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ABSTRACT

Immigrants face a particularly high risk of unhealthy ageing. It is well-known that the probability of having multiple chronic conditions simultaneously, or multimorbidity, tends to increase with age. This study investigates the immigrant-native disparities in age-related health decline, focusing on the number of chronic health conditions; and considers the heterogeneity of this decline within immigrant populations by origin and receiving country. We use data from the Survey of Health, Ageing and Retirement in Europe on adults aged 50 to 79 from 28 European countries, and employ fixed-effects regression models to account for the unobserved heterogeneity related to individual characteristics, including migration background. Our results indicate that immigrants have a higher number of chronic conditions at all ages relative to their native-born peers, but also that the immigrant-native differential in the number of chronic conditions decreases from age 65 onwards. When considering differences by origin country, we find that the speed of chronic disease accumulation is slower among immigrants from the Americas and the Asia and Oceania country groups than it among natives. When looking at differences by receiving country group, we observe that the speed of health decline is slower among immigrants in Eastern Europe than among natives, particularly at older ages. Our findings suggest that age-related trajectories of health vary substantially among immigrant populations by origin and destination country, which underscore that individual migration histories play a persistent role in shaping the health of ageing immigrant populations throughout the life course.

Keywords Migrants; Chronic conditions; Longitudinal; Fixed-effects models; Europe

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Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

Author Contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Su Yeon Jang. The first draft of the manuscript was written by Su Yeon Jang and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

INTRODUCTION

The concept of healthy ageing postulates that the age-effect on later life health deterioration is not a constant but rather a variable, dependent to individual and social contexts [1,2]. This heterogeneity in the speed of age-related health decline is, for example, reflected in the accumulation of chronic health conditions. It is well-known that older people have a higher prevalence of several chronic diseases compared to the younger population, and therefore are more likely suffer from several long-term health conditions simultaneously, or from multimorbidity [3,4]. However, the speed at which people develop such chronic health conditions differs across individual and social contexts such as gender, race/ethnicity, socioeconomic status, and life experience [4–6].

The immigrant populations throughout Europe are ageing fast [7,8]. Therefore, it is important to understand how the health conditions of immigrant populations in European countries develop as they age. Several cross-sectional studies have reported that the risk of multimorbidity is lower among immigrants than among natives, and that the gap increases with the length of stay in the receiving country [9,10]. While previous studies have examined the association between migration and the risk of multimorbidity, the age-related profile in the speed of chronic disease accumulation among older people with or without a migration background is yet to be investigated.

There is considerable evidence that on several other indicators of healthy ageing, such as self-assessed health and well-being, immigrants have better health upon arrival than the natives [11,12]. This immigrant health advantage is a phenomenon that is often referred to as the “healthy immigrant effect” (HIE). Although immigrants exhibit a higher level of health upon arrival in the receiving country, existing studies on the HIE have generally found that over time, the health of immigrants converges towards the level of natives [13,14].

Conversely, some research has found that immigrants in Europe are more likely than the native-born population to have functional limitations, mental health problems, poor self-rated health, and chronic medical conditions, albeit with variation by country of origin and destination [14,15]. In Europe, a large share of immigrants arrived during the period of decolonisation after World War II (1945 to the mid-1960s), the post-war economic expansion period (1960s to 1970s), or the period following the disintegration of the Soviet Union (mid-1990s to 2000s) [16]. Therefore, migration pathways differ considerably across European countries depending on historical

factors, which may, in turn, partly explain the mixed findings on the existence of the HIE in Europe.

Heterogeneity within immigrant populations confounds the association between age and health. For instance, immigrants who experienced fewer political and civil liberties in their country of origin are less selected with respect to self-rated health [17]. Another study has shown that although immigrants from less-developed countries of origin tend to have a lower number of chronic conditions upon arrival in the receiving country, the rate at which they experience an increase in the number of such conditions over the course of their stay in the receiving country is faster than the rate among immigrants from developed nations [14]. To account for such heterogeneity in patterns of age-related changes in chronic health conditions within immigrant populations, fixed-effects models can be a useful tool. Fixed-effects models control for the individual-specific, time-invariant, unobserved characteristics that immigrants bring with them to the host country that may play role in their health and health behaviour, such as their genetic predisposition to develop chronic conditions, as well as their values, norms, and beliefs [18]. Fixed-effects models make it possible to address the selection issue related to time-constant characteristics, and to interpret the link between the age and the health of immigrants in a causal way.

This paper aims to examine immigrant-native disparities in the rate of chronic disease accumulation using fixed-effects models. We first examine the question of whether the *age-related accumulation of chronic conditions differs between immigrants and natives.* Building upon earlier research on immigrant-native health convergence, we expect the number of chronic health conditions to accumulate faster in immigrants than in their native-born peers. We then extend our first question to investigate whether *the estimated immigrant-native differential in age-related health status varies depending on the country of origin and the receiving country* to explore the heterogeneity of immigrants by origin and receiving country.

METHODS

Data and Study Population

This study utilises data from wave 1 to wave 8 (2004–2020) of the Survey of Health, Ageing and Retirement in Europe (SHARE), a panel study on the health and socio-economic background of people aged 50 or older and their spouses in 28 European countries and Israel. We do not include data from wave 3 in our analysis, as it did not

collect information on present medical problems (n = 139,778). We exclude spousal participants who were younger than age 50 at the time of the survey, as chronic health conditions are more prevalent than at older ages (n = 137,387) [4]. Furthermore, immigrants may choose to migrate back to their home country when they experience health deterioration in later life [19,20]. Due to the lack of statistical power after age 79 because of the age composition of the immigrant population, and in order to minimise the selection bias from return migration, we limit our sample to participants under age 80 (n = 124,780). As our focus is on heterogeneity within European immigrant populations, we do not include participants from Israel in the analysis (n = 121,157). After excluding respondents with missing observations on the main and additional covariates of the analyses, our final sample includes a total of 118,786 participants (310,274 person-years).

Multimorbidity and Chronic Diseases

This study uses the number of chronic health conditions as the outcome measure. We first determine the prevalence of doctor-diagnosed conditions through the question: *"Has a doctor ever told you that you had/do you currently have …?*" Our analysis includes 15 selected chronic conditions that have been used elsewhere to study multimorbidity [21]. To prevent overestimation of the counts due to the vague distinctions between some conditions, we re-categorise the list into nine groups: cardiovascular diseases, diabetes, chronic respiratory diseases, arthritis, musculoskeletal diseases, stomach ulcer, Parkinson's disease, mental disorders, and cancer (Table S1). Several of these conditions are episodic, and the extremity of the fluctuations between "active" and "inactive" phases varies across social contexts [22,23]. To account for variability in health resilience between immigrants and natives, we count only the conditions that were currently present at the follow-up survey waves. However, as some of the conditions under the drug treatment may have been unreported due to attenuated symptoms, we additionally consider selected medication uses for cardiovascular diseases, diabetes, chronic respiratory diseases, musculoskeletal diseases, and mental disorders through the question: "*Do you currently take drugs at least once a week for …?* (Table S1)" Finally, we count all chronic conditions prevalent in each individual at each survey wave.

Age and Background Variables

Our main variable of interest – age – is grouped into 5-year categories: 50–54, 55–59, 60–64, 65–69, 70–74, and 75–79. We also include in our analysis time-constant variables of gender and education level and time-varying variables of income, employment, and marital status to control for potential variations in the speed of chronic disease accumulation due to immigrants' demographic and socio-economic characteristics. For education level, we distinguish between three groups based on the 1997 version of the International Standard Classification of Education: low (levels 0–2), medium (levels 3–4), and high (levels 5–6). For income, country- and wave-specific tertiles of the imputed household net income distribution are used as cut points to divide the range into low, medium, and high levels. For employment status, we distinguish between two states: working (employed or self-employed) and not working (retired, unemployed, permanently sick or disabled, homemaker, nursing home resident, or other). Similarly, for marital status, we classify participants as married (regardless of cohabitation with the spouse) or not married (never married, divorced, or widowed).

Immigration Background

Our study defines immigrants as foreign-born individuals. To enable the estimation of regional variations in multimorbidity trajectories among immigrants, we group immigrants based on their origin and receiving countries. Countries are classified into geographical subgroups as defined by the United Nations, with the exceptions of Cyprus (reassigned to the Southern Europe group) and the former Soviet republics (assigned to the Eastern Europe group regardless of the current borders) (Table S1) [24]. The origin country groups are Africa, the Americas, Asia and Oceania, Eastern Europe, and other European countries; while the receiving country groups are Eastern, Northern, Southern, and Western Europe.

Statistical Analysis

We first explore the association between age, immigration status, and the number of chronic conditions with pooled ordinary least square (OLS) models in order to analyse the age-related changes in chronic diseases cross-sectionally, while examining the impact of unobserved factors that is crossed out in the fixed-effects estimations. The predicted number of conditions of person *i* at time *t* (y_{it}) follows the simplified equation:

$$y_{it} = \alpha + \beta_1 \, Immigration_{,i} + \sum \beta_{n+1} \, Age_{n,it} + \sum \beta_{n+7} \, Immigration_i \, Age_{n,it} + \mu \, X_{it} + \gamma \, Z_i + \varepsilon_{it} \quad (1)$$

where α is the intercept, $Immigration_{,i}$ is the dummy variable for having the immigrant background, $\sum \beta_n \, Age_{n,it}$ is the effect of age on the number of conditions in each of six 5-year age groups, $\sum \beta_{n+6} \, Immigration_i \, Age_{n,it}$ *is* the interaction between immigration status and age to test whether the age effect differs between immigrants and native-born persons, X_{it} is a vector for time-varying factors, Z_i is a vector for time-constant characteristics, and ε_{it} is the error term.

Then, we use fixed-effects regression models to account for the unobserved heterogeneity within immigrants with the following equation:

$$y_{it} = \alpha_i + \sum \beta_n \, Age_{n,it} + \sum \beta_{n+6} \, Immigration_i \, Age_{n,it} + \mu \, X_{it} + \varepsilon_{it} \quad (2)$$

where α_i is an intercept that represents the combined effect of all time-constant characteristics of an individual, which is differenced out from the demeaning process. To illustrate the predicted number of chronic conditions in the overall populations at age 50, we use the weighted mean of individual fixed effects as the artificially calculated intercept. Since fixed-effects models wipe out all time-constant characteristics of an individual, we include only those individuals who participated in two or more survey waves in our fixed-effects models (81,148 persons, 272,636 person-years). Furthermore, we implement the random-effects models that consider α_i as a set of random variables, which are included in the online supplementary material.

We construct our models using the stepwise approach. Based on Eq. 1, the first model includes only the demographic variables of age, gender, and immigrant background (Model 1). In Model 2, we add the age-immigration interaction term to the first model (Model 2). Finally, we add the socio-economic variables of education, income, employment, and marital status to the model (Model 3). In all three steps, the fixed-effects models (Eq. 2) do not include time-constant variables of gender, immigration, and education. We then repeat the analysis from our final model (Model 3) in regionally stratified samples for each of the origin and receiving country groups.

Additionally, prior investigations on the HIE among elderly adults have underscored the importance of the timing of immigration, as the health of immigrants who arrived during adulthood tends to decline faster than

the health of immigrants who arrived at younger ages [25,26]. Therefore, we assess the sensitivity of the estimates to the effects of age at migration by performing a stratified analysis for each of the immigrant subgroups by their age at arrival (0–17, 18–34, and ≥35). Furthermore, we assess the potential bias from the attrition of the panel in our sample by rerunning the analysis among study participants who did not drop out since they first entered the survey.

RESULTS

Table 1 presents the summary statistics of the sample by gender and immigration based on the participants' first entry into the panel. The final sample includes 108,447 native (49,225 men and 59,222 women) and 10,339 immigrant (4,581 men and 5,758 women) participants. The proportion of respondents with two or more chronic conditions at study entry is higher in immigrants than in natives irrespective of gender. Among men, the immigrant-native differences are statistically significant only in those with two or five or more conditions, while the trend is clearer among women, with significantly higher proportions of immigrants than of natives having three, four, or five or more chronic conditions.

[Table 1]

Figure 1 illustrates the age-specific prevalence of chronic health conditions by immigration background and gender at study entry (detailed results in Table S2). The results show a trend of higher chronic disease prevalence from one or more to five or more conditions in immigrants than in natives of both genders under age 70, with differences in the level of statistical significance. From age 70 onwards, the proportion of immigrant men with one or more chronic conditions is lower than that of their native-born peers with two or more conditions at age 70 to 74 and with three or more two five or more conditions at age 75 to 79, but the results are statistically insignificant. Similarly, immigrant women aged 75 to 79 show a lower prevalence of one or more chronic conditions than native women, but the results are not statistically significant. Additional subgroup analyses by origin and receiving country report similar patterns (Figure S1-2; detailed results in Table S3-4).

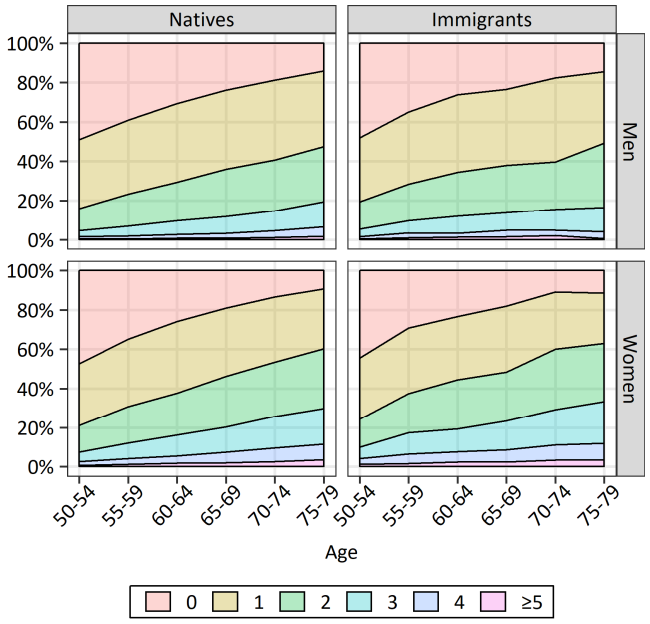

Fig. 1 Age-specific prevalence of chronic conditions at study entry by immigration background and gender

Table 2 shows the estimated results from the OLS and fixed-effects models for the age-related number of chronic diseases. According to the OLS model that includes only the demographic variables of age, gender, and immigration background; being older, being a woman, and having an immigration background is related to having a higher number of chronic conditions (Model 1). The interaction between age and immigrant status in Model 2 shows that the age-related number of chronic conditions is higher among immigrants than among their native-born peers at ages under 65, and is lower at older ages, but the results show no statistical significance. After including the socio-economic factors of education, income, employment, and marital status, the interaction between age and immigrant status shows a higher number of conditions at all ages among immigrants than among their native-born peers, but the results are statistically significant only at ages under 65 (Model 3).

[Table 2]

Figure 2 is the graphical representation of the predicted number of chronic health conditions from Model 3 (panel a) and the immigrant-native health differentials from the estimation (panel b). Figure 2 (a) displays the results of our OLS estimates, which show that the immigrant health disadvantage is present across all age groups. The immigrant-native differential in the number of chronic conditions in each age group (Figure 2 panel b) indicates that the immigrant health disadvantage reaches its peak at age 60 to 64, and decreases from age 65

onwards.

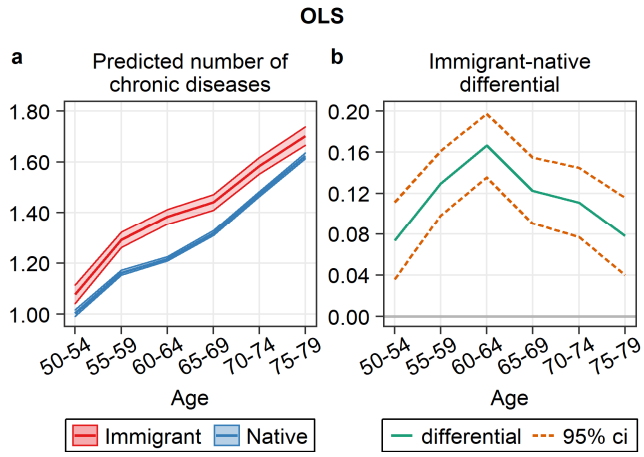

Fig. 2 Chronic health condition trajectories from the OLS estimation. a predicted number of chronic conditions by immigration background; b immigrant-native differentials from the estimation

Note: All covariates calculated at the average; shaded areas from panel a indicate 95% confidence intervals

In the next step, to account for unobserved heterogeneity, we employ fixed-effects models (Table 2; columns 4 to 6). The immigrant health disadvantage in the number of chronic health problems becomes less apparent in the fixed-effects models, particularly at older ages. Similar to the OLS estimates, our fixed-effects findings indicate that older people are predicted to have a higher number of chronic conditions than younger individuals (Model 1). Furthermore, interactions between age groups and immigration status on the number of chronic conditions show a trend of chronic disease accumulation that is faster until age 64, and is slower at ages 65 and above, but the results are not statistically significant, as in the OLS estimates (Model 2). This trend remains the same after adjusting for the socio-economic variables of income, employment, and marital status, with no statistical significance in all age groups (Model 3).

Figure 3 illustrates the age effects on chronic disease development from the fixed-effects Model 3 (panel a), and the immigrant-native differentials derived from the model (panel b). Contrary to the OLS curves, our fixed-effects estimates display a minimal gap in the trajectories of the development of chronic health conditions (Figure 3a). For the immigrant-native differential in the development of age-related chronic health conditions, the fixed-effects graphics show a declining trend at older ages, as in the OLS estimates (Figure 3b).

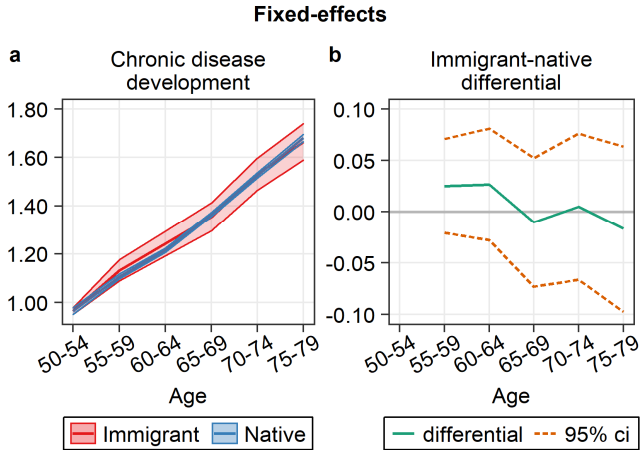

Fig. 3 Age effects on the development of chronic health conditions from the fixed-effects estimation. a group-specific development of chronic health conditions by immigration background; b immigrant-native differentials from the estimation

Note: All covariates calculated at the average; shaded areas from panel a indicate 95% confidence intervals

The random-effects estimates reported in the supplementary material show a pattern similar to that of the OLS and fixed-effects results, with a faster speed of chronic disease accumulation in immigrants than in natives in the under-65 age groups (Table S5). The prediction and differential curves from the random-effects estimations also show a similar trend: i.e., that the immigrant health disadvantage remains at all ages, but decreases at older ages (Figure S3).

Regional Variations in Age-Related Health Trajectories by Immigration Background

We assess regional variations in the age-related development of chronic health conditions in immigrant and native populations by region of origin and receiving country (Figure 4 and 5, respectively) employing fixed-effects models. Our analyses reveal substantial variation in the development of chronic conditions and the immigrant-native differential in health decline by receiving and origin country group. Figure 4 shows that the age-related increase in chronic conditions among immigrants from Eastern and other European countries is largely similar to that among natives at all ages (details in Table S6). Conversely, for immigrants from the Africa, the Americas, and the Asia and Oceania country groups, the age-related profiles of the accumulation of chronic health

conditions are different. Results from Figure 4 panel a show that immigrants from the Africa and the Asia and Oceania country groups have a higher number of chronic conditions than natives at younger ages (ages 60 to 69 for Africa; ages 55 to 64 for Asia and Oceania), while there are no significant immigrant-native differences in the rate of change at older ages. Among immigrants from the Americas, the number of chronic conditions is predicted to be higher from age 75 onwards. The differential curves in Figure 4 panel b indicate that the speed of chronic disease accumulation increases until age 69 and becomes slower from age 70 onwards among immigrants from African countries, while the speed of chronic disease accumulation is slower at younger ages and is faster at older ages among immigrants from the Americas and the Asia and Oceania country groups than among the natives.

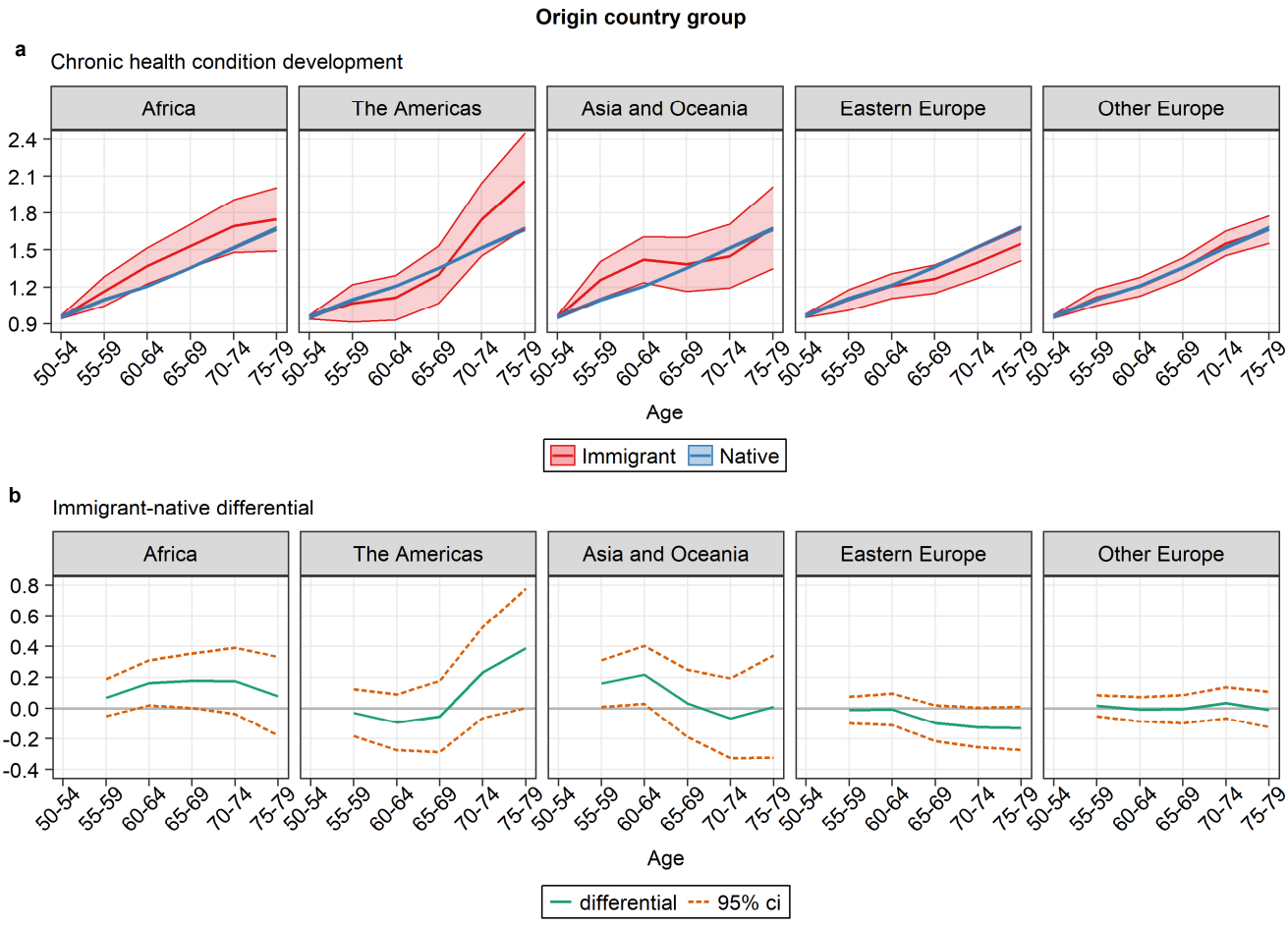

Fig. 4 Regional variations in the development of chronic health conditions by immigration background between origin country groups. a group-specific development of chronic health conditions by immigration background; b immigrant-native differentials from the estimation

Note: All covariates calculated at the average; shaded areas from panel a indicate 95% confidence intervals

The fixed-effects analysis by receiving country group shows that immigrants in Eastern Europe have a significantly lower number of chronic health conditions than the natives, while the predicted number of chronic conditions is higher among immigrants in Western Europe than among the natives at all ages, except in the 65 to 69 age group (Figure 5, panel a; detailed results in Table S7). Among immigrants in Northern and Southern Europe, the number of chronic diseases differs significantly from that among the native population at all ages. The immigrant-native differential curves from panel b in Figure 5 show that the speed of chronic disease accumulation is slower among immigrants than among natives in Eastern Europe, but it is largely similar between immigrants and natives in Northern, Southern, and Western Europe. However, there is a slight decline in the speed of the accumulation of chronic health conditions among immigrants than among natives at older ages in Northern and Southern Europe.

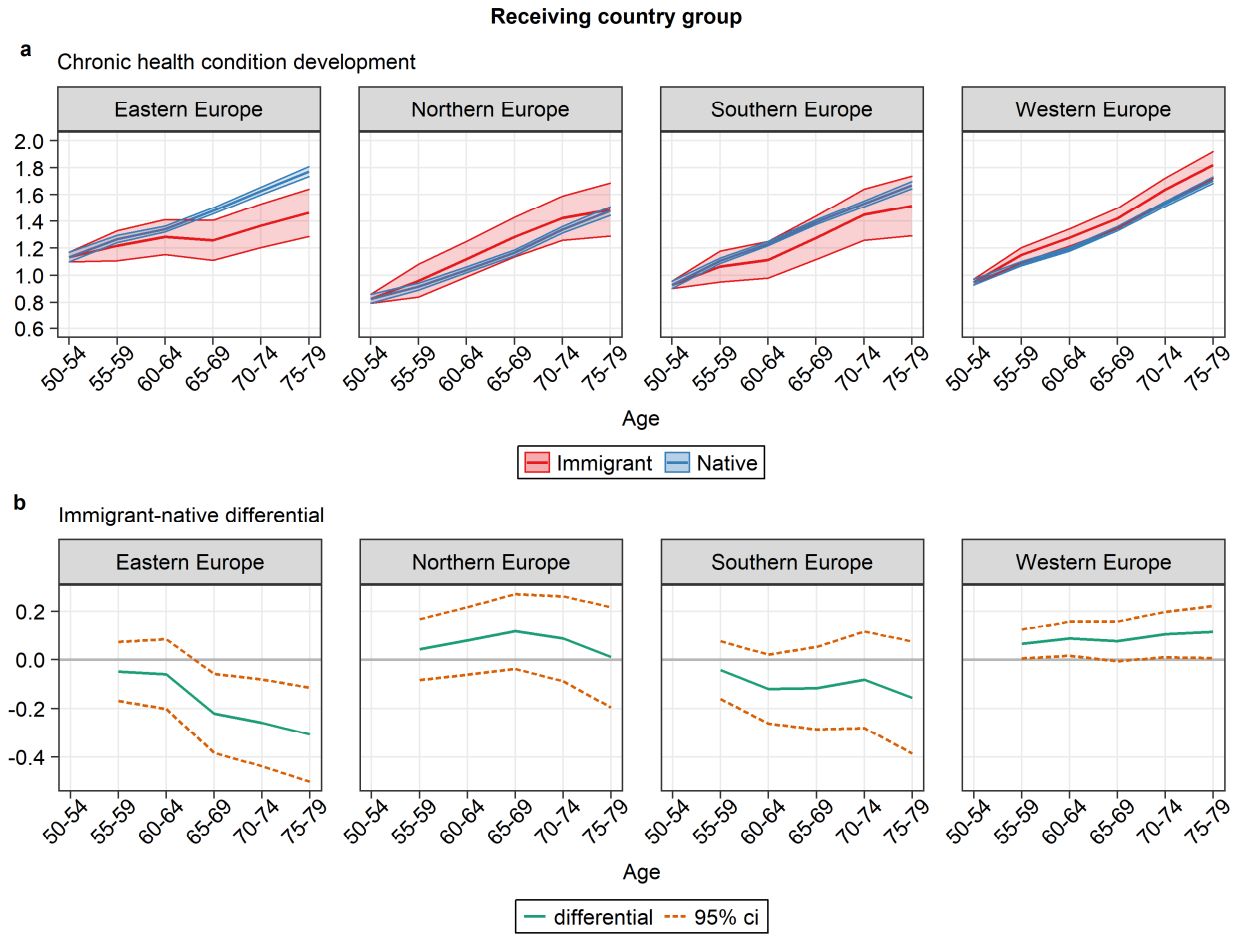

Fig. 5 Regional variations in the development of chronic health conditions by immigration background between

receiving country groups. a group-specific development of chronic health conditions by immigration background; b immigrant-native differentials from the estimation

Note: All covariates calculated at the average; shaded areas from panel a indicate 95% confidence intervals

Sensitivity Analyses

We implemented additional analyses with models including the age at migration to determine whether migrating in adulthood affects the relationship between age and health outcomes in older immigrants (Table S8). Overall, the patterns of age-related health decline among immigrants arriving before age 35 are similar to those among native-born persons. Only immigrants who migrated at ages 35 or older display a greater increase in the number of chronic conditions compared to that of natives. Furthermore, we assessed the potential bias from panel attrition in our sample by rerunning the analysis among study participants who did not drop out of the survey at the final wave 8 (Table S9, Fig. S4–5). The results among the participants who remained in the study for the whole study period are very similar to the patterns observed in the total sample, which suggests that there is no significant panel attrition bias.

DISCUSSION

A key challenge in the study of migrant health is controlling for the heterogeneous experiences that immigrants face in the origin and the receiving country before, during, and after migration [27]. It is often not possible to observe and measure these characteristics. Using fixed-effects regression models that account for individual time-constant determinants of health, we attempted to provide insight into the causal pathways between age and multimorbidity progression in immigrant populations, relative to those among natives. Our results indicated that immigrants have more chronic conditions than their native-born peers at all ages, but the age-related speed in the accumulation of chronic diseases is slower among immigrants than among natives, especially at older ages.

Cross-sectional findings of the current study showed that immigrants have a higher prevalence of chronic conditions at younger ages irrespective of gender and the regional subgroups of the origin and receiving countries. This indicates that immigrant status is associated with the development of a higher number of chronic health

conditions, when the effects of age are not considered. Our results are in line with those of earlier cross-sectional studies in Europe on well-known indicators of migrant health in later life, which showed that immigrants have poorer health than natives [14,15,28]. However, in the longitudinal analysis of both fixed-effects and random-effects models in our study, we found that the relative rate of chronic disease accumulation accelerates only until age 64, and then slows down from age 65 onwards, although our results lacked statistical significance. This trend is not found in the literature. Our findings indicated that when accounting for age-related changes, there may be a trend of immigrants being healthier than natives, especially at older ages.

Our analyses of age-related changes in the number of chronic conditions showed that immigrants accumulate chronic diseases at a slower speed than natives at older ages. These favourable age-related health trajectories of immigrants can be explained by the stronger family network and health behaviours of immigrants. Outside of time-constant characteristics such as gender and education, factors that are known to aggravate the progression of chronic disease accumulation over time include the lack of social support [6] and having an unhealthy lifestyle [29,30]. In general, immigrants receive less emotional support from their surrounding networks than the native population, which has a negative impact on their mental and physical health [31,32]. Nonetheless, immigrant family ties grow stronger with the length of their stay in the receiving country [33]. This is particularly true for immigrants who arrive at younger ages, as they are more likely to migrate with their family [34].

Another factor to consider when seeking to explain our finding that immigrants have better health than natives at older ages is health behaviour. Although immigrants are more likely to adopt unhealthy lifestyles as the length of their stay in the receiving country increases [35], their likelihood of quitting smoking [36–38], reducing their alcohol consumption [38], and increasing their physical inactivity [39,40] increases concurrently. This tendency among immigrants to return to a healthy behavioural norm may result in the slower accumulation of chronic diseases at older ages, as has been found in the current study. Conversely, immigrants who arrive at younger ages tend to go through an easier and more complete process of integration into the receiving society, which may lead them to adopt health behaviours and cultural beliefs similar to those of the native population. The results of our sensitivity analysis, which showed that immigrants who arrived as a child or during young adulthood have a similar or a lower number of age-related chronic health conditions at older ages than that of natives, can be partly explained by these previous findings, as those immigrants who arrived at younger ages are more likely to

have familiarised themselves with the unhealthy norms of the receiving country.

Our analyses of regional variations by origin and receiving country revealed a higher predicted number of chronic health conditions among immigrants from Africa and Asia and Oceania at ages younger than 65, which converges to that of the native population at older ages. Immigrants are more likely than natives to work in risky occupations, which can lead to a faster deterioration in health due to the high physical burdens and adverse environmental conditions associated with these occupations [28,41]. In particular, immigrants from less developed regions, who have higher chances of working in physically demanding occupations, have much steeper self-assessed mental, functional, and chronic physical health declines than natives [42,43]. Our results on the faster accumulation of chronic diseases in immigrants from Africa and Asia and Oceania at working ages reflect the association between the work-related burdens of these immigrants and their adverse health outcomes.

Our study found a slower accumulation of chronic diseases among immigrants living in Eastern Europe from age 65 onwards. As international migration to Eastern Europe is largely characterised by massive inflows from neighbouring countries during the post-Soviet era, many immigrant groups in Eastern Europe have a cultural background similar to that of the native population [44]. Cultural congruity between the origin and the destination countries appears to shape immigrant health trajectories. Immigrants from countries with a cultural background similar to that of the receiving society are more likely to experience better physical and psychological conditions than the overall foreign-born population [45,46]. Furthermore, a higher level of language- and identity-related acculturation to the majority culture leads to a lower risk of developing chronic health problems and cognitive impairment at older ages [47,48]. Findings from the current study support the assumption that cultural congruity between the origin and the receiving countries leads to better age-related health outcomes.

This study has some limitations. First, while the fixed-effects models control for the time-constant characteristics within an individual, some unobserved, time-varying characteristics remain uncontrolled, and could confound the association between age and the progression in the number of chronic health conditions among immigrants. For example, immigrants may accept the unhealthy lifestyle of the native population over the course of their stay in the receiving country, which can upwardly bias the amount of health deterioration they experience at older ages. We are not able to account for such changes due to data unavailability, but it is a topic worth investigating in future studies.

Second, there is an issue of selection bias due to panel attrition in SHARE, which is a common issue in longitudinal designs. As declining health can lead participants to drop out of the survey, a panel may seem to get healthier over time; an effect that is often referred to as panel attrition bias. Panel attrition bias could be particularly more problematic in our study if immigrants were more likely to attrite from the study than natives due to poor health and/or return migration to their home country [19,20]. Our sensitivity analysis focusing on individuals who remained in the study over the whole study period showed very similar results to those of the main analyses. However, due to the nature of a panel survey, the possibility of effects from differential panel attrition still remains, which may have led to an underestimation of the number of chronic health conditions at older ages among both immigrants and natives.

In conclusion, having an immigrant background is associated with age-health trajectories, as immigrants tend to have a greater number of chronic conditions relative to the native-born population at all ages, but the age-related increase in the number of chronic conditions at ages 65 and older is slower among immigrants than among their native-born peers. Trajectories of health decline vary by receiving and origin country even after taking the unchanging innate characteristics in each region into account. Our findings on the health gap between natives and immigrants by region and origin suggest that the effects of individual migration histories may persist throughout the life course.

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463 Table 1. Baseline characteristics [a] of the study population by gender and immigration background

	Men				Women			
	Natives		Immigrants		Natives		Immigrants	
	N	%	N	%	N	%	N	%
Total	49,225	(100.0)	4,581	(100.0)	59,222	(100.0)	5,758	(100.0)
Entry wave (year)								
Wave 1 (2004-2005)	10,308	(20.9)	847	(18.5) ***	11,797	(19.9)	1,011	(17.6) ***
Wave 2 (2006-2007)	5,804	(11.8)	388	(8.5) ***	6,951	(11.7)	500	(8.7) ***
Wave 4 (2010-2011)	12,906	(26.2)	1,501	(32.8) ***	16,019	(27.0)	2,021	(35.1) ***
Wave 5 (2012-2013)	8,234	(16.7)	1,054	(23.0) ***	9,376	(15.8)	1,136	(19.7) ***
Wave 6 (2014-2015)	4,596	(9.3)	529	(11.5) ***	5,538	(9.4)	668	(11.6) ***
Wave 7 (2017-2019)	7,005	(14.2)	234	(5.1) ***	9,046	(15.3)	376	(6.5) ***
Wave 8 (2019-2020)	372	(0.8)	28	(0.6)	495	(0.8)	46	(0.8)
Age groups								
50 – 54	9,949	(20.2)	1,025	(22.4) ***	14,349	(24.2)	1,519	(26.4) ***
55 – 59	9,910	(20.1)	912	(19.9)	11,675	(19.7)	1,149	(20.0)
60 – 64	9,608	(19.5)	838	(18.3) *	10,748	(18.1)	953	(16.6) **
65 – 69	8,407	(17.1)	767	(16.7)	9,172	(15.5)	801	(13.9) **
70 – 74	6,570	(13.3)	622	(13.6)	7,434	(12.6)	751	(13.0)
75 – 79	4,781	(9.7)	417	(9.1)	5,844	(9.9)	585	(10.2)
Education								
Low	17,409	(35.4)	1,406	(30.7) ***	25,066	(42.3)	2,175	(37.8) ***
Medium	21,024	(42.7)	1,862	(40.6) **	22,875	(38.6)	2,163	(37.6)
High	10,792	(21.9)	1,313	(28.7) ***	11,281	(19.0)	1,420	(24.7) ***
Household income (tertiles)								
Low	17,544	(35.6)	1,525	(33.3) **	25,400	(42.9)	2,506	(43.5)
Medium	14,113	(28.7)	1,514	(33.0) ***	16,158	(27.3)	1,700	(29.5) ***
High	17,568	(35.7)	1,542	(33.7) **	17,664	(29.8)	1,552	(27.0) ***
Employment								
Not working	30,722	(62.4)	2,942	(64.2) *	41,082	(69.4)	3,939	(68.4)
Employed/self-employed	18,503	(37.6)	1,639	(35.8) *	18,140	(30.6)	1,819	(31.6)
Marital status								
Not Married	8,620	(17.5)	681	(14.9) ***	17,256	(29.1)	1,864	(32.4) ***
Married	40,605	(82.5)	3,900	(85.1) ***	41,966	(70.9)	3,894	(67.6) ***
Region of residence [b]								
Eastern Europe	12,755	(25.9)	993	(21.7) ***	16,485	(27.8)	1,475	(25.6) ***
Northern Europe	6,081	(12.4)	344	(7.5) ***	6,887	(11.6)	448	(7.8) ***
Southern Europe	13,921	(28.3)	818	(17.9) ***	16,641	(28.1)	974	(16.9) ***
Western and Central Europe	16,468	(33.5)	2,426	(53.0) ***	19,209	(32.4)	2,861	(49.7) ***
Origin country group [c]								
Africa	0	(0.0)	502	(11.0)	0	(0.0)	505	(8.8)
The Americas	0	(0.0)	169	(3.7)	0	(0.0)	259	(4.5)
Asia and Oceania	0	(0.0)	314	(6.9)	0	(0.0)	313	(5.4)
Eastern Europe	0	(0.0)	1,402	(30.6)	0	(0.0)	2,095	(36.4)
Other European countries	0	(0.0)	2,194	(47.9)	0	(0.0)	2,586	(44.9)
Number of chronic conditions								
0	15,584	(31.7)	1,380	(30.1) *	16,917	(28.6)	1,523	(26.5) ***
1	18,964	(38.5)	1,713	(37.4)	19,896	(33.6)	1,803	(31.3) ***
2	9,720	(19.7)	973	(21.2) *	12,687	(21.4)	1,296	(22.5)

3	3,511	(7.1)	358	(7.8)	6,228	(10.5)	707	(12.3) ***
4	1,087	(2.2)	108	(2.4)	2,508	(4.2)	307	(5.3) ***
≥ 5	359	(0.7)	49	(1.1) *	986	(1.7)	122	(2.1) *

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

[a] Unweighted observations of samples at study entry.

[b] Northern Europe = Denmark, Finland, Ireland, Sweden; Western Europe = Austria, Belgium, France, Germany, Luxembourg, Netherlands, Switzerland; Southern Europe = Croatia, Cyprus, Greece, Italy, Malta, Portugal, Slovenia, Spain; Eastern Europe = Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia.

[c] Country classifications based on the geographic regions documented on the current and previous versions of "Standard Country or Area Codes for Statistical Use" by the Statistics Division of the United Nations Secretariat (https://unstats.un.org/unsd/methodology/m49/#geo-regions). All regions followed the documentations except for the former Soviet republics (classified as Eastern European countries) and Cyprus (classified as a Southern European country). European regions were first classified into four geographical regions (East, North, South, and West/Centre) and Northern, Southern, Western Europe were later grouped as "other European countries" for the analyses (see Table A1 for the detailed list of countries).

Table 2. Number of chronic conditions developed by age and immigration background

	OLS			Fixed-effects		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Age group (ref: 50–54)						
55–59	0.223***	0.220***	0.158***	0.151***	0.149***	0.142***
	(0.007)	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)
60–64	0.412***	0.408***	0.213***	0.285***	0.283***	0.251***
	(0.007)	(0.008)	(0.008)	(0.007)	(0.008)	(0.008)
65–69	0.616***	0.616***	0.314***	0.452***	0.453***	0.399***
	(0.007)	(0.008)	(0.008)	(0.008)	(0.009)	(0.009)
70–74	0.805***	0.807***	0.470***	0.621***	0.620***	0.562***
	(0.008)	(0.008)	(0.009)	(0.010)	(0.010)	(0.011)
75–79	0.980***	0.984***	0.620***	0.778***	0.779***	0.716***
	(0.008)	(0.008)	(0.009)	(0.011)	(0.011)	(0.012)
Immigrant (ref: Native)	0.110***	0.103***	0.073***			
	(0.007)	(0.020)	(0.019)			
Woman (ref: Man)	0.240***	0.240***	0.182***			
	(0.004)	(0.004)	(0.004)			
Age group x Immigration status						
55–59 x Immigrant		0.038	0.056*		0.023	0.025
		(0.025)	(0.025)		(0.023)	(0.023)
60–64 x Immigrant		0.047	0.093***		0.019	0.027
		(0.025)	(0.025)		(0.028)	(0.028)
65–69 x Immigrant		-0.001	0.049		-0.016	-0.010
		(0.026)	(0.025)		(0.032)	(0.032)
70–74 x Immigrant		-0.017	0.037		-0.000	0.005
		(0.026)	(0.026)		(0.036)	(0.036)
75–79 x Immigrant		-0.048	0.004		-0.021	-0.017
		(0.028)	(0.027)		(0.041)	(0.041)
Education (ref: Low)						
Medium			-0.144***			
			(0.005)			
High			-0.229***			
			(0.005)			
Income (ref: Low)						
Medium			-0.023***			-0.001
			(0.005)			(0.004)
High			-0.064***			0.008
			(0.005)			(0.004)
Employed (ref: Not working)			-0.397***			-0.101***
			(0.006)			(0.007)
Married (ref: Not married)			-0.097***			-0.067***
			(0.005)			(0.012)
Constant	0.657***	0.657***	1.221***	0.928***	0.928***	1.041***
	(0.006)	(0.007)	(0.009)	(0.007)	(0.007)	(0.012)
Number of persons	118,786	118,786	118,786	81,148	81,148	81,148
Number of person-years	310,274	310,274	310,274	272,636	272,636	272,636

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

478 SUPPLEMENTARY MATERIAL

479 Table S1. Description of categorisation for selected variables

Variable	Description
Origin country group	
Africa	Africa, Algeria, Angola, Benin, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Congo, Congo (Democratic Republic of), Congo (Republic of), Cote d'Ivoire, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Ethiopia (before Eritrea broke away), Former Protectorate of Northern Rhodesia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Libyan Arab Jamahiriya, Madagascar, Mali, Mauritania, Mauritius, Morocco, Mozambique, Nigeria, Reunion, Rwanda, Sao Tome and Principe, Senegal, Somalia, South Africa, Sudan, Tanzania (United Republic of), Togo, Tunisia, Zambia, Zimbabwe
The Americas	Argentina, Aruba, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Cuba, Curaçao, Dominican Republic, Ecuador, El Salvador, French Guiana, Greenland, Grenada, Guadeloupe, Haiti, Honduras, Martinique, Mexico, Netherlands Antilles, Paraguay, Peru, Suriname, United States of America, Uruguay, Venezuela
Asia and Oceania	Afghanistan, Afghan-Turkish, Australia, Bangladesh, Bhutan, Borneo Island, Cambodia, China, Former Netherlands East-Indies, French Polynesia, Hong Kong, India, Indonesia, Iran (Islamic Republic of), Iraq, Israel, Japan, Jordan, Korea (Republic of), Lao People's Democratic Republic, Lebanon, Macau, Malaysia, Minor Asia, New Zealand, Pakistan, Palestinian Territory (occupied), Philippines, Singapore, Sri Lanka, Syrian Arab Republic, Taiwan, Thailand, Turkey, Turkish-Kurdish, Viet Nam
Eastern Europe [a]	Armenia, Azerbaijan, Belarus, Bulgaria, Chechnya, Czech Republic, Czechoslovakia, Estonia, Former Eastern Territory of German Reich, Georgia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Republic of, Poland, Romania, Russian Federation, Slovakia, Tajikistan, Turkmenistan, Ukraine, Union of Soviet Socialist Republics, Uzbekistan
Other European countries	Albania, Austria, Belgium, Bosnia and Herzegovina, Croatia, Cyprus, Denmark, Faroe Islands, Finland, Former Territories of German Reich, France, German Spanish, Germany, Greece, Iceland, Ireland, Italy, Kosovo, Liechtenstein, Luxembourg, Macedonia (former Yugoslav Republic of), Malta, Monaco, Montenegro, Netherlands, Norway, Portugal, Serbia, Slovenia, Socialist Federal Republic of Yugoslavia, Spain, Sweden, Switzerland, United Kingdom
Region of residence	
Eastern Europe [a]	Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia
Northern Europe	Denmark, Finland, Ireland, Sweden
Southern Europe	Croatia, Cyprus, Greece, Italy, Malta, Portugal, Slovenia, Spain
Western/central Europe	Austria, Belgium, France, Germany, Luxembourg, Netherlands, Switzerland
Chronic conditions	
Cardiovascular diseases	Diagnoses: heart attack (including myocardial infarction, coronary thrombosis, or any other heart problem including congestive heart failure), high blood pressure or hypertension, high blood cholesterol, stroke, and/or cerebral vascular disease;

	Medication: drugs for high blood cholesterol, high blood pressure, coronary or cerebrovascular diseases, and/or other heart diseases
Diabetes	Diagnoses: diabetes and/or high blood sugar; Medication: drugs for diabetes
Chronic respiratory diseases	Diagnoses: chronic lung disease (e.g., chronic bronchitis or emphysema) and/or asthma; Medication: drugs for chronic bronchitis and/or asthma
Arthritis	Diagnoses: arthritis, rheumatoid arthritis, osteoarthritis, and/or other rheumatism
Musculoskeletal diseases	Diagnoses: osteoporosis, hip fracture, and/or femoral fracture; Medication: drugs for osteoporosis (hormonal and non-hormonal)
Stomach ulcer	Diagnoses: stomach ulcer, duodenal ulcer, and/or peptic ulcer
Parkinson's disease	Diagnoses: Parkinson's disease
Mental disorders	Diagnoses: affective or emotional disorders including anxiety, nervous, or psychiatric problems; Drug intake: drugs for sleep problems, anxiety, and/or depression
Cancer	Diagnoses: cancer or malignant tumour, including leukaemia or lymphoma, but excluding minor skin cancers

480 [a] Including the former Soviet republics

Table S2. Age-specific number of chronic conditions at study entry by gender and immigrant status

Age group	Number of chronic conditions	Men				Women			
		Natives		Immigrants		Natives		Immigrants	
		N	%	N	%	N	%	N	%
50 – 54	None	4,871	(49.0)	492	(48.0)	6,787	(47.3)	673	(44.3) *
	One or more	5,078	(51.0)	533	(52.0)	7,562	(52.7)	846	(55.7) *
	Two or more	1,579	(15.9)	198	(19.3) **	3,022	(21.1)	371	(24.4) **
	Three or more	454	(4.6)	56	(5.5)	1,060	(7.4)	151	(9.9) ***
	Four or more	145	(1.5)	15	(1.5)	358	(2.5)	61	(4.0) ***
	Five or more	37	(0.4)	4	(0.4) [a]	95	(0.7)	17	(1.1)
55 – 59	None	3,869	(39.0)	319	(35.0) *	4,071	(34.9)	336	(29.2) ***
	One or more	6,041	(61.0)	593	(65.0) *	7,604	(65.1)	813	(70.8) ***
	Two or more	2,319	(23.4)	258	(28.3) **	3,598	(30.8)	430	(37.4) ***
	Three or more	679	(6.9)	88	(9.6) **	1,418	(12.1)	199	(17.3) ***
	Four or more	176	(1.8)	31	(3.4) ***	480	(4.1)	73	(6.4) ***
	Five or more	35	(0.4)	8	(0.9) *[a]	140	(1.2)	18	(1.6)
60 – 64	None	2,939	(30.6)	219	(26.1) **	2,776	(25.8)	222	(23.3)
	One or more	6,669	(69.4)	619	(73.9) **	7,972	(74.2)	731	(76.7)
	Two or more	2,819	(29.3)	289	(34.5) **	4,057	(37.7)	423	(44.4) ***
	Three or more	927	(9.6)	101	(12.1) *	1,731	(16.1)	184	(19.3) *
	Four or more	245	(2.5)	27	(3.2)	589	(5.5)	72	(7.6) **
	Five or more	70	(0.7)	11	(1.3)	189	(1.8)	23	(2.4)
65 – 69	None	2,005	(23.8)	180	(23.5)	1,740	(19.0)	144	(18.0)
	One or more	6,402	(76.2)	587	(76.5)	7,432	(81.0)	657	(82.0)
	Two or more	3,022	(35.9)	291	(37.9)	4,239	(46.2)	388	(48.4)
	Three or more	998	(11.9)	105	(13.7)	1,856	(20.2)	187	(23.3) *
	Four or more	273	(3.2)	37	(4.8) *	685	(7.5)	69	(8.6)
	Five or more	63	(0.7)	11	(1.4)	175	(1.9)	19	(2.4)
70 – 74	None	1,229	(18.7)	110	(17.7)	1,002	(13.5)	81	(10.8) *
	One or more	5,341	(81.3)	512	(82.3)	6,432	(86.5)	670	(89.2) *
	Two or more	2,669	(40.6)	247	(39.7)	3,970	(53.4)	451	(60.1) ***
	Three or more	971	(14.8)	96	(15.4)	1,915	(25.8)	220	(29.3) *
	Four or more	296	(4.5)	30	(4.8)	706	(9.5)	84	(11.2)
	Five or more	71	(1.1)	13	(2.1) *	186	(2.5)	25	(3.3)
75 – 79	None	671	(14.0)	60	(14.4)	541	(9.3)	67	(11.5)
	One or more	4,110	(86.0)	357	(85.6)	5,303	(90.7)	518	(88.5)
	Two or more	2,269	(47.5)	205	(49.2)	3,523	(60.3)	369	(63.1)
	Three or more	928	(19.4)	69	(16.5)	1,742	(29.8)	195	(33.3)
	Four or more	311	(6.5)	17	(4.1)	676	(11.6)	70	(12.0)
	Five or more	83	(1.7)	2	(0.5)	201	(3.4)	20	(3.4)

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; [a] p-value for Fisher's exact test

Table S3. Age-specific number of chronic conditions at study entry by origin country and immigrant status

Age group	Number of chronic conditions	Natives		Africa		The Americas		Asia and Oceania		Eastern Europe		Other Europe	
		N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)
50 – 54	None	11,658	(48.0)	163	(43.5)	102	(53.1)	139	(51.5)	294	(45.2)	467	(44.2) *
	One or more	12,640	(52.0)	212	(56.5)	90	(46.9)	131	(48.5)	357	(54.8)	589	(55.8) *
	Two or more	4,601	(18.9)	83	(22.1)	32	(16.7)	58	(21.5)	153	(23.5) **	243	(23.0) **
	Three or more	1,514	(6.2)	20	(5.3)	12	(6.2)	21	(7.8)	53	(8.1)	101	(9.6) ***
	Four or more	503	(2.1)	13	(3.5)	3	(1.6) [a]	3	(1.1)	20	(3.1)	37	(3.5) **
	Five or more	132	(0.5)	2	(0.5) [a]	1	(0.5) [a]	2	(0.7) [a]	4	(0.6) [a]	12	(1.1) *
55 – 59	None	7,940	(36.8)	74	(31.2)	29	(29.9)	46	(35.7)	197	(33.3)	309	(30.7) ***
	One or more	13,645	(63.2)	163	(68.8)	68	(70.1)	83	(64.3)	395	(66.7)	697	(69.3) ***
	Two or more	5,917	(27.4)	76	(32.1)	26	(26.8)	44	(34.1)	211	(35.6) ***	331	(32.9) ***
	Three or more	2,097	(9.7)	34	(14.3) *	7	(7.2)	15	(11.6)	93	(15.7) ***	138	(13.7) ***
	Four or more	656	(3.0)	12	(5.1)	2	(2.1) [a]	4	(3.1) [a]	38	(6.4) ***	48	(4.8) **
	Five or more	175	(0.8)	4	(1.7) [a]	0	(0.0) [a]	1	(0.8) [a]	8	(1.4) [a]	13	(1.3)
60 – 64	None	5,715	(28.1)	38	(24.7)	16	(27.1)	30	(34.9)	143	(23.1) **	214	(24.5) *
	One or more	14,641	(71.9)	116	(75.3)	43	(72.9)	56	(65.1)	477	(76.9) **	658	(75.5) *
	Two or more	6,876	(33.8)	68	(44.2) **	25	(42.4)	30	(34.9)	258	(41.6) ***	331	(38.0) *
	Three or more	2,658	(13.1)	25	(16.2)	5	(8.5)	15	(17.4)	107	(17.3) **	133	(15.3)
	Four or more	834	(4.1)	7	(4.5)	1	(1.7) [a]	7	(8.1) [a]	40	(6.5) **	44	(5.0)
	Five or more	259	(1.3)	2	(1.3) [a]	0	(0.0) [a]	3	(3.5) [a]	15	(2.4) *	14	(1.6)
65 – 69	None	3,745	(21.3)	18	(15.7)	8	(21.1)	24	(36.9) **	97	(17.9)	177	(21.9)
	One or more	13,834	(78.7)	97	(84.3)	30	(78.9)	41	(63.1) **	446	(82.1)	630	(78.1)
	Two or more	7,261	(41.3)	56	(48.7)	12	(31.6)	20	(30.8)	254	(46.8) *	337	(41.8)
	Three or more	2,854	(16.2)	23	(20.0)	6	(15.8)	11	(16.9)	112	(20.6) **	140	(17.3)
	Four or more	958	(5.4)	10	(8.7)	3	(7.9) [a]	4	(6.2) [a]	38	(7.0)	51	(6.3)
	Five or more	238	(1.4)	1	(0.9) [a]	1	(2.6) [a]	2	(3.1) [a]	13	(2.4)	13	(1.6)
70 – 74	None	2,231	(15.9)	14	(19.4)	3	(20.0) [a]	10	(17.9)	74	(12.1) *	90	(14.6)
	One or more	11,773	(84.1)	58	(80.6)	12	(80.0) [a]	46	(82.1)	540	(87.9) *	526	(85.4)
	Two or more	6,639	(47.4)	35	(48.6)	5	(33.3)	20	(35.7)	330	(53.7) **	308	(50.0)
	Three or more	2,886	(20.6)	15	(20.8)	3	(20.0) [a]	8	(14.3)	161	(26.2) ***	129	(20.9)
	Four or more	1,002	(7.2)	5	(6.9)	0	(0.0) [a]	3	(5.4) [a]	67	(10.9) ***	39	(6.3)
	Five or more	257	(1.8)	1	(1.4) [a]	0	(0.0) [a]	2	(3.6) [a]	22	(3.6) **	13	(2.1)
75 – 79	None	1,212	(11.4)	6	(11.1)	2	(7.4) [a]	2	(9.5) [a]	61	(12.8)	56	(13.2)
	One or more	9,413	(88.6)	48	(88.9)	25	(92.6) [a]	19	(90.5) [a]	416	(87.2)	367	(86.8)
	Two or more	5,792	(54.5)	31	(57.4)	16	(59.3)	9	(42.9)	284	(59.5) *	234	(55.3)
	Three or more	2,670	(25.1)	13	(24.1)	9	(33.3)	5	(23.8)	134	(28.1)	103	(24.3)
	Four or more	987	(9.3)	3	(5.6)	2	(7.4) [a]	3	(14.3) [a]	43	(9.0)	36	(8.5)
	Five or more	284	(2.7)	3	(5.6) [a]	0	(0.0) [a]	1	(4.8) [a]	11	(2.3)	7	(1.7)

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; [a] p-value for Fisher's exact test

485 Table S4. Age-specific number of chronic conditions at study entry by receiving country and immigrant status

Age group	Number of chronic conditions	Eastern Europe				Northern Europe				Southern Europe				Western Europe			
		Natives		Immigrants		Natives		Immigrants		Natives		Immigrants		Natives		Immigrants	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
50 – 54	None	2,658	(46.8)	154	(40.4) *	1,448	(49.0)	108	(48.2)	3,201	(51.5)	210	(48.1)	4,351	(46.1)	693	(46.1)
	One or more	3,027	(53.2)	227	(59.6) *	1,510	(51.0)	116	(51.8)	3,018	(48.5)	227	(51.9)	5,085	(53.9)	809	(53.9)
	Two or more	1,126	(19.8)	109	(28.6) ***	516	(17.4)	48	(21.4)	1,062	(17.1)	78	(17.8)	1,897	(20.1)	334	(22.2)
	Three or more	400	(7.0)	41	(10.8) **	141	(4.8)	12	(5.4)	329	(5.3)	22	(5.0)	644	(6.8)	132	(8.8) **
	Four or more	145	(2.6)	17	(4.5) *	45	(1.5)	7	(3.1) [a]	97	(1.6)	6	(1.4)	216	(2.3)	46	(3.1)
	Five or more	34	(0.6)	4	(1.0) [a]	12	(0.4)	2	(0.9) [a]	22	(0.4)	2	(0.5) [a]	64	(0.7)	13	(0.9)
55 – 59	None	2,220	(36.3)	115	(29.0) **	991	(40.0)	54	(33.8)	2,276	(38.1)	156	(35.5)	2,453	(35.0)	330	(31.0) *
	One or more	3,901	(63.7)	281	(71.0) **	1,489	(60.0)	106	(66.2)	3,699	(61.9)	283	(64.5)	4,556	(65.0)	736	(69.0) *
	Two or more	1,805	(29.5)	149	(37.6) ***	600	(24.2)	53	(33.1) *	1,548	(25.9)	107	(24.4)	1,964	(28.0)	379	(35.6) ***
	Three or more	678	(11.1)	67	(16.9) ***	179	(7.2)	13	(8.1)	535	(9.0)	33	(7.5)	705	(10.1)	174	(16.3) ***
	Four or more	219	(3.6)	25	(6.3) **	50	(2.0)	7	(4.4) [a]	172	(2.9)	9	(2.1)	215	(3.1)	63	(5.9) ***
	Five or more	58	(0.9)	6	(1.5) [a]	13	(0.5)	1	(0.6) [a]	35	(0.6)	3	(0.7) [a]	69	(1.0)	16	(1.5)
60 – 64	None	1,551	(26.7)	85	(18.9) ***	722	(30.0)	34	(26.0)	1,630	(28.4)	80	(25.9)	1,812	(28.3)	242	(26.8)
	One or more	4,257	(73.3)	364	(81.1) ***	1,683	(70.0)	97	(74.0)	4,107	(71.6)	229	(74.1)	4,594	(71.7)	660	(73.2)
	Two or more	2,115	(36.4)	211	(47.0) ***	735	(30.6)	48	(36.6)	1,866	(32.5)	102	(33.0)	2,160	(33.7)	351	(38.9) **
	Three or more	851	(14.7)	92	(20.5) **	234	(9.7)	18	(13.7)	711	(12.4)	39	(12.6)	862	(13.5)	136	(15.1)
	Four or more	275	(4.7)	36	(8.0) **	64	(2.7)	3	(2.3) [a]	216	(3.8)	9	(2.9)	279	(4.4)	51	(5.7)
	Five or more	97	(1.7)	15	(3.3) *	15	(0.6)	1	(0.8) [a]	66	(1.2)	3	(1.0) [a]	81	(1.3)	15	(1.7)
65 – 69	None	990	(19.7)	71	(18.8)	551	(25.3)	41	(29.5)	995	(19.6)	58	(22.0)	1,209	(22.9)	154	(19.5) *
	One or more	4,048	(80.3)	306	(81.2)	1,630	(74.7)	98	(70.5)	4,089	(80.4)	206	(78.0)	4,067	(77.1)	634	(80.5) *
	Two or more	2,207	(43.8)	181	(48.0)	828	(38.0)	50	(36.0)	2,117	(41.6)	96	(36.4)	2,109	(40.0)	352	(44.7) *
	Three or more	881	(17.5)	86	(22.8) *	282	(12.9)	24	(17.3)	871	(17.1)	39	(14.8)	820	(15.5)	143	(18.1)
	Four or more	318	(6.3)	32	(8.5)	76	(3.5)	5	(3.6) [a]	308	(6.1)	11	(4.2)	256	(4.9)	58	(7.4) **
	Five or more	71	(1.4)	8	(2.1)	23	(1.1)	2	(1.4) [a]	63	(1.2)	4	(1.5) [a]	81	(1.5)	16	(2.0)
70 – 74	None	509	(13.7)	54	(10.9)	317	(19.2)	13	(15.7)	641	(15.0)	34	(17.6)	764	(17.5)	90	(15.0)
	One or more	3,213	(86.3)	442	(89.1)	1,335	(80.8)	70	(84.3)	3,624	(85.0)	159	(82.4)	3,601	(82.5)	511	(85.0)
	Two or more	1,901	(51.1)	287	(57.9) **	709	(42.9)	35	(42.2)	2,047	(48.0)	88	(45.6)	1,982	(45.4)	288	(47.9)
	Three or more	846	(22.7)	149	(30.0) ***	265	(16.0)	17	(20.5)	917	(21.5)	37	(19.2)	858	(19.7)	113	(18.8)
	Four or more	268	(7.2)	64	(12.9) ***	78	(4.7)	2	(2.4) [a]	345	(8.1)	12	(6.2)	311	(7.1)	36	(6.0)
	Five or more	68	(1.8)	22	(4.4) ***	15	(0.9)	2	(2.4) [a]	101	(2.4)	4	(2.1) [a]	73	(1.7)	10	(1.7)
75 – 79	None	283	(9.9)	36	(9.8)	168	(13.0)	7	(12.7)	376	(11.5)	18	(12.0)	385	(12.1)	66	(15.4)
	One or more	2,583	(90.1)	333	(90.2)	1,124	(87.0)	48	(87.3)	2,906	(88.5)	132	(88.0)	2,800	(87.9)	362	(84.6)

Two or more	1,661	(58.0)	243	(65.9) **	634	(49.1)	36	(65.5) *	1,788	(54.5)	75	(50.0)	1,709	(53.7)	220	(51.4)
Three or more	794	(27.7)	117	(31.7)	260	(20.1)	18	(32.7) *	845	(25.7)	35	(23.3)	771	(24.2)	94	(22.0)
Four or more	316	(11.0)	37	(10.0)	91	(7.0)	6	(10.9) [a]	309	(9.4)	7	(4.7)	271	(8.5)	37	(8.6)
Five or more	93	(3.2)	9	(2.4)	26	(2.0)	2	(3.6) [a]	92	(2.8)	0	(0.0) *[a]	73	(2.3)	11	(2.6)

* p < 0.05; ** p < 0.01; *** p < 0.001; [a] p-value for Fisher's exact test

Table S5. Random-effects estimation of the number of chronic conditions development by age and immigration background

	Random-effects		
	Model 1	Model 2	Model 3
Age group (ref: 50–54)			
55–59	0.191***	0.189***	0.159***
	(0.006)	(0.006)	(0.006)
60–64	0.360***	0.358***	0.254***
	(0.006)	(0.006)	(0.007)
65–69	0.551***	0.552***	0.387***
	(0.007)	(0.007)	(0.008)
70–74	0.740***	0.740***	0.554***
	(0.007)	(0.007)	(0.008)
75–79	0.914***	0.917***	0.711***
	(0.008)	(0.008)	(0.009)
Immigrant (ref: Native)	0.096***	0.094***	0.084***
	(0.010)	(0.019)	(0.019)
Woman (ref: Man)	0.235***	0.235***	0.190***
	(0.006)	(0.006)	(0.006)
Age group x Immigration status			
55–59 x Immigrant		0.030	0.041*
		(0.020)	(0.020)
60–64 x Immigrant		0.029	0.055*
		(0.022)	(0.022)
65–69 x Immigrant		-0.012	0.014
		(0.024)	(0.024)
70–74 x Immigrant		-0.008	0.022
		(0.025)	(0.025)
75–79 x Immigrant		-0.036	-0.007
		(0.027)	(0.027)
Education (ref: Low)			
Medium			-0.157***
			(0.006)
High			-0.253***
			(0.008)
Income (ref: Low)			
Medium			-0.004
			(0.004)
High			-0.015***
			(0.004)
Employed (ref: Not working)			-0.238***
			(0.005)
Married (ref: Not married)			-0.102***
			(0.006)
Constant	0.714***	0.714***	1.119***
	(0.007)	(0.007)	(0.010)
Number of persons	118,786	118,786	118,786
Number of person-years	310,274	310,274	310,274

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

Table S6. Fixed-effects estimation of the number of chronic conditions by the origin country group

	Africa	The Americas	Asia and Oceania	Eastern Europe	Other European countries
Age group (ref: 50–54)					
55–59	0.142***	0.142***	0.142***	0.142***	0.142***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
60–64	0.251***	0.251***	0.251***	0.251***	0.251***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
65–69	0.400***	0.400***	0.399***	0.399***	0.400***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
70–74	0.563***	0.563***	0.562***	0.562***	0.563***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
75–79	0.717***	0.718***	0.717***	0.717***	0.718***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Age group x Immigration status					
55–59 x Immigrant	0.068	-0.030	0.160*	-0.012	0.016
	(0.062)	(0.078)	(0.077)	(0.044)	(0.035)
60–64 x Immigrant	0.164*	-0.093	0.216*	-0.007	-0.007
	(0.075)	(0.093)	(0.095)	(0.053)	(0.041)
65–69 x Immigrant	0.178*	-0.054	0.030	-0.099	-0.007
	(0.090)	(0.119)	(0.112)	(0.060)	(0.046)
70–74 x Immigrant	0.176	0.230	-0.067	-0.126	0.034
	(0.109)	(0.151)	(0.132)	(0.066)	(0.052)
75–79 x Immigrant	0.076	0.389*	0.008	-0.131	-0.010
	(0.131)	(0.198)	(0.170)	(0.072)	(0.059)
Income (ref: Low)					
Medium	-0.003	-0.002	-0.001	-0.002	-0.001
	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)
High	0.004	0.005	0.005	0.007	0.006
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Working (ref: Not working)	-0.100***	-0.100***	-0.101***	-0.101***	-0.100***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Married (ref: Not married)	-0.060***	-0.062***	-0.062***	-0.065***	-0.064***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Constant	1.027***	1.027***	1.027***	1.038***	1.031***
	(0.013)	(0.013)	(0.013)	(0.012)	(0.012)
Number of persons	74,856	74,517	74,593	76,561	77,473
Number of person-years	251,741	250,684	250,884	257,403	260,468

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

Table S7. Fixed-effects estimation of the number of chronic conditions by the receiving country group

	Eastern Europe	Northern Europe	Southern Europe	Western Europe
Age group (ref: 50–54)				
55–59	0.134 ***	0.092 ***	0.178 ***	0.137 ***
	(0.017)	(0.016)	(0.014)	(0.010)
60–64	0.208 ***	0.215 ***	0.305 ***	0.243 ***
	(0.020)	(0.019)	(0.016)	(0.012)
65–69	0.344 ***	0.341 ***	0.465 ***	0.397 ***
	(0.023)	(0.022)	(0.018)	(0.015)
70–74	0.492 ***	0.512 ***	0.603 ***	0.584 ***
	(0.026)	(0.025)	(0.021)	(0.016)
75–79	0.637 ***	0.652 ***	0.742 ***	0.759 ***
	(0.030)	(0.028)	(0.023)	(0.019)
Age group x Immigration status				
55–59 x Immigrant	-0.048	0.043	-0.043	0.064 *
	(0.061)	(0.064)	(0.060)	(0.030)
60–64 x Immigrant	-0.059	0.078	-0.120	0.087 *
	(0.072)	(0.071)	(0.072)	(0.036)
65–69 x Immigrant	-0.221 **	0.117	-0.117	0.076
	(0.082)	(0.079)	(0.086)	(0.042)
70–74 x Immigrant	-0.259 **	0.087	-0.082	0.104 *
	(0.091)	(0.089)	(0.101)	(0.048)
75–79 x Immigrant	-0.308 **	0.011	-0.156	0.114 *
	(0.099)	(0.105)	(0.117)	(0.055)
Income (ref: Low)				
Medium	-0.004	-0.004	0.012	-0.010
	(0.010)	(0.011)	(0.009)	(0.007)
High	0.008	-0.002	0.021 *	0.000
	(0.010)	(0.011)	(0.009)	(0.007)
Working (ref: Not working)	-0.129 ***	-0.082 ***	-0.102 ***	-0.097 ***
	(0.015)	(0.015)	(0.014)	(0.010)
Married (ref: Not married)	-0.068 **	0.028	-0.140 ***	-0.065 ***
	(0.024)	(0.026)	(0.025)	(0.018)
Constant	1.214 ***	0.837 ***	1.054 ***	1.026 ***
	(0.027)	(0.029)	(0.027)	(0.019)
Number of persons	19,340	9,426	23,401	28,981
Number of person-years	59,925	34,236	74,927	103,548

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

494 Table S8. Age effects on developing chronic conditions by immigration background stratified by age at migration

	OLS			Random-effects			Fixed-effects		
	0–17	18–34	≥ 35	0–17	18–34	≥ 35	0–17	18–34	≥ 35
Age group (ref: 50–54)									
55–59	0.159***	0.159***	0.159***	0.159***	0.159***	0.159***	0.142***	0.142***	0.142***
	(0.008)	(0.008)	(0.008)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)
60–64	0.215***	0.213***	0.215***	0.255***	0.254***	0.255***	0.251***	0.251***	0.251***
	(0.008)	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)	(0.008)
65–69	0.317***	0.315***	0.317***	0.388***	0.387***	0.389***	0.400***	0.400***	0.399***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.009)	(0.009)	(0.009)
70–74	0.473***	0.470***	0.474***	0.555***	0.554***	0.556***	0.562***	0.563***	0.562***
	(0.009)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.011)	(0.011)	(0.011)
75–79	0.623***	0.621***	0.624***	0.713***	0.712***	0.714***	0.717***	0.717***	0.717***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.012)	(0.012)	(0.012)
Immigrant (ref: Native)	0.197***	0.067*	-0.110**	0.173***	0.105***	-0.107**			
	(0.033)	(0.027)	(0.041)	(0.033)	(0.027)	(0.041)			
Woman (ref: Man)	0.179***	0.178***	0.177***	0.188***	0.186***	0.186***			
	(0.004)	(0.004)	(0.004)	(0.006)	(0.006)	(0.006)			
Age group x Immigration status									
55–59 x Immigrant	-0.022	0.079*	0.122*	-0.003	0.042	0.107*	-0.000	0.013	0.107*
	(0.043)	(0.035)	(0.054)	(0.034)	(0.028)	(0.045)	(0.039)	(0.033)	(0.053)
60–64 x Immigrant	-0.007	0.130***	0.163**	-0.006	0.057	0.146**	0.010	-0.006	0.146*
	(0.042)	(0.035)	(0.054)	(0.037)	(0.031)	(0.049)	(0.046)	(0.039)	(0.064)
65–69 x Immigrant	-0.021	0.036	0.185***	-0.024	-0.021	0.153**	-0.010	-0.085	0.191**
	(0.042)	(0.036)	(0.056)	(0.039)	(0.033)	(0.052)	(0.053)	(0.045)	(0.074)
70–74 x Immigrant	-0.051	0.019	0.207***	-0.029	-0.024	0.207***	-0.011	-0.092	0.315***
	(0.042)	(0.037)	(0.059)	(0.041)	(0.036)	(0.057)	(0.059)	(0.052)	(0.085)
75–79 x Immigrant	-0.077	-0.001	0.130*	-0.044	-0.059	0.164**	-0.004	-0.151*	0.337***
	(0.045)	(0.039)	(0.062)	(0.044)	(0.039)	(0.062)	(0.066)	(0.059)	(0.100)
Education (ref: Low)									
Medium	-0.145***	-0.146***	-0.143***	-0.159***	-0.159***	-0.156***			
	(0.005)	(0.005)	(0.005)	(0.007)	(0.007)	(0.007)			
High	-0.229***	-0.228***	-0.225***	-0.252***	-0.252***	-0.248***			
	(0.006)	(0.006)	(0.006)	(0.008)	(0.008)	(0.008)			
Income (ref: Low)									
Medium	-0.023***	-0.023***	-0.023***	-0.003	-0.003	-0.004	-0.001	-0.000	-0.003
	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)

High	-0.063***	-0.063***	-0.062***	-0.015***	-0.015***	-0.015***	0.006	0.006	0.006
	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)
Working (ref: Not working)	-0.393***	-0.396***	-0.392***	-0.235***	-0.237***	-0.235***	-0.101***	-0.101***	-0.100***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)	(0.006)	(0.007)	(0.007)	(0.007)
Married (ref: Not married)	-0.098***	-0.095***	-0.096***	-0.102***	-0.100***	-0.100***	-0.063***	-0.063***	-0.065***
	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.012)	(0.012)	(0.012)
Constant	1.221***	1.222***	1.217***	1.119***	1.120***	1.116***	1.033***	1.034***	1.028***
	(0.009)	(0.009)	(0.009)	(0.010)	(0.010)	(0.010)	(0.012)	(0.012)	(0.013)
Number of persons	111,969	113,241	110,460	111,969	113,241	110,460	76,652	77,428	75,486
Number of person-years	293,202	296,204	288,576	293,202	296,204	288,576	257,885	260,391	253,602

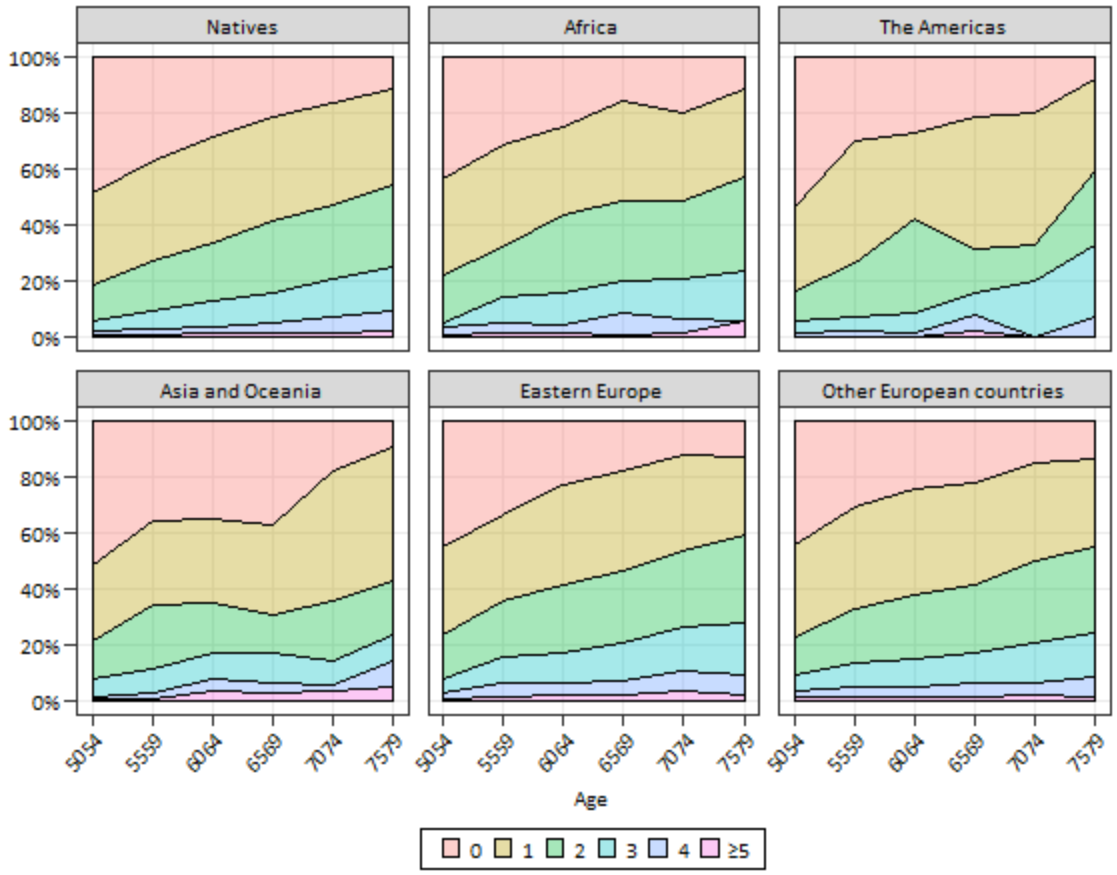
* p < 0.05; ** p < 0.01; *** p < 0.001

Table S9. Panel attrition bias check

	OLS			Random-effects			Fixed-effects		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Age group (ref: 50–54)									
55–59	0.229***	0.222***	0.169***	0.204***	0.200***	0.174***	0.170***	0.166***	0.160***
	(0.010)	(0.010)	(0.010)	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
60–64	0.419***	0.411***	0.224***	0.372***	0.368***	0.272***	0.309***	0.305***	0.271***
	(0.009)	(0.010)	(0.010)	(0.008)	(0.008)	(0.008)	(0.009)	(0.009)	(0.010)
65–69	0.622***	0.619***	0.321***	0.565***	0.563***	0.407***	0.480***	0.477***	0.420***
	(0.009)	(0.010)	(0.011)	(0.008)	(0.008)	(0.009)	(0.010)	(0.010)	(0.011)
70–74	0.819***	0.818***	0.484***	0.757***	0.755***	0.578***	0.653***	0.648***	0.586***
	(0.009)	(0.010)	(0.011)	(0.009)	(0.009)	(0.010)	(0.011)	(0.012)	(0.012)
75–79	1.003***	1.006***	0.643***	0.940***	0.941***	0.746***	0.820***	0.817***	0.750***
	(0.010)	(0.010)	(0.011)	(0.009)	(0.010)	(0.011)	(0.013)	(0.013)	(0.014)
Immigrant (ref: Native)	0.125***	0.087***	0.061*	0.108***	0.085***	0.078**			
	(0.009)	(0.026)	(0.026)	(0.013)	(0.025)	(0.025)			
Woman (ref: Man)	0.229***	0.229***	0.174***	0.225***	0.225***	0.182***			
	(0.005)	(0.005)	(0.005)	(0.007)	(0.007)	(0.007)			
Age group x Immigration status									
55–59 x Immigrant		0.086*	0.098**		0.052*	0.060*		0.041	0.042
		(0.034)	(0.033)		(0.026)	(0.026)		(0.030)	(0.030)
60–64 x Immigrant		0.102**	0.138***		0.058*	0.079**		0.053	0.058
		(0.033)	(0.032)		(0.028)	(0.028)		(0.034)	(0.034)
65–69 x Immigrant		0.029	0.074*		0.016	0.038		0.034	0.037
		(0.033)	(0.033)		(0.030)	(0.030)		(0.039)	(0.039)
70–74 x Immigrant		0.009	0.059		0.021	0.045		0.062	0.065
		(0.034)	(0.033)		(0.031)	(0.031)		(0.043)	(0.043)
75–79 x Immigrant		-0.027	0.020		-0.018	0.006		0.041	0.042
		(0.035)	(0.034)		(0.034)	(0.034)		(0.049)	(0.049)
Education (ref: Low)									
Medium			-0.149***			-0.168***			
			(0.006)			(0.008)			
High			-0.242***			-0.264***			
			(0.007)			(0.010)			
Income (ref: Low)									
Medium			-0.020**			0.000			0.003
			(0.006)			(0.005)			(0.005)

High			-0.057***			-0.012*			0.006
			(0.006)			(0.005)			(0.005)
Working (ref: Not working)			-0.403***			-0.231***			-0.105***
			(0.007)			(0.007)			(0.008)
Married (ref: Not married)			-0.084***			-0.088***			-0.067***
			(0.006)			(0.007)			(0.013)
Constant	0.644***	0.647***	1.203***	0.702***	0.704***	1.095***	0.894***	0.894***	1.008***
	(0.008)	(0.008)	(0.011)	(0.008)	(0.008)	(0.013)	(0.008)	(0.008)	(0.014)
Number of persons	75,826	75,826	75,826	75,826	75,826	75,826	52,619	52,619	52,619
Number of person-years	208,170	208,170	208,170	208,170	208,170	208,170	184,963	184,963	184,963

497 * p < 0.05; ** p < 0.01; *** p < 0.001



498

499 Fig. S1 Number of chronic conditions at study entry by immigration status, origin country group, and age group

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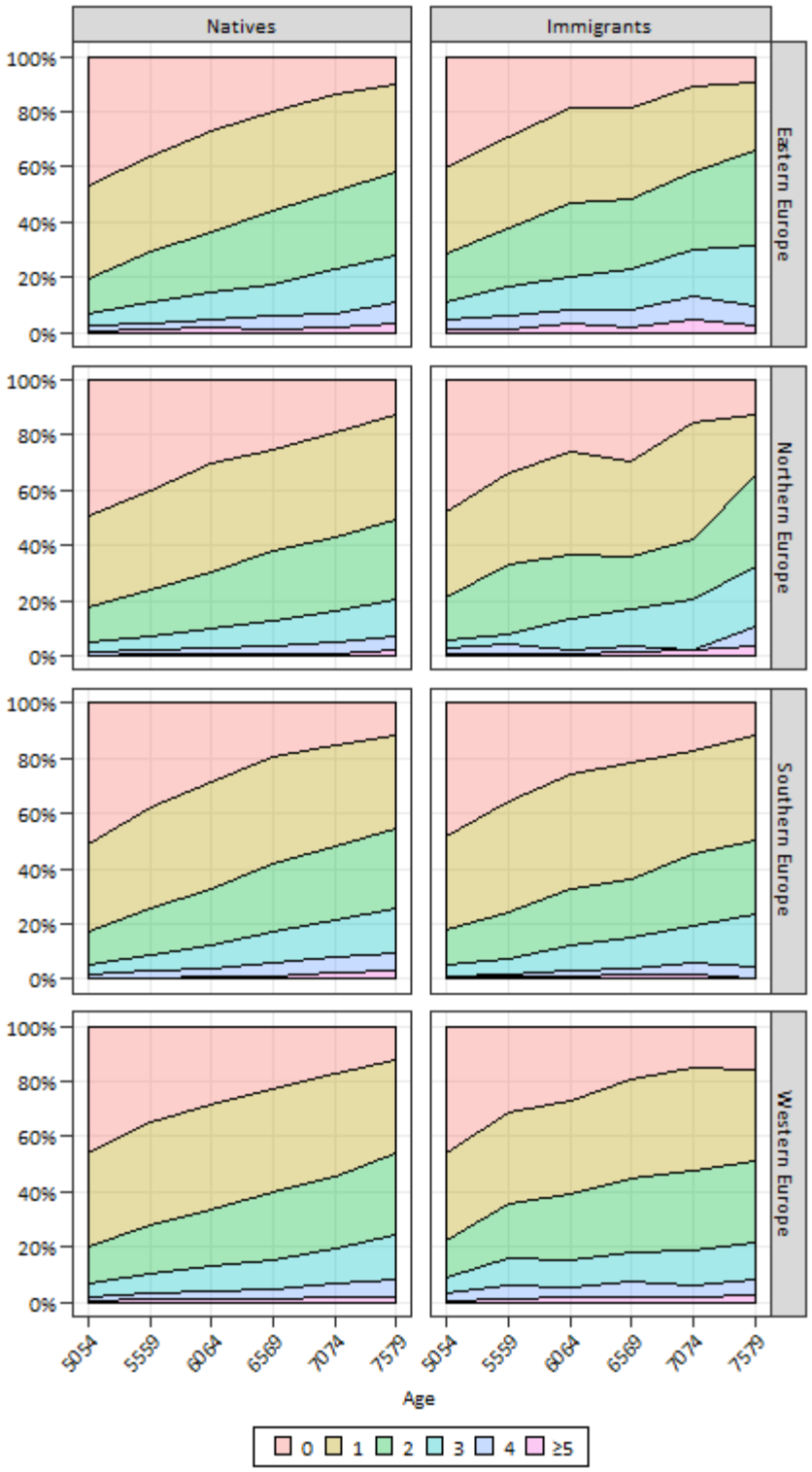
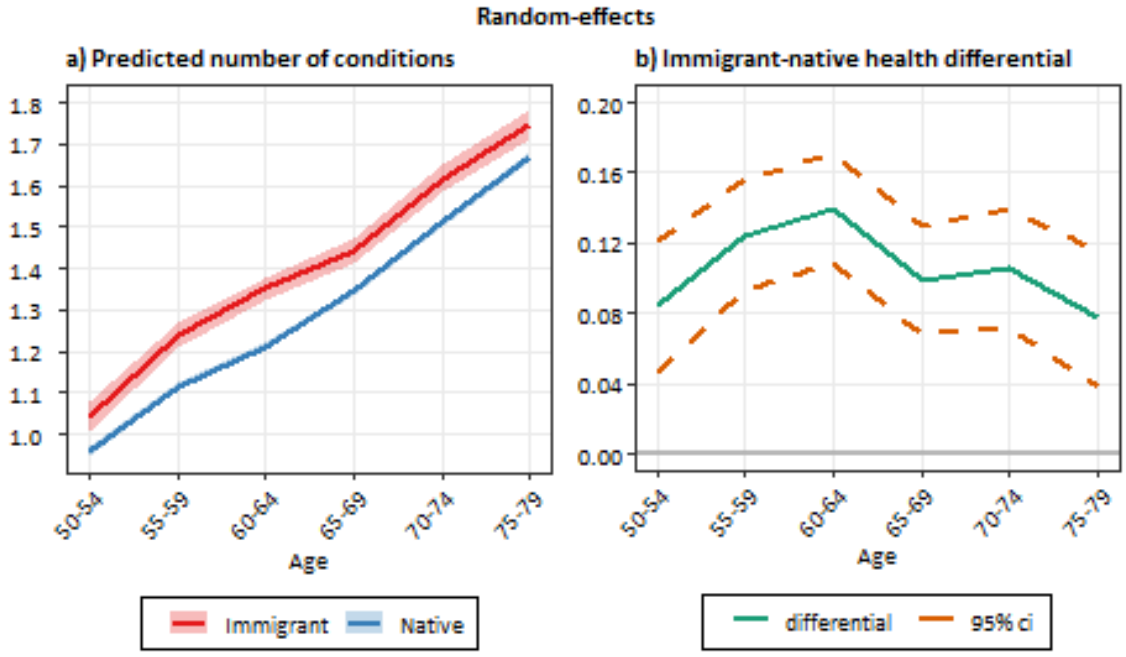


Fig. S2 Number of chronic conditions at study entry by immigration status, receiving country group, and age group



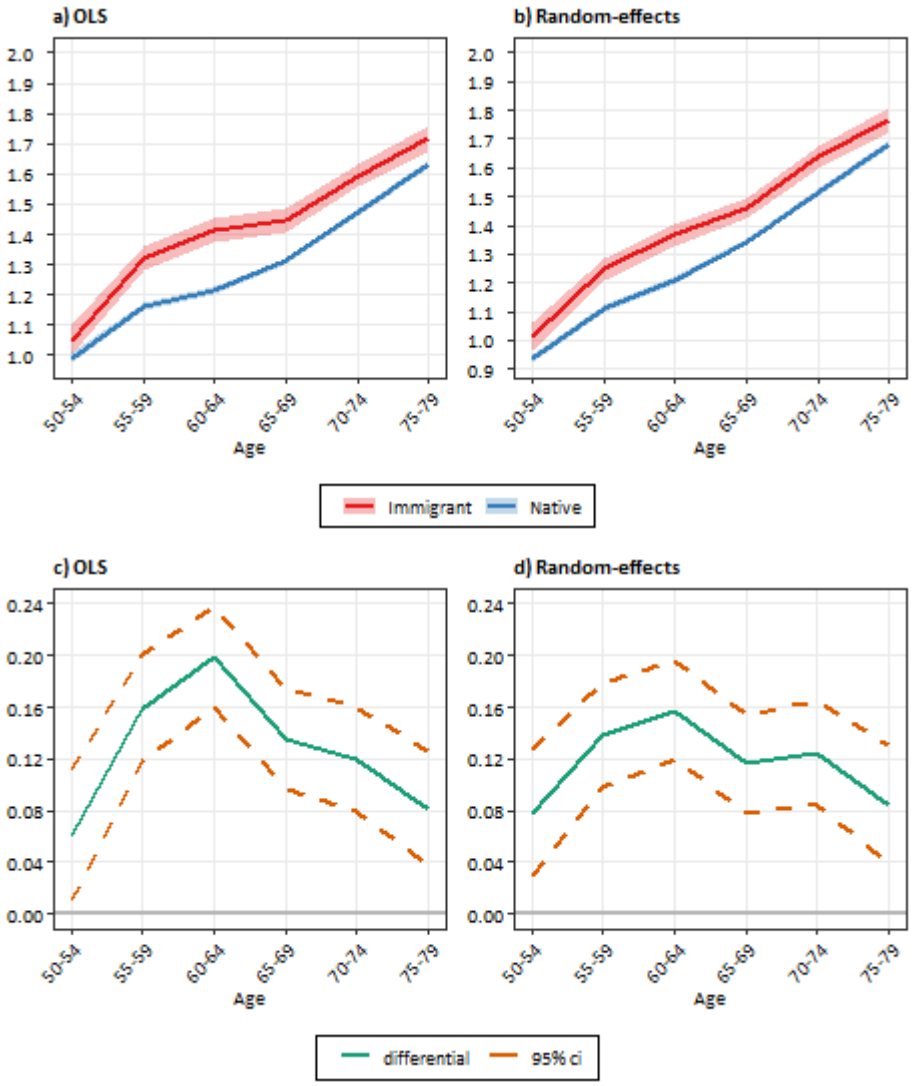
504

505 Fig. S3 Chronic health condition trajectories by immigration status from the random-effects estimation. Panels

506 represent the predicted number of chronic conditions (a) and immigrant-native differentials from the estimation

507 (b), respectively.

508 *Note:* Shaded areas from panel a and b indicate 95% confidence intervals.



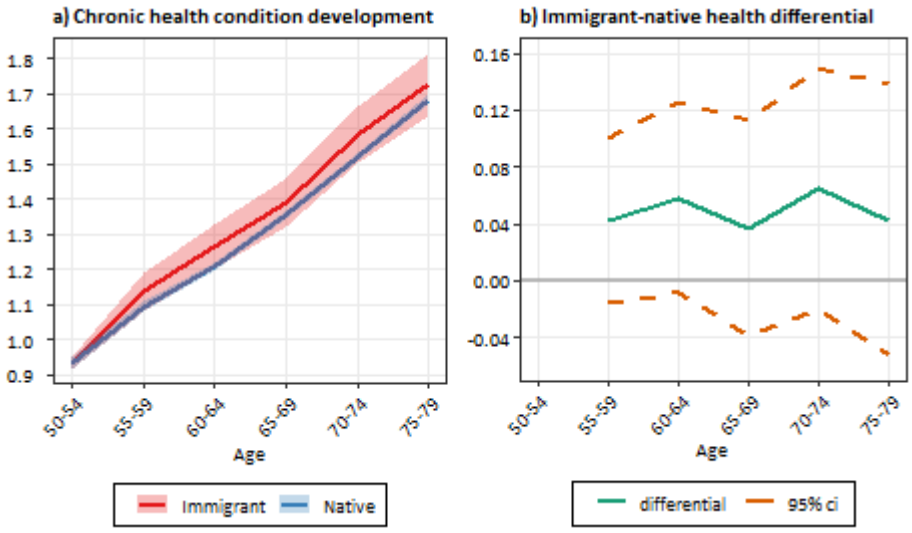
509

510 Fig. S4 Panel attrition bias check from the random-effects estimation in the participants staying in the panel. Panels

511 represent the predicted number of chronic conditions (a, b) and immigrant-native differentials from the estimation

512 (c, d), respectively.

513 *Note:* Shaded areas from panel a and b indicate 95% confidence intervals.



514

515 Fig. S5 Panel attrition bias check from the fixed-effects estimation in the participants staying in the panel. Panels

516 represent group-specific chronic health condition development by the immigration background (a) and immigrant-

517 native differentials from the estimation (b), respectively.

518 *Note:* Shaded area from panel a indicates 95% confidence intervals.