association between overall level of social isolation and health outcomes is driven more by some forms of isolation than by others. The interaction between cumulative social isolation and cohort was associated with self-rated general health. Despite lower levels of self-rated general health for those born in 1970, the difference between the general health of this cohort and those born in 1958 was smallest for cohort members with a high social isolation score of 3 and much larger for those with low scores of 0. This shows that the health of the two cohorts is more similar for those with higher levels of social isolation. See Supplementary Figure S2. for the marginal mean plot.

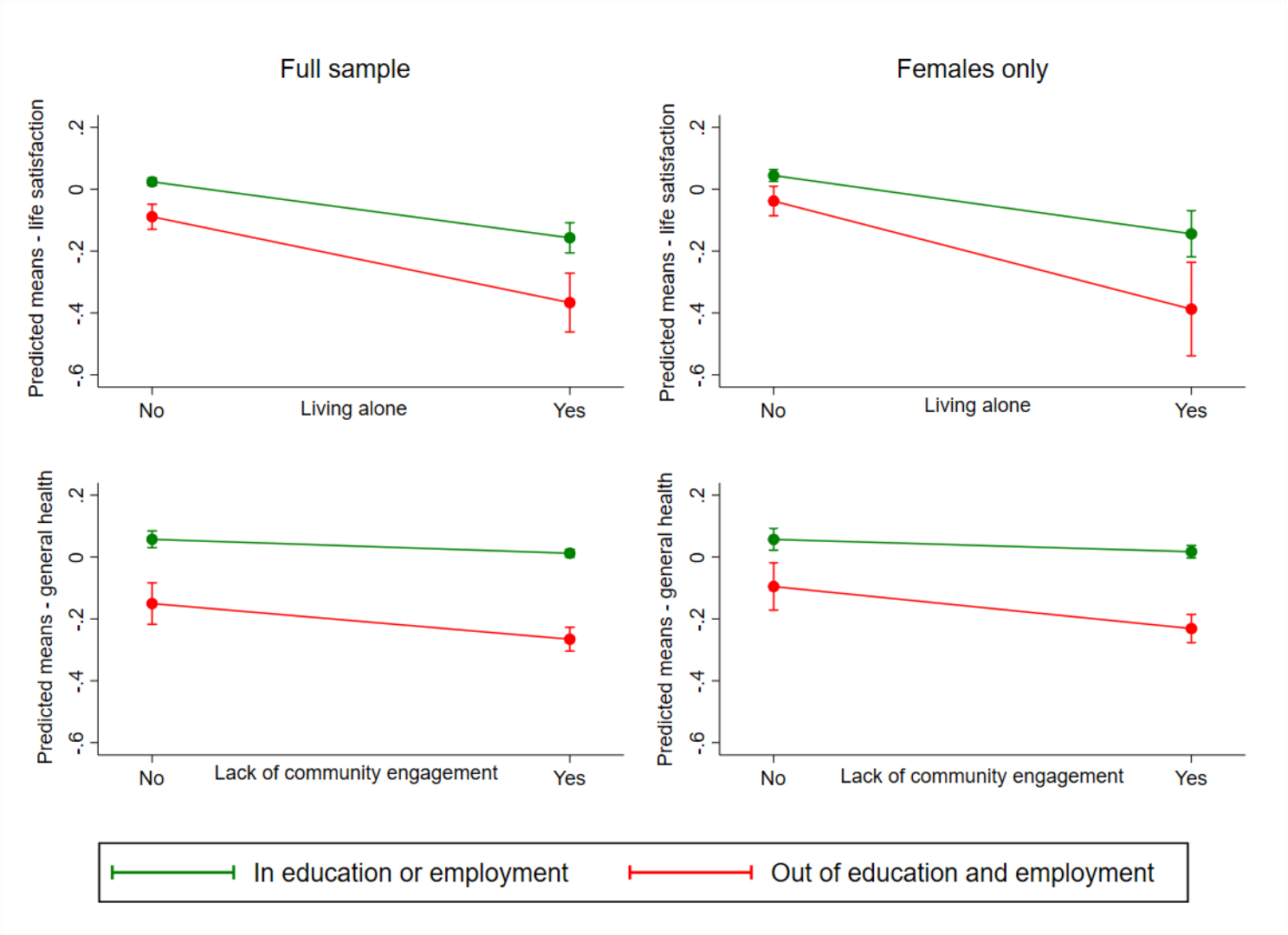
Table 4. *Linear multivariable regression models for the cumulative social isolation score to identify 1) 'dose response' effects using the cumulative social isolation score, and 2) cohort effects in any 'dose-response' associations with psychological distress, life satisfaction and self-rated general health –multiply imputed (m=50) models (N = 32,391)*

All coefficients presented are for the cumulative social isolation score as the exposure	Psychological distress coef [95% CI] *N*		Life satisfaction coef [95% CI] *N*		Self-rated general health coef [95% CI] *N*	
	(1)'Dose response'	(2)*Cohort	(1) 'Dose response'	(2)*Cohort	(1)'Dose response'	(2)*Cohort
Full sample model	.070*** [.046 - .094] *32,391*	-.007 [-.045 - .032] *32,391*	-.119*** [-.143 - -.094] *32,391*	-.003 [-.040 - .034] *32,391*	-.106*** [-.127 - -.086] *32,391*	-.081*** [-.122 - -.039] *32,391*
Males only	.064*** [.033 - .095] *15,810*	-.011 [-.061 - .039] *15,810*	-.128*** [-.159 - -.097] *15,810*	-.006 [-.057 - .046] *15,810*	-.108*** [-.137 - -.079] *15,810*	-.087*** [-.144 - -.031] *15,810*
Females only	.079*** [.050 - .109] *15,221*	-.009 [-.061 - .044] *15,221*	-.108*** [-.139 - -.077] *15,221*	-.000 [-.052 - .051] *15,221*	-.108*** [-.132 - -.083] *15,221*	-.071*** [-.122 - -.020] *15,221*

Note: *All models are adjusted for the full covariate set and are run once with a cohort dummy variable and again to include a cohort interaction term (*cohort). Coefficients are reported for 'dose response' and cohort interaction effects.*

**** p<0.01, ** p<0.05, * p<0.1*

Figure 2. *Model predicted marginal mean plots for significant (p<.10) interactions between multiple social isolation indicators in the full imputed sample (N = 32,391) and for females only (N = 15,221)*



Additive and multiplicative effects

The only significant interactions (p<.10) were being out of education and employment by living alone on life satisfaction and being out of education and employment by lack of community engagement on self-rated general health. Cohort members out of education and employment had lower life satisfaction and general health overall; however, the difference in scores between those in and out of education and employment was greatest for those living alone and lacking community engagement. Individuals who lived alone and were out of education and employment reported the lowest levels of life satisfaction. Furthermore, those lacking community engagement showed poorer self-rated general health compared with cohort members engaging more with their community. This difference was much larger for individuals who were also out of education and employment. These interactions were found to be significant in the same direction in the female only sample but not in the male only sample (see Figure 2.). No additional three-way interactions by cohort were observed. For the full set of results from the linear multivariable regression models using multiply imputed data, see Supplementary Table S9.

Latent class analysis

Latent class models were run estimating an increasing number of classes between one and five. Goodness-of-fit statistics for all class solutions can be found in Supplementary Table S12. Given similar BIC, ABIC, AIC and entropy values when compared to the two-class solution, and a significant Vuong-Lo-Mendell-Rubin adjusted likelihood ratio test indicating a better fit to the data, the three-class solution was identified as the optimal class solution for these data. Despite all groups in the three-class solution being characterised by a high probability of limited community engagement, the first class included those who also lived alone, the second class those who lacked regular contact with friends and relatives outside the household, and the third class had a low probability of isolation across all contexts except the community. The proportion of the sample allocated to each class was assessed by sex and cohort with males and those born in the 1970 BCS cohort having a greater likelihood of membership to the more isolated classes (see Supplementary Table S13.). Although this was the optimal solution for these data, it was concluded that the classes were not qualitatively different from the various combinations of social isolation experiences investigated in the interaction effects models i.e., the combination of two isolation experiences. For this reason, class membership was not modelled against health outcomes.

Sensitivity analyses

Results from the independent effects models were checked against models which also included all other social isolation indicators to understand the independent effect of each form of social isolation net of other isolation experiences. Results from these models produced similar conclusions. The complete case and impute and delete models also produced similar results and are included in Supplementary Tables S6, S7, S8, S10 and S11.

Discussion

To date, there is limited evidence from large scale, UK population-based studies on social isolation and its relationship to health. In particular, few studies focus on these experiences in mid-life, which is arguably an important life stage due to known patterns of low wellbeing and diverse family compositions, social networks and labour market participation. The

current study captured multiple indicators of social isolation to investigate the independent, cumulative and interactive association of these experiences with psychological distress, life satisfaction and self-rated general health in mid-life. The patterning of social isolation during this life stage was also investigated using latent class analyses. Stratification of all analyses by sex, and analysis of cohort effects for those born in the 1970 BCS and 1958 NCDS, also provided the opportunity to consider social isolation within different time periods and increasingly diverse and complex life course trajectories with regards to family formation, care, and labour market participation (Lachman, 2015).

After controlling for demographic and prior socioeconomic and health characteristics, a lack of frequent contact with friends and relatives and limited community engagement were associated with lower life satisfaction and self-rated general health but not higher psychological distress. In the current study, a lack of frequent contact with friends and relatives outside of the household was defined as less than monthly contact and few study members reported isolation on this domain. In contrast, a lack of community engagement, based on not being a member of a community group or organisation, less than monthly religious activity and a lack of volunteering was highly prevalent in these cohorts (Mansfield et al., 2024). It could be that there is a wellbeing benefit for the minority who regularly engage with their community, but given that not doing so has become normalised, a significant increase in psychological distress is not observed. In the UK, the past decade and a half has seen dramatic cuts to local government funding for community and cultural services resulting in poorer health and wellbeing (Fahy et al., 2023). Limited membership of clubs and organisations will likely be driven by a decline in the availability of these community groups and services and also individuals' resources. Findings demonstrate the importance of reinvesting in community assets for population wellbeing and are further supported by recent research demonstrating the benefit of life course social participation for physical activity in mid-life (Tsoli et al., 2024).

With existing research that shows higher mental health conditions, psychological distress and lower life satisfaction for those who live alone (McElroy et al., 2023), we might have expected this negative association for all outcomes in the current study. However, living alone was *only* associated with lower life satisfaction. Differences in results across the study outcomes highlights the relevance of investigating social isolation in relation to the complete state of physical, mental and social wellbeing (WHO, 1948). As a global self-assessment of quality of life, life satisfaction is often used as an indicator of overall wellbeing. In contrast, psychological distress refers to impairing symptoms of emotional suffering such as anxiety and depression. Although considerable overlap has been found, many correlates of mental illness and wellbeing are distinct, and the current study provides further support for the separation of these concepts in research to avoid their conflation (Patalay & Fitzsimons, 2016). Overall, social isolation appeared to be most consistently and strongly associated with lower life satisfaction when compared with psychological distress and self-rated general health.

Being out of education and employment in mid-life was the consistent isolation indicator associated with higher psychological distress. A lack of labour market participation was also associated with lower life satisfaction and self-rated general health. These findings support a recent US study that found disconnection from work in early adulthood continued to be a risk factor for depressive symptoms in mid-life (Caniglia, 2024). Although an association

between being out of education and employment and poorer health was seen for both sexes in the current study, males appeared to be more negatively affected. This aligns with findings from a recent review of the association between unemployment and mental health which suggested that this vulnerability may arise from traditional gender roles and men's greater dependence on socioeconomic success (Virgolino et al., 2022). Beyond the detrimental mental health related to the identity and stigma of unemployment, the review also highlights the role of financial strain, which includes having to engage with welfare systems known to negatively impact wellbeing (Wickham et al., 2020). In the current study we cannot determine the extent to which the negative associations between being out of education and employment and health were due to a lack of social contact or other psychological and financial aspects related to work or study that are known to affect wellbeing (Virgolino et al., 2022). Similarly, despite investigating social isolation in mid-life and health outcomes a few years later, this study does not account for health problems or caring responsibilities in mid-life that may be, for example, the reason for unemployment.

In addition to findings relating to independent indicators of social isolation, a 'dose-response' relationship was found where higher cumulative social isolation scores were associated with greater psychological distress, lower life satisfaction, and poorer self-rated general health aligning with existing literature on mid (Hämmig, 2019; Lay-Yee et al., 2023; Sehmi et al., 2020; Luo & Li 2022) and older adults (Coyle & Dugan, 2012; Golden et al., 2009; Holt-Lunstad et al., 2015; Steptoe et al., 2013). However, given that independent associations varied by form of isolation and specific health outcome, results indicate that the association between overall level of social isolation and health could mask important discrepancies between rates and health impacts of different isolation experiences. This has implications for producing policies that can reduce specific forms of isolation most toxic for health (Klinenberg, 2016; Luo & Li, 2022), and is support for future research that comprehensively investigates multiple forms of isolation across contexts and both their independent and combined effects on health (d'Hombres et al., 2021; Huisman & van Tilburg, 2021).

The detrimental health effects of some social isolation experiences in mid-life were more pronounced for those born in 1958 (mid-life survey in 2004) when compared to those born in 1970 (mid-life survey in 2012). For example, those born in 1958 were more negatively impacted by living alone and being out of education and employment, with lower life satisfaction and self-rated general health, when compared with those born in 1970. We might expect that during 2012, a period of greater economic precarity and austerity measures, we might see a stronger negative association between being out of education and employment and health outcomes. However, rates of unemployment were higher for the 1970 BCS cohort in mid-life during this period. Therefore, the health costs for those born in 1958 could be due to social norms i.e., being unemployed at a time when rates were lower has a more detrimental effect on mental health (Virgolino et al., 2022). For the 1970 BCS cohort in mid-life during 2012, we see overall lower levels of self-rated general health when compared to those born in 1958 experiencing mid-life in 2004. However, for individuals with higher cumulative social isolation scores i.e., those most isolated, self-rated health was more similar between the two cohorts indicating that higher levels of social isolation have remained consistently negative for general health over time.

Examination of the interactive effects of various combinations of isolation experiences on health revealed few significant associations. This suggests that, in general, the effect of

multiple forms of isolation is additive as opposed to multiplicative i.e., the negative health impacts that arise from different forms of social isolation do not magnify each other. Two exceptions were observed whereby cohort members lacking community engagement in the current study showed lower self-rated general health compared with cohort members engaging more with their community, and this difference was greater for those who were also out of education and employment. Similarly, cohort members who lived alone reported lower life satisfaction, particularly if they were also out of education and employment. These results only held in the female sample which is important given we know that women's labour market trajectories are complex (Widmer & Ritschard, 2009), with more time out in mid-life (Mansfield et al., 2024). Policies that increase parents' choices around labour market participation should be prioritised, and, for women who are out of education and employment during this life stage, more opportunities for community involvement might improve their overall health.

We attempted to identify groups of people based on distinct combinations of social isolation experiences. In these data, modelling suggested a potential 3 group solution, however, all groups were characterised by a high probability of limited community engagement, with the first group also more likely to live alone, the second also more likely to lack regular contact with friends and relatives outside the household, and the third with a low probability of isolation across all contexts except the community. For the purposes of modelling health outcomes, the patterning of social isolation experiences was not deemed qualitatively different enough from the interaction terms, and so further models including class membership as a predictor of health were not conducted. However, examination of the patterning of social isolation by sex showed that males had a greater likelihood of membership to the more isolated classes. For males only, the association between living alone and poorer self-rated general health was also approaching significance with no association found for females. These findings support previous studies that suggest men are more isolated across the lifecourse than females (Umberson et al., 2022; Read et al., 2020), and could indicate that men living alone have reduced positive health behaviours (Berkman et al., 2000). Study members born in the 1970 BCS cohort were also more likely to belong to classes experiencing multiple forms of isolation, supporting previous research that showed an increase in some forms of social isolation over time in the UK (Mansfield et al., 2024).

This study provides evidence from two large scale, population-based studies on social isolation in mid-life and its relationship to health in Great Britian. Investigating multiple indicators of social isolation across a range of relational contexts enabled a better understanding of the specific conditions leading to poor health and the stability of these associations over time. Despite including multiple social isolation indicators, the current study was limited by the information available across both cohort studies. More comprehensive measurement of study members' social networks and frequency of contact, for example, number of friends, may have seen more distinct patterning in the latent class analysis and the opportunity to model unique clusters of social isolation experiences against the various health outcomes.

Conclusion

A 'dose-response' relationship was found with higher social isolation scores associated with greater psychological distress, lower life satisfaction, and poorer self-reported general health.

Independent associations varied by form of isolation, justifying future research that investigates both the individual and combined effects of different social isolation experiences. In the current study, the effects of different combinations of social isolation on health appeared to be additive. Findings varied by outcome, with stronger and more consistent associations between social isolation and lower levels of life satisfaction when compared with psychological distress and self-rated general health.

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