Loneliness and mortality: The moderating effect of positive affect

Beller, Johannes

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Loneliness and mortality: The moderating effect of positive affect

Johannes Beller

Center for Public Health and Healthcare: Medical Sociology, Hannover Medical School, Hannover, Germany

Correspondence
Johannes Beller, Center for Public Health and Healthcare: Medical Sociology, Hannover Medical School, Carl-Neuberg-Straße 1, 30625 Hannover, Germany.
Email: beller.johannes@mh-hannover.de

Abstract

Although the adverse association of loneliness with health and mortality are well documented, less is known about moderating factors of this relationship. According to the "buffering theory," it is argued that positive affect moderates the negative associations of stressors with health. The current study contributes to the literature by asking: Does positive affect also moderate the relationship between loneliness and mortality? A large population-based sample of middle-aged and older adults in Germany from 2008 was used ($N = 4442$). Mortality was monitored up to 2020, resulting in a maximum follow-up period of observation of 12 years, in which mortality events could be observed. Loneliness was measured using an adapted German version of the De Jong Gierveld Loneliness Scale, while positive affect was measured with an adapted German version of the Positive and Negative Affect Schedule. Using Cox survival regression, it was found that loneliness significantly predicted increased mortality risk ($HR = 1.20$; $p = .029$); conversely, positive affect significantly predicted decreased mortality risk ($HR = 0.63$; $p < .001$). Furthermore, a significant interaction emerged between loneliness and positive affect in predicting mortality ($HR = 0.70$; $p = .001$):

The strength of the association of loneliness with mortality decreased with increasing levels of positive affect. Positive affect attenuates the association between loneliness and mortality, supporting previous empirical research and theories on the buffering effect of positive affect. If replicated in further studies, interventions that promote positive affect might be beneficial to mitigate the negative associations of loneliness with health.

KEYWORDS
buffer, health, loneliness, morbidity, mortality, positive affect

INTRODUCTION

Loneliness has been defined as the subjective feeling of having inadequate social relationships (Hawkley & Cacioppo, 2010; Perlman & Pelau, 1981). As the *subjective* aspect of an individual's social connectedness, loneliness thus differs from social isolation, which represents an individual's objective social connectedness (Beller & Wagner, 2018a). Transient feelings of loneliness are common; severe and chronic feelings of loneliness, however, represent a major hazard to health (Hawkley & Cacioppo, 2010; Holt-Lunstad et al., 2015; National Academies of Sciences, Engineering, and Medicine [USA], 2020). Loneliness is argued to be a central factor to overall health and well-being of people of all age groups (Hawkley & Cacioppo, 2010). However, older adults and younger adults seem to suffer from loneliness the most: The prevalence of loneliness has been found to be largest in older and younger adults while following a complex nonlinear trajectory across age (Luhmann & Hawkley, 2016; Yang & Victor, 2011). For example, in Germany, it was found that 7.0 per cent of adults aged 60+ report frequent loneliness, whereas 4.4 per cent of adults aged 30–59 and 5.1 per cent of adults aged <30 report the same (Yang & Victor, 2011). Loneliness is associated with a diverse set of worse health outcomes, including physical, cognitive, and mental health (Beller & Wagner, 2018a; Hakulinen et al., 2018; Sundström et al., 2020). Loneliness has been shown to be associated with health outcomes via several interrelated pathways. According to the evolutionary theory of loneliness, feeling lonely amounts to feeling unsafe, which in turn results in greater perception of social threat in the environment. In turn, these negative social expectations lead to behavior of others that confirms these negative perceptions, activating a set of adverse mechanisms in the lonely individual: Diminished health behaviors, like reduced capacity for self-regulation, reduced sleep quality, and with it reduced restorative effects, neurobiological dysregulation, such as a dysregulation of the hypothalamic–pituitary–adrenal (HPA) axis and with it increased inflammatory processes and reduced immune functioning (Cacioppo et al., 2002; Hawkley & Cacioppo, 2010). Consequently, loneliness has also been shown to be a major predictor of mortality (Beller & Wagner, 2018b; Holt-Lunstad et al., 2015; Rico-Uribe et al., 2018).

While the negative associations of loneliness with health are well established, only relatively few studies have investigated potential moderators of this relationship (National Academies of Sciences, Engineering, and Medicine [USA], 2020). There are many potential moderators, as suggested by the socio-ecological model of loneliness (Holt-Lunstad, 2018). Empirical studies have focused mostly on the moderating effect of sociodemographic factors like age and gender. Regarding age, the mortality risk seems to be increased in middle aged as compared with older adults (Holt-Lunstad et al., 2015). Additionally, despite the often held assumption that social relationships are more important to health in women than in men, two recent meta-analyses have found similar associations of loneliness with mortality in both men and women, suggesting that gender does not moderate the relationship between loneliness and health (Holt-Lunstad et al., 2015; Rico-Uribe et al., 2018). Only recently, other studies have investigated further potential moderators besides these demographic indicators like objective social isolation and culture (Beller & Wagner, 2018b, 2020), with results suggesting that loneliness tends to predict even worse health outcomes in socially isolated adults and among those living in more collectivistic countries. Thus, although there are numerous studies on how loneliness is associated with worse health, insufficient knowledge about potential moderators of this relationship exists.

POSITIVE AFFECT AS A POTENTIAL MODERATOR OF THE LONELINESS–HEALTH RELATIONSHIP

Positive affect refers to the experience of positive emotions such as happiness, joy, excitement, or contentment by people (Pressman et al., 2019; Pressman & Cohen, 2005). Numerous studies have found that positive affect is related to better health, by its association with biomarkers of neuroendocrine, inflammatory, and cardiovascular functioning, like increased self-regulation, improved sleep quality, and lower levels of inflammation (e.g. Dockray & Steptoe, 2010; Steptoe et al., 2005, 2007). Numerous studies have also shown that, consequently, positive affect is also associated with reduced mortality rates (Zhang & Han, 2016). In general, two hypotheses have been proposed that try to explain these associations of positive affect with health (Petrie et al., 2018): the direct-effect hypothesis and the buffering hypothesis. On the one hand, according to the direct-effect hypothesis, the experience of positive affect might directly alter processes and behaviors associated with healthy functioning like increased immune function and physical activity (Steptoe et al., 2009). Alternatively, according to the buffering hypothesis, positive affect predicts better health because positive affect acts as a buffer to stressors, in the sense that positive affects protects against the negative consequences of risk factors, such as stress in predicting mortality (Fredrickson et al., 2000; Okely et al., 2017; Pressman & Cohen, 2005). Originally, the buffering hypothesis had been focused on positive affect and physiological stress, while later work has also examined the buffering hypothesis in the context of subjective distress (van Steenbergen et al., 2021). Thus, the experience of positive affect could reduce health-adverse psychological, physiological, and behavioral responses to stressors like catastrophic thinking, overactivation of the HPA axis, or substance abuse (van Steenbergen et al., 2021).

Empirically, several studies have shown results in accordance with the stress-buffering hypothesis, in the sense that positive affect indeed buffers the negative effects of stressors as proposed by the buffering theory. For example, Ong et al. (2004) studied the role of positive emotions in a sample of 34 recently bereaved older adults. They found that positive emotions significantly reduced the stress–depression relationship. In another study, Fredrickson et al. (2000) measured cardiovascular indicators following a stress induction task in 170 students. They found that participants who viewed films that elicited amusement or contentment following the stress induction task were characterized by quicker cardiovascular recovery than other participants. Lastly, Meyer et al. (2015) studied a sample of 564 cardiac patients, who completed a rehabilitation program. By conducting subgroup analyses, they found that the subgroup with both high negative affect and low positive affect had the highest rates of cardiovascular disease related events.

THE CURRENT STUDY

Although the adverse associations of loneliness with health are well established and although theory suggests that positive affect might buffer the negative effects of loneliness on health, no study to date has examined whether positive affect indeed moderates the association between loneliness and health. The current study strives to fill this gap in the literature. Using a population-based sample of German middle-aged and older adults, it is examined whether positive affect moderates the association of loneliness and health: Based on the buffering hypothesis of positive affect, it is hypothesised that loneliness' association with mortality is buffered with increasing levels of positive affect. The research question is: Does positive affect moderate the loneliness–health relationship?

METHODS

Sample

The data stem from the public release of the German Ageing Survey (DEAS), a longitudinal, representative study on Germans above the age of 40, provided by the Research Data Center of the German Centre of Gerontology (Klaus et al., 2017). The use of the German Ageing Survey was granted to the main author by the Research Data Center of the German Centre of Gerontology. I used questionnaire data from the 2008 wave (Motel-Klingebiel et al., 2019). Participants were drawn randomly by national probability sampling. In a first step, communities were randomly selected. In a second step, residents proportional to the number of residents above the age of 40 in the given community were drawn randomly from registers of the local registration offices. The final sample included all participants who agreed to fill out the drop-off questionnaire, resulting in a sample size of $N = 4442$. The response rate was about 36 per cent and thus comparable with other population-based surveys in Germany (e.g. Lange et al., 2017).

In order to control for possible nonresponse bias (e.g. certain participants might be reluctant to answer survey questions), missing values (0% to 2% per variable) were imputed using the missForest algorithm (Stekhoven & Buhlmann, 2012). The missForest algorithm is a nonparametric imputation method based on an iteratively applied random forests machine learning technique. Initially, all missing data are imputed using the mean/mode. Then, multiple random forest analyses are conducted, predicting the missing values for each variable based on the other variables in the dataset, with each iteration leading to improved missing values predictions. The missForest algorithm has been shown to work especially well with complex data and needs only minimal distributional assumptions and is therefore preferentially used in the current study. According to well-established rules of thumb (Vittinghoff & McCulloch, 2007), one would need about 90 events for a Cox survival regression to obtain accurate parameter estimates in this case. As 475 events occurred during the observation period, the analyses should be reasonably powerful to accurately detect substantial associations of the predictors and mortality.

Prior to the data collection, written informed consent was given by all participants of the study. Ethics board approval was not required for the current study, because only secondary data analysis of the completely anonymized data was conducted. The permanent advisory board to the German Ageing Survey concluded that the DEAS study also did not need approval from an ethics committee because it did not meet the criteria for requiring an ethical statement (risk for the respondents, lack of information about the aims of the study, and examination of patients). The permanent advisory board, however, approved of the sampling method, the consent to participate, and the instruments used in the study, which were also in line with national regulations.

Measures

Subjective loneliness was assessed with an adapted German version of the six-item De Jong Gierveld Loneliness Scale (De Jong Gierveld & Van Tilburg, 2006). This scale was developed specifically for the use in large surveys of older adults. Its psychometric reliability and validity have been established in diverse samples (De Jong Gierveld & Van Tilburg, 2010). Example items include "I often feel rejected" and "There are enough people that I feel close to" (reverse scored). Participants could choose to respond on a scale from *strongly disagree* (0) to *strongly agree* (3). Thus, mean scores ranged from 0 (low loneliness) to 3 (high loneliness).

Positive affect was measured via the 10-item positive affect subscale of the German version of the Positive Affect Negative Affect Scale (Watson et al., 1988). Although, originally, a two-factor model of affect (positive affect and negative affect) was assumed, there is currently a debate as to the factorial structure of the PANAS scale in the literature (e.g. Villodas et al., 2011). Thus, in this study, only the positive affect subscale is used. Respondents are asked to indicate the extent to which they have felt positive distinct emotions ("enthusiastic," "excited," "strong," "interested," "proud," "alert," "inspired," "determined," "attentive," and "active") "during the past few months." Participants could choose to respond on a scale from *very slightly or not at all* (1) to *extremely* (5). Mean positive affect scores could thus range from 1 (low positive affect) to 5 (high positive affect).

All-cause mortality was monitored for all participants who agreed to further study contact via official government records retrieved from the registration office and information acquired upon recontact. Detailed information on the cause of death was not available due to German data protection laws. Missing data regarding follow-up mortality were treated as right censored, as is standard practice in survival analysis (Kleinbaum & Klein, 2012). All in all, a follow-up period of up to 146 months (12.2 years) resulted.

As additional covariates, I included smoking (whether participants smoked daily), health checkup (whether participants had ever participated in a general health checkup), multimorbidity (whether participants reported at least two chronic conditions on a 20-item list of self-reported conditions including diabetes, arthrosis, and high blood pressure), education, age, and gender. Education was coded taking both school education and professional training/academic training into account, resulting in a four-level classification scheme (participants without completed vocational qualification and up to a maximum of a graduation degree were coded as 1; participants with vocational qualifications or qualifications for university entrance were coded as 2; participants with finished upgrading training [e.g. as a master craftsman] were coded as 3; and participants with completed university studies were coded as 4).

Statistical analyses

I used bivariate correlation and Cox survival regression analyses as statistical analyses. Cox survival analysis can explicitly account for differences in survival time and right censoring of observations. As the exact mean time of survival is generally unknown in health psychology studies (many participants in the study survive the observation period and hence the exact mean survival time is unknown and cannot be calculated), it is impossible to predict average life years gained without making very strong assumptions. In Cox survival analysis, which has been favorably used to analyze survival data, this problem is solved by estimating the relative probability of survival across time instead. Thereby, similar to logistic regression, one can estimate how the mortality risk changes in accordance to a set of predictors like loneliness and positive affect. The resulting coefficients in a Cox regression analysis are mostly reported as hazard ratios (HRs). Similar to logistic regression, these might be interpreted as the relative increase in the mortality risk when increasing the respective predictor by one unit (in the case of numeric variables) or as the relative increase in the mortality risk of belonging to a certain category compared with a reference group (in the case of categorical variables). Unlike standardised mean differences, no rules of thumb regarding effect size exist, as, akin to unstandardised scores, HRs depend on the unit of the variable. However, even comparatively small effects such as $HR = 1.10$ might be seen as practically important in this case, as they denote a population-based increase in risk of mortality by a unit increase in the predictor (e.g. in the case of $HR = 1.10$ a 10% increase in the relative risk of mortality).

First, descriptive and correlation analyses are conducted. Then, Cox survival regression analyses are calculated separately for loneliness and positive affect as a baseline result. Finally, a full Cox survival regression including both loneliness, positive affect, and their interaction is conducted. Several robustness analyses were additionally carried out by providing stratified results according to gender (men vs. women) and age group (middle-aged vs. older adults). Furthermore, it was investigated whether participants who could be followed for more than 10 years differed substantially from those who could not be followed for at least 10 years. All analyses were conducted with R and the R packages haven, missForest, and survival (R Core Team, 2021; Stekhoven, 2013; Therneau, 2021; Wickham, 2021).

RESULTS

As seen in Table 1, participants were on average 61.80 years old ($SD = 11.88$, $Min = 40$, $Max = 85$; 49% female) and had a medium level of education ($M = 2.49$, $SD = 0.96$). About 11 per cent of participants ($n = 475$) died during the observation period of up to 12.17 years. In the univariate analyses, loneliness was associated with increased mortality, while positive affect was associated with decreased mortality. Loneliness and positive affect correlated moderately negative with each other ($r = -.31$). Further descriptive statistics, including means/percentages, standard deviations, score ranges, and intercorrelations can be found in Table 1. Additionally, in separate preliminary baseline analyses, when controlling for multimorbidity, smoking, health checkups, age, gender, and education loneliness still significantly predicted increased mortality in a Cox survival regression analysis ($HR = 1.20$; 95% CI = [1.02; 1.42]; $p = .029$). Similarly, when controlling for multimorbidity, smoking, health checkups, age, gender, and education positive affect still significantly predicted reduced mortality in a Cox survival regression analysis ($HR = 0.63$; 95% CI = [0.54; 0.74]; $p < .001$).

TABLE 1 Demographics and spearman intercorrelations of the study variables

	M/%	*SD*	Range	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1. Mortality (deceased)	11%	-	0; 1	-							
2. Loneliness	1.75	0.56	1–4	.04**	-						
3. Positive affect	3.52	0.57	1–5	−.12***	−.31***	-					
4. Multimorbidity (yes)	60%	-	0; 1	.15***	.14***	−.19***	-				
5. Smoking (yes)	15%	-	0; 1	.01	.07***	−.01	−.08***	-			
6. Health checkup (yes)	68%	-	0; 1	−.01	−.07***	.06***	.12***	−.11***	-		
7. Age	61.8	11.88	40–85	.27***	−.07***	−.18***	.33***	−.24***	.14***	-	
8. Gender (female)	49%	-	0; 1	−.11***	−.08***	.04**	−.02	−.07***	−.04*	−.11***	-
9. Education	2.49	0.96	1–4	−.05**	−.03*	.20***	−.06***	−.05***	.04*	−.16***	−.19***

Notes: *M* = mean; *SD* = standard deviation.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 2 depicts the results of the full Cox survival regression analyses. When accounting for survival time, multimorbidity ($HR = 1.48$), smoking ($HR = 2.45$), and age ($HR = 1.10$) predicted increased mortality risk, whereas health checkups ($HR = 0.77$), being female ($HR = 0.64$), and higher educational level ($HR = 0.87$) predicted decreased mortality risk. Additionally, there was a significant interaction effect between loneliness and positive affect in predicting mortality risk ($HR = 0.70$): The effect size of loneliness in predicting mortality risk gets smaller with increasing levels of positive affect (Figure 1).

Regarding robustness analyses, only small differences between participants who could be followed throughout an observation period of more than 10 years and those who could not emerged (Table A1). Furthermore, the general results generally seem robust when analyzing a list-wise deleted dataset (i.e. cases with missing values were removed) and when stratifying the analyses by gender and age group (Table A2–A4; however, please note that only insignificant p-values regarding the interaction effect between loneliness and positive affect were found in women, with $p = .053$, and in middle-aged adults, with $p = .061$).

DISCUSSION

Investigating the association of loneliness and positive affect with mortality, I found that both loneliness and positive affect significantly predicted mortality: Loneliness predicted an increased mortality risk, whereas positive affect predicted a decreased mortality risk. Additionally, a significant interaction of loneliness and positive affect in predicting mortality emerged. The adverse association of loneliness with mortality was buffered by high values of positive affect. The strength of this buffering was substantial: The predicted association of loneliness with mortality nearly disappeared for individuals high in positive affect (+2*SD* above mean; Figure 1).

Theoretical and practical implications

These results are in accordance with previous studies (Pressman et al., 2019; Pressman & Cohen, 2005). Numerous studies have shown that loneliness predicts increased mortality risk

TABLE 2 Cox survival analysis of loneliness and positive affect predicting mortality

	HR	95% CI	*z*	*p*
Loneliness	3.34	[1.67; 6.71]	3.40	.001
Positive affect	1.23	[0.80; 1.90]	0.96	.338
Multimorbidity (yes)	1.48	[1.16; 1.88]	3.21	.001
Smoking (yes)	2.45	[1.87; 3.19]	6.56	<.001
Health checkup (yes)	0.77	[0.63; 0.93]	−2.69	.007
Age	1.10	[1.09; 1.11]	17.24	<.001
Gender (female)	0.64	[0.53; 0.79]	−4.29	<.001
Education	0.87	[0.78; 0.96]	−2.80	.005
Loneliness * positive affect	0.70	[0.57; 0.87]	−3.28	.001

Notes: HR = hazard ratio; 95% CI = 95% confidence interval of HR; z = z value of HR; p = p-value.

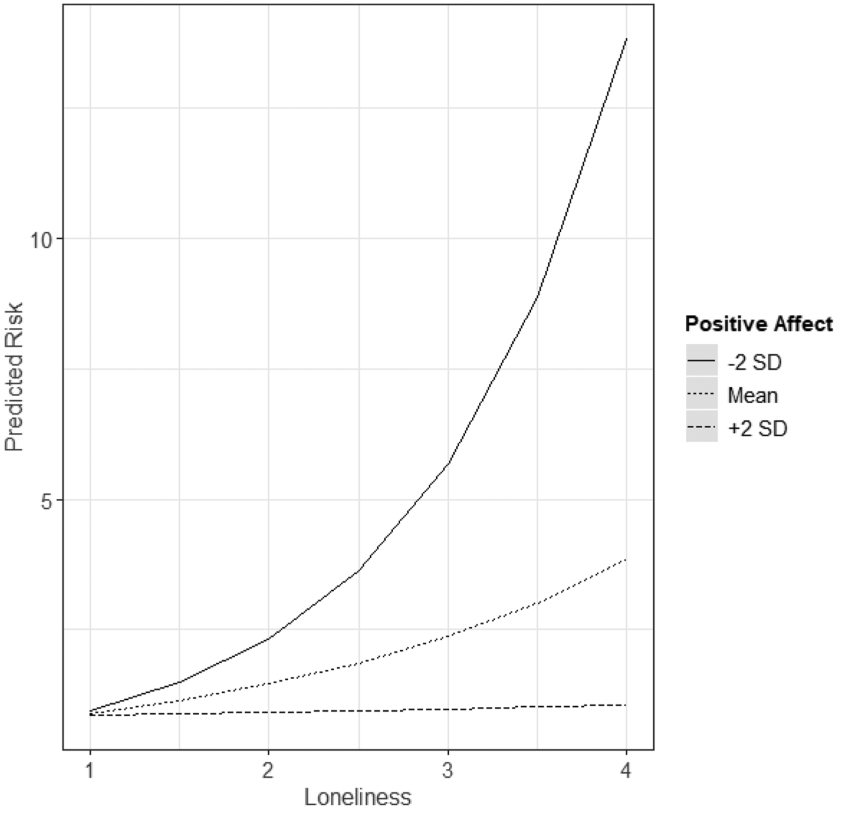

FIGURE 1 Loneliness as a predictor of mortality risk according to different levels of positive affect. *Note*: The three different lines represent the predicted relative mortality risk (*y* axis), compared with the sample average, for different value combinations of loneliness (*x* axis) and positive affect (three different lines). Assuming a mean positive affect score (dotted line), a slight increase in mortality risk for increasing values of loneliness is predicted; assuming a low positive affect score that is two standard deviations below the sample mean (solid line), a strongly exponentially increasing mortality risk for increasing values of loneliness is predicted; and assuming a high positive affect score that is two standard deviations above the sample mean (dashed line), no substantial increases in the mortality risk for increasing values of loneliness is predicted. For example, a high value of loneliness = 3 is predicted to be associated with no substantial increases in mortality as compared with the sample average when positive affect is high, but with a nearly 250 per cent increased risk of mortality when positive affect is at its mean value, and with a nearly 600 per cent increased risk of mortality when positive affect is low

(Holt-Lunstad et al., 2015). Similarly, the positive association of positive affect with longevity is well established (Diener & Chan, 2011). Finally, the stress-buffering theory of positive affect suggested that positive affect buffers the negative effect of stressors on health, which had also been seconded empirically (van Steenbergen et al., 2021). However, going beyond the previous literature the current study is the first to empirically confirm the buffering theory with regards to the adverse implications of loneliness, which had been described as an emerging public health crisis (Holt-Lunstad, 2017). Thus, while the stress-buffering hypothesis had focused on its potential buffering properties regarding physiological stress, these results suggest that the buffering hypothesis might be more widely applicable, which should be further investigated in future studies.

Why might positive affect buffer the relationship between loneliness and health? Regarding loneliness, it is well established that multiple pathways contribute to the negative association of loneliness and health, including compromised health behaviors, sleep disturbances, as well as maladaptive neuroendocrine and immune functioning (Hawkley & Cacioppo, 2010). Interestingly, positive affect has been shown to be associated with improved health through some similar pathways of, for example, improved health behaviors, better sleep, and improved endocrine and immune functioning (Ong et al., 2017; Pressman et al., 2019). Therefore, positive affect might buffer loneliness by protecting against some of the negative changes in the mediators through which loneliness is associated negatively with health (van Steenbergen et al., 2021). As an alternative explanation, some definitions of loneliness focus more on affect, describing loneliness as a *distressing feeling* accompanying one's perception that one's social needs are not being met adequately (Hawkley & Cacioppo, 2010). Following this definition, a lack of positive affect might be one defining characteristic of loneliness as a construct; consequently, individuals scoring high on a loneliness scale and low on a positive affect scale might be seen as lonelier than individuals who score high on both the loneliness scale and the positive affect scale. Thus, positive affect might also partly buffer the relationship between loneliness and health, because being high in positive affect directly translates into feeling less distressing loneliness. However, given the only moderate empirical association between loneliness and positive affect obtained in this study ($r = -.31$), it seems unlikely that this potential reason could fully explain the observed interaction. As already discussed, this is the first study to examine the buffering implications of positive affect on loneliness. As such, future studies must examine the concrete mechanisms by which positive affect might buffer the negative associations of loneliness with health, for example, by analyzing cause-specific mortality and by examining the differential effect of loneliness as a feeling compared with other discrete emotions. Lastly, there might be other variables relating to all loneliness, positive affect, and mortality that might partly explain the observed interaction, like mental health, personality, or lifestyle variables. However, as already stated, studies are largely lacking on potential moderators of the loneliness–health relationship, and future studies are needed before firm conclusions can be drawn.

These results might also be important from a practical perspective. Given the substantive negative association of loneliness with health, several interventions to decrease loneliness have been developed, with unsatisfactory results (Masi et al., 2011): Among the studies with a randomized designs, interventions to reduce loneliness reported an average standardised effect size of −0.198, which can only be judged as small and as too ineffective to normalize high loneliness levels. The current study suggests a new hypothesis regarding a possible approach by which the negative effects of loneliness on health might be additionally managed: If empirically proven by intervention studies, a negative potential effect of loneliness on health might also be buffered by interventions that increase positive affect. In recent years, several of these interventions that increase positive affect have been evaluated, such as three good things, loving kindness meditation and best possible self (Snyder & Lopez, 2020). In general, small but substantial effect sizes for these interventions in increasing positive affect and similar constructs are found (Koydemir et al., 2021). For example, a recent meta-analysis found an overall effect of $d = 0.22$ of positive psychological interventions—interventions primarily aimed at raising positive feelings, positive cognitions or positive behavior—on increased well-being, and an overall effect of $d = 0.43$ for studies targeting multiple domains of well-being (Koydemir et al., 2021). Therefore, loneliness interventions might profit from including positive psychological interventions. However, to test this hypothesis, experiments and intervention studies are first needed.

Strengths and limitations

The current study has several strengths, including the population-based data and the long observation time. Additionally, it represents the first study to test and verify the potential interaction between positive affect and loneliness in predicting worse health outcomes. Nonetheless, several limitations of the current study and opportunities for future research must be noted. First, while the results were generally replicated under different analytical designs, the moderating effect of loneliness and positive affect was not significant in women ($p = .053$), while it was very significant in men ($p = .009$). While these differences in significance might simply be due to statistical variation, other substantial explanations might also be possible. For example, while meta-analytical evidence has generally not reported much difference in the mortality risk of loneliness between genders, another single study found that mediators for the loneliness–health relationship partly differed between men and women (Christiansen et al., 2016). Therefore, it might be possible that the buffering effect of positive affect is more applicable to men. Similarly, the moderating effect of loneliness and positive affect was not statistically significant in middle-aged adults ($p = .061$), while it was very significant in older adults ($p = .004$). Thus, the generalizability of the moderating influence of positive affect should be investigated by future studies.

Furthermore, although comparable with other German surveys, the response rate could have been higher. Perhaps affective states such as loneliness and positive affect might predispose survey participation, such that a selective participation bias cannot be ruled out (Beller et al., 2022). Future studies with higher response rates should be employed to replicate these results. Similarly, some small differences in right censoring have been found to be informative in the sense that participants who could not be followed throughout the whole observation period differed from those who could. As such it cannot be guaranteed that the reported associations between loneliness, positive affect and mortality are unbiased. However, to partly account for this, missing values were imputed in the analyses and statistical methods such as Cox survival regression were used that can account for right censoring. However, future studies are still needed that explore the association of loneliness and positive affect to study participation and dropout.

Moreover, regarding the generalizability of the study results, it has been suggested that some of the effects of loneliness might depend on culture. Therefore, although a large, national population-based sample was used in this study, the results need to be replicated in other samples from other countries. In a similar vein, empirical studies on other potential biopsychosocial moderators of the loneliness–health relationship are lacking. Thus, while the current study provides the first evidence for a moderating effect of positive affect in the loneliness–health relationship, future studies must try to replicate and expand upon my results, for example, by analyzing other health outcomes or by investigating additional moderating factors.

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CONFLICT OF INTEREST

The author declares that he has no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the German Centre of Gerontology. Restrictions apply to the availability of these data, which were used under license for this study. Data are available at https://www.dza.de/en/fdz/german-ageing-survey/data.html with the permission of the German Centre of Gerontology.

ETHICS STATEMENT

Prior to the data collection, written informed consent was given by all participants of the study. Ethics board approval was not required for the current study, because only secondary data analysis of the completely anonymized data was conducted. The permanent advisory board to the German Ageing Survey concluded that the DEAS study also did not need approval from an ethics committee because it did not meet the criteria for requiring an ethical statement (risk for the respondents, lack of information about the aims of the study, and examination of patients). The permanent advisory board, however, approved of the sampling method, the consent to participate, and the instruments used in the study, which were also in line with national regulations.

ORCID

Johannes Beller https://orcid.org/0000-0002-3041-9895

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APPENDIX

TABLE A1 Sample statistics of participants who could not be followed for at least 10 years during the follow-up observation period as compared with those participants who could be followed for at least 10 years

	Stratified by follow-up observation time		
	Level	**<10 years**	**≥10 years**
Sample size		2145	1822
Loneliness, mean (*SD*)		1.77 (0.54)	1.71 (0.57)
Positive affect, mean (*SD*)		3.60 (0.52)	3.48 (0.58)
Smoking (%)	No	85.4	85.6
	Yes	14.6	14.4
Health checkup (%)	No	30.0	33.4
	Yes	70.0	66.6
Multimorbidity (%)	No	41.2	44.0
	Yes	58.8	56.0
Age, mean (*SD*)		59.11 (11.05)	62.53 (11.99)
Gender (%)	Male	48.9	50.3
	Female	51.1	49.7
bildung4_08 (%)	Low (1)	7.0	13.1
	Low–intermediate (2)	49.1	59.3
	Intermediate (3)	14.6	10.2
	High (4)	29.3	17.4

Note: $N = 3967$. Only participants who were not confirmed to have died during follow-up could be included.

TABLE A2 Cox survival analysis of loneliness and positive affect predicting mortality in women and men

	HR	95% CI	*z*	*p*
Women				
Loneliness	3.67	[0.95; 14.17]	1.89	.059
Positive affect	1.42	[0.64; 3.15]	0.86	.390
Multimorbidity (yes)	1.80	[1.17; 2.79]	2.65	.008
Smoking (yes)	4.10	[2.50; 6.73]	5.58	<.001
Health checkup (yes)	0.68	[0.49; 0.94]	−2.30	.021
Age	1.12	[1.10; 1.14]	11.73	<.001
Education	0.98	[0.82; 1.17]	−0.22	.829
Loneliness * positive affect	0.66	[0.44; 1.01]	−1.93	.053
Men				
Loneliness	3.11	[1.36; 7.12]	2.69	.007
Positive affect	1.16	[0.69; 1.95]	0.55	.581
Multimorbidity (yes)	1.35	[1.01; 1.80]	2.05	.040
Smoking (yes)	2.02	[1.47; 2.79]	4.29	<.001
Health checkup (yes)	0.84	[0.65; 1.07]	−1.42	.155
Age	1.09	[1.08; 1.11]	12.7	<.001
Education	0.82	[0.73; 0.93]	−3.12	.002
Loneliness*positive affect	0.71	[0.55; 0.92]	−2.61	.009

Notes: *HR* = hazard ratio; 95% CI = 95% confidence interval of *HR*; *z* = *z* value of *HR*; *p* = *p*-value.

TABLE A3 Cox survival analysis of loneliness and positive affect predicting mortality in middle-aged adults (ages 40–70) and older adults (ages 71+)

	HR	95% CI	*z*	*p*
Middle-aged adults				
Loneliness	4.01	[0.93; 17.41]	1.86	.063
Positive affect	1.26	[0.55; 2.90]	0.54	.587
Multimorbidity (yes)	2.06	[1.46; 2.91]	4.09	<.001
Smoking (yes)	0.58	[0.43; 0.78]	−3.53	<.001
Health checkup (yes)	1.46	[1.05; 2.02]	2.27	.023
Age	1.09	[1.07; 1.11]	8.11	<.001
Gender (female)	0.50	[0.36; 0.68]	−4.32	<.001
Education	0.82	[0.69; 0.97]	−2.35	.019
Loneliness * positive affect	0.66	[0.43; 1.02]	−1.87	.061
Older adults				
Loneliness	3.77	[1.61; 8.81]	3.06	.002
Positive affect	1.38	[0.80; 2.36]	1.16	.246
Multimorbidity (yes)	2.76	[1.79; 4.26]	4.59	<.001
Smoking (yes)	0.99	[0.76; 1.29]	−0.07	.948
Health checkup (yes)	1.49	[1.04; 2.12]	2.17	.030
Age	1.13	[1.10; 1.16]	8.32	<.001
Gender (female)	0.78	[0.60; 1.01]	−1.87	.061
Education	0.90	[0.80; 1.02]	−1.59	.111
Loneliness * positive affect	0.68	[0.52; 0.88]	−2.87	.004

Notes: *HR* = hazard ratio; 95% CI = 95% confidence interval of *HR*; *z* = *z* value of *HR*; *p* = *p*-value.

TABLE A4 Cox survival analysis of loneliness and positive affect predicting mortality in a list-wise deleted dataset ($N = 4147$)

	HR	95% CI	*z*	*p*
Loneliness	2.97	[1.16; 7.59]	2.27	.023
Positive affect	1.22	[0.71; 2.11]	0.72	.472
Multimorbidity (yes)	1.45	[1.11; 1.89]	2.75	.006
Smoking (yes)	2.09	[1.54; 2.84]	4.70	<.001
Health checkup (yes)	0.84	[0.67; 1.04]	−1.58	.113
Age	1.10	[1.08; 1.11]	14.92	<.001
Gender (female)	0.58	[0.46; 0.73]	−4.62	<.001
Education	0.86	[0.77; 0.96]	−2.66	.008
Loneliness * positive affect	0.73	[0.55; 0.97]	−2.19	.028

Notes: *HR* = hazard ratio; 95% CI = 95% confidence interval of *HR*; *z* = *z* value of *HR*; *p* = *p*-value.