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Abstract

Objectives

Despite often having better health at arrival, and at young ages, there is evidence that immigrants age at a faster pace than non-immigrants over the life course. One potential mediator in the relationship between migration background and health deterioration is loneliness. This study examines the direct impact of migration-related factors on mental and physical health trajectories, as well as their indirect effects through loneliness in the German context.

Methods

Using data from the 2012–2020 German Socio-Economic Panel (SOEP), we apply a parallel process latent growth curve model (PPM) with mediation analysis to examine the long-term impact of migration background and age at migration on physical and mental health trajectories. We also explore the mediating role of loneliness in this relationship. The analysis is stratified by gender.

Results

Loneliness fully mediates the relationship between migration background and mental health, as immigrants are more likely to experience loneliness, which in turn leads to worse mental health. Immigrants who moved to Germany after age 18 are more likely to experience loneliness, resulting in poorer mental health. This mechanism is particularly pronounced among women.

Discussion

Loneliness contributes to mental health disparities between immigrants and non-immigrants. Women who migrated after age 18 are particularly vulnerable. This study presents an innovative approach to examining the mechanisms behind health disparities by migration background.

Interventions targeted at reducing loneliness may help to reduce health disparities between immigrants and non-immigrants.

Introduction

Although immigrants tend to have better health upon arrival and at younger ages, their health deteriorates more rapidly than that of non-immigrants, often resulting in similar or even worse health outcomes in later life (Antecol & Bedard, 2006). This pattern is also observed in Germany, particularly for mental health and self-rated health (Ferrara et al., 2024; Loi et al., 2024, 2025). Previous studies primarily describe disparities in health and health trajectories between immigrants and non-immigrants (Nesterko et al., 2019), but the mechanisms underlying these differences are not yet fully explored. Therefore, this study investigates whether loneliness is one of the mechanisms behind the rapid health deterioration of immigrants. Using a longitudinal panel survey in Germany, we apply longitudinal mediation analysis to examine whether and how loneliness drives the health decline disparities between immigrants and non-immigrants, and the role of age at migration in this relationship. We focus on loneliness because the first challenge for immigrants is rebuilding their social networks in the receiving country, where they face additional barriers (Hurtado-de-Mendoza et al., 2014). These barriers could persist into older age, with loneliness playing a significant role in immigrant health decline (Wu & Penning, 2015). We use the case of Germany, where the current social landscape is markedly influenced by immigrants (Borkert & Bosswick, 2012). Gaining insight into the mechanisms underlying this pattern is crucial not only for researchers, but also for policymakers seeking to design interventions and policies to prevent accelerated health decline among immigrants.

Immigrant health paradox

Immigrants often have better health than non-immigrants upon their arrival in the receiving country, a phenomenon known as the healthy immigrant effect (Kennedy et al., 2015; Markides & Rote, 2018). This effect is considered a paradox given immigrants' lower socioeconomic position.

However, immigrants' health deteriorates more rapidly over time than that of non-immigrants, leading to a diminished health advantage or even worse health outcomes. However, immigrants have lower mortality than non-immigrants (Wallace et al., 2022). As a result of these interconnected mechanisms, immigrants are living longer, but in poorer health (Boen & Hummer, 2019; Wallace, 2024). This pattern, described by the unhealthy assimilation hypothesis, has been observed in many countries, including in Germany (Antecol & Bedard, 2006; Jang et al., 2023; Loi et al., 2025).

At least three hypotheses have been proposed to explain the healthy immigrant effect. First, the selectivity hypothesis suggests that immigrants are positively selected in their country of origin, meaning their pre-migration factors may contribute to better health upon arrival (Feliciano, 2020). Second, the cultural hypothesis asserts that immigrants have more favorable health behaviors than non-immigrants, which positively impact their health (Fenelon, 2013; Riosmena et al., 2017). Third, the better health of immigrants may be explained by the "salmon bias," which suggests that older immigrants with poor health tend to return to their country of origin, resulting in an artificial overestimation of good health among immigrants who stay in the receiving country (Palloni & Arias, 2004).

However, the unhealthy assimilation hypothesis has been challenged. Previous studies attribute the health decline among immigrants to structural factors, neighborhood environment, and cultural assimilation. Structural explanations include discrimination (Agudelo-Suárez et al., 2011; Gee et al., 2009), limited health care access (Antecol & Bedard, 2006; Razum & Bozorgmehr, 2016), greater vulnerability to adverse life events (Loi et al., 2024), and poor economic and social conditions (Loi & Hale, 2019). The literature on neighborhood effects suggests that immigrants are less able to relocate to more resourceful neighborhoods, resulting in

greater exposure to disadvantaged neighborhood environments (Lersch, 2013). Cultural assimilation, including adaptation to the behaviors of the receiving country, leads to the erosion of immigrants' initial health advantage over time (Akresh, 2007). However, few studies explore the role of loneliness in health disparities between immigrants and non-immigrants, despite evidence showing that immigrants tend to experience higher loneliness levels than non-immigrants (Joshi et al., 2024; Wu & Penning, 2015).

Migration-specific factors, including age at migration and length of stay in the receiving country, have been found to modify immigrants' health risks. Evidence from Europe suggests that migrating at older ages and staying longer in the receiving country are associated with poorer health outcomes (Honkaniemi et al., 2020; Lanari & Bussini, 2012; Lanari et al., 2018). These findings can be interpreted using the life-course perspective, particularly the crucial period model and the accumulation model (Ben-Shlomo et al., 2014). In terms of age at migration, the crucial period model suggests that certain social and environmental exposures amplify health effects during specific life stages (Honkaniemi et al., 2020). Therefore, migrating at particular ages may reduce health risks. The accumulation model explains the impact of length of stay, positing that prolonged exposure to a risky environment in the receiving country contributes to poorer health outcomes later in life (Lanari & Bussini, 2012; Loi & Hale, 2019).

This study focuses on the unhealthy assimilation hypothesis, as understanding its mechanisms can help prevent immigrants' rapid health decline. However, the existing research on the unhealthy assimilation hypothesis has three limitations. First, most existing studies focus on determining whether the unhealthy assimilation hypothesis applies in specific contexts rather than on exploring its underlying mechanisms, and there is little evidence on the factors contributing to this hypothesis in Germany (Ferrara et al., 2024; Nesterko et al., 2019). Second, existing studies

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seeking to explain the mechanisms behind the unhealthy assimilation hypothesis primarily focus on structural factors or immigrants' adaptation to unhealthy behaviors, while overlooking the socio-psychological perspective (Akresh, 2007; Antecol & Bedard, 2006). Third, in terms of methodology, previous studies primarily use cross-sectional designs (Loi & Hale, 2019) or a descriptive approach (Loi et al., 2025), and even recent methodological developments cannot fully identify the mechanisms behind the unhealthy assimilation hypothesis. For instance, fixed-effect models are still unable to answer the "why" question underlying this hypothesis (Brunori, 2024).

Loneliness as a mediator

Loneliness, defined as an individual's subjective feeling of a lack of satisfying human relationships, has been recognized as a public health issue and is receiving increased attention (Hawkley & Cacioppo, 2010). Loneliness has been linked to increased mortality; cardiovascular, metabolic, and neurological disorders; mental health outcomes; and overall well-being across multiple contexts (Hawkley, 2022; Park et al., 2020). Furthermore, evidence shows that immigrants are more likely to experience loneliness than non-immigrants, especially at older ages (Joshi et al., 2024; Wu & Penning, 2015; Zhao et al., 2023).

The loneliness experienced by immigrants can be understood using the stress process model, which suggests that immigrants often lack the resources to cope with stressors during the transition process. These stressors, such as cultural dislocation, acculturation, dwindling of social networks, and social and economic difficulties, can lead to loneliness (Diwan et al., 2004; Ponizovsky & Ritsner, 2004; Stewart et al., 2008; Treas & Mazumdar, 2002). Joshi and colleagues (2024) summarized the multi-dimensional social and economic factors related to the loneliness of immigrants. For example, immigrants may lack social support while struggling to establish their social network in the receiving country, leading to increased loneliness (Hurtado-de-Mendoza et

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al., 2014; Stewart et al., 2008). This study examines the relationship between migration background, loneliness, and health.

Migration-related factors, such as age at migration, can influence loneliness levels. Some studies indicate that migration in childhood can be stressful (Mossakowski, 2007), while others show that migrating at older ages is a particular risk factor, as older immigrants are not socialized in the receiving country and often face challenges in learning a new language and creating or extending their network of friends. These difficulties hinder adaptation and inclusion, resulting in higher loneliness rates (Treas, 2008; Treas & Batalova, 2009; Treas & Mazumdar, 2002). Length of stay in the receiving country often serves as a proxy for immigrants' social integration: the longer their stay, the more likely immigrants are to adopt the norms and behaviors of the receiving country. However, adaptation may also lead to increased isolation from the community of origin. Thus, length of stay can have both positive and negative effects on loneliness (Ajrouch, 2008; Singh & Siahpush, 2001). This study also explores how migration-related factors moderate the loneliness levels associated with immigrants' health status.

Gender disparities

Previous literature documents gender differences in migrant health (Trappolini & Giudici, 2021; Wandschneider et al., 2020). In Germany, women experience faster health decline than men (Loi et al., 2025). Evidence also shows that women are more likely than men to acculturate to the unhealthy behaviors of non-immigrants (Lopez-Gonzalez et al., 2005). Moreover, due to differences in social networks, men and women may experience and value loneliness in distinct ways, and the pathway from loneliness to health varies by gender (Boehlen et al., 2022). The social relationship perspective suggests that although women tend to have larger and more active social networks, they are more sensitive to the interpersonal context and are more likely to live alone due

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to their longer life expectancy, which increases their risk of loneliness (Barreto et al., 2021; Stokes & Levin, 1986). Immigrant women face increased barriers in rebuilding social networks in the receiving country due to socio-psychological factors. As a result, immigrant women tend to experience higher loneliness levels (Hurtado-de-Mendoza et al., 2014). Therefore, it is essential to examine the mechanisms of the unhealthy assimilation hypothesis by gender.

The German context

Modern migration history in Germany can be divided into three stages. The first stage involved the return of German prisoners of war and refugees of German descent from both Germany and the former German Democratic Republic (GDR) after World War II. The second stage involved the "Gastarbeiter" (guest worker) program, which recruited large numbers of immigrant workers from Turkey, Italy, and other European countries to support Germany's economy starting in the 1950s (Borkert & Bosswick, 2012). More recently, following German unification in 1990, immigration from Eastern Europe increased, and Germany saw a significant influx of refugees from Syria in 2015 (Ayoub, 2023).

Aims and research questions

This study aims to address the following research question: Is loneliness a pathway to immigrants' health decline? We examine whether loneliness contributes to health disparities between immigrants and non-immigrants, and whether this pathway varies by gender. We use an innovative and direct approach to examining the mechanisms behind the unhealthy assimilation hypothesis through longitudinal analysis: the parallel process latent growth curve model.

Age at migration is an important determinant of immigrants' health in the receiving country – with earlier ages at migration typically indicating better inclusion via, for instance, greater language proficiency, school attendance, and socialization in the receiving country. – We investigate whether the impact of loneliness differs depending on the age at migration. Due to the

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limited sample size for immigrants who have been in Germany for less than 10 years, and because the effect of loneliness may be confounded by arrival cohort, birth cohort, and age at migration (Ferrara et al., 2024; Zheng & Yu, 2022), we include the analysis of length of stay in the appendix.

First, we employ a parallel process latent growth curve model (PPM) with mediation analysis to investigate whether loneliness mediates the relationship between migration background and mental and physical health trajectories. The analysis is stratified by. Next, we apply the same analytical approach to examine whether the mediating effect of loneliness on health trajectories varies by age at migration and by gender. The two sets of hypotheses are listed below.

H1.1 Immigrants are more likely to experience loneliness than non-immigrants, which negatively impacts their mental and physical health trajectories.

H1.2 This relationship is more pronounced among women, as they are more likely to experience loneliness.

H2.1 Immigrants who migrate at older ages are more likely to experience loneliness than non-immigrants, which negatively impacts their mental and physical health trajectories.

H2.2 This relationship is more pronounced among women, as they are more likely to experience loneliness.

Methods

Data and sample

We use data from the German Socio-Economic Panel (G-SOEP), a yearly nationally representative panel survey in Germany that started in 1984 (Goebel, 2023). The survey includes ~30,000 individuals in 15,000 households, covering information on family structure, occupation, education, income, health, and well-being. We restrict the sample to 2012-2020, as loneliness was first

measured in 2013. To address the potential reverse effect, whereby individuals with poor health are more likely to experience loneliness, we control for health status in 2012. Since mental and physical health data are collected biennially, we include waves 2012, 2014, 2016, 2018, and 2020. We select individuals who participated in at least three waves from 2014 to 2020, and restrict the sample to individuals under age 80 to mitigate the "salmon bias," whereby older immigrants with poor health are more likely to return to their home country. This selective emigration statistically results in statistically better health among immigrants (Turra & Elo, 2008). The final analytical sample for migration background consists of 7,243 individuals, while the sample for age at migration is 7,190 (53 cases are missing data on the year of immigration). See Appendix Table 1 for the detailed sample selection procedure.

We conduct two sensitivity tests to ensure the robustness of the findings. We first account for the length of stay among immigrants, as it is a strong predictor of immigrant health (Loi & Hale, 2019; Trappolini & Giudici, 2021). Then, recognizing that COVID-19 may lead to changes in mental and physical health, which could be considered a period effect, we analyze the model by excluding the 2020 wave to eliminate potential COVID-19 effects (Pierce et al., 2021).

Measures

Our outcomes are the physical (PCS) and the mental component summary (MCS). The two outcomes are measured biennially since 2002 based on the SOEP-specific version of the 12-item Short-Form Health survey (SF-12v2). The SF-12v2 is a frequently used measure of overall health status, and is considered reliable. The PCS and MCS variables are computed through exploratory factor analysis and z-transformed to a range of 0-100, with higher values corresponding to better health (Andersen et al., 2007). We use the PCS and MCS scores from 2014, 2016, 2018, and 2020 to assess mental and physical health trajectories.

The mediator in this study is loneliness. Loneliness is measured using the three-item short version of the UCLA Loneliness Scale, which asks respondents how often they feel (1) a lack of companionship, (2) left out, and (3) isolated from others (Hughes et al., 2004). Each item is rated on a five-point scale, ranging from "never" to "very often." We calculate the mean score of the three items, resulting in a scale ranging from 1 to 5, with higher scores indicating greater loneliness. This measure demonstrates good validity and reliability (Russell, 1996). Details on the scale's development and validation can be found in Hughes et al. (2004).

The main predictors are migration-related factors, including migration background and age at migration. We define migration background using the place of birth criterion: an individual is an immigrant if s/he was born outside of Germany, and is a non-immigrant if s/he was born in Germany (0 = non-immigrant; 1 = immigrant). We calculate age at migration by subtracting the birth year from the immigrant year (age at migration = immigrant year – birth year). We categorize age at migration into three groups (1 = 0-5 years; 2 = 6-17 years; 3 = 18+ years) to capture the varying impacts of migration at different life stages, as the timing of migration can have distinct long-term effects on health (Gubernskaya, 2014; Honkaniemi et al., 2020). These cut-offs refer to critical life-course periods for individuals: pre-school ages, school ages, and after school completion ages. We also note that the length of stay in Germany is an important indicator. However, among men, the sample size for immigrants with less than 10 years of residence is below 30, reducing statistical power. Therefore, we include the analyses of the length of stay in the sensitivity analysis presented in the appendix (see Appendix Figures A2 and A3).

The socio-demographic covariates include age (18-80), gender (0 = women; 1 = men), educational attainment (1 = less than high school; 2 = high school; 3 = more than high school), household income quartiles (1 = lowest 25%; 2 = 25–50%; 3 = 50–75%; 4 = highest 25%),

household size (1–10), marital status (0 = other; 1 = married), and employment status (0 = unemployed; 1 = employed). To account for potential reverse effects from health to loneliness, we include mental and physical health status in 2012 (baseline). Additionally, we create a binary attrition variable to model health missingness over time (0 = participation in all four waves; 1 = non-participation in all four waves).

Analytical strategy

Our statistical analysis consists of three main steps. First, we use descriptive and bivariate analyses to explore the distribution of key variables and examine differences between immigrants and non-immigrants by gender using χ^2 tests and *t*-tests. This analysis is conducted using Stata 18. Then, we use a parallel process model (PPM) with mediation analysis to examine the direct effect of migration-related factors (migration background and age at migration) on mental and physical health trajectories (initial health status [i.e., intercept] and longitudinal changes [i.e., slope]), as well as its indirect effect through loneliness (see Figure 1). These analyses are then stratified by gender to examine gender differences in this relationship. The advantages of PPM are as follows: First, this approach separates measurement error by using latent variable processes. Second, it allows for the inclusion of multiple outcomes in a single model, enabling the examination of their relationships simultaneously. Third, it distinguishes between individual and within-individual changes, providing a better understanding of the healthy immigrant effect and unhealthy assimilation hypothesis. Finally, it can be flexibly applied within mediation analysis to directly examine the mechanisms (Wickrama et al., 2016).

The PPM is conducted sequentially. We first estimate two unconditional latent growth curve models (LGCMs) for mental and physical health to identify baseline health status and longitudinal changes in health outcomes. We then combine these models into a parallel process

model to analyze dual health trajectories. Third, the parallel process model is conditioned on migration background, loneliness, and covariates to examine both the direct effects of migration background on mental and physical health trajectories and its indirect effects through loneliness. The analysis is then stratified by gender. Finally, we apply the same model to assess the impact of age at migration on health trajectories and its indirect effects through loneliness, with results stratified by gender.

We perform LCGM and PPM with mediation analysis using M*plus* 8.11 and handle missing values using full information maximum likelihood (FIML) to include more cases in the analysis (Enders & Bandalos, 2001; Muthén & Muthén, 1998-2017; Wickrama et al., 2016). We use the following metrics to assess model fit: model χ^2, the comparative fit index (CFI), the Tucker-Lewis Index (TLI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). The recommended cut-offs for a proper model are CFI and TLI above 0.9 and RMSEA and SRMR below 0.08 (Hu & Bentler, 1999). The mediation effect is evaluated using the delta method, along with 1000 bootstrapped replications to get the bootstrapped confidence intervals (Muthén & Muthén, 1998-2017).

Results

Descriptive statistics and bivariate analysis

Descriptive statistics of the full sample and bivariate analysis for migration background by gender are presented in Table 1. Mental health levels for the full sample remained relatively stable over time, while physical health showed a declining trend, with the mean score decreasing from 49.18 (SD = 9.75) in 2012 to 47.15 (SD = 10.26) in 2020. The average loneliness score for the full sample was 1.96 (SD = 0.72). Of the sample, 8.75% were immigrants, with 68.14% having migrated to Germany after age 18. The average age of the full sample was 53.19 years (SD = 14.65). Over

90% of participants had completed high school or higher education. The average household size was 2.4 (SD = 1.14), and more than 64% were married and employed.

Bivariate analysis showed that non-immigrant women had better mental health than immigrant women, with the gap increasing over time. Additionally, compared to immigrant women, non-immigrant women reported lower loneliness levels, were older, had higher education and household income levels, had smaller household sizes, and were less likely to be married. A similar pattern was observed among men, with non-immigrant men having better mental health, reporting higher loneliness levels, being older, having higher education and household income levels, and smaller household sizes than immigrant men.

PPM with mediation analysis: Migration background, loneliness, and health trajectories

The results of the unconditional LGCM for dual health trajectories showed significant linear change for both mental and physical health, with mental and physical health declining over time (see Appendix Table A1). Figure 1 presents the conditional PPM results with mediation analysis for the impact of migration background (reference = non-immigrant) on mental and physical health trajectories and its indirect effects through loneliness. The model showed satisfactory model fits ($\chi^2(df)$ = 1225.820 (74), $p < 0.001$; CFI = 0.967; TLI = 0.936; RSMEA = 0.047; SRMR = 0.018). Results for the full sample showed that immigrants had higher loneliness levels (β = 0.039, $p < 0.01$), which in turn led to lower mental health levels (β = −0.223, $p < 0.001$). Table 2 presents the mediation test results, showing a significant pathway from migration background to loneliness, and in turn to mental health (β = −0.009, $p < 0.01$). However, migration background was not significantly associated with the rate of change in mental or physical health. Figure 2 presents the findings for the subgroup analysis. It shows that this pattern was particularly significant among women (Immigrants - loneliness: β = 0.056, $p < 0.01$; loneliness - mental health: β = −0.238, $p <$

0.001; Immigrants – loneliness - mental health: $\beta = -0.013$, $p < 0.01$). Additionally, immigrant women had worse physical health than non-immigrant women ($\beta = -0.026$, $p < 0.05$). Among men, loneliness was significantly associated with mental health ($\beta = -0.209$, $p < 0.001$), but there was no significant link between immigrant status and loneliness, and no mediation pathway from immigrant status to health through loneliness (see Appendix Table A2 for detailed coefficient estimates).

PPM with mediation analysis: Age at migration, loneliness, and health trajectories

Figure 3 presents the conditional PPM results for the impact of age at migration (reference = non-immigrant) on mental and physical health trajectories and its indirect effects through loneliness. The model fits are acceptable ($\chi^2(df) = 1234.938$ (78); CFI $= 0.967$; TLI $= 0.935$; RSMEA $= 0.045$; SRMR $= 0.017$). Results for the full sample showed that migrating to Germany after age 18 was associated with higher loneliness levels ($\beta = 0.05$, $p < 0.001$), and in turn with lower mental health levels ($\beta = -0.221$, $p < 0.001$). Table 2 shows a significant mediation pathway from migration background to mental health through loneliness ($\beta = -0.011$, $p < 0.001$). Additionally, migrating to Germany after age 18 was associated with worse physical health ($\beta = -0.025$, $p < 0.05$), while migrating at early ages (0-5) was associated with faster mental health decline ($\beta = -0.038$, $p < 0.05$). The subgroup analysis indicates that the mediation pathway was particularly significant among women. Specifically, for women, migrating after age 18 was associated with increased loneliness ($\beta = 0.066$, $p < 0.001$), and in turn with poorer mental health ($\beta = -0.234$, $p < 0.001$), resulting in an overall significant indirect effect ($\beta = -0.015$, $p < 0.001$; see Table 2 and Figure 4). Immigrant women who migrated after age 18 had worse physical health than non-immigrant women ($\beta = -0.033$, $p < 0.05$). For men, we found no mediation pathway from immigrant status to health through loneliness. Men who migrated at younger ages (0–5) experienced faster health

decline than non-immigrant men ($\beta = -0.068$, p < 0.05) (see Appendix Table A3 for detailed coefficient estimates).

Sensitivity test

To ensure the robustness of our results, we conducted two sensitivity tests. First, we accounted for immigrants' length of stay, categorizing them into two groups: those who had stayed for less than 10 years and those who had stayed for more than 10 years. However, the statistical power was reduced due to the limited sample size of the former group (immigrant men who had stayed for less than 10 years: 27). The results remained consistent, showing that both short- and long-term immigrants were more likely to experience loneliness, which was associated with worse mental health (see Appendix Figures A2 and A3). Mediation analysis confirmed a significant pathway from both short and long lengths of stay to loneliness, and in turn to mental health. Second, we reanalyzed the model to account for potential COVID-19 effects by excluding the 2020 wave. Although the model resulted in an inadmissible solution (i.e., negative variances of growth parameter), the findings remained consistent, showing that the mediation path from migration background to mental health through loneliness persisted (see Appendix Table A2, Figures A4 and A5).

Discussion

Building on existing research on the unhealthy assimilation hypothesis (Ferrara et al., 2024; Loi et al., 2024, 2025), this study explores how loneliness contributes to the faster health decline of immigrants compared to non-immigrants, and how the pathway varies by gender. Moreover, this study makes use of an innovative approach to directly examine the mechanisms underlying the rapid health deterioration of immigrants. The descriptive and bivariate analyses reveal that mental health disparities between immigrants and non-immigrants have widened over time, suggesting

that immigrants experience faster mental health decline than non-immigrants in Germany. This gap is particularly pronounced among women, indicating that immigrant women are aging with poorer mental health than both men and non-immigrant women, in line with previous studies (Loi et al., 2024, 2025). We find no evidence for the healthy immigrant effect, as our observation period starts in 2012, with most immigrants in our sample (92.25%) having lived in Germany for over 10 years. A long stay in Germany diminishes their initial health advantage (Loi & Hale, 2019). Additionally, immigrants experience higher loneliness levels than non-immigrants, with immigrant women reporting higher loneliness levels than other groups, consistent with previous studies (Ponizovsky & Ritsner, 2004; Wu & Penning, 2015).

The PPM with mediation analysis reveals that loneliness fully mediates the relationship between migration status and mental health, but not physical health, thus partially supporting H1.1. The findings are consistent with previous studies linking immigration to loneliness and loneliness to health outcomes, while extending this research by showing a mediation path from migration status to loneliness and health outcomes (Hawkley, 2022; Joshi et al., 2024; Wu & Penning, 2015). Our results show that immigrants are more likely to experience loneliness, which in turn affects their mental health. However, we do not find a mediation path between migration status and the rate of mental health change. This could have statistical reasons, as we rigorously control for health status in 2012, with early health status explaining later health changes. Since we focus on testing the mechanisms to measure the health selection effect and provide solid findings in the mediation analysis, we control for early health status in our analysis. For physical health, the same statistical reasoning may apply, as mental health might affect physical health, explaining the link between loneliness and physical health.

The subgroup analysis by gender shows that the mediation path is significant only among women, supporting H1.2. Specifically, the link between migration status and loneliness is significant among immigrant women, but not among immigrant men. These findings align with previous studies showing that immigrant women are more likely to experience loneliness, with distinct mechanisms for health changes identified for both immigrant men and women (Loi et al., 2024; Ponizovsky & Ritsner, 2004). One explanation for why immigrant women are more likely to experience loneliness than immigrant men refers to the social network perspective, which posits that immigrant women encounter additional barriers to establishing social networks in the receiving country due to socioeconomic, environmental, and psychosocial factors (Hurtado-de-Mendoza et al., 2014). Additionally, women tend to suffer more from a lack of social support (Shin & Park, 2023). However, this explanation requires further examination in future research. Gender differences may also arise from other dimensions of factors contributing to loneliness, ranging from the micro (individual) to the macro (structural and cultural) level, such as differing social network or support needs and ways of evaluating loneliness (Joshi et al., 2024).

The results of the PPM with mediation analysis for age at migration suggest that loneliness mediates the relationship only for those who migrated to Germany after age 18. Individuals who migrated after this age are more likely to experience loneliness, which leads to poor mental health. Moreover, these individuals have worse physical health than non-immigrants. Thus, H2.1 is partially supported. These findings align with previous studies suggesting that individuals who migrate at older ages are particularly vulnerable, and highlight the importance of the socialization process in the receiving country, as migrating later in life can hinder adaptation and inclusion, e.g., through language and cultural barriers, leading to higher loneliness levels (Treas & Batalova, 2009; Treas & Mazumdar, 2002). The subgroup analysis by gender reveals a similar pattern for migration

status, showing that the pathway is particularly significant among women. Loneliness specifically mediates the relationship between migration after age 18 and mental health, with this group also experiencing poor physical health. Thus, H2.2 is supported. The findings indicate that immigrant women who migrated after age 18 are particularly vulnerable, as they are more likely to experience loneliness, which undermines both their mental and their physical health. Regarding the length of stay in Germany, the findings show that both short-term (less than 10 years) and long-term (more than 10 years) immigrants are more likely to experience loneliness, which undermines their mental health. Consistent with previous findings, this pathway is more pronounced among women (see Appendix Figures A2 and A3).

This study also has limitations. First, the loneliness measure is collected every four years starting in 2013. However, the PPM approach requires at least three waves of health data, meaning that loneliness data for 2017 are not available to select as a mediator in this study (since only two waves of health data are available after 2017). Therefore, we are unable to control for baseline loneliness or changes in loneliness over time in this study. Second, as this study focuses on the mechanisms behind immigrants' rapid health decline, the current design is not suitable for examining the healthy immigrant effect. We do not track or compare immigrants' health changes since migration with those of non-immigrants, but instead focus on a specific window to examine health decline differences. Additionally, the PPM of health trajectories provides population averages. Future studies examining health trajectory heterogeneity should use the growth mixture model (Wickrama et al., 2016). Third, the health outcomes are self-reported, which may introduce recall bias. Future studies could examine disease diagnoses to avoid potential recall bias. Fourth, this study only investigates the mechanisms in the German context. Although our findings are generally consistent with previous literature, these mechanisms may vary across contexts and

require further investigation. Fourth, even though we removed respondents over age 80, we cannot fully control for the "salmon bias" effect (Palloni & Arias, 2004). The salmon bias hypothesis suggests that immigrants may appear healthier than they are because those with serious health problems are more likely to return to their country of origin, leaving a healthier population behind. However, in our study, we find that older immigrants have worse health outcomes than non-immigrants. This implies that if we could fully account for selective out-migration, the observed health disparities would likely be even larger. Therefore, we are confident in the robustness and conservative nature of our findings. Finally, although this study employs a longitudinal design, which strengthens the causal argument, the observational design limits the ability to make causal inferences.

Despite these limitations, this study makes theoretical, methodological, and empirical contributions. Theoretically, this study introduces and examines a key mechanism (i.e., loneliness) to explain immigrants' rapid health decline from a socio-psychological perspective. It also provides a reminder for future research to explore additional mechanisms from different perspectives and test these mechanisms in other settings.

Methodologically, compared to conventional and recent methods that use random and fixed regression models to examine the immigrant health paradox (Brunori, 2024; Ferrara et al., 2024), the PPM approach with mediation analysis has several advantages. First, the PPM can handle measurement errors with latent constructs (Muthen, 2004). Second, it allows for the inclusion of multiple outcomes in a single model, enabling the measurement of correlations between outcomes, as different dimensions of health are often correlated. Third, it can distinguish between individual and within-individual differences, allowing for the estimation of the healthy immigrant effect (between-individual differences) and the unhealthy assimilation hypothesis (within-individual

changes) in a single model (Wickrama et al., 2016). Finally, it is flexible and can directly examine the mechanisms for various research purposes, such as incorporating mediating factors to investigate underlying processes, which can generate clearer and more direct results (Cheong et al., 2003).

This study provides evidence that loneliness contributes to immigrants' health decline, reminding policymakers to address these issues from a socio-psychological perspective. The results show that women who migrated to Germany after age 18 are particularly vulnerable. Although practical methods to mitigate loneliness require further investigation, such as from a social network perspective, our findings underscore the need for policymakers to prioritize this group by designing targeted policies or interventions to reduce their social isolation, which can negatively impact their mental health.

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Table 1. Sample characteristics and bivariate analysis (Total N = 7,243)

	Full sample	Women (N = 3,927)			Men (N = 3,316)		
		Immigrants	**Non-immigrants**		**Immigrants**	**Non-immigrants**	
	M (SD) / N (%)	**M (SD) / N (%)**	**M (SD) / N (%)**	**χ² / t-test**	**M (SD) /N (%)**	**M (SD) / N (%)**	**χ² / t-test**
Mental health (0-100)							
2012	51.14 (9.71)	49.30 (9.36)	50.28 (10.15)	t = 1.79	51.42 (9.32)	52.33 (9.12)	t = 1.55
2014	51.99 (9.51)	49.81 (9.93)	51.16 (9.84)	t = 2.49*	52.49 (9.18)	53.18 (8.93)	t = 1.19
2016	52.68 (9.54)	50.12 (10.3)	51.90 (9.86)	t = 3.28**	53.18 (8.97)	53.84 (8.96)	t = 1.15
2018	51.83 (9.86)	49.44 (10.17)	51.24 (10.21)	t = 3.22**	51.41 (9.59)	52.83 (9.31)	t = 2.33*
2020	51.21 (9.93)	48.65 (10.45)	50.53 (10.07)	t = 3.36***	50.90 (10.17)	52.41 (9.53)	t = 2.41*
Physical health (0-100)							
2012	49.18 (9.75)	49.14 (9.41)	48.64 (10.19)	t = −0.91	49.53 (9.26)	49.77 (9.27)	t = 0.40
2014	48.75 (9.96)	47.98 (10.15)	48.31 (10.30)	t = 0.57	48.86 (9.81)	49.34 (9.52)	t = 0.78
2016	47.86 (10.00)	47.66 (10.15)	47.32 (10.45)	t = −0.59	48.26 (9.84)	48.48 (9.41)	t = 0.35
2018	47.13 (10.22)	46.76 (10.10)	46.62 (10.60)	t = −0.24	48.13 (9.86)	47.69 (9.78)	t = −0.69
2020	47.15 (10.26)	46.94 (10.20)	46.89 (10.51)	t = −0.09	47.80 (10.08)	47.52 (10.00)	t = 1.10
Loneliness (1-5)	1.96 (0.72)	2.14 (0.78)	1.97 (0.73)	t = −4.24***	2.00 (0.82)	1.92 (0.67)	t = −2.06*
Migration background							
Immigrant	634 (8.75%)	372 (9.47%)	-		262 (7.90%)	-	
Non-immigrant	6609 (91.25%)	-	3555 (90.53%)		-	3054 (92.10%)	
Age at migration							
18 and over	396 (68.16%)	234 (69.23%)	-		162 (66.67%)	-	
6-17	119 (20.48%)	69 (20.41%)	-		50 (20.58%)	-	
0-5	66 (11.36%)	35 (10.36%)	-		31 (12.78%)	-	
Age (18-80)	53.19 (14.65)	49.34 (13.31)	52.94 (14.63)	t = 4.55***	50.98 (14.56)	54.15 (14.72)	t = 3.34***
Educational attainment							
Less than high school	670 (9.25%)	90 (24.19%)	395 (11.11%)	χ^2 = 62.18***	53 (20.23%)	132 (4.32%)	χ^2 = 118.08***
High school	4422 (61.05%)	178 (47.85%)	2278 (64.08%)		142 (54.20%)	1824 (59.72%)	
Above high school	2151 (29.70%)	104 (27.96%)	882 (24.81%)		67 (25.57%)	1098 (35.95%)	
Household income quartiles							
Lowest 25%	1740 (24.01%)	60 (16.13%)	943 (26.53%)	χ^2 = 32.35***	51 (19.47%)	686 (22.46%)	χ^2 = 10.32*
25%-50%	1846 (25.49%)	122 (32.80%)	916 (25.77%)		78 (29.77%)	730 (23.90%)	
50%-75%	1839 (25.39%)	117 (31.45%)	835 (23.49%)		80 (30.53%)	807 (26.42%)	
Highest 25%	1818 (25.10%)	73 (19.62%)	861 (24.22%)		53 (20.23%)	831 (27.21%)	
Household size (1-10)	2.40 (1.14)	2.78 (1.34)	2.34 (1.10)	t = −7.13***	2.77 (1.14)	2.40 (1.11)	t = −5.13***
Marital status							
Married	4650 (64.20%)	271 (72.85%)	2146 (60.37%)	χ^2 = 22.18***	183 (69.85%)	2050 (67.13%)	χ^2 = 0.81
Others	2593 (35.80%)	101 (27.15%)	1409 (39.63%)		79 (30.15%)	1004 (32.87%)	

| | Full sample | Women (*N* = 3,927) | | | Men (*N* = 3,316) | | |
| | | Immigrants | Non-immigrants | | Immigrants | Non-immigrants | |
	M (SD) / N (%)	M (SD) / N (%)	M (SD) / N (%)	χ^2 / *t*-test	M (SD) /N (%)	M (SD) / N (%)	χ^2 / *t*-test
Employment status							
Employed	4666 (64.42%)	244 (65.59%)	2188 (61.55%)	$\chi^2 = 2.34$	177 (67.56%)	2057 (67.35%)	$\chi^2 = 0$
Unemployed	2577 (35.58%)	128 (34.41%)	1367 (38.45%)		85 (32.44%)	997 (32.65%)	

Note: M = mean, SD = standard deviation, N = count, % = percentage; ***p < 0.001, **p < 0.01, *p < 0.05.

Table 2. Standardized results for the mediation analysis in the parallel process latent growth curve model

Model paths	Full sample		Women		Men	
	β	SE	β	SE	β	SE
Migration background (N = 7,243)						
Immigrant → Loneliness → I_M	−0.009**	0.003	−0.013**	0.004	−0.003	0.004
Immigrant → Loneliness → S_M	0.001	0.001	0.002	0.002	0	0.001
Immigrant → Loneliness → I_P	0	0	−0.001	0.001	0	0
Immigrant → Loneliness → S_P	−0.001	0.001	−0.002	0.002	0	0.001
Age at migration (N = 7,190)						
Age at migration (older than 18) → Loneliness → I_M	−0.011***	0.003	−0.015***	0.004	−0.005	0.004
Age at migration (older than 18) → Loneliness → S_M	0.001	0.001	0.002	0.002	0	0.001
Age at migration (older than 18) → Loneliness → I_P	0	0.001	−0.001	0.001	0	0.001
Age at migration (older than 18) → Loneliness → S_P	−0.002	0.001	−0.002	0.002	−0.001	0.002
Age at migration (6-17) → Loneliness → I_M	0	0.003	-0.002	0.004	0.001	0.003
Age at migration (6-17) → Loneliness → S_M	0	0	0	0.001	0	0.001
Age at migration (6-17) → Loneliness → I_P	0	0	0	0	0	0
Age at migration (6-17) → Loneliness → S_P	0	0	0	0.001	0	0.001
Age at migration (0-5) → Loneliness → I_M	-0.001	0.002	-0.005	0.004	0.004	0.003
Age at migration (0-5) → Loneliness → S_M	0	0	0.001	0.001	0	0.001
Age at migration (0-5) → Loneliness → I_P	0	0	0	0.001	0	0
Age at migration (0-5) → Loneliness → S_P	0	0	-0.001	0.001	0.001	0.001

Note: I_M = Intercept of mental health; S_M = Slope of mental health; I_P = Intercept of physical health; S_P = Slope of physical health; β = Standardized coefficient; SE = Standard Error; $\chi2(df)$ = chi square and degree of freedom; CFI = comparative fit index; TLI = Tucker-Lewis Index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; ***$p < 0.001$, **$p < 0.01$.
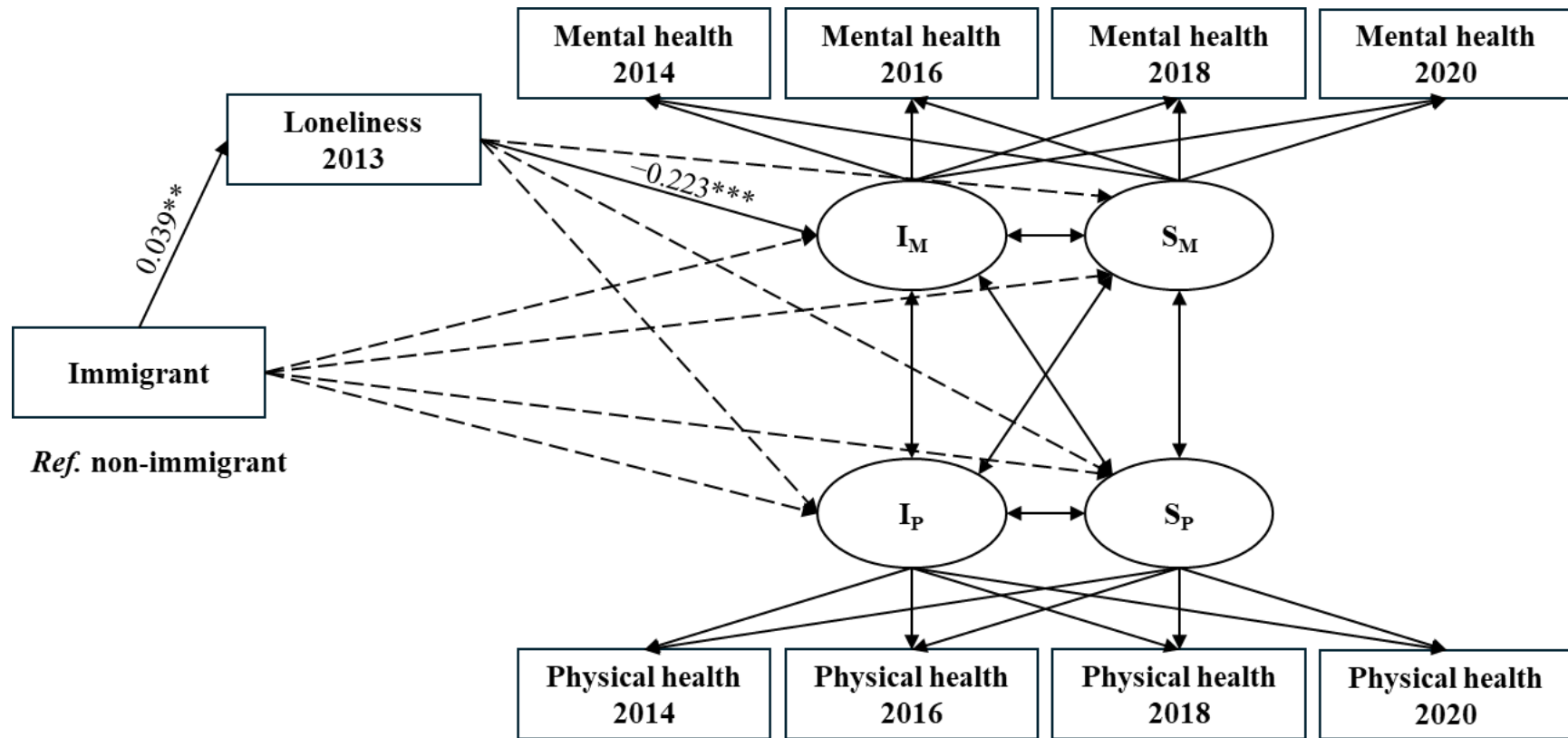
Figure 1. Standardized results from the mediation analysis in the parallel process latent growth curve model (N = 7,243)

Note: I_M = Intercept of mental health; S_M = Slope of mental health; I_P = Intercept of physical health; S_P = Slope of physical health. The dotted lines indicate non-significant model paths. The solid lines indicate significant paths. *Ref.* = reference. Covariates: age, gender, educational attainment, household income, household size, marital status, employment status, mental and physical health in 2012, and an attrition variable to account for data loss from 2014 to 2020.
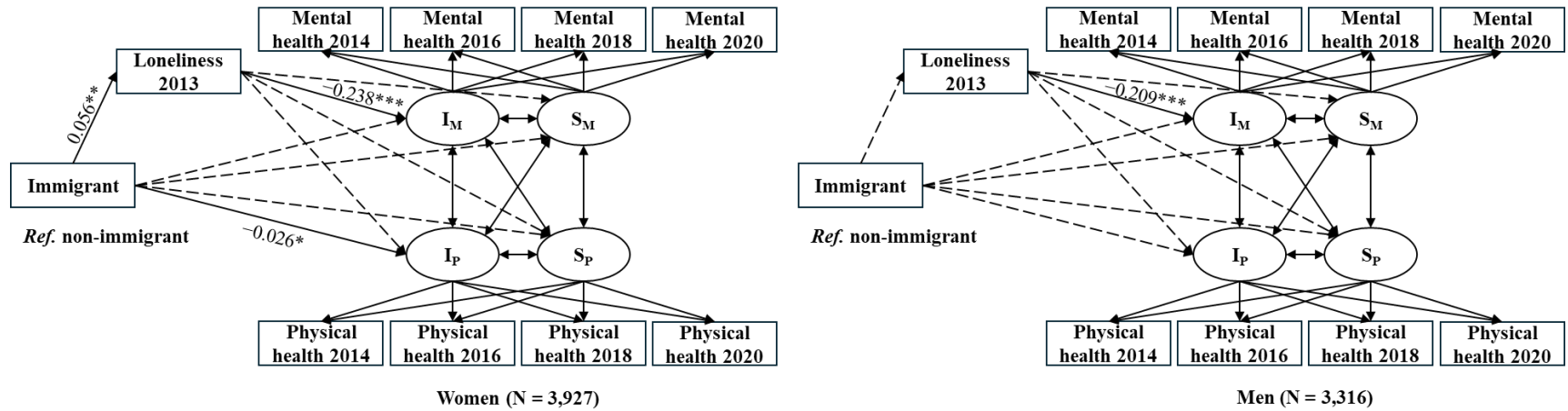
Figure 2. Standardized results from the mediation analysis in the parallel process latent growth curve model by gender

Note: I_M = Intercept of mental health; S_M = Slope of mental health; I_P = Intercept of physical health; S_P = Slope of physical health. The dotted lines indicate non-significant model paths. The solid lines indicate significant paths. *Ref.* = reference. Covariates: age, educational attainment, household income, household size, marital status, employment status, mental and physical health in 2012, and an attrition variable to account for data loss from 2014 to 2020.

Figure 3. Standardized results from the mediation analysis in the parallel process latent growth curve model for the full sample (N = 7,190)

Note: I_M = Intercept of mental health; S_M = Slope of mental health; I_P = Intercept of physical health; S_P = Slope of physical health. The solid lines indicate significant paths. The dotted lines indicate non-significant model paths. Non-significant paths and observed variables in the parallel process model are omitted from this figure. *Ref.* = reference. Covariates: age, educational attainment, household income, household size, marital status, employment status, mental and physical health in 2012, and an attrition variable to account for data loss from 2014 to 2020.
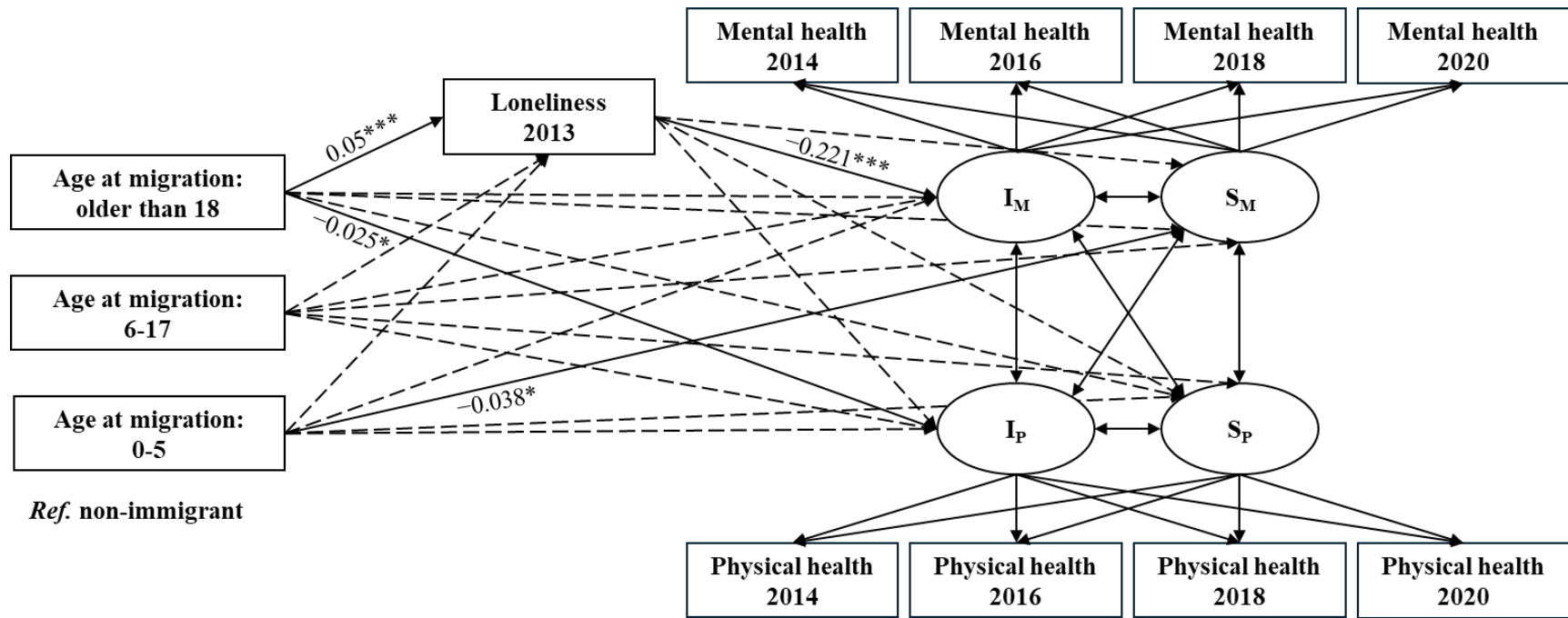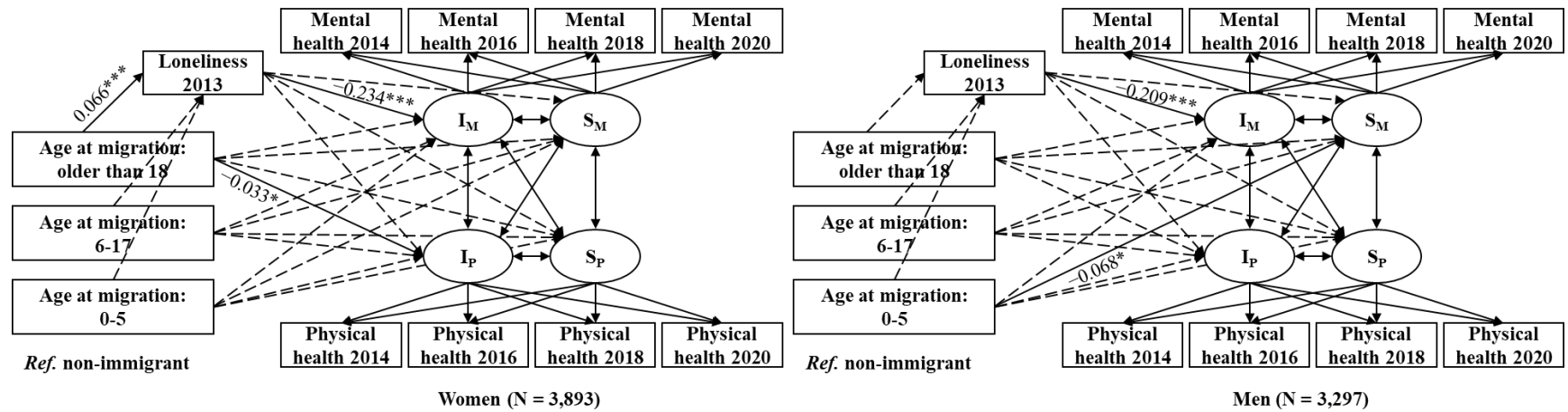
Figure 4. Standardized results from the mediation analysis in the parallel process latent growth curve model by gender

Note: I_M = Intercept of mental health; S_M = Slope of mental health; I_P = Intercept of physical health; S_P = Slope of physical health. The solid lines indicate significant paths. The dotted lines indicate non-significant model paths. Non-significant paths and observed variables in the parallel process model are omitted from this figure. *Ref.* = reference. Covariates: age, educational attainment, household income, household size, marital status, employment status, mental and physical health in 2012, and an attrition variable to account for data loss from 2014 to 2020.
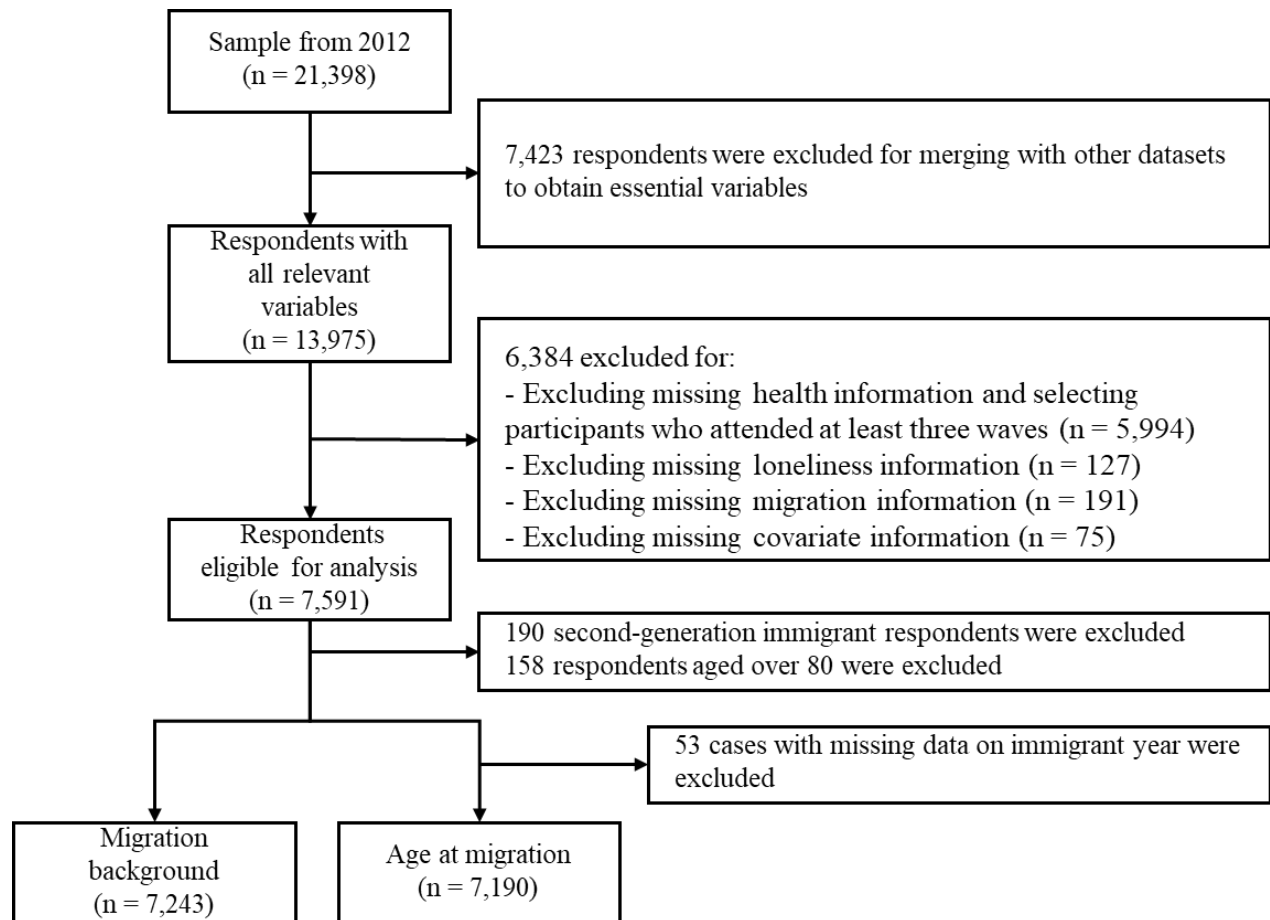
Appendix

Figure A1. Sample selection procedure

Table A1. Unstandardized estimates for unconditional latent growth curve models for full samples and subsamples

| | **Mean** | | | | **Variance** | |
	Estimate	SE	*p*	Estimate	SE	*p*
Full sample						
I_M	52.353	0.106	0.000	51.606	1.519	0.000
S_M	−0.296	0.042	0.000	3.264	0.288	0.000
I_P	48.596	0.112	0.000	69.251	1.603	0.000
S_P	−0.624	0.035	0.000	2.201	0.207	0.000
Women						
I_M	51.399	0.150	0.000	55.409	2.244	0.000
S_M	−0.253	0.060	0.000	3.757	0.430	0.000
I_P	48.075	0.159	0.000	76.263	2.345	0.000
S_P	−0.562	0.049	0.000	2.536	0.296	0.000
Men						
I_M	53.485	0.147	0.000	44.911	1.959	0.000
S_M	−0.348	0.058	0.000	2.698	0.375	0.000
I_P	49.218	0.157	0.000	60.089	2.132	0.000
S_P	−0.697	0.050	0.000	1.783	0.287	0.000

Note. I_M = Intercept of mental health; S_M = Slope of mental health; I_P = Intercept of physical health; S_P = Slope of physical health.

Table A2. Standardized results for mediation effects from the mediation analysis in the parallel process latent growth curve model for migration background (Total $N = 7,243$)

	Full sample		Women		Men	
	β	SE	β	SE	β	SE
Immigrant → I_M	−0.005	0.011	−0.014	0.015	0.009	0.017
Immigrant → S_M	−0.04	0.022	−0.028	0.029	−0.057	0.037
Immigrant → I_P	−0.018	0.009	−0.026*	0.013	−0.004	0.014
Immigrant → S_P	0.021	0.021	0.034	0.029	0.001	0.036
Immigrant → Loneliness	0.039**	0.012	0.056**	0.016	0.013	0.02
Loneliness → I_M	−0.223***	0.015	−0.238***	0.019	−0.209***	0.021
Loneliness → S_M	0.023	0.025	0.037	0.033	0.001	0.04
Loneliness → I_P	−0.006	0.01	−0.02	0.014	0.014	0.014
Loneliness → S_P	−0.036	0.024	−0.035	0.035	−0.033	0.04
Age → I_M	0.122***	0.017	0.103***	0.023	0.152***	0.025
Age → S_M	0.048	0.032	0.058	0.042	0.027	0.048
Age → I_P	−0.165***	0.013	−0.159***	0.018	−0.176***	0.018
Age → S_P	−0.157***	0.031	−0.073	0.041	−0.275***	0.049
Age → Loneliness	−0.142***	0.016	−0.165***	0.019	−0.095***	0.024
Men → I_M	0.058***	0.012				
Men → S_M	−0.005	0.022				
Men → I_P	0.012	0.009				
Men → S_P	−0.031	0.022				
Men → Loneliness	0.021	0.011				
Education → I_M	0.015	0.012	0.025	0.016	0.001	0.02
Education → S_M	−0.034	0.024	−0.031	0.031	−0.035	0.04
Education → I_P	0.066*	0.01	0.051***	0.013	0.085***	0.015
Education → S_P	0.045	0.024	0.042	0.029	0.069	0.037
Education → Loneliness	−0.022	0.012	−0.008	0.016	−0.049**	0.017
Household income → I_M	−0.023	0.017	−0.031	0.025	−0.013	0.025
Household income → S_M	0.083*	0.033	0.048	0.044	0.131*	0.053
Household income → I_P	0.036**	0.014	0.049**	0.019	0.021	0.02
Household income → S_P	0.033	0.033	0.055	0.044	0.005	0.052
Household income → Loneliness	−0.066***	0.016	−0.065**	0.022	−0.073**	0.024
Household size → I_M	−0.025	0.016	−0.03	0.022	−0.021	0.021
Household size → S_M	0.004	0.027	0.026	0.038	−0.026	0.041
Household size → I_P	0.002	0.012	0.005	0.018	0	0.016

	Full sample		Women		Men	
	β	*SE*	*β*	*SE*	*β*	*SE*
Household size → S_P	−0.023	0.027	−0.042	0.038	0.008	0.042
Household size → Loneliness	−0.024	0.014	−0.019	0.019	−0.028	0.021
Married → I_M	0.002	0.015	0.007	0.02	−0.005	0.022
Married → S_M	−0.034	0.028	−0.041	0.035	−0.014	0.045
Married → I_P	−0.006	0.011	−0.009	0.015	−0.004	0.017
Married → S_P	0.05	0.028	0.082*	0.036	0.011	0.045
Married → Loneliness	−0.049***	0.013	−0.03	0.017	−0.082***	0.021
Employed → I_M	0.021	0.016	0.013	0.022	0.032	0.027
Employed → S_M	0.031	0.033	0.045	0.041	0.004	0.053
Employed → I_P	−0.007	0.013	−0.009	0.018	−0.002	0.02
Employed → S_P	0.017	0.032	0.04	0.042	−0.024	0.053
Employed → Loneliness	−0.008	0.017	−0.014	0.022	0.01	0.026
Mental health in 2012 → I_M	0.584***	0.015	0.572***	0.02	0.607***	0.02
Mental health in 2012 → S_M	−0.192***	0.028	−0.179***	0.037	−0.207***	0.045
Mental health in 2012 → I_P	0.116***	0.011	0.105***	0.014	0.13***	0.017
Mental health in 2012 → S_P	−0.022	0.024	−0.02	0.032	−0.023	0.043
Mental health in 2012 → Loneliness	−0.347***	0.012	−0.346***	0.017	−0.345***	0.018
Physical health in 2012 → I_M	0.089***	0.015	0.093***	0.019	0.085***	0.022
Physical health in 2012 → S_M	0.047	0.026	0.036	0.034	0.066	0.044
Physical health in 2012 → I_P	0.72***	0.01	0.71***	0.013	0.736***	0.014
Physical health in 2012 → S_P	−0.198***	0.026	−0.185***	0.036	−0.216***	0.045
Physical health in 2012 → Loneliness	−0.161***	0.013	−0.165***	0.017	−0.157***	0.02
Attrition → I_M	−0.016	0.012	−0.011	0.018	−0.022	0.017
Attrition → S_M	−0.014	0.028	0.023	0.036	−0.069	0.042
Attrition → I_P	−0.013	0.01	−0.005	0.013	−0.02	0.014
Attrition → S_P	−0.037	0.027	−0.038	0.037	−0.037	0.044
Attrition → Loneliness	−0.004	0.011	0.02	0.014	−0.034*	0.016

Note. I_M = Intercept of mental health; S_M = Slope of mental health; I_P = Intercept of physical health; S_P = Slope of physical health; β = Standardized coefficient; SE = Standard Error; ***p < 0.001, **p < 0.01, *p < 0.05.

Table A3. Standardized results for mediation effects from the mediation analysis in the parallel process latent growth curve model for age at migration (Total $N = 7{,}190$)

	Full sample		Women		Men	
	β	*SE*	β	*SE*	β	*SE*
Age at migration						
18 and over → I_M	−0.006	0.012	−0.011	0.015	0.001	0.018
18 and over → S_M	−0.035	0.021	−0.047	0.027	−0.013	0.037
18 and over → I_P	−0.025*	0.01	−0.033*	0.013	−0.012	0.016
18 and over → S_P	−0.002	0.023	0.002	0.03	−0.006	0.037
18 and over → Loneliness	0.05***	0.013	0.066***	0.017	0.025	0.022
6-17 → I_M	−0.005	0.011	−0.018	0.016	0.011	0.014
6-17 → S_M	0.004	0.022	0.042	0.029	−0.055	0.033
6-17 → I_P	0.006	0.008	0.005	0.012	0.008	0.011
6-17 → S_P	0.028	0.019	0.052	0.027	−0.007	0.029
6-17 → Loneliness	0.002	0.012	0.007	0.017	−0.006	0.015
0-5 → I_M	0.001	0.008	−0.006	0.01	0.012	0.014
0-5 → S_M	−0.038*	0.018	−0.018	0.024	−0.068	0.028*
0-5 → I_P	0.007	0.008	0.013	0.009	0.002	0.014
0-5 → S_P	0.024	0.017	0.012	0.018	0.037	0.029
0-5 → Loneliness	0.002	0.011	0.02	0.017	−0.018	0.014
Loneliness → I_M	−0.221***	0.014	−0.234***	0.02	−0.209***	0.021
Loneliness → S_M	0.024	0.026	0.035	0.035	0.006	0.041
Loneliness → I_P	−0.006	0.011	−0.02	0.015	0.013	0.015
Loneliness → S_P	−0.033	0.026	−0.029	0.034	−0.034	0.04
Age → I_M	0.123***	0.017	0.103***	0.023	0.156***	0.024
Age → S_M	0.043	0.032	0.059	0.039	0.01	0.047
Age → I_P	−0.162***	0.013	−0.155***	0.018	−0.175***	0.019
Age → S_P	−0.156***	0.031	−0.074	0.041	−0.27***	0.047
Age → Loneliness	−0.145***	0.016	−0.168***	0.019	−0.1***	0.024
Men → I_M	0.058***	0.012				
Men → S_M	−0.006	0.022				
Men → I_P	0.011	0.009				
Men → S_P	−0.028	0.022				
Men → Loneliness	0.02	0.011				
Education → I_M	0.015	0.013	0.026	0.017	0.002	0.019
Education → S_M	−0.034	0.024	−0.029	0.031	−0.038	0.039

	Full sample		Women		Men	
	β	*SE*	*β*	*SE*	*β*	*SE*
Education → I$_P$	0.067***	0.01	0.052***	0.014	0.086***	0.015
Education → S$_P$	0.041	0.023	0.038	0.032	0.065	0.038
Education → Loneliness	−0.021	0.012	−0.009	0.016	−0.046**	0.017
Household income → I$_M$	−0.024	0.017	−0.031	0.024	−0.015	0.025
Household income → S$_M$	0.085**	0.032	0.047	0.045	0.142**	0.05
Household income → I$_P$	0.036**	0.014	0.051**	0.018	0.019	0.021
Household income → S$_P$	0.034	0.032	0.052	0.042	0.011	0.051
Household income → Loneliness	−0.066***	0.016	−0.063**	0.023	−0.075**	0.024
Household size → I$_M$	−0.025	0.015	−0.028	0.021	−0.02	0.021
Household size → S$_M$	0.003	0.029	0.026	0.039	−0.029	0.04
Household size → I$_P$	0.002	0.012	0.004	0.017	0	0.017
Household size → S$_P$	−0.022	0.029	−0.041	0.038	0.009	0.042
Household size → Loneliness	−0.026	0.014	−0.022	0.019	−0.027	0.02
Married → I$_M$	0.001	0.015	0.006	0.02	−0.006	0.022
Married → S$_M$	−0.03	0.028	−0.037	0.037	−0.008	0.044
Married → I$_P$	−0.005	0.012	−0.008	0.015	−0.004	0.018
Married → S$_P$	0.05	0.028	0.081*	0.035	0.01	0.045
Married → Loneliness	−0.048**	0.014	−0.029	0.017	−0.082***	0.022
Employed → I$_M$	0.022	0.017	0.012	0.023	0.038	0.027
Employed → S$_M$	0.024	0.033	0.043	0.041	−0.012	0.053
Employed → I$_P$	−0.008	0.014	−0.011	0.018	0	0.02
Employed → S$_P$	0.011	0.032	0.035	0.042	−0.031	0.052
Employed → Loneliness	−0.006	0.016	−0.013	0.022	0.013	0.025
Mental health in 2012 → I$_M$	0.584***	0.014	0.572***	0.02	0.607***	0.02
Mental health in 2012 → S$_M$	−0.19***	0.028	−0.177***	0.038	−0.207***	0.043
Mental health in 2012 → I$_P$	0.115***	0.011	0.103***	0.015	0.13***	0.017
Mental health in 2012 → S$_P$	−0.022	0.024	−0.018	0.032	−0.025	0.043
Mental health in 2012 → Loneliness	−0.347***	0.012	−0.346***	0.016	−0.345***	0.019
Physical health in 2012 → I$_M$	0.088***	0.014	0.091***	0.02	0.084***	0.022
Physical health in 2012 → S$_M$	0.05	0.026	0.037	0.034	0.074	0.041
Physical health in 2012 → I$_P$	0.72***	0.01	0.71***	0.014	0.735***	0.015
Physical health in 2012 → S$_P$	−0.197***	0.027	−0.182***	0.036	−0.218***	0.047
Physical health in 2012 → Loneliness	−0.161***	0.013	−0.164***	0.017	−0.159***	0.02
Attrition → I$_M$	−0.017	0.013	−0.013	0.017	−0.022	0.018
Attrition → S$_M$	−0.013	0.028	0.026	0.037	−0.069	0.043

	Full sample		Women		Men	
	β	*SE*	β	*SE*	β	*SE*
Attrition $\rightarrow$ I$_P$	−0.012	0.01	−0.004	0.014	−0.02	0.014
Attrition $\rightarrow$ S$_P$	−0.041	0.029	−0.043	0.036	−0.041	0.042
Attrition $\rightarrow$ Loneliness	−0.004	0.011	0.021	0.014	−0.035*	0.016

Note. I$_M$ = Intercept of mental health; S$_M$ = Slope of mental health; I$_P$ = Intercept of physical health; S$_P$ = Slope of physical health; β = Standardized coefficient; SE = Standard Error; ***p < 0.001, **p < 0.01, *p < 0.05.
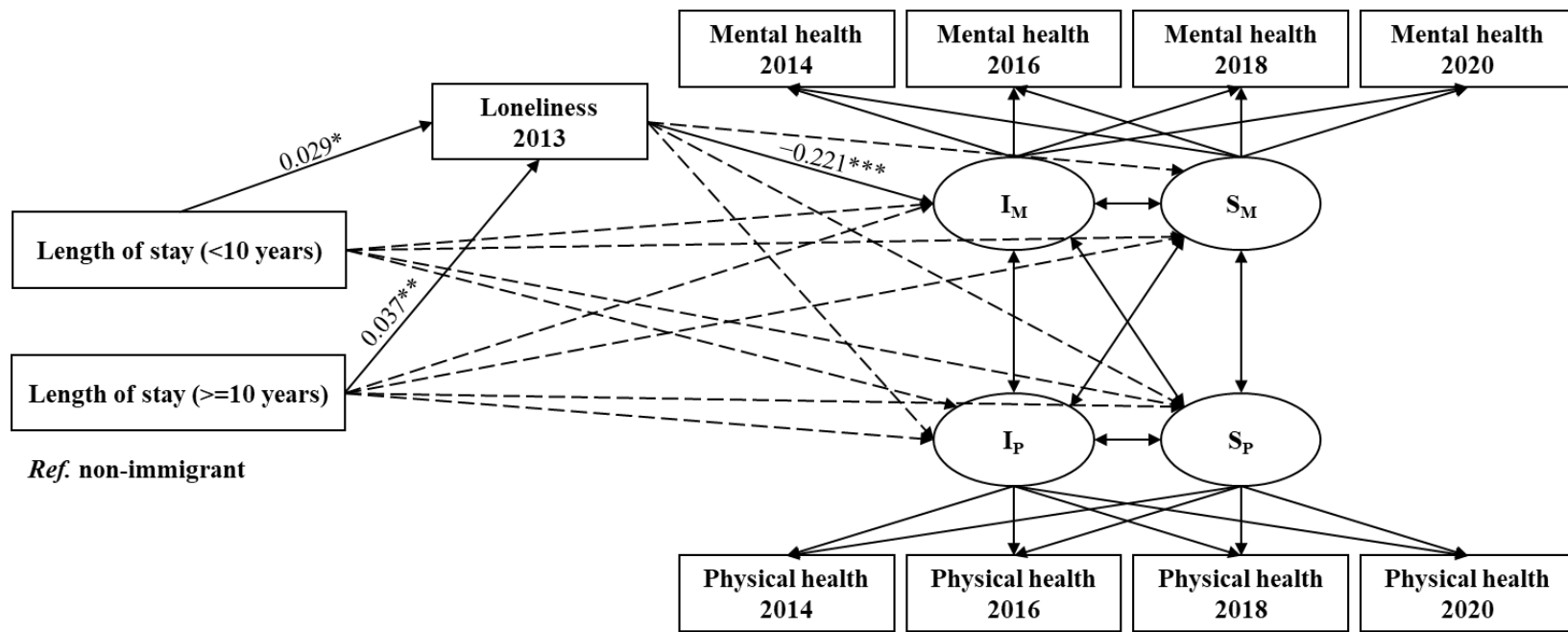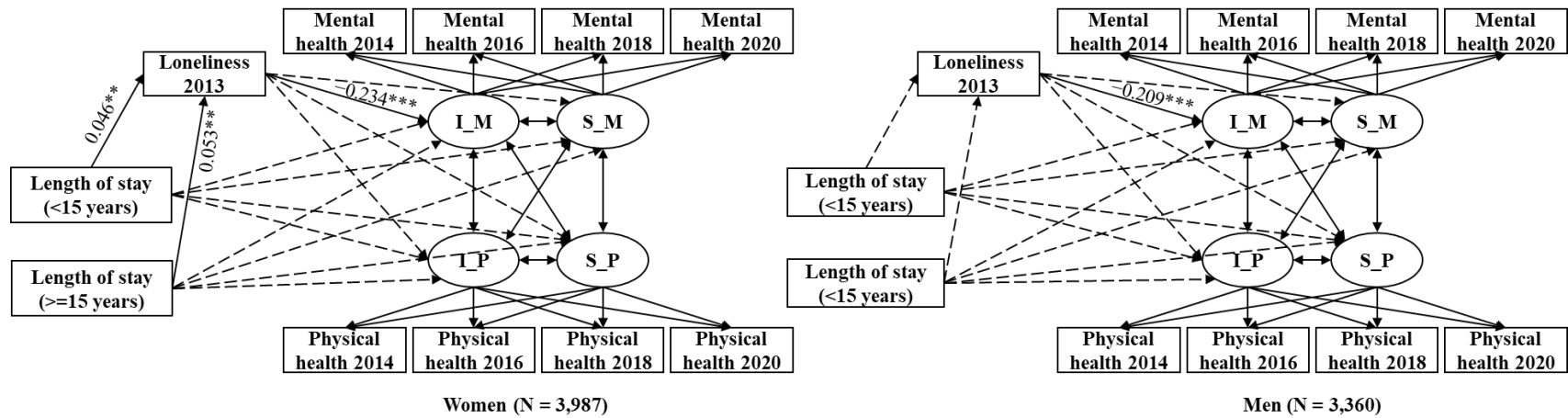
Figure A2. Standardized results from the mediation analysis in the parallel process latent growth curve model (N = 7,190)

Note. I_M = Intercept of mental health; S_M = Slope of mental health; I_P = Intercept of physical health; S_P = Slope of physical health; The dotted lines indicate non-significant model paths; The solid lines indicate significant paths; Covariates: age, gender, educational attainment, household income, household size, marital status, employment status, mental and physical health in 2012, and an attrition variable to account for data loss from 2014 to 2020.

Figure A3. Standardized results from the mediation analysis in the parallel process latent growth curve model by gender

Note. I_M = Intercept of mental health; S_M = Slope of mental health; I_P = Intercept of physical health; S_P = Slope of physical health; The dotted lines indicate non-significant model paths; The solid lines indicate significant paths; Covariates: age, educational attainment, household income, household size, marital status, employment status, mental and physical health in 2012, and an attrition variable to account for data loss from 2014 to 2020.
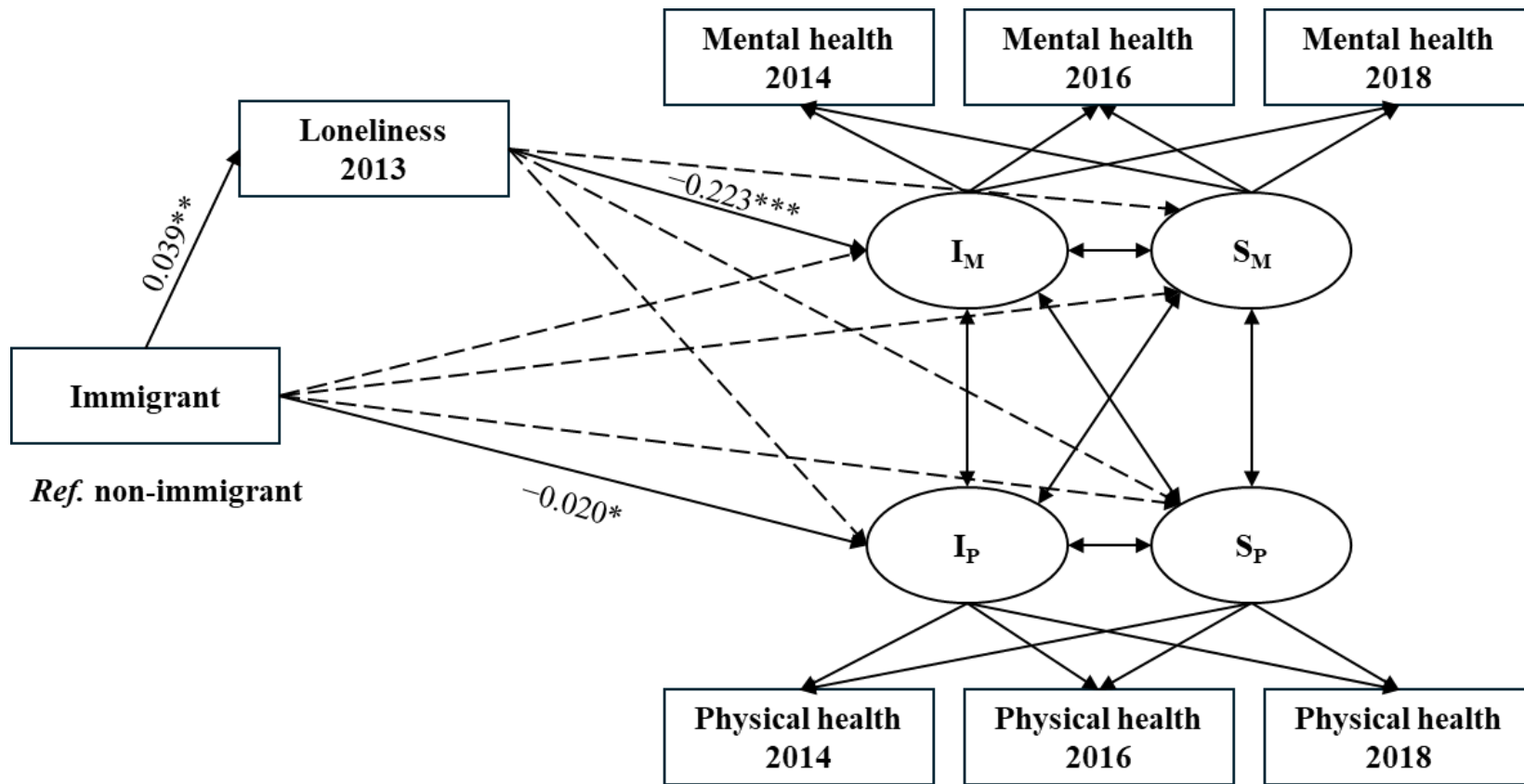
Figure A4. Standardized results from the mediation analysis in the parallel process latent growth curve model (N = 7,190)

Note. I_M = Intercept of mental health; S_M = Slope of mental health; I_P = Intercept of physical health; S_P = Slope of physical health; The dotted lines indicate non-significant model paths; The solid lines indicate significant paths; Covariates: age, gender, educational attainment, household income, household size, marital status, employment status, mental and physical health in 2012, and an attrition variable to account for data loss from 2014 to 2020.
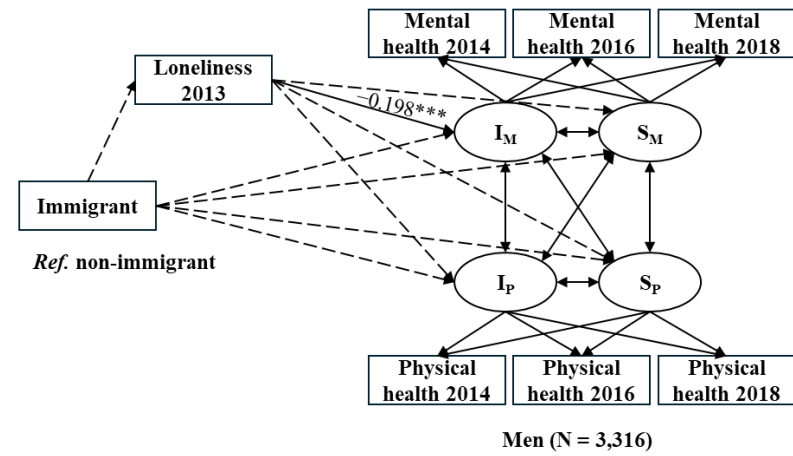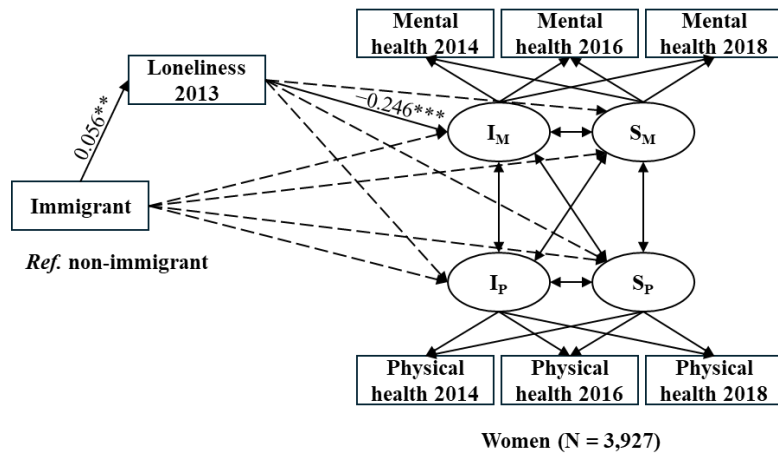
Figure A5. Standardized results from the mediation analysis in the parallel process latent growth curve model by gender
Note. I_M = Intercept of mental health; S_M = Slope of mental health; I_P = Intercept of physical health; S_P = Slope of physical health; The dotted lines indicate non-significant model paths; The solid lines indicate significant paths; Covariates: age, educational attainment, household income, household size, marital status, employment status, mental and physical health in 2012, and an attrition variable to account for data loss from 2014 to 2020.