



HAL
open science

Evaluating Loneliness Measurements across the European Union

Bastien Paris, Ivan Ropovik, Miguel Alejandro A. Silan, Beatrice d'Hombres,
Elizabeth Casabianca, Hans Ijzerman

► **To cite this version:**

Bastien Paris, Ivan Ropovik, Miguel Alejandro A. Silan, Beatrice d'Hombres, Elizabeth Casabianca, et al.. Evaluating Loneliness Measurements across the European Union. 2025. hal-04927864

HAL Id: hal-04927864

<https://hal.science/hal-04927864v1>

Preprint submitted on 4 Feb 2025

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Evaluating Loneliness Measurements across the European Union

Bastien Paris

KU Leuven, UC Louvain & Annecy Behavioral Science Lab

Ivan Ropovik

Charles University in Prague, Czech Academy of Sciences & Slovak Academy of Sciences

Miguel Silan

Université Lumière Lyon 2 & Annecy Behavioral Science Lab

Béatrice d’Hombres

Joint Research Centre of the European Commission

Elizabeth Casabianca

Joint Research Centre of the European Commission

Hans IJzerman

Annecy Behavioral Science Lab & University of Oxford

We wrote this registered report in the past tense to avoid errors when completing the Stage 2 Registered Report.

Author note: Béatrice d’Hombres and Elizabeth Casabianca have reviewed the data before the submission of this Registered Report. The final decisions for data analysis, hypothesis, and inferences are all with Bastien Paris, Miguel Silan, Ivan Ropovik, and Hans IJzerman. Paris, Silan, Ropovik, and IJzerman did not have access to the full data prior to In Principle Acceptance. They received data for the exploratory fold from Casabianca, who kept the confirmatory fold until after In Principle Acceptance.

30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54

Abstract

Loneliness has been associated with several detrimental effects for individuals and societies, making it a priority for monitoring across the European Union. While many loneliness measures currently exist, notable gaps exist regarding knowledge of their psychometric structure, reliability, comparability, and validity, particularly as it pertains to their suitability for EU-wide population surveys. Relying on data from the *EU Loneliness Survey* covering the 27 EU member states ($N=25,646$), we examined the factor structure, internal consistency, measurement invariance, and construct validity of the six-item De Jong Gierveld Loneliness Scale (DJGLS-6), the three-item UCLA Loneliness Scale (T-ILS), and a single-item measure of loneliness. Following a process of analyses in an exploratory fold, followed by pre-registered confirmatory analyses testing the model sharpened in the exploratory fold, we found (a) the DJGLS-6 to show [poor/acceptable/very good] fit to a [one/two] factor structure for XX countries, [sufficient/insufficient] internal consistency for XX countries, [measurement invariance property described here], and [sufficient/insufficient] construct validity for XX countries, (b) the T-ILS to show [poor/acceptable/very good] fit to a one factor structure for XX countries, [sufficient/insufficient] internal consistency for XX countries, [measurement invariance property described here], and [sufficient/insufficient] construct validity for XX countries, and (c) the single-item measure of loneliness to show [sufficient/insufficient] construct validity for XX countries. Overall, the evidence suggests [based on the results described above, we will conclude on the suitability of the DJGLS-6, T-ILS, and single-item measure for monitoring loneliness in the European Union].

Keywords: loneliness; measurement; inventory; measurement properties, European Union.

MEASURING LONELINESS IN THE EU 3

Question	Hypothesis	Sampling Plan	Analysis Plan	Rationale for deciding the sensitivity of the test for confirming or disconfirming the hypothesis	Interpretation given different outcomes	Theory that could be shown wrong by the outcomes
<p>Is the model fit sufficient for a) the DJGLS-6, and b) the T-ILS across the European Union?</p>	<p>Following analyses on the exploratory fold, we expect the DJGLS-6 to provide a sufficient fit to a two-factor structure for 14 countries, and the T-ILS to provide a sufficient fit for a one-factor structure for 25 countries (Appendix A).</p>	<p>We will partition the data from the EU Loneliness Survey ($N = 25,646$, covering the 27 EU member states) into separate exploratory and confirmatory folds of similar sizes (approximately 500 participants per country and per fold). We will stratify the data to ensure similarities in terms of countries between folds.</p> <p>Elizabeth Casabianca, who is not involved in drawing inferences from the analyses, will supervise the splitting of the folds.</p>	<p>We will assess the factor structure of the DJGLS-6 and T-ILS using confirmatory factor analysis on the factor structures identified in the exploratory fold, for each country separately.</p>	<p>A sample size of $n=500$ per country and fold has been found to be the minimum ideal number of participants for factor analyses under various conditions (MacCallum et al., 1999).</p>	<p>We applied the same criteria as in exploratory fold: We evaluated the fit as acceptable (sufficient) with Comparative Fit Index (CFI) values $\geq .90$ and Root Mean Squared Error of Approximation (RMSEA) values $\leq .08$, and as very good with CFI values $\geq .95$ and RMSEA values $\leq .06$ (De Roover et al., 2022; Hu & Bentler, 1999).</p> <p>In case the conclusion regarding the adequacy of model fit converges, we will consider the analyses in the confirmatory fold a successful replication.</p> <p>In case the model fit obtained from confirmatory factor analyses does not reach an acceptable level, we will consider the measure to be inadequate for the proposed factor structure.</p>	<p>If the model fit for either scale in a country is poor, it means the concept does not map onto the measure as theorized. In that case, we will make recommendations for those countries on how to develop new measures.</p>
<p>How high is the internal consistency of a) the DJGLS-6, and b) the T-ILS across the European Union?</p>	<p>Following analyses on the exploratory fold, we expect the DJGLS-6 to demonstrate sufficient internal consistency for 24 countries, and the T-ILS to demonstrate</p>	<p>We will partition the data from the EU Loneliness Survey ($N = 25,646$, covering the 27 EU member states) into separate exploratory and confirmatory</p>	<p>We will assess the internal consistency of the DJGLS-6 and T-ILS by computing McDonald's ω.</p> <p>We will report the ω unidimensional in case of a one-factor structure, or</p>	<p>No clear guidelines exist regarding sample size requirements on internal consistency analyses. However, sample sizes for each country will be larger than a</p>	<p>We will apply the same criteria as in exploratory fold: We considered ω values $\geq .60$ as indicators of sufficient internal consistency for the DJGLS-6 and T-ILS.</p>	<p>For both the two subscales of the DJGLS-6 and the T-ILS, if we find insufficient internal consistency for a given country ($\omega < .60$), then we recommend against using that measure for that</p>

MEASURING LONELINESS IN THE EU 4

	<p>sufficient internal consistency for the 27 countries (Appendix A).</p>	<p>folds of similar sizes (approximately 500 participants per country and per fold). We will stratify the data to ensure similarities in terms of countries between folds.</p> <p>Elizabeth Casabianca, who is not involved in drawing inferences from the analyses, will supervise the splitting of the folds.</p>	<p>the ω hierarchical in case of a n-factors structure.</p>	<p>conservative threshold of $n=400$ proposed by Charter (1999).</p>	<p>If estimates are on the same side of the .6 threshold, we considered it a successful replication.</p> <p>In case the measure does not have sufficient internal consistency, items within the measure can't be thought to all measure loneliness.</p>	<p>country. In addition, we will recommend strategies to develop new measures.</p>
<p>Are a) the DJGLS-6, and b) the T-ILS invariant across the European Union?</p>	<p>Following analyses on the exploratory fold, we expect the DJGLS-6 to demonstrate scalar invariance across 2 clusters of countries, and the T-ILS to demonstrate scalar invariance across the 27 countries (Appendix A).</p>	<p>We will partition the data from the EU Loneliness Survey ($N = 25,646$, covering the 27 EU member states) into separate exploratory and confirmatory folds of similar sizes (approximately 500 participants per country and per fold). We will stratify the data to ensure similarities in terms of countries between folds.</p> <p>Elizabeth Casabianca, who is not involved in drawing inferences from the analyses, will supervise the splitting of the folds.</p>	<p>We will assess the measurement invariance of the DJGLS-6 and T-ILS using multigroup confirmatory factor analysis on the clusters of countries identified in the exploratory fold. For clusters of countries where at least metric invariance holds, we will further examine whether the given measure exhibits invariant measurement properties across levels of gender (female/male) and age (6 groups).</p>	<p>Again, a sample size of $n=500$ has been found to be the minimum ideal number of participants for factor analyses under various circumstances (MacCallum et al., 1999)</p>	<p>We applied the same criteria as in exploratory fold. We established configural invariance with the same criteria as for the factor structure property (i.e., CFI values $\geq .90$ and RMSEA values $\leq .08$);</p> <p>We established metric and scalar invariance if the corresponding measurement model has Δ CFI value $\geq -.02$ or Δ RMSEA value $\leq .03$ compared to the subordinate model (i.e., configural or metric, respectively).</p> <p>In case the same level of invariance across the given clusters of countries is found, we will consider it a successful replication.</p> <p>If a measure does not reach scalar invariance across countries, factor</p>	<p>If scalar invariance is not achieved across EU countries for a particular measure, it could threaten the validity of results in studies investigating differences in loneliness prevalence between countries that do not exhibit invariance with that measure.</p>

					means cannot be meaningfully compared between these countries, making the measure inadequate for cross-country comparisons.	
<p>Does the construct validity of a) the DJGLS-6, b) the T-ILS, and c) the single-item measure of loneliness across the European Union meet the minimum standards set forth?</p> <p>Specifically, are they significant in the expected direction? It is important to note that our minimum standard permits only minimal theoretical interpretation. This standard does not evaluate the relative effect size between constructs (e.g., social support versus depression). In other words, we will assess whether there is sufficient, though not necessarily sophisticated, construct validity.</p>	<p>Following analyses on the exploratory fold, we expect the DJLS-6 to demonstrate sufficient construct validity for 25 countries, the T-ILS to demonstrate sufficient construct validity for 22 countries, and the single-item to demonstrate sufficient construct validity for 19 countries (Appendix A).</p>	<p>We will partition the data from the EU Loneliness Survey ($N = 25,646$, covering the 27 EU member states) into separate exploratory and confirmatory folds of similar sizes (approximately 500 participants per country and per fold). We will stratify the data to ensure similarities in terms of countries between folds.</p> <p>Elizabeth Casabianca, who is not involved in drawing inferences from the analyses, will supervise the splitting of the folds.</p>	<p>We will assess the three measures' construct validity through tests of their nomological networks, by reporting bivariate latent correlation coefficients (correlations of factor scores) with various items, for each country separately.</p>	<p>Our sample sizes will be larger than the threshold of $n=250$ at which correlations appear to stabilize (Schönbrodt & Perugini, 2013).</p>	<p>We applied the same criteria as in exploratory fold. At least two-thirds of the latent correlations obtained have to be significant at the nominal rate of $p < 0.05$ per country for 12 tests ($p < 0.004$ when corrected for multiple comparisons using Bonferroni correction), of magnitude $r \geq .10$, and in the expected direction: positive latent correlation with the indicator of negative emotion, and negative latent correlations with the indicators of social connectedness, positive emotion, and health.</p> <p>We will apply Fisher's z-transformation to the correlation coefficients from the exploratory and confirmatory fold and will calculate the z-score for their difference. We will then use a BIC approximation (implicitly assuming a unit information prior) to compute Bayes factors (Wagenmakers, 2007) to assess to what degree do the data support the H_0 of no</p>	<p>For all measures, insufficient construct validity in a given country would question whether the measure assesses loneliness, and may lead to inaccurate assessments and lack of confidence in results of studies that employ the measure in that country.</p>

					<p>difference between the correlations.</p> <p>We will consider the correlation coefficients to be successfully replicated if either both correlation coefficients are significant, above $r \geq .10$, and in the same direction, or in case the BF01 (in favor of the null) is larger than 3 (taken as an indication of equivalence of the correlation coefficients).</p> <p>In case the loneliness measure does not have sufficient construct validity, we will consider the measure to be inadequate for measuring loneliness.</p>
--	--	--	--	--	---

56 **Evaluating loneliness measurements across the European Union**

57 Loneliness, the negative experience caused by a discrepancy between one's desired
58 and achieved social relations (Perlman & Peplau, 1981), has gained massive interest in
59 worldwide politics over the last decade. The World Health Organization (2023) has launched
60 a commission on social connection, the US Surgeon General portrayed loneliness as a public
61 health crisis (Scheimer & Chakrabarti, 2020), both the UK and Japan appointed a minister to
62 address loneliness (Prime Minister's Office of Japan, 2021; UK Government, 2018), and the
63 European Union's Commission instituted a research group on loneliness (European
64 Commission, 2022). Such increased attention across countries and organizations underscores
65 the rising importance of strengthening social ties in our societies.

66 One crucial step in addressing loneliness in the European Union (EU) is
67 understanding it across different countries, languages, and cultures to monitor it accurately
68 and effectively. Accurate and effective monitoring, in turn, relies on measurement meeting
69 various hallmarks of measurement quality both across and within different cultural settings.
70 Many loneliness measures are available in the literature (Maes et al., 2022; Mund et al.,
71 2023), but surprising gaps exist regarding knowledge of their psychometric structure,
72 reliability, comparability, and validity, particularly as it pertains to their suitability for EU-
73 wide population surveys. Relying on data collected in the 27 EU member states, we aimed to
74 fill this gap by providing an examination of the psychometric properties of the three-item
75 UCLA Loneliness Scale (T-ILS; Hughes et al., 2004), the six-item De Jong Gierveld
76 Loneliness Scale (DJGLS-6; De Jong Gierveld & Van Tilburg, 2006), and a single-item
77 measure of loneliness.

78 **Loneliness' Impact on EU Citizens and its Measurement**

79 Loneliness poses substantial societal costs, with studies estimating loneliness to be
80 associated with greater healthcare use and expenditures (Beutel et al., 2017; Gerst-Emerson

81 & Jayawardhana, 2015; Holt-Lunstad et al., 2017). Loneliness impacts health and longevity
82 similar to other clinical risk factors (Holt-Lunstad et al., 2010; Pantell et al., 2013). Research
83 suggests, for instance, that a one-point increase in loneliness is associated with a 26%
84 increased risk of early death consistently across different demographic groups (Holt-Lunstad
85 et al., 2015). Loneliness is associated with cardiovascular disease, hypertension (Hawkley et
86 al., 2010; Valtorta et al., 2016), with a greater decline in activities of daily living and motor
87 performance (Perissinotto et al., 2012; Buchman et al., 2010), and longer use of skilled
88 nursing facility (Pomeroy et al., 2023a).

89 These impacts on physical health translate to economic costs. In the Netherlands, for
90 instance, loneliness is associated with an increased spending in mental healthcare costs by
91 11.1% and general practitioner costs by 0.5% (Meisters et al., 2021). Loneliness in Spain is
92 estimated to have a total cost of 14 billion euros per year, accounting for 1.17% of Spain's
93 Gross Domestic Product (GDP) as of 2021 (Observatorio Estatal de la Soledad No Deseada,
94 2023). The costs associated with productivity losses are over 8 billion euros per year,
95 approximately 0.67% of the country's GDP. Loneliness in Spain also leads to a significant
96 reduction in quality of life, equating to a loss of more than 1 million Quality Adjusted Life
97 Years (QALYs), not associated with mortality. Moreover, premature deaths due to loneliness
98 contribute to an annual loss of nearly 18,000 QALYs, indicating that the total loss in quality
99 of life due to loneliness represents 2.79% of the total healthy life years of the Spanish
100 population over 15 years of age. Loneliness thus seems to have significant costs, which may
101 extend across the EU. However, the complexity of measuring loneliness has led to
102 uncertainties regarding the precise relationship of loneliness and various health outcomes.

103 For example, it is not always clear which of the factors (i.e., social isolation or
104 loneliness) predict health outcomes just as it is unclear what is the direction of causal effects
105 at play. Further, while loneliness is consistently correlated with worse mental and physical

106 health (for reviews, see Hawkey & Cacioppo, 2010; Leigh-Hunt et al., 2017; Park et al.,
107 2020) the impact of loneliness on mortality could be confounded by other factors like
108 socioeconomic status, access to care, and health conditions (Elovainio et al., 2017;
109 Perissinotto et al., 2012). Most studies do not include measures of social isolation and
110 loneliness. Notable exceptions are by Valtorta et al. (2018) who find that loneliness, but not
111 social isolation, increases the risk of heart disease and stroke, while Hakulinen et al. (2018)
112 report both loneliness and social isolation as risk factors. The evidence on the cumulative
113 effect of loneliness on cardiovascular disease risk is equally mixed: Hawkey et al. (2010)
114 and Caspi et al. (2006) suggest a dose-response relationship, but Valtorta et al. (2018) does
115 not. These differences between reports may be due to sampling differences, inaccuracies in
116 statistical reporting, or measurement error.

117 Perhaps part of the problem of measuring loneliness is conceptual. Loneliness on the
118 one hand and social isolation and exclusion on the other hand, are thought to be distinct
119 constructs (Perlman & Peplau, 1981; Pomeroy et al., 2023b; Prohaska et al., 2020).
120 Loneliness has been defined by some researchers as subjective social isolation (Holt-Lunstad
121 et al., 2015), by others as the negative experience caused by a discrepancy between one's
122 desired and achieved social relations (Perlman & Peplau, 1981; see also Fried et al., 2020),
123 and sometimes more specifically as inadequate experience to an intimate other person, family
124 and friends, and community life and collective identity and roles (Prohaska et al., 2020).

125 Loneliness is most-assessed as a general construct (e.g., Russell., 1996), yet
126 researchers have long argued for the multidimensionality of loneliness (Van Tilburg, 2021;
127 Weiss, 1973). Researchers and practitioners alike often distinguish between *social loneliness*,
128 the type of loneliness that arises when a person perceives to lack social resources, and
129 *emotional loneliness*, which arises when a person perceives to lack close emotional
130 attachments (Maes et al., 2022), while loneliness can be acute or chronic. Overall, there is a

131 general consensus in the field for consolidation and consensus of definitions and therefore
132 measurement for loneliness and its related concepts (e.g., Pomeroy et al., 2023b; Prohaska et
133 al., 2020). At the heart of all these issues is the mapping of the concept of loneliness to its
134 measurement. To effectively design and implement targeted interventions and policies for
135 addressing loneliness in the EU, one crucial first step is to evaluate measurement tools for
136 population surveys.

137 **Measures of Loneliness: Focus on Population Monitoring**

138 Current-available (short or long-form) measures are likely not suitable to provide
139 policy recommendations. First, correlations between different single-item measures of
140 loneliness and multi-item measures can be as low as .27 (Gallup, 2022). Second, uncertainty
141 around prevalence rates remains. For instance, within the same year (2022), prevalence rates
142 of single-item loneliness estimated by different surveys (the Joint Research Centre [JRC] EU-
143 wide loneliness measurement [which we currently study] and the Meta-Gallup State of Social
144 Connection study; Gallup, 2022) differ – on average – by 4.04 percentage points in 23 EU
145 member states, with some estimates differing by as much as 8 percentage points.¹ Finally,
146 different researchers have vastly different inferences for the same populations in whether
147 loneliness remains stable (Hawkley et al., 2019), decreases in prevalence (Clark et al., 2015;
148 Trzesniewski & Donnellan, 2010), slightly increases in prevalence (Buecker et al., 2021), or
149 increases so rapidly that it can be classified as an epidemic (Scheimer & Chakrabarti, 2020).
150 Measurement error is potentially at the heart of such different inferences.

151 Measures to assess loneliness in the general population range from single-item
152 measures to multiple-item questionnaires, with various degrees of suitability for population
153 surveys (for recent reviews of loneliness measures, see Maes et al., 2022; Mund et al., 2023),

¹ Note that the JRC's EU 27 survey was conducted online with a non-probability (quota) based sample and 16+, whereas the Gallup Survey was conducted with a probability sample, face-to-face or via telephone, and 15+. Sampling and survey mode differences could therefore maybe explain a part of the difference.

154 ranging from single-item (e.g., “How much of the time, during the past 4 weeks, have you
155 been feeling lonely”, European Commission, 2018) to composite indexes (e.g., the UCLA
156 loneliness scale; Russell et al., 1978). Single-item measures are cost-effective and under
157 resource constraints, they allow for the measurement of additional latent constructs,
158 encouraging the development and testing of causally more comprehensive, theoretically
159 sophisticated models (Hayduk & Littvay, 2012). They are also easy to deploy for the
160 monitoring of larger populations. However, they come with several disadvantages: The terms
161 “loneliness” or “lonely” are explicitly stated in these measures, making them more vulnerable
162 to social desirability bias for those respondents who perceive stigma surrounding loneliness
163 (Barreto et al., 2022; Kerr & Stanley, 2021; Russell, 1982).

164 Relatedly, an inherent problem remains for single-item measures to examine several
165 important types of validity evidence. Namely, (1) it is unknowable how tight the link is
166 between the single-item measure and the underlying latent construct of loneliness, (2) we
167 cannot examine how well the latent factor determines the variance in the single-item measure
168 relative to other theoretically equivalent operationalizations of the loneliness construct, (3) in
169 substantive research applications, it is not possible to separate the true loneliness variance
170 from the systematic error due to construct-irrelevant factors and random measurement error,
171 and (4) it is not possible to examine whether the measurement of the underlying construct is
172 invariant with regards to different population subgroups (or EU member states) (Chen, 2008;
173 Greiff & Scherer, 2018; Meredith, 1993). Single-item measures are also typically associated
174 with higher measurement error with a concomitant less precise assessment of the underlying
175 construct (Allen et al., 2022).

176 On the other hand, composite indexes typically provide more robust psychometric
177 insights into the multi-dimensional nature of loneliness (e.g., for general loneliness: Russell
178 et al., 1978; for emotional and social loneliness: DiTommaso & Spinner, 1993), across

179 different age groups (e.g., children, Asher et al., 1984, Marcoen et al., 1987; adolescents,
180 Marcoen et al., 1987; adults, DiTommaso & Spinner, 1993), and different contexts (e.g.,
181 school, Twenge et al., 2021; work, Wright et al., 2006). The most-used questionnaires of
182 loneliness include the various versions of the UCLA Loneliness Scale (Russell, 1996; Russell
183 et al., 1978, 1980) and the De Jong Gierveld Loneliness Scale (DJGLS; De Jong Gierveld &
184 Kamphuis, 1985). While these questionnaires are specifically designed to overcome the
185 limitations of single-item measures, a major drawback to using them in population surveys is
186 their length. Ultimately, the distinction between single-item and multiple-item measures
187 comes down to a tradeoff balancing the required accuracy and precision of inferences drawn
188 from these measures, pragmatic issues and intended use, and the associated diminishing
189 returns of adding items.

190 Researchers have therefore reduced lengthier scales to a three-item UCLA Loneliness
191 Scale (T-ILS; Hughes et al., 2004), designed to assess general loneliness, and a six-item
192 DJGLS (DJGLS-6; De Jong Gierveld & Van Tilburg, 2006), designed to assess either general
193 loneliness or social and emotional loneliness. Recent item-content analysis on both scales
194 suggests that the T-ILS assesses social loneliness (with the three items) and that the DJGLS-6
195 assesses both social loneliness (with two items) and emotional loneliness (with three items),
196 with one item identified as not measuring loneliness (Maes et al., 2022).

197 **Gaps in Our Psychometric Understanding of the DJGLS-6, the T-ILS, and single-item** 198 **measures in the EU**

199 Overall, some psychometric evidence for the factor structure and the comparability of
200 the DJGLS-6 and the T-ILS, as well as evidence for the reliability and the construct validity
201 of the DJGLS-6, T-ILS, and direct measures of loneliness in the EU exist, but considerable
202 gaps remains if one were to use these measures for population monitoring.

203 Recent reviews of the available evidence of internal consistency (coherence of
204 response patterns among items) of the DJGLS-6 (Alsubheen et al., 2023) and the T-ILS
205 (Alsubheen et al., 2021) show that their respective factor structure has been studied unevenly
206 across the EU. The DJGLS-6 demonstrated a two-factor model in Bulgaria, France, Germany,
207 the Netherlands, and Spain (Caballer et al., 2022; De Jong Gierveld & Van Tilburg, 2006,
208 2010) but no data seem available for other countries. Conversely, evidence of structural
209 validity for the T-ILS appears to be lacking in the EU, with apparently no formal assessment
210 of its factor structure to date. In addition, the DJGLS-6 demonstrated evidence of sufficient
211 internal consistency in Bulgaria, France, Germany, and the Netherlands (De Jong Gierveld &
212 Van Tilburg, 2006, 2010), but insufficient internal consistency in Spain (Caballer et al.,
213 2022), whereas evidence of sufficient internal consistency has been reported for the T-ILS in
214 Denmark, Finland, Germany, Hungary, Norway, and Spain (Anderssen et al., 2020; Caballer
215 et al., 2022; Jakobsen et al., 2020; Lukács et al., 2019; Mund et al., 2023; Oksanen et al.,
216 2023; Witthöft et al., 2022). However, internal consistency is typically examined through
217 Cronbach's α , which often yields biased estimates of internal consistency due to the
218 assumption that each item in a scale has the same true score variance, which rarely holds
219 (Flora, 2020; McNeish, 2018; Sijtsma, 2009).

220 Furthermore, while measurement invariance (equivalent psychometric meaning of the
221 measured construct across subgroups) is a prerequisite to meaningfully compare loneliness
222 scores between groups (Chen, 2008; Greiff & Scherer, 2018; Meredith, 1993), its evidence
223 for the DJGLS-6 and the T-ILS in the EU is still lacking (Alsubheen et al., 2021, 2023).
224 Country differences in loneliness across Europe (e.g., De Jong Gierveld & Tesch-Römer,
225 2012; Hansen & Slagsvold, 2016; Surkalim et al., 2022; Yang & Victor, 2011) may therefore
226 rest on statistical artifacts if scalar invariance of the loneliness measure employed cannot be
227 established between different regions. It is therefore unclear to what extent the DJGLS-6 and

228 T-ILS can be meaningfully compared across EU member states, potentially rendering
229 prevalence comparisons between countries biased. Of course, for single-item measures, no
230 possibilities to meaningfully model the underlying latent factor and to test measurement
231 invariance or internal consistency exist.

232 Similar gaps exist for these measures' construct validity (operationalized using the
233 nomological network – a theoretical structure connecting observations and constructs).
234 Scores to these measures have been associated with indicators of social connectedness,
235 emotions, and health, but evidence has been gathered non-exhaustively across the EU. For
236 instance, higher scores on the DJGLS-6 (indicating greater feelings of loneliness) were found
237 among participants who lived alone (Austrian and Greek samples; Heidinger & Richter,
238 2020; Parlapani et al., 2020), and those that were non-married (Croatian and German
239 samples; Kristensen et al., 2019; Piccitto et al., 2022). Higher scores were also associated
240 with poorer subjective health (Dutch and Spanish samples; De Jong Gierveld & Van Tilburg,
241 2006; Pino et al., 2014), higher depressive symptoms (French, German, Irish, and Italian
242 sample; Cena et al., 2023; Kristensen et al., 2019; Schnittger et al., 2012; Van den Broek &
243 Grundy, 2018), and more frequent suicidal thoughts (Estonian sample; Stickley et al., 2018).

244 Similarly, while the T-ILS has demonstrated evidence of construct validity in Austria,
245 Belgium, Czech Republic, Luxembourg, and Spain (Ayuso-Mateos et al., 2023; Loran et al.,
246 2021; Mayerl et al., 2021; Meckovsky et al., 2023; Ribeiro et al., 2021), evidence from other
247 EU member states appears to be lacking. Higher loneliness scores to the T-ILS (indicating
248 greater feelings of loneliness) were observed more frequently among non-married individuals
249 (Czech and Luxembourger samples; Meckovsky et al., 2023; Ribeiro et al., 2021), as well as
250 in individuals with higher depressive symptoms (Austrian and Spanish samples; Ayuso-
251 Mateos et al., 2023; Mayerl et al., 2021), and higher psychological distress (Belgian sample;
252 Loran et al., 2021).

253 Finally, evidence of good test-retest reliability has recently been reported for three
254 single-item measures of loneliness (i.e., “I feel lonely”, “I feel alone”, “How often do you
255 feel lonely”) in a German sample (Mund et al., 2023). The authors also reported the single-
256 item measures to be well-integrated into a nomological network of variables. For instance,
257 single-item measures yielded higher loneliness scores among participants with higher
258 depressive symptoms, smaller support network, or less satisfaction with friends and social
259 contacts. However, these results may not generalize to other single-item measures or across
260 the EU. In sum, a broader evaluation of a variety of measurement properties of the DJGLS-6,
261 T-ILS, and the single-item measure of loneliness included in the present study is needed to
262 determine their suitability for EU population surveys.

263 **Research Overview**

264 The goal of the present study was to provide an EU-wide evaluation of the
265 measurement properties of three loneliness measures potentially suitable for population
266 surveys: the DJGLS-6, the T-ILS, and a single-item measure of loneliness. Our work
267 contributes to the existing literature by providing an assessment of the factor structure,
268 reliability, measurement invariance, and nomological network of the DJGLS-6 and T-ILS and
269 the nomological network of a single-item measure of loneliness for all the 27 EU member
270 states. To do so, we relied on data from the *EU Loneliness Survey*, an EU-wide survey
271 conducted by the JRC in collaboration with the Directorate-General for Employment, Social
272 Affairs & Inclusion and totaling 25,646 respondents covering the 27 EU member states.

273 Based on previous research, we expected the DJGLS-6 to provide an adequate fit for a
274 two-factor model assessing emotional and social loneliness with sufficient internal
275 consistency, and the T-ILS to provide a sufficient fit for a one-factor model assessing social
276 loneliness with sufficient internal consistency ($\omega \geq .60$). We also expected the DJGLS-6, T-
277 ILS, and direct measure of loneliness to be well integrated into their nomological network,

278 with positive correlations between loneliness scores and indicators of negative emotions, and
279 negative correlations between loneliness scores and indicators of social connectedness,
280 positive emotion, and health. However, our confidence in deriving these predictions was not
281 very strong given that the psychometric properties of the DJGLS-6, T-ILS, and single-item
282 measures have been examined unevenly across the EU. We did not have any predictions for
283 the outcomes of our measurement invariance analyses, given the dearth of research on the
284 topic across the EU. This involved systematically testing at what level of invariance the data
285 generated by the measures support. The goal was to examine whether the psychometric
286 meaning of the measured constructs was equivalent across different cultural contexts, gender,
287 and age.

288 **Methods**

289 **Participants**

290 The respondents of the *EU Loneliness survey* ($N = 25,646$) were recruited from
291 established online consumer panels, with approximately 1,000 completed responses per
292 country except for Cyprus, Luxembourg and Malta ($N = 503$, $N = 370$ and $N = 529$,
293 respectively). The targeted population were adults 16 years or older, who were residents in
294 the country. We used quotas based on the population of each Member State to reflect the
295 target population in terms of age, gender, educational attainment, and Nomenclature of
296 Territorial Units for Statistics (NUTS) region of residence. These simple, non-interlocking
297 quotas were mapped to population shares calculated from Eurostat's official population
298 statistics by male/female gender, six age groups (16-25, 26-35, 36-45, 46-55, 56-65, and
299 65+), three education groups (International Standard Classification of Education ISCED level
300 0-2; levels 3 and 4 and levels 5-8); and 2-16 geographical regions depending on the country.
301 Moreover, *ex-post* sampling weights were calculated to account for possible further

302 underrepresentation of the abovementioned socio-demographic groups. We present the
303 sample sizes and descriptives on age, gender, and loneliness scores by country in Table 1.²

304 **Data collection**

305 Data collection occurred between November and December 2022 and was
306 implemented by a Consortium consisting of LE Europe, Ipsos and VVA Market Research.
307 The recruitment and sampling strategy was based on the use of panel providers with
308 established online consumer panels in all EU 27 Member States. For this specific survey, the
309 Consortium collaborated with the Cint online platform, a single network of panels that
310 covered all EU 27 Member States. Following the JRC's collection requirements, selected
311 panelists should not have completed any survey in the last 14 days.

312 The survey was originally drafted in English. Once the English version was finalized,
313 professional translators forward-translated the entire survey into the national language of
314 each member state (with the exception of Ireland and Malta, where only an English version of
315 the survey was used). Thirty-one out of the 82 survey questions of the main questionnaire
316 were back-translated. Back translation was reserved for more complex questions. For the
317 remainder of the questions either existing translations (4 questions) or forward-translation
318 were used. Instructions to translators are provided in the survey on our OSF page:
319 <https://osf.io/unfrc/>.

320 Eligible participants received invitations to fill the online survey, for an average
321 completion time of 28 minutes. The JRC Research Ethics Board (REB) reviewed the project
322 for the data collection. As the survey included sensitive and 'special category' data as defined
323 under the General Data Protection Regulation (GDPR), such as questions on health,
324 participants were asked to give informed consent to participate in the survey by answering
325 positively to the question "Do you agree to answer the survey?". If participants did not agree,

² We did not dichotomize the single-item loneliness variable as is sometimes done, as dichotomization of continuous variables "has only negative consequences and should be avoided" (Irwin & McClelland, 2003).

326 they were informed that they could not continue the survey and then asked once again for
327 their agreement. Participants then answered questions. The T-ILS and DJGLS-6 were
328 counterbalanced in order, such that half of the respondents were randomly assigned to a
329 version of the questionnaire where the T-ILS was shown first and the DJGLS-6 second, with
330 a battery of unrelated questions in between, and for the other half of the sample the order of
331 the scales was reversed. The first section of the survey included screening and profiling
332 questions that gathered demographic information to implement the quotas. Respondents were
333 then screened out if they were not eligible based on age (i.e. less than 16 years old) or if their
334 quota had already been filled (i.e., the maximum number of responses for the relevant socio-
335 demographic group had already been reached). Following the screening questions,
336 participants answered the survey.

337 **Measures**

338 Loneliness was assessed using the DJGLS-6, T-ILS, and a single-item measure. The
339 DJGLS-6 consisted of six items (e.g., “I miss having people around”) answered with *No* (0),
340 *More or less* (1), or *Yes* (2), and was used to measure social and emotional loneliness. The T-
341 ILS consisted of three items (e.g., “How often do you feel isolated from others”) answered
342 with *Hardly ever or never* (1), *Some of the time* (2), or *Often* (3), and was used to measure
343 general loneliness. Both the DJGLS-6 and T-ILS were averaged into a single score. The
344 single-item measure came from the EUSILC survey (European Commission, 2018), and
345 asked the respondent to report on the frequency of feeling lonely over the preceding 4 weeks
346 (i.e., “How much of the time, during the past 4 weeks, have you been feeling lonely”) on a 5-
347 point scale, ranging from *None of the time* to (1) to *All of the time* (5). For all measures,
348 higher scores indicated higher loneliness. All the loneliness measures included in this survey
349 are also provided in Table 2.

350 Several modules covering a variety of topics were administered along with the
351 loneliness measures. These modules included –but were not limited to– social media
352 consumption behaviors (17 items; e.g., “I use social media to get in contact with new
353 people”), civic attitudes (3 items; e.g., “I’m willing to give to good causes without expecting
354 anything in return”), or childhood experiences (5 items; e.g., “When growing up, have you
355 always lived with both of your parents?”), social support (4 items, e.g., “How often is each of
356 the following types of support available to you, if you need it: Someone to help you if you
357 were confined to bed”).

358 We selected three categories of measures to be part of the nomological network
359 analyses: 1) social activities and attitudes, which consisted of a) a composite measure of
360 perceived social support (4 items; e.g., “how often is available someone to share your most
361 private worries and fears with”, $\omega = .86$) and b) single-item measures of the participants’
362 closeness in relationship with friends (“How many of your friends would you say you have a
363 close relationship with?”) and family (“How many of your family members would you say
364 you have a close relationship with?”), occurrences of in-person meetings with friends (“On
365 average, how often do you do each of the following with any of your friends? Meet up face-
366 to-face (include both arranged and chance meetings)”) and family (“On average, how often
367 do you do each of the following with any members of your family (e.g., brothers, sisters,
368 parents, children, in-laws or grandchildren)? Meet up face-to-face (include both arranged and
369 chance meetings)”), frequency of virtual meetings with friends (“On average, how often do
370 you do each of the following with any of your friends? Talk/chat via phone, internet or social
371 media”) and family (“On average, how often do you do each of the following with any
372 members of your family (e.g., brothers, sisters, parents, children, in-laws or grandchildren)?
373 Talk/chat via phone, internet or social media”), occurrences of contacts with neighbors
374 (“How often do you have any contact, even something as simple as saying "hello", with any

375 of your neighbours?”), and frequency of participation in social activities (“Over the last 12
376 months, how frequently did you do each of the following activities? Participated in social
377 activities of a club, society and/or association”), 2) one-item indicators of emotional states
378 (depression [“Over the past week, how frequently have you felt the following way?
379 Depressed”] and happiness [“Over the past week, how frequently have you felt the following
380 way? Happy”]), and 3) an indicator of health (“In general, would you say your [physical and
381 mental] health is”). The full survey and all answer options are available at our OSF page:
382 <https://osf.io/3dxsv/>.

383 **General Analytic Plan**

384 We followed a cross-validation procedure to evaluate the measurement properties of
385 the DJGLS-6, T-ILS, and single-item measure of loneliness. Elizabeth Casabianca, an author
386 not involved at the level of data contingent choices, chose a fixed random seed number and
387 used a dedicated R script to automatically partition the dataset into two folds—exploratory
388 and confirmatory—of equal sample sizes³. Stratification was performed based on the *country*
389 variable to maintain a consistent representation of countries between folds. We first
390 conducted the analyses of the measurement properties of the loneliness instruments on the
391 exploratory fold. Once we had analyzed the exploratory fold, we then wrote our conclusions
392 and – based on the findings – pre-registered resulting hypotheses prior to testing them in our
393 confirmatory fold.

394 For the DJGLS-6, we (a) determined the optimal factor structure through exploratory
395 factor analyses and subsequently validated it by confirmatory factor analysis, along which we
396 evaluated the fit of the factor structures usually employed in the literature using confirmatory
397 factor analysis, (b) assessed their internal consistency using McDonald’s ω , (c) assessed their

³ While it is generally preferable to allocate a higher proportion of data for training, we chose to split the data in half to ensure approximately 500 participants per country per fold. This decision aligns with research findings that suggest 500 is a minimum ideal number of participants for factor analyses under various circumstances (MacCallum et al., 1999).

398 measurement invariance properties (across countries, and within clusters of countries that
399 were invariant, across gender and age) through a combination of multigroup confirmatory
400 factor analyses and mixture multigroup factor analyses. For the T-ILS, we carried out the
401 same analysis except for where the three-item structure does not allow for a formal test of the
402 factor model. There, we assessed the internal structure by the adequacy of factor loadings
403 only. Finally, we evaluated the construct validity of the DGLS-6, T-ILS, and single-item
404 measure of loneliness through analyses of their nomological network. We conducted analyses
405 using the R programming language (version 4.3.1.; R Core Team, 2022). All our scripts are
406 available at our OSF page: <https://osf.io/7u4e8/>.

407 *Factor Analyses and Internal Consistency*

408 The DJGLS-6 is typically thought to consist of two factors (assessing emotional and
409 social loneliness; De Jong Gierveld & Van Tilburg, 2006), while the T-ILS is thought to
410 consist of one factor (assessing general loneliness; Hughes et al., 2004). However, given that
411 factor structure is relatively unexamined in EU-wide samples, in our first fold, we conducted
412 both exploratory (exploring the optimal factor structure for both scales) and confirmatory
413 (testing the two predicted factors for the DJGLS-6 and one factor for the T-ILS) factor
414 analyses to identify its optimal structure across countries, balancing theoretical parsimony
415 with model fit.

416 To retain the most optimal factor structure following exploratory factor analyses, we
417 used Empirical Kaiser Criterion (Braeken & Van Assen, 2017). As a robustness check, we
418 also report the results of parallel analysis (Horn, 1965) in the supplementary materials.
419 Parallel analysis and Empirical Kaiser Criterion both retain a factor structure when its
420 eigenvalue is greater than the mean eigenvalue from its random counterpart. The Empirical
421 Kaiser Criterion tends to outperform parallel analysis when used on short scales with
422 correlated dimensions (Braeken & Van Assen, 2017). In case these methods yielded

423 inconsistent results, we favored the factor structure identified by the Empirical Kaiser
424 Criterion but for the sake of transparency, we also mentioned the inconsistency of results
425 when an alternatively justifiable method is used. We subsequently conducted confirmatory
426 factor analyses to assess the fit of the structure we retained.

427 Following common guidelines, we evaluated the fit as acceptable with Comparative
428 Fit Index (CFI) values $\geq .90$ and Root Mean Squared Error of Approximation (RMSEA)
429 values $\leq .08$, and as very good with CFI values $\geq .95$ and RMSEA values $\leq .06$ (De Roover et
430 al., 2022; Hu & Bentler, 1999). Given the large size of the sample included in the study, we
431 expected the χ^2 test of model fit to consistently return significant p -values. Consequently, we
432 did not use p -values nor RMSEA confidence intervals to make inferences when evaluating
433 the fit of the factor structures (but still reported them for the sake of transparency and
434 completeness). Instead, we considered the model fit to be sufficient with CFI values $\geq .90$ and
435 RMSEA values $\leq .08$ (see also De Roover et al., 2022; Hu & Bentler, 1999). In parallel, we
436 conducted confirmatory factor analyses to assess the fit of the structures typically used in the
437 literature for both measures (i.e., two factors assessing emotional and social loneliness for the
438 DJGLS-6; one factor assessing general loneliness for the T-ILS), using the same guidelines to
439 evaluate model fit (i.e., acceptable with Comparative Fit Index (CFI) values $\geq .90$ and Root
440 Mean Squared Error of Approximation (RMSEA) values $\leq .08$; good with CFI values $\geq .95$
441 and RMSEA values $\leq .06$). If the factor structure typically used in the literature did not match
442 the most optimal structure identified through exploratory factor analysis, we decided on a
443 structure for the subsequent analyses. Again, our decision aimed to balance theoretical
444 parsimony with model fit.

445 We conducted the factor analyses using the Weighted Least Squares Mean and
446 Variance adjusted (WLSMV) estimation method whenever possible. This choice stemmed
447 from the unsuitability of treating the DJGLS-6 and T-ILS as continuous measures due to their

448 response formats (i.e., 3-point Likert type answers for both measures). Previous research has
449 shown that treating this type of measures as continuous would challenge the assumption of
450 multivariate normality that undermines the Maximum Likelihood (ML) estimation method
451 commonly employed in factor analyses, making this estimation method less appropriate for
452 measures answered with less than five response categories (Li, 2015; Rhemtulla et al., 2012;
453 for contrasting views, see Robitzsch, 2020). All aggregate (across countries) latent models
454 employed sampling weights to balance out unequal sampling probabilities caused by the fact
455 that sample sizes across countries were similar (while country population sizes vary widely).
456 For all latent variable models, we handled the missing data using listwise deletion, as only
457 1.9% of the data for loneliness measures were missing. Here, we preferred the ability to
458 directly model the ordinal character of the data using WLSMV over imputing the little
459 amount of missing data by Full Information Maximum Likelihood.

460 Finally, we assessed the internal consistency of the DJGLS-6 and T-ILS for each
461 country separately using McDonald's omega (ω). While the Cronbach's alpha (α) is the most
462 popular metric for assessing internal consistency, its use is conditioned by a set of
463 assumptions that are rarely met, leading to the reporting of biased estimates of internal
464 consistency in most cases (Flora, 2020; McNeish, 2018; Sijtsma, 2009).

465 To select the right metric for internal consistency of the DJGLS-6 and T-ILS, we
466 followed guidelines reported by Flora (2020) and reported the ω for unidimensional
467 categorical items. There are no clear guidelines as to which minimum ω value would indicate
468 sufficient internal consistency, with some authors suggesting a minimum value ranging
469 between .50 and .70 (Tavakol & Dennick, 2011; Watkins, 2017). As internal consistency is
470 positively correlated to the number of items of a measure (Cortina, 1993), we took a medium
471 ω value $\geq .60$ as indicator of sufficient internal consistency given the short length of the
472 DJGLS-6 and T-ILS.

473 *Measurement Invariance*

474 We conducted measurement invariance tests to assess the comparability of scores
475 from the DJGLS-6 and T-ILS across countries in the EU (as well as across gender and age for
476 clusters of countries that were invariant), using a combination of multigroup confirmatory
477 factor analysis (Meredith & Teresi, 2006) and mixture multigroup factor analysis (De
478 Roover, 2021; De Roover et al., 2017, 2022). In practice, measurement invariance tests are
479 often conducted through multigroup confirmatory factor analysis and allow for establishing
480 measurement invariance at three different levels, in an incremental manner. First, configural
481 invariance is established if the factor structure of the measurement model is equivalent across
482 groups. In case configural invariance holds, metric (weak) invariance is then established if
483 factor loadings are equivalent across groups, after which scalar (strong) invariance is
484 established if both factor loadings and item intercepts are equivalent across groups.
485 Following the rejection of one level of measurement invariance, researchers usually resort to
486 pairwise comparisons of specific groups to establish that level of measurement invariance in
487 a smaller number of groups.

488 One important drawback to this strategy is the number of comparisons one would
489 have to do in case the number of groups is large: With 27 groups (i.e., one for each EU
490 member state), the number of pairwise comparisons would amount to 351, which increases
491 the risk of false positives and makes it hard to disentangle invariant parameters from non-
492 invariant parameters, and for which groups they apply (De Roover et al., 2022). Mixture
493 multigroup factor analysis proposes a parsimonious solution to that problem, as it allows to
494 unravel clusters of groups in which the measurement model is invariant across groups on both
495 factor loadings and item intercepts (i.e., clusters of groups that are invariant at the scalar
496 level). Only under scalar invariance is it then justified to compare prevalence rates across
497 countries and interpret the observed differences between countries' scale scores as the

498 difference in the level of the underlying construct. However, mixture multigroup factor
499 analysis is still an imperfect solution to our specific case, as it models factor analyses using
500 the Maximum Likelihood (ML) method, which – as explained above – is less appropriate on
501 3-point Likert type measures like the DJGLS-6 and T-ILS.

502 Our procedure for testing measurement invariance was thus as follows: We first tried
503 to establish measurement invariance across the 27 EU member states using multigroup
504 confirmatory factor analysis. Configural invariance was established following the same
505 indicators as for our confirmatory factor analyses ($CFI \geq .90$ and $RMSEA$ values $\leq .08$),
506 metric invariance was established in case the model that imposed equivalent factor loadings
507 had significant ΔCFI value $\geq -.02$ or $\Delta RMSEA$ value $\leq .03$ compared to the configural model,
508 and scalar invariance was established in case the model that imposed equivalent factor
509 loadings and item intercepts had ΔCFI value $\geq -.02$ or $\Delta RMSEA$ value $\leq .03$ compared to the
510 metric model. Those cut-offs values appear to be appropriate for detecting measurement
511 invariance across many groups (Rutkowski & Svetina, 2014).

512 In case measurement invariance failed at any level, instead of doing pairwise
513 comparisons to pinpoint invariant countries, we resorted to mixture multigroup factor
514 analysis to unravel clusters of countries invariant at the scalar level. Loneliness scores would
515 then be comparable within the given cluster of countries. Specifically, we used the
516 *MixtureMG_FA* function from the *mixmgfa* R package (De Roover, 2021; De Roover et al.,
517 2022) to provide cluster solutions of countries with equivalent factor loadings and item
518 intercepts. We selected the best clustering solution using a combination of (a) the Convex
519 Hull procedure (CHull; Ceulemans & Kiers, 2006; Ceulemans & Van Mechelen, 2005),
520 which is a generalization of the scree-test (Cattell, 1966) that provides the optimal clustering
521 solution via a maximized scree ratio and visual detection of an elbow in the CHull plot; and
522 (b) the Bayesian Information Criterion (BIC; Schwarz, 1978) with the number of groups G as

523 sample size (BIC_G) that provides the optimal clustering solution via a minimized BIC_G
524 value.

525 In case the two methods yielded different optimal clustering solutions, we favored the
526 clustering solution returned by the CHull method, which does not make distributional
527 assumptions on the data (De Roover et al., 2022). Following this, as mixture multigroup
528 factor analysis does not support the estimation method that best fits categorical data (De
529 Roover et al., 2022), we subsequently assessed measurement invariance on the unraveled
530 clusters using multigroup confirmatory factor analysis again and concluded on the invariance
531 of the measure following these analyses.

532 For each cluster of countries, where the measures exhibited strong invariance of
533 measurement properties, we also tested invariance across levels of gender (female/male) and
534 age (in 6 groups: 16-25, 26-35, 36-45, 46-55, 56-65, 65+), using the same approach and
535 criteria.

536 ***Construct Validity: Nomological Network***

537 We evaluated the construct validity of the DJGLS-6, T-ILS, and single-item measure
538 of loneliness through analyses of their nomological network, by examining latent correlations
539 between the loneliness measures with composite measures and items concurrently
540 administered in the EU Loneliness Survey, for each country separately. For multiple-item
541 measures, we have fitted a CFA model using WLSMV estimator, explicitly modeling the
542 items as ordered, and extracted the measurement error-free for the unitary latent factor. For
543 single-item measures, we conservatively assumed ~50% reliability (to make the measurement
544 model identified), modeling a latent variable having a single ordered indicator by fixing the
545 factor loading to .70. Then, we computed zero-order Pearson's correlation coefficients to
546 quantify the relationship between the measurement error-free factor scores of the three

547 loneliness measures with factor scores for indicators of social activities and attitudes,
548 indicators of emotions, and an indicator of health.

549 We considered the loneliness measures to show sufficient construct validity in case at
550 least two-thirds of the latent correlations obtained were in the expected direction, significant
551 at the .05 level adjusted with Bonferroni correction applied at the country level (with 12
552 correlation tests per country, this corresponds to an α threshold adjusted to .004), and a $|r| \geq$
553 .10. We expected positive latent correlations between the loneliness scores and the indicator
554 of negative emotion, and negative correlations between the loneliness scores and the
555 indicators of social activities and attitudes, positive emotion, and health. In addition, we
556 computed latent correlation coefficients to quantify the relationship between the three
557 loneliness measures (i.e., the DJGLS-6, T-ILS, and single-item measure of loneliness).

558 For the estimation of zero-order correlations of factor scores, we handled the 1.9% of
559 missing data using pairwise deletion.

560 **Results**

561 **Results from the exploratory fold**

562 In summary, both the DJGLS-6 and T-ILS provided evidence of adequate
563 measurement properties on factor structure, internal consistency, measurement invariance,
564 and construct validity. More specifically, the DJGLS-6 provided a good fit for a two-factor
565 structure for 14 countries, sufficient internal consistency (for both subscales) for 24 countries,
566 provided evidence of measurement invariance across two different clusters of countries, and
567 provided evidence of sufficient construct validity for 25 countries. The T-ILS showed
568 sufficient internal consistency for all 27 countries, provided evidence of measurement
569 invariance across the 27 EU member states, and provided evidence of sufficient construct
570 validity for 22 countries. The one-item measure of loneliness provided evidence of sufficient
571 construct validity for 19 countries.

572 *Factor Analyses and Internal Consistency*

573 Following factor analyses in our exploratory fold, we decided to retain a two-factor
 574 structure for the DJGLS-6, and a one factor structure for the T-ILS. The DJLGS-6 provided a
 575 very good fit to a two-factor structure for 8 countries, good fit for 6 countries and poor fit for
 576 13 countries, with sufficient internal consistency for 24 countries. For the T-ILS, the unitary
 577 factor explained the majority of variance ($\lambda > .71$) for all the three items in 25 countries and
 578 the scale score showed sufficient internal consistency for all countries. Table 3 presents the
 579 model fit and internal consistency values obtained across the 27 EU member states and for
 580 each member state separately, for each measure.

581 **DJGLS-6.** Results of the parallel analysis and Empirical Kaiser Criterion extraction
 582 techniques suggested that a two-factor structure was the most appropriate for the DJGLS-6
 583 across the 27 EU member states. We found this two-factor model to provide a good fit to the
 584 data ($\chi^2 = 299$, $df = 8$, $p < .001$, CFI = .989, RMSEA = .055, CI 90% [.050, .060]). The scale
 585 scores had a sufficient mean internal consistency ($\omega_{\text{social}} = .82$, ranging from .78 to .86;
 586 $\omega_{\text{emotional}} = .73$, ranging from .56 to .86). The scale showed – in accordance with our a priori
 587 set standard of $\omega = .60$ – insufficient internal consistency in Finland, France, and Romania
 588 (emotional subscale, in all three cases).

589 In parallel, we tested the model fit of the two-factor structure usually employed in the
 590 literature across the 27 EU member states, using confirmatory factor analysis. We also tested
 591 a unitary factor model and found the model to provide a poor fit to the data ($\chi^2 = 3023$, $df = 9$,
 592 $p < .001$, CFI = .887, RMSEA = .166, CI 90% [.161, .171]) with sufficient mean internal
 593 consistency ($\omega = .90$). The unitary factor model fitted the data significantly worse, $\chi^2_{\text{diff}} =$
 594 1103, $p < .001$. We therefore chose to retain the two-factor structure. This structure thus acted
 595 as a representation of the overarching loneliness construct subjected to further measurement
 596 invariance assessment and nomological network analyses.

597 For the structure we retained, we report the model fit indices and internal consistency
598 obtained across the 27 EU member states and for each country separately in Table 3.

599 **T-ILS.** As the T-ILS is a three-item scale, the only possible hierarchical structure is a
600 one-factor structure, corresponding to the factor structure employed in the literature. As this
601 model has zero degrees of freedom and is thus just-identified, it is not possible to subject it to
602 a formal model test. The fitted unitary model explained the variance in the three items well in
603 25 countries, as all item loadings were above .71 (denoting >50% construct-relevant
604 variance), ranging from .79 to .92. The scale showed sufficient internal consistency, with a
605 mean $\omega = .83$, with estimates ranging from .77 to .87, thus showing sufficient internal
606 consistency for all countries. We report the factor loadings and internal consistency of the
607 scale obtained across the 27 EU member states and for each country separately in Table 3.

608 *Measurement Invariance*

609 We conducted multigroup confirmatory factor analyses to establish configural, metric,
610 and scalar invariance of the DJGLS-6 and T-ILS across the 27 EU member states, in an
611 incremental manner. As we failed to establish measurement invariance for the DJGLS-6 at
612 the scalar level, we resorted to mixture multigroup factor analyses to unravel clusters of
613 countries invariant at the scalar level, and subsequently performed multigroup confirmatory
614 factor analyses on the unraveled clusters as sensitivity tests.

615 **DJGLS-6.** To establish configural invariance of the DJGLS-6, we first assessed if the
616 two-factor structure of the measure provided an acceptable fit for the 27 EU member states
617 using multigroup confirmatory factor analysis. The two-factor structure provided a poor fit
618 across the 27 EU member states ($\chi^2 = 910$, $df = 216$, $p < .001$, CFI = .992, RMSEA = .085,
619 CI 90% [.079, .090]), which suggests that configural invariance does not hold across the
620 countries and which suggests that the same measurement model does not hold for all groups.

621 As configural invariance could not be established using multigroup confirmatory
622 factor analysis, we resorted to mixture multigroup factor analysis to unravel clusters of
623 countries with equivalent factor loadings and item intercepts (i.e., clusters of countries
624 invariant at the scalar level). We computed a mixture multigroup factor analysis on the two-
625 factor structure of the DJGLS-6 across the 27 EU member states by using the *MixtureMG_FA*
626 function of the *mixmgfa* R package (De Roover, 2021; De Roover et al., 2022). We set the
627 function to provide cluster solutions from 1 to 6, with 5000 iterations and 50 runs, and
628 constrained the measurement model to have equivalent factor loadings and item intercepts per
629 cluster. Both the Convex Hull procedure and BIC_G criterion suggested a 3-clusters solution.
630 After further inspection of the Convex Hull plot, we decided to retain a 3-clusters solution as
631 a clear elbow could be detected on the plot around the 3-clusters solution. The clusters were
632 the following: Cluster A (Estonia, Finland, France, Romania), Cluster B (Belgium, Bulgaria,
633 Croatia, Cyprus, Czechia, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Malta,
634 Portugal, Slovakia, Slovenia, Spain), and Cluster C (Austria, Denmark, Latvia, Lithuania,
635 Netherlands, Poland, Sweden). That the countries are invariant at the scalar level within these
636 clusters means that the mean scores on the DJGLS-6 can safely be compared within, but not
637 across, these three clusters.

638 As mixture multigroup factor analysis currently does not handle categorical data in
639 the most appropriate way, we further conducted multigroup confirmatory factor analyses on
640 the unraveled clusters. We display the results of these analyses in Table 4. The findings were
641 consistent with the conclusions drawn from the mixture multigroup factor analysis for
642 clusters B and C, where scalar invariance was successfully established. However, for cluster
643 A, we failed to establish configural invariance.

644 Within cluster C, the DJGLS-6 also showed strong (scalar) measurement invariance
645 across levels of gender (women/men) and age (16-25, 26-35, 36-45, 46-55, 56-65, 65+),

646 meaning that the mean scores for men and women and across age groups within cluster C can
647 be compared. Within cluster B, however, we failed to establish configural invariance across
648 levels of gender and age. The detailed results are shown in the supplementary materials.

649 **T-ILS.** Given that an unrestricted unitary factor model with just three indicators is
650 just-identified, it is not possible to assess configural invariance. Therefore, to assess
651 measurement invariance, we directly imposed equal factor loadings across countries and thus
652 tested metric invariance as the first step. The metric model showed a good fit to the data ($\chi^2 =$
653 $93, df = 52, p < .001, CFI = .999, RMSEA = .041, CI 90\% [.027, .055]$), suggesting that
654 metric invariance holds across the countries and that the factor loadings and factor structure is
655 identical across groups.

656 To establish scalar invariance of the T-ILS, we then compared the performance of a
657 model that imposed equal factor loadings and item intercepts across countries (i.e., a scalar
658 model) to the performance of the metric model, using multigroup confirmatory factor
659 analysis. The scalar model performed significantly worse than the metric model, but still well
660 in absolute terms ($\chi^2 = 236, df = 104, p < .001, CFI = .998, RMSEA = .053, CI 90\% [.044,$
661 $.062]$). Differences between the models fit were smaller than the cut-off values we set for
662 measurement invariance ($\Delta CFI = .001, \Delta RMSEA = .012$), which suggests that scalar
663 invariance holds across the countries and that the mean scores for the T-ILS can thus be
664 compared across groups.

665 The T-ILS further exhibited scalar invariance across levels of genders and age.
666 Detailed results can be found in the supplementary materials.

667 ***Construct Validity***

668 We assessed the construct validity of the DJGLS-6, T-ILS, and the single-item
669 measure of loneliness by establishing their nomological network for each country separately.
670 In addition, we found the three measures to be significantly correlated (and in the expected

671 direction) to the constructs in the nomological network. The two scales of the DJGLS-6
672 (emotional and social loneliness) showed sufficient construct validity across 25/27 (92.59%)
673 countries, the T-ILS scale across 22/27 (81.48%) countries, and the single-item measure of
674 loneliness for 19/27 (70.37%) countries. We provide a heatmap (Figure 1) that summarizes
675 all the different latent correlations obtained for each country, for the DJGLS-6, T-ILS, and
676 single-item measure of loneliness, respectively. The corresponding tables are available in
677 supplementary materials.

678 To gain a more detailed insight into the predictive validity of the three loneliness
679 measures, we have also broken down the nomological network into three more narrow
680 domains, namely (1) social activities and attitudes (social support, closeness in relationship
681 with friends and family, in-person and remote meetings with friends and family, contacts
682 with neighbors, and participation in social activities), (2) emotional states (depression and
683 happiness), and (3) health, which was reported through a one-item self-rated health question.
684 Using the same criteria as for the full nomological network, loneliness measures show
685 predictive validity for the three domains in the following number of EU countries: DJGLS-6,
686 24 countries (88.89%) for social activities and attitudes, 27 (100%) for emotional states, and
687 25 (92.59%) for health; T-ILS, 19 countries (70.37%) for social activities and attitudes, 27
688 (100%) for emotional states, and 27 (100%) for health; Single-item measure, 14 countries
689 (51.85%) for social activities and attitudes, 27 (100%) for emotional states, and 26 (96.30%)
690 for health.

691 Lastly, apart from the separate nomological networks for the three loneliness
692 measures, we have also examined the convergent validity by estimating their intercorrelations
693 (Pearson's correlations of factor scores). The results show that the emotional subscale of the
694 DJGLS-6, T-ILS, and the single-item measure of loneliness all correlate at between .67 and
695 .68. The social subscale of the DJGLS-6, however, exhibited markedly smaller correlations

696 with the other scales ranging from .35 (with the single-item measure) to .42 (with the T-ILS).
697 Overall and per-country latent correlation matrices for all study variables can be found in
698 supplementary materials.

699 **Summary of the Exploratory Fold and Hypotheses for the Confirmatory Fold**

700 In our exploratory fold, we found that overall, the factor structure for the T-ILS and
701 for the DJGLS-6 holds and that the reliability is sufficient across countries (with the
702 exception of Finland, France, and Romania; DJGLS-6 emotional subscale). The T-ILS
703 demonstrated scalar invariance across all countries, which means that its scores are
704 comparable across the EU. It also exhibited scalar invariance for gender and age. For the
705 DJGLS-6, on the other hand, both the model and scores are not fully comparable across
706 countries, but only within two distinct clusters of countries. A third cluster of countries was
707 identified for the DJGLS-6, but configural invariance could not be established in it.

708 When examining the scales' content validity through a surface examination
709 nomological network, the DJGLS-6 provided sufficient construct validity in 25/27 countries,
710 whereas the T-ILS showed sufficient construct validity for 22/27 countries. For the single-
711 item measure of loneliness, we are unable to provide information about its comparability
712 across countries, whether it maps onto the construct through its underlying factor structure, or
713 its internal coherence. Again, on the surface, the single-item loneliness measure shows
714 sufficient construct validity for 19/27 countries.

715 Building on the findings obtained from the analyses conducted on the exploratory
716 fold, we pre-registered a new set of hypotheses, aiming to replicate and cross-validate the
717 exploratory findings in the confirmatory fold. More specifically, we pre-registered (1) the
718 factor structure (to assess with confirmatory factor analysis directly) and internal consistency
719 of the DJGLS-6 two-factor structure, and the T-ILS one-factor structure, (2) the measurement
720 invariance properties (to assess with multigroup confirmatory factor analyses directly)

721 obtained for the DJGLS-6, and for the T-ILS, and (3) the correlations obtained through the
722 nomological network analyses, for the DJGLS-6, T-ILS , and for the single-item measure of
723 loneliness.

724 We applied the following rules for judging the replication success. (1) For model fit
725 evaluation, we applied the same criteria as in exploratory fold. When the analysis in the
726 confirmatory fold led to the same conclusion, we deemed that as a successful replication,
727 either of a positive (+/+) or negative result (-/-). In case the conclusion regarding the
728 adequacy of model fit diverged, we considered the data to be inconclusive. (2) For reliability,
729 if the internal consistency estimates for the exploratory and confirmatory fold were on the
730 same side of the .6 threshold, we considered it a successful replication. (3) For invariance
731 testing, we considered the measurement properties to be invariant if at least the same level of
732 invariance at least across the given cluster of countries was found in the confirmatory fold.
733 (4) For nomological network, we applied Fisher's z -transformation to the correlation
734 coefficients from exploratory and confirmatory fold and calculated the z -score for their
735 difference. We then used a BIC approximation (implicitly assuming a unit information prior)
736 to compute Bayes factors (Wagenmakers, 2007) to assess to what degree do the data support
737 the H_0 of no difference between the correlations. We deemed the given correlation effect
738 successfully replicated either if both correlations were significant, above $|r| \geq .10$, and in the
739 same direction, or in case the BF_{01} (in favor of the null) was larger than 3 (taken as an
740 indication of equivalence of the correlation coefficients).

741 *Factor analyses and internal consistency*

742 We replicated both the factor structure configuration and internal consistency of the
743 DJGLS-6 and T-ILS obtained on the exploratory fold for **XX** countries out of **XX** for the
744 DJGLS-6, and **XX** countries out of **XX** for the T-ILS.

745 **DJGLS-6.** [In line with the results of the exploratory analyses/Contrary to the results of the
 746 exploratory analyses], the DJLGS-6 provided [a poor/an acceptable/a very good] fit to a
 747 [one/two] factor structure, [with a sufficient/but, with an insufficient] level of overall internal
 748 consistency equal to $\omega = \text{XX}$. The country-specific factor structure found in the exploratory
 749 fold was cross-validated in **XX** countries out of **XX**, with sufficient ($\omega > .60$) internal
 750 consistency for **XX** countries out of **XX**. [Here, we also provide the detailed results of the
 751 same analyses as in the exploratory fold].

752 **T-ILS.** [Consistent with the results found in the exploratory phase/Contrary to the results
 753 found in the exploratory phase], the unitary-factor model adequately explained the variance
 754 (item loadings $> .71$) in [only one/only two/all three] items, yielding [a sufficient/an
 755 insufficient] level of overall internal consistency, $\omega = \text{XX}$. The factor loadings suggested a
 756 good fit to the unitary-factor structure in **XX** countries out of **XX**, with sufficient internal
 757 consistency for **XX** countries out of **XX**. [Here, we also provide the detailed results of the
 758 same analyses as in the exploratory fold]

759 *Measurement invariance*

760 We [attained/partially attained/failed to attain] at least the same level of between-
 761 country measurement invariance of the DJGLS-6 and T-ILS obtained on the exploratory fold.

762 **DJGLS-6.** [In line with the results of the exploratory analyses/Contrary to the results of the
 763 exploratory analyses], the DJLGS-6 [provided/provided partial/did not provide] evidence of
 764 at least the same level of measurement invariance at least across the cluster of countries
 765 identified in the exploratory analyses [Detailed results for country, gender, and age invariance
 766 follow here].

767 **T-ILS.** [Consistent with the results found in the exploratory phase/Contrary to the results
 768 found in the exploratory phase], the T-ILS [provided/ provided partial/did not provide]
 769 evidence of equally restrictive measurement invariance at least across the cluster of countries

770 identified in the exploratory analyses. [Detailed results for country, gender, and age
771 invariance follow here].

772 *Construct Validity*

773 At least the same level of evidence (a minimum of 2/3 nomological network
774 correlations being significant, above $|r| \geq .10$, and in the same direction) about construct
775 validity was found in XX countries (positive evidence in XX and negative evidence in XX
776 countries) for DJGLS-6, in XX countries (positive in XX, negative in XX countries) for the
777 T-ILS and in XX countries (positive in XX, negative in XX countries) for the single-item
778 measure. [Here, we will describe in detail the results of testing the nomological networks].

779 **Discussion**

780 [Discussion will be added following the analyses]

781 **Author Contributions:** Author contributions will be added upon completion of the project.

782 **Conflict of Interest:** Two of the proposing authors are members of the Joint Research Centre
783 of the European Commission (Béatrice d'Hombres and Elizabeth Casabianca). They may
784 thus have an interest in a positive outcome of the analyses above. However, all analyses are
785 managed and inferences are drawn by the other three authors, who do not have a vested
786 interest in the outcome one way or another.

787 Three authors, including the lead author, are members of a start-up, Annecy Behavioral
788 Science Lab, a for-profit research organization that provides multi-country research services
789 on loneliness, social connection, and human flourishing (Bastien Paris, Hans IJzerman and
790 Miguel Silan). This start-up is dedicated to applying rigor and pre-registration throughout the
791 research process.

792

793 All authors thus commit to the highest standards of scientific rigor, transparency, and
794 assessment of evidence regardless of the direction or implications of the results.

References

- 795
796 Allen, M. S., Ilescu, D., & Greiff, S. (2022). Single item measures in psychological
797 science. *European Journal of Psychological Assessment*, 38(1), 1–5.
798 <https://doi.org/10.1027/1015-5759/a000699>
- 799 Alsubheen, S. A., Oliveira, A., Habash, R., Goldstein, R., & Brooks, D. (2021).
800 Systematic review of psychometric properties and cross-cultural adaptation of the
801 University of California and Los Angeles loneliness scale in adults. *Current*
802 *Psychology*, 42(14), 11819–11833. <https://doi.org/10.1007/s12144-021-02494-w>
- 803 Alsubheen, S. A., Oliveira, A., Habash, R., Goldstein, R., & Brooks, D. (2023).
804 Measurement properties and cross-cultural adaptation of the De Jong Gierveld
805 Loneliness Scale in adults. *European Journal of Psychological Assessment*.
806 <https://doi.org/10.1027/1015-5759/a000784>
- 807 Anderssen, N., Sivertsen, B., Lønning, K. J., & Malterud, K. (2020). Life satisfaction
808 and mental health among transgender students in Norway. *BMC Public Health*,
809 20(1), 138. <https://doi.org/10.1186/s12889-020-8228-5>
- 810 Asher, S. R., Hymel, S., & Renshaw, P. D. (1984). Loneliness in children. *Child*
811 *Development*, 55(4), 1456–1464. <https://doi.org/10.2307/1130015>
- 812 Ayuso-Mateos, J. L., Morillo, D., Haro, J. M., Olaya, B., Lara, E., & Miret, M. (2023).
813 Changes on depression and suicidal ideation under severe lockdown restrictions
814 during the first wave of the COVID-19 pandemic in Spain: A longitudinal study in
815 the general population. *Epidemiology and Psychiatric Sciences*, 32.
816 <https://doi.org/10.1017/S2045796023000677>
- 817 Barreto, M., van Breen, J., Victor, C., Hammond, C., Eccles, A., Richins, M. T., &
818 Qualter, P. (2022). Exploring the nature and variation of the stigma associated with

- 819 loneliness. *Journal of Social and Personal Relationships*, 39(9), 2658–2679.
820 <https://doi.org/10.1177/02654075221087190>
- 821 Beutel, M. E., Klein, E. M., Brähler, E., Reiner, I., Jünger, C., Michal, M., Wiltink, J.,
822 Wild, P. S., Münzel, T., Lackner, K. J., & Tibubos, A. N. (2017). Loneliness in the
823 general population: Prevalence, determinants and relations to mental health. *BMC*
824 *Psychiatry*, 17(1), 97. <https://doi.org/10.1186/s12888-017-1262-x>
- 825 Braeken, J., & van Assen, M. A. L. M. (2017). An empirical Kaiser criterion.
826 *Psychological Methods*, 22(3), 450–466. <https://doi.org/10.1037/met0000074>
- 827 Buchman, A. S., Boyle, P. A., Wilson, R. S., James, B. D., Leurgans, S. E., Arnold, S.
828 E., & Bennett, D. A. (2010). Loneliness and the rate of motor decline in old age:
829 the rush memory and aging project, a community-based cohort study. *BMC*
830 *Geriatrics*, 10, 1-8.
- 831 Buecker, S., Mund, M., Chwastek, S., Sostmann, M., & Luhmann, M. (2021). Is
832 loneliness in emerging adults increasing over time? A preregistered cross-temporal
833 meta-analysis and systematic review. *Psychological Bulletin*, 147(8), 787–805.
834 <https://doi.org/10.1037/bul0000332>
- 835 Caballer, A., Belmonte, O., Castillo, A., Gasco, A., Sansano, E., & Montoliu, R. (2022).
836 Equivalence of chatbot and paper-and-pencil versions of the De Jong Gierveld
837 Loneliness Scale. *Current Psychology*, 41(9), 6225–6232.
838 <https://doi.org/10.1007/s12144-020-01117-0>
- 839 Caspi, A., Harrington, H., Moffitt, T. E., Milne, B. J., & Poulton, R. (2006). Socially
840 isolated children 20 years later: Risk of cardiovascular disease. *Archives of*
841 *Pediatrics & Adolescent Medicine*, 160(8), 805–811.
842 <https://doi.org/10.1001/archpedi.160.8.805>

- 843 Cattell, R. B. (1966). The scree test for the number of factors. *Multivariate Behavioral*
844 *Research, 1*(2), 245-276.
- 845 Cena, L., Trainini, A., Zecca, S., Bonetti Zappa, S., Cunegatti, F., & Buizza, C. (2023).
846 Loneliness, affective disorders, suicidal ideation, and the use of psychoactive
847 substances in a sample of adolescents during the COVID-19 pandemic: A cross-
848 sectional study. *Journal of Child and Adolescent Psychiatric Nursing, 36*(3), 188–
849 198. <https://doi.org/10.1111/jcap.12412>
- 850 Ceulemans, E., & Kiers, H. A. L. (2006). Selecting among three-mode principal
851 component models of different types and complexities: A numerical convex hull
852 based method. *British Journal of Mathematical and Statistical Psychology, 59*(1),
853 133–150. <https://doi.org/10.1348/000711005X64817>
- 854 Ceulemans, E., & Van Mechelen, I. (2005). Hierarchical classes models for three-way
855 three-mode binary data: Interrelations and model selection. *Psychometrika, 70*(3),
856 461–480. <https://doi.org/10.1007/s11336-003-1067-3>
- 857 Charter, R. A. (1999). Sample Size Requirements for Precise Estimates of Reliability,
858 Generalizability, and Validity Coefficients. *Journal of Clinical and Experimental*
859 *Neuropsychology, 21*(4), 559–566. <https://doi.org/10.1076/jcen.21.4.559.889>
- 860 Chen, F. F. (2008). What happens if we compare chopsticks with forks? The impact of
861 making inappropriate comparisons in cross-cultural research. *Journal of*
862 *Personality and Social Psychology, 95*(5), 1005–1018.
863 <https://doi.org/10.1037/a0013193>
- 864 Clark, D. M. T., Loxton, N. J., & Tobin, S. J. (2015). Declining loneliness over time:
865 Evidence from American colleges and high schools. *Personality and Social*
866 *Psychology Bulletin, 41*(1), 78–89. <https://doi.org/10.1177/0146167214557007>

- 867 Cortina, J. M. (1993). What is coefficient alpha? An examination of theory and
868 applications. *Journal of Applied Psychology*, 78(1), 98–104.
869 <https://doi.org/10.1037/0021-9010.78.1.98>
- 870 De Jong Gierveld, J., & Kamphuis, F. (1985). The development of a Rasch-type
871 loneliness scale. *Applied Psychological Measurement*, 9(3), 289–299.
872 <https://doi.org/10.1177/014662168500900307>
- 873 De Jong Gierveld, J., & Tesch-Römer, C. (2012). Loneliness in old age in Eastern and
874 Western European societies: Theoretical perspectives. *European Journal of Ageing*,
875 9(4), 285–295. <https://doi.org/10.1007/s10433-012-0248-2>
- 876 De Jong Gierveld, J., & Van Tilburg, T. (2006). A 6-item scale for overall, emotional,
877 and social loneliness: Confirmatory tests on survey data. *Research on Aging*, 28(5),
878 582–598. <https://doi.org/10.1177/0164027506289723>
- 879 De Jong Gierveld, J., & Van Tilburg, T. (2010). The De Jong Gierveld short scales for
880 emotional and social loneliness: Tested on data from 7 countries in the UN
881 generations and gender surveys. *European Journal of Ageing*, 7(2), 121–130.
882 <https://doi.org/10.1007/s10433-010-0144-6>
- 883 De Roover, K. (2021). Finding clusters of groups with measurement invariance:
884 unraveling intercept non-invariance with mixture multigroup factor analysis.
885 *Structural Equation Modeling: A Multidisciplinary Journal*, 28(5), 663–683.
886 <https://doi.org/10.1080/10705511.2020.1866577>
- 887 De Roover, K., Vermunt, J. K., & Ceulemans, E. (2022). Mixture multigroup factor
888 analysis for unraveling factor loading noninvariance across many groups.
889 *Psychological Methods*, 27(3), 281–306. <https://doi.org/10.1037/met0000355>
- 890 De Roover, K., Vermunt, J. K., Timmerman, M. E., & Ceulemans, E. (2017). Mixture
891 simultaneous factor analysis for capturing differences in latent variables between

- 892 higher level units of multilevel data. *Structural Equation Modeling: A*
893 *Multidisciplinary Journal*, 24(4), 506–523.
894 <https://doi.org/10.1080/10705511.2017.1278604>
- 895 DiTommaso, E., & Spinner, B. (1993). The development and initial validation of the
896 Social and Emotional Loneliness Scale for Adults (SELSA). *Personality and*
897 *Individual Differences*, 14(1), 127–134. [https://doi.org/10.1016/0191-](https://doi.org/10.1016/0191-8869(93)90182-3)
898 [8869\(93\)90182-3](https://doi.org/10.1016/0191-8869(93)90182-3)
- 899 Elovainio, M., Hakulinen, C., Pulkki-Råback, L., Virtanen, M., Josefsson, K., Jokela,
900 M., Vahtera, J., & Kivimäki, M. (2017). Contribution of risk factors to excess
901 mortality in isolated and lonely individuals: An analysis of data from the UK
902 Biobank cohort study. *The Lancet Public Health*, 2(6), e260–e266.
903 [https://doi.org/10.1016/S2468-2667\(17\)30075-0](https://doi.org/10.1016/S2468-2667(17)30075-0)
- 904 European Commission (2018). *Material deprivation, well-being and housing difficulties*.
905 European Commission.
906 [https://ec.europa.eu/eurostat/documents/1012329/8706724/2018+EU-](https://ec.europa.eu/eurostat/documents/1012329/8706724/2018+EU-SILC+module_assessment.pdf)
907 [SILC+module_assessment.pdf](https://ec.europa.eu/eurostat/documents/1012329/8706724/2018+EU-SILC+module_assessment.pdf)
- 908 European Commission (2022). *Loneliness in the European Union*. European
909 Commission. [https://joint-research-centre.ec.europa.eu/scientific-activities-](https://joint-research-centre.ec.europa.eu/scientific-activities-z/loneliness_en)
910 [z/loneliness_en](https://joint-research-centre.ec.europa.eu/scientific-activities-z/loneliness_en)
- 911 Flora, D. B. (2020). Your coefficient alpha is probably wrong, but which coefficient
912 omega is right? A tutorial on using R to obtain better reliability estimates. *Advances*
913 *in Methods and Practices in Psychological Science*, 3(4), 484–501.
914 <https://doi.org/10.1177/2515245920951747>
- 915 Fried, L., Prohaska, T., Burholt, V., Burns, A., Golden, J., Hawkey, L., Lawlor, B.,
916 Leavey, G., Lubben, J., O’Sullivan, R., Perissinotto, C., van Tilburg, T., Tully, M.,

- 917 & Victor, C. (2020). A unified approach to loneliness. *The Lancet*, 395(10218),
918 114. [https://doi.org/10.1016/S0140-6736\(19\)32533-4](https://doi.org/10.1016/S0140-6736(19)32533-4)
- 919 Gallup (2022). *The state of social connections methodology report*. Gallup.
920 [https://dataforgood.facebook.com/dfg/resources/state-of-social-connections-](https://dataforgood.facebook.com/dfg/resources/state-of-social-connections-methodology-report)
921 [methodology-report](https://dataforgood.facebook.com/dfg/resources/state-of-social-connections-methodology-report)
- 922 Gerst-Emerson, K., & Jayawardhana, J. (2015). Loneliness as a public health issue: The
923 impact of loneliness on health care utilization among older adults. *American*
924 *Journal of Public Health*, 105(5), 1013–1019.
925 <https://doi.org/10.2105/AJPH.2014.302427>
- 926 Greiff, S., & Scherer, R. (2018). Still comparing apples with oranges? *European Journal*
927 *of Psychological Assessment*, 34(3), 141–144. [https://doi.org/10.1027/1015-](https://doi.org/10.1027/1015-5759/a000487)
928 [5759/a000487](https://doi.org/10.1027/1015-5759/a000487)
- 929 Hakulinen, C., Pulkki-Råback, L., Virtanen, M., Jokela, M., Kivimäki, M., & Elovainio,
930 M. (2018). Social isolation and loneliness as risk factors for myocardial infarction,
931 stroke and mortality: UK Biobank cohort study of 479 054 men and women. *Heart*,
932 104(18), 1536–1542. <https://doi.org/10.1136/heartjnl-2017-312663>
- 933 Hansen, T., & Slagsvold, B. (2016). Late-life loneliness in 11 European countries:
934 Results from the Generations and Gender Survey. *Social Indicators Research*,
935 129(1), 445–464. <https://doi.org/10.1007/s11205-015-1111-6>
- 936 Hawkey, L. C., & Cacioppo, J. T. (2010). Loneliness matters: A theoretical and
937 empirical review of consequences and mechanisms. *Annals of Behavioral*
938 *Medicine*, 40(2), 218–227. <https://doi.org/10.1007/s12160-010-9210-8>
- 939 Hawkey, L. C., Thisted, R. A., Masi, C. M., & Cacioppo, J. T. (2010). Loneliness
940 predicts increased blood pressure: 5-year cross-lagged analyses in middle-aged and

- 941 older adults. *Psychology and Aging*, 25(1), 132–141.
942 <https://doi.org/10.1037/a0017805>
- 943 Hawkey, L. C., Wroblewski, K., Kaiser, T., Luhmann, M., & Schumm, L. P. (2019).
944 Are U.S. older adults getting lonelier? Age, period, and cohort differences.
945 *Psychology and Aging*, 34(8), 1144–1157. <https://doi.org/10.1037/pag0000365>
- 946 Hayduk, L. A., & Littvay, L. (2012). Should researchers use single indicators, best
947 indicators, or multiple indicators in structural equation models? *BMC Medical*
948 *Research Methodology*, 12(1). <https://doi.org/10.1186/1471-2288-12-159>
- 949 Heidinger, T., & Richter, L. (2020). The effect of COVID-19 on loneliness in the
950 elderly. An empirical comparison of pre-and peri-pandemic loneliness in
951 community-dwelling elderly. *Frontiers in Psychology*, 11.
952 <https://www.frontiersin.org/articles/10.3389/fpsyg.2020.585308>
- 953 Holt-Lunstad, J., Smith, T. B., & Layton, J. B. (2010). Social relationships and mortality
954 risk: a meta-analytic review. *PLoS medicine*, 7(7), e1000316.
- 955 Holt-Lunstad, J., Robles, T. F., & Sbarra, D. A. (2017). Advancing social connection as
956 a public health priority in the United States. *American Psychologist*, 72(6), 517–
957 530. <https://doi.org/10.1037/amp0000103>
- 958 Holt-Lunstad, J., Smith, T. B., Baker, M., Harris, T., & Stephenson, D. (2015).
959 Loneliness and social isolation as risk factors for mortality: A meta-analytic review.
960 *Perspectives on Psychological Science*, 10(2), 227–237.
961 <https://doi.org/10.1177/1745691614568352>
- 962 Horn, J. L. (1965). A rationale and test for the number of factors in factor analysis.
963 *Psychometrika*, 30(2), 179–185. <https://doi.org/10.1007/BF02289447>
- 964 Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure
965 analysis: Conventional criteria versus new alternatives. *Structural Equation*

- 966 *Modeling: A Multidisciplinary Journal*, 6(1), 1–55.
- 967 <https://doi.org/10.1080/10705519909540118>
- 968 Hughes, M. E., Waite, L. J., Hawkey, L. C., & Cacioppo, J. T. (2004). A short scale for
969 measuring loneliness in large surveys: Results from two population-based studies.
970 *Research on Aging*, 26(6), 655–672. <https://doi.org/10.1177/0164027504268574>
- 971 Irwin, J. R., & McClelland, G. H. (2003). Negative consequences of dichotomizing
972 continuous predictor variables. *Journal of Marketing Research*, 40(3), 366-371.
- 973 Jakobsen, I. S., Madsen, L. M. R., Mau, M., Hjemdal, O., & Friborg, O. (2020). The
974 relationship between resilience and loneliness elucidated by a Danish version of the
975 resilience scale for adults. *BMC Psychology*, 8(1), 131.
976 <https://doi.org/10.1186/s40359-020-00493-3>
- 977 Kerr, N. A., & Stanley, T. B. (2021). Revisiting the social stigma of loneliness.
978 *Personality and Individual Differences*, 171, 110482.
979 <https://doi.org/10.1016/j.paid.2020.110482>
- 980 Kristensen, K., König, H.-H., & Hajek, A. (2019). The association of multimorbidity,
981 loneliness, social exclusion and network size: Findings from the population-based
982 German Ageing Survey. *BMC Public Health*, 19(1), 1383.
983 <https://doi.org/10.1186/s12889-019-7741-x>
- 984 Lasgaard, M., Friis, K., & Shevlin, M. (2016). “Where are all the lonely people?” A
985 population-based study of high-risk groups across the life span. *Social Psychiatry
986 and Psychiatric Epidemiology*, 51(10), 1373–1384. [https://doi.org/10.1007/s00127-
987 016-1279-3](https://doi.org/10.1007/s00127-016-1279-3)
- 988 Leigh-Hunt, N., Bagguley, D., Bash, K., Turner, V., Turnbull, S., Valtorta, N., & Caan,
989 W. (2017). An overview of systematic reviews on the public health consequences

- 990 of social isolation and loneliness. *Public Health*, 152, 157–171.
991 <https://doi.org/10.1016/j.puhe.2017.07.035>
- 992 Li, C.-H. (2015). Confirmatory factor analysis with ordinal data: Comparing robust
993 maximum likelihood and diagonally weighted least squares. *Behavior Research*
994 *Methods*, 48(3), 936–949. <https://doi.org/10.3758/s13428-015-0619-7>
- 995 Lorant, V., Smith, P., Van den Broeck, K., & Nicaise, P. (2021). Psychological distress
996 associated with the COVID-19 pandemic and suppression measures during the first
997 wave in Belgium. *BMC Psychiatry*, 21(1), 112. [https://doi.org/10.1186/s12888-](https://doi.org/10.1186/s12888-021-03109-1)
998 [021-03109-1](https://doi.org/10.1186/s12888-021-03109-1)
- 999 Luhmann, M., & Hawkley, L. C. (2016). Age differences in loneliness from late
1000 adolescence to oldest old age. *Developmental Psychology*, 52(6), 943–959.
1001 <https://doi.org/10.1037/dev0000117>
- 1002 Lukács, A., Sasvári, P., Varga, B., & Mayer, K. (2019). Exercise addiction and its
1003 related factors in amateur runners. *Journal of Behavioral Addictions*, 8(2), 343–
1004 349. <https://doi.org/10.1556/2006.8.2019.28>
- 1005 MacCallum, R. C., Widaman, K. F., Zhang, S., & Hong, S. (1999). Sample size in factor
1006 analysis. *Psychological Methods*, 4(1), 84–99. [https://doi.org/10.1037/1082-](https://doi.org/10.1037/1082-989X.4.1.84)
1007 [989X.4.1.84](https://doi.org/10.1037/1082-989X.4.1.84)
- 1008 Maes, M., Qualter, P., Lodder, G. M. A., & Mund, M. (2022). How (not) to measure
1009 loneliness: A review of the eight most commonly used scales. *International Journal*
1010 *of Environmental Research and Public Health*, 19(17), Article 17.
1011 <https://doi.org/10.3390/ijerph191710816>
- 1012 Marcoen, A., Goossens, L., & Caes, P. (1987). Loneliness in pre-through late
1013 adolescence: Exploring the contributions of a multidimensional approach. *Journal*
1014 *of Youth and Adolescence*, 16(6), 561–577. <https://doi.org/10.1007/BF02138821>

- 1015 Mayerl, H., Stolz, E., & Freidl, W. (2021). Longitudinal effects of COVID-19-related
1016 loneliness on symptoms of mental distress among older adults in Austria. *Public*
1017 *Health, 200*, 56–58. <https://doi.org/10.1016/j.puhe.2021.09.009>
- 1018 McNeish, D. (2018). Thanks coefficient alpha, we'll take it from here. *Psychological*
1019 *Methods, 23*(3), 412–433. <https://doi.org/10.1037/met0000144>
- 1020 Meckovsky, F., Furstova, J., Kosarkova, A., Meier, Z., Tavel, P., & Malinakova, K.
1021 (2023). Loneliness is associated with problematic internet use but not with the
1022 frequency of substance use: A Czech cross-sectional study. *International Journal of*
1023 *Public Health, 68*. <https://doi.org/10.3389/ijph.2023.1606537>
- 1024 Meisters, R., Westra, D., Putrik, P., Bosma, H., Ruwaard, D., & Jansen, M. (2021). Does
1025 loneliness have a cost? A population-wide study of the association between
1026 loneliness and healthcare expenditure. *International Journal of Public Health, 66*,
1027 581286. <https://doi.org/10.3389/ijph.2021.581286>
- 1028 Meredith, W. (1993). Measurement invariance, factor analysis and factorial invariance.
1029 *Psychometrika, 58*(4), 525–543. <https://doi.org/10.1007/BF02294825>
- 1030 Meredith, W., & Teresi, J. A. (2006). An essay on measurement and factorial invariance.
1031 *Medical Care, 44*(11), S69–S77.
- 1032 Mund, M., Maes, M., Drewke, P. M., Gutzeit, A., Jaki, I., & Qualter, P. (2023). Would
1033 the real loneliness please stand up? The validity of loneliness scores and the
1034 reliability of single-item scores. *Assessment, 30*(4), 1226–1248.
1035 <https://doi.org/10.1177/10731911221077227>
- 1036 Observatorio Estatal de la Soledad No Deseada (2023). *El coste de la soledad no*
1037 *deseada en España*. Observatorio Estatal de la Soledad No Deseada.
1038 <https://www.soledades.es/estudios/el-coste-de-la-soledad-no-deseada-en-espana>

- 1039 Oksanen, A., Oksa, R., Celuch, M., Cvetkovic, A., & Savolainen, I. (2023). COVID-19
1040 anxiety and wellbeing at work in Finland during 2020–2022: A 5-wave longitudinal
1041 survey study. *International Journal of Environmental Research and Public Health*,
1042 20(1). <https://doi.org/10.3390/ijerph20010680>
- 1043 Park, C., Majeed, A., Gill, H., Tamura, J., Ho, R. C., Mansur, R. B., Nasri, F., Lee, Y.,
1044 Rosenblat, J. D., Wong, E., & McIntyre, R. S. (2020). The effect of loneliness on
1045 distinct health outcomes: A comprehensive review and meta-analysis. *Psychiatry*
1046 *Research*, 294, 113514. <https://doi.org/10.1016/j.psychres.2020.113514>
- 1047 Pantell, M., Rehkopf, D., Jutte, D., Syme, S. L., Balmes, J., & Adler, N. (2013). Social
1048 isolation: a predictor of mortality comparable to traditional clinical risk factors.
1049 *American Journal of Public Health*, 103(11), 2056-2062.
- 1050 Parlapani, E., Holeva, V., Nikopoulou, V. A., Sereslis, K., Athanasiadou, M., Godosidis,
1051 A., Stephanou, T., & Diakogiannis, I. (2020). Intolerance of uncertainty and
1052 loneliness in older adults during the COVID-19 pandemic. *Frontiers in Psychiatry*,
1053 11. <https://www.frontiersin.org/articles/10.3389/fpsy.2020.00842>
- 1054 Perissinotto, C. M., Stijacic Cenzer, I., & Covinsky, K. E. (2012). Loneliness in older
1055 persons: A predictor of functional decline and death. *Archives of Internal Medicine*,
1056 172(14), 1078–1084. <https://doi.org/10.1001/archinternmed.2012.1993>
- 1057 Perlman, D., & Peplau, L. A. (1981). Toward a social psychology of loneliness. In S.
1058 Duck & R. Gilmour (Eds.), *Personal relationships in disorder* (pp. 31–56).
1059 Academic Press.
- 1060 Piccitto, G., Liefbroer, A. C., & Emery, T. (2022). Does the survey mode affect the
1061 association between subjective well-being and its determinants? An experimental
1062 comparison between face-to-face and web mode. *Journal of Happiness Studies*,
1063 23(7), 3441–3461. <https://doi.org/10.1007/s10902-022-00553-y>

- 1064 Pino, L., González-Vélez, A. E., Prieto-Flores, M.-E., Ayala, A., Fernandez-Mayoralas,
1065 G., Rojo-Perez, F., Martinez-Martin, P., & Forjaz, M. J. (2014). Self-perceived
1066 health and quality of life by activity status in community-dwelling older adults.
1067 *Geriatrics & Gerontology International*, *14*(2), 464–473.
1068 <https://doi.org/10.1111/ggi.12119>
- 1069 Pomeroy, M. L., Cudjoe, T. K. M., Cuellar, A. E., Ihara, E. S., Ornstein, K. A., Bollens-
1070 Lund, E., Kotwal, A. A., & Gimm, G. W. (2023a). Association of social isolation
1071 with hospitalization and nursing home entry among community-dwelling older
1072 adults. *JAMA Internal Medicine*. <https://doi.org/10.1001/jamainternmed.2023.3064>
- 1073 Pomeroy, M. L., Mehrabi, F., Jenkins, E., O’Sullivan, R., Lubben, J., & Cudjoe, T. K.
1074 M. (2023b). Reflections on measures of social isolation among older adults. *Nature*
1075 *Aging*, *3*(12), 1463–1464. <https://doi.org/10.1038/s43587-023-00472-4>
- 1076 Prohaska, T., Burholt, V., Burns, A., Golden, J., Hawkey, L., Lawlor, B., Leavey, G.,
1077 Lubben, J., O’Sullivan, R., Perissinotto, C., Tilburg, T. van, Tully, M., Victor, C.,
1078 & Fried, L. (2020). Consensus statement: Loneliness in older adults, the 21st
1079 century social determinant of health? *BMJ Open*, *10*(8), e034967.
1080 <https://doi.org/10.1136/bmjopen-2019-034967>
- 1081 Prime Minister's Office of Japan (2021, September 27). *Preparatory meeting of the*
1082 *collaborative platform for loneliness and isolation measures*. Prime Minister's
1083 Office of Japan. https://japan.kantei.go.jp/99_suga/actions/202109/00033.html
- 1084 R Core Team (2022). *R: A language and environment for statistical computing*. R
1085 Foundation for Statistical computing. <https://www.R-project.org>
- 1086 Rhemtulla, M., Brosseau-Liard, P. É., & Savalei, V. (2012). When can categorical
1087 variables be treated as continuous? A comparison of robust continuous and

- 1088 categorical SEM estimation methods under suboptimal conditions. *Psychological*
1089 *Methods*, 17(3), 354–373. <https://doi.org/10.1037/a0029315>
- 1090 Ribeiro, F., Schröder, V. E., Krüger, R., & Leist, A. K. (2021). The evolution and social
1091 determinants of mental health during the first wave of the COVID-19 outbreak in
1092 Luxembourg. *Psychiatry Research*, 30.
1093 <https://doi.org/10.1016/j.psychres.2021.114090>
- 1094 Rico-Uribe, L. A., Caballero, F. F., Martín-María, N., Cabello, M., Ayuso-Mateos, J. L.,
1095 & Miret, M. (2018). Association of loneliness with all-cause mortality: A meta-
1096 analysis. *PLoS ONE*, 13(1). Scopus. <https://doi.org/10.1371/journal.pone.0190033>
- 1097 Robitzsch, A. (2020). Why ordinal variables can (almost) always be treated as
1098 continuous variables: Clarifying assumptions of robust continuous and ordinal
1099 factor analysis estimation methods. *Frontiers in Education*, 5.
1100 <https://www.frontiersin.org/articles/10.3389/feduc.2020.589965>
- 1101 Russell, D. (1982). The measurement of loneliness. In L. A. Pervin & D. Perlman (Eds.),
1102 *Loneliness: A sourcebook of current theory, research and therapy* (pp. 81–104).
1103 John Wiley.
- 1104 Russell, D. (1996). UCLA Loneliness Scale (Version 3): Reliability, validity, and factor
1105 structure. *Journal of Personality Assessment*, 66(1), 20–40.
1106 https://doi.org/10.1207/s15327752jpa6601_2
- 1107 Russell, D., Peplau, L. A., & Cutrona, C. E. (1980). The revised UCLA Loneliness
1108 Scale: Concurrent and discriminant validity evidence. *Journal of Personality and*
1109 *Social Psychology*, 39(3), 472–480. <https://doi.org/10.1037/0022-3514.39.3.472>
- 1110 Russell, D., Peplau, L. A., & Ferguson, M. L. (1978). Developing a measure of
1111 loneliness. *Journal of Personality Assessment*, 42(3), 290–294.
1112 https://doi.org/10.1207/s15327752jpa4203_11

- 1113 Rutkowski, L., & Svetina, D. (2014). Assessing the hypothesis of measurement
1114 invariance in the context of large-scale international surveys. *Educational and*
1115 *Psychological Measurement*, 74(1), 31–57.
1116 <https://doi.org/10.1177/0013164413498257>
- 1117 Scheimer, D., & Chakrabarti, M. (2020, March 23). *Former surgeon general Vivek*
1118 *Murthy: Loneliness is a public health crisis*. WBUR.
1119 <https://www.wbur.org/onpoint/2020/03/23/vivek-murthy-loneliness>
- 1120 Schnittger, R. I. B., Wherton, J., Prendergast, D., & Lawlor, B. A. (2012). Risk factors
1121 and mediating pathways of loneliness and social support in community-dwelling
1122 older adults. *Aging & Mental Health*, 16(3), 335–346.
1123 <https://doi.org/10.1080/13607863.2011.629092>
- 1124 Schönbrodt, F. D., & Perugini, M. (2013). At what sample size do correlations stabilize?
1125 *Journal of Research in Personality*, 47(5), 609–612.
1126 <https://doi.org/10.1016/j.jrp.2013.05.009>
- 1127 Schwarz, G. (1978). Estimating the dimension of a model. *The Annals of Statistics*, 6(2),
1128 461-464.
- 1129 Sijtsma, K. (2009). On the use, the misuse, and the very limited usefulness of cronbach's
1130 alpha. *Psychometrika*, 74(1), 107–120. <https://doi.org/10.1007/s11336-008-9101-0>
- 1131 Stickley, A., Koyanagi, A., Inoue, Y., & Leinsalu, M. (2018). Childhood hunger and
1132 thoughts of death or suicide in older adults. *The American Journal of Geriatric*
1133 *Psychiatry*, 26(10), 1070–1078. <https://doi.org/10.1016/j.jagp.2018.06.005>
- 1134 Surkalim, D. L., Luo, M., Eres, R., Gebel, K., Buskirk, J. van, Bauman, A., & Ding, D.
1135 (2022). The prevalence of loneliness across 113 countries: Systematic review and
1136 meta-analysis. *BMJ*, 376, e067068. <https://doi.org/10.1136/bmj-2021-067068>

- 1137 Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International*
1138 *Journal of Medical Education*, 2, 53–55. <https://doi.org/10.5116/ijme.4dfb.8dfd>
- 1139 Trzesniewski, K. H., & Donnellan, M. B. (2010). Rethinking “Generation Me”: A study
1140 of cohort effects from 1976-2006. *Perspectives on Psychological Science*, 5(1), 58–
1141 75. <https://doi.org/10.1177/1745691609356789>
- 1142 Twenge, J. M., Haidt, J., Blake, A. B., McAllister, C., Lemon, H., & Le Roy, A. (2021).
1143 Worldwide increases in adolescent loneliness. *Journal of Adolescence*, 93, 257–
1144 269. <https://doi.org/10.1016/j.adolescence.2021.06.006>
- 1145 UK Government (2018, October 15). *PM launches government's first loneliness*
1146 *strategy*. UK Government. [https://www.gov.uk/government/news/pm-launches-](https://www.gov.uk/government/news/pm-launches-governments-first-loneliness-strategy)
1147 [governments-first-loneliness-strategy](https://www.gov.uk/government/news/pm-launches-governments-first-loneliness-strategy)
- 1148 Valtorta, N. K., Kanaan, M., Gilbody, S., & Hanratty, B. (2018). Loneliness, social
1149 isolation and risk of cardiovascular disease in the English Longitudinal Study of
1150 Ageing. *European Journal of Preventive Cardiology*, 25(13), 1387–1396.
1151 <https://doi.org/10.1177/2047487318792696>
- 1152 Valtorta, N. K., Kanaan, M., Gilbody, S., Ronzi, S., & Hanratty, B. (2016). Loneliness
1153 and social isolation as risk factors for coronary heart disease and stroke: Systematic
1154 review and meta-analysis of longitudinal observational studies. *Heart (British*
1155 *Cardiac Society)*, 102(13), 1009–1016. [https://doi.org/10.1136/heartjnl-2015-](https://doi.org/10.1136/heartjnl-2015-308790)
1156 [308790](https://doi.org/10.1136/heartjnl-2015-308790)
- 1157 van den Broek, T., & Grundy, E. (2018). Parental health limitations, caregiving and
1158 loneliness among women with widowed parents: Longitudinal evidence from
1159 France. *European Journal of Ageing*, 15(4), 369–377.
1160 <https://doi.org/10.1007/s10433-018-0459-2>

- 1161 Van Tilburg, T. G. (2021). Social, emotional, and existential Loneliness: A test of the
1162 multidimensional concept. *The Gerontologist*, *61*(7), e335–e344.
1163 <https://doi.org/10.1093/geront/gnaa082>
- 1164 Victor, C. R., & Yang, K. (2012). The prevalence of loneliness among adults: A case
1165 study of the United Kingdom. *The Journal of Psychology*, *146*(1–2), 85–104.
1166 <https://doi.org/10.1080/00223980.2011.613875>
- 1167 Watkins, M. W. (2017). The reliability of multidimensional neuropsychological
1168 measures: From alpha to omega. *The Clinical Neuropsychologist*, *31*(6–7), 1113–
1169 1126. <https://doi.org/10.1080/13854046.2017.1317364>
- 1170 Wagenmakers, E.-J. (2007). A practical solution to the pervasive problems of p values.
1171 *Psychonomic Bulletin & Review*, *14*(5), 779–804.
1172 <https://doi.org/10.3758/bf03194105>
- 1173 Weiss, R. S. (1973). *The experience of emotional and social isolation*. MIT Press.
- 1174 Witthöft, M., Jungmann, S. M., Germer, S., & Bräscher, A.-K. (2022). Early adverse
1175 effects of behavioural preventive strategies during the COVID-19 pandemic in
1176 Germany: An online general population survey. *Clinical Psychology in Europe*,
1177 *4*(3). <https://doi.org/10.32872/cpe.7205>
- 1178 World Health Organization (2023, November 15). *WHO launches commission to foster*
1179 *social connection*. World Health Organization. [https://www.who.int/news/item/15-
1180 11-2023-who-launches-commission-to-foster-social-connection](https://www.who.int/news/item/15-11-2023-who-launches-commission-to-foster-social-connection)
- 1181 Wright, S. L., Burt, C. D. B., & Strongman, K. T. (2006). *Loneliness in the Workplace:*
1182 *Construct definition and scale development*. <http://hdl.handle.net/10092/2751>
- 1183 Yang, K., & Victor, C. (2011). Age and loneliness in 25 European nations. *Ageing &*
1184 *Society*, *31*(8), 1368–1388. <https://doi.org/10.1017/S0144686X1000139X>

Table 1*Sample Size and Descriptive Statistics by Country*

Country	N	Age			Gender distribution (%)			Loneliness (DJGLS-6)			Loneliness (T-ILS)			Loneliness (direct)		
		Mdn	Mean	SD	Male	Female	Other	Mdn	Mean	SD	Mdn	Mean	SD	Mdn	Mean	SD
Austria	504	46	46.38	15.25	48.41	50.99	0.40	3	3.66	3.05	2	2.02	1.79	1	1.10	1.10
Belgium	502	47	47.53	16.47	47.21	52.39	0.20	4	4.51	3	2	2.01	2	1	1.16	1.17
Bulgaria	501	46	45.93	14.03	45.91	52.89	0.80	4	4.21	3.06	1	1.62	1.81	1	1.04	1.12
Croatia	505	48	47.16	14.21	48.12	51.29	0.40	4	4.63	2.85	2	2	1.69	1	1.11	1.03
Cyprus	252	39	40.96	13.57	46.03	53.97	0	4	4.15	3.13	2	2	1.81	1	1.11	1.15
Czechia	501	47	47.81	15.75	46.51	53.49	0	4	4.55	2.93	2	2.11	1.83	1	1.16	1.08
Denmark	504	45	46.86	17.78	48.81	50.40	0.40	3	3.59	3.24	1	1.86	1.88	1	1.16	1.15
Estonia	505	39	42.29	14.47	40.99	56.83	0.99	4	4.92	3.06	2	2.29	1.98	1	1.19	1.15
Finland	504	48	46.88	15.74	47.62	50.79	1.59	4	4.22	2.91	2	2.10	1.91	1	1.05	1.07
France	500	50	50.02	15.97	47.40	52.20	0.40	4	4.23	2.67	1	1.46	1.70	1	1.09	1.05
Germany	553	53	51.74	15.19	50.81	49.01	0.18	4	4.06	2.95	2	2.02	1.78	1	1.11	1.15
Greece	504	46	44.33	11.96	48.02	50.79	0.60	4	4.33	3.05	2	2.27	1.90	1	1.28	1.17
Hungary	502	48	48.95	15.52	49.40	50.40	0	4	4.41	2.94	2	1.91	1.84	1	1.01	1.13
Ireland	505	37	38.70	13.69	50.30	48.32	0.79	5	4.90	2.96	2	2.32	1.88	1	1.46	1.17
Italy	500	51	50.43	16.13	51	49	0	4	4.12	2.98	1	1.84	1.89	1	1.15	1.15
Latvia	505	44	44.37	13.82	45.54	53.27	0.59	5	5.01	2.92	2	2.04	1.81	1	1.12	1.08
Lithuania	506	48	47.40	14.98	46.44	52.37	0.59	4	4.02	3.05	1	1.63	1.60	1	1.05	1.11
Luxembourg	185	35	35.78	11.14	47.57	50.81	0.54	5	5.17	3.04	3	2.55	1.78	2	1.60	1.13
Malta	265	32	33.83	10.60	35.85	63.02	0.75	4	4.71	3.10	2	2.31	1.88	1	1.36	1.12
Netherlands	504	44	46.69	17.31	50.99	48.02	0.40	3	3.44	2.94	1	1.82	2.01	1	0.89	1.05
Poland	501	46	45.74	14.06	47.70	52.10	0.20	3	3.86	3.27	2	1.95	1.86	1	1.30	1.13
Portugal	502	48.50	46.50	13.61	46.81	52.59	0.40	3	3.89	2.90	1	1.76	1.74	1	1.29	1.07
Romania	504	45	45.18	14.44	45.63	53.17	0.60	5	4.90	2.69	1	1.92	1.93	1	1.18	1.13
Slovakia	502	45	45.95	14.70	48.61	51.39	0	5	4.60	3.10	3	2.36	1.69	1	1.15	1.05
Slovenia	504	44	44.72	13.33	50	49.60	0	4	4.54	2.93	2	2.04	1.87	1	1.07	1.08
Spain	505	48	46.51	13.83	43.96	55.45	0.40	4	4.17	2.79	1	1.76	1.79	1	1.13	1.04
Sweden	504	48	49.04	18.33	49.21	50.20	0.40	3	3.72	3.23	2	2.05	1.91	1	1.20	1.14
All countries	12829	45	46.03	15.32	47.45	51.80	0.43	4	4.29	3.02	2	1.98	1.85	1	1.15	1.11

Note. Descriptive statistics for the exploratory fold. We report here the total number of missing for age ($N = 0$), gender ($N = 40$), educational attainment ($N = 87$), and DJGLS-6 ($N = 661$), T-ILS ($N = 407$), and single-item loneliness ($N = 522$) scores.

Table 2*Loneliness Measures Included in the Survey*

Measure	Subscale	General prompt	Question #	Question Content (Answer Options)
T-ILS	N/A	Please indicate how often you feel each of the following: <Note:> Remember that your answers are anonymous and strictly confidential.	1	Feel that you lack companionship (Hardly ever or never; Some of the time; Often; Prefer not to say)
T-ILS	N/A		2	Feel left out (Hardly ever or never; Some of the time; Often; Prefer not to say)
T-ILS	N/A		3	Feel isolated from others (Hardly ever or never; Some of the time; Often; Prefer not to say)
DJGLS-6	Emotional	Please indicate for each of the statements, the extent to which they apply to your situation and the way you feel now.<Note:> Remember that your answers are anonymous and strictly confidential.	1	I experience a general sense of emptiness (Yes, More or less, No, Prefer not to say)
DJGLS-6	Emotional		2	I miss having people around (Yes, More or less, No, Prefer not to say)
DJGLS-6	Emotional		3	I often feel rejected (Yes, More or less, No, Prefer not to say)
DJGLS-6	Social		4	There are plenty of people I can rely on when I have problems (Yes, More or less, No, Prefer not to say)
DJGLS-6	Social		5	There are many people I can trust completely (Yes, More or less, No, Prefer not to say)
DJGLS-6	Social		6	There are enough people that I feel close to (Yes, More or less, No, Prefer not to say)
One-item	N/A		1	How much of the time, during the past 4 weeks, have you been feeling lonely? (All of the time, Most of the time, Some of the time, A little of the time, None of the time, Don't know, Prefer not to say)

Table 3*Factor Structure Fits and Internal Consistencies of the DJGLS-6 and T-ILS*

Country	DJGLS-6 (two-factor structure)					T-ILS (one factor structure)			
	χ^2	CFI	RMSEA	ω_{emot}	ω_{social}	λ Item 1	λ Item 2	λ Item 3	ω_{total}
Austria	24.67	0.99	0.07	0.76	0.82	0.69	0.78	1.00	0.82
Belgium	61.89	0.98	0.12	0.71	0.79	0.80	0.86	0.98	0.86
Bulgaria	26.60	0.99	0.07	0.71	0.82	0.79	0.90	0.91	0.83
Croatia	59.97	0.98	0.12	0.74	0.79	0.77	0.88	0.95	0.83
Cyprus	15.07	1.00	0.06	0.75	0.86	0.75	0.85	0.95	0.82
Czechia	40.59	0.99	0.09	0.74	0.82	0.81	0.92	0.92	0.85
Denmark	43.69	0.99	0.10	0.84	0.84	0.80	0.92	0.92	0.85
Estonia	37.62	0.99	0.09	0.67	0.79	0.87	0.90	0.92	0.87
Finland	41.72	0.99	0.09	0.56	0.83	0.78	0.90	0.94	0.85
France	64.04	0.97	0.12	0.56	0.80	0.88	0.86	0.94	0.85
Germany	30.04	0.99	0.07	0.75	0.80	0.66	0.89	0.90	0.80
Greece	18.17	1.00	0.05	0.74	0.82	0.75	0.91	0.86	0.81
Hungary	36.63	0.99	0.09	0.68	0.80	0.84	0.89	0.96	0.86
Ireland	20.41	0.99	0.06	0.72	0.79	0.86	0.80	0.82	0.80
Italy	37.32	0.99	0.09	0.76	0.79	0.81	0.92	0.95	0.86
Latvia	37.37	0.99	0.09	0.81	0.81	0.81	0.91	0.89	0.84
Lithuania	2.96	1.00	0.00	0.82	0.84	0.81	0.80	0.85	0.77
Luxembourg	13.83	0.99	0.07	0.70	0.79	0.83	0.84	0.71	0.77
Malta	14.43	0.99	0.06	0.70	0.79	0.80	0.88	0.94	0.85
Netherlands	20.23	1.00	0.06	0.76	0.79	0.80	0.91	0.96	0.86
Poland	20.38	1.00	0.06	0.86	0.85	0.86	0.88	0.88	0.84
Portugal	29.11	0.99	0.07	0.74	0.78	0.77	0.81	0.95	0.81
Romania	79.90	0.98	0.14	0.56	0.84	0.75	0.92	0.90	0.83
Slovakia	22.84	1.00	0.06	0.68	0.85	0.73	0.84	0.88	0.79
Slovenia	37.56	1.00	0.09	0.85	0.82	0.84	0.84	0.97	0.85
Spain	45.78	0.99	0.10	0.68	0.83	0.80	0.85	0.94	0.83

Sweden	27.94	0.99	0.07	0.76	0.85	0.86	0.90	0.94	0.87
All countries	683.70	0.99	0.08	0.73	0.82	0.79	0.88	0.92	0.83

Note. We decided on the factor structure after reviewing the exploratory and confirmatory analyses.

Table 4*Results of the Multigroup Confirmatory Factor Analyses on the Unraveled Clusters*

Cluster ID	Configural model			Metric Model			Scalar model			Decision about invariance
	χ^2 (df, p)	CFI	RMSEA	χ^2 (df, p)	CFI (Δ CFI)	RMSEA (Δ RMSEA)	χ^2 (df, p)	CFI (Δ CFI)	RMSEA (Δ RMSEA)	
A	223 (32, <.001)	0.98	0.11	No invariance
B	510 (128, <.001)	0.99	0.08	658 (188, <.001)	0.99 (0)	0.08 (0)	789 (248, <.001)	0.99 (0)	0.07 (.01)	Scalar
C	177 (56, <.001)	1	0.07	236 (80, <.001)	0.99 (.01)	0.06 (.01)	278 (104, <.001)	0.99 (0)	0.06 (0)	Scalar

Note. Cluster A: Estonia, Finland, France, Romania. Cluster B: Belgium, Bulgaria, Croatia, Cyprus, Czechia, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Malta, Portugal, Slovakia, Slovenia, Spain. Cluster C: Austria, Denmark, Latvia, Lithuania, Netherlands, Poland, Sweden.

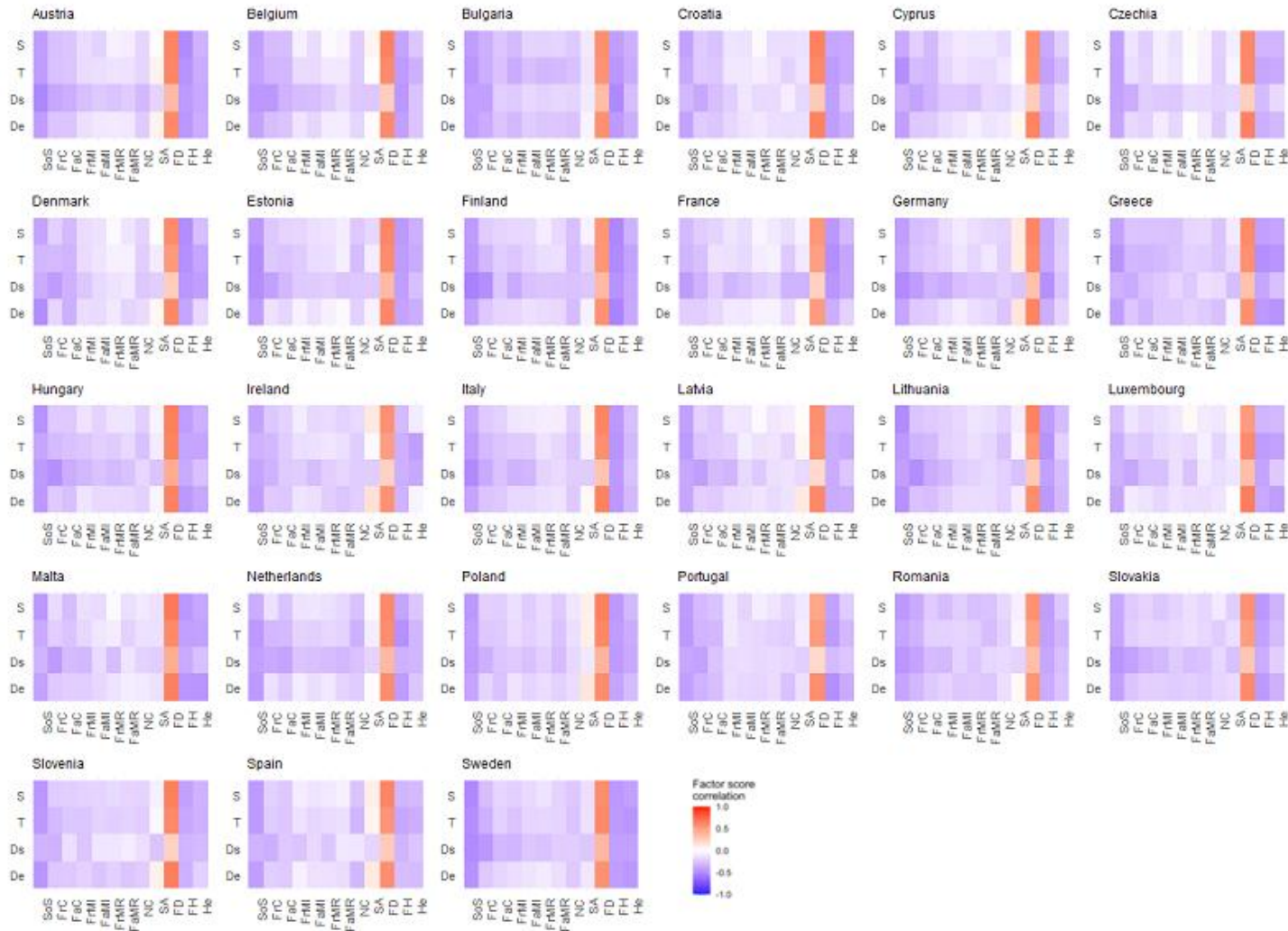


Figure 1. Heatmap of the correlations between loneliness measures and relevant correlates. De = DJGLS-6 emotional, Ds = DJGLS-6 social, T = T-ILS, S = Single-item measure, SoS = Social support, FrC = Friends closeness, FaC = Family closeness, FrMI = Friends meet in-person, FaMI = Family meet in-person, FrMR = Friends meet remote, FaMR = Family meet remote, NC = Neighbours contact, SA = Social activities, FD = Feeling depressed, FH = Feeling happy, He = Health.

Portugal	+	+	Poland, Sweden); No configural invariance across countries in cluster A (Estonia, Finland, France, Romania).	+	+	+		+	+
Romania	-	-		+	+	+		+	+
Slovakia	+	+		+	+	+		+	+
Slovenia	-	+		+	+	+		+	+
Spain	-	+		+	+	+		+	-
Sweden	+	+		+	+	+		+	+