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Personal Resources and Structural–Relational Circumstances

Show Additive Associations With Loneliness in Spanish Adults Aged 55 and Older

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Abstract

Background: Interventions against loneliness in later life increasingly target personal resources — resilience, meaning, empathy — on the assumption that strengthening them offsets structural–relational circumstances that put older adults at risk. This moderation claim is rarely tested directly; we test it in a cross-sectional sample of community-dwelling Spanish older adults.

Methods: 302 adults aged 55 or older were recruited through community centres in Castilla-La Mancha, Spain. Loneliness was assessed with a Spanish adaptation of the De Jong Gierveld Loneliness Scale. Structural–relational circumstances (marital status, education, living arrangement, pandemic fear, messaging-app use) and personal resources (empathy, resilience, presence and search for meaning) entered a three-block hierarchical regression, followed by nine models testing the interaction of three structural risks (widowhood, living without family, low education) with three personal resources. A sensitivity analysis established the minimum interaction effect detectable at 80% power.

Results: Structural–relational circumstances were associated with loneliness: widowhood ($r = .26$ vs. married, $p_{\text{Holm}} = .006$), low education (mean 4.76 vs. 2.83, no schooling vs. university) and living without family. Personal resources showed stronger bivariate associations: empathy ($\rho = -.323$), resilience ($\rho = -.312$) and presence of meaning ($\rho = -.268$), all $p < .001$. Structural–relational circumstances added $\Delta R^2 = .064$; personal resources added a further $\Delta R^2 = .142$. Resilience statistically accounted for approximately a quarter of the association between meaning and loneliness ($ab = -.058$, 95% CI $[-.094, -.026]$). None of the nine interaction tests approached significance (all $p \geq .19$; largest $|\beta| = 0.149$); the design had 80% power to detect effects of $\beta \approx .14$ or larger, so smaller buffering effects cannot be ruled out. Messaging-app use, often reported as protective, correlated strongly with age and did not survive adjustment. The pattern was robust to restricting the sample to participants aged 65 and older, and to an ordinal treatment of education.

Conclusions: Personal resources and structural–relational circumstances were consistent with an additive, not interactive, pattern of association with loneliness. This test of a rarely examined moderation claim bears on how loneliness interventions should be targeted; whether these approaches are complementary requires longitudinal or experimental study.

Keywords: loneliness; older adults; widowhood; resilience; meaning in life; moderation; structural–relational circumstances; digital connectivity.

1 Background

Unwanted loneliness — the distress arising from a discrepancy between desired and perceived relationships [1] — affects one in five adults in Spain and persists beyond two years in two thirds of cases [2]. It is distinct from objective isolation: a person can live accompanied and feel alone [3, 4].

Two literatures address it, and they rarely meet. One documents circumstances tied to socioeconomic and relational disadvantage across the life course: widowhood, living alone, low education and shrinking networks [5, 6]. We refer to these jointly as structural–relational circumstances, while recognising their heterogeneity — educational attainment reflects cumulative material and social conditions, widowhood a relational transition, and living arrangement can reflect autonomy as much as disadvantage — and we return to this heterogeneity in the Discussion. The other literature documents personal resources that correlate with lower loneliness: resilience [7], repeatedly identified as protective in later life [8–10]; meaning in life [11], predicting loneliness with an effect size comparable to health status [12]; and empathy [13].

The practical stakes lie in how the second literature is read. Resource-building interventions — resilience training, meaning-centred therapy, self-compassion programmes [14] — are typically justified on the grounds that personal resources *buffer* the impact of adverse circumstances. That is a moderation claim: it predicts that the association between, say, widowhood and loneliness is weaker among the resilient. The word “buffer” appears throughout this literature, but the interaction it implies is seldom tested.

The distinction is not semantic. If the two domains are additive, resource-building will help everyone by roughly the same amount and leave the disadvantage gap untouched, so it complements structural intervention rather than substituting for it. If they interact, resources could be targeted where they matter most. The policy implications differ, and the question is directly testable.

We therefore report three things: which structural–relational circumstances predict loneliness in this sample, how much personal resources add, and — the substantive question — whether the two interact. We also examine frequency of messaging-app use, which has been reported as protective in older adults [15], since it sits at the boundary between the two domains.

Guided by this rationale, we specified four analytic expectations before conducting the analyses reported here; this is a secondary analysis of an existing dataset and was not preregistered. We expected that structural–relational circumstances — widowhood, low education, living without family — would be associated with greater loneliness; that personal resources — empathy, resilience, presence of meaning — would be associated with lower loneliness; that, as the central analytic question of the study, personal resources would moderate the association between structural–relational risk and loneliness; and, exploratorily, that resilience would statistically account for part of the association between presence of meaning and loneliness. The first two are addressed by the hierarchical regression and indirect-association model in Sections 3.1–3.2; the moderation question is addressed by the nine interaction tests in Section 3.2.

2 Method

2.1 Participants

Three hundred and two community-dwelling adults aged 55 or older were recruited in Castilla-La Mancha, Spain, through community centres. Adults approached who declined to participate most commonly cited distrust (of the study or of sharing personal data) and lack of time; these reasons were noted informally by recruiters and were not systematically logged, so no denominator for the approached-but-not-enrolled pool is available. The sample was 70.2%

female and 96% urban. Age bands were 55–64 (26.2%), 65–74 (34.4%), 75–84 (29.5%) and 85–94 (9.9%). Marital status was married (43.7%), widowed (28.5%), single (18.5%), divorced (7.6%) and separated (1.7%). Completed primary education was modal (46.0%), followed by university (23.2%). Just under half (49.3%) reported a cardiovascular condition and 44.7% reported current or past emotional problems. All 302 participants had complete data on the loneliness, structural–relational and personal-resource variables used in the analyses reported below; no case-wise or variable-wise imputation was required.

2.2 Measures

Loneliness was assessed with a Spanish adaptation of the 11-item De Jong Gierveld Loneliness Scale [4], yielding a total score and emotional (6-item) and social (5-item) subscales. Internal consistency was $\omega = .813$ for the total, .785 emotional and .676 social.

Personal resources were assessed as follows. Empathy: Spanish adaptation [16] of the Empathy Quotient [17], 23 items ($\omega = .654$). Resilience: 10-item Connor–Davidson Resilience Scale [7] ($\omega = .656$). Meaning in life: Meaning in Life Questionnaire [11], yielding presence ($\omega = .704$) and search ($\omega = .897$) subscales. Empathy and resilience reliability is modest and we return to this in the limitations.

Structural–relational circumstances were taken from a sociodemographic and health questionnaire: age band, sex, education, marital status, living arrangement, self-reported emotional problems, cardiovascular condition, fear experienced during the COVID-19 pandemic, and a 6-point item on frequency of messaging-app use.

Several of these predictors were recoded for the regression and interaction models. Low education contrasts participants with completed primary schooling or less against those with secondary education, vocational training or higher (118 of 302 in the higher-education category); this is a coarser cut than the four-category gradient reported descriptively in Section 3.1. Widowhood contrasts widowed participants against all other marital-status categories (married, single, divorced, separated) combined. Not with family contrasts participants living with family or a partner against all other living arrangements reported in the questionnaire (the instrument did not further distinguish living alone from living with non-family others, in an institution, or with unrelated carers, so this contrast cannot be decomposed further with the available data). Pandemic fear is a binary self-report (yes/no) of whether the participant experienced fear during the pandemic. Age was collected in four 10-year bands (55–64, 65–74, 75–84, 85–94). For regression and correlation analyses, these ordered bands were represented by their midpoints (59.5, 69.5, 79.5, 89.5) as a numeric age proxy. Figure 3b therefore displays mean age-band midpoints rather than individual ages. Age, sex and the continuous personal-resource scores entering the hierarchical regression were standardised (z -scored) prior to analysis, and so were the binary structural–relational predictors (widowhood, low education, not with family, pandemic fear) within that regression. For the nine interaction models reported in Section 3.2, each binary risk indicator entered on its original 0/1 coding and was multiplied by the standardised resource score to form the interaction term, so those interaction coefficients reflect a one-unit (present vs. absent) contrast in risk combined with a one-SD contrast in the resource, rather than a product of two standardised terms.

2.3 Analysis

Group differences use Kruskal–Wallis with ε^2 and Holm-corrected pairwise Mann–Whitney tests; associations use Spearman’s ρ . A three-block hierarchical regression entered demographic variables, then structural–relational circumstances, then personal resources, all standardised.

The substantive test is moderation. We fitted nine models, each regressing standardised loneliness on one structural risk (widowhood; living without family; low education), one personal resource (empathy, resilience, presence of meaning) and their product. We report all

nine, significant or not, and interpret them jointly: the claim under test is general, so a single significant interaction among nine would not support it.

Mediation of the meaning–loneliness association by resilience was estimated with 5,000 bootstrap resamples. Given the cross-sectional design, we describe it throughout as a statistical indirect association and not as a causal pathway, since meaning, resilience and loneliness were measured within minutes of each other and their temporal order cannot be established from these data.

Because product terms compound the measurement error of their components, we conducted a post-hoc sensitivity analysis for the interaction tests: using the observed N , the degrees of freedom of each two-predictor-plus-interaction model, $\alpha = .05$ and a target power of .80, we solved for the minimum detectable interaction effect via the noncentral F distribution [18]. This indicates what size of buffering effect the design could reliably detect, and lets us interpret the nine null interactions with an explicit sense of their resolution rather than treating non-significance as evidence of a true zero.

We also conducted two further robustness checks: (i) the nine interaction models re-estimated with adjustment for age, sex and the two structural risks not involved in each specific interaction, and (ii) the final hierarchical model re-estimated as a negative binomial regression, given that total loneliness is a bounded, overdispersed count rather than a continuous variable. Both are reported alongside the corresponding unadjusted analyses in Section 3.2.1. Collinearity among predictors in the final regression model was assessed with variance inflation factors (VIF).

This is a secondary analysis of an existing dataset; hypotheses were not pre-registered and p -values are nominal except where Holm correction is stated.

3 Results

Total loneliness averaged 3.46 ($SD = 2.67$, $Mdn = 3$, range 0–11), emotional 2.24 ($SD = 1.87$) and social 1.22 ($SD = 1.22$).

3.1 Bivariate associations

Marital status, living arrangement and education were each associated with loneliness (Figure 1).

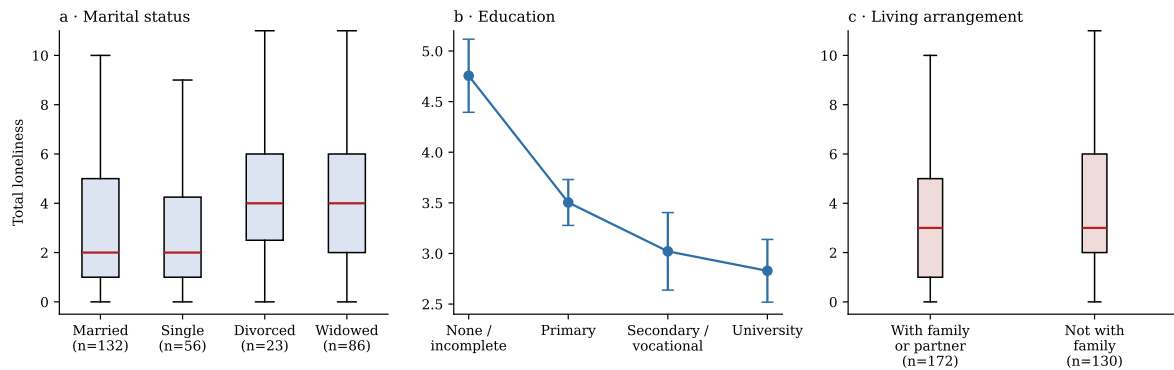


Figure 1: Total loneliness by (a) marital status, (b) education and (c) living arrangement. Boxes show median and interquartile range; panel (b) shows means with ± 1 standard error.

Marital status: $H(3) = 16.33$, $p < .001$, $\varepsilon^2 = .045$. Widowed participants scored higher than married ($Mdn = 4$ vs. 2; $r = .26$, $p_{\text{Holm}} = .006$) and than single participants ($r = .29$,

$p_{\text{Holm}} = .018$). Divorced participants had the same median as widowed but the comparison against married did not survive correction ($p_{\text{Holm}} = .078$, $n = 23$).

Education showed a monotone gradient: means of 4.76 (no completed primary schooling, $n = 45$), 3.50 (primary), 3.02 (secondary or vocational) and 2.83 (university); $H(3) = 18.79$, $p < .001$, $\varepsilon^2 = .053$ — the largest structural effect observed.

Living arrangement: $H(6) = 19.88$, $p = .003$, $\varepsilon^2 = .047$; participants not living with family or a partner scored higher. Fear during the COVID-19 pandemic was also associated with loneliness ($H = 9.66$, $p = .002$, $\varepsilon^2 = .029$; $Mdn = 4$ vs. 2), and self-reported emotional problems more weakly ($H = 5.52$, $p = .019$).

Two variables showed nothing: sex ($H = 0.76$, $p = .383$; identical medians) and cardiovascular condition ($H = 1.16$, $p = .885$).

Empathy ($\rho = -.323$), resilience ($\rho = -.312$) and presence of meaning ($\rho = -.268$) were each inversely associated with loneliness (all $p < .001$). Search for meaning was unrelated on every dimension ($\rho = -.019$, $p = .74$). The contrast between presence and search is instructive: it is the settled sense of having found purpose, not the active process of looking for it, that accompanies lower loneliness here.

Resilience statistically accounted for part of the cross-sectional association between presence of meaning and loneliness, in a statistical indirect-association model rather than a causal mediation model. Meaning was associated with resilience ($a = +0.326$), resilience was associated with lower loneliness adjusting for meaning ($b = -0.177$), and the indirect association was $ab = -0.058$ (bootstrap 95% CI $[-0.094, -0.026]$), about 25.5% of the total association ($c = -0.226$; direct $c' = -0.168$). Because all three constructs were measured within minutes of each other, this indicates a statistical decomposition of a concurrent association and does not order the constructs in time or imply a causal pathway.

3.2 Hierarchical regression and interaction analysis

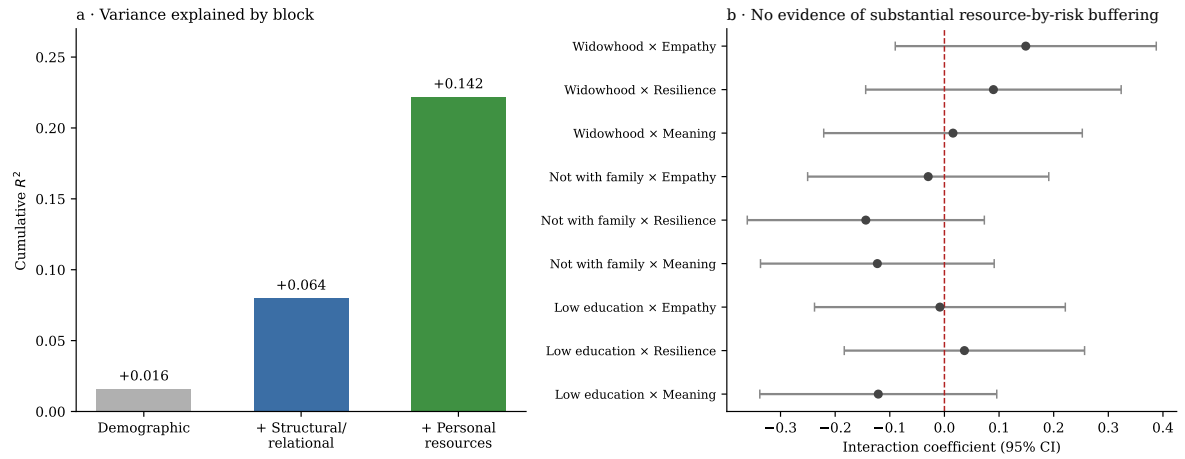


Figure 2: (a) Cumulative R^2 by predictor block. (b) Interaction coefficients from nine models crossing three structural risks with three personal resources, with 95% confidence intervals.

In hierarchical regression ($N = 302$), demographic variables (age, sex) explained 1.6% of variance. Because education reflects accumulated social and material disadvantage and showed the largest bivariate gradient of any predictor in this sample (Section 3.1), it was entered in the structural-relational block alongside widowhood, living arrangement, pandemic fear and messaging-app use; this block added $\Delta R^2 = .064$ ($F(5, 294) = 4.08$, $p = .001$). A collinearity check across the full model (variance inflation factors) found no evidence of problematic overlap among predictors (all VIF ≤ 1.8 ; Table 1). In the reported hierarchical decomposition, personal

resources accounted for an additional $\Delta R^2 = .142$ ($F(3, 291) = 17.65$, $p < .001$), compared with $\Delta R^2 = .064$ for the preceding structural-relational block; because ΔR^2 depends on the order in which blocks are entered, this describes the increment attributable to resources over and above the preceding blocks under this specification, not an order-independent measure of relative importance. The final model explained 22.1% ($F(10, 291) = 8.27$, $p < .001$, adjusted $R^2 = .195$); its coefficients are unaffected by which block education is assigned to, since block assignment only changes how ΔR^2 is attributed, not the final fit.

Table 1: Final hierarchical model predicting total loneliness ($N = 302$, $R^2 = .221$, adjusted $R^2 = .195$, $F(10, 291) = 8.27$, $p < .001$). All predictors standardised (z -scored); VIF = variance inflation factor.

Predictor	β	SE	95% CI	p	VIF
Age	+0.039	0.068	[−0.095, +0.172]	.570	1.72
Sex (female)	−0.062	0.055	[−0.170, +0.046]	.260	1.12
Low education	+0.071	0.058	[−0.044, +0.185]	.225	1.26
Widowhood	+0.035	0.063	[−0.090, +0.159]	.584	1.50
Not with family	+0.099	0.058	[−0.014, +0.212]	.086	1.24
Pandemic fear	+0.101	0.053	[−0.004, +0.205]	.059	1.06
Messaging-app use	−0.033	0.069	[−0.170, +0.103]	.632	1.80
Empathy	−0.156	0.058	[−0.269, −0.042]	.007	1.24
Resilience	−0.164	0.058	[−0.278, −0.050]	.005	1.26
Meaning (presence)	−0.206	0.057	[−0.317, −0.094]	<.001	1.20

In that final model only the three resources reached significance (empathy $\beta = -0.156$, $p = .007$; resilience $\beta = -0.164$, $p = .005$; meaning $\beta = -0.206$, $p < .001$). Living without family ($\beta = +0.099$, $p = .087$) and pandemic fear ($\beta = +0.101$, $p = .059$) approached it; low education ($\beta = +0.071$, $p = .225$) and widowhood ($\beta = +0.035$, $p = .584$) did not, their bivariate effects being largely carried by overlapping predictors (age, living arrangement).

None of the nine interaction tests approached conventional significance (Figure 2b). Coefficients ranged from -0.144 to $+0.149$ with p -values from .19 to .94; every confidence interval comfortably included zero, and the signs were inconsistent across pairings — positive for widowhood, negative for living without family. A post-hoc sensitivity analysis (Section 2.3) indicated that, with $N = 302$ and the degrees of freedom of each two-predictor-plus-interaction model, the design had 80% power to detect a standardised interaction coefficient of approximately $|\beta| = .14$ or larger (Cohen’s $f^2 \approx .026$) — almost exactly the size of the largest coefficient observed. We can therefore rule out buffering effects of this magnitude or larger with reasonable confidence, but smaller interaction effects remain within the design’s blind spot; the nulls should be read accordingly, as evidence against a substantial buffering effect rather than against any effect at all.

With nine simultaneous tests, we also applied a Holm correction to the unadjusted p -values (Table 2, final column); none would have been significant after correction. This does not change the substantive reading: the inferential target here was the joint pattern across nine prespecified tests and the precision of the individual estimates, not the identification of any single significant interaction, so a multiplicity correction — while worth reporting — is not doing the interpretive work in this design.

3.2.1 Robustness checks

Two robustness checks address concerns raised about confounding and about the suitability of ordinary least squares for a bounded count outcome.

First, we re-estimated all nine interaction models adjusting for age, sex and the two structural risks not involved in that particular interaction (e.g., the widowhood $\times$ empathy model

Table 2: Interaction between structural risk and personal resources predicting total loneliness. Standardised coefficients from nine separate models; p_{Holm} is the Holm-adjusted p -value across the nine tests (all = 1.000).

Interaction term	β	95% CI	p	p_{Holm}
Widowhood $\times$ empathy	+0.149	[−0.090, +0.388]	.221	1.000
Widowhood $\times$ resilience	+0.090	[−0.144, +0.324]	.451	1.000
Widowhood $\times$ meaning	+0.016	[−0.221, +0.252]	.896	1.000
Not with family $\times$ empathy	−0.030	[−0.250, +0.191]	.791	1.000
Not with family $\times$ resilience	−0.144	[−0.361, +0.073]	.193	1.000
Not with family $\times$ meaning	−0.123	[−0.337, +0.091]	.260	1.000
Low education $\times$ empathy	−0.008	[−0.238, +0.221]	.944	1.000
Low education $\times$ resilience	+0.037	[−0.183, +0.257]	.743	1.000
Low education $\times$ meaning	−0.121	[−0.338, +0.096]	.273	1.000

additionally adjusted for living arrangement and education). Adjusted coefficients were uniformly smaller than their unadjusted counterparts (range −0.059 to +0.057, all $p \geq .28$; Table 3), so confounding by the other structural-relational circumstances does not explain, and if anything slightly narrows, the already-null interaction pattern.

Table 3: Interaction coefficients adjusted for age, sex and the two structural risks not involved in each specific interaction.

Interaction term	β	95% CI	p
Widowhood $\times$ empathy	+0.057	[−0.052, 0.165]	.303
Widowhood $\times$ resilience	+0.041	[−0.064, 0.146]	.443
Widowhood $\times$ meaning	+0.016	[−0.090, 0.123]	.762
Not with family $\times$ empathy	−0.006	[−0.117, 0.104]	.911
Not with family $\times$ resilience	−0.059	[−0.166, 0.049]	.283
Not with family $\times$ meaning	−0.047	[−0.153, 0.059]	.380
Low education $\times$ empathy	+0.016	[−0.097, 0.129]	.779
Low education $\times$ resilience	+0.041	[−0.067, 0.148]	.455
Low education $\times$ meaning	−0.040	[−0.147, 0.066]	.459

Second, because total loneliness is a bounded count (range 0–11, mean 3.46, variance 7.15, indicating overdispersion relative to a Poisson model), we re-estimated the final hierarchical model as a negative binomial regression. Although the negative binomial distribution does not explicitly model the upper bound of 11, it was used as a sensitivity analysis to assess whether the main inferences were robust to overdispersion and non-normality of the count outcome, not as a fully bounded model of the scale. The pattern of significance was materially the same as the linear model: empathy ($b = -0.129$, $p = .005$), resilience ($b = -0.132$, $p = .005$) and meaning ($b = -0.125$, $p = .003$) remained the only significant predictors, and none of the structural-relational variables reached significance. This indicates the main conclusions are not an artefact of treating a bounded count outcome as continuous, though a model that explicitly bounds the scale (e.g., ordinal or beta-binomial regression) would be a natural further check.

Third, because 26.2% of the sample was aged 55–64, below some conventional definitions of “older adult,” we re-estimated the hierarchical model and the nine interaction tests restricted to participants aged 65 or older ($n = 223$). The pattern was unchanged: empathy, resilience and meaning remained the only significant predictors (all $p \leq .016$), and none of the nine interactions approached significance, with one exception — not with family $\times$ resilience reached $p = .035$ — that would not survive a Holm correction and that we read as consistent with sampling variation given the other eight null tests. Fourth, because dichotomising education

discards the graded structure evident in Section 3.1, we re-estimated the final model with education entered as an ordinal four-level variable instead of the binary contrast. Under this specification education became a significant predictor ($\beta = -0.123$, $p = .038$, versus $\beta = -0.071$, $p = .225$ for the binary contrast), consistent with the binary cut losing power relative to the descriptive gradient; the coefficients and significance of the three personal resources were essentially unchanged. Additional sensitivity analyses — heteroscedasticity and influence diagnostics, an ordinal-outcome specification of total loneliness, and a cumulative structural-risk index — are summarised in the Supplementary Material and did not alter these conclusions.

3.3 Loneliness subscales: emotional and social

The final hierarchical model was also estimated separately for the emotional and social loneliness subscales (Table 4). All three personal resources predicted both subscales, with no clear specialisation into an emotional-only or social-only role. Living without family and low education were associated with emotional but not social loneliness, and widowhood was not significant for either subscale. Model fit was similar for the total and emotional outcomes ($R^2 = .221$ and $.219$) and lower for social loneliness ($R^2 = .145$).

Table 4: Standardised coefficients from the final hierarchical model, estimated separately for total loneliness and the emotional and social subscales.

Predictor	Total β (p)	Emotional β (p)	Social β (p)
Empathy	-0.156 (.007)	-0.120 (.039)	-0.158 (.010)
Resilience	-0.164 (.005)	-0.135 (.020)	-0.153 (.013)
Meaning (presence)	-0.206 (<.001)	-0.164 (.004)	-0.199 (.001)
Widowhood	+0.035 (.584)	+0.094 (.137)	-0.069 (.302)
Not with family	+0.099 (.086)	+0.131 (.024)	+0.016 (.786)
Low education	+0.071 (.225)	+0.115 (.049)	-0.021 (.730)
R^2	.221	.219	.145

3.4 Frequency of messaging-app use

Frequency of messaging-app use was associated with total ($\rho = -.193$, $p < .001$) and emotional loneliness ($\rho = -.212$, $p < .001$) but not social loneliness ($\rho = -.062$, $p = .286$).

It was also associated with the numeric age-band proxy at $\rho = -.596$. Using age-band mid-points, participants who never used messaging had a mean age proxy of 80.1 years, compared with 66.4 years among daily users (Figure 3b). Adjusting for age alone reduced the association with emotional loneliness to $\rho_{\text{partial}} = -.153$ ($p = .008$); in the full model it did not survive ($\beta = -0.033$, $p = .632$).

We therefore read messaging-app use in this sample as an indicator of relative youth and its correlates rather than as an independent protective factor. Studies reporting protective effects of digital connectivity in older adults without age adjustment risk describing an age gradient.

4 Discussion

The central result is a null, and a reasonably well-resolved one within its limits: nine tests, three structural risks crossed with three personal resources, none approaching significance, with coefficients small and inconsistent in sign, and a sensitivity analysis indicating the design could detect interaction effects at or above the size of the largest coefficient observed.

Within this sample, the observed associations were more consistent with additive main effects than with detectable resource-by-risk interactions. The adjusted interaction models

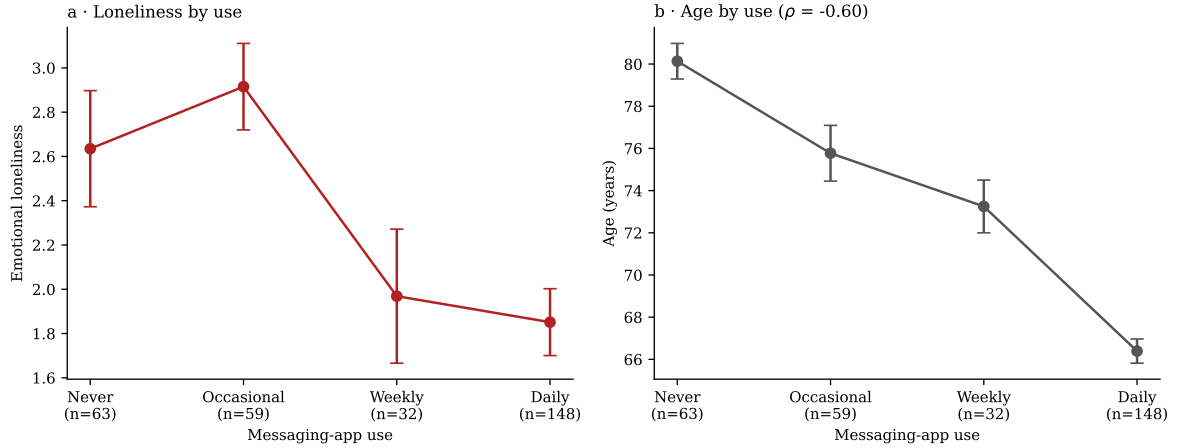


Figure 3: (a) Emotional loneliness and (b) age-band midpoint proxy by frequency of messaging-app use. Bars show ± 1 standard error.

(Section 3.2.1) provided no evidence that the associations of empathy, resilience or meaning with loneliness differed materially across the structural-risk groups examined.

This bears on how the protective-factor literature is used. Describing resilience or meaning as a “buffer” invites the inference that strengthening them offsets adverse circumstances. This cross-sectional evidence does not support a substantial offsetting effect; it is more consistent with the two domains adding rather than interacting.

We are not arguing that such interventions are ineffective. In this hierarchical decomposition, and conditional on the selected order of block entry, the incremental variance associated with the resource block was roughly twice that associated with the preceding structural-relational block. The argument is narrower: the observed cross-sectional associations do not indicate that personal resources substitute for structural-relational circumstances, though only experimental or longitudinal designs can test that directly.

The largest structural gradient was educational, not relational: mean loneliness of 4.76 among participants without completed primary schooling against 2.83 among university graduates, a difference approaching one standard deviation. This is worth emphasising because loneliness in later life is usually framed relationally — widowhood, network size, living alone — and educational disadvantage is a different kind of target, associated with lifelong material and social conditions that a relational intervention does not reach.

4.1 Limitations

The design is cross-sectional. No causal reading is available, including the indirect-association model, and the interaction nulls concern concurrent association rather than intervention response: it remains possible that increasing resilience in a widowed person would compensate in a way that between-person variation does not reveal.

The sensitivity analysis in Section 2.3 indicates the design was reasonably powered to detect interaction effects near the largest coefficient observed ($|\beta| \approx .14$), but not smaller ones; the nulls should be interpreted with that resolution in mind, not as evidence that no buffering effect of any size exists. Reliability was modest for empathy and resilience ($\omega \approx .65$) and for the social loneliness subscale ($\omega = .676$). Measurement error attenuates observed associations and, importantly, attenuates interaction terms more severely than main effects, since the product term compounds the error in both components.

Sensitivity checks addressed two further concerns. Interaction coefficients were robust to adjustment for age, sex and the remaining structural-relational circumstances, and the pattern

of significant resource associations and null structural associations was also similar in a negative-binomial sensitivity analysis addressing overdispersion in the loneliness count (Section 3.2.1); that model was not intended to represent the scale’s upper bound of 11. Collinearity was not a material concern in the final model (all VIF ≤ 1.8 ; Table 1).

The connectivity measure is a single frequency item, and cannot distinguish who is contacted or to what effect.

The sample is a convenience sample from one Spanish region, predominantly female and 96% urban; the divorced subgroup ($n = 23$) is too small to support firm conclusions. This regional scope limits the generalisability of the specific prevalence estimates reported here, but the substantive contribution of this study — a direct test of whether personal resources buffer structural and relational disadvantage, and an analytic strategy for resolving that test’s null result — addresses a question and a methodological gap that are not region-specific and have not, to our knowledge, been reported together in a single sample previously. With 70.2% women, the sample is not ideally configured to test whether the sex null generalises, particularly given that sex differences in loneliness may operate through widowhood and living arrangement rather than through sex itself. Non-participation among those approached was not systematically logged beyond informally noted reasons (distrust, lack of time; Section 2.1), so we cannot rule out selective non-response by, for example, more isolated or distrustful individuals, which would tend to understate the loneliness gradients reported here. The analyses were not pre-registered, and structural–relational circumstances here covers a heterogeneous set of sociodemographic and relational variables rather than a single theoretically unified construct (Introduction).

5 Conclusions

In 302 Spanish older adults, structural–relational circumstances and personal resources were each associated with unwanted loneliness. In the reported hierarchical decomposition, personal resources accounted for roughly twice the incremental variance of the preceding structural–relational block. None of nine interaction tests approached significance, and a sensitivity analysis indicates this null is reasonably well resolved against effects near the largest coefficient observed, though not against smaller ones. The apparent protective association of messaging-app use was largely an age-band gradient.

Loneliness in later life appears in these cross-sectional data to be more consistent with additive associations of personal resources and structural–relational circumstances than with substantial resource-by-risk interactions. These cross-sectional results are compatible with independent associations of personal resources and structural–relational circumstances with loneliness. Whether resource-focused and circumstance-focused interventions are complementary requires longitudinal or experimental study.

Declarations

Ethics approval and consent to participate

Approved by the Research Ethics Committee of the Hospital Virgen de la Luz, Cuenca, Spain (approval number REG: 2026/PI0326, granted 9 February 2026). All participants gave written informed consent. Conducted in accordance with the Declaration of Helsinki. This is a secondary analysis of an existing dataset and was not preregistered; no trial or study protocol registration number applies.

Consent for publication

Not applicable (no individual person’s data, images, or identifiable information are reported).

Availability of data and materials

Analysis code will be deposited in a public repository prior to acceptance. Anonymised participant-level data will be made available in a public repository following completion of the wider study of which this analysis forms part; access conditions will be specified at that time. Requests in the interim may be directed to the corresponding author.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

R.G.B. contributed to conception, data analysis and manuscript preparation. A.I.C.S. and R.L.L. contributed to data interpretation and critical revision of the manuscript. R.C.A. contributed to conception, study supervision and critical revision of the manuscript. All authors read and approved the final manuscript.

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