

**Faculté de santé publique**

# **Health, Structural or Functional Aspects of Social Connection: What Mediates the Relationship Between Socioeconomic Status and Loneliness ?**

**The case of income**

Mémoire réalisé par  
**Coralie Lefebvre**

Promoteur  
**Vincent Lorient**

Année académique 2025-2026  
**Master en sciences de la santé publique, finalité spécialisée**



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### **Le plagiat**

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### **Use of Artificial Intelligence**

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# I. Introduction

In recent years, especially since the Covid-19 pandemic, the issue of loneliness has been capturing the attention of major international players. In 2020, the European Parliament for example launched a pilot project on loneliness in Europe (Regner, 2024) and, in 2023, the World Health Organization (WHO) launched its Commission on Social Connection, aiming to address the issues of social isolation and loneliness (WHO, 2025). While the pandemic seems to have bolstered the attention of these major international organizations, for many other actors, concern for the issue of loneliness predates the pandemic. Such is the case of the United Kingdom for instance. In 2018, the country even appointed a “minister for loneliness” (Yeginsu, 2018).

Over the years, researchers have studied the adverse effects loneliness can have on individuals and the societies they live in. Such adverse effects have been found for both physical and mental health. Loneliness appears to increase the risk and/or worsen the symptoms of various health issues. It has namely been associated with hypertension, cardiovascular diseases, higher levels of cortisol, disrupted sleep patterns, dementia, depression, suicidality and self-harm (Akhter-Khan et al., 2021; Beutel et al., 2017; Cacioppo et al., 2006; D’Hombres et al., 2024; Freilich, 2023; Holt-Lunstad et al., 2015; Holt-Lunstad, 2024; Mann et al., 2022; Matthews et al., 2016; Wood & Mikton, 2025). Most notably, loneliness has been tied to a higher risk of premature death (Holt-Lunstad et al., 2015). The WHO estimates a yearly toll of around 871 000 deaths (Wood & Mikton, 2025).

The impacts of loneliness are however not limited to health. Societal cohesion is for example expected to be affected, as lonely individuals have been found to be less trusting of others and less empathetic (Cuccu and Stepanova, 2021; D’Hombres et al., 2024). Higher levels of absenteeism and unemployment, as well as decreases in productivity, have also been associated with loneliness, implying a potential economic impact for individuals, but also wider economies (Bowers et al., 2022; Morrish et al., 2022). Loneliness, through its impact on health and economic systems, can thus represent an important economic cost at the national level.

Considering all these potential consequences of loneliness, it is easy to understand why this issue has garnered such attention and what is at stake. While exact numbers in terms of

prevalence of loneliness vary from study to study, the WHO (2025) estimates that around one in six people experiences loneliness.

Beyond attempting to assess the impacts of loneliness, researchers have also aimed to identify potential protective and risk factors for loneliness. Although many have been identified, this thesis will focus on socioeconomic status, health and social connection variables (such as social network size or social support). In particular, we aim to explore the ways through which socioeconomic status may impact loneliness. Despite several researchers' findings of an association between socioeconomic status and loneliness, the relationship between these two does not appear to have been much elaborated upon.

Our approach in this thesis is shaped by theoretical frameworks from the literature that suggest that socioeconomic status indirectly impacts loneliness via more “proximal” factors like health and social connection variables, which are more directly linked to loneliness. Our contribution to the existing literature will take the form of a more formal mediation analysis that aims to explore this hypothesized indirect pathway between socioeconomic status (studied through one of its facets: income) and loneliness, using health variables, structural and functional aspects of social connection as mediators.

From a public health perspective, we find this topic to be of great interest for exploration, seeing as socioeconomic status is a known source of inequities of outcomes in this field. Therefore, by studying this relationship we are exploring an under-researched mechanism, as well as socioeconomic inequities in terms of loneliness.

## II. Literature Review

### II. 1. A definition of loneliness and related concepts

While many definitions of loneliness have been suggested, Perlman & Peplau's 1981 definition appears to be a widely referenced and foundational definition in the field of loneliness research. These authors define loneliness as "*the unpleasant experience that occurs when a person's network of social relations is deficient in some important way, either quantitatively or qualitatively*" (p.31). Perlman & Peplau point out three major elements of this definition. Firstly, loneliness is caused by deficiencies in one's social relationships. Secondly, it is a subjective experience. Finally, the experience of loneliness is distressing in nature. In the following three sections, we will expand on these statements.

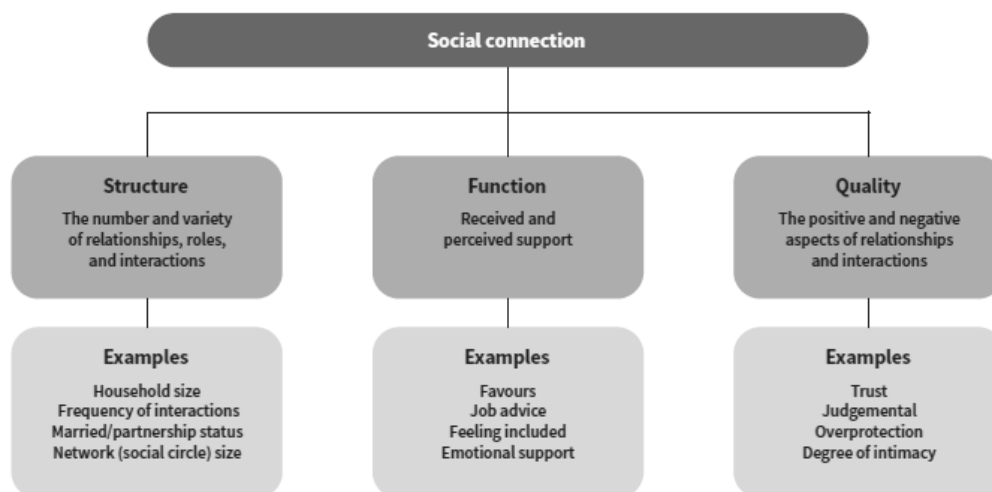
#### 1) Deficiencies in social relations

Deficiencies in social relations are not exclusively related to the size of one's social network. While larger social networks may act as a protective factor against loneliness (Hawkley et al., 2008), people with a great number of social connections may still experience loneliness. Conversely, people with a very small social network will not necessarily feel lonely. As Perlman & Peplau (1981) point out in their definition, the quality of one's social relations also comes into play in explaining why individuals may feel lonely. For instance, for those with more social ties, a perceived lack of depth of those relationships may lead to feelings of loneliness, whereas those with only a few but very close social ties may avoid such feelings of loneliness (Mauri et al., 2024).

#### 2) The subjective nature of loneliness

These differences in experiences highlight the inherent subjectiveness of loneliness. It is ultimately this subjectiveness that distinguishes loneliness from a phenomenon like social isolation, which is an objective experience. The WHO defines social isolation as "*an objective lack of roles, relationships or interactions with others*" (Mikton et al., p.10, 2025). To make the distinction between these two concepts clear, the term of *perceived* social isolation has also been used to refer to loneliness.

Both loneliness and social isolation are forms of social disconnection, which is the antithesis of social connection. According to the WHO, social connection is “*an umbrella term used to describe how people relate to and interact with each other in three dimensions: structural, functional and quality*” (see Figure 1) (Mikton et al., p.9, 2025). The structural dimension relates to the existence of relationships, roles and interactions and is often measured quantitatively (Holt-Lunstad, 2022). The functional dimension refers to the type and amount of support a person receives or perceives as available from their relationships. Finally, the quality dimension gives us information concerning the positive or negative nature of the relationships and interactions (Mikton et al. , 2025). Seen through the lens of the concept of social connection, we understand that social isolation focuses more on the structural aspects of social (dis)connection, where loneliness takes all of these dimensions into account.



**Figure 1:** The three dimensions of social connection

Source: Mikton, C., Officer, A., Surkalim, D.L. (2025). Chapter 1: Key concepts – social connection, social isolation and loneliness. In: From loneliness to social connection - charting a path to healthier societies: report of the WHO Commission on Social Connection. Geneva: World Health Organization; 2025. Licence: CC BY-NC-SA 3.0 IGO.

Although a link does exist between social isolation and loneliness, with socially isolated people being more at risk of experiencing loneliness, as we have established regarding social network sizes, a person *can* be lonely without necessarily being socially isolated, and a socially isolated individual will not necessarily feel lonely (De Jong Gierveld et al., 2018; Perlman & Peplau, 1981). Researchers like Coyle and Dugan (2012) have shown that the two concepts only weakly correlate ( $r = 0.201$ ,  $p < .001$ ). An example that can also help illustrate

how these concepts are distinct, though correlated, is a study conducted by Barnes et al. (2022) among a large sample of older adults in the United States. In their study, they found that 9.1% of their sample was considered both lonely *and* socially isolated, while 9.8% were found to just be lonely and 20.6% to be socially isolated only. De Jong Gierveld et al. (2018) further suggest that a person's own standards and expectations will shape how lonely or how socially integrated they feel.

### **3) The distressing nature of loneliness**

The distressing and unpleasant nature of loneliness is what distinguishes it from other experiences such as so-called “positive” loneliness, which is a voluntary retreat from social relations, often with a certain goal in mind of religious, spiritual, artistic, meditative nature (De Jong Gierveld et al., 2018). When we refer to loneliness in this thesis, it must be understood that we are assuming an involuntary, unwanted and unpleasant experience for the person living through it.

When discussing loneliness, some authors further differentiate between types of loneliness. These distinctions can be based on the nature of the relationship seen as lacking, the duration or the intensity of the experience (Mauri et al., 2024). With regard to the nature of the affected relationships, Weiss (1973) distinguished between loneliness of an emotional versus a social nature. Emotional loneliness relates to intimate relationships and is more so linked to the quality of relationships. On the other hand, social loneliness refers to deficiencies in one's broader social network and corresponds more to an issue of quantity of social relations (Mauri et al., 2024; De Jong Gierveld et al., 2018). From the duration point of view, loneliness can be transient or chronic. It can also be situational, meaning it has been spurred on by a shock in one's personal life circumstances such as the death of a partner or the loss of a job (Mauri et al., 2024). The intensity of the feeling may furthermore vary from one individual to the other.

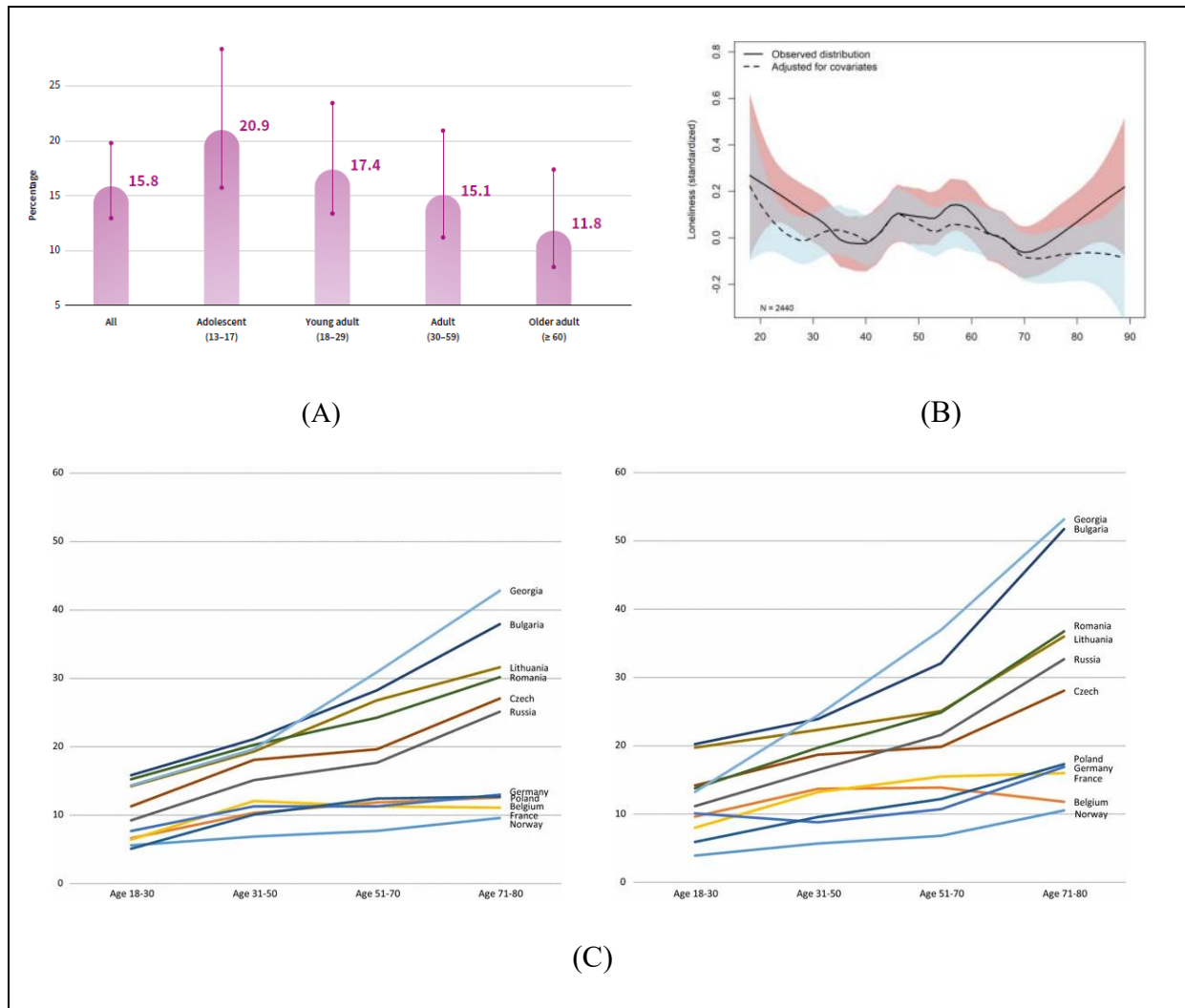
## II. 2. Main factors associated with loneliness

Many researchers have contributed to the literature on potential risk factors for loneliness and have attempted to establish a profile of those most vulnerable to loneliness. Theoretical frameworks can help us better understand the relationship between these determinants of loneliness and this unpleasant experience. Two models we will explore are Hawkley et al.'s (2008) filtration model and De Jong Gierveld & Tesch-Römer's (2012) integrative model. These models are particularly interesting when trying to conceptualize how socioeconomic status may impact loneliness.

### 1) An overview of the main factors associated with loneliness

#### Demographic factors

Age and sex/gender (generally studied as a binary variable) are among the most frequently examined determinants of loneliness. They appear in most studies on loneliness, if not as factors studied in and of themselves, then as controls. The relationships found between age and loneliness and between sex and loneliness are however not always consistent across studies. Indeed, although loneliness has often intuitively been associated with old age, a range of different types of relationships have been found: more or less linear increase (Hansen & Slagsvold, 2016), linear decrease (Barreto et al., 2021; Pyle & Evans, 2018; Surkalim & Mikton, 2025), several fluctuations throughout the lifespan (Hawkley & Luhmann, 2022; Luhmann & Hawkley, 2016)... Figure 2 illustrates a few different relationships found in the literature. These differences may arise from how age is treated in these studies. Surkalim & Mikton (2025) for example recognize that their category of 60-year-olds and over may encompass older adults with varying experiences of loneliness. The relatively more positive results of the younger portion of adults over 60 (which represents a larger subset than those over 80) may overshadow more intense loneliness felt by those over the age of 80.



**Figure 2 : (A)** Downward trend observed between age and loneliness in global prevalence of loneliness (with 95% uncertainty interval), **(B)** Fluctuations in loneliness throughout the lifespan using results from U.S. samples (observed versus adjusted for covariates, with 95% confidence intervals), **(C)** Relationship between age and loneliness for men (left) and women (right) in 11 European countries

**Sources:** (A) Surkalim, D. L. & Mikton, C. (2025) Chapter 2: Scale of the problem. In: From loneliness to social connection - charting a path to healthier societies: report of the WHO Commission on Social Connection. Geneva: World Health Organization; 2025. Licence: CC BY-NC-SA 3.0 IGO.

(B) Hawkley, L. C., Buecker, S., Kaiser, T., & Luhmann, M. (2022). Loneliness from Young Adulthood to Old Age: Explaining Age Differences in Loneliness. *International journal of behavioral development*, 46(1), 39–49. <https://doi.org/10.1177/0165025420971048>

(C) Hansen, T., Slagsvold, B. Late-Life Loneliness in 11 European Countries: Results from the Generations and Gender Survey. *Soc Indic Res* 129, 445–464 (2016). <https://doi.org/10.1007/s11205-015-1111-6>

When it comes to sex, some studies suggest women are overall lonelier, although differences between the sexes tend to be minimal (Maes et al., 2019; Surkalim & Mikton, 2025). Some suggest that at different ages, the most vulnerable sex can change. For example, according to Surkalim & Mikton (2025), young adult men are lonelier than young adult women, but adolescent girls are lonelier than adolescent boys. Among older adults, women supposedly tend to be more lonely (Hansen & Slagsvold, 2016; Surkalim & Mikton, 2025). It has been suggested that results may vary depending on the measure of loneliness used (direct versus indirect measures), as men may be less open to disclosing feelings of loneliness when asked directly (Berlingieri et al., 2024; Borys & Perlman, 1985; Luhmann & Hawkley, 2016).

Another demographic characteristic studied has been marginalized groups. Sexual and racial/ethnic minorities, migrants, asylum seekers and refugees have often been associated with an increased risk of loneliness (Barjaková et al., 2023; Hutten et al., 2022; Surkalim & Mikton, 2025).

### **Socioeconomic factors**

A range of socioeconomic variables have been studied in the literature. The most common ones are education, employment status and financial situation (often measured through income). All three have been associated with loneliness, though results are sometimes mixed.

#### ***a) Education***

While some studies have determined that education operates as a protective factor against loneliness (Hutten et al., 2022; Kung et al., 2022; Pagan, 2020; Pinquart & Sörensen, 2001; Victor & Yang, 2012), others have suggested that a protective role of education is only (significantly) observed before controlling for other variables (Dahlberg et al., 2018; Luhmann & Hawkley, 2016; Nicolaisen & Thorsen, 2014; Tonković et al., 2021). In a 2016 study, Luhmann & Hawkley even found that the initially negative relationship they observed between education and loneliness became positive once other covariates were introduced. Those with higher levels of education became the loneliest, whereas the least educated were the least lonely. They further found that the initial effect of education on loneliness appeared to be confounded with income.

### ***b) Employment status***

Employment status appears to function as a protective factor against loneliness, with the employed experiencing lower levels of loneliness than the unemployed (Morrish & Medina-Lara, 2021; Pagan, 2020; Surkalim & Mikton, 2025). The OECD (2025) found that 12% of the unemployed felt lonely compared to 4% of the employed. Some authors suggest that the effect of employment on loneliness varies throughout the subject's lifetime (Hutten et al., 2022; Luhmann & Hawkley, 2016). For example, having a paid job appears to be more important in middle adulthood than for younger adults and retirement-aged adults. Middle adulthood is usually when people are most immersed in the professional world and when labor participation is highest, explaining why being employed may be more important to those in this life stage (Hutten et al., 2022).

Luhmann & Hawkley (2016), however, observed – similarly to what they had seen with education – that when income and other covariates were taken into consideration in their model, the initially negative (protective) relationship between work status and loneliness became positive. After adding these variables, full-time workers were the loneliest, and the unemployed the least lonely.

Some studies suggest that a bidirectional relationship may exist between employment and loneliness. In particular, these studies discovered that while unemployment may lead to feelings of loneliness, loneliness could also increase the likelihood of experiencing unemployment (Morrish et al., 2022; Morrish & Medina-Lara, 2021).

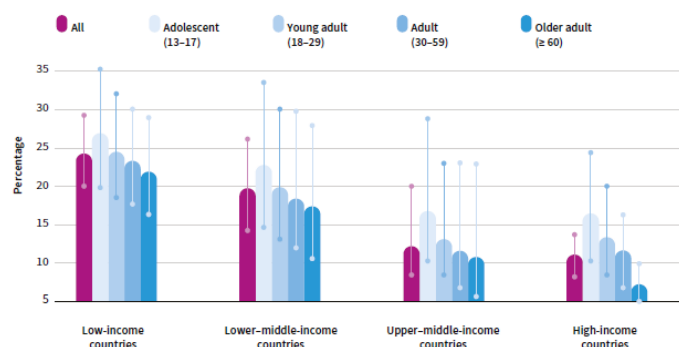
### ***c) Income/Financial situation***

The literature generally finds a negative relationship between income/financial situation and loneliness (Berlingieri et al., 2024; Hawkley et al., 2022; Hutten et al., 2022; Niedzwiedz et al., 2016; Pagan, 2020). Kung et al. (2022) even talk of an economic gradient for loneliness. Looking at quintiles of income, the OECD (2025) found that the share of respondents reporting feeling lonely most or all of the time in the past four weeks was highest in the lowest quintile and decreased moving up the income ladder (1<sup>st</sup> quintile: 13%, 2<sup>nd</sup> quintile: 6%, 3<sup>rd</sup> quintile: 4%, 4<sup>th</sup> quintile: 3% and 5<sup>th</sup> quintile: 2%). A 2023 Gallup study also showed that feelings on household income appeared to affect feelings of loneliness: 32% of people who reported “*finding it difficult on current income*” experienced loneliness the

previous day, compared to 17% and 16% respectively for those who reported “*getting by on current income*” and “*living comfortably on current income*” (Dugan, 2024).

Contrary to the other socioeconomic factors we have mentioned, income/financial situation tends to remain a relevant factor at all stages of life, even if the strength of the relationship may vary across these stages (Hutten et al., 2022; Luhmann & Hawkley, 2016). Some studies have found a stronger association between income and loneliness than between the other socioeconomic factors and loneliness (Luhmann & Hawkley, 2016; Pinquart & Sörensen, 2001) As we have seen, in some studies it is even suggested that the effects of education and employment on loneliness may be confounded with income (Luhmann & Hawkley, 2016).

Zooming out to a more macro scale, studies have also found that feelings of loneliness are most pronounced in low-income countries. Surkalim & Mikton (2025) for example compared prevalence of loneliness by World Bank country income groups. They found a progressive increase in loneliness across all age groups from high-income countries to low-income countries (see Figure 3). All of these elements lead us to conclude that people in more tenuous financial situations tend to feel lonelier and that there may be an underlying socioeconomic dimension to loneliness.



**Figure 3:** “*Global prevalence (%) of loneliness by World Bank country income group, 2014-2023 (with 95% uncertainty intervals)*”

Source: Surkalim, D. L. & Mikton, C. (2025) Chapter 2: Scale of the problem. In: From loneliness to social connection - charting a path to healthier societies: report of the WHO Commission on Social Connection. Geneva: World Health Organization; 2025. Licence: CC BY-NC-SA 3.0 IGO.

### **Health factors**

A wide range of health factors have been linked to loneliness in the literature. Poor (subjective) health, functional limitations, chronic conditions and disabilities appear to be associated with elevated levels of loneliness (Dahlberg et al., 2022; Emerson et al., 2023; Hutten et al., 2022; Luhmann & Hawkey, 2016; Pagan, 2020; Victor & Yang, 2012). Some authors have suggested that the actual impact of these health conditions on one's feelings of loneliness may vary with age, sex or with how much they end up affecting one's ability to interact socially (De Jong Gierveld et al., 2018; Hansen & Slagsvold, 2016; Hutten et al., 2022). Beyond physical health, higher levels of stress and mental health struggles, such as depression and social anxiety, have also been linked to higher degrees of loneliness (Campagne, 2019; Nuyen et al., 2020; Victor & Yang, 2012; Wolters et al., 2023).

Some studies have suggested that loneliness itself can have harmful effects on health. Some of these potential impacts on health are elevated levels of stress and blood pressure, increased cortisol levels, cardiovascular diseases, disrupted sleep, increased risks of depression, suicide or self-harm and even premature mortality (Akhter-Khan et al., 2021; Beutel et al., 2017; Cacioppo et al., 2006; D'Hombres et al., 2024; Freilich, 2023; Holt-Lunstad, 2024; Holt-Lunstad et al., 2015; Mann et al., 2022; Matthews et al., 2016; Wood & Mikton, 2025).

With most studies conducted on cross-sectional data, the actual direction of the relationship between health and loneliness is a bit murky. However, a certain level of bidirectionality seems likely. In fact, some longitudinal studies have found evidence for a bidirectional relationship between loneliness and stress, depression or other mental disorders (Chen et al., 2023; Nuyen et al., 2020; Sbarra et al., 2023). Bidirectional relationships have also been found with physical exercise, self-rated health and functional limitations (Luo et al., 2012; Luo & Waite, 2014).

Some authors have also pointed toward potential self-perpetuating cycles between health issues and loneliness (Achterbergh et al., 2020; Ahmed et al., 2023). For example, a depressed individual may withdraw from social interactions and activities, leading them to feel more isolated and lonely, which may in turn worsen feelings of depression and continue the cycle. A sick individual may be more likely to be more socially isolated due to their illness (e.g. if it causes mobility issues) and start feeling lonely, further impacting their health and ability to partake in social activities which could alleviate these feelings of loneliness.

### **Social connection factors**

Many factors across all three dimensions of social connection have been associated with loneliness. In terms of the structural dimension, relationship status, household composition, network size and frequency of social interaction are among the most cited predictors of loneliness. For the functional and quality dimensions, social support as well as the perceived quality of this support and of relationships appear to be particularly important.

Regarding relationship status, having a partner has been associated with lower levels of loneliness, compared to single adults (Luhmann & Hawkley, 2016; Nicolaisen & Thorsen, 2014). Barjaková et al. (2023) claim it may even be one of the strongest predictors of loneliness. This protective nature of intimate partner relationships may however change in the event of a non-supportive partner (Hawkley et al., 2008).

In terms of household composition, living alone has often been linked to higher levels of loneliness (Dahlberg et al., 2022; Hawkley et al., 2022; Hutten et al., 2022; Sundström et al., 2009; Tonković et al., 2021). For example, the OECD (2025) found that 14% of those living alone felt very lonely, compared to 4% of those living with others. More than simply living with others, living with a partner has been suggested to be of particular importance (De Jong Gierveld et al., 2012; Hansen & Slagsvold, 2016; Sundström et al., 2009). The impact of having and living with children appears to be mixed. Living with children can imply more responsibilities, limiting social connection opportunities and leading to more loneliness. But living without children can also be associated with loneliness for those whose children no longer live with them or those who may feel social pressure to be parents (Luhmann & Hawkley, 2016).

Larger networks and higher frequency of social interaction have also been found to be protective, even independently of the quality of the relationships considered (Hawkley et al., 2022; Hawkley et al., 2008; Tonković et al., 2021). However, that does not mean to say that the quality of relationships does not matter. In fact, one's level of satisfaction with one's social relationships, conflict within relationships, etc. have also been found to be important (Hawkley et al., 2008 ; Tonković et al., 2021). Functional aspects of social connection like the perceived availability of social support from friends and family have also been linked to less loneliness (Dahlberg et al., 2018; Segrin, 2003).

Some authors have suggested that, for younger people, the quantitative aspects of social connections may matter more, whereas concern for the quality of relationships gains in

importance with age (Luhmann & Hawkley, 2016; Victor & Yang, 2012). Among older adults, the quality of relationships appears to play a more important role in the association with loneliness (Barjaková et al., 2023; Pinguart & Sörensen, 2001). Some findings however suggest that, for children and teens too, the quality of friendships may matter more than the quantity of friendships (Lodder et al., 2015).

For some authors, like Segrin (2003), family and friends may play different roles in the relationship with loneliness. Segrin (2003) for instance found that while the importance of contact with family diminished with age, contact with friends remained important throughout the lifetime.

## **2) Theoretical frameworks**

### **Hawkley et al.'s (2008) filtration model**

In Hawkley et al.'s (2008) conceptual framework, the authors explain loneliness through a filtration model in which distal factors shape and operate through proximal factors that more directly impact loneliness. Distal factors include demographic characteristics such as age, gender and ethnicity, and structural factors such as income and education. The demographic factors operate through the structural ones. Health, stress, social roles and contact opportunities make up the proximal factors in this model. The idea is that these will affect the size and quality of social networks and relationships more directly. In the authors' eyes, it is these last two elements that will ultimately determine loneliness.

### **De Jong Gierveld & Tesch-Römer's (2012) integrative model**

In De Jong Gierveld & Tesch-Römer's (2012) integrative model, both individual-level factors (quality of living conditions, level of social integration and individual social expectations) and societal-level factors (societal welfare, demographic composition and cultural norms and values) are considered.

At the individual level, the model rests on three distinct theoretical conceptual approaches to loneliness: the deficit approach, the cognitive discrepancy approach and the living situation approach. Depending on the approach, loneliness is either seen as the result of unfulfilled

social needs, unmet social expectations or poor living conditions. As seen in Table 1, each individual-level factor in the integrative model corresponds to one of these approaches. De Jong Gierveld & Tesch-Römer (2012) for instance describe the level of social integration as “*a necessary condition for the fulfilment of social needs*” (p.288), thus linking the deficit approach to the factor “level of social integration”.

**Table 1:** The three theoretical conceptual approaches to loneliness and their corresponding individual-level factor

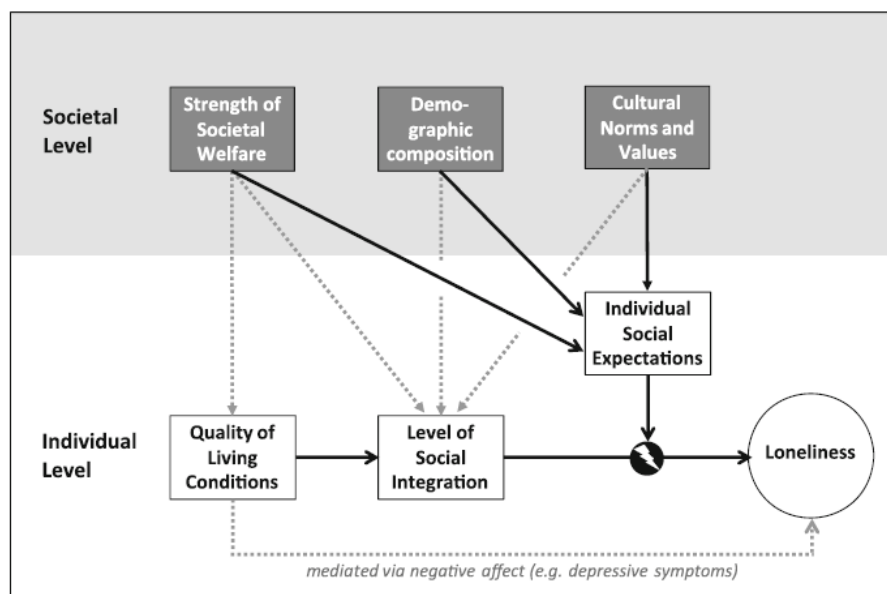
| Theoretical conceptual approach to loneliness | Loneliness as a result of... | Corresponding individual-level factor |
|-----------------------------------------------|------------------------------|---------------------------------------|
| <b>Deficit approach</b>                       | Unfulfilled social needs     | Level of social integration           |
| <b>Cognitive discrepancy approach</b>         | Unmet social expectations    | Individual social expectations        |
| <b>Living situation approach</b>              | Poor living conditions       | Quality of living conditions          |

Based on: De Jong Gierveld, J., & Tesch-Römer, C. (2012). Loneliness in old age in Eastern and Western European societies: theoretical perspectives. *European journal of ageing*, 9(4), 285–295.  
<https://doi.org/10.1007/s10433-012-0248-2>

In the lower part of Figure 4, we see how these different individual-level factors interact with each other. A person’s living conditions are expected to influence their level of social integration (the quantity and quality of their relationships and of social support, their involvement in social activities). De Jong Gierveld & Tesch Römer (2012) further suggest that the quality of living conditions may affect loneliness through another channel: its impact on an individual’s affective states and, more specifically, on depressive symptoms. The relationship between social integration and social expectation plays out through the evaluation of needs. When judging whether their social needs have been met, a person will inevitably rely on their individual preferences and social expectations. Personal expectations will thus inform whether one considers one’s needs met.

Adding societal-level factors to this model shows how a wider societal context can inform individual social expectations and the other individual-level factors. Societal welfare, demographic composition as well as cultural norms and values may shape individuals’ expectations regarding social relationships and needs. They can also more directly impact individual living conditions and create or inhibit social integration opportunities.

The addition of this more macro level can be useful when aiming to understand differences in loneliness levels between countries. Hansen & Slagsvold (2016), provide an interesting illustration of this societal level impacting the micro level (individual level) in the context of observed differences in levels of loneliness between older adults living in Eastern versus Western/Northern European countries. They attributed these differences in large part to inequalities in socioeconomic status, health and social networks/marital status at the macro level. They further hypothesized that the higher levels of loneliness found in Eastern Europe may stem from persistent socioeconomic inequalities and political instability in these regions, as these may have impacted trust and social integration. They further suggested collectivistic cultural values often found in these countries, while potentially helpful in combatting loneliness through promotion of social contact and integration, may also add pressure and expectations to be well integrated, to have many friends or family as a support network, etc. If these expectations are not or cannot be met, this may increase loneliness. Social security and welfare structures may also help explain differences found between countries, as better health outcomes have been found in countries with stronger such institutions, and as these institutions may also lead to more social participation (Hansen & Slagsvold, 2016; Saltkjel et al., 2013). In other words, this study shows how these different societal-level factors may impact individuals, their living conditions, health, level of social integration and expectations.



**Figure 4:** The integrative model

Source: De Jong Gierveld, J. & Tesch-Römer, C. (2012). Loneliness in old age in Eastern and Western European societies: theoretical perspectives. *European journal of ageing*, 9(4), 285–295. <https://doi.org/10.1007/s10433-012-0248-2>

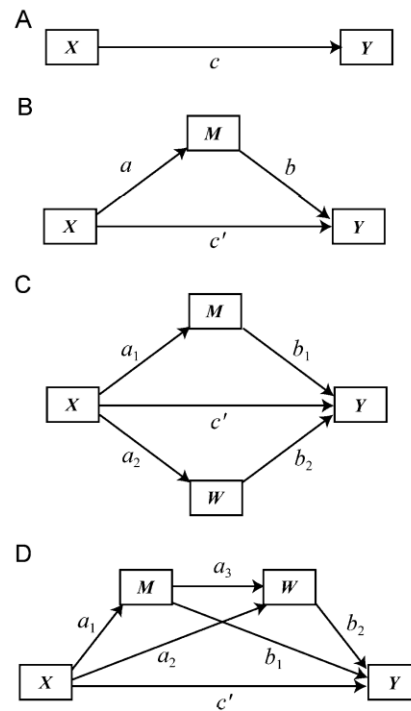
In both Hawkey et al. (2008) and De Jong Gierveld & Tesch-Römer's (2012) models, socioeconomic factors operate indirectly through other – more proximal – variables. Hawkey et al. (2008), for example, posit that education's protective nature against loneliness is due to its positive impact on the size of one's social network and the quality of relationships a higher level of education enables, as well as its association with lower levels of chronic stress. Income's impact on loneliness is, according to them, largely understood through its association with better health outcomes. For De Jong Gierveld and Tesch-Römer (2012), poor living conditions can jeopardize one's level of social integration (social support, quantity and quality of relationships, ...). Socioeconomic status can also affect health and psychological well-being of individuals and, in this way, impact loneliness.

Based on these authors' works, it would seem that socioeconomic factors may impact loneliness *through* their effects on social connection and health-related variables. These theoretical frameworks thus essentially make the case for a mediation of the socioeconomic status-loneliness relationship through social connection and health. Mediation analysis, in its simplest form, aims to explain the relationship between an independent variable (X; e.g. socioeconomic status) and a dependent variable (Y; e.g. loneliness), through the existence of an intervening variable, also called a mediator (M; e.g. social connection or health). The idea behind mediation is that of a causal chain, where the independent variable exerts an influence on the mediator variable, which in turn impacts the dependent variable. In more complex mediation models, several mediators may be studied at once, either in parallel or sequentially (or a mix of both) (Hayes, 2009).

Mediation models are often represented visually through path diagrams (see Figure 5), where the direct and indirect pathways through which the independent variable's impacts on the dependent variable are shown. For simple mediation models (see Figure 5B), three paths exist which are often referred to as the a-path ( $X \rightarrow M$ ), the b-path ( $M \rightarrow Y$ ) and the c'-path ( $X \rightarrow Y$ ). The total effect  $c$  of X on Y is the sum of the direct effect  $c'$  and indirect effect  $a*b$  of X on Y:  $c = c' + a*b$ .

Mediation can be partial or full. If after accounting for the mediator the coefficient  $c'$  remains significant, then we say that there is partial mediation: the effect of X on Y is only partially explained through the mediator. On the other hand, if the  $c'$  coefficient is no longer significant after taking the mediator into account, then we speak of complete or full

mediation: all of the effect we initially observed from X to Y is actually explained through the mediator (MacKinnon, 2007).



**Figure 5: (A)** The total effect of X on Y, **(B)** simple mediation model, **(C)** parallel mediation model, **(D)** hybrid between a parallel and sequential mediation model

Source: Hayes, A. F. (2009). Beyond Baron and Kenny: Statistical mediation analysis in the new millennium. *Communication monographs*, 76(4), 408-420.

## II. 3. Socioeconomic status and proximal factors

In previous sections we showed that socioeconomic status, health and social connection have all been associated with loneliness. Through our theoretical frameworks, we showed that the relationship between socioeconomic factors and loneliness may actually operate through health and social connection. In this section, we explore the literature on the relationship between socioeconomic factors and these more proximal factors, aiming to find additional support for the hypothesis of an indirect effect of socioeconomic status on loneliness, through social connection and health variables.

## **1) Socioeconomic status and health**

Socioeconomic status is a well-recognized determinant of health. It can affect exposure (e.g. through living conditions and work conditions), stress levels, health behaviors, health literacy and access to healthcare (Adler & Newman, 2002; Baum et al., 1999; Braveman & Gottlieb, 2014; Hawkey et al., 2008). This is believed to explain socioeconomic inequalities (or the social gradient) observed in mortality and morbidity.

We previously identified different health factors that had been linked to loneliness. The following examples show that these same factors may also be associated with socioeconomic status. In terms of physical health, some findings indicate functional limitations and disabilities, as well as steeper declines in physical health in middle adulthood, may be associated with lower socioeconomic status (Koster et al., 2006; Minkler et al., 2006). Subjective health, too, appears to be influenced by this determinant of health, as individuals in lower (perceived) socioeconomic situations have also been found to report worse ratings (Hakeberg & Wide Boman, 2017; Präg, 2020; Präg et al., 2016). According to De Jong Gierveld & Tesch-Römer (2012), psychological distress is more common among those experiencing financial hardship. Some authors have found depression to be associated with lower socioeconomic status, with socioeconomic status potentially increasing the risk of depression, though some selection may be at play (Jespersen et al., 2025; Lorant, 2003).

## **2) Socioeconomic status and social connection factors**

In terms of social connection, research suggests socioeconomically disadvantaged individuals tend to have smaller, less complex and less diverse social networks (Campbell et al., 1986; Hawkey et al., 2008; Pinquart & Sörensen, 2001). They are also more likely to have fewer close ties (Cavicchiolo et al., 2022; OECD, 2025). As Aartsen et al. (2017) suggest, individuals with more advantageous resources (competencies or material resources) may be able to bring more individuals into their social network. Hansen & Slagsvold (2016) for example hypothesize that socioeconomic status may impact one's self-esteem and social skills, boosting confidence and making them more attractive to others.

Education, income and work status may impact social interaction opportunities. Financial constraints can for example limit individuals' ability to engage in paying social activities that would increase social contacts (Hawkey et al., 2008; Surkalim & Mikton, 2025).

Employment, on the other hand, can be a source of social interaction (Surkalim & Mikton, 2025). It can however also reduce one's free time and flexibility in daily life to interact with friends and family, and to build strong social networks (Luhmann & Hawkley, 2016; OECD, 2025). Higher paid jobs may be more demanding and, as such, lead to less free time left over for socializing (OECD, 2025). Education can affect these income and job prospects. According to the OECD (2025), the less educated are, for example, more likely to have lower paying jobs and to therefore have to work several jobs, which may limit opportunities for socializing outside of work. In contrast, some authors have found that lower education levels and poverty were actually associated with more socializing (Davis et al., 2023).

In terms of frequency of interactions, the OECD (2025) noted that the unemployed, the least educated and the poorest were simultaneously the most likely to spend time with friends and family daily, but also to never see or meet up with friends and family. Davis et al. (2025), on the other hand, found no significant differences in the time spent socializing across deciles of income. Other studies have found lower socioeconomic statuses to have fewer contacts with friends and family (Krause & Borawski-Clark, 1995). Bianchi & Vohs (2016) further suggest that, as their resources increase, individuals may shift their attention away from family and neighbors to spend more time with friends instead.

With respect to the more functional and qualitative aspects of social connection, some studies have found that those with lower socioeconomic standing are more likely to lack social support. For example, they are more likely to report having no one to turn to in times of need, to lack a confidant or partner, etc. (Kung et al., 2022; OECD, 2025; Weyers et al., 2008). A study among the elderly found that those with higher levels of education had broader social networks and a "stronger sense of social support" (Chen et al., 2024). The more socioeconomically disadvantaged are also more likely to report more dissatisfaction within their relationships (Krause & Borawski-Clark, 1995; OECD, 2025). They may also be more likely to experience interpersonal conflict (De Jong Gierveld & Tesch-Römer, 2012).

## II. 4. Objectives of this thesis and hypotheses

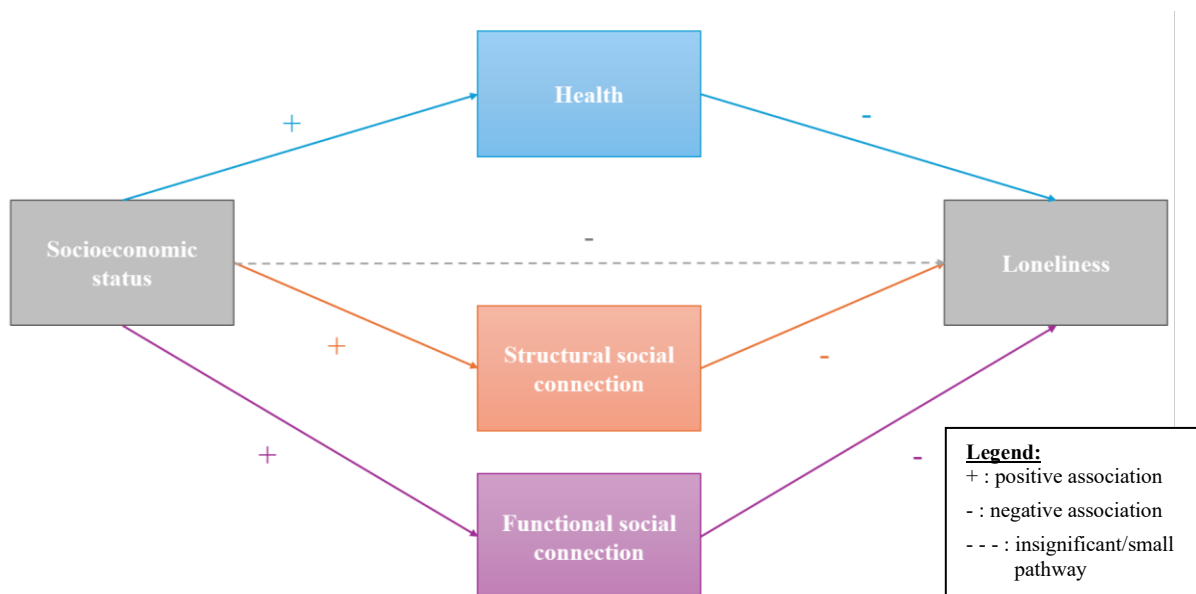
The literature has shown that worse socioeconomic standing tends to be associated with higher levels of loneliness. It has been further suggested that the impact of socioeconomic status on loneliness may actually be indirect. Social connection and health may function as so-called proximal factors (or mediators) that are both impacted by socioeconomic status *and* more directly impact loneliness. While some literature hints at such a mechanism, it does not really delve into its exploration, and even less so through explicit mediation analysis.

In this thesis, through formal mediation analysis, we will attempt to establish whether the relationship between socioeconomic status and loneliness is explained through socioeconomic status' impact on social connection and health variables. Social connection and health being quite broad concepts, we aim to test a few potential mediators related to each to see which appear to be most important. In terms of social connection, this means trying to cover the different dimensions of this concept, as these may play distinct roles in determining loneliness. In doing this, we hope to identify and ultimately answer the question: *What mediates the relationship between socioeconomic status and loneliness?*

This is particularly interesting to study considering that socioeconomic status is a known source of inequality in the field of public health (Adler & Newman, 2002; Adler & Ostrove, 1999; Braveman & Gottlieb, 2014; Cutler et al., 2008). Understanding how socioeconomic inequalities in loneliness operate is essential to know if we hope to act upon these. By identifying pathways through which socioeconomic status is linked to loneliness and their strength, we can also identify pathways through which inequities in loneliness arise and potential entryways for intervention. Note that our interest in this thesis is more focused on this mechanism at the more individual level, as opposed to studying inequalities between countries. Additionally, though the papers in which our theoretical frameworks were presented focused on older populations (De Jong Gierveld & Tesch-Römer, 2012; Hawkey et al., 2008), we hope to test this mechanism more generally/broadly.

Our research hypotheses are the following and our represented in Figure 6:

1. Better socioeconomic status is associated with lower levels of loneliness.
2. Better socioeconomic status is associated with better health and social connection outcomes (structural, functional/quality) which are in turn associated with lower levels of loneliness.
3. When mediators of health and social connection are accounted for, the direct effect of socioeconomic status becomes small and/or insignificant.
4. Social connection mediators are more important than health mediators.



**Figure 6:** Visual representation of our research hypotheses

### III. Methodology

To answer our research question, we exploited publicly available data from the EU27 sample of the European Union Loneliness Survey 2022 (or EU Loneliness Survey). This online survey gathered information on feelings of loneliness, social connection and health, among other variables. Data from this survey was used to run mediation analyses between socioeconomic status (studied through income deciles) and loneliness.

#### III. 1. EU Loneliness Survey 2022

In 2020, the European Parliament launched a pilot project on loneliness, which was carried out in collaboration with the European Commission's Joint Research Center (JRC) and Directorate-General for Employment, Social Affairs and Inclusion. In 2024, the project culminated in the publication of the book "*Loneliness in Europe: Determinants, Risks and Interventions*", which explores the different factors associated with loneliness as well as the public awareness and effectiveness of interventions against loneliness. Results from this book are largely based on the EU Loneliness Survey that was developed and conducted as part of this project. All information given in this section regarding this survey were either found in this book or in the "*EU Loneliness Survey – Methodological report*" which was published alongside the dataset.

Two samples resulted from the EU Loneliness Survey: the EU4 sample and the EU27 sample. The former is smaller and restricted to 4 EU countries (France, Italy, Poland and Sweden) but is based on probability sampling, whereas the latter gathers data from all 27 EU countries but is non-probabilistic.

In this thesis we use the EU27 sample. A total of 25,646 people completed the survey, with roughly 1000 responses from each Member State, with the exception of Cyprus (503), Luxembourg (370) and Malta (529). Respondents aged 16 and up were recruited from established consumer panels to fill out the survey. Mauri et al. (2024) point out that some populations may be more difficult to reach through such panels, leading to a certain selection bias. As a result, they advise caution when drawing conclusions for the general population based on this data.

To improve representativeness in this non-probability sample, age, gender, education, economic and geographic distribution quotas were implemented during the data collection phase. These quotas reflected the latest available data on the distribution of each of these characteristics in each country. They did not take intersectionality of these characteristics within countries into account, however, meaning each quota was established independently of the other characteristics. Due to some populations (mainly the older and the lower educated) being harder to reach, some quotas were eventually opened to ensure the desired amount of surveys were completed in each country.

Table 2 compares, for each Member State, a few key demographic characteristics between the reference population and the EU27 sample. This comparison allows us to observe the persistent underrepresentation in many countries of respondents without a university degree and those above the age of 56. To try to improve representativeness, weights were added to the dataset. First, weights based on country-specific sociodemographic characteristics were added, with one version only taking these sociodemographic factors into account ( $w\_country$ ) and another also considering quintiles of household disposable income ( $w\_country\_5$ ). Corrections for population size of EU Member States were also added as weights to this model ( $w\_population$ ). These two types of weights were then regrouped through multiplication under EU-level weights ( $w\_eu27$ ,  $w\_eu27\_5$ ).

For the rest of this thesis, it is important to note the limitations of this sample, namely its non-probabilistic nature, its underrepresentation of certain subgroups in the population and its cross-sectional nature. The first two elements point to a certain selection bias which needs to be kept in mind when interpreting our results. The cross-sectional nature of the data implies we must also be careful with our conclusions when trying to study causal relationships.

**Table 2:** Comparison between gender, age and education distributions between EU27 sample and the reference population

|             | Gender |         |        |         | Age groups |         |       |         |       |         |       |         |       |         |       |         | Education |         |        |         |       |         |
|-------------|--------|---------|--------|---------|------------|---------|-------|---------|-------|---------|-------|---------|-------|---------|-------|---------|-----------|---------|--------|---------|-------|---------|
|             | Male   |         | Female |         | 16-25      |         | 26-35 |         | 36-45 |         | 46-55 |         | 56-65 |         | > 65  |         | Low       |         | Medium |         | High  |         |
|             | N (%)  | Pop (%) | N (%)  | Pop (%) | N (%)      | Pop (%) | N (%) | Pop (%) | N (%) | Pop (%) | N (%) | Pop (%) | N (%) | Pop (%) | N (%) | Pop (%) | N (%)     | Pop (%) | N (%)  | Pop (%) | N (%) | Pop (%) |
| Austria     | 48.40  | 49      | 50.90  | 51      | 11.10      | 13      | 19.50 | 16      | 22.70 | 16      | 21.50 | 18      | 14.50 | 16      | 10.60 | 21      | 8.90      | 20      | 25.00  | 50      | 65.10 | 30      |
| Belgium     | 48.90  | 49      | 50.50  | 51      | 12.80      | 14      | 19.30 | 16      | 19.10 | 16      | 18.90 | 16      | 16.30 | 16      | 13.40 | 22      | 5.60      | 27      | 36.80  | 37      | 57.40 | 36      |
| Bulgaria    | 46.90  | 48      | 52.00  | 52      | 10.60      | 11      | 16.40 | 15      | 21.70 | 17      | 28.50 | 17      | 14.80 | 16      | 8.10  | 24      | 2.10      | 22      | 26.00  | 53      | 71.50 | 25      |
| Croatia     | 48.80  | 49      | 51.00  | 51      | 11.00      | 11      | 16.60 | 16      | 22.60 | 19      | 20.10 | 17      | 14.40 | 15      | 15.50 | 23      | 5.50      | 12      | 63.70  | 67      | 30.50 | 21      |
| Cyprus      | 49.20  | 49      | 49.50  | 51      | 16.00      | 15      | 19.70 | 16      | 18.10 | 14      | 15.90 | 17      | 12.20 | 15      | 18.20 | 23      | 12.60     | 27      | 12.10  | 41      | 74.30 | 33      |
| Czechia     | 49.00  | 49      | 50.90  | 51      | 6.10       | 12      | 15.70 | 15      | 16.70 | 14      | 23.70 | 17      | 20.10 | 17      | 17.70 | 24      | 5.20      | 20      | 26.50  | 53      | 67.50 | 27      |
| Denmark     | 44.70  | 47      | 53.80  | 53      | 12.60      | 12      | 30.10 | 17      | 25.40 | 17      | 15.00 | 16      | 10.30 | 16      | 6.60  | 23      | 12.60     | 16      | 29.70  | 47      | 56.70 | 37      |
| Estonia     | 48.70  | 49      | 49.40  | 51      | 23.80      | 16      | 24.00 | 16      | 27.10 | 20      | 15.50 | 17      | 6.90  | 14      | 2.70  | 17      | 3.60      | 23      | 18.70  | 37      | 76.70 | 41      |
| Finland     | 47.90  | 48      | 51.10  | 52      | 12.50      | 12      | 13.70 | 13      | 27.00 | 17      | 34.30 | 18      | 10.20 | 15      | 2.30  | 25      | 2.40      | 29      | 32.90  | 44      | 64.10 | 27      |
| France      | 48.30  | 49      | 50.90  | 51      | 12.50      | 12      | 13.50 | 13      | 20.80 | 18      | 29.70 | 19      | 16.80 | 16      | 6.60  | 22      | 3.40      | 42      | 23.90  | 24      | 72.30 | 34      |
| Germany     | 47.70  | 48      | 52.10  | 52      | 10.70      | 15      | 15.20 | 14      | 16.60 | 15      | 22.60 | 16      | 15.30 | 15      | 19.60 | 24      | 4.30      | 25      | 28.30  | 42      | 67.20 | 33      |
| Greece      | 48.00  | 48      | 51.40  | 52      | 11.40      | 13      | 14.50 | 14      | 18.90 | 16      | 28.30 | 16      | 16.70 | 17      | 10.20 | 24      | 0.70      | 20      | 50.30  | 58      | 48.50 | 22      |
| Hungary     | 48.20  | 48      | 51.40  | 52      | 11.00      | 11      | 12.40 | 12      | 15.40 | 15      | 23.70 | 19      | 16.30 | 16      | 21.20 | 26      | 7.50      | 43      | 41.30  | 41      | 51.00 | 17      |
| Ireland     | 46.70  | 48      | 53.30  | 52      | 15.50      | 16      | 29.60 | 20      | 27.00 | 17      | 13.70 | 14      | 10.50 | 14      | 3.60  | 19      | 2.60      | 24      | 16.90  | 38      | 79.70 | 38      |
| Italy       | 44.70  | 45      | 53.90  | 55      | 12.30      | 11      | 18.60 | 16      | 27.80 | 16      | 24.50 | 16      | 11.60 | 17      | 5.20  | 24      | 6.80      | 14      | 34.00  | 53      | 58.20 | 32      |
| Latvia      | 45.70  | 46      | 53.20  | 54      | 10.50      | 12      | 16.80 | 16      | 19.00 | 15      | 25.40 | 17      | 16.10 | 17      | 12.30 | 22      | 0.80      | 10      | 12.90  | 53      | 85.40 | 37      |
| Lithuania   | 45.70  | 50      | 53.20  | 50      | 23.80      | 14      | 32.20 | 19      | 28.40 | 18      | 11.10 | 18      | 4.10  | 14      | 0.50  | 16      | 6.80      | 28      | 31.90  | 32      | 59.20 | 40      |
| Luxembourg  | 47.20  | 47      | 52.50  | 53      | 11.40      | 13      | 16.20 | 15      | 19.40 | 18      | 21.40 | 17      | 15.90 | 15      | 15.80 | 22      | 5.00      | 20      | 36.80  | 57      | 58.00 | 23      |
| Malta       | 35.30  | 52      | 63.10  | 48      | 26.70      | 13      | 37.40 | 21      | 22.90 | 18      | 10.40 | 14      | 2.30  | 14      | 0.40  | 21      | 1.10      | 43      | 19.80  | 32      | 77.10 | 26      |
| Netherlands | 49.10  | 49      | 50.20  | 51      | 14.60      | 15      | 20.90 | 15      | 19.50 | 14      | 14.60 | 17      | 13.50 | 16      | 16.90 | 22      | 3.00      | 27      | 25.50  | 38      | 70.80 | 35      |
| Poland      | 47.80  | 48      | 52.10  | 52      | 11.90      | 12      | 19.00 | 17      | 24.60 | 19      | 21.00 | 15      | 15.30 | 16      | 8.30  | 21      | 3.10      | 14      | 42.10  | 59      | 53.90 | 27      |
| Portugal    | 46.30  | 47      | 53.30  | 53      | 12.50      | 13      | 13.20 | 13      | 18.30 | 17      | 32.40 | 17      | 16.40 | 16      | 7.10  | 25      | 2.10      | 50      | 27.90  | 27      | 69.60 | 23      |
| Romania     | 48.00  | 48      | 51.20  | 52      | 13.00      | 13      | 18.20 | 15      | 21.50 | 18      | 25.20 | 18      | 15.00 | 15      | 7.10  | 21      | 9.30      | 26      | 33.10  | 59      | 56.40 | 15      |
| Slovakia    | 49.60  | 50      | 49.60  | 50      | 11.50      | 11      | 19.50 | 14      | 31.00 | 18      | 17.80 | 17      | 12.60 | 17      | 7.60  | 23      | 2.20      | 16      | 48.60  | 54      | 48.80 | 30      |
| Slovenia    | 48.20  | 48      | 51.50  | 52      | 12.50      | 12      | 18.20 | 17      | 21.80 | 20      | 23.20 | 16      | 13.60 | 16      | 10.70 | 19      | 2.70      | 14      | 52.00  | 64      | 45.10 | 23      |
| Spain       | 48.70  | 49      | 50.40  | 51      | 13.90      | 13      | 16.20 | 15      | 16.00 | 15      | 26.10 | 15      | 15.70 | 16      | 12.20 | 26      | 7.50      | 18      | 23.70  | 43      | 68.60 | 39      |
| Sweden      | 49.70  | 50      | 49.60  | 50      | 12.50      | 14      | 18.50 | 17      | 18.60 | 15      | 17.60 | 16      | 13.30 | 14      | 19.60 | 23      | 7.90      | 22      | 33.00  | 41      | 58.90 | 38      |

Source: Berlingieri, F., Casabianca, E., Colagrossi, M., D’hombres, B., Kovacic, M., Mauri, C., Nurminen, M., Schnepf, S.V. & Stepanova, E. (2024). EU Loneliness Survey — Methodological Report. Publications Office of the European Union, Luxembourg, 2024. doi:10.2760/2083329, JRC139563.

## III. 2. Measures

### 1) Dependent variable

Our dependent variable is the 3-item University of California Los Angeles Loneliness Scale (3-item UCLA-LS), a global unidimensional measure of loneliness. It is a shortened version of Russel et al.'s (1980) Revised 20-item UCLA-LS, created by Hughes et al. in 2004 and often used today in large-scale population surveys (Department for Culture, Media and Sport, 2025). It has been found to be a reliable, valid and internally consistent measure, that strongly correlates with its source measure (Hughes et al., 2004).

Participants were asked how often they felt that they lacked companionship, felt left out, and felt isolated from others, with possible responses to each item being: 1 = “*Hardly ever or never*”, 2 = “*Some of the time*”, 3 = “*Often*”. Results for each item were then added up to form a final score that ranges from 3 to 9, where higher scores correspond to higher levels of loneliness. Note that if any response was missing at the item-level, the final score was labeled missing.

### 2) Independent variable

In this thesis, we chose to focus on one indicator of socioeconomic status to simplify analysis and interpretation as we will already be running several models with different hypotheses in terms of mediators. For simplicity's sake in our models, we chose to focus on an independent variable we could most easily justify treating as approximately continuous, based on common practice and risk/extent of bias we would introduce through this practice. Our independent variable will thus be income deciles.

In terms of income, participants could choose from ten country-specific weekly, monthly or yearly income brackets corresponding to the estimated income deciles in each country. These deciles were determined using information from the 2019 European Union Statistics on Income and Living Conditions (EU-SILC) and adjusted for the change in the harmonized index of consumer prices between 2019 and 2022 by country.

### **3) Mediator variables**

To ensure we explored a few different avenues through which decile of income could influence loneliness, we studied several mediators related to health and social connection. In terms of health, the EU Loneliness Survey possessed information on participants' subjective health and chronic health conditions. In terms of social connection, we had at our disposal information regarding the frequency of social interactions with friends and family respectively, as well as the number of close friends and family participants reported having (structural dimension), and on perceived available social support (functional dimension).

#### **Health**

##### **a) *Subjective health rating***

Participants were asked to rate how good their physical and mental health was on a Likert-type scale (1 = “*Very good*”, 2 = “*Fairly good*”, 3 = “*Average*”, 4 = “*Fairly poor*”, 5 = “*Very poor*”). For a more intuitive interpretation, we inverted the scale such that higher scores represent better subjective health ratings.

##### **b) *Health condition***

Participants were also asked questions regarding potential chronic health conditions. They were first asked whether they had “*any physical or mental health conditions or illnesses lasting or expected to last for 12 months or more*”. If they responded affirmatively, they were then asked if and the extent to which the condition(s)/illness(es) reduced their ability to carry out day-to-day activities (1 = “*Yes, a lot*”, 2 = “*Yes, a little*”, 3 = “*Not at all*”). Based on these responses, we created a single variable ranging from 1 to 4 (1 = “*No health condition*”, 2 = “*Health condition, with no impact*”, 3 = “*Health condition, with a little impact*”, 4 = “*Health condition, with a big impact*”).

#### **Structural aspects of social connection**

##### **a) *Frequency of interactions with friends and family***

Participants were asked how often they met up face-to-face with friends and family they did not live with, through both arranged and chance meetings (*friends\_meet\_face* and *family\_meet\_face*) and how often they communicated with friends and family via phone,

internet or social media (*friends\_meet\_tele* and *family\_meet\_tele*). Responses ranged from 1 to 7 (1 = “Never”, 2 = “Every two months or less frequently”, 3 = “Once a month”, 4 = “Every two weeks”, 5 = “Every week”, 6 = “More than once a week”, 7 = “Daily”).

By adding up frequency of in-person meetings and electronic communication with friends and family respectively, we obtained two variables reflecting global frequency of social interaction with friends and family. Each of these range from 2 to 14, with higher scores reflecting higher frequency of social interaction. We could then use this total score as a continuous variable in our model.

#### ***b) Number of close friends and family***

Respondents were asked how many of their friends and family respectively they had a close relationship with, including those living with them. Responses could range from 0 to 100. As can be expected, responses are extremely right-skewed. To deal with this issue without removing observations as those reporting extremely higher numbers may still hold valuable information on the relationship between income and loneliness, we created categories for each variable where answers were separated into: “0”, “1-2”, “3-5”, “6-10”, “11-20”, “21+”.

#### **Functional aspects of social connection : social support**

In terms of social support, the EU Loneliness Survey asked respondents to rate how often each of the following types of support were available to them if necessary: “Someone to help you if you were confined to bed”, “Someone to share your most private worries and fears with”, “Someone to do something enjoyable with” and “Someone to love and make you feel wanted”. Each of these questions received a rating from 1 to 5 (1 = “None of the time”, 2 = “A little of the time”, 3 = “Some of the time”, 4 = “Most of the time”, 5 = “All of the time”).

Adding these ratings up, we can obtain a total score that ranges from 4 to 20, with higher scores indicating higher levels of social support. We can then treat this variable as a continuous variable.

#### 4) Control variables/Covariates

Age, gender, relationship status and country of residence of respondents were added as covariates to our models. The age of participants was gathered based on date of birth they declared and was treated as a continuous variable in our models. Respondents could identify within 3 gender categories: “Male”, “Female” or “Other”. For our models, these were dummy-coded, with “Female” as the reference group. In terms of relationship status, respondents could either be “Single” (1), “In a relationship” (2), “Married or cohabitating” (3), “Separated or divorced” (4) or “Widowed” (5). We collapsed these answers into two groups for those currently in a relationship (2 and 3 recoded as 1) and those not currently in a relationship (1, 4 and 5 recoded as 0). Survey responses came from across the 27 EU Member States. Countries appeared as 26 dummy-coded variables in our models, with Austria as the reference group.

### III. 3. Analysis

We ran path analyses using the *lavaan* package (version 0.6-21) in R (version 4.5.2) to study different potential pathways through which the relationship between income decile and loneliness could be explained. This multivariate technique allows us to model and run simultaneous regressions for a set of observed variables. It is useful when wanting to study complex systems of relationships between variables and enables us to estimate all paths and effects in one single step.

After running some exploratory checks on our data (e.g. checking univariate distributions, linearity and risk of multicollinearity, etc. see Appendix A for more details), we started our mediation analysis. We first ran three distinct models based on groups of potential intervening variables. Model 1 focused on mediation through health variables and Model 2 through structural social connection variables. As we wished to test several potential mediators for these concepts, we used parallel mediation models. Since we only studied one intervening variable for functional aspects of social connection, Model 3 was a simple mediation model. We identified and extracted the “strongest mediator” from the first two models to input them into one final model alongside social support. In the final model (Model 4) we then compared the most influential mediators from each domain (health, structural and

functional social connection) to assess which might contribute the most to the relationship between income decile and loneliness. Selection criteria to determine the “strongest mediator” were the size of the standardized coefficients of indirect effects, their significance and the significance of contrast tests between indirect effects. Significance tests of indirect effects relied on the delta method.

Parameters of interest to us were (standardized) estimates for the total effect, direct effect, specific indirect effects and total indirect effect of income decile on loneliness, as well as the a-path and b-path coefficients that make up the indirect effects. We also calculated the total proportion mediated ( $= \text{indirect effect} / \text{total effect}$ ) and the proportion mediated by each specific indirect effect.

These parameters were estimated using the maximum likelihood with robust (Huber-White) standard errors (MLR) estimator and missing data was handled with full information maximum likelihood (FIML). Consequently, all our variables were treated as continuous/numeric. Though some authors have suggested that treating Likert scales or ordinal variables with five or more categories in this way can be acceptable (Huh & Gim, 2025; Rhemtulla et al., 2012), treating skewed ordinal variables or variables with fewer than five categories (such as our health condition variable) as numeric/continuous is a heavier assumption and may introduce more bias (Rhemtulla et al., 2012). We thus chose to run robustness checks for some of our models with the weighted least squares mean and variance adjusted (WLSMV) estimator. As recommended by Preacher & Hayes (2008), in models with several intervening variables, we allowed them to covary, recognizing they may correlate as well as to account for any potential shared unexplained variance. This can help reduce risk of bias in our b-path estimates. In all our models, survey weights ( $w_{eu27\_5}$ ) were also taken into account.

Further details regarding statistical analysis can be found in Appendix B.

## IV. Results

### IV. 1. Descriptive statistics & missing data

Our final sample was made up of 25,646 individuals. Descriptive statistics results we discuss in this section can be found in Table 3 and Table 4. Table 3 is a sample characteristics table where counts (N) and percentages (%) are given for different groups in our sample. Table 4 gives information on means, standard deviations (SD), skewness and kurtosis, as well as the range of our variables.

All countries combined, there was a relatively even split between men and women in our sample, with slightly more women than men (51.66% vs. 47.58%). Respondents ranged from 15 to 91 years of age, with a mean age of 44.32 years (SD= 15.20). Younger and older age groups were present in smaller proportions than the 26 to 56 age groups, with respondents over the age of 65 being the least represented.

The overwhelming majority of respondents (94.28%) declared having at least completed secondary education, with 62.21% having pursued post-secondary schooling. Most of the sample (64.96%) was also currently employed or in paid work, 14.27% was retired, 9.40% was unemployed or permanently sick or disabled and 6.06% was still currently pursuing education. In terms of income, across the 10 deciles, respondents were more or less evenly spread, though lower proportions of respondents were identified as belonging to the lowest deciles of their country. Around 7.63% of respondents also chose not to disclose their level of income.

In our sample, around 38.17% of individuals were found to be lonely, with 11.49% being flagged as very lonely. Only 3.20% of respondents did not answer at least one of the items that make up the 3-item UCLA-LS. In terms of health, respondents rated their health around 3.49 (SD = 0.96) on average and most declared not having any health condition (55.45%). Contact with friends and family was on average fairly regular, between 9-10 on a scale from 2 to 14 (friends: 9.15, SD = 3.10; family: 9.57, SD = 3.02). Respondents additionally reported on average 1 to 5 close friends or family members (pre-transformation of our variables, we found respondents reported on average 4.15 (SD = 5.90) close friends and 4.66 (SD = 4.52) close family members). With regard to social support, the average respondent scored 14.60 (SD = 4.21) on a scale from 4 to 20.

**Table 3:** Sample characteristics table

|                                                         | N =    | %      |
|---------------------------------------------------------|--------|--------|
| <b>Gender</b>                                           |        |        |
| Male                                                    | 12,203 | 47.58% |
| Female                                                  | 13,249 | 51.66% |
| Other/Prefer not to say                                 | 194    | 0.76%  |
| <b>Age</b>                                              |        |        |
| 16-25                                                   | 3,344  | 13.04% |
| 26-35                                                   | 4,784  | 18.65% |
| 36-45                                                   | 5,498  | 21.44% |
| 46-55                                                   | 5,679  | 22.14% |
| 56-65                                                   | 3,558  | 13.87% |
| > 65                                                    | 2,771  | 10.80% |
| <b>Education</b>                                        |        |        |
| Not completed primary                                   | 124    | 0.48%  |
| Completed primary                                       | 1,180  | 4.60%  |
| Completed secondary                                     | 8,226  | 32.08% |
| Completed post secondary                                | 9,496  | 37.03% |
| Completed upper level education (master, PhD, ...)      | 6,458  | 25.18% |
| Prefer not to say                                       | 162    | 0.63%  |
| <b>Income deciles</b>                                   |        |        |
| Decile 1                                                | 1,604  | 6.25%  |
| Decile 2                                                | 1,614  | 6.29%  |
| Decile 3                                                | 1,937  | 7.55%  |
| Decile 4                                                | 2,296  | 8.95%  |
| Decile 5                                                | 2,541  | 9.91%  |
| Decile 6                                                | 2,911  | 11.35% |
| Decile 7                                                | 2,883  | 11.24% |
| Decile 8                                                | 2,886  | 11.25% |
| Decile 9                                                | 2,633  | 10.27% |
| Decile 10                                               | 2,385  | 9.30%  |
| Prefer not to say                                       | 1,956  | 7.63%  |
| <b>Work status</b>                                      |        |        |
| In paid work                                            | 16,659 | 64.96% |
| In education                                            | 1,555  | 6.06%  |
| Unemployed, actively looking for job                    | 1,281  | 4.99%  |
| Unemployed, not actively looking for job                | 577    | 2.25%  |
| Permanently sick or disabled                            | 554    | 2.16%  |
| Retired                                                 | 3,659  | 14.27% |
| Doing housework (e.g. looking after children or others) | 805    | 3.14%  |
| Other                                                   | 556    | 2.17%  |
| <b>Loneliness</b>                                       |        |        |
| Not lonely                                              | 15,035 | 58.63% |
| Slightly to moderately lonely                           | 6,843  | 26.68% |
| Very lonely                                             | 2,947  | 11.49% |
| Prefer not to say                                       | 821    | 3.20%  |

**Notes:** Three individuals aged 15 are included in age group 16-25. Any inconsistencies in the sum of category percentages are due to missing data. Individuals with scores of 6-7 on the 3-item UCLA-LS were counted as slightly/moderately lonely and those with scores of 8-9 as very lonely, consistent with past research (Mauri et al., 2024; Steptoe et al., 2013).

**Table 4:** Descriptive statistics

| Variable                                  | Unit of measure | Mean  | SD    | Skewness | Kurtosis | Min | Max |
|-------------------------------------------|-----------------|-------|-------|----------|----------|-----|-----|
| <i>Income</i>                             | Decile          | 5.94  | 2.69  | -0.21    | -1.01    | 1   | 10  |
| <i>Loneliness (UCLA)</i>                  | Score (3-9)     | 5.00  | 1.85  | 0.58     | -0.71    | 3   | 9   |
| <i>Age</i>                                | Years           | 44.32 | 15.20 | 0.21     | -0.77    | 15  | 91  |
| <i>Subjective health</i>                  | Score (1-5)     | 3.49  | 0.96  | -0.34    | -0.18    | 1   | 5   |
| <i>Health condition</i>                   | Score (1-4)     | 1.70  | 1.03  | 1.06     | -0.41    | 1   | 4   |
| <i>Frequency of interaction (friends)</i> | Score (2-14)    | 9.15  | 3.10  | -0.36    | -0.67    | 2   | 14  |
| <i>Frequency of interaction (family)</i>  | Score (2-14)    | 9.57  | 3.02  | -0.50    | -0.48    | 2   | 14  |
| <i>Number of close friends</i>            | Category (1-6)  | 2.74  | 0.96  | 0.52     | 0.61     | 1   | 6   |
| <i>Number of close family</i>             | Category (1-6)  | 2.99  | 0.92  | 0.36     | 0.18     | 1   | 6   |
| <i>Social support</i>                     | Score (4-20)    | 14.60 | 4.21  | -0.59    | -0.43    | 4   | 20  |

**Note:** *SD*= standard deviation

Missingness among our variables of interest was low to moderate. Across all of our variables, only 4.76% of information was missing. Some variables had a higher percentage of missing information, namely social support (15.29%), health condition (14.34%) income (7.63%), number of close friends and/or family members (7.79% and 7.00% respectively). For social support, missingness was mostly due to missingness in one item (11.48% missingness for *social\_support\_a*, compared to 5.70%, 4.88% and 4.09% in other items; see Appendix A).

## IV. 2. Models

We obtained just-identified models ( $df = 0$ ), implying these were fully saturated and their fit indices uninformative. This does not, however, prevent interpretation of our mediation results. Across all models, the total effect of income decile on loneliness was consistently and significantly around -0.09 in terms of unstandardized coefficient and -0.14 in terms of standardized coefficient, suggesting higher incomes were associated with lower levels of loneliness. Our main models explained between 17-30% of the variance in loneliness. As a primary goal was to compare indirect effects, we present standardized results in the body of this thesis. Unstandardized results can be found in Appendix C, along with our robustness checks and visual representation of our (standardized) mediation results.

Our robustness checks further corroborated our findings and conclusions, with significant results generally remaining significant for our parameters of interest across checks and with slight to moderate changes in sizes of effects. Overall conclusions regarding which mediators were the strongest in each model stayed the same.

## 1) Model 1

**Table 5:** Direct, indirect and total effects of income decile on loneliness through subjective health and health condition

|                                                  | $\beta$       | SE           | z-value        | p-value           | 95% CI        |               |
|--------------------------------------------------|---------------|--------------|----------------|-------------------|---------------|---------------|
|                                                  |               |              |                |                   | Lower         | Upper         |
| <b>Total effect</b>                              | <b>-0.139</b> | <b>0.015</b> | <b>-9.010</b>  | <b>&lt; 0.001</b> | <b>-0.170</b> | <b>-0.109</b> |
| <b><u>Direct effect</u></b>                      |               |              |                |                   |               |               |
| Income → Loneliness                              | <b>-0.069</b> | <b>0.015</b> | <b>-4.627</b>  | <b>&lt; 0.001</b> | <b>-0.098</b> | <b>-0.040</b> |
| <b><u>Indirect effects</u></b>                   |               |              |                |                   |               |               |
| <b>Subjective health</b>                         | <b>-0.059</b> | <b>0.005</b> | <b>-11.462</b> | <b>&lt; 0.001</b> | <b>-0.069</b> | <b>-0.049</b> |
| (a <sub>1</sub> ) Income → Subjective health     | 0.207         | 0.015        | 14.134         | < 0.001           | 0.178         | 0.236         |
| (b <sub>1</sub> ) Subjective health → Loneliness | -0.285        | 0.016        | -17.485        | < 0.001           | -0.317        | -0.253        |
| <b>Health condition</b>                          | <b>-0.012</b> | <b>0.003</b> | <b>-4.506</b>  | <b>&lt; 0.001</b> | <b>-0.017</b> | <b>-0.007</b> |
| (a <sub>2</sub> ) Income → Health condition      | -0.119        | 0.017        | -7.205         | < 0.001           | -0.152        | -0.087        |
| (b <sub>2</sub> ) Health condition → Loneliness  | 0.097         | 0.018        | 5.484          | < 0.001           | 0.062         | 0.132         |
| <b>Total indirect effect</b>                     | <b>-0.071</b> | <b>0.006</b> | <b>-12.400</b> | <b>&lt; 0.001</b> | <b>-0.082</b> | <b>-0.059</b> |

*Note:* age, gender, relationship status and country fixed effects as control variables;  $\beta$ = standardized coefficients; SE= standard errors; CI = confidence interval

$R^2 = 20.9\%$  (loneliness)

Total proportion mediated = 50.6%

We found that about half of the total effect of income decile on loneliness was mediated by health. Both subjective health and health condition were found to be significant pathways through which income decile was associated with loneliness. Even after accounting for these mediators, there remained a significant direct effect of income decile on loneliness ( $\beta = -0.069$ ,  $p < .001$ ). As such, subjective health and health condition only partially mediated the association between income decile and loneliness.

As seen in Table 5, for each mediator, the a-path and b-path were significant. We found a positive relationship between income decile and subjective health ( $\beta = 0.207$ ,  $p < 0.001$ ) and

a negative one between subjective health and loneliness ( $\beta = -0.285$ ,  $p < 0.001$ ). The opposite was true for health condition, with income decile being negatively linked to health condition ( $\beta = -0.119$ ,  $p < .001$ ,) and health condition positively predicting loneliness ( $\beta = 0.097$ ,  $p < 0.001$ ).

While income decile was indirectly associated with loneliness through both subjective health ( $\beta = -0.059$ ,  $p < 0.001$ ) and health condition ( $\beta = -0.012$ ,  $p < 0.001$ ), subjective health emerged as the stronger mediator in this model. Around 42% of the income-loneliness relationship was mediated by subjective health versus around 8% by health condition. Moreover, studying the contrast between these indirect effects showed there was a significant difference between the two ( $\Delta\beta$  [95% CI] =  $-0.047$  [ $-0.059$ ,  $-0.036$ ],  $p < 0.001$ ). Considering these results, we kept subjective health as a mediator for our final model.

## **2) Model 2**

In our second model (see Table 6), 37% of the total effect of income decile on loneliness was mediated by the structural aspects of social connection we considered. Once again, this was only a partial mediation, considering a direct effect of income decile on loneliness remained after accounting for our mediators ( $\beta = -0.088$ ,  $p < 0.001$ ).

For all mediators, higher income decile was associated with better structural social connection outcomes, and these better structural outcomes with lower levels of loneliness. Although all four indirect pathways we modeled were found to be significant, among our four mediators, the number of friends appeared to be the strongest mediator ( $\beta = -0.024$ ,  $p < 0.001$ ). Standardized indirect effects were comparatively weaker for the number of close family members ( $\beta = -0.011$ ,  $p < 0.001$ ) and the frequency of interaction with family ( $\beta = -0.010$ ,  $p < 0.001$ ) or friends ( $\beta = -0.007$ ,  $p = 0.001$ ). Around 17% of the relationship between income and loneliness was mediated through the number of close friends, compared to 8% through the number of close family members and 7% and 5% respectively through frequency of interaction with family and friends.

Looking at pairwise contrasts showed that the indirect effect through the number of close friends differed significantly from the indirect effects through number of close family ( $\Delta\beta$  [95% CI] =  $-0.014$  [ $-0.021$ ,  $-0.006$ ],  $p = 0.001$ ), frequency of interaction with family ( $\Delta\beta$  [95% CI] =  $-0.014$  [ $-0.022$ ,  $-0.006$ ],  $p = 0.001$ ) and frequency of interaction with friends ( $\Delta\beta$

[95% CI] = -0.017 [-0.025, -0.009],  $p < 0.001$ ). On the other hand, non-significant pairwise contrasts were found between the indirect effects through number of close family versus frequency of contact with family ( $\Delta\beta$  [95% CI] = 0.000 [-0.007, 0.006],  $p = 0.913$ ), through number of close family versus frequency of interaction with friends ( $\Delta\beta$  [95% CI] = -0.003 [-0.009, 0.003],  $p = 0.285$ ), and through frequency of interaction with friends versus family ( $\Delta\beta$  [95% CI] = -0.003 [-0.010, 0.004],  $p = 0.421$ ) were all non-significant. The indirect effect through the number of friends was thus stronger than the other three indirect effects.

Based on these findings, we chose to retain number of friends as a mediator of structural social connection for our final model.

**Table 6:** Direct, indirect and total effects of income decile on loneliness through frequency of interaction with friends and family, and through number of close friends and family members

|                                                  | $\beta$       | SE           | z-value        | p-value           | 95% CI        |               |
|--------------------------------------------------|---------------|--------------|----------------|-------------------|---------------|---------------|
|                                                  |               |              |                |                   | Lower         | Upper         |
| <b>Total effect</b>                              | <b>-0.141</b> | <b>0.010</b> | <b>-9.049</b>  | <b>&lt; 0.001</b> | <b>-0.113</b> | <b>-0.073</b> |
| <b><u>Direct effect</u></b>                      |               |              |                |                   |               |               |
| Income → Loneliness                              | <b>-0.088</b> | <b>0.015</b> | <b>-5.699</b>  | <b>&lt; 0.001</b> | <b>-0.119</b> | <b>-0.058</b> |
| <b><u>Indirect effects</u></b>                   |               |              |                |                   |               |               |
| <b>Frequency family</b>                          | <b>-0.010</b> | <b>0.002</b> | <b>-4.352</b>  | <b>&lt; 0.001</b> | <b>-0.015</b> | <b>-0.006</b> |
| (a <sub>1</sub> ) Income → Frequency family      | 0.115         | 0.016        | 7.043          | < 0.001           | 0.083         | 0.148         |
| (b <sub>1</sub> ) Frequency family → Loneliness  | -0.089        | 0.016        | -5.416         | < 0.001           | -0.121        | -0.057        |
| <b>Frequency friends</b>                         | <b>-0.007</b> | <b>0.002</b> | <b>-3.469</b>  | <b>0.001</b>      | <b>-0.012</b> | <b>-0.003</b> |
| (a <sub>2</sub> ) Income → Frequency friends     | 0.118         | 0.017        | 7.075          | < 0.001           | 0.085         | 0.150         |
| (b <sub>2</sub> ) Frequency friends → Loneliness | -0.064        | 0.016        | -3.898         | < 0.001           | -0.096        | -0.032        |
| <b>Number family</b>                             | <b>-0.011</b> | <b>0.002</b> | <b>-4.719</b>  | <b>&lt; 0.001</b> | <b>-0.015</b> | <b>-0.006</b> |
| (a <sub>3</sub> ) Income → Number family         | 0.118         | 0.016        | 7.419          | < 0.001           | 0.087         | 0.150         |
| (b <sub>3</sub> ) Number family → Loneliness     | -0.090        | 0.015        | -5.948         | < 0.001           | -0.120        | -0.060        |
| <b>Number friends</b>                            | <b>-0.024</b> | <b>0.003</b> | <b>-7.119</b>  | <b>&lt; 0.001</b> | <b>-0.031</b> | <b>-0.018</b> |
| (a <sub>4</sub> ) Income → Number friends        | 0.166         | 0.017        | 9.687          | < 0.001           | 0.133         | 0.200         |
| (b <sub>4</sub> ) Number friends → Loneliness    | -0.145        | 0.015        | -9.509         | < 0.001           | -0.175        | -0.115        |
| <b>Total indirect effect</b>                     | <b>-0.053</b> | <b>0.005</b> | <b>-10.056</b> | <b>&lt; 0.001</b> | <b>-0.063</b> | <b>-0.042</b> |

**Note:** age, gender, relationship status and country fixed effects as control variables;  $\beta$ = standardized coefficients; SE= standard errors; CI = confidence interval

$R^2 = 17.3\%$  (loneliness)

Total proportion mediated = 37.4%

### 3) Model 3

**Table 7:** Direct, indirect and total effects of income decile on loneliness through social support

|                                 | $\beta$       | SE           | z-value       | p-value           | <u>95% CI</u> |               |
|---------------------------------|---------------|--------------|---------------|-------------------|---------------|---------------|
|                                 |               |              |               |                   | Lower         | Upper         |
| <b>Total effect</b>             | <b>-0.140</b> | <b>0.010</b> | <b>-8.977</b> | <b>&lt; 0.001</b> | <b>-0.112</b> | <b>-0.072</b> |
| <b><u>Direct effect</u></b>     |               |              |               |                   |               |               |
| Income → Loneliness             | <b>-0.078</b> | <b>0.015</b> | <b>-5.037</b> | <b>&lt; 0.001</b> | <b>-0.108</b> | <b>-0.047</b> |
| <b><u>Indirect effect</u></b>   |               |              |               |                   |               |               |
| <b>Social support</b>           | <b>-0.062</b> | <b>0.004</b> | <b>-9.463</b> | <b>&lt; 0.001</b> | <b>-0.049</b> | <b>-0.032</b> |
| (a) Income → Social support     | 0.170         | 0.016        | 10.368        | < 0.001           | 0.138         | 0.203         |
| (b) Social support → Loneliness | -0.365        | 0.015        | -23.866       | < 0.001           | -0.395        | -0.335        |

*Note:* age, gender, relationship status and country fixed effects as control variables;  $\beta$ = standardized coefficients; SE= standard errors; CI = confidence interval

$R^2 = 22.0\%$  (loneliness)

Total proportion mediated = 44.5%

Social support mediated around 45% of the total effect of income decile on loneliness in this model (see Table 7). Mediation was once more only partial, with a significant direct effect remaining after accounting for social support ( $\beta = -0.078$ ,  $p < 0.001$ ). Higher deciles of income were associated with better social support ( $\beta = 0.170$ ,  $p < 0.001$ ) and higher social support was linked to lower levels of loneliness ( $\beta = -0.365$ ,  $p < 0.001$ ). This implied an overall negative indirect effect of income decile through social support ( $\beta = -0.041$ ,  $p < 0.001$ ).

### 4) Model 4

Retaining only the strongest mediator from each model, we estimated one final model with subjective health, the number of close friends and social support as mediators (see Table 8). We found in this case that 88% of the total effect of income decile on loneliness was mediated through these variables. Further, the direct effect of income became nonsignificant ( $\beta = -0.012$ ,  $p = 0.223$ ), suggesting (nearly) full mediation of income decile through self-rated health, number of friends and social support.

Income decile was positively associated with all three mediators, although subjective health showed the strongest association with income decile ( $\beta = 0.206$ ,  $p < 0.001$ ), followed by social support ( $\beta = 0.168$ ,  $p < 0.001$ ) and number of friends ( $\beta = 0.154$ ,  $p < 0.001$ ). On the b-path, all mediators had a negative relationship with loneliness, consistent with what we found in our previous models. Social support ( $\beta = -0.286$ ,  $p < 0.001$ ) had the strongest direct association with loneliness, followed by subjective health ( $\beta = -0.263$ ,  $p < 0.001$ ) and, more weakly, by the number of close friends ( $\beta = -0.126$ ,  $p < 0.001$ ).

**Table 8:** Direct, indirect and total effects of income decile on loneliness through subjective health, number of close friends and social support

|                                                  | $\beta$       | SE           | z-value        | p-value           | 95% CI        |               |
|--------------------------------------------------|---------------|--------------|----------------|-------------------|---------------|---------------|
|                                                  |               |              |                |                   | Lower         | Upper         |
| <b>Total effect</b>                              | <b>-0.139</b> | <b>0.015</b> | <b>-9.020</b>  | <b>&lt; 0.001</b> | <b>-0.170</b> | <b>-0.109</b> |
| <b><u>Direct effect</u></b>                      |               |              |                |                   |               |               |
| Income → Loneliness                              | <b>-0.017</b> | <b>0.015</b> | <b>-1.153</b>  | <b>0.249</b>      | <b>-0.046</b> | <b>0.012</b>  |
| <b><u>Indirect effects</u></b>                   |               |              |                |                   |               |               |
| <b>Subjective health</b>                         | <b>-0.055</b> | <b>0.005</b> | <b>-11.911</b> | <b>&lt; 0.001</b> | <b>-0.064</b> | <b>-0.046</b> |
| (a <sub>1</sub> ) Income → Subjective health     | 0.206         | 0.015        | 14.079         | < 0.001           | 0.178         | 0.235         |
| (b <sub>1</sub> ) Subjective health → Loneliness | -0.265        | 0.013        | -20.023        | < 0.001           | -0.291        | -0.239        |
| <b>Number friends</b>                            | <b>-0.019</b> | <b>0.003</b> | <b>-6.664</b>  | <b>&lt; 0.001</b> | <b>-0.025</b> | <b>-0.013</b> |
| (a <sub>2</sub> ) Income → Number friends        | 0.165         | 0.017        | 9.593          | < 0.001           | 0.132         | 0.199         |
| (b <sub>2</sub> ) Number friends → Loneliness    | -0.116        | 0.014        | -8.400         | < 0.001           | -0.143        | -0.089        |
| <b>Social support</b>                            | <b>-0.049</b> | <b>0.005</b> | <b>-9.229</b>  | <b>&lt; 0.001</b> | <b>-0.059</b> | <b>-0.038</b> |
| (a <sub>3</sub> ) Income → Social support        | 0.168         | 0.016        | 10.281         | < 0.001           | 0.136         | 0.201         |
| (b <sub>3</sub> ) Social support → Loneliness    | -0.289        | 0.016        | -18.661        | < 0.001           | -0.320        | -0.259        |
| <b>Total indirect effect</b>                     | <b>-0.122</b> | <b>0.008</b> | <b>-15.687</b> | <b>&lt; 0.001</b> | <b>-0.138</b> | <b>-0.107</b> |

*Note:* age, gender, relationship status and country fixed effects as control variables;  $\beta$ = standardized coefficients; SE= standard errors; CI = confidence interval

$R^2 = 29.9\%$  (loneliness)

Total proportion mediated = 87.8%

Comparing standardized indirect effects, we found that subjective health appeared to be the strongest mediator in our model ( $\beta = -0.054$ ,  $p < 0.001$ ), followed by social support ( $\beta = -0.048$ ,  $p < 0.001$ ) and then the number of friends ( $\beta = -0.019$ ,  $p < 0.001$ ). Around 39% of the relationship between income and loneliness was mediated by subjective health, 35% by social support and 14% by the number of close friends. Contrasts showed that the difference

between indirect effects through social support and subjective health was ultimately not significant ( $\Delta\beta$  [95% CI] = -0.006 [-0.019, 0.008],  $p = 0.392$ ), while both were significantly stronger mediators than number of friends (subjective health versus number of friends:  $\Delta\beta$  [95% CI] = -0.035 [-0.046, -0.025],  $p < 0.001$  & social support versus number of friends:  $\Delta\beta$  [95% CI] = -0.030 [-0.018, -0.041],  $p < 0.001$ ).

### IV. 3. A return to our hypotheses

Our results ultimately supported all but one of our research hypotheses. Consistent with our first hypothesis, we indeed found a significant negative total effect of income decile on loneliness in all of our models. Secondly, the associations along the hypothesized a-paths (income decile  $\Rightarrow$  health and/or social connection variables) and b-paths (health and/or social connection variables  $\Rightarrow$  loneliness) were both significant and aligned with our expectations: better health and social connection outcomes were linked to higher income and associated with lower levels of loneliness. Third, when health and social connection variables (both structural and functional) were included in a single model, the direct effect of income was no longer significant.

In our final hypothesis we posited that we would find “*Social connection mediators are more important than health mediators*”. Together, number of friends and social support mediate around 48% of the total effect of income decile on loneliness in our final model, compared to self-rated health’s 39%. Taken separately, however, the number of friends constituted a weaker indirect pathway to loneliness than subjective health, and subjective health and social support appeared to be equally important pathways to loneliness.

# V. Discussion

## V. 1. Key findings

In this thesis we set out to answer the question of what mediates the relationship between socioeconomic status (which we measured through income deciles) and loneliness. A sub-objective was to identify the seemingly most influential mediators of this relationship. Through mediation analyses, we studied potential pathways through which income decile might be associated with loneliness. Theoretical frameworks from the literature helped us identify health and social connection as potential avenues through which this relationship plays out (De Jong Gierveld & Tesch-Römer, 2012; Hawkley et al., 2008). We reviewed different health and social connection variables as potential mediators. Considering that past research has made the distinction between different dimensions of social connection (Holt-Lunstad, 2022; Mikton et al., 2025), we treated structural and functional indicators of social connection as distinct groups of mediators. We ran parallel mediation models, with the first three helping to identify the most important mediator of their domain (with the exception of Model 3 where we only had social support as an indicator of functional social connection). Our last model placed each of these top contenders in one final parallel mediation model.

While the total effect of income decile on loneliness may not have been the largest in our dataset, our analyses still enabled us to study this mediation mechanism. All of the mediators we studied appeared to significantly mediate the relationship between income decile and loneliness, though some more strongly than others. Subjective health, social support and the number of close friendships were the strongest mediators in terms of health, functional and structural social connection respectively. In our final model, while subjective health initially appeared to be the strongest mediator of the three, we found that the difference between the indirect effects through social support and subjective health was actually not significant, implying both mediators may be as important in explaining why/how income may be related to loneliness.

Modeled separately, neither health, nor structural or functional social connection were enough to fully explain the negative association between income decile and loneliness. However, in our final model, the effect of income decile on loneliness appeared to be nearly fully mediated by our top three mediators (proportion mediated 88% and non-significant direct effect of income decile on loneliness). This suggests that the relationship between

income and loneliness may be almost fully explained through subjective health, the number of close friends and social support. All three domains thus appear relevant, though insufficient on their own to understand this relationship.

## **V. 2. Health, structural and functional social connection**

In this section, we discuss in further detail the results from our different models, employing the literature to better understand them. We will begin by discussing the role of health in the income-loneliness relationship. After this, we will direct our attention to social connection, distinguishing between its structural and functional aspects.

### **1) Health**

Our findings suggest that a higher position in the income distribution may lead to better health outcomes, which may in turn result in lower levels of loneliness. These findings are generally consistent with our expectations based on the literature, aligning with the concept of the social gradient of health (Adler & Newman, 2002; Braveman & Gottlieb, 2014; Cutler et al., 2008; Hakeberg & Wide Boman, 2017) and with previous literature on the association between health and loneliness (e.g. Dahlberg et al., 2022; Emerson et al., 2023; Hutten et al., 2022; Luhmann & Hawkey, 2016; Luo & Waite, 2014; Pagan, 2020; Victor & Yang, 2012). In particular, we gleaned from Model 1 that the relationship between income decile and loneliness appeared to operate more strongly through self-rated health than health condition status/severity. Indeed, subjective health had stronger associations with both income decile and loneliness respectively.

To understand why this may be, studying what influences self-rated health can be useful. With respect to the association between income and subjective health, socioeconomic status may impact frameworks of evaluation (Dowd & Zajacova, 2007; Jylhä, 2009; OECD, 2023). The OECD (2023) for example found individuals belonging to lower quintiles tend to be “less positive” about their health. Regarding its relationship with loneliness, subjective health is also a much broader construct that can encompass many facets of health, therefore leading to more “opportunities” to correlate with loneliness. Indeed, research on self-rated health shows that many factors may enter into self-evaluation of health, including formal diagnoses,

physical and functional symptoms, but also more affective considerations (Jylhä, 2009; Kaplan & Baron-Epel, 2003; Mutz & Müller, 2026). In a recent study conducted in Germany, participants were asked to rate their health and then explain why they chose their answer (Mutz & Müller, 2026). Physical health appeared to dominate the evaluation, followed by psychological health, lifestyle choices (e.g. nutrition, physical exercise practices, ...) and social/societal criteria. In terms of psychological health, depression, which has been associated with loneliness, has been found to be a predictor of poor self-rated health (Byun et al., 2021; Han & Jylhä, 2006; Victor & Yang, 2012). Similarly to lower income, it can also push individuals toward more pessimistic evaluations of their health (Jylhä, 2009). Like depression, other health factors that influence respondents' rating of their health may have strong ties to loneliness, potentially helping to explain why subjective health appeared to be a strong pathway in our models.<sup>1</sup>

Though physical health appears to guide most ratings of subjective health, research has suggested that more general feelings and moods can affect these ratings. In that sense, it is not fully outside the realm of possibility that feeling lonely itself might affect some ratings. Similarly to depression and income, it could influence frameworks of evaluations and drive lonely individuals toward more negative evaluations of their situation. Beyond this potential impact, we have seen that loneliness has the potential to impact health outcomes. While our models study a certain directionality, with subjective health informing on feelings of loneliness, there is likely an element of bidirectionality to the relationship between subjective health and loneliness. In fact, longitudinal studies seem to support this idea (Luo et al., 2012; Luo & Waite, 2014). As a result, it is possible that part of the indirect effect we observed actually reflects bidirectional associations between subjective health and loneliness.

## **2) Structural versus functional aspects of social connection**

### **a) Structural social connection**

For structural social connection, we studied four mediators. As we decided to distinguish between friends and family, we included two mediators concerning frequency of interaction and two concerning the size of the close relationship network. By doing this, we were able to

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<sup>1</sup> Note that the role of chronic health conditions and their severity could also be partially underestimated due to most respondents reporting having no health condition at all.

pin down specific indirect effects for each of these sources of structural connection. While all four mediators were significant, the number of close friendships stood out as the strongest one. It uniquely accounted for around 17% of the total effect of income decile on loneliness in our structural connection model (Model 2). Among our three weaker intervening variables, none sat on a notably stronger indirect pathway than the rest. They all mediated between 5 to 8% of the relationship between income decile and loneliness.

Relative to the associations between income decile and our mediators (a-paths), we consistently found better outcomes for those with higher incomes. The number of close friends appeared to be the most reactive to changes in income decile, while our results suggest the other three intervening variables may be similarly impacted by such changes. For frequency of interaction, this means there did not appear to be much of a difference between the positive effect of income on interaction with friends versus family. On the other hand, with respect to the number of close relationships, friendships appeared more responsive to an increase in income decile compared to family relationships. This may reflect the more voluntary nature of friendship. As income increases, individuals may choose to further invest themselves in developing their friendships. These friendships, as opposed to family relationships which may rest more on the principle of solidarity, may have higher demands and expectations of reciprocity and exchange (Böhnke, 2008). So, with additional resources at their disposal, individuals may be better equipped to foster their friendships. Higher incomes may also enable individuals to access and partake in new types of activities, offering them more opportunities to meet people and to diversify their network. Furthermore, as mentioned in our review of the literature, some authors have hypothesized that individuals with more resources may also be more attractive to others because of gains in confidence and social skills (Aartsen et al., 2017; Hansen & Slagsvold, 2016). For family, these previously cited benefits of increased income may be less relevant, yet we still observed a positive association between income decile and size of the close family network. A possible explanation is that family relationships may improve thanks to lower financial pressure and strain. Past research has indeed found that such economic stressors may have adverse effects on family relationships (Conger et al., 1994, 2010).

In the relationship with loneliness (b-paths), all four structural social connection mediators had negative associations with loneliness, meaning that increases in size of the network or in the frequency of interaction appeared to decrease feelings of loneliness. Once again, the largest association was with the number of close friends. Having more friends may

mean having greater diversity in relationships, having more sources of identity, of belonging and of potential support, all of which may help in combatting feelings of loneliness (Berkman & Glass, 2000; De Jong Gierveld et al., 2006; Kersten et al., 2025). Our findings suggest that, in the relationship with loneliness, having more close friends may matter more than interacting with them more frequently. While some studies also find size of the (friendship) network to matter more than frequency of interaction (e.g. Hawkley et al., 2008, Park & Shin, 2026), we could not find many studies that truly compared these indicators.

Concerning the frequency of interaction, let us add nuance to our findings by remembering how this variable was defined in the EU Loneliness Survey. Our measures of contact frequency explicitly excluded cohabitating friends and family from consideration. Had it included individuals with whom respondents lived, the picture may have been slightly different, as contact with cohabitants may provide additional protection against loneliness, helping them to avoid feeling completely socially isolated.

While the indirect effect of income decile through the number of close friends was the clear “winner” in terms of strongest structural social connection mediators, it ended up being the weakest when compared to social support and health. This suggests that, ultimately, having a larger number of (close) friends may matter less than receiving strong social support from your network and being healthy. Even in the structural connection model, the total proportion mediated by our four mediators (Model 2: proportion mediated 37%) was smaller than the proportion mediated in the health (Model 1: 51%) and the functional connection model (Model 3: 45%).

## **b) Functional social connection**

In terms of functional social connection, we only studied one potential mediator: social support. Modeled on its own, it mediated nearly half of the total effect of income decile on loneliness. Once studied alongside subjective health and the number of close friends, social support uniquely accounted for around 35% of the total effect of income decile on loneliness. In our final model, we further found that the indirect effects through social support had a similar contribution to the one through subjective health in the relationship between decile of income and loneliness.

Consistent with our expectations based on the literature (Kung et al., 2022; OECD, 2025; Weyers et al., 2008), our models found that income decile positively impacts social support. However, what appeared to drive up our indirect effect via social support was more specifically this mediator's association with loneliness. While previous research suggests that different types of social support (emotional, tangible, ...) and who the support comes from can be more or less important in the mediation mechanism or in the relationship with loneliness (Chen & Feeley, 2014; Tough et al., 2021), our measure of social support did not make these distinctions. Nevertheless, in our models, social support had some of the strongest direct negative associations with loneliness.

This stronger link between social support and loneliness may be explained by the fact that, like loneliness, this measure may also be distorted by one's own perceptions and expectations of social relationships. Indeed, if one were to respond less favorably to items on the social support scale, this might indicate that they explicitly feel that they are lacking support and that their relationships are not providing what they would expect from them. Earlier in this thesis we defined loneliness as an unpleasant experience arising from deficiencies in the quantity or quality of relationships (Perlman & Peplau, 1981). In this context, this measure which reports on perceived availability of social support might then inform on these *perceived* deficiencies (especially in quality).

### **c) Quality over quantity**

Our results indicate that the indirect effect through social support was significantly larger than the indirect effect through number of friends. This difference in indirect effects appeared to be mostly driven by social support's stronger tie to loneliness. Indeed, while their associations with income decile were comparable, the association between social support and loneliness was more than twice as large as the one between the number of close friendships and loneliness. This finding aligns with prior research on loneliness suggesting that the quality of relationships matters more than quantity of relationships (Norlin et al., 2025; Peng & Roth, 2025; Pinquart & Sörensen, 2001; Wheeler et al., 1983). These for example find that conflict and strain within relationships tend to be more strongly linked to loneliness. While we did not have such explicit measures of quality of relationships in our models, perceived social support could be used as a proxy for respondents' judgement regarding the quality of

their relationships. In fact, previous studies have used social support as a measure of relationship quality (e.g. Norlin et al., 2025).

Let us also remark that while our measures of number of friends and family members are undeniably structural, quantitative aspects of social connection, these variables also hold some information regarding the perceived quality of these relationships. Individuals were not simply asked to list how many friends or family members they had, rather how many *close* ones. As such, these measures may already indicate some level of qualitative evaluation of those relationships. This may further explain why the number of friends appeared to matter more than did interacting with them more frequently.

Some authors have suggested that, as individuals age, the more qualitative aspects of relationships take precedence (e.g. Norlin et al., 2025; Pinquart & Sörensen, 2001Victor & Yang, 2012). While we can neither confirm nor contest this hypothesis considering we did not differentiate between age groups in our own research, we can only say that we find this quality over quantity preference appears to hold in a general population.

### **V. 3. Implications for loneliness interventions**

We found a significant negative total effect of income decile on loneliness, consistent with the idea of the existence of socioeconomic inequalities in loneliness. Our results suggest these may primarily operate through subjective health, social support and – to a lesser extent – number of close friendships. Considering that individuals with lower incomes may have worse outcomes in these areas, it would be advisable to either target these individuals for intervention or to be sensitive to potential barriers to accessibility when designing interventions.

Since poor subjective health and lower social support appeared to constitute the strongest pathways to loneliness, focusing on these two in particular may be pertinent. In terms of health, improving access to healthcare and mental health support could prove beneficial in reducing loneliness. Public health interventions like prevention and health promotion programs, etc. could also be useful. Subjective health, as previously mentioned, can encompass many elements. It may be useful to further explore and narrow down the

components of subjective health that are driving this mediation in order to more efficiently target potential intervention points.

As social support is another important pathway through which income inequalities appear to operate, working on strengthening the social networks of the more vulnerable may be especially interesting when aiming to address inequalities in loneliness. Group-based interventions that improve social support can be successful in reducing loneliness (Ehlers et al., 2017). Some group-based interventions could have the combined benefit of increasing both the size of one's network *and* perceived social support. Consistent with what we discussed in the previous section, research has found that interventions only addressing the more quantitative aspects of social disconnection showed mixed results in terms of success (Lim et al., 2019; Masi et al., 2011; Morrish et al., 2023).

When discussing subjective health and social support, we pointed out that both of these measures may be sensitive to perceptions. A judgement on quality (be it of one's own health or of social relationships) will inevitably be shaped by one's perceptions and expectations. Socioeconomic disadvantage may negatively impact these evaluations, with a bias toward pessimism (Dowd & Zajacova, 2007; Jylhä, 2009). Interventions addressing maladaptive cognitions may for this reason be a particularly effective intervention strategy. Though not focused on the issue of socioeconomic inequities, past studies/meta-analyses have found acting on cognition, for example through cognitive behavioral therapy, to be a promising intervention angle to reduce loneliness (Mann et al. 2017; Masi et al., 2011; Morrish et al., 2023; Yu et al., 2023).

#### **V. 4. Limitations and perspectives for future research**

There are several limitations to the current work, primarily the cross-sectional nature of our data. In this thesis, we ran mediation models between income decile and loneliness, making assumptions regarding the directionality of the relationships between the variables we studied based on theoretical frameworks from the literature. However, the cross-sectional nature of our data means temporal ordering cannot truly be assessed and, therefore, that directionality and causality cannot meaningfully be tested. Consequently, our results should be read as associations and *potential* support for the mediation of the relationship between

income decile and loneliness through health, structural and functional social connection. For more thorough results, future studies with longitudinal designs should explore this mediation mechanism.

Regarding the relationships we studied, we also made simplifying assumptions, which did not account for all the different ways in which variables could be related. The relationships between the variables we incorporated in our models could however be much more complex, with reciprocal relationships, indirect effects passing through several mediators, etc. For example, when discussing the relationship between health and loneliness, several authors have suggested that health may impact loneliness through its influence on social connection opportunities (Hawkley et al., 2008; Hutten et al., 2022; Van Tilburg & Broese Van Groenou, 2002). Others have argued that social networks themselves may impact health (Berkman & Glass, 2000). The relationship between health and socioeconomic status can also be complex, with bidirectional effects. Indeed, income may impact things like access to healthcare, living conditions, exposure to detrimental environments, stress, etc., leading to worse health outcomes (Adler & Newman, 2002; Baum et al., 1999; Braveman & Gottlieb, 2014; Cutler et al., 2008). But one's health condition can also affect one's ability to participate in the work force, impacting revenue (Cutler et al., 2008). Future research further exploring these complex relationships, especially with longitudinal designs, could be of benefit. Additionally, while we studied several potential mediators of health and social connection, there are many others that could also have been tested in the mediation mechanism between socioeconomic status and loneliness. For example, a more explicit measure of the perceived quality of relationships could be included.

Concerning the composition of our sample, we would be remiss not to mention a likely selection bias that resulted from the non-probability sampling design of the EU27 sample and the recruitment strategy from consumer panels. As seen in our methods and results sections, our sample underrepresented the least educated as well as older adults (65+ year olds). For our research, this means that the most vulnerable individuals could be missing from this survey. Beyond the fact that we observed the lowest percentages of respondents falling within the lowest income deciles, even within these deciles, the poorest could be underrepresented.

In this thesis, we used deciles of income as a measure of socioeconomic status. While this measure may constitute a useful indicator of status, as it already gives an idea of where individuals fall within their country's income distribution, it can be less precise. A great

variety of income levels may be hidden behind income deciles, and particularly in the lowest and highest deciles. As such, our results may show flatter trends. Additionally, income is only one indicator of socioeconomic status. Future research could explore whether and how the pattern we observed between our measure of socioeconomic status and loneliness changes with other measures, such as occupational prestige, education, employment status, etc. or with composite measures.

On the topic of measures, let us also remark that those we used rely on self-reporting. This type of data collection can introduce different types of bias, most notably recall bias and social desirability bias, although the latter may be of less concern for online surveys (Althubaiti, 2016; Chang & Krosnick, 2009 cited by Mauri et al., 2024). Another potential source of bias within our work lies within our treatment of certain variables as numeric/continuous when they are in fact ordinal. This may have been a riskier decision for certain variables with fewer categories, which is why we also chose to run robustness checks with another estimator more adapted to the handling of ordinal data.

Finally, in this thesis, when we set out to study the relationship between socioeconomic status and loneliness through mediation analysis, our main focus was on finding support for the mediation mechanism itself in a general population, and not in establishing differences between countries or examining pathways through which socioeconomic inequality operates in particular subgroups. Instead of using multilevel modeling, we merely controlled for country fixed effects. We did not run any analyses on subgroups of the population, nor did we analyze interaction terms. While this may not have been our focus in this thesis, that does not make these analyses any less interesting. In fact, although our own findings were consistent with the idea of a potential socioeconomic gradient in loneliness, they were relatively modest. While this may have been partly due to the nature of our measure of socioeconomic status and the potential absence of the most vulnerable, socioeconomic inequalities and/or loneliness levels may also be more pronounced in some countries or subgroups. Exploring the relationship between socioeconomic status and loneliness in these specific subgroups or countries may be particularly interesting. Our own analyses suggest that socioeconomic inequalities in loneliness operate through health and social connection (and particularly through subjective health, social support and number of close friends). It could be of interest to check how this may differ between age groups, genders, sick versus healthy, etc. or from one country to the next. Though we focused on the lower part of their model, De Jong Gierveld and Tesch-Römer (2012) showed how different societal contexts (cultural values,

demographics, societal welfare) could influence individual-level factors and shape individual expectations regarding acceptable levels of social integration. In a sample like ours, which gathers data across many countries, this could be a topic for further exploration. For now, our findings and recommendations may provide useful insights on potential points of attention for future research focusing on these subgroups or country-level differences.

## VI. Conclusion

Socioeconomic disadvantage has been linked to loneliness in prior research. In this thesis, we were interested in better understanding why this may be. Guided by theoretical frameworks from the literature (De Jong Gierveld & Tesch-Römer, 2012; Hawkley et al., 2008), we decided to study this link through formal mediation analysis, examining health and social connection as potential pathways through which this relationship may play out. As our aim was to answer the question of what mediates the relationship between socioeconomic status and loneliness and to identify which pathways might be most important, we considered a few potential mediators. We differentiated these as either being representative of health or of structural or functional social connection.

Subjective health, the number of close friends and social support stood out as having the strongest (unique) indirect effects in terms of each of these constructs. For our measure of socioeconomic status (income decile), we ultimately found that its association with loneliness was nearly fully mediated by just these three intervening variables in a parallel mediation model. None of our previous models studying health variables, structural social connection variables or social support were enough to fully mediate the relationship on their own. Once all three of our chosen mediators were in the model, the direct effect of income decile on loneliness was no longer significant. We further found that, of these “top three” mediators, subjective health and social support appeared to contribute the most to the association between income decile and loneliness.

Subjective health and social support may be particularly pertinent avenues for intervention, although further exploration of the pathway through subjective health may be needed to more accurately identify which specific aspects of this variable may be driving the indirect effect. Considering the negative total association we found between income decile and loneliness, we would recommend targeting the more socioeconomically disadvantaged for intervention or prevention.

An important limitation of this study is that it cannot meaningfully assess causality due to the cross-sectional nature of the data on which we based our mediations. For this reason, future research adopting more longitudinal designs would be beneficial to our understanding of the subject.

More complex relationships between socioeconomic status, mediators and loneliness could also be examined in future works. Future studies could also examine the socioeconomic status-loneliness link within different subgroups of the population or study how wider societal contexts may affect this relationship.

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# Appendices

## Appendix A: Exploratory checks

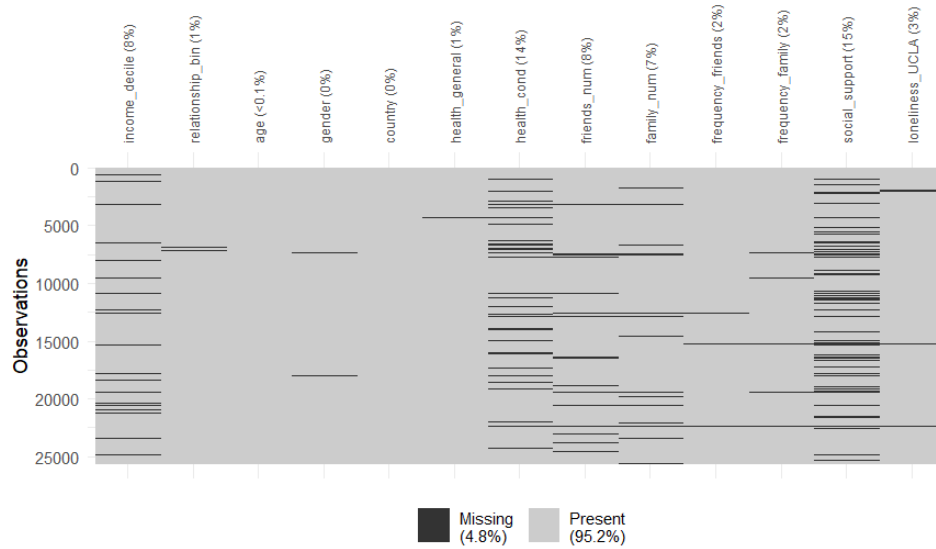
A few quick exploratory checks were run in the process of choosing our variables and how to define our models. The main ones concerned checking if, and the extent to which, data was missing among our variables of interest, checking their distribution, as well as checking linearity and multicollinearity. These different checks were mostly run treating our variables as approximately numeric/continuous as this is how they would be treated in our main analyses. In terms of missing data, we recoded “*Not applicable*”, “*Don’t know*” and “*Prefer not to say*” responses as missing and visualized missing data among our variables of interest. Table A.1. shows missingness in the raw, pre-transformation variables, while Figure A.1. visualizes missingness in our final variables.

**Table A.1.:** Number of missing observations in raw variables of the EU Loneliness Survey 2022 and origin of missingness

| Variable                   | NA    | Not applicable (997) | Don't know (998) | Prefer not to say (999) | Total missing responses | Percentage missing responses |
|----------------------------|-------|----------------------|------------------|-------------------------|-------------------------|------------------------------|
| health_condition_intensity | 17738 | 0                    | 126              | 34                      | 17898                   | 69.79%                       |
| health_condition           | 0     | 0                    | 2864             | 654                     | 3518                    | 13.72%                       |
| social_support_a           | 0     | 0                    | 2358             | 585                     | 2943                    | 11.48%                       |
| friends_n_1__open          | 1997  | 0                    | 0                | 0                       | 1997                    | 7.79%                        |
| income_decile              | 0     | 0                    | 0                | 1956                    | 1956                    | 7.63%                        |
| family_n_1__open           | 1795  | 0                    | 0                | 0                       | 1795                    | 7%                           |
| social_support_d           | 0     | 0                    | 893              | 569                     | 1462                    | 5.70%                        |
| social_support_b           | 0     | 0                    | 752              | 500                     | 1252                    | 4.88%                        |
| social_support_c           | 0     | 0                    | 651              | 399                     | 1050                    | 4.09%                        |
| loneliness_ucla_b          | 0     | 0                    | 0                | 502                     | 502                     | 1.96%                        |
| friends_meet_face          | 0     | 0                    | 0                | 481                     | 481                     | 1.88%                        |
| loneliness_ucla_c          | 0     | 0                    | 0                | 430                     | 430                     | 1.68%                        |
| family_meet_face           | 0     | 0                    | 0                | 421                     | 421                     | 1.64%                        |
| friends_meet_tele          | 0     | 0                    | 0                | 419                     | 419                     | 1.63%                        |
| loneliness_ucla_a          | 0     | 0                    | 0                | 413                     | 413                     | 1.61%                        |
| health_general             | 0     | 0                    | 0                | 338                     | 338                     | 1.32%                        |
| family_meet_tele           | 0     | 0                    | 0                | 317                     | 317                     | 1.24%                        |
| relationship               | 0     | 0                    | 0                | 182                     | 182                     | 0.71%                        |
| gender                     | 0     | 0                    | 0                | 80                      | 80                      | 0.31%                        |
| age                        | 0     | 12                   | 0                | 0                       | 12                      | 0.05%                        |

**Note:** *health\_condition* and *health\_condition\_intensity* make up our *health condition* variable; *friends\_n\_1\_\_open* and *family\_n\_1\_\_open* are the raw counts of number of friends and family; *friends\_meet\_face* and *friends\_meet\_tele* make up

our measure of frequency of interaction with friends (idem for the family equivalent); health\_general is subjective health/self-rated health; several summed items make up our social support and loneliness scales.



**Figure A.1. :** Missing data visualization graph (final variables)

For distributions, we plotted histograms to get a general sense of the shape of the univariate distributions of our variables, and looked at their descriptive statistics, with a particular interest for skewness and kurtosis. Through this process, we were able to identify the raw variables for number of friends and family as potentially problematic (with very high skew and kurtosis considering most responses sat on the lower end of the 0-100 range), which led us to transforming them into the ordinal variable we used for our models. Additionally, these checks helped identify our health condition variable as one to be careful with in terms of interpretation, seeing as most answers appeared in one single category (among those who answered the health condition questions, 64.73% declared having no chronic health condition). We also found support for using the robust maximum likelihood (MLR) estimator when treating our variables as approximately numeric/continuous.

We checked whether linearity looked to be a relatively decent assumption, mainly through scatterplots and residual-versus-fitted plots with “loess” lines. Overall, we found this assumption to be acceptable. Deviations from the linear trend were not too excessive in bivariate scatterplots and remained relatively close to 0 in residual-versus-fitted plots.

Regarding multicollinearity, we did not flag any major risks of multicollinearity. While some variables were more tightly correlated than others, correlations did not tend to be extreme. Our main predictors sat below the conservative threshold of 5 in terms of Variance Inflation Factors (VIF). Some of our country dummies had slightly higher VIFs, but not problematically so.

## **Appendix B: Additional details on our analysis**

### **1) Choice of maximum likelihood with robust standard errors (MLR) estimator**

The choice of using the MLR estimator in our main analyses was made based on the different elements we had to take into consideration. The MLR estimator is appropriate when dealing with non-normal distribution of variables, it is compatible with sample weights (“sampling.weights” argument in *lavaan* terminology) and with the full information maximum likelihood (FIML) approach of handling missing data. This approach allows us to avoid having to drop observations based on some survey questions being left unanswered, or where respondents answered “*Not applicable*”, “*Don’t know*” or “*Prefer not to say*” (which were recoded as missing). FIML further assumes missing data is missing at random (MAR), which is a more relaxed, more plausible assumption than the missing completely at random (MCAR) assumption that pairwise or listwise deletion requires. A certain limitation here is that we cannot, however, fully rule out the possibility that some data may actually be missing not at random (MNAR).

### **2) Regarding the delta method**

In *lavaan*, the default method used to estimate standard errors (SE) for indirect effects is the delta method. This method is often seen as less powerful than bootstrapping, which has been found to estimate more robust confidence intervals and does not assume a normal sampling distribution of the indirect effect contrary to the delta method (Preacher & Hayes, 2008). This assumption of normal distribution of the indirect effect is often seen as an unlikely occurrence. Despite its shortcomings, several authors proposed that with large sample sizes, using the delta method may not be as problematic. Some have found that in such cases, these methods appear to converge in power and Type I errors (Briggs, 2006; Williams & MacKinnon, 2008). According to Preacher & Hayes (2008), the delta method’s assumption of normality of distribution of the indirect effects is also more reasonable with larger sample sizes. Still, bootstrapped SEs and confidence intervals are often recommended when possible. In our case, bootstrapping failed to run with our setup with weights and FIML. When combined with our weights it would silently switch back to MLR estimation. Therefore, we did not bootstrap SEs.

### **3) Robustness check with the weighted least squares mean and variance adjusted (WLSMV) estimator**

While the WLSMV is in fact the default estimator in *lavaan* when endogenous variables<sup>2</sup> are declared as ordered, it works with pairwise or listwise deletion of missing variables, which makes stronger assumptions regarding the missingness mechanism. Considering pairwise deletion was incompatible with the use of sampling weights, our robustness checks were run with listwise deletion, meaning all observations with any missing data in our variables of interest were deleted.

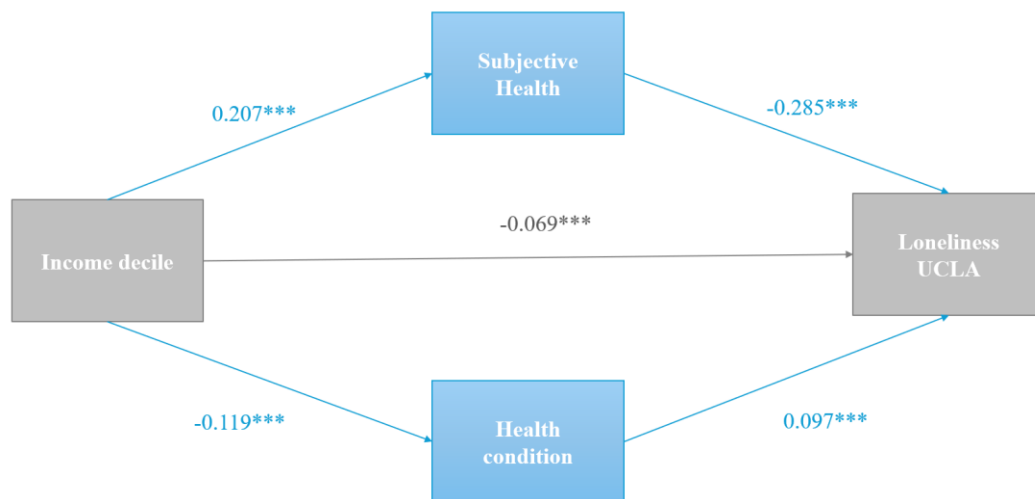
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<sup>2</sup> Endogenous variables refer to mediators (M) and outcome variables (Y).

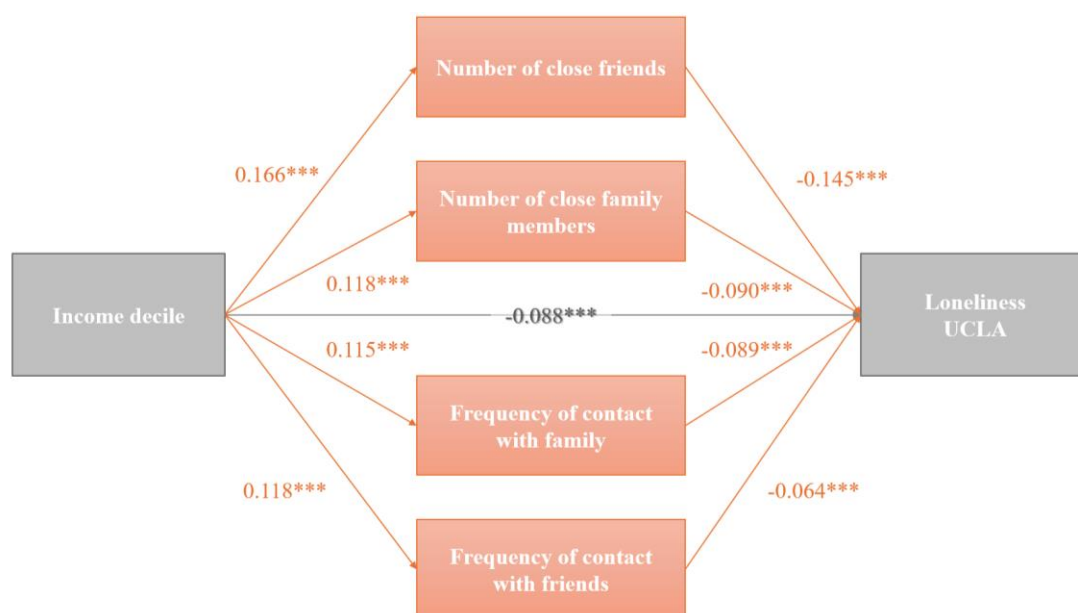
## Appendix C: Models, unstandardized results and robustness checks

### PATH DIAGRAMS

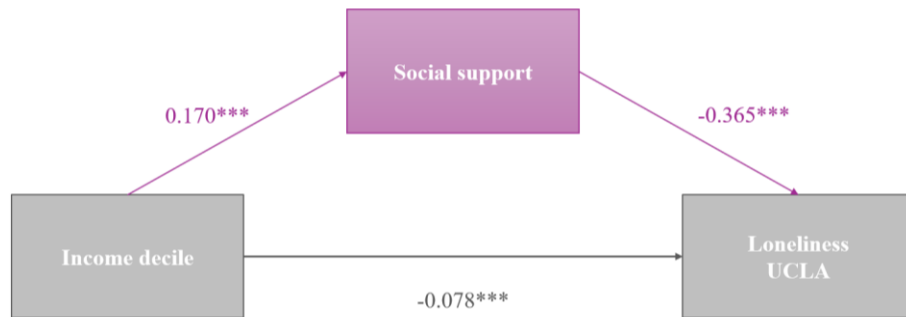
**Notes:** Significance in the following path diagrams is indicated by \* ( $p < 0.05$ ) / \*\* ( $p < 0.01$ ) / \*\*\* ( $p < 0.001$ ) / ns. (not significant). Age, gender, relationship status and country fixed effects were included as controls.



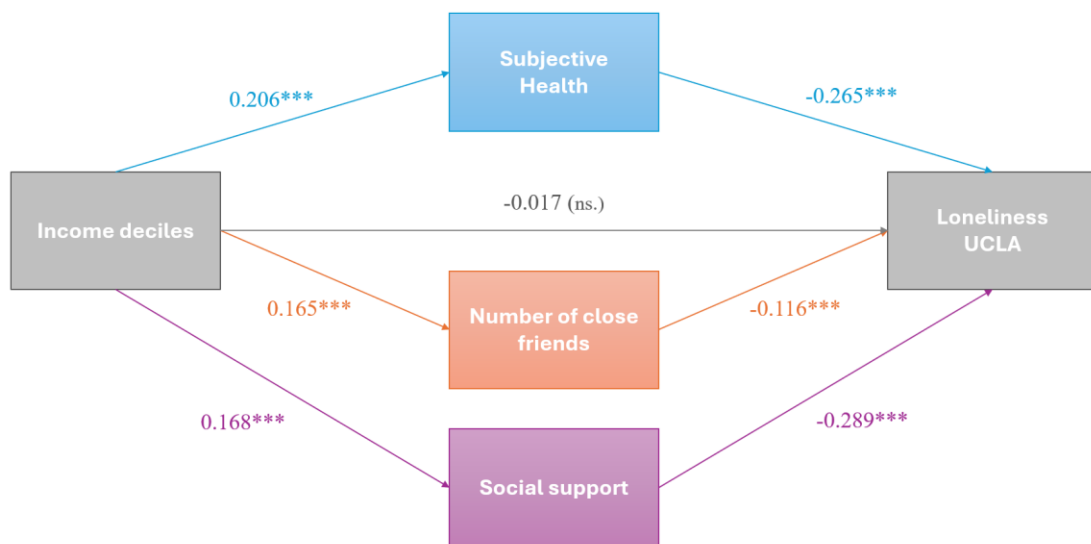
**Figure C.1 :** Parallel mediation linking income decile to loneliness through subjective health and health condition (standardized coefficients and level of significance)



**Figure C.2 :** Parallel mediation linking income decile to loneliness through the number of close friends and family members and through frequency of interaction with friends and family members (standardized coefficients and level of significance)



**Figure C.3. :** Simple mediation linking income decile to loneliness through social support (standardized coefficients and level of significance)



**Figure C.4. :** Parallel mediation linking income decile to loneliness through subjective health, number of close friends and social support (standardized coefficients and level of significance)

## MODEL 1

### Unstandardized results

**Table C.1.1.:** Direct, indirect and total effects of income decile on loneliness through subjective health and health condition (unstandardized)

|                                                  | Estimate      | SE           | z-value        | p-value           | 95% CI        |               |
|--------------------------------------------------|---------------|--------------|----------------|-------------------|---------------|---------------|
|                                                  |               |              |                |                   | Lower         | Upper         |
| <b>Total effect</b>                              | <b>-0.092</b> | <b>0.010</b> | <b>-8.977</b>  | <b>&lt; 0.001</b> | <b>-0.112</b> | <b>-0.072</b> |
| <b><u>Direct effect</u></b>                      |               |              |                |                   |               |               |
| Income → Loneliness                              | <b>-0.045</b> | <b>0.010</b> | <b>-4.629</b>  | <b>&lt; 0.001</b> | <b>-0.065</b> | <b>-0.026</b> |
| <b><u>Indirect effects</u></b>                   |               |              |                |                   |               |               |
| <b>Subjective health</b>                         | <b>-0.039</b> | <b>0.003</b> | <b>-11.304</b> | <b>&lt; 0.001</b> | <b>-0.046</b> | <b>-0.032</b> |
| (a <sub>1</sub> ) Income → Subjective health     | 0.071         | 0.005        | 13.635         | < 0.001           | 0.061         | 0.081         |
| (b <sub>1</sub> ) Subjective health → Loneliness | -0.549        | 0.032        | -17.170        | < 0.001           | -0.611        | -0.486        |
| <b>Health condition</b>                          | <b>-0.008</b> | <b>0.002</b> | <b>-4.492</b>  | <b>&lt; 0.001</b> | <b>-0.011</b> | <b>-0.004</b> |
| (a <sub>2</sub> ) Income → Health condition      | -0.044        | 0.006        | -7.189         | < 0.001           | -0.056        | -0.032        |
| (b <sub>2</sub> ) Health condition → Loneliness  | 0.174         | 0.032        | 5.472          | < 0.001           | 0.112         | 0.237         |
| <b>Total indirect effect</b>                     | <b>-0.046</b> | <b>0.004</b> | <b>-12.188</b> | <b>&lt; 0.001</b> | <b>-0.054</b> | <b>-0.039</b> |

*Note:* age, gender, relationship status and country fixed effects as control variables;  $\beta$ = standardized coefficients; SE= standard errors; CI = confidence interval

$R^2$ = 20.9% (loneliness)

Total proportion mediated = 50.6%

### **Robustness check: WLSMV estimator (standardized)**

*Health condition* and *subjective health* are treated as ordinal. Considering listwise deletion of missing cases, the sample size changes from our main analyses: N= 20,103 (as opposed to N= 25,646).

**Table C.1.2.:** Direct, indirect and total effects of income decile on loneliness through subjective health and health condition (standardized)

|                                                  | $\beta$       | SE           | z-value        | p-value           | <u>95% CI</u> |               |
|--------------------------------------------------|---------------|--------------|----------------|-------------------|---------------|---------------|
|                                                  |               |              |                |                   | Lower         | Upper         |
| <b>Total effect</b>                              | <b>-0.143</b> | <b>0.016</b> | <b>-9.161</b>  | <b>&lt; 0.001</b> | <b>-0.174</b> | <b>-0.113</b> |
| <b><u>Direct effect</u></b>                      |               |              |                |                   |               |               |
| Income → Loneliness                              | <b>-0.065</b> | <b>0.015</b> | <b>-4.304</b>  | <b>&lt; 0.001</b> | <b>-0.095</b> | <b>-0.036</b> |
| <b><u>Indirect effects</u></b>                   |               |              |                |                   |               |               |
| <b>Subjective health</b>                         | <b>-0.063</b> | <b>0.006</b> | <b>-11.299</b> | <b>&lt; 0.001</b> | <b>-0.074</b> | <b>-0.052</b> |
| (a <sub>1</sub> ) Income → Subjective health     | 0.226         | 0.015        | 15.078         | < 0.001           | 0.197         | 0.256         |
| (b <sub>1</sub> ) Subjective health → Loneliness | -0.279        | 0.018        | -15.583        | < 0.001           | -0.314        | -0.244        |
| <b>Health condition</b>                          | <b>-0.015</b> | <b>0.003</b> | <b>-4.322</b>  | <b>&lt; 0.001</b> | <b>-0.021</b> | <b>-0.008</b> |
| (a <sub>2</sub> ) Income → Health condition      | -0.139        | 0.019        | -7.359         | < 0.001           | -0.176        | -0.102        |
| (b <sub>2</sub> ) Health condition → Loneliness  | 0.106         | 0.021        | 5.178          | < 0.001           | 0.066         | 0.146         |
| <b>Total indirect effect</b>                     | <b>-0.078</b> | <b>0.006</b> | <b>-12.828</b> | <b>&lt; 0.001</b> | <b>-0.090</b> | <b>-0.066</b> |

*Note:* age, gender, relationship status and country fixed effects as control variables;  $\beta$ = standardized coefficients; SE= standard errors; CI = confidence interval

$R^2$ = 19.7% (loneliness)

Total proportion mediated = 54.3%

## MODEL 2

### Unstandardized results

**Table C.2.1.:** Direct, indirect and total effects of income decile on loneliness through frequency of interaction with friends and family, and through number of close friends and family members (unstandardized)

|                                                  | Estimate      | SE           | z-value       | p-value           | 95% CI        |               |
|--------------------------------------------------|---------------|--------------|---------------|-------------------|---------------|---------------|
|                                                  |               |              |               |                   | Lower         | Upper         |
| <b>Total effect</b>                              | <b>-0.093</b> | <b>0.010</b> | <b>-9.049</b> | <b>&lt; 0.001</b> | <b>-0.113</b> | <b>-0.073</b> |
| <b><u>Direct effect</u></b>                      |               |              |               |                   |               |               |
| Income → Loneliness                              | <b>-0.058</b> | <b>0.010</b> | <b>-5.694</b> | <b>&lt; 0.001</b> | <b>-0.078</b> | <b>-0.038</b> |
| <b><u>Indirect effects</u></b>                   |               |              |               |                   |               |               |
| <b>Frequency family</b>                          | <b>-0.007</b> | <b>0.002</b> | <b>-4.348</b> | <b>&lt; 0.001</b> | <b>-0.010</b> | <b>-0.004</b> |
| (a <sub>1</sub> ) Income → Frequency family      | 0.128         | 0.018        | 7.005         | < 0.001           | 0.092         | 0.163         |
| (b <sub>1</sub> ) Frequency family → Loneliness  | -0.053        | 0.010        | -5.409        | < 0.001           | -0.072        | -0.034        |
| <b>Frequency friends</b>                         | <b>-0.005</b> | <b>0.001</b> | <b>-3.466</b> | <b>0.001</b>      | <b>-0.008</b> | <b>-0.002</b> |
| (a <sub>2</sub> ) Income → Frequency friends     | 0.132         | 0.019        | 7.069         | < 0.001           | 0.096         | 0.169         |
| (b <sub>2</sub> ) Frequency friends → Loneliness | -0.037        | 0.010        | -3.889        | < 0.001           | -0.056        | -0.019        |
| <b>Number family</b>                             | <b>-0.007</b> | <b>0.001</b> | <b>-4.713</b> | <b>&lt; 0.001</b> | <b>-0.010</b> | <b>-0.004</b> |
| (a <sub>3</sub> ) Income → Number family         | 0.040         | 0.005        | 7.364         | < 0.001           | 0.030         | 0.051         |
| (b <sub>3</sub> ) Number family → Loneliness     | -0.174        | 0.029        | -5.942        | < 0.001           | -0.231        | -0.116        |
| <b>Number friends</b>                            | <b>-0.016</b> | <b>0.002</b> | <b>-7.081</b> | <b>&lt; 0.001</b> | <b>-0.020</b> | <b>-0.012</b> |
| (a <sub>4</sub> ) Income → Number friends        | 0.059         | 0.006        | 9.595         | < 0.001           | 0.047         | 0.071         |
| (b <sub>4</sub> ) Number friends → Loneliness    | -0.270        | 0.029        | -9.340        | < 0.001           | -0.327        | -0.213        |
| <b>Total indirect effect</b>                     | <b>-0.035</b> | <b>0.003</b> | <b>-9.974</b> | <b>&lt; 0.001</b> | <b>-0.041</b> | <b>-0.028</b> |

*Note:* age, gender, relationship status and country fixed effects as control variables;  $\beta$ = standardized coefficients; SE= standard errors; CI = confidence interval

$R^2$ = 17.3% (loneliness)

Total proportion mediated = 37.4%

### **Robustness check: WLSMV estimator (standardized results)**

*Number of friends* and *number of family* are treated as ordinal. Considering listwise deletion of missing cases, the sample size changes from our main analyses: N= 20,942 (as opposed to N= 25,646).

Note that sizes of indirect effects through number of close family and frequency of interaction with friends are found to be significantly different in this robustness check at  $p = 0.046$ .

**Table C.2.2.:** Direct, indirect and total effects of income decile on loneliness through frequency of interaction with friends and family, and through number of close friends and family members (standardized)

|                                                  | $\beta$       | SE           | z-value        | p-value           | <u>95% CI</u> |               |
|--------------------------------------------------|---------------|--------------|----------------|-------------------|---------------|---------------|
|                                                  |               |              |                |                   | Lower         | Upper         |
| <b>Total effect</b>                              | <b>-0.139</b> | <b>0.015</b> | <b>-9.032</b>  | <b>&lt; 0.001</b> | <b>-0.169</b> | <b>-0.109</b> |
| <b><u>Direct effect</u></b>                      |               |              |                |                   |               |               |
| Income → Loneliness                              | <b>-0.081</b> | <b>0.015</b> | <b>-5.324</b>  | <b>&lt; 0.001</b> | <b>-0.111</b> | <b>-0.051</b> |
| <b><u>Indirect effects</u></b>                   |               |              |                |                   |               |               |
| <b>Frequency family</b>                          | <b>-0.011</b> | <b>0.002</b> | <b>-4.821</b>  | <b>&lt; 0.001</b> | <b>-0.015</b> | <b>-0.006</b> |
| (a <sub>1</sub> ) Income → Frequency family      | 0.114         | 0.016        | 7.246          | < 0.001           | 0.083         | 0.145         |
| (b <sub>1</sub> ) Frequency family → Loneliness  | -0.094        | 0.015        | -6.393         | < 0.001           | -0.123        | -0.065        |
| <b>Frequency friends</b>                         | <b>-0.008</b> | <b>0.002</b> | <b>-3.914</b>  | <b>&lt; 0.001</b> | <b>-0.011</b> | <b>-0.004</b> |
| (a <sub>2</sub> ) Income → Frequency friends     | 0.109         | 0.016        | 6.851          | < 0.001           | 0.078         | 0.141         |
| (b <sub>2</sub> ) Frequency friends → Loneliness | -0.069        | 0.015        | -4.719         | < 0.001           | -0.097        | -0.040        |
| <b>Number family</b>                             | <b>-0.014</b> | <b>0.003</b> | <b>-5.024</b>  | <b>&lt; 0.001</b> | <b>-0.019</b> | <b>-0.008</b> |
| (a <sub>3</sub> ) Income → Number family         | 0.130         | 0.017        | 7.807          | < 0.001           | 0.097         | 0.162         |
| (b <sub>3</sub> ) Number family → Loneliness     | -0.106        | 0.017        | -6.392         | < 0.001           | -0.138        | -0.073        |
| <b>Number friends</b>                            | <b>-0.026</b> | <b>0.004</b> | <b>-7.009</b>  | <b>&lt; 0.001</b> | <b>-0.033</b> | <b>-0.019</b> |
| (a <sub>4</sub> ) Income → Number friends        | 0.172         | 0.017        | 10.149         | < 0.001           | 0.139         | 0.205         |
| (b <sub>4</sub> ) Number friends → Loneliness    | -0.151        | 0.016        | -9.296         | < 0.001           | -0.182        | -0.119        |
| <b>Total indirect effect</b>                     | <b>-0.058</b> | <b>0.006</b> | <b>-10.428</b> | <b>&lt; 0.001</b> | <b>-0.069</b> | <b>-0.047</b> |

*Note:* age, gender, relationship status and country fixed effects as control variables;  $\beta$ = standardized coefficients; SE= standard errors; CI = confidence interval

$R^2 = 18.1\%$  (loneliness)

Total proportion mediated = 41.7%

### **MODEL 3**

#### **Unstandardized results**

**Table C.3.:** Direct, indirect and total effects of income decile on loneliness through social support (unstandardized)

|                                 | Estimate      | SE           | z-value       | p-value           | <u>95% CI</u> |               |
|---------------------------------|---------------|--------------|---------------|-------------------|---------------|---------------|
|                                 |               |              |               |                   | Lower         | Upper         |
| <b>Total effect</b>             | <b>-0.092</b> | <b>0.010</b> | <b>-8.977</b> | <b>&lt; 0.001</b> | <b>-0.112</b> | <b>-0.072</b> |
| <b><u>Direct effect</u></b>     |               |              |               |                   |               |               |
| Income → Loneliness             | <b>-0.051</b> | <b>0.010</b> | <b>-5.036</b> | <b>&lt; 0.001</b> | <b>-0.071</b> | <b>-0.031</b> |
| <b><u>Indirect effect</u></b>   |               |              |               |                   |               |               |
| <b>Social support</b>           | <b>-0.041</b> | <b>0.004</b> | <b>-9.463</b> | <b>&lt; 0.001</b> | <b>-0.049</b> | <b>-0.032</b> |
| (a) Income → Social support     | 0.261         | 0.026        | 10.185        | < 0.001           | 0.211         | 0.312         |
| (b) Social support → Loneliness | -0.157        | 0.007        | -22.822       | < 0.001           | -0.170        | -0.143        |

*Note:* age, gender, relationship status and country fixed effects as control variables;  $\beta$ = standardized coefficients; SE= standard errors; CI = confidence interval

$R^2 = 22.0\%$  (loneliness)

Total proportion mediated = 44.5%

## MODEL 4

### Unstandardized results

**Table C.4.1.:** Direct, indirect and total effects of income decile on loneliness through subjective health, number of close friends and social support (unstandardized)

|                                                  | Estimate      | SE           | z-value        | p-value           | 95% CI        |               |
|--------------------------------------------------|---------------|--------------|----------------|-------------------|---------------|---------------|
|                                                  |               |              |                |                   | Lower         | Upper         |
| <b>Total effect</b>                              | <b>-0.092</b> | <b>0.010</b> | <b>-8.986</b>  | <b>&lt; 0.001</b> | <b>-0.112</b> | <b>-0.072</b> |
| <b><u>Direct effect</u></b>                      |               |              |                |                   |               |               |
| Income → Loneliness                              | <b>-0.011</b> | <b>0.010</b> | <b>-1.153</b>  | <b>0.249</b>      | <b>-0.030</b> | <b>0.008</b>  |
| <b><u>Indirect effects</u></b>                   |               |              |                |                   |               |               |
| <b>Subjective health</b>                         | <b>-0.036</b> | <b>0.003</b> | <b>-11.763</b> | <b>&lt; 0.001</b> | <b>-0.042</b> | <b>-0.030</b> |
| (a <sub>1</sub> ) Income → Subjective health     | 0.071         | 0.005        | 13.585         | < 0.001           | 0.060         | 0.081         |
| (b <sub>1</sub> ) Subjective health → Loneliness | -0.510        | 0.026        | -19.666        | < 0.001           | -0.560        | -0.459        |
| <b>Number friends</b>                            | <b>-0.013</b> | <b>0.002</b> | <b>-6.645</b>  | <b>&lt; 0.001</b> | <b>-0.016</b> | <b>-0.009</b> |
| (a <sub>2</sub> ) Income → Number friends        | 0.059         | 0.006        | 9.504          | < 0.001           | 0.046         | 0.071         |
| (b <sub>2</sub> ) Number friends → Loneliness    | -0.215        | 0.026        | -8.333         | < 0.001           | -0.266        | -0.165        |
| <b>Social support</b>                            | <b>-0.032</b> | <b>0.004</b> | <b>-9.168</b>  | <b>&lt; 0.001</b> | <b>-0.039</b> | <b>-0.025</b> |
| (a <sub>3</sub> ) Income → Social support        | 0.258         | 0.026        | 10.109         | < 0.001           | 0.208         | 0.308         |
| (b <sub>3</sub> ) Social support → Loneliness    | -0.124        | 0.007        | -18.166        | < 0.001           | -0.138        | -0.111        |
| <b>Total indirect effect</b>                     | <b>-0.081</b> | <b>0.005</b> | <b>-15.382</b> | <b>&lt; 0.001</b> | <b>-0.091</b> | <b>-0.070</b> |

**Note:** age, gender, relationship status and country fixed effects as control variables;  $\beta$ = standardized coefficients; SE= standard errors; CI = confidence interval

$R^2 = 29.9\%$  (loneliness)

Total proportion mediated = 87.8%

### **Robustness check: WLSMV estimator (standardized)**

*Subjective health* and *number of friends* are treated as ordinal. Considering listwise deletion of missing cases, the sample size changes from our main analyses: N= 18,980 (as opposed to N= 25,646).

**Table C.4.2.:** Direct, indirect and total effects of income decile on loneliness through subjective health, number of close friends and social support (standardized)

|                                                  | Estimate      | SE           | z-value        | p-value           | 95% CI        |               |
|--------------------------------------------------|---------------|--------------|----------------|-------------------|---------------|---------------|
|                                                  |               |              |                |                   | Lower         | Upper         |
| <b>Total effect</b>                              | <b>-0.146</b> | <b>0.016</b> | <b>-9.106</b>  | <b>&lt; 0.001</b> | <b>-0.177</b> | <b>-0.115</b> |
| <b><u>Direct effect</u></b>                      |               |              |                |                   |               |               |
| Income → Loneliness                              | <b>-0.008</b> | <b>0.015</b> | <b>-0.504</b>  | <b>0.614</b>      | <b>-0.037</b> | <b>0.022</b>  |
| <b><u>Indirect effects</u></b>                   |               |              |                |                   |               |               |
| <b>Subjective health</b>                         | <b>-0.064</b> | <b>0.005</b> | <b>-12.608</b> | <b>&lt; 0.001</b> | <b>-0.074</b> | <b>-0.054</b> |
| (a <sub>1</sub> ) Income → Subjective health     | 0.232         | 0.016        | 14.856         | < 0.001           | 0.202         | 0.263         |
| (b <sub>1</sub> ) Subjective health → Loneliness | -0.274        | 0.013        | -21.270        | < 0.001           | -0.299        | -0.249        |
| <b>Number friends</b>                            | <b>-0.022</b> | <b>0.003</b> | <b>-6.668</b>  | <b>&lt; 0.001</b> | <b>-0.028</b> | <b>-0.015</b> |
| (a <sub>2</sub> ) Income → Number friends        | 0.188         | 0.017        | 10.877         | < 0.001           | 0.154         | 0.222         |
| (b <sub>2</sub> ) Number friends → Loneliness    | -0.115        | 0.014        | -8.214         | < 0.001           | -0.142        | -0.087        |
| <b>Social support</b>                            | <b>-0.053</b> | <b>0.005</b> | <b>-10.142</b> | <b>&lt; 0.001</b> | <b>-0.063</b> | <b>-0.043</b> |
| (a <sub>3</sub> ) Income → Social support        | 0.175         | 0.016        | 10.988         | < 0.001           | 0.144         | 0.207         |
| (b <sub>3</sub> ) Social support → Loneliness    | -0.303        | 0.013        | -23.699        | < 0.001           | -0.328        | -0.278        |
| <b>Total indirect effect</b>                     | <b>-0.138</b> | <b>0.008</b> | <b>-16.553</b> | <b>&lt; 0.001</b> | <b>-0.155</b> | <b>-0.122</b> |

*Note:* age, gender, relationship status and country fixed effects as control variables;  $\beta$ = standardized coefficients; SE= standard errors; CI = confidence interval

$R^2$ = 31.1% (loneliness)

Total proportion mediated = 94.8%

