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Abstract

Background: Who we live with in later life significantly influences the daily care support we receive, potentially moderating chronic disease trajectories. For immigrants, this relationship is further complicated by cultural preferences for certain living arrangements. This study examines the differential role of living arrangements in chronic disease accumulation among native-born and immigrant older adults in Europe.

Methods: Using data from the Survey of Health, Ageing and Retirement in Europe (2006-2022), we analyze how living arrangements moderate the relationship between age, migration background, and the number of chronic diseases. We also conduct stratified analyses based on immigrants' countries of origin. All models employ inverse probability weights for panel attrition and panel-robust standard errors for longitudinal data. Analyses are conducted separately for men and women.

Results: Immigrants show a higher chronic disease burden compared to native-born individuals, but living arrangements appear to moderate this disparity. Among native-born men and women, the predicted number of chronic diseases is lowest for couple households and highest for single households. Conversely, no significant differences are observed across living arrangements among immigrant men, regardless of origin. Among immigrant women, the predicted number of chronic diseases is highest when they are living alone, similar to the pattern among native-born women. However, among immigrant women from less developed countries, the burden is highest when they are living in a family. Notably, the moderation of living arrangements on chronic disease trajectories differs between native-born and immigrants primarily in baseline levels, not in accumulation rates.

Conclusion: Older immigrants, particularly men from highly developed countries and women from less developed countries, may experience fewer health benefits from living with a partner or with family. Our findings indicate that these immigrant households may

have excessive caregiving burdens, which could contribute to unhealthy aging among immigrants in later life.

Keywords Immigrants; Chronic diseases; Living arrangements; Family; Aging; Europe

Introduction

Many high-income countries worldwide are facing the rapid aging of their populations, leading to growing caregiving needs for older adults (United Nations, 2017b). This unprecedented demand can strain even the most robust welfare systems, including those in several European countries, resulting in the burden of care falling to informal caregivers due to limitations in formal support (Dukhovnov et al., 2022; Suanet et al., 2012). Chronically ill older adults, in particular, frequently rely on their informal care networks – mainly co-residing household members – for medical support and assistance in activities of daily living (Adelman et al., 2014; Schulz et al., 2020; Wolff & Spillman, 2014). Hence, in aging societies, it is of great importance to understand how people's living arrangements at older ages can translate into long-term health outcomes.

As the number of immigrants has grown, their health has become a significant public health concern across European societies (International Organization for Migration (IOM), 2021; Kristiansen et al., 2016). Scholars have recently investigated how the health of immigrants evolves as they age in a foreign country, especially in European settings, where they often have an initial health advantage but a less favorable trajectory with age compared to the native-born population (Bousmah et al., 2019; Jang et al., 2023; Loi et al., 2024). While less is known about the mechanisms driving these aging disparities, one potential contributor is the different living arrangements of native-born and immigrant individuals. Immigrants face unique circumstances, such as having left many family members in their country of origin and being influenced by culturally preferred forms of living arrangements from their home country (Albertini & Mantovani, 2022; Barbiano et al., 2018; de Valk & Schans, 2008). These circumstances may shape the extent to which living arrangements moderate the long-term health trajectories of immigrants compared to those of their native-born counterparts.

In this study, we explore the differential role of living arrangements in chronic disease accumulation among native-born and immigrant older adults in Europe using population-representative data from the Survey of Health, Ageing and Retirement in Europe (SHARE). Our paper extends the current knowledge in mainly two ways. First, findings from this study provide evidence of whether and how living arrangements moderate the relationship between age and the accumulation of chronic diseases among native-born and immigrant older adults. Second, our origin-specific analyses contribute to a better understanding of whether the role of living arrangements varies across cultures with different expectations for familial arrangements in later life. These insights can help to identify population subgroups with particularly high caregiving burdens.

Living arrangements and chronic disease accumulation

Living arrangements, which refer to with whom individuals live and how they are related to these co-residents, are important determinants for physical and mental health at older ages. Evidence suggests that compared to living alone, living with a partner or family members is generally associated with lower mortality (Lund et al., 2002; Staehelin et al., 2012), better self-rated and mental health (Aranda, 2015; Courtin & Avendano, 2016; Zunzunegui et al., 2001), and reduced chronic diseases (Wang et al., 2022). Hence, along with global population aging, understanding the implications of living arrangements for health trajectories in later life is becoming increasingly important (United Nations, 2017b).

Studies suggest that within the broader context of social relationships, interpersonal connections can either mitigate or exacerbate the detrimental effects of aging on health outcomes (Benson et al., 2019). This moderating role of social relationships in age-related health decline is also observed within shared living arrangements. Particularly for older adults with chronic diseases, co-residing family members can closely monitor the symptoms

of their health conditions and promote healthy behaviors, such as having a balanced diet and regular physical exercise and adhering to the prescribed treatment (Gallant et al., 2010; Wolff & Spillman, 2014). At the same time, more intense interactions among family members may negatively affect older adults' health, exacerbating their health problems and the progression of chronic diseases (Dekhtyar et al., 2019; Olaya et al., 2017; Woods et al., 2020).

The mechanisms through which relationships within shared living arrangements influence healthy aging processes can help to explain disparities in the speed of chronic disease accumulation across different populations. Prior work has shown that living in materially deprived areas, having lower educational attainment, and experiencing occupational stress are related to faster chronic disease accumulation (Dekhtyar et al., 2019; Lyons et al., 2023). These socioeconomically disadvantaged groups are more likely to transition to less favorable living arrangements (e.g., living alone or being institutionalized) at older ages, which suggests that their accelerated accrual of long-term health conditions may stem from the absence or reduction of benefits from supportive living arrangements and robust social relationships with the people with whom they are living.

Living arrangements and health among immigrants

An essential aspect of family solidarity is that the family network is expected to be available to provide needed care and support (Alburez-Gutierrez et al., 2023). Thus, in populations with limited family networks, individuals are less likely to receive support from their family members due to their physical unavailability. Immigrants often face considerable challenges in relocating with their family members (e.g., spouses, children, parents, and other relatives), resulting in a restricted family network in their host country (Barbiano et al., 2018). This limitation in family networks can lead to immigrants having fewer options for shared living arrangements, which are essential sources of informal care at older ages. With fewer family

members available for them to live with, the caregiving responsibilities for older immigrants may fall on a smaller number of people, potentially leading to an excessive burden of care in immigrant families (Adelman et al., 2014; Szinovacz & Davey, 2007). This concentration of the caregiving burden can result in reduced quality of care and, consequently, adverse health outcomes for care recipients (Kuzuya et al., 2011).

Importantly, research has shown that immigrants form families in patterns that differ not only from those of native-born individuals but also between men and women (Barbiano et al., 2018; Castro Torres & Gutierrez-Vazquez, 2022). For instance, compared to immigrant men, immigrant women are more likely to arrive in the host country for family reunification purposes and thus have a higher probability of living with family at older ages (Barbiano et al., 2018). Consequently, the excessive caregiving burden within immigrant families may tend to fall on immigrant women, potentially leading to gender disparities in the association between living arrangements and health outcomes among immigrants.

Cultural variations in the common and preferred types of living arrangements can further complicate their implications for immigrants' health at older ages. In wealthier and more developed countries, older adults usually live in one-generation households rather than in larger families (Reher & Requena, 2018). Multigenerational households and close-knit family living arrangements are more prevalent in less economically developed countries, such as those in Asia, Africa, and parts of Latin America (Esteve & Reher, 2024; Gallant et al., 2010; Reher & Requena, 2018). These differences in prevailing norms across cultures suggest that immigrants from different countries of origin can have widely varying preferences and expectations regarding their living arrangements in later life. It has, for instance, been shown that Turkish and Moroccan immigrants in the Netherlands have stronger expectations of living with their children at older ages than other immigrant groups (de Valk & Schans, 2008). When immigrants' ideal living arrangements in later life do not match their reality,

they may experience diminished well-being and decreased life satisfaction, compromising their physical and mental health at older ages (Aranda, 2015; Tosi & Grundy, 2018).

Several previous studies have observed an initial health advantage for immigrants upon their arrival in the receiving country (Akresh & Frank, 2008; Constant et al., 2017; Ichou & Wallace, 2019; Loi & Hale, 2019; Riosmena et al., 2017). However, this initial advantage tends to diminish over time as immigrants age in the host society (Antecol & Bedard, 2006; Bousmah et al., 2019; Loi et al., 2024; Loi & Hale, 2019; Reiss et al., 2015). This trend of eroding health benefits suggests that immigrants experience rapid health deterioration – or unhealthy aging. This assumption is supported by a recent study showing that in Europe, immigrants accumulate chronic diseases faster with age than native-born individuals (Jang et al., 2023).

One potential mechanism driving inequalities in healthy aging between immigrants and native-born individuals is their differential experiences with various living arrangements. Existing studies on general social relationships have found that immigrants often receive less emotional support from their social networks than native-born individuals, leading to adverse physical and mental health outcomes (Salinero-Fort et al., 2011; Vega et al., 1991; Xu et al., 2017). Although the number of quantitative studies is limited, existing research suggests that living with others may protect older immigrants against depression (Mui, 1999; Wilmoth & Chen, 2003). However, to the best of our knowledge, no previous work has examined whether living arrangements moderate long-term health trajectories, as measured by chronic disease accumulation, more strongly among immigrants than among native-born individuals.

Research aims

In this paper, we aim to comprehensively describe how living alone, with a partner, or with family can influence the long-term health trajectories of native-born and immigrant older

adults in Europe. Our study is guided by the following research question: *Does the role of living arrangements in the age-related accumulation of chronic diseases differ between native-born and immigrant older adults?* Considering that immigrant households typically have more limited family networks in the host society, and thus often have an excessive burden in effectively managing the health of care recipients, we expect to find a smaller protective effect of shared living arrangements against chronic disease accumulation among immigrants than among their native-born counterparts. We also expect the impact of living arrangements on chronic disease accumulation to vary across immigrant groups based on their country of origin. Specifically, we hypothesize that compared to immigrants from more developed countries, immigrants from less developed countries (as measured by the Human Development Index), who are more likely to have strong traditions of familial living arrangements, benefit more from living with a partner or family members in terms of the accumulation of chronic diseases.

Methods

Data and study population

We use data from the Survey of Health, Ageing and Retirement in Europe (SHARE), a population-representative longitudinal study of the health and socioeconomic characteristics of older adults in 28 European countries and Israel. Our analysis includes participants from waves 2 to 9 (2006–2022), except for wave 3, during years in which medical histories for all chronic diseases of interest to us are provided (n = 151,687). We focus on individuals with information on familial relationships, which includes respondents of the cover screen questionnaire in waves 2 through 7, and all respondents in waves 8 and 9 (n = 132,894). We exclude individuals living with non-family members (n = 132,227) due to the high heterogeneity within these non-family groups, which may include friends, ex-partners, or

other non-family members (e.g., formal caregivers). Despite its small size, the exclusion of these individuals makes more detailed analyses difficult. In order to address the lack of statistical power due to scarce data on immigrants at extreme ages, the sample is limited to participants aged 50-79 (n = 116,809). Furthermore, we maintain our focus on immigrants in Europe by excluding participants from Israel (n = 114,314). After removing respondents with missing information on the outcome and covariates, our final analytic sample includes 112,358 individuals (263,822 observations).

Number of chronic diseases

Our study uses the number of chronic diseases as the outcome measure. We construct this variable using self-reported data on doctor-diagnosed conditions and drug use (detailed information in Table S1). As in prior work, we select 12 chronic diseases that appear with high or medium frequencies in studies on the co-occurrence of multiple chronic diseases: heart attack, stroke, hypertension, diabetes, chronic respiratory diseases, arthritis, osteoporosis, mental disorders, stomach disorders, stomach ulcer, Parkinson's disease, dementia, and cancer (Hafezparast et al., 2021). We combine heart attack and stroke, given that SHARE collects drug usage information that is not differentiated for these two diseases. Since most chronic conditions are considered irreversible, we define individuals who have ever had a condition as prevalent (Griffith et al., 2018). Finally, we count the number of prevalent chronic diseases in each person at each survey wave.

Key independent variables

This study focuses on three key variables: age, migration background, and living arrangements. Age is estimated as a continuous variable using the year and month of birth. We center age at 50 years, the lower bound of the age range in our study, allowing the

intercept to represent the expected outcome at age 50 rather than zero, which is a more meaningful reference given our focus on older ages. Migration background is determined based on the country of birth, with individuals born in the interview country being classified as native-born and those born elsewhere being classified as immigrants. Living arrangements are grouped into three categories: living alone, living as a couple, and living as a family. Living as a couple is defined as co-residing only with a spouse or partner. Living as a family is defined as co-residing with other family members, such as children, parents, and other relatives, irrespective of the presence of a spouse or partner in the household.

Confounders

Our models include education, income, employment, and parental status to control for potential variations in the outcomes due to differences in socioeconomic characteristics. Education is categorized into three levels: low (lower secondary education or less), medium (upper secondary or post-secondary non-tertiary education), and high (tertiary education). Household income is divided into low, medium, and high levels using the imputed household net income provided in SHARE, based on tertile cutoffs calculated for each country at each wave. Employment status is categorized into working and not working. Parental status is grouped into two categories: having a child and being childless.

Statistical analysis

Our study applies the weighted least square (WLS) linear regression models. We cluster standard errors at the individual level to account for the longitudinal nature of our data. As the main focus of our study is how age-related changes in health differ between native-born and immigrant individuals, it is important to deal with different probabilities of panel attrition between the two groups. In particular, immigrants may migrate back to their home countries

when they suffer health problems at older ages, resulting in immigrant panels that seemingly remain healthier as they age than their native-born counterparts (Palloni & Arias, 2004). We apply the inverse probability of censoring weighting approach to account for the differential attrition (Robins et al., 1995). We predict the probability of panel attrition from models that include linear and quadratic terms of age, migration background, and the interaction between migration background and age terms. Final weights are calculated as the cumulative product of the inverse probability of panel participation from the baseline up to the observation time point within each individual.

To comprehensively address our research question, we construct three progressive models (model specifications in Table 1). On the basis of recent findings indicating that the speed of chronic disease accumulation differs between immigrants and native-born individuals, we include migration background, age (linear and quadratic terms), and the interaction between migration background and age in all our models (Jang et al., 2023). We begin by examining the general relationship between living arrangements and chronic disease accumulation at older ages by fitting a model that includes living arrangements in addition to baseline variables (Model 1). Building on this foundation, we assess how living arrangements moderate chronic disease accumulation trajectories, focusing on two aspects. First, we examine whether living arrangements moderate the relationship between being an immigrant and the number of chronic diseases in general – i.e., the intercept of the disease accumulation trajectory – by introducing an interaction term between migration background and living arrangements to the model (Model 2). Second, we test the moderating effects of living arrangements on the speed of chronic disease accumulation – i.e., the slope of the trajectory – specific to an individual's migration status by adding a three-way interaction between migration background, age terms, and living arrangements to the model (Model 3). We

present all our results in graphical form as the predicted number of chronic diseases to facilitate interpretation, with detailed results provided in the online supplementary material.

Table 1. Model specifications

Models	Model specification
Model 1	Migration background + Age + Migration background × Age + Living arrangements + Confounders [a]
Model 2	Model 1 + Migration background × Living arrangements
Model 3	Model 2 + Migration background × Age × Living arrangements

[a] Confounders include education, household income, employment status, and parental status

Living arrangements at older ages vary considerably between men and women, as the higher mortality among men leads to more women experiencing spousal loss and living alone at older ages (Kamiya, 2024). Therefore, we perform all our analyses for men and women separately. Furthermore, as living arrangements among immigrants can correlate with cultural norms and familial values from their home countries, we explore how the results vary by country of origin. We rerun our final model, Model 3, in stratified samples that include native-born individuals and immigrants from each origin group. Drawing from previous international comparative reports on household formations, we categorize the origin countries according to their level of development, as determined by the Human Development Index (HDI) (Esteve & Reher, 2024; Reher & Requena, 2018). The HDI is commonly used in investigations of country-level determinants of living arrangements, as it collectively measures the wealth, education, and life expectancy of a country, all of which are important correlates of its cultural dynamics. We group countries of origin based on their HDI scores in 2015 into low (HDI < 0.7), medium (HDI ≥ 0.7), and high (HDI ≥ 0.8) development countries (list of countries in Table S2) (Bousmah et al., 2019; Reher & Requena, 2018).

Sensitivity analysis

In the literature, health deterioration among immigrants is often explained by acculturation, whereby immigrants adopt negative health behaviors over time in the receiving country (Reiss et al., 2015). However, we do not include length of stay in our models because approximately 97% of our observations are of immigrants who had been in the receiving country for ten or more years. By this time, immigrants' health outcomes had likely converged to those of the native-born population, making the length of stay less relevant in our study (Loi & Hale, 2019). We perform additional analysis excluding immigrants who have stayed in the receiving country for less than ten years, thereby ruling out the strongest acculturation effects.

There are also potential issues regarding our country of origin groupings, as the HDI has been criticized, especially for giving too little consideration to disparities in national income (Sagar & Najam, 1998). Therefore, we run a sensitivity analysis using the gross national income (GNI) per capita instead of the HDI to determine the development levels of the origin countries. We use the GNI per capita in 2015 to group countries of origin into low- (≤ US$ 4,035), medium- (> US$ 4,035 and ≤ US$ 12,475), and high-income (US$ 12,475) economies, with the cutoff lines being drawn from the World Bank classification system (list of countries in Table S3) (United Nations, 2017a).

Results

Descriptive characteristics

Table 2 shows the baseline characteristics of the study population. Compared to the native-born sample (45,643 men and 56,911 women), the immigrant men (4,318) and women (5,544) in the analyses are, on average, younger. Additionally, compared to their native-born counterparts, both the male and the female immigrant populations include higher shares of

individuals with high education, low household income, and one or more children and those who are living as a family.

Table 2. Baseline characteristics [a] of the study population by immigration background

	Men			Women		
	Native-born	Immigrant		Native-born	Immigrant	
Total	45,623	4,318		56,876	5,541	
Age, mean (SD)	63.70 (8.00)	63.20 (8.23)	***	63.32 (8.23)	63.08 (8.45)	*
Education						
Low	14,062 (30.8%)	1,210 (28.0%)	***	21,368 (37.6%)	1,947 (35.1%)	***
Medium	20,915 (45.8%)	1,801 (41.7%)	***	23,647 (41.6%)	2,165 (39.1%)	***
High	10,646 (23.3%)	1,307 (30.3%)	***	11,861 (20.9%)	1,429 (25.8%)	***
Household income						
Low	15,461 (33.9%)	1,514 (35.1%)		22,475 (39.5%)	2,372 (42.8%)	***
Medium	12,690 (27.8%)	1,283 (29.7%)	**	16,010 (28.1%)	1,645 (29.7%)	*
High	17,472 (38.3%)	1,521 (35.2%)	***	18,391 (32.3%)	1,524 (27.5%)	***
Employment status						
Not working	29,019 (63.6%)	2,763 (64.0%)		39,281 (69.1%)	3,822 (69.0%)	
(Self-) Employed	16,604 (36.4%)	1,555 (36.0%)		17,595 (30.9%)	1,719 (31.0%)	
Parental status						
No child	9,432 (20.7%)	579 (13.4%)	***	11,172 (19.6%)	851 (15.4%)	***
Have child	36,191 (79.3%)	3,739 (86.6%)	***	45,704 (80.4%)	4,690 (84.6%)	***
Living arrangements						
Living alone	7,166 (15.7%)	679 (15.7%)		14,201 (25.0%)	1,526 (27.5%)	***
Living as a couple	25,360 (55.6%)	2,263 (52.4%)	***	26,611 (46.8%)	2,405 (43.4%)	***
Living as a family	13,097 (28.7%)	1,376 (31.9%)	***	16,064 (28.2%)	1,610 (29.1%)	

[a] Unweighted observations of samples at study entry

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Figure 1 illustrates the age-specific mean of the number of chronic diseases for all observations included in the analysis. Overall, the average number of chronic diseases increases with age for both men and women, regardless of their migration background and living arrangements. Specifically, compared to their native-born counterparts, immigrant men have a higher number of chronic diseases on average across almost all ages when they are

living as a couple. Conversely, native-born and immigrant men who are living alone have a more similar number of chronic diseases. Among women, we observe an immigrant disadvantage at all ages regardless of living arrangements.

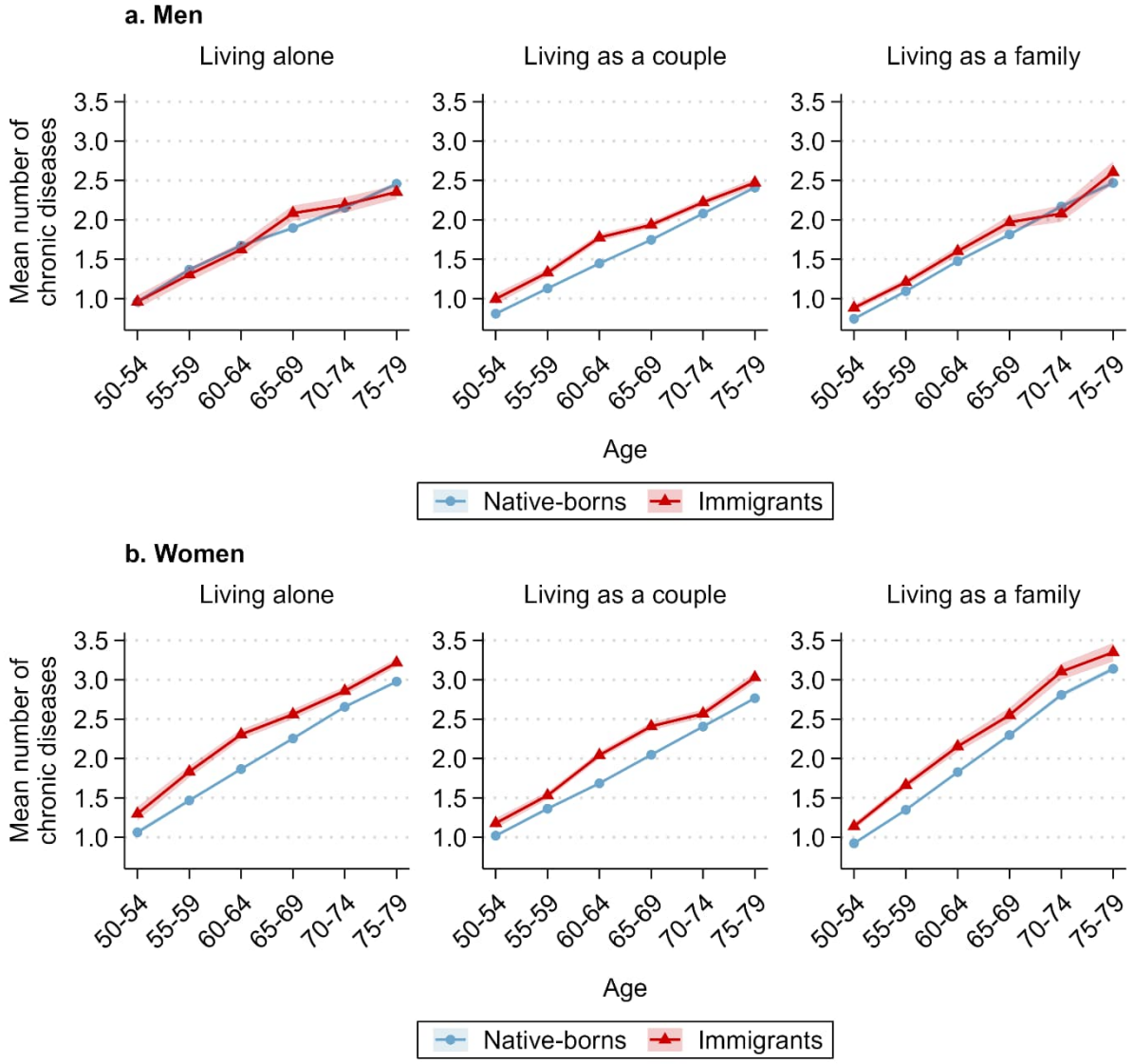

Figure 1. Mean number of chronic diseases in each age group of our study population by migration background and living arrangements for (a) men and (b) women

Predicted number of chronic diseases

Figure 2 presents the predicted number of chronic diseases by migration background and living arrangements based on each specified model (model estimates in Table S4; predictions in

Table S5). For analyses among men, all models show that native-born men living alone have a higher predicted number of chronic diseases than those living as a couple or a family, while the predicted outcome does not differ significantly among immigrant men regardless of their living arrangements. Model 1 reveals that living as a couple or as a family is related to having fewer chronic diseases than living alone for both native-born and immigrant men, although the benefit is not statistically significant for immigrants. In Model 2, which includes the interaction between migration background and living arrangements, the predicted number of chronic diseases becomes largely similar across living arrangements for immigrant men (alone: 1.90 [1.76–2.04]; couple: 1.94 [1.87–2.01]; family: 1.86 [1.75–1.96]), while the benefits of living as a couple or as a family remain for native-born men (alone: 1.84 [1.80–1.88]; couple: 1.71 [1.69–1.73]; family: 1.70 [1.67–1.73]). Finally, we observe only minimal changes in the predicted estimates after adjusting for the three-way interaction between migration background, age, and living arrangements (Model 3).

Analyses for women show that the role of living arrangements in chronic disease accumulation at older ages does not differ significantly between native-born and immigrant women (Figure 2). In all models, the predicted numbers of chronic diseases are lowest for women living as a couple and are highest for women living alone, irrespective of their immigrant history/background. The final model shows that immigrant and native-born women living as a couple (native-born: 1.99 [1.97–2.01]; immigrant: 2.30 [2.22–2.38]) have fewer chronic diseases than women living alone (native-born: 2.16 [2.13–2.19]; immigrant: 2.49 [2.39–2.59]). Notably, unlike native-born men, we do not observe a benefit of shared living arrangements for women living with family (native-born: 2.10 [2.07–2.14]; immigrant: 2.45 [2.33–2.57]).

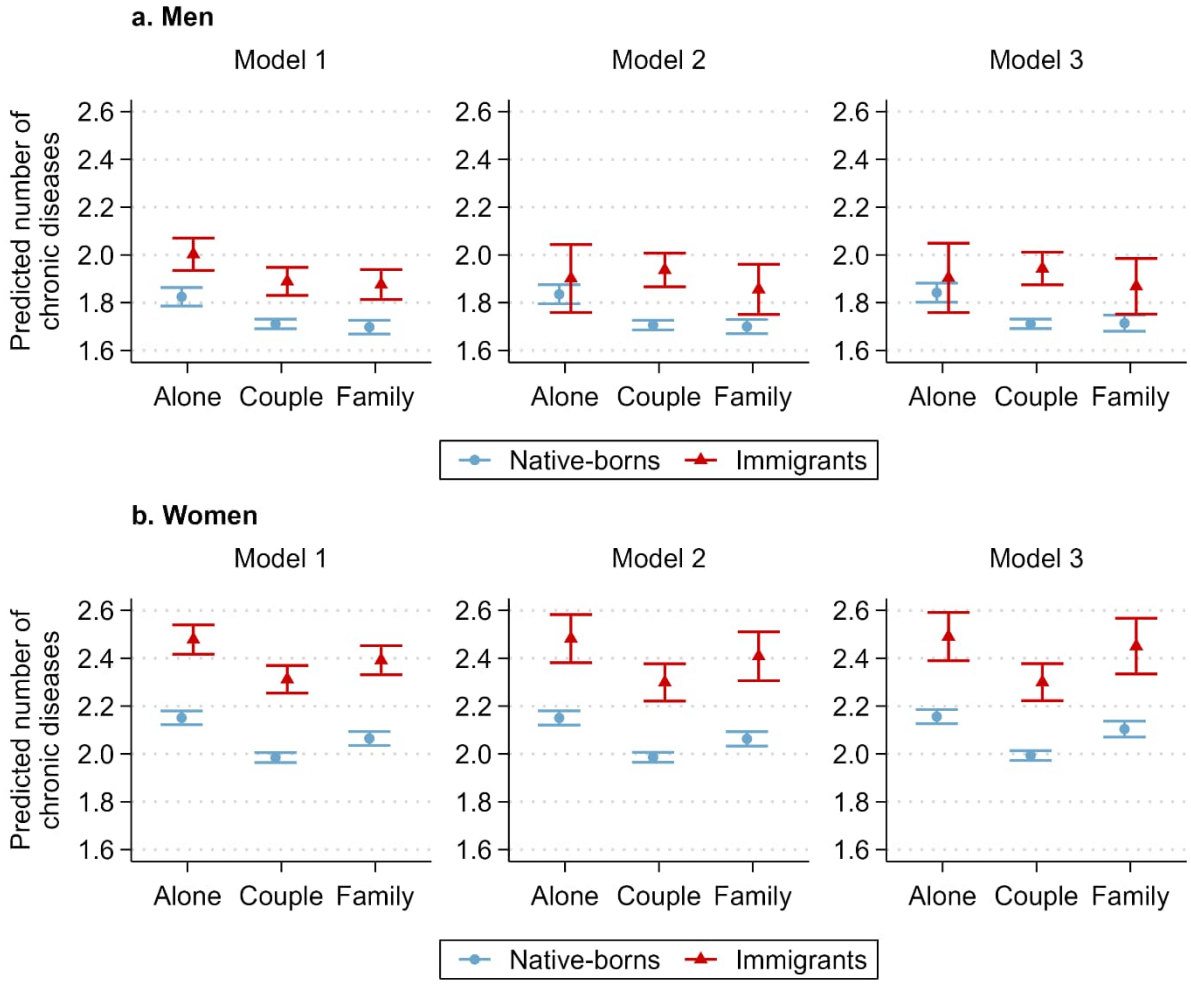

Figure 2. Predicted number of chronic diseases by migration background and living arrangements, based on model analyses among (a) men and (b) women. Model 1 includes migration background, linear and quadratic terms of age, an interaction between migration background and age terms, and living arrangements. Model 2 adds an interaction term between migration background and living arrangements to Model 1. Model 3 adds an interaction term between migration background, age terms, and living arrangements to Model 2. All models are adjusted for education, household income, employment status, and parental status. Non-focal predictors are set to the average level across observations in the sample.

Chronic disease accumulation

Figure 3 extends the findings presented in Figure 2 by illustrating the age-related trajectories of chronic disease accumulation for men and women by their migration background and living arrangements. Consistent with Figure 2, Figure 3 shows that compared to their native-born counterparts, immigrant men living alone have a similar number of chronic diseases regardless of age, while those living as a couple or as a family have a higher number of

chronic diseases at almost all ages. Notably, the slopes of disease accumulation trajectories are only marginally different between native-born and immigrant men across all living arrangements. These patterns reveal that living arrangements can moderate the relationship between migration background and the overall number of chronic diseases at older ages, but not the speed at which these conditions are accumulated.

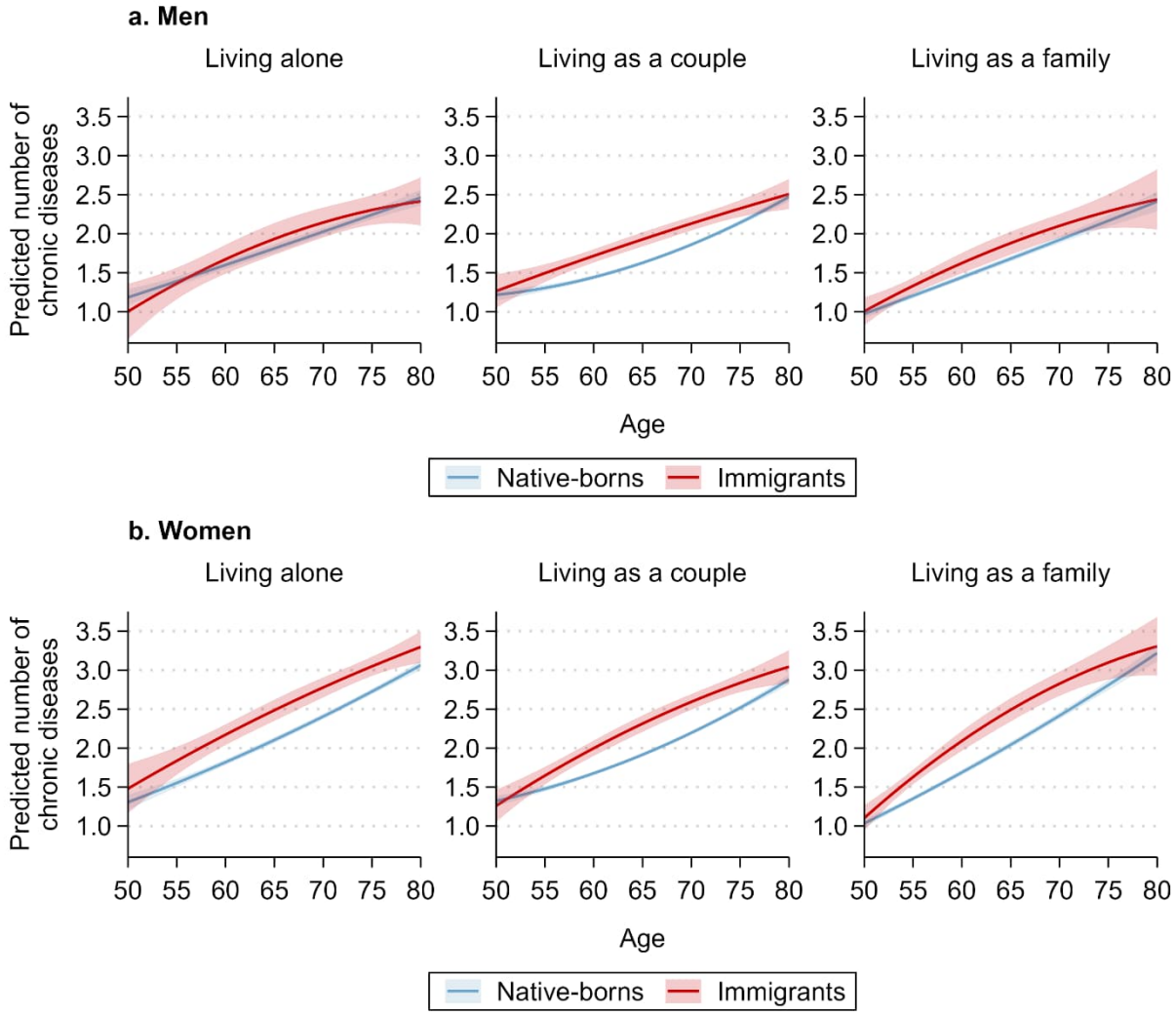

Figure 3. Predicted age-related profiles of chronic disease accumulation by migration background and living arrangements based on Model 3 analyses among (a) men and (b) women. Non-focal predictors are set to the average level across observations in the sample.

The age-specific predictions for women are also consistent with the findings in Figure 2, as the predicted number of chronic diseases among immigrants is higher than that among

their native-born counterparts regardless of living arrangements at almost all ages (Figure 3). Similar to the findings for men, the chronic disease trajectories of native-born and immigrant women appear to be nearly the same across all living arrangements. As there are only minimal differences in both the general levels and the slopes of the chronic disease accumulation trajectories, our findings suggest that the role of living arrangements in later-life health does not differ significantly between native-born and immigrant women.

Country of origin variations in the chronic disease burden

Figure 4 presents the variations in the predicted number of chronic diseases by the development level of the origin country, as measured by the HDI (model estimates in Table S6; prediction results in Table S7). Among men, we find no statistically significant differences in the predicted number of chronic diseases across living arrangements for immigrants from both low HDI countries (alone: 2.27 [95% CI: 1.70–2.84]; couple: 1.75 [1.50–1.99]; family: 1.64 [1.31–1.98]) and high HDI countries (alone: 1.83 [1.67–2.00]; couple:1.98 [1.90–2.06]; family: 1.99 [1.83–2.14]). Among women immigrants, those from low HDI countries are predicted to have the highest number of chronic diseases when they are living in a family (2.80 [2.51–3.09]), while those from high HDI countries are predicted to have the highest number of chronic diseases when they are living alone (2.50 [2.38–2.63]. Additionally, living as a couple is related to the lowest predicted number of chronic diseases, regardless of the country of origin (low HDI countries: 2.14 [1.87–2.41]; medium HDI countries: 2.32 [2.15–2.49]; high HDI countries: 2.32 [2.23–2.41]).

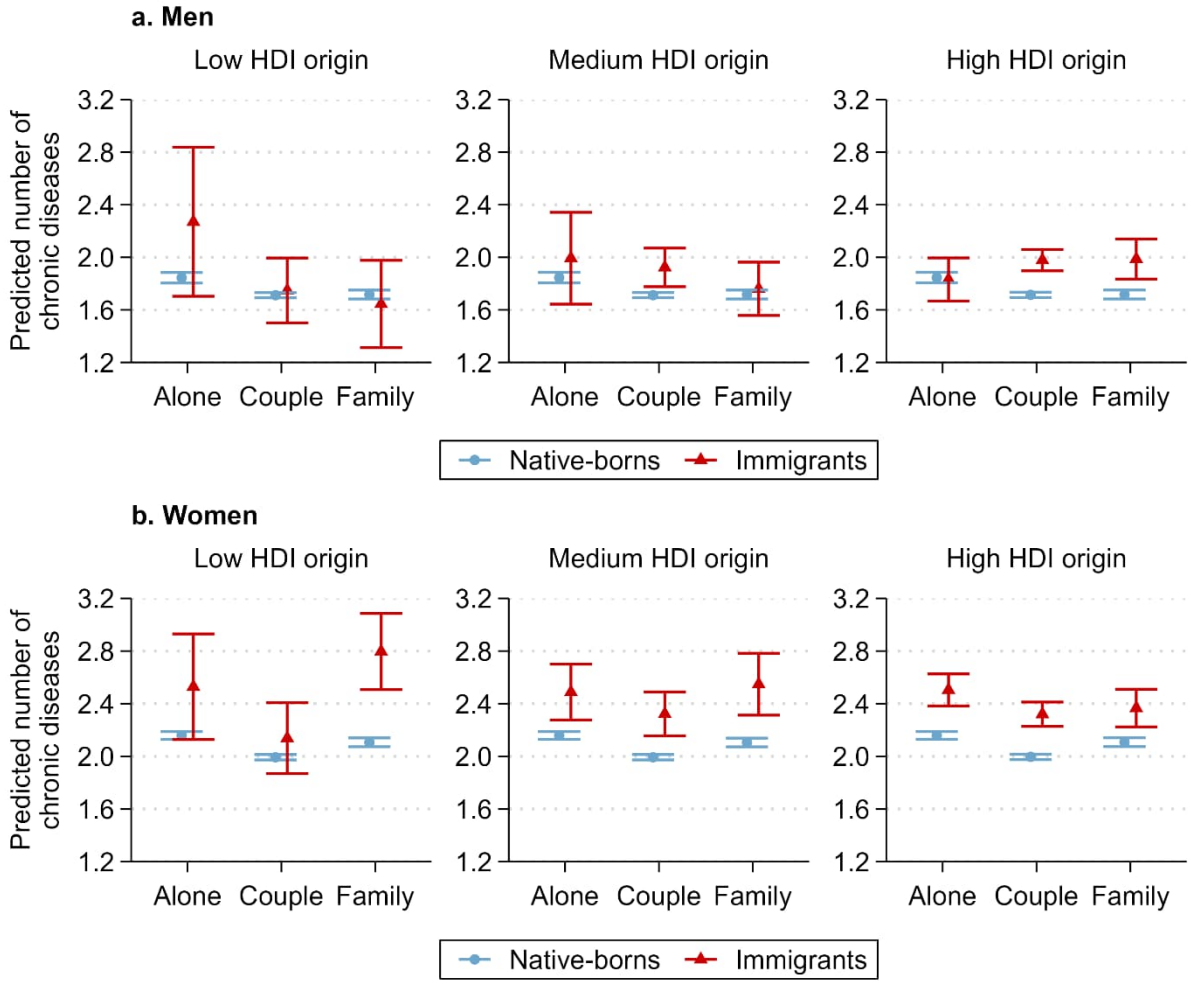

Figure 4. Predicted number of chronic diseases by migration background and living arrangements based on Model 3 analyses in samples stratified by country of origin among (a) men and (b) women. Origin countries are grouped based on the Human Development Index (HDI) into low (HDI < 0.7), medium (HDI ≥ 0.7), and high (HDI ≥ 0.8) development countries. Non-focal predictors are set to the average level across observations in the sample

To further examine how these patterns develop over the years along with age, we examine the age-related trajectories of chronic disease accumulation across different origin countries and living arrangements (Figures S1–2). Compared to their native-born counterparts, male immigrants across all origin countries accumulate chronic diseases at similar speeds regardless of their living arrangements (Figure S1). We do, however, observe some differences in the rate of chronic disease accumulation between immigrant women from low and medium HDI countries compared to native-born women (Figure S2). Specifically,

compared to their native-born counterparts, immigrant women from low HDI countries are predicted to accumulate chronic diseases at a faster rate when living with family, while those from medium HDI countries exhibit an accelerated speed of disease accumulation when living as a couple. Conversely, we do not observe such disparities across living arrangements for immigrant women from high HDI countries, as they have a higher number of chronic diseases than native-born women across all living arrangements.

Findings from sensitivity analysis

Our additional analyses of samples excluding immigrants who stayed in the receiving country for less than ten years show results consistent with our main findings (Table S8, Figure S3). Hence, we conclude that the exclusion of length of stay does not bias our results. Regarding the country of origin, the gap in the predicted numbers of chronic diseases between native-born and immigrant individuals change in origin groups defined using GNI per capita instead of the HDI (Table S9, Figure S4). While the results for men are mostly similar to the main findings, some details change for women, although the trend remains the same. Contrary to our main findings, immigrant women from low-income economies face a significant disadvantage in the predicted number of chronic diseases when they live alone or as a couple. Furthermore, the observed disadvantage among immigrant women from high HDI countries who live alone or as a family disappears in high-income countries.

Discussion

Summary of findings

In this study, we examine the role of living arrangements in chronic disease accumulation among native-born and immigrant individuals in Europe. Overall, immigrants have a higher chronic disease burden than native-born individuals. However, this disparity varies depending

on living arrangements, with men and women showing different patterns. Our results indicate that for both native-born men and native-born women, living with a partner or in a family is associated with having fewer chronic diseases at older ages, although the advantage is less apparent for women living in a family. For immigrants, however, this protective role of shared living arrangements differs between men and women, remaining robust among women but weakening considerably among men. Consequently, compared to their native-born counterparts, immigrant men living as a couple or as a family are predicted to have more chronic diseases, while immigrant women have a higher disease burden regardless of their living arrangements. The differences in the role of living arrangements in chronic disease accumulation among native-born and immigrant individuals are primarily in the baseline level of chronic diseases, rather than in the speed at which these conditions are accumulated. Our findings further suggest that the role of living arrangements in chronic disease accumulation varies based on the development level of the origin country. Specifically, we show that women from low HDI countries who live as a family have a particularly high chronic disease burden.

Interpretations

As hypothesized, we found that native-born individuals living with a partner or as a family have a lower number of chronic diseases, while the protective effect of having shared living arrangements is lost for immigrants, especially for men. This observation aligns with our theoretical expectation that due to the excessive caregiving burden in immigrant families, family support within the household may not provide the same level of health benefits for immigrants as for their native-born counterparts. Our findings are striking, particularly considering that family solidarity and partnership are critical sources of the emotional, instrumental, and financial support immigrants need to navigate the challenges of life in a

new country (Creese et al., 2008; Held, 2018; Singh et al., 2015). Indeed, previous studies have observed more frequent intergenerational transfers of care and support among families within immigrant communities than among families of the majority population across Europe (Albertini et al., 2019). We extend the literature by suggesting that despite the potential intensity of their partnership relationships and familial relationships, the informal care and support at home immigrant older adults receive from their partner or family may be less effective in managing their long-term health conditions than is the case for their native-born counterparts.

One thing to note is that immigrant women are predicted to have a higher number of chronic diseases than native-born women not only when they are living as a couple or as a family, but also when they are living alone, leading to a consistent immigrant disadvantage for women irrespective of their living arrangements. This persistent disadvantage suggests that living arrangements may play a less significant role in chronic disease accumulation among immigrant women due to the unique challenges they face that transcend the benefits and challenges associated with certain types of living arrangements. Our findings are in line with previous studies showing that immigrant women are less positively selected in terms of health. Research on migration intentions and health outcomes has shown that immigrants with more voluntary motivations for migration, such as pursuing economic or educational opportunities, tend to be more positively selected in terms of health (Moullan & Jusot, 2014). As immigrant women often migrate for family reunification purposes, they may have weaker health selection than men, who are more likely to move for economic and educational purposes (Gkiouleka & Huijts, 2020).

Our study further reveals that the implications of living arrangements for chronic disease accumulation at older ages vary among immigrants depending on their countries of origin. We hypothesized that for immigrants from less developed countries with strong

traditions of familial care, there is a stronger protective association between living with a family and chronic disease accumulation than for immigrants from highly developed countries. However, we do not observe significant differences in the chronic disease burden across living arrangements for immigrant men from high HDI countries. Moreover, for women, we find a pattern that further diverges from the hypothesis, as, contrary to expectations, immigrant women from less developed countries are observed to face the highest chronic disease burden when they are living with family. We speculate that this discrepancy between the hypothesis and the outcomes of our study, especially for women, may be attributed to traditional gender roles that place a disproportionate caregiving burden on women from less developed countries, who are expected to provide extensive care for other family members at the expense of their own health (Juárez & Gayet, 2014; Llácer et al., 2007). Furthermore, such increased household responsibilities may limit women's time and energy for self-care and health-promoting activities (Chou, 2007). However, it is important to consider that the available data do not allow us to test these hypotheses, especially considering the origin-specific groups.

Our study highlights the need to invest in social support systems that effectively integrate immigrants, rather than assuming that they will solely rely on their informal networks. Immigrant families are less likely to use formal care without a significant disease diagnosis, as they have language barriers and are less aware of these services (Shrestha et al., 2023). Findings from our study suggest that these access issues should be addressed, as living with a partner or with family members appears not sufficient for managing chronic diseases and long-term health for immigrants. In fact, for some immigrant groups, family-based living arrangements may even amplify health difficulties due to factors such as cultural norms, caregiving expectations, and acculturation challenges. Therefore, it is crucial to develop comprehensive and culturally sensitive support systems that can complement and enhance the

care provided within immigrant households, while also taking into account the cultural diversity of different immigrant communities.

Methodological considerations and limitations

When interpreting our findings, there are several methodological aspects and limitations to consider. First, panel attrition in SHARE may introduce selection bias, particularly if immigrants have dropped out of the survey at a higher rate than their native-born counterparts due to poor health and/or return migration to their home country. While we apply inverse probability weights based on the probability of dropping out of the panel to account for the issue of unequal attrition, it is still possible that our model is insufficient to capture all the complexities associated with the differential attrition between native-born and immigrant individuals.

Second, the potential for reverse causality challenges establishing causal relationships between living arrangements and chronic health outcomes. Changes in older adults' living arrangements may be a response to changes in their health status. For instance, having failing health may motivate older adults to start living with family members, such as their adult children, to receive needed health support. The selective return migration may also partially explain the patterns we observe among immigrants, as immigrant men who have no one to take care of them might have moved back to their country of origin. However, we are not able to test this hypothesis due to the small number of transitions across living arrangement states, especially among immigrant men and women.

Third, the limited sample size of the immigrant population in our data does not allow us to analyze differences across receiving countries. The aging trajectories of immigrants can be heterogeneous based on their life experiences, which can vary considerably depending on both their origin and receiving countries (Kristiansen et al., 2016). While our study provides

valuable insights into the overall and origin-specific patterns of how living arrangements shape chronic disease accumulation trajectories, it cannot capture the variations in specific host country contexts, such as different social support systems and integration policies.

Finally, our approach to grouping origin countries using the HDI from 2015 presents potential limitations. Ideally, the best time point to group immigrants based on their country of origin is the year of migration, given that our aim is to determine the cultural norms and values that immigrants may have brought with them from their home countries. However, due to data availability constraints, we use the 2015 HDI, as it provides information on the greatest number of countries. While this approach is acceptable given the strong historical consistency of the HDI, some immigrants may be from countries with different development levels at the time of their migration.

Conclusion

To conclude, findings from our study provide evidence that living arrangements have different implications for age-related chronic disease accumulation among native-born and immigrant older adults in Europe. In particular, our findings suggest that among immigrants, living with a partner or with family has reduced benefits for later life health, which may be one of the mechanisms underlying their more rapid health deterioration with age. Our findings indicate that some immigrant households may have excessive caregiving burdens that prevent them from effectively managing the long-term health conditions of their older co-residents, and that might, in turn, contribute to unhealthy aging among immigrants in later life. This highlights the need to develop culturally sensitive support systems that are easily accessible for immigrant families.

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Author contributions (CRediT)

Su Yeon Jang: Conceptualization, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review and editing; **Anna Oksuzyan:** Conceptualization, Writing – review and editing; **Frank J. van Lenthe:** Conceptualization, Writing – review and editing; **Mikko Myrskylä:** Conceptualization, Writing – review and editing; **Silvia Loi:** Conceptualization, Writing – review and editing

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Data sharing

This study uses publicly available data from the Survey of Health, Ageing and Retirement in Europe (SHARE), waves 1 through 9 (https://share-eric.eu/data/).

Declaration of interests

We have nothing to declare.

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Supplementary Material

Table S1. Description of categorization for chronic health conditions

Category	Codes of conditions/drugs from SHARE (description)
Heart attack/stroke	ph006d1 (a heart attack including myocardial infarction, coronary thrombosis, or any other heart problem including congestive heart failure), ph00d4 (a stroke or cerebral vascular disease), ph011d3 (drugs for other heart diseases), ph011d4 (drugs for coronary or cerebrovascular diseases)
Hypertension	ph006d2 (high blood pressure or hypertension), ph011d2 (drugs for high blood pressure)
Diabetes	ph006d5 (diabetes or high blood sugar), ph011d6(drugs for diabetes)
Chronic lung diseases	ph006d6 (chronic lung disease such as chronic bronchitis or emphysema), ph011d14 (drugs for chronic bronchitis)
Arthritis	ph006d8 (arthritis including osteoarthritis, or rheumatism; coded until 4), ph006d19 (rheumatoid arthritis; coded from wave 5 to 8), ph006d20 (osteoarthritis or other rheumatism; coded from wave 5 to 8)
Osteoporosis	ph011d11 (drugs for osteoporosis, hormonal; coded until wave 4), ph011d12 (drugs for osteoporosis, non-hormonal; coded until wave 4), ph011d11 (drugs for osteoporosis; coded from wave 5 to 8)
Mental disorders	mh022 (other affective or emotional disorders, including anxiety, nervous, or psychiatric problems; until wave 4), ph006d18 (other affective or emotional disorders including anxiety, nervous, or psychiatric problems; coded from wave 5 to 8), ph011d9 (drugs for sleep problems), ph011d10 (drugs for anxiety or depression)
Stomach ulcers	ph006d11 (stomach ulcer or duodenal ulcer, peptic ulcer)
Parkinson’s disease	ph006d12 (Parkinson’s disease)
Dementia	ph006d16 (Alzheimer's disease, dementia, organic brain syndrome, senility or any other serious memory impairment, organic brain syndrome, senility or any other serious memory impairment)
Cancer	ph006d10 (cancer or malignant tumour, including leukaemia or lymphoma, but excluding minor skin cancers)

Table S2. Country of origin groupings by development level based on the Human Development Index (HDI) in 2015

Low (< 0.7)		Medium (0.700–0.799)		High (≥ 0.800)	
Mean	0.556	Mean	0.759	Mean	0.888
Indonesia	0.698	Kazakhstan	0.799	Norway	0.952
Viet Nam	0.697	Georgia	0.798	Switzerland	0.952
Philippines	0.696	Albania	0.797	Iceland	0.948
Egypt	0.695	Serbia	0.794	Germany	0.941
Gabon	0.692	Borneo Island	0.792	Sweden	0.937
Kyrgyzstan	0.689	Costa Rica	0.792	Denmark	0.936
Bolivia	0.688	Malaysia	0.792	Hong Kong	0.936
Guyana	0.686	Mauritius	0.791	Singapore	0.935
El Salvador	0.663	Thailand	0.789	Australia	0.933
Cabo Verde	0.658	Grenada	0.786	New Zealand	0.933
Iraq	0.656	Iran	0.782	Netherlands	0.932
Morocco	0.656	North Macedonia	0.777	Finland	0.930
Tajikistan	0.651	Soviet Union	0.775	Canada	0.927
Equatorial Guinea	0.648	Mexico	0.769	Liechtenstein	0.926
Nicaragua	0.644	Armenia	0.769	Ireland	0.924
Bhutan	0.625	Venezuela	0.766	Belgium	0.924
India	0.619	Cuba	0.765	United States	0.924
Congo	0.610	Ecuador	0.764	United Kingdom	0.923
Honduras	0.610	Ukraine	0.764	Luxembourg	0.914
Laos	0.604	Sri Lanka	0.760	Japan	0.913
Bangladesh	0.604	Colombia	0.758	Austria	0.910
Sao Tome and Principe	0.595	Peru	0.758	Republic of Korea	0.908
Angola	0.591	Bosnia-Herzegovina	0.757	Slovenia	0.903
Ghana	0.586	Lebanon	0.756	Israel	0.899
Kenya	0.575	Brazil	0.752	France	0.893
Cambodia	0.564	Azerbaijan	0.751	Czech Republic	0.891
Zambia	0.563	Libya	0.749	Spain	0.889
Cameroon	0.562	Republic of Moldova	0.749	Malta	0.887
Comoros	0.556	China	0.741	Estonia	0.883
Syrian Arab Republic	0.552	Dominican Republic	0.739	Greece	0.881
Haiti	0.549	Jordan	0.738	Italy	0.881
Zimbabwe	0.544	Paraguay	0.738	Cyprus	0.874
Mauritania	0.536	Algeria	0.736	Czechoslovakia	0.871
Pakistan	0.525	Turkmenistan	0.725	Poland	0.869
Nigeria	0.520	Tunisia	0.724	Lithuania	0.865
Sudan	0.514	South Africa	0.721	Latvia	0.853
Togo	0.510	Jamaica	0.712	Slovakia	0.852
Benin	0.509	State of Palestine	0.710	Argentina	0.850
Rwanda	0.509	Suriname	0.707	Portugal	0.850
Tanzania	0.507	Uzbekistan	0.701	Chile	0.846
Côte d'Ivoire	0.501			Croatia	0.844
Senegal	0.501			Hungary	0.839
Madagascar	0.499			Montenegro	0.827

Afghanistan	0.479	Russian Federation	0.823
Eritrea	0.473	Türkiye	0.821
Liberia	0.472	Yugoslavia	0.817
Guinea-Bissau	0.470	Romania	0.813
Gambia	0.467	Bulgaria	0.809
Democratic Republic of the Congo	0.457	Belarus	0.809
Ethiopia	0.455	Uruguay	0.807
Guinea	0.449		
Mozambique	0.445		
Sierra Leone	0.438		
Burundi	0.420		
Burkina Faso	0.413		
Mali	0.409		
Chad	0.388		
Central African Republic	0.367		

Table S3. Country of origin groupings by national income based on gross national income (GNI) per capita in 2015

Low (< US$ 4,035)		Medium (US$ 4,035–12,475)		High (> US$ 12,475)	
Mean	1,729	Mean	7,406	Mean	37,244
Angola	3,930	Türkiye	12,080	Norway	93,440
Sri Lanka	3,860	Russian Federation	11,740	Switzerland	86,810
Jordan	3,860	Kazakhstan	11,380	Luxembourg	73,530
State of Palestine	3,670	Mexico	10,660	Macao	60,760
El Salvador	3,490	Costa Rica	10,610	Australia	60,550
Indonesia	3,420	Mauritius	10,410	Denmark	60,510
Cabo Verde	3,360	Malaysia	10,400	Sweden	58,440
Philippines	3,350	Brazil	10,160	Faroe Islands	57,780
Republic of Moldova	3,290	Yugoslavia	9,947	United States	56,510
Morocco	3,290	Romania	9,610	Singapore	53,160
Egypt	3,160	Equatorial Guinea	9,410	Iceland	52,790
Congo	3,100	Libya	8,830	Ireland	50,420
Bolivia	2,900	Suriname	8,640	Netherlands	49,300
Nigeria	2,860	China	7,890	Canada	47,580
Ukraine	2,800	Gabon	7,660	Austria	47,480
Uzbekistan	2,740	Soviet Union	7,465	Finland	47,180
Bhutan	2,680	Lebanon	7,440	Germany	45,780
Viet Nam	2,480	Bulgaria	7,430	Belgium	45,570
Honduras	2,020	Colombia	7,400	United Kingdom	44,380
Côte d'Ivoire	2,010	Montenegro	7,260	Hong Kong	41,180
Laos	1,970	Cuba	7,220	France	41,130
Ghana	1,870	Grenada	7,140	New Zealand	40,650
Nicaragua	1,870	Turkmenistan	6,790	Japan	39,380
Mauritania	1,690	Belarus	6,750	Israel	36,550
India	1,590	Azerbaijan	6,610	Italy	33,000
Zambia	1,540	South Africa	6,550	Republic of Korea	28,720
Cameroon	1,520	Dominican Republic	6,500	Spain	28,460
Comoros	1,470	Peru	6,290	Cyprus	26,090
Haiti	1,430	Paraguay	6,090	Aruba	25,320
Sao Tome and Principe	1,390	Ecuador	5,990	Malta	25,230
Kenya	1,330	Serbia	5,960	Borneo Island	24,325
Senegal	1,330	Thailand	5,580	Slovenia	22,270
Pakistan	1,320	Guyana	5,560	Portugal	20,460
Tajikistan	1,250	North Macedonia	5,550	Greece	20,190
Sudan	1,240	Iran	5,480	Curaçao	18,780
Zimbabwe	1,220	Algeria	5,460	Estonia	18,570
Bangladesh	1,210	Iraq	5,460	Czech Republic	18,370
Kyrgyzstan	1,180	Bosnia-Herzegovina	5,130	Czechoslovakia	18,065
Benin	1,140	Jamaica	4,870	Slovakia	17,760
Cambodia	1,070	Georgia	4,500	Uruguay	16,900
Tanzania	960	Albania	4,390	Lithuania	15,190
Syrian Arab Republic	910	Armenia	4,080	Latvia	15,110
Chad	880	Tunisia	4,070	Chile	14,220

Togo	860	Croatia	13,510
Mali	770	Poland	13,250
Guinea	750	Hungary	13,230
Rwanda	730	Argentina	12,600
Burkina Faso	680		
Guinea-Bissau	670		
Mozambique	660		
Liberia	630		
Afghanistan	600		
Ethiopia	590		
Gambia	580		
Sierra Leone	550		
Somalia	500		
Madagascar	470		
Democratic Republic of the Congo	440		
Central African Republic	370		
Burundi	250		

Table S4. Role of living arrangements in chronic disease accumulation by migration background for men and women

	Men			Women		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
(Intercept)	1.561 ***	1.568 ***	1.539 ***	1.657 ***	1.657 ***	1.685 ***
	(0.039)	(0.039)	(0.057)	(0.033)	(0.034)	(0.052)
Immigrant (ref: Native-born)	-0.032	-0.113	-0.182	0.055	0.050	0.174
	(0.070)	(0.099)	(0.189)	(0.065)	(0.087)	(0.170)
Age	0.031 ***	0.031 ***	0.041 ***	0.050 ***	0.050 ***	0.048 ***
	(0.003)	(0.003)	(0.008)	(0.003)	(0.003)	(0.006)
Age^2	0.000 ***	0.000 ***	0.000	0.000 ***	0.000 ***	0.000 *
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Immigrant × Age terms						
Immigrant × Age	0.035 **	0.032 **	0.036	0.042 ***	0.043 ***	0.026
	(0.011)	(0.011)	(0.028)	(0.010)	(0.011)	(0.022)
Immigrant × Age^2	-0.001 **	-0.001 **	-0.001	-0.001 ***	-0.001 ***	-0.001
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Living arrangements (ref: Alone)						
Living as a couple	-0.114 ***	-0.129 ***	0.033	-0.166 ***	-0.164 ***	0.016
	(0.022)	(0.023)	(0.061)	(0.018)	(0.018)	(0.054)
Living as a family	-0.127 ***	-0.135 ***	-0.211 ***	-0.086 ***	-0.088 ***	-0.271 ***
	(0.024)	(0.025)	(0.057)	(0.021)	(0.021)	(0.052)
Immigrant × Couple		0.164 *	0.229		-0.019	-0.237
		(0.083)	(0.220)		(0.066)	(0.200)
Immigrant × Family		0.090	0.215		0.014	-0.105
		(0.090)	(0.208)		(0.075)	(0.186)
Native-born × Age × Couple			-0.028 **			-0.020 **
			(0.009)			(0.007)
Native-born × Age × Family			0.005			0.014
			(0.009)			(0.008)
Native-born × Age^2 × Couple			0.001 **			0.000 *
			(0.000)			(0.000)
Native-born × Age^2 × Family			0.000			0.000
			(0.000)			(0.000)
Immigrant × Age × Couple			-0.030			0.008
			(0.031)			(0.026)
Immigrant × Age × Family			-0.008			0.038
			(0.033)			(0.027)
Immigrant × Age^2 × Couple			0.001			-0.000
			(0.001)			(0.001)
Immigrant × Age^2 × Family			0.000			-0.001
			(0.001)			(0.001)
Education (ref: Low)						
Medium	-0.143 ***	-0.143 ***	-0.142 ***	-0.256 ***	-0.256 ***	-0.251 ***
	(0.020)	(0.020)	(0.020)	(0.018)	(0.018)	(0.018)
High	-0.290 ***	-0.289 ***	-0.287 ***	-0.467 ***	-0.467 ***	-0.457 ***
	(0.022)	(0.022)	(0.022)	(0.021)	(0.021)	(0.021)

Household income (ref: Low)						
Medium	-0.054 ***	-0.055 ***	-0.053 ***	-0.111 ***	-0.111 ***	-0.100 ***
	(0.015)	(0.015)	(0.015)	(0.014)	(0.014)	(0.014)
High	-0.140 ***	-0.141 ***	-0.138 ***	-0.158 ***	-0.158 ***	-0.152 ***
	(0.015)	(0.015)	(0.015)	(0.014)	(0.014)	(0.014)
Working (ref: Not working)	-0.554 ***	-0.554 ***	-0.558 ***	-0.479 ***	-0.479 ***	-0.490 ***
	(0.018)	(0.018)	(0.018)	(0.017)	(0.017)	(0.017)
Have child (ref: No child)	0.017	0.018	0.021	0.029	0.029	0.031 *
	(0.018)	(0.018)	(0.018)	(0.015)	(0.015)	(0.015)
Number of persons	49,941	49,941	49,941	62,417	62,417	62,417
Number of observations	112,132	112,132	112,132	151,690	151,690	151,690
R-squared	0.146	0.146	0.147	0.178	0.178	0.179
Inverse probability weights	1.647	1.647	1.647	1.532	1.532	1.532
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table S5. Predicted number of chronic diseases for men and women by migration background and living arrangements

	Men		Women	
	Native-born	Immigrant	Native-born	Immigrant
Model 1				
Living alone	1.82 (1.79, 1.86)	2.00 (1.94, 2.07)	2.15 (2.12, 2.18)	2.48 (2.42, 2.54)
Living as a couple	1.71 (1.69, 1.73)	1.89 (1.83, 1.95)	1.98 (1.96, 2.01)	2.31 (2.25, 2.37)
Living as a family	1.70 (1.67, 1.73)	1.88 (1.81, 1.94)	2.06 (2.04, 2.09)	2.39 (2.33, 2.45)
Model 2				
Living alone	1.84 (1.80, 1.88)	1.90 (1.76, 2.04)	2.15 (2.12, 2.18)	2.48 (2.38, 2.58)
Living as a couple	1.71 (1.69, 1.73)	1.94 (1.87, 2.01)	1.99 (1.97, 2.01)	2.30 (2.22, 2.38)
Living as a family	1.70 (1.67, 1.73)	1.86 (1.75, 1.96)	2.06 (2.03, 2.09)	2.41 (2.31, 2.51)
Model 3				
Living alone	1.84 (1.80, 1.88)	1.90 (1.76, 2.05)	2.16 (2.13, 2.19)	2.49 (2.39, 2.59)
Living as a couple	1.71 (1.69, 1.73)	1.94 (1.87, 2.01)	1.99 (1.97, 2.01)	2.30 (2.22, 2.38)
Living as a family	1.71 (1.68, 1.75)	1.87 (1.75, 1.98)	2.10 (2.07, 2.14)	2.45 (2.33, 2.57)

Table S6. Role of living arrangements in chronic disease accumulation by migration background for men and women, with immigrant samples stratified by the Human Development Index (HDI) of the origin country

	Men			Women		
	Low	Medium	High	Low	Medium	High
(Intercept)	1.522 ***	1.524 ***	1.540 ***	1.682 ***	1.684 ***	1.685 ***
	(0.058)	(0.058)	(0.057)	(0.052)	(0.052)	(0.052)
Immigrant (ref: Native-born)	0.092	-0.596	-0.243	-0.211	-0.056	0.304
	(0.566)	(0.419)	(0.194)	(0.542)	(0.303)	(0.211)
Age	0.042 ***	0.042 ***	0.041 ***	0.048 ***	0.048 ***	0.048 ***
	(0.008)	(0.008)	(0.008)	(0.006)	(0.006)	(0.006)
Age^2	0.000	0.000	0.000	0.000 *	0.000 *	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Immigrant × Age terms						
Immigrant × Age	0.101	0.089	0.028	0.096	0.047	0.011
	(0.090)	(0.067)	(0.031)	(0.076)	(0.042)	(0.027)
Immigrant × Age^2	-0.004	-0.002	-0.001	-0.003	-0.001	-0.000
	(0.003)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)
Living arrangements (ref: Alone)						
Living as a couple	0.028	0.027	0.033	0.015	0.014	0.016
	(0.061)	(0.061)	(0.061)	(0.055)	(0.055)	(0.055)
Living as a family	-0.215 ***	-0.215 ***	-0.213 ***	-0.271 ***	-0.273 ***	-0.269 ***
	(0.057)	(0.057)	(0.057)	(0.052)	(0.052)	(0.052)
Immigrant × Couple	-0.262	0.585	0.371	-0.225	0.025	-0.324
	(0.643)	(0.475)	(0.240)	(0.633)	(0.391)	(0.244)
Immigrant × Family	-0.024	0.472	0.322	0.505	-0.000	-0.244
	(0.617)	(0.431)	(0.229)	(0.542)	(0.329)	(0.235)
Native-born × Age × Couple	-0.028 **	-0.028 **	-0.028 **	-0.021 **	-0.021 **	-0.020 **
	(0.009)	(0.009)	(0.009)	(0.007)	(0.007)	(0.007)
Native-born × Age × Family	0.006	0.005	0.005	0.014	0.014	0.014
	(0.009)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)
Native-born × Age^2 × Couple	0.001 **	0.001 **	0.001 **	0.000 *	0.000 *	0.000 *
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Native-born × Age^2 × Family	0.000	0.000	-0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Immigrant × Age × Couple	-0.098	-0.087	-0.025	0.007	-0.048	0.022
	(0.101)	(0.074)	(0.035)	(0.090)	(0.054)	(0.032)
Immigrant × Age × Family	-0.072	-0.064	0.004	-0.069	0.068	0.038
	(0.104)	(0.072)	(0.039)	(0.084)	(0.054)	(0.034)
Immigrant × Age^2 × Couple	0.004	0.002	0.000	-0.001	0.002	-0.001
	(0.003)	(0.002)	(0.001)	(0.003)	(0.002)	(0.001)
Immigrant × Age^2 × Family	0.002	0.002	-0.000	0.004	-0.002	-0.001
	(0.004)	(0.002)	(0.001)	(0.003)	(0.002)	(0.001)
Education (ref: Low)						
Medium	-0.142 ***	-0.143 ***	-0.147 ***	-0.261 ***	-0.263 ***	-0.257 ***
	(0.020)	(0.020)	(0.020)	(0.019)	(0.019)	(0.019)

High	-0.271 ***	-0.278 ***	-0.289 ***	-0.457 ***	-0.461 ***	-0.465 ***
	(0.023)	(0.023)	(0.022)	(0.022)	(0.022)	(0.021)
Household income (ref: Low)						
Medium	-0.050 **	-0.052 **	-0.051 **	-0.088 ***	-0.091 ***	-0.099 ***
	(0.016)	(0.016)	(0.015)	(0.014)	(0.014)	(0.014)
High	-0.132 ***	-0.132 ***	-0.139 ***	-0.138 ***	-0.141 ***	-0.150 ***
	(0.016)	(0.016)	(0.015)	(0.014)	(0.014)	(0.014)
Working (ref: Not working)	-0.546 ***	-0.546 ***	-0.559 ***	-0.488 ***	-0.489 ***	-0.484 ***
	(0.018)	(0.018)	(0.018)	(0.017)	(0.017)	(0.017)
Have child (ref: No child)	0.020	0.022	0.027	0.029	0.035 *	0.027
	(0.019)	(0.018)	(0.018)	(0.016)	(0.016)	(0.016)
Number of persons	46,102	46,644	48,419	57,331	58,136	60,675
Number of observations	103,813	104,865	109,072	139,413	141,136	147,862
R-squared	0.146	0.147	0.147	0.179	0.179	0.179
Inverse probability weights	1.634	1.628	1.641	1.523	1.519	1.531
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table S7. Predicted number of chronic diseases by migration background and living arrangements for men and women based on origin-stratified analysis

	Men		Women	
	Native-born	Immigrant	Native-born	Immigrant
Low HDI origin				
Living alone	1.84 (1.80, 1.88)	2.27 (1.70, 2.84)	2.16 (2.13, 2.19)	2.53 (2.13, 2.93)
Living as a couple	1.71 (1.69, 1.73)	1.75 (1.50, 1.99)	1.99 (1.97, 2.01)	2.14 (1.87, 2.41)
Living as a family	1.72 (1.68, 1.75)	1.64 (1.31, 1.98)	2.11 (2.07, 2.14)	2.80 (2.51, 3.09)
Medium HDI origin				
Living alone	1.85 (1.81, 1.89)	1.99 (1.64, 2.34)	2.16 (2.13, 2.19)	2.49 (2.28, 2.70)
Living as a couple	1.71 (1.69, 1.73)	1.92 (1.78, 2.07)	1.99 (1.97, 2.01)	2.32 (2.15, 2.49)
Living as a family	1.72 (1.68, 1.75)	1.76 (1.56, 1.96)	2.10 (2.07, 2.14)	2.55 (2.31, 2.78)
High HDI origin				
Living alone	1.85 (1.81, 1.89)	1.83 (1.67, 2.00)	2.16 (2.13, 2.19)	2.50 (2.38, 2.63)
Living as a couple	1.71 (1.69, 1.73)	1.98 (1.90, 2.06)	2.00 (1.98, 2.02)	2.32 (2.23, 2.41)
Living as a family	1.72 (1.68, 1.75)	1.99 (1.83, 2.14)	2.11 (2.07, 2.14)	2.37 (2.22, 2.51)

Table S8. Robustness checks for the impact of years since migration

	Men	Women
(Intercept)	1.539 ***	1.688 ***
	(0.057)	(0.052)
Immigrant (ref: Native-born)	-0.172	0.254
	(0.197)	(0.176)
Age	0.041 ***	0.048 ***
	(0.008)	(0.006)
Age^2	0.000	0.000 *
	(0.000)	(0.000)
Immigrant × Age terms		
Immigrant × Age	0.036	0.020
	(0.029)	(0.023)
Immigrant × Age^2	-0.001	-0.001
	(0.001)	(0.001)
Living arrangements (ref: Alone)		
Living as a couple	0.033	0.016
	(0.061)	(0.054)
Living as a family	-0.211 ***	-0.271 ***
	(0.057)	(0.052)
Immigrant × Couple	0.268	-0.267
	(0.230)	(0.209)
Immigrant × Family	0.251	-0.157
	(0.219)	(0.192)
Native-born × Age × Couple	-0.028 **	-0.020 **
	(0.009)	(0.007)
Native-born × Age × Family	0.005	0.014
	(0.009)	(0.008)
Native-born × Age^2 × Couple	0.001 **	0.000 *
	(0.000)	(0.000)
Native-born × Age^2 × Family	0.000	0.000
	(0.000)	(0.000)
Immigrant × Age × Couple	-0.035	0.010
	(0.032)	(0.027)
Immigrant × Age × Family	-0.014	0.042
	(0.034)	(0.028)
Immigrant × Age^2 × Couple	0.001	-0.000
	(0.001)	(0.001)
Immigrant × Age^2 × Family	0.000	-0.001
	(0.001)	(0.001)
Education (ref: Low)		
Medium	-0.143 ***	-0.253 ***
	(0.020)	(0.018)
High	-0.287 ***	-0.458 ***
	(0.022)	(0.021)
Household income (ref: Low)		
Medium	-0.053 ***	-0.101 ***
	(0.015)	(0.014)

High	-0.139	***	-0.153	***
	(0.015)		(0.014)	
Working (ref: Not working)	-0.557	***	-0.492	***
	(0.018)		(0.017)	
Have child (ref: No child)	0.022		0.032	*
	(0.018)		(0.015)	
Number of persons	49,791		62,234	
Number of observations	111,821		151,312	
R-squared	0.146		0.179	
Inverse probability weights	1.646		1.531	
	(0.002)		(0.001)	

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table S9. Robustness checks on country of origin groupings using gross national income (GNI) per capita

	Men			Women		
	Low	Medium	High	Low	Medium	High
(Intercept)	1.523 ***	1.525 ***	1.539 ***	1.683 ***	1.676 ***	1.694 ***
	(0.058)	(0.057)	(0.057)	(0.052)	(0.052)	(0.052)
Immigrant (ref: Native-born)	0.479	-0.509 *	-0.322	-0.353	0.314	0.136
	(0.566)	(0.247)	(0.224)	(0.427)	(0.256)	(0.247)
Age	0.042 ***	0.042 ***	0.041 ***	0.048 ***	0.048 ***	0.048 ***
	(0.008)	(0.008)	(0.008)	(0.006)	(0.006)	(0.006)
Age^2	0.000	0.000	0.000	0.000 *	0.000 *	0.000 *
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Immigrant × Age terms						
Immigrant × Age	0.021	0.115 **	0.013	0.126 *	0.037	0.003
	(0.079)	(0.042)	(0.037)	(0.060)	(0.032)	(0.033)
Immigrant × Age^2	-0.002	-0.004 *	0.000	-0.004 *	-0.001	-0.000
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
Living arrangements (ref: Alone)						
Living as a couple	0.028	0.028	0.031	0.014	0.015	0.015
	(0.061)	(0.061)	(0.061)	(0.055)	(0.055)	(0.055)
Living as a family	-0.214 ***	-0.215 ***	-0.214 ***	-0.272 ***	-0.271 ***	-0.272 ***
	(0.057)	(0.057)	(0.057)	(0.052)	(0.052)	(0.052)
Immigrant × Couple	-0.277	0.540	0.359	-0.124	-0.430	-0.115
	(0.637)	(0.299)	(0.283)	(0.505)	(0.313)	(0.286)
Immigrant × Family	-0.386	0.626 *	0.228	0.607	-0.062	-0.346
	(0.606)	(0.273)	(0.270)	(0.444)	(0.281)	(0.273)
Native-born × Age × Couple	-0.028 **	-0.028 **	-0.028 **	-0.021 **	-0.021 **	-0.021 **
	(0.009)	(0.009)	(0.009)	(0.007)	(0.007)	(0.007)
Native-born × Age × Family	0.005	0.006	0.005	0.014	0.014	0.014
	(0.009)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)
Native-born × Age^2 × Couple	0.001 **	0.001 **	0.001 **	0.000 *	0.000 *	0.000 *
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Native-born × Age^2 × Family	0.000	-0.000	-0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Immigrant × Age × Couple	-0.053	-0.100 *	-0.009	-0.036	0.010	0.011
	(0.092)	(0.048)	(0.042)	(0.074)	(0.041)	(0.038)
Immigrant × Age × Family	-0.004	-0.102 *	0.039	-0.098	0.024	0.078
	(0.094)	(0.049)	(0.047)	(0.068)	(0.041)	(0.041)
Immigrant × Age^2 × Couple	0.003	0.003 *	-0.000	0.001	-0.000	-0.000
	(0.003)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)
Immigrant × Age^2 × Family	0.001	0.003	-0.001	0.005 *	-0.001	-0.002
	(0.003)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)
Education (ref: Low)						
Medium	-0.139 ***	-0.143 ***	-0.150 ***	-0.258 ***	-0.257 ***	-0.269 ***
	(0.020)	(0.020)	(0.020)	(0.019)	(0.019)	(0.019)
High	-0.275 ***	-0.274 ***	-0.291 ***	-0.458 ***	-0.457 ***	-0.467 ***
	(0.023)	(0.023)	(0.023)	(0.022)	(0.022)	(0.022)

Household income (ref: Low)						
Medium	-0.051 **	-0.050 **	-0.050 **	-0.088 ***	-0.092 ***	-0.098 ***
	(0.016)	(0.016)	(0.016)	(0.014)	(0.014)	(0.014)
High	-0.132 ***	-0.132 ***	-0.138 ***	-0.138 ***	-0.144 ***	-0.145 ***
	(0.016)	(0.015)	(0.015)	(0.014)	(0.014)	(0.014)
Working (ref: Not working)	-0.547 ***	-0.548 ***	-0.556 ***	-0.490 ***	-0.484 ***	-0.489 ***
	(0.018)	(0.018)	(0.018)	(0.017)	(0.017)	(0.017)
Have child (ref: No child)	0.020	0.021	0.027	0.029	0.032 *	0.030
	(0.019)	(0.018)	(0.018)	(0.016)	(0.016)	(0.016)
Number of persons	46,233	47,360	47,569	57,498	59,334	59,308
Number of observations	104,112	106,307	107,332	139,831	144,048	144,526
R-squared	0.146	0.146	0.148	0.180	0.181	0.178
Inverse probability weights	1.633	1.632	1.638	1.523	1.521	1.529
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

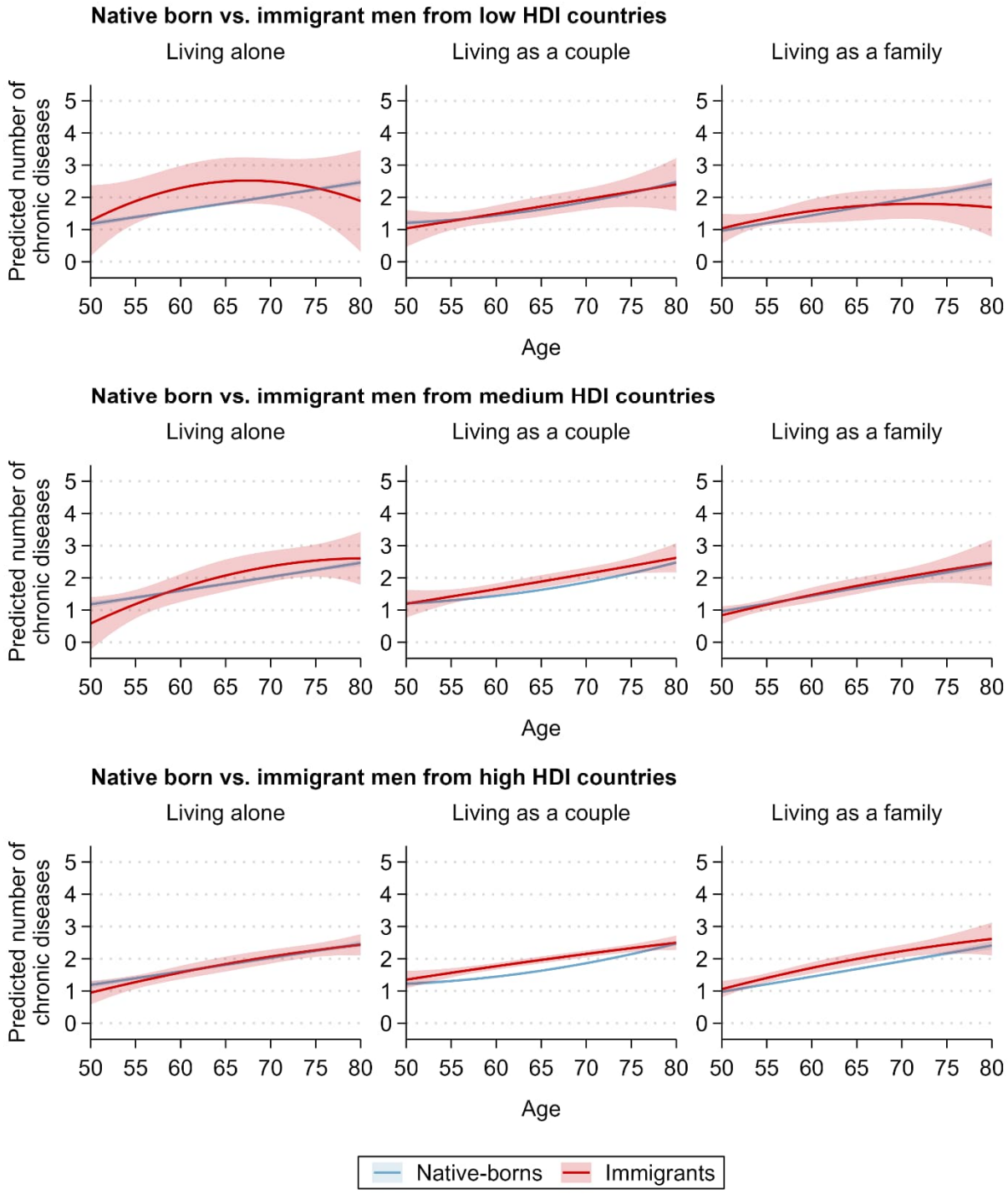

Figure S1. Predicted age-related profiles of chronic disease accumulation by migration background and living arrangements among men based on origin-stratified analysis. Origin countries are grouped based on the Human Development Index (HDI) into low (HDI < 0.7), medium (HDI ≥ 0.7), and high (HDI ≥ 0.8) development countries. Non-focal predictors are set to the average level across observations in the sample.

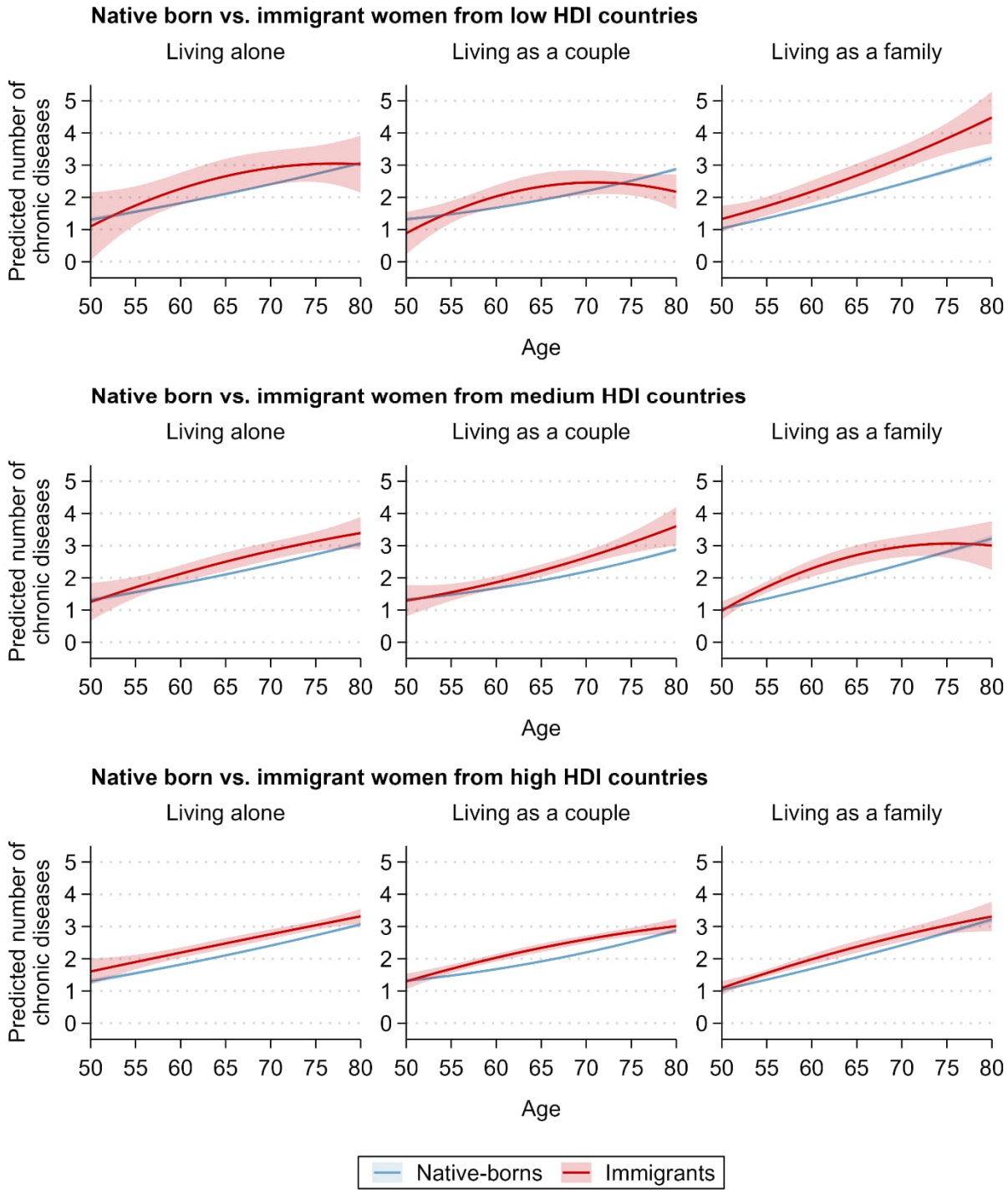

Figure S2. Predicted age-related profiles of chronic disease accumulation by migration background and living arrangements among women based on origin-stratified analysis. Origin countries are grouped based on the Human Development Index (HDI) into low (HDI < 0.7), medium (HDI ≥ 0.7), and high (HDI ≥ 0.8) development countries. Non-focal predictors are set to the average level across observations in the sample.

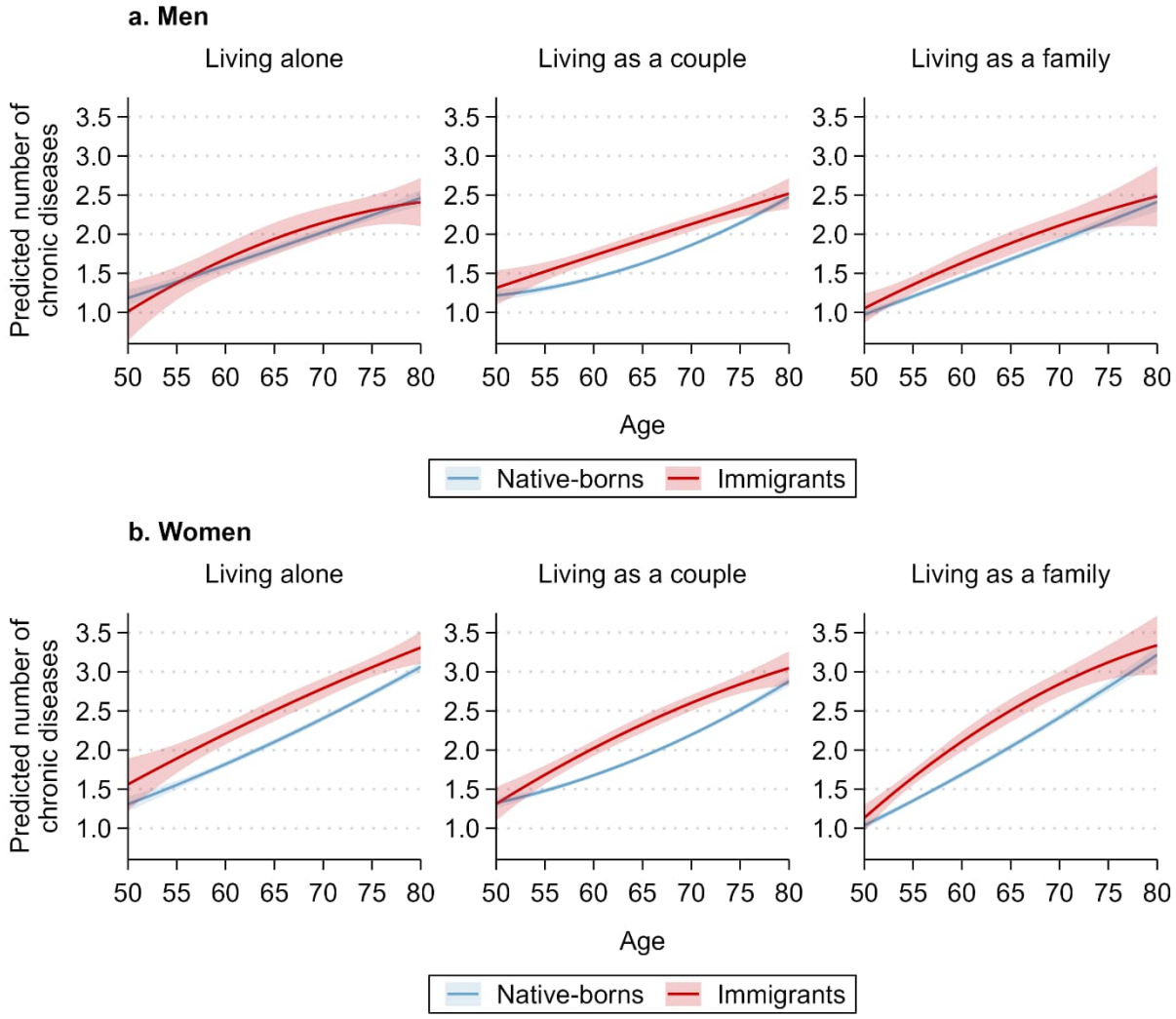

Figure S3. Predicted age-related profiles of chronic disease accumulation by migration background and living arrangements for (a) men and (b) women, in samples excluding immigrants who stayed less than 10 years in the receiving country. Non-focal predictors are set to the average level across observations in the sample.

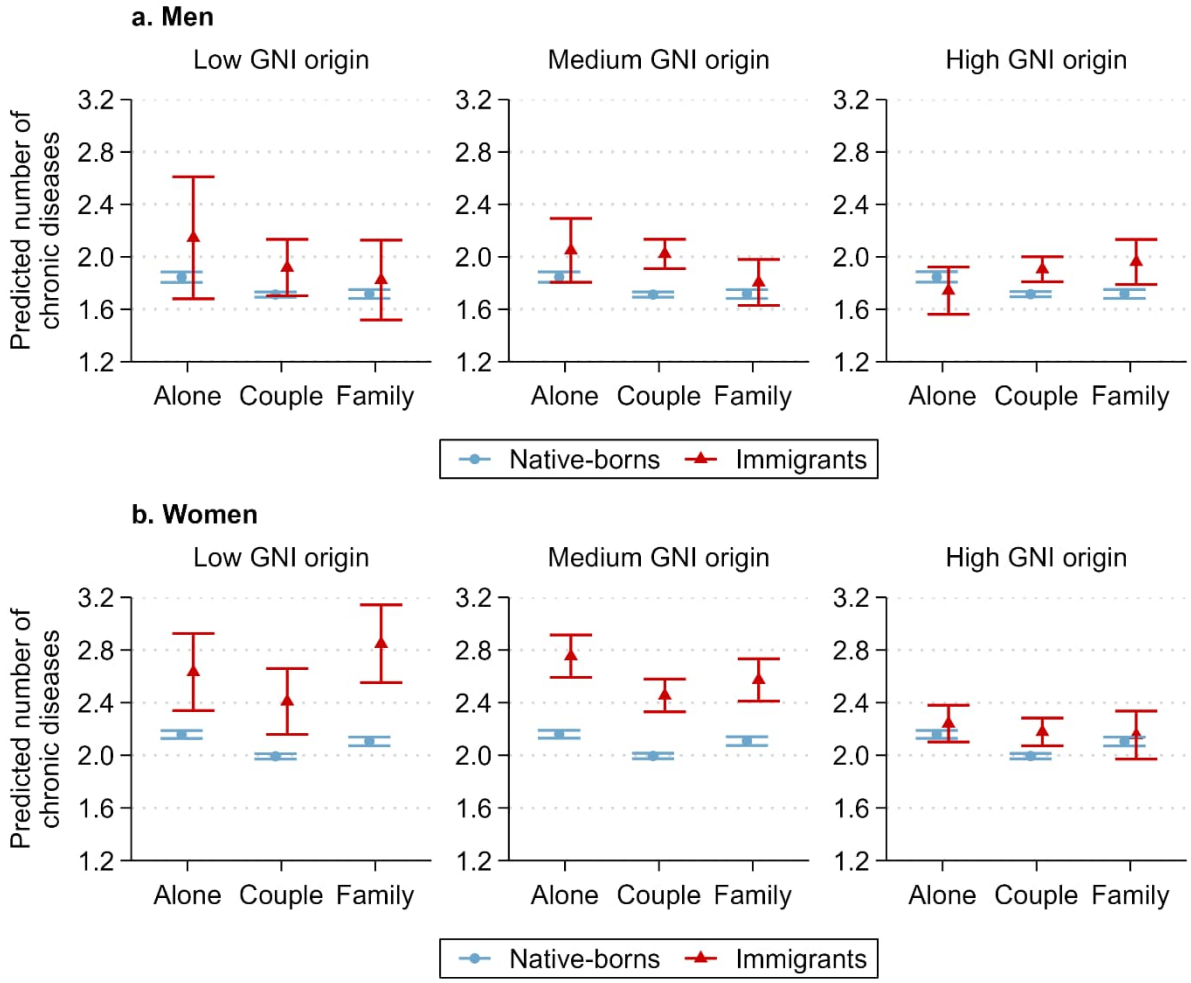

Figure S4. Predicted number of chronic diseases by migration background and living arrangements for (a) men and (b) women. Origin countries are grouped based on gross national income (GNI) per capita into low- (≤ US$ 4,035), medium- (> US$ 4,035 and ≤ US$ 12,475), and high-income (> US$ 12,475) economies. Non-focal predictors are set to the average level across observations in the sample.