



Research paper

The role of loneliness in the association between sexual orientation and depressive symptoms among older adults: A prospective cohort study

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ABSTRACT

Background: This study aims to understand the mechanisms contributing to the elevated risk of depression among sexual minority older adults compared to heterosexuals. Specifically, the role of loneliness as a potential mediator is investigated to inform targeted interventions for preventing depression in sexual minority populations.

Methods: Data from the English Longitudinal Study of Ageing, focusing on adults aged over 50, were analysed. Sexual orientation (sexual minority or heterosexual) and loneliness scores (UCLA scale) were assessed at wave six (2010–2011), while depressive symptoms (CES–D) were assessed at wave seven (2013–14). Linear regression models and mediation analyses, using g-computation formula and adjusted for confounders, were conducted.

Results: The sample included 6794 participants, with 478 (7.0 %) identifying as sexual minorities. After adjustments, sexual minorities scored higher on depressive symptoms at wave seven (mean difference): 0.23, 95 % CI 0.07 to 0.39) and loneliness at wave six (MD: 0.27, 95 % CI 0.08 to 0.46). Loneliness was positively associated with depressive symptoms (coefficient: 0.27, 95 % CI 0.26 to 0.29). In mediation analyses, loneliness explained 15 % of the association between sexual orientation and subsequent depressive symptoms.

Limitations: The dataset used sexual behaviour rather than desire and identity, potentially skewing representation of sexual minorities. Additionally, transgender older adults were not included due to limited gender diversity reported within the ELSA dataset.

Conclusions: Loneliness appears to be a significant modifiable mechanism contributing to the heightened risk of depressive symptoms in sexual minority older adults compared with their heterosexual counterparts.

1. Introduction

There is a rapidly ageing population worldwide. Between 2015 and 2020, the proportion of older adults globally is estimated to increase from approximately 12 % to 22 % (Nations, 2017; Officer et al., 2020). Among older adults depression is a common, potentially underdiagnosed and under-treated illness that is associated with substantial morbidity and mortality (Carter, 2011). Evidence suggests that the prevalence of depression is rising among older adults (Rodda et al., 2011). However, there are no widely used public health interventions to

prevent depression in this population.

Sexual minority older adults (i.e. those who identify as lesbian, gay, bisexual, queer, or are attracted to people of the same gender) are at increased risk of depression compared with heterosexuals (Beam and Collins, 2019). There is also evidence that sexual minority older adults (aged 55 or older) have 2.24 increase in odds of depression than heterosexuals of a similar age, and sexual minority youth (under the age of 35) have an increased 1.92 odds of depression compared to heterosexual of a similar age (Semlyen et al., 2016). However, evidence on modifiable mechanisms which might explain the association between sexual

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orientation and depressive symptoms among older adults which could inform preventative interventions is scarce. Minority stress theory (Brooks, 1981; Meyer, 1995) is commonly used to explain the mental health disparity in sexual minorities in terms of the additional stressors, e.g. discrimination, stigma, microaggressions, and violence, minoritized groups face compared to the general population. Studies have shown that minority stress contributes to the disparity in depressive symptoms experienced by older sexual minority adults (Hoy-Ellis and Fredriksen-Goldsen, 2016; Hoy-Ellis and Fredriksen-Goldsen, 2017; Mongelli et al., 2019), but fewer studies have attempted to investigate subsequent psycho-social mechanisms explaining this association. Greater cognitive decline and chronic health conditions, common in older age people, for instance, have also been posited as mechanisms linking minority stress to mental health outcomes in older sexual minority adults who report higher levels of both compared to older heterosexual adults (Hoy-Ellis and Fredriksen-Goldsen, 2016; Correro and Nielson, 2020; Lick et al., 2013). Loneliness is another putative, yet understudied, mechanism.

Loneliness is a painful emotional state caused by a discrepancy between a person's desired quality of meaningful social relationships, and the relationships they perceive they have (Lee et al., 2021). Although there is overlap between the constructs of loneliness and depression, there is also evidence that they are distinct (Lee et al., 2021). Loneliness affects one third of older adults, who are often exposed to life-changing events such as retirement, loss of social roles, reduced social networks, and bereavement (Holt-Lunstad, 2017). Alongside other key risk factors for mental health difficulties in older adults such as poor physical health, and declining cognitive capabilities (Lövdén et al., 2020; Cunningham et al., 2020) there is strong evidence that exposure to loneliness increases the risk of subsequent depressive symptoms, and that this association is independent of other risk factors such as social isolation, physical health, and cognitive decline (Lee et al., 2021).

Cross-sectional and longitudinal studies have previously shown that experiences of minority stress – i.e. the increased exposure to stressors include discrimination, stigma, microaggressions, and violence experienced by minorities individuals – and discrimination are associated with greater loneliness and perceived lack of social support in sexual minority adults (Elmer et al., 2022; Kittiteerasack et al., 2022; Lattanner et al., 2022). Increased social anxiety and social inhibition have been posited as mechanisms explaining this association (Elmer et al., 2022). Furthermore, compared with heterosexuals, sexual minority older adults are more likely to be single, to not have children, and to have lost loved ones to human immunodeficiency virus (HIV) or suicide (Kim and Fredriksen-Goldsen, 2016). About half of older gay and bisexual men, and more than a quarter of lesbians and bisexual women live alone, compared with less than a fifth of heterosexuals (Fredriksen-Goldsen et al., 2013). Sexual minorities are also less likely to see family (Jopling and Barnett, 2014). Fears about being their true selves could also lead to fewer meaningful connections, and social invisibility. Sexual minorities might therefore experience higher levels of loneliness than heterosexuals, and loneliness might contribute to the excess risk of subsequent depression in this group.

A recent meta-analysis excluded studies which lacked a heterosexual comparison group and identified four studies which compared loneliness in sexual minorities ($n = 481$) and heterosexuals ($n = 4176$) (Gorzynski and Fasoli, 2022). Loneliness was found to be higher among the sexual minority compared with the heterosexual group. However, three of the four studies included were of children or young adults, and the one study of older adults found no evidence of a difference in loneliness between groups. Although one small cross-sectional study restricted to a sample of sexual and gender minority adults found that loneliness mediated the association between minority stress and depressive symptoms (Kittiteerasack et al., 2022), to our knowledge, no study has investigated the extent to which loneliness might explain the increased risk of depression in sexual minorities compared with heterosexuals. If loneliness contributes to the increased risk of depression in sexual minority older adults, interventions which reduce loneliness

could also reduce the risk of subsequent depression.

Our hypothesis was that, independent of pre-existing depression, sexual minority older adults would have higher levels of loneliness than heterosexuals. We also hypothesized that higher levels of loneliness would be a mechanism that explained part of the excess risk of depressive symptoms in sexual minorities compared with heterosexuals.

2. Methods

2.1. Sample

2.1.1. English Longitudinal Study of Ageing (ELSA)

ELSA is a nationally representative cohort of adults over the age of 50 that began in 2002 (wave 1). Participants were recruited from an annual cross-sectional survey designed to monitor the health of the general population and then followed-up every 2 years. At wave one the total sample size was 12,099, with a mean age of 65 years (SD: 10.2) (Stephens et al., 2013; Netuveli et al., 2006). ELSA has collected data on demographics, physical and mental health, and biological, cognitive and social factors (Stephens et al., 2013). Our study used waves six and seven (collected in 2010–2011, and 2013–14 respectively), as sexual orientation was first recorded in wave six. Our analyses were based on participants with complete data on the sexual orientation exposure, as we imputed missing outcome and confounder data.

2.2. Exposure

Sexual orientation (at wave six) was classified in terms of sexual behaviour, with participants asked “Which statement best describes your sexual experiences over your lifetime? Please include all sexual experiences including sexual intercourse, fondling, and petting.” The options given are gendered in a binary manner (man or woman), and use the Kinsey scale for sexual attraction with the following format:

- Entirely women/men (entirely heterosexual)
- Mostly women/men, but some experience with men/women (mostly heterosexual)
- Equally women and men (entirely bisexual)
- Mostly men/women, but some experience with women/men (mostly gay/lesbian)
- Entirely men/women (entirely gay/lesbian)
- No sexual desire in lifetime (asexual)

We used responses from the Kinsey Scale to classify sexual orientation, consistent with previous studies (Tetley et al., 2018; Grabovac et al., 2019; Kinsey et al., 1948).

We created a binary variable with sexual minorities as a collective group, due to relatively small numbers in individual groups. The sexual minority group included those who indicated being bisexual, mostly homosexual, entirely homosexual, and asexual. Where a participant indicated being mostly heterosexual, we included them in the sexual minority group. This is consistent with evidence that people classified as mostly heterosexual have worse mental health than those classified as entirely heterosexual (Vranganova and Savin-Williams, 2014; Irish et al., 2019; Plöderl and Tremblay, 2015).

2.3. Mediator

We used continuous loneliness scores at wave six as the mediator, to reduce biases due to attrition and based on the assumption that reverse causation between sexual orientation and loneliness was implausible. Loneliness was measured using the short version of the University of California, Los Angeles Loneliness Scale (R-UCLA) (Yin et al., 2019). The R-UCLA included three items: “How often do you feel you lack companionship?” “How often do you feel left out?”, and “How often do you feel isolated from others?” Responses were scored on a Likert scale

from one “hardly ever or never” to three “often” and total scores ranged from 3 to 9. The R-UCLA has been psychometrically validated in older adults, with high internal consistency and a one-factor model (Neto, 2014).

2.4. Outcome

We used depressive symptoms measured at wave seven, with the short Centre for Epidemiologic Studies Depression Scale (CES–D) (Radloff, 1977). The CES-D includes eight items relating to depressive symptoms over the past week. Consistent with prior studies, we removed one item, “whether felt lonely much of the time during past week” to avoid inflating associations with the loneliness scale (Lee et al., 2021). The subsequent seven item total CES-D score (range: 0–7) at wave seven was our primary outcome. The CES-D has good psychometric properties and has been validated for screening depressive symptoms among older adults, with high Cronbach’s alphas and good construct validity (Mohebbi et al., 2018).

2.5. Confounders

We selected confounders for each path of the mediation model (Fig. 1) based on previous studies and theoretical assumptions (Lee et al., 2021; Grabovac et al., 2019; Irish et al., 2019). Confounders common to all three paths were: age, sex, education (i.e., number of degrees, diplomas), and ethnicity. We additionally adjusted path C (Fig. 1; association between loneliness and depressive symptoms) for employment status, self-reported health, marital status, depressive symptoms at wave six and sexual orientation, as these were associated with our mediator (loneliness) and outcome (depressive symptoms). We assumed that depressive symptoms at wave six were on the causal pathway from sexual orientation to depressive symptoms at wave seven (path A) and were not a potential causal factor of sexual orientation as reverse causation (i.e., depression causing sexual orientation) is not a plausible assumption. We therefore did not adjust for depressive symptoms as a confounder within path A (sexual orientation to depressive symptoms at wave seven). In mediation analyses using g-formula, self-reported health, marital status, and depressive symptoms at wave six were classified as intermediate confounders, as these are known to be associated with our mediator (loneliness) and outcome

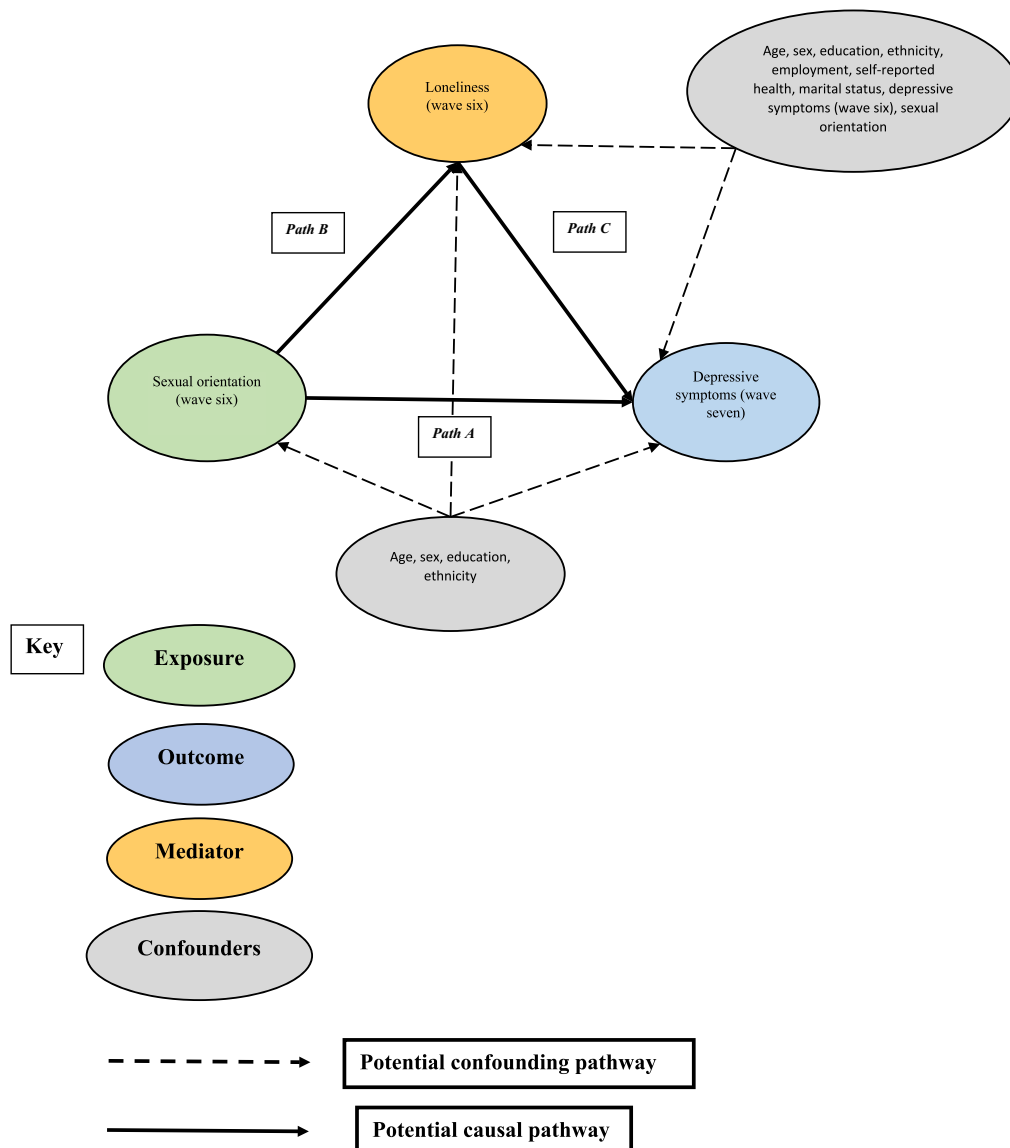


Fig. 1. Mediation model.

(depressive symptoms at wave seven), but could be caused by our exposure (sexual orientation) (Griffin et al., 2021; Tsai et al., 2013; Yarns et al., 2016; Frisch, 2021). Depression may have preceded loneliness within this sample, but we were primarily concerned with subsequent depression following loneliness and therefore adjusted for depression at baseline as an intermediate confounder.

2.6. Analysis

2.6.1. Descriptive statistics

We described normally distributed variables using means and standard deviations, and skewed variables using medians and inter-quartile ranges. We presented the descriptives on 1) the full sample who participated in wave 6 of ELSA, (2) those with complete data on the exposure, i.e. our analytical sample, and (3) by exposure level.

2.6.2. Missing data

We investigated differences between participants with complete data on loneliness and depressive symptoms and those with missing data. (Sterne et al., 2009). Following this, we performed multiple imputation with chained equations (MICE) to replace missing data (White et al., 2011). We imputed missing data in the confounders, mediator, and outcome, and restricted analyses to those with complete data on the exposure. Analyses using multiple imputation to replace missing data are presented as our main analyses to increase statistical power and precision, due to high missingness in the loneliness to depressive symptoms pathway (Fig. 2, Path C).

Prior to running a full mediation model, we investigated whether there was evidence of an association for each of the individual paths of our proposed mediation model. To do this, we used univariable and multivariable (confounders shown in Fig. 1) linear regression models to investigate whether sexual orientation was associated with depressive symptoms (Path A) and loneliness scores (Path B), and whether loneliness was associated with subsequent depressive symptoms (Path C).

We subsequently used g-computation formula (Gformula) (Daniel et al., 2011), which allowed for the estimation of mediation effects after accounting for confounders, including intermediate confounders, i.e. confounders of the mediator-outcome pathway caused by the exposure. In the context of our analyses depression at wave six was a hypothesized intermediate confounder. We estimated the Total Controlled Effect (TCE) of sexual orientation on depressive symptoms, which is the sum of the Natural Indirect Effect (NIE) and the Natural Direct Effect (NDE). The Natural Indirect Effect refers to the effect of sexual orientation on depressive symptoms that is mediated by loneliness. The Natural Direct Effect refers to the effect of sexual orientation on depressive symptoms which operates through mechanisms other than loneliness. The final portion of the model gives the Proportion Mediated (PM), which is the NIE divided by the TCE. This estimates the proportion of the association between exposure and outcome that is accounted for by the mediator (VanderWeele, 2016). All analyses were conducted using Stata/MP 17 (StataCorp, 2021).

2.6.3. Sensitivity analyses

We conducted complete case analyses of the mediation model (including participants with complete data on all variables used in the analysis), to compare with the main analyses based on multiple imputation. As an additional sensitivity analysis, we replaced the outcome with depressive symptoms at wave eight and the mediator with loneliness scores at wave seven. This allowed us to investigate whether a longer follow-up period changed our findings. We repeated all analyses using this sample.

3. Results

3.1. Sample

A total of 10,372 people participated at wave six. Of these, 6794 (65.6 %) provided data on sexual orientation and were therefore included in the analytical sample. Most participants were female ($n = 3734$, 55.0 %), white ($n = 6624$, 97.5 %), and the mean age was 65.8 years (standard deviation = 8.8, range: 50 to 89 years). Median age was 65 years (Inter Quartile Range (IQR) = 59–72). Of the 6794 participants, 478 (7.0 %) were classified as sexual minorities. The sexual minority group included those who indicated being bisexual (61, 12.8 %), mostly homosexual (22, 4.6 %), entirely homosexual (53, 11.1 %), and asexual (91, 19.0 %, data not presented in table). Compared to heterosexuals, a greater proportion of sexual minority participants identified as females (67.5 % vs 54.0 %), had a higher education (6.3 % vs 4.4 %), and were employed (35.1 % vs 32.9 %). Compared to heterosexual participants, a greater proportion of sexual minority participants reported poor health, trouble with pain, and had mobility impairments. (Table 1).

3.2. Missing data

Those who had data on sexual orientation at wave 6, were representative of the total cohort of participants at that wave in terms of sex, although white participants were slightly over-represented in the analytical sample. There were also a greater proportion of participants who were married, employed, with good health and no mobility impairment in the analytical sample compared to the total ELSA sample (see Table 1). Of the 6794 participants with complete sexuality data, 117 (1.4 %) of participants had missing loneliness data, and 893 (13.1 %) had missing in depressive symptoms data. A greater proportion of male participants, participants from ethnic minority backgrounds, and with poorer self-reported health, greater pain, and mobility impairment baseline had missing data on depression. There were fewer overall differences observed between participants with available and missing data on loneliness, (Supplementary Table 1).

3.3. Traditional regression analyses

3.3.1. The association between sexual orientation and depressive symptoms

In unadjusted analyses, there was evidence that depressive symptoms at wave seven were 0.27 (95 % CI 0.11 to 0.43) points higher among sexual minorities than heterosexuals (Table 2, path A). Following adjustments, the mean difference in depressive symptoms was 0.23 points (95 % CI 0.07 to 0.39).

3.3.2. The association between sexual orientation and loneliness

In unadjusted analyses, there was evidence that sexual minorities had higher loneliness scores than heterosexuals at wave six (mean difference: 0.35 95 % CI 0.16 to 0.54) (Table 2, path B). After adjustments, the mean difference in loneliness scores was 0.27 (95 % CI 0.08 to 0.46).

3.3.3. The association between loneliness and depressive symptoms

In unadjusted analyses, higher loneliness scores were positively associated with subsequent depressive symptoms (coefficient: 0.29 95 % CI 0.27 to 0.31) (Table 2, path C). In the adjusted model, we still observed strong evidence of an association (0.12, 95 % CI 0.10 to 0.14).

3.4. Mediation analyses

All estimates are reported after adjustment for confounders. Consistent with the coefficient in the initial analysis of path A, being a sexual minority older adult was associated with increased subsequent depressive symptoms (TCE: 0.24 (95 % CI 0.06 to 0.42)). We found evidence of a Natural Indirect Effect from sexual orientation to subsequent depressive symptoms through loneliness (NIE: 0.03 (95%CI 0.01

Table 1
Comparison of the characteristics of heterosexual and sexual minority older adults at wave six using all available data.

	Total sample at wave 6, N (%)	Total sexual orientation, N (%)	Sexual orientation	
			Heterosexual (n, %)	Sexual minority (n, %)
Participants' characteristics***	10,372 (100 %)	6794 (100 %)	6316 (100 %)	478 (100 %)
Gender				
Male	4679 (45.1 %)	3060 (45.0 %)	2905 (46.0 %)	155 (32.5 %)
Female	5693 (54.9 %)	3734 (55.0 %)	3411 (54.0 %)	323 (67.5 %)
Ethnicity				
Ethnic minority	390 (3.7 %)	170 (2.5 %)	154 (2.4 %)	16 (3.3 %)
White	9978 (96.3 %)	6624 (97.5 %)	6162 (97.6 %)	462 (96.7 %)
Education (number of qualifications, i.e., diploma/bachelor's degree/PhD)				
No qualifications	9356 (90.2 %)	6105 (89.8 %)	5693 (90.1 %)	412 (86.2 %)
One qualification only	569 (5.5 %)	385 (5.7 %)	349 (5.5 %)	36 (7.5 %)
More than one qualification	447 (4.3 %)	304 (4.5 %)	274 (4.4 %)	30 (6.3 %)
Marital status				
Married or equivalent	6954 (67.1 %)	4712 (69.4 %)	4454 (70.5 %)	258 (54.0 %)
Single, divorced, or widowed	3416 (32.9 %)	2081 (30.6 %)	1861 (29.5 %)	220 (46.0 %)
Employment status				
Employed	3264 (31.7 %)	2230 (33.1 %)	2064 (32.9 %)	166 (35.1 %)
Unemployed	7020 (68.3 %)	4512 (66.9 %)	4205 (67.1 %)	307 (64.9 %)
Self-reported general health				
Good health	7101 (72.5 %)	5076 (74.7 %)	4734 (75.0 %)	342 (71.7 %)
Fair/poor health	2690 (27.5 %)	1716 (25.3 %)	1581 (25.0 %)	135 (28.3 %)
Interviewer assessed mobility impairment				
Present	348 (4.8 %)	149 (3.0 %)	136 (2.9 %)	13 (4.2 %)
Absent	6870 (95.2 %)	4815 (97.0 %)	4519 (97.1 %)	296 (95.8 %)
Often troubled with pain				
Yes	4116 (42.0 %)	2865 (42.2 %)	2652 (42.0 %)	213 (44.6 %)
No	5676 (58.0 %)	3927 (57.8 %)	3662 (58.0 %)	265 (55.4 %)

	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Age in years	66.5 (9.3)	65.8 (8.8)	65.9 (8.8)	64.7 (9.1)
UCLA* loneliness scale score	7.8 (2.1)	7.8 (2.0)	7.8 (2.0)	8.2 (2.3)
CESD** (depressive symptoms score wave seven)	1.2 (1.7)	1.2 (1.6)	1.1 (1.7)	1.4 (1.8)

*UCLA – University of California, Los Angeles Loneliness Scale.
 **CESD – Centre for Epidemiologic Studies Depression Scale minus loneliness item.
 ***Individual variables' N vary due to missing values.
 All variables were measured at wave six except for depressive symptoms (at wave seven).

to 0.06)), representing 15 % of the total effect of sexual minority status on depressive symptoms. Finally, we also found evidence of a Natural Direct Effect between sexual orientation and depressive symptoms (NDE: 0.21 (95%CI (0.03 to 0.38)) (see Table 3).

3.5. Sensitivity analyses

3.5.1. Complete case analysis

The results in the complete case analyses (path A, $n = 5864$; path B, $n = 6619$; path C, $n = 5723$) were consistent with those from the imputed data, suggesting minimal bias from missing data (supplementary Table 2). In mediation analyses based on the complete case data ($n = 5723$), we found evidence that a natural indirect effect through loneliness was present between sexual orientation and depressive symptoms (0.04 (0.01 to 0.07) (supplementary Table 3).

When we analysed the depressive symptoms outcome at wave eight and the loneliness mediator at wave seven results from traditional linear regression analyses were consistent with the main analyses. Results from the imputed causal mediation analysis using g-formula produced an NIE consistent with the main analyses (0.05, 95 % CI 0.01 to 0.08). Point estimates for the TCE and NDE were similar to the main analyses, with broadly overlapping confidence intervals. However, statistical evidence for the TDE and NDE was weaker in the sensitivity compared with the main analyses (supplementary Table 5). A similar pattern was observed when restricting the sample to those with complete data on waves six, seven, and eight (supplementary tables 6 and 7).

4. Discussion

This is the first large population-based cohort study to investigate the extent to which loneliness explains the excess risk of depressive symptoms in sexual minority compared with heterosexual older adults. We found evidence that sexual minority older adults were at increased risk of loneliness compared with heterosexuals, and that loneliness accounted for 15 % the association between sexual orientation and future depressive symptoms. Although an effect size of 15 % might appear small from a clinical perspective, from a public health viewpoint it could represent a large reduction in risk if addressed (Carey et al., 2023).

Our finding, that sexual minorities experienced higher levels of loneliness than heterosexuals, is consistent with cross-sectional studies from the Netherlands, US, and China (Fokkema and Kuiper, 2009; Hu et al., 2016; Doyle and Molix, 2016). Our study extends this evidence by using a large nationally representative cohort and finding that loneliness is a potential mechanism that contributes to the increased risk of subsequent depressive symptoms in sexual minorities compared with heterosexuals. Sexual minorities might experience higher levels of loneliness than heterosexuals for several reasons that result from minority stress (Brooks, 1981; Meyer, 1995). These include social isolation, lack of meaningful social connections, rejection, discrimination, stigma, and abuse (including familial, interpersonal, and substance abuse). Although given the nature of our sample, we did not examine specific examples of minority stress or pathways linking the latter to loneliness, we found that around 15 % of the additional depressive symptoms experienced by sexual minority compared to heterosexual older adults could be explained by the former experiencing higher levels of loneliness. Crucially, our study was able to clearly disentangle the temporality of these associations and expand on a previously largely cross-sectional body of evidence thus providing robust support to the hypothesis that loneliness could be a mechanism linking minority stress to depression. Our results are in line with putative mechanisms highlighted in the introduction, linking sexual minority status and experience of minority stress to greater loneliness and depression, potentially via increased social isolation and social anxiety. Loneliness, in turn, may increase the risk of depression through social, psychological and biological pathways (Mann et al., 2017). Meaningful social connections are rewarding, and reduced experience of social rewards has been associated with depression (Zhang et al., 2020). People who are lonely may also develop negative views of their self, world and future which are associated with subsequent depression (Goswick and Jones, 1981; Atilgan, 2011). Loneliness might also be associated with biological consequences that could increase the risk of depression, for example altered immune

Table 2
Univariable and multivariable linear regression analyses.

Multiply Imputed sample <i>N</i> = 6794	Unadjusted			Adjusted*		
	Regression coefficient	95 % CI	<i>P</i> value	Regression coefficient	95 % CI	<i>P</i> value
Path A (sexual orientation to depressive symptoms)	0.27	0.11 to 0.43	0.001	0.23	0.07 to 0.39	0.005
Path B (sexual orientation to loneliness)	0.35	0.15 to 0.54	<0.001	0.27	0.08 to 0.46	0.006
Path C (loneliness to depressive symptoms)	0.29	0.27 to 0.30	<0.001	0.12	0.10 to 0.14	<0.001

Regression coefficients are mean differences (unstandardised) for binary exposures (sexual orientation; Paths A and B) and unstandardised regression coefficients for continuous exposures (loneliness; Path C).

Path A: the association between sexual orientation (wave six) and depressive symptoms (wave seven)

*Adjusted for sex, age, education, and ethnicity.

Path B: association between sexual orientation (wave six) and loneliness (wave six)

*Adjusted for age, sex, education, and ethnicity.

Path C: association between loneliness (wave six) and depressive symptoms (wave seven)

*Adjusted for sex, age, ethnicity, education, employment status, self-reported health, marital status, depressive symptoms at wave six, and sexual minority status.

Table 3
Mediation analyses, based on multiply imputed sample restricted to those with complete sexual orientation data (*n* = 6794).

Effect	Regression coefficient (95 % CI)	<i>P</i> value
Total Controlled Effect (TCE)	0.24 (0.06 to 0.42)	0.01
Natural Direct Effect (NDE)	0.21 (0.03 to 0.38)	0.02
Natural Indirect Effect (NIE)	0.03 (0.01 to 0.06)	0.03

TCE – the overall effect of sexual orientation on depressive symptoms taking both the NDE and NIE into account.

NDE – the effect of sexual orientation on depressive symptoms when not mediated by loneliness.

NIE – the effect of sexual orientation on depressive symptoms mediated through loneliness.

All estimates adjusted for age, sex, ethnicity, employment status, and education (as traditional confounders). Self-reported health, marital status, and depressive symptoms at wave six were classified as intermediate confounders.

function or hypothalamic–pituitary–adrenal axis activity (Xia and Li, 2018). Our findings suggest that interventions which reduce loneliness among sexual minority older adults could lead to significant reduction in the risk of future depressive symptoms in this population (Carey et al., 2023).

4.1. Strengths and limitations

Our sample was large and nationally representative of English older adults. However, as with all longitudinal studies, there was attrition from baseline to follow-up and this could have introduced selection bias. We replaced missing data using multiple imputation, which should reduce biases due to attrition but there was still attrition from waves one to six, which may have led to selection bias. However, within-cohort associations should still be valid even when attrition is selective (Wolke et al., 2009). We used variables associated with missing data, to strengthen the missing-at-random assumption. However, we cannot rule out the possibility that data were missing not at random, which could lead to biases not addressed by multiple imputation. Although we adjusted for a wide range of potential confounders, like any observational study, we cannot rule out the possibility of residual confounding. For example, there were no measures of discrimination, a potential confounder of the association between loneliness and depressive symptoms.

A further limitation concerns the sexual orientation exposure variable, and how it was measured. The ELSA survey asks participants to reflect on lifetime experiences and desires, but the response format mainly refers to behaviours which could misclassify participants. This could occur as the question does not relate to a person's attraction to sexes/genders but instead on their sexual behaviours. Participants who have only had sexual experiences with the opposite gender but are attracted to more than one gender may have been misclassified as

heterosexual. Future studies could examine desire and attraction in conjunction with experience and behaviour and consult LGBTQ+ people to ensure adequate questions are offered. Misclassification may also have occurred if sexual minority orientation was under-reported because of stigma and discrimination (Irish et al., 2019; Mercer et al., 2013). However, it is possible that if any misclassification in this sense had occurred in our sample, this would have led to under-reporting of sexual minority status and, potentially, to an underestimation of the effect sizes of the associations under investigation. We also measured sexual orientation at one point in time whereas sexual orientation is often fluid, and such fluidity may be associated with mental health. We were unable to investigate different sexual minority groups due to small numbers within certain categories. We used a collective sexual minority group, which increased the power and precision of our analyses. However, the limitation of this approach is that mental health has been found to vary across sexual minority groups and gender. For example, bisexual women have been found to have worse mental health than other groups (Plöderl and Tremblay, 2015). Although future studies in larger samples should investigate this variation, our findings still offer important insights on aetiological processes underpinning depression in older adults which could inform public health interventions aimed at this population.

Another limitation is that the assessment of gender was binary in the ELSA study and our findings are unlikely to generalise to the trans (transgender, non-binary, and gender diverse) community. There is a need to expand questions to encompass gender diversity. Trans people are often cited as high risk for depressive disorders (Stonewall, 2018). This is particularly important as trans communities are frequently excluded or omitted from research that pertains to the LGBTQ+ community. The proportion of ethnic minority participants was small in ELSA, which could also affect generalisability. The sample was also not representative of the institutionalised population of England.

We were interested in whether loneliness accounted for the excess risk of depression among sexual minorities compared with heterosexuals. There is evidence that loneliness and depression have a bidirectional relationship (Cacioppo et al., 2006; Hsueh et al., 2019; Luo et al., 2012). However, our hypotheses related to the direction of association from loneliness to depressive symptoms rather than vice versa, to inform public health interventions to prevent depression. We adjusted for depressive symptoms measured at the same time as loneliness, to reduce the possibility of reverse causation (i.e., sexual orientation increasing the risk of depressive symptoms then subsequent loneliness, rather than vice versa).

Our findings suggest that interventions which reduce loneliness among sexual minority older adults could reduce the risk of future depressive symptoms in this population. Interventions could include community engagement activities, supported video communication, online support, telephone befriending, and social prescribing. Interventions need to centre the needs of sexual minority older adults

through recognising the importance of community and shared identities, in order to build meaningful connections, and alleviate minority stress.

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Credit authorship contribution statement

Talen Wright: Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Methodology. **Francesca Solmi:** Methodology, Supervision, Writing – review & editing, Validation. **Olesya Ajnakina:** Writing – review & editing. **Elizabeth Ingram:** Writing – review & editing. **Aaron Kandola:** Writing – review & editing. **Stephen Lee:** Writing – review & editing. **Eleonora Iob:** Writing – review & editing. **Andrew Steptoe:** Writing – review & editing. **Ben Thomas:** Writing – review & editing. **Gemma Lewis:** Conceptualization, Funding acquisition, Methodology, Supervision, Writing – review & editing.

Declaration of competing interest

The authors have no conflicts of interest to declare.

Data availability

Data are available through application to the UK Data Service.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jad.2024.04.001>.

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