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# Healthy immigrants, unhealthy ageing? Analysis of health decline among older migrants and natives across European countries

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ABSTRACT

The probability of having multiple chronic conditions simultaneously, or multimorbidity, tends to increase with age. Immigrants face a particularly high risk of unhealthy ageing. This study investigates the immigrant-native disparities in the speed of age-related chronic disease accumulation, focusing on the number of chronic health conditions; and considers the heterogeneity of this trajectory within immigrant populations by origin and receiving country. We use data from the Survey of Health, Ageing and Retirement in Europe from 2004 to 2020 on adults aged 50 to 79 from 28 European countries and employ both cross-sectional and longitudinal analyses. For longitudinal panel analyses, we use fixed-effects regression models to account for the unobserved heterogeneity related to individual characteristics including migration background. Our results indicate that immigrants report 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 is among natives. When looking at differences by receiving country group, we observe that the speed of accumulating chronic diseases 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.

## 1. 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 on individual and social contexts (Christensen et al., 2009; Kristiansen et al., 2016). This heterogeneity in the speed of age-related health decline is, for example, reflected in the accumulation of chronic health conditions. Older people have a higher prevalence of several chronic diseases compared to the younger population, and therefore are more likely to suffer from several long-term health conditions simultaneously, or from multimorbidity (Barnett et al., 2012; Strauss et al., 2014). 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 (Barnett et al., 2012; Cezard et al., 2021; Dekhtyar et al., 2019).

The immigrant populations throughout Europe are ageing fast (Eurostat, 2021; OECD & European Union, 2015). Therefore, it is important to understand the implications of ageing on the development of health conditions among immigrant populations in European countries and whether or not the age-effect differs from that of the native-born group. There is considerable evidence that immigrants have better health upon arrival to the receiving country than the natives on several indicators of healthy ageing, which includes a higher level of self-assessed health, lower chronic disease prevalence, and a lower risk of multimorbidity (Argeseanu Cunningham et al., 2008; Biddle et al., 2007; Diaz, Poblador-Pou, et al., 2015; Kennedy et al., 2014; McDonald

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& Kennedy, 2004). This immigrant health advantage is a phenomenon that is often referred to as the "healthy immigrant effect" (HIE). A popular explanation for the initial health advantage in immigrants is the positive selection, that only the healthy individuals choose and complete the migration (Jasso et al., 2004; Marmot et al., 1984). However, several existing studies on the HIE have found that over time, the health of immigrants converges towards the level of natives (Antecol & Bedard, 2006; Bousmah et al., 2019; Diaz, Kumar, et al., 2015; Gimeno-Feliu et al., 2017). The literature documents that immigrants go through negative acculturation processes, assimilating towards the unhealthy norms of the receiving country (Angel et al., 2001; Antecol & Bedard, 2006). Immigrants also experience additional stress from the unfamiliar culture, discrimination, and limited social support, which leads to adverse health outcomes (Berry et al., 1987; Grove & Zwi, 2006).

Although a wide range of literature supports the HIE, a limited body of research on older immigrants in Europe provides rather contradictory results. On the one hand, several studies have supported the presence of the HIE in multiple European countries, with the initial immigrant health advantage that dissipates over time (Bousmah et al., 2019; Constant et al., 2017). On the other hand, some other 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 (Nielsen & Krasnik, 2010; Sand & Gruber, 2016; Solé-Auró & Crimmins, 2008). One possible explanation for these mixed findings is the diversity in the background across different subgroups of migrants in Europe. In Europe, a large share of immigrants arrived mainly during the period of decolonisation after World War II (1945 to the mid-1960s), the post-war economic expansion period (1960s–1970s), or the period following the disintegration of the Soviet Union (mid-1990s–2000s) (Zimmermann, 1995). Each of the European regions has different immigration and emigration rates throughout each of these major migration incoming phases. For instance, numerous individuals moved to the UK, France, Netherlands, and Belgium from their formal territories overseas after the war, while countries in Northern and Western Europe recruited labour migration in response to the post-war economic growth (Castles & Miller, 1998; Zimmermann, 1995). In the post-Soviet era, the major migration flow in Europe was the east-west migration from the Eastern to the Northern and Western European Countries (Zimmermann, 1995). As a result, immigrants in Europe have diverse characteristics and, therefore, cannot be pooled together under the term "ageing immigrants" without consideration of this heterogeneity (Kristiansen et al., 2016; Warnes et al., 2004).

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 (Huijts & Kraaykamp, 2012). 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 (Bousmah et al., 2019). In the receiving country, immigrants may be exposed to a health-promoting environment, including improved nutrition, but they may also experience discrimination and social stigma based on their migration background resulting in taking up low-skilled jobs and, consequently, in poorer health (Hatzenbuehler & Link, 2014; Spallek et al., 2011). Also, macro-level characteristics, such as policies aiming to integrate immigrants into society, are found to be important determinants of immigrants' health outcomes (Giannoni et al., 2016; Malmusi, 2015). Drawing on these findings, there are reasons to believe that the healthy ageing processes in immigrants differ not only from that of the native-born population but also within the foreign-born populations themselves, based on differential experiences in the origin and receiving countries. However, the age-related trajectories of the health of immigrants versus native-born persons are largely understudied, while the attempt to take the heterogeneity within migrants into account is nearly absent.

This paper aims to address this gap in knowledge and untangle the implications of ageing in older migrants versus natives in Europe by following the question, *"Does the speed of age-related chronic disease accumulation differ between immigrants and natives?"* We employ fixed-effects models to control for the individual-specific, time-invariant, unobserved characteristics that immigrants may bring with them to the host country, such as their genetic predisposition to develop chronic conditions, as well as values, norms, and beliefs about health and health behaviour of the origin country (Allison, 2009). Following the overall aim, we first examine the immigrant-native gap in the rate of accumulation of chronic conditions over age. Building upon earlier research, we expect the number of chronic health conditions to accumulate faster in immigrants than in their native-born peers. We then extend our understanding by investigating whether the estimated immigrant-native differential in the 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.

## 2. Material and methods

### 2.1. 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 socioeconomic background of people aged 50 or older and their spouses in 28 European countries and Israel (Börsch-Supan et al., 2013). We do not include data from wave 3 in our analysis, as it did not collect information on present medical problems (n = 505). 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 = 2382) (Barnett et al., 2012). Furthermore, immigrants may choose to migrate back to their home country when they experience health deterioration in later life (Palloni & Arias, 2004). 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 = 12,602). As our focus is on heterogeneity within European immigrant populations, we do not include participants from Israel in the analysis (n = 3624). After excluding respondents with missing observations on the main and additional covariates of the analyses (n = 2186), our final sample includes a total of 118,826 participants (310,326 person-years).

### 2.2. 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 (Salisbury et al., 2011). 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 (Bisquera et al., 2022; Griffith et al., 2018). 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.

### 2.3. 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 include age as a categorical instead of a continuous variable in our models because we expect a non-linearity in the relationship between age and health outcomes within our sample. In each age group, socioeconomic positions may vary across individuals with different migration statuses (i.e., natives versus immigrants), which is often revealed in income or employment (Edberg et al., 2011; Feliciano, 2020). Further, the level of education and marital status, which are two factors that are closely related to several health outcomes, may also differ between immigrants and their native-born peers (Feliciano, 2020). Therefore, 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 socioeconomic 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 divided by the square root of household size 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).

### 2.4. Immigrant status

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) (UNSD, 2021). 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.

### 2.5. Statistical analysis

We explore the association between age, immigration status, and the number of chronic conditions in both cross-sectional and longitudinal perspectives using linear regression models. We select linear models over Poisson or negative binomial, considering that the overall exposure is nearly unidentifiable for our outcome measure, the number of chronic diseases. As there are several chronic diseases considered, it is challenging to define the total number of times that the event could have occurred.

First, we run cross-sectional analyses with pooled ordinary least square (OLS) models. The predicted number of conditions of person $i$ at time $t$ ($y_{it}$) follows the simplified equation:

$$y_{it} = \alpha + \beta_1\, Immigration_i + \sum \beta_{n+1}\, Age_{n,it} + \sum \beta_{n+6}\, Immigration_i\, Age_{n,it} + \mu\, X_{it} + \gamma\, Z_i + \varepsilon_{it} \quad (1)$$

where $\alpha$ is the intercept, $Immigration_i$ is the dummy variable for having the immigrant background, $\sum \beta_{n+1}\, Age_{n,it}$ is the effect of age on the number of conditions in each of five 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 $\varepsilon_{it}$ is the error term.

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

$$y_{it} = \alpha_i + \sum \beta_n\, Age_{n,it} + \sum \beta_{n+5}\, Immigration_i\, Age_{n,it} + \mu\, X_{it} + \varepsilon_{it} \quad (2)$$

where $\alpha_i$ 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 $\alpha_i$ 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 socioeconomic 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.

### 2.6. Sensitivity analysis

We check the robustness of our results in several steps. First, we test the sensitivity of our results to some observable time-varying characteristics. One main example of the time-varying characteristic that may have an impact on our results is the changes to health behaviours, as immigrants may accept the lifestyle of the native population over the course of their stay in the receiving country, which may have healthier or unhealthier patterns compared to their earlier behaviours. Therefore, studies on the changes in the health behaviour of immigrants present mixed finding that immigrants are more likely to be physically inactive and less likely to consume alcohol or smoke than natives (Gadd et al., 2005; Wändell et al., 2007), while immigrants have a healthier dietary pattern compared to the native-born population in some other cases such as migrants in France and the US (Dixon et al., 2000; Méjean et al., 2007). In SHARE, health behaviour information is not available for part of the sample in waves 6 and 7. We run separate analyses in individuals who have information on health behaviours of smoking, alcohol consumption, and physical activity (72,058 participants; 237,309 observations). In this subsample, we first run Models 1, 2, and 3, which are defined above. Then, we add the binary variable of smoking to Model 3 (Model 4). Finally, we add binary variables of heavy drinking (more than two drinks/day on average) and vigorous physical activity to Model 4 (Model 5). For each of the health behaviours, we impute missing observations by using the information from the last wave to minimise the sample size reduction.

Second, we assess the sensitivity of the estimates to the effects of age at migration. Because younger age at migration is linked to greater integration in host societies (Aslund et al., 2009; Söhn, 2011), we expect that individuals who immigrate when they are young are ageing similarly to native peers. Prior investigations on the HIE among elderly adults have underscored the importance of the age at immigration, as the health of immigrants who arrived during adulthood tends to decline faster than the health of immigrants who arrived at younger ages (Gubernskaya, 2015; Lanari et al., 2018). Therefore, we perform a stratified analysis from our final model (Model 3) for each of the immigrant subgroups by their age at arrival (0–17, 18–34, and ≥35).

Third, we perform sensitivity analyses of our results to the disease groupings used in the study that counts cardiovascular diseases and diabetes as two separate conditions. In the study of multimorbidity, the count number of chronic diseases can be overestimated due to the inclusion of risk factors that are also stand-alone conditions (Griffith et al., 2018). One representative example is the association between cardiovascular diseases and diabetes, which are both included in our study. Patients who have diabetes experience a substantially higher risk of cardiovascular diseases. Therefore, we run additional analyses with the redefined outcome measure of the number of chronic diseases that combines cardiovascular diseases and diabetes as a single condition (Nesto, 2004; Xu et al., 2018).

Fourth, we test the sensitivity of our results to the missing observations. For this purpose, we run our final model (Model 3) using all covariates with a separate category of "missing". By following this method, we are able to include all respondents who are originally ineligible in the final sample, which gives us a total of 120,349 participants (314,994 observations) in total for the analysis. Further, to assess if the impact of missing observations varies by the immigrant status, we perform a stratified analysis in immigrants and natives, respectively.

Finally, we assess the potential bias due to the attrition from the survey. Attrition bias may be present when participants drop out of the survey at a different rate in one group from another, considering that individuals may stop participating in the survey in cases of critical health conditions, leaving the remaining sample of healthier individuals (Nunan et al., 2018). As the causes of the attrition may vary from one participant to another, we run two separate analyses for the attrition due to any reasons (ineligibility, death, or simple non-interview) and due to death only, respectively. We use the inverse probability weighting approach, where we predict the probability of dropping out of the survey with the demographic and socioeconomic characteristics. Then, we run the analyses based on the model that includes the panel attrition variable (i.e., a dummy variable that codes the drop-out sample as one and the others as zero on their final participating wave) to our final model (Model 4). Based on this model, we compare the unweighted estimates to the weighted findings using the inverse probability weights.

## 3. Results

### 3.1. Age-related profiles of chronic disease accumulation by immigrant status

Table 1 presents the summary statistics of the sample by immigration based on the participants' first entry into the panel. The final sample includes 108,313 native and 10,513 immigrant participants. Immigrants have a higher share of women compared to the native population. The proportion of the respondents in the youngest age group of 50–54 is higher in immigrants than in natives. Within immigrants there is a higher proportion of the respondents who are highly educated or have the lowest household income compared to the native-born individuals. The highest percentage of participants reside in Western and Central Europe, while the lowest proportion are from Northern European countries, regardless of the place of birth. The distribution of study participants in the immigrant sample is even more unequal, with more than half (50.5%) of the participants living in the Western and Central

**Table 1**
Baseline characteristics [a] of the study population by gender and immigrant status.

| | Natives | | Immigrants | | |
|---|---|---|---|---|---|
| | N | % | N | % | |
| Total | 108,313 | (100.0) | 10,513 | (100.0) | |
| Entry wave (year) | | | | | |
| Wave 1 (2004–2005) | 22,099 | (20.4) | 1868 | (17.8) | *** |
| Wave 2 (2006–2007) | 12,750 | (11.8) | 891 | (8.5) | *** |
| Wave 4 (2010–2011) | 28,821 | (26.6) | 3557 | (33.8) | *** |
| Wave 5 (2012–2013) | 17,599 | (16.2) | 2197 | (20.9) | *** |
| Wave 6 (2014–2015) | 10,128 | (9.4) | 1211 | (11.5) | *** |
| Wave 7 (2017–2019) | 16,061 | (14.8) | 714 | (6.8) | *** |
| Wave 8 (2019–2020) | 855 | (0.8) | 75 | (0.7) | |
| Gender | | | | | |
| Men | 49,154 | (45.4) | 4648 | (44.2) | * |
| Women | 59,159 | (54.6) | 5865 | (55.8) | * |
| Age groups | | | | | |
| 50–54 | 24,259 | (22.4) | 2566 | (24.4) | *** |
| 55–59 | 21,557 | (19.9) | 2098 | (20.0) | |
| 60–64 | 20,341 | (18.8) | 1820 | (17.3) | *** |
| 65–69 | 17,552 | (16.2) | 1600 | (15.2) | ** |
| 70–74 | 13,988 | (12.9) | 1401 | (13.3) | |
| 75–79 | 10,616 | (9.8) | 1028 | (9.8) | |
| Education | | | | | |
| Low | 42,443 | (39.2) | 3640 | (34.6) | *** |
| Medium | 43,820 | (40.5) | 4095 | (39.0) | ** |
| High | 22,050 | (20.4) | 2778 | (26.4) | *** |
| Household income (tertiles) | | | | | |
| Low | 43,646 | (40.3) | 4382 | (41.7) | ** |
| Medium | 30,025 | (27.7) | 3134 | (29.8) | *** |
| High | 34,642 | (32.0) | 2997 | (28.5) | *** |
| Employment | | | | | |
| Not working | 71,721 | (66.2) | 7009 | (66.7) | |
| Employed/self-employed | 36,592 | (33.8) | 3504 | (33.3) | |
| Marital status | | | | | |
| Not Married | 25,831 | (23.8) | 2589 | (24.6) | |
| Married | 82,482 | (76.2) | 7924 | (75.4) | |
| Region of residence [b] | | | | | |
| Eastern Europe | 29,231 | (27.0) | 2583 | (24.6) | *** |
| Northern Europe | 12,968 | (12.0) | 794 | (7.6) | *** |
| Southern Europe | 30,550 | (28.2) | 1831 | (17.4) | *** |
| Western and Central Europe | 35,564 | (32.8) | 5305 | (50.5) | *** |
| Origin country group [c] | | | | | |
| Africa | | | 1013 | (9.6) | |
| The Americas | | | 430 | (4.1) | |
| Asia and Oceania | | | 627 | (6.0) | |
| Eastern Europe | | | 3607 | (34.3) | |
| Other European countries | | | 4836 | (46.0) | |
| Number of chronic conditions | | | | | |
| 0 | 32,426 | (29.9) | 2934 | (27.9) | *** |
| 1 | 38,834 | (35.9) | 3589 | (34.1) | *** |
| 2 | 22,386 | (20.7) | 2312 | (22.0) | ** |
| 3 | 9729 | (9.0) | 1078 | (10.3) | *** |
| 4 | 3593 | (3.3) | 423 | (4.0) | *** |
| ≥5 | 1345 | (1.2) | 177 | (1.7) | *** |

*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/Center) and Northern, Southern, Western Europe were later grouped as "other European countries" for the analyses (see Table A1 for the detailed list of countries).

Europe area. 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.

Fig. 1 illustrates the age-specific prevalence of chronic health conditions by immigrant status 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 under age 75, with differences in the level of statistical significance. From age 75 onwards, the proportions of immigrants with one or more chronic conditions, four or more conditions, and five or more conditions are lower than those of their native-born peers, but the results are statistically insignificant. Additional subgroup analyses by gender, origin and receiving country report similar patterns that immigrants have a higher prevalence of having multiple chronic diseases at younger ages, but the proportion becomes lower than that of their native-born peers at older ages (Figs. S1–3; detailed results in Tables S3–5).

Table 2 shows the estimated results from the cross-sectional analyses of the pooled OLS models and the longitudinal estimations from fixed-effects models for the age-related number of chronic diseases. First, our cross-sectional analyses from the OLS models show the deduced group-level associations. According to the OLS model that includes only the demographic variables of age, gender, and immigrant status; being older, being a woman, and having an immigrant status 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).

Fig. 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). Fig. 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 (Fig. 2 panel b) indicates that the immigrant health disadvantage reaches its peak at age 60 to 64 and decreases from age 65 onwards.

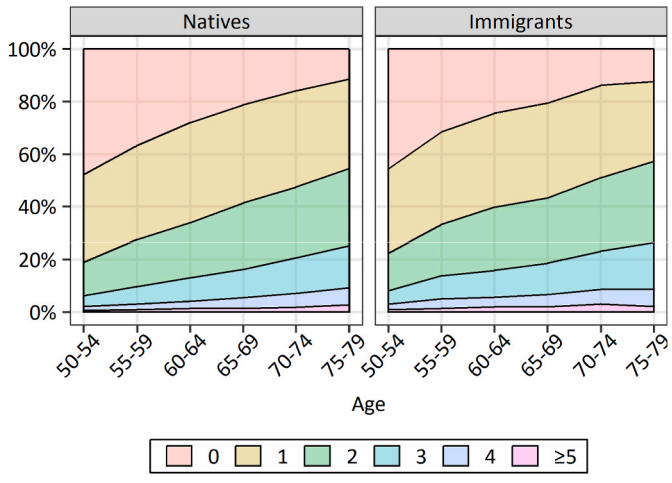


**Fig. 1.** Age-specific prevalence of chronic conditions at study entry by immigrant status.

In the next step, to account for unobserved heterogeneity, we employ fixed-effects models and explore within-subject changes longitudinally (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 report 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).

Fig. 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 (Fig. 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 (Fig. 3b).

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 S6). 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 (Fig. S4).

### 3.2. *Regional variations in age-related health trajectories by immigrant status*

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 (Figs. 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. Fig. 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 S7). 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 Fig. 4 panel a show that immigrants from the Africa and the Asia and Oceania country groups report 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 Fig. 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.

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 (Fig. 5, panel a; detailed results in Table S8). 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 Fig. 5 show that the

**Table 2**
Number of chronic conditions developed by age and immigrant status.

| | OLS | | | | | | Fixed-effects | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Model 1 | | Model 2 | | Model 3 | | Model 1 | | Model 2 | | Model 3 | |
| **Age group (ref: 50–54)** | | | | | | | | | | | | |
| 55–59 | 0.223 | *** | 0.219 | *** | 0.160 | *** | 0.151 | *** | 0.149 | *** | 0.142 | *** |
| | (0.007) | | (0.008) | | (0.008) | | (0.007) | | (0.007) | | (0.007) | |
| 60–64 | 0.412 | *** | 0.408 | *** | 0.216 | *** | 0.285 | *** | 0.283 | *** | 0.250 | *** |
| | (0.007) | | (0.008) | | (0.008) | | (0.007) | | (0.008) | | (0.008) | |
| 65–69 | 0.616 | *** | 0.616 | *** | 0.317 | *** | 0.452 | *** | 0.452 | *** | 0.399 | *** |
| | (0.007) | | (0.008) | | (0.008) | | (0.008) | | (0.009) | | (0.009) | |
| 70–74 | 0.806 | *** | 0.807 | *** | 0.474 | *** | 0.621 | *** | 0.620 | *** | 0.562 | *** |
| | (0.008) | | (0.008) | | (0.009) | | (0.010) | | (0.010) | | (0.011) | |
| 75–79 | 0.979 | *** | 0.983 | *** | 0.623 | *** | 0.778 | *** | 0.779 | *** | 0.717 | *** |
| | (0.008) | | (0.008) | | (0.009) | | (0.011) | | (0.011) | | (0.012) | |
| **Immigrant (ref: Native)** | 0.112 | *** | 0.103 | *** | 0.073 | *** | | | | | | |
| | (0.007) | | (0.019) | | (0.019) | | | | | | | |
| **Woman (ref: Man)** | 0.240 | *** | 0.240 | *** | 0.183 | *** | | | | | | |
| | (0.004) | | (0.004) | | (0.004) | | | | | | | |
| **Age group x Immigration status** | | | | | | | | | | | | |
| 55–59 × Immigrant | | | 0.037 | | 0.056 | * | | | 0.028 | | 0.030 | |
| | | | (0.025) | | (0.025) | | | | (0.023) | | (0.023) | |
| 60–64 × Immigrant | | | 0.047 | | 0.094 | *** | | | 0.019 | | 0.027 | |
| | | | (0.025) | | (0.025) | | | | (0.028) | | (0.028) | |
| 65–69 × Immigrant | | | −0.004 | | 0.047 | | | | −0.016 | | −0.010 | |
| | | | (0.026) | | (0.025) | | | | (0.032) | | (0.032) | |
| 70–74 × Immigrant | | | −0.008 | | 0.046 | | | | 0.006 | | 0.012 | |
| | | | (0.026) | | (0.026) | | | | (0.036) | | (0.036) | |
| 75–79 × Immigrant | | | −0.045 | | 0.009 | | | | −0.016 | | −0.011 | |
| | | | (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 | | | | | −0.017 | *** | | | | | 0.001 | |
| | | | | | (0.005) | | | | | | (0.004) | |
| High | | | | | −0.058 | *** | | | | | 0.012 | ** |
| | | | | | (0.005) | | | | | | (0.004) | |
| **Employed (ref: Not working)** | | | | | −0.397 | *** | | | | | −0.102 | *** |
| | | | | | (0.006) | | | | | | (0.007) | |
| **Married (ref: Not married)** | | | | | −0.105 | *** | | | | | −0.068 | *** |
| | | | | | (0.005) | | | | | | (0.011) | |
| **Constant** | 0.657 | *** | 0.658 | *** | 1.220 | *** | 0.929 | *** | 0.929 | *** | 1.039 | *** |
| | (0.006) | | (0.007) | | (0.009) | | (0.007) | | (0.007) | | (0.012) | |
| Number of persons | 118,826 | | 118,826 | | 118,826 | | 81,190 | | 81,190 | | 81,190 | |
| Number of person-years | 310,326 | | 310,326 | | 310,326 | | 272,690 | | 272,690 | | 272,690 | |
| R-squared | 0.080 | | 0.080 | | 0.107 | | 0.029 | | 0.029 | | 0.031 | |

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

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.

### 3.3. Sensitivity analyses results

First, we examined whether the changes in smoking, alcohol consumption, and physical activity may underlie the relationship between migration background and chronic disease accumulation (Table S9, Fig. S5). Results are consistent with the findings from our main results that the speed of chronic disease accumulation in immigrants compared to natives becomes slower at older ages.

Second, we performed 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 S10). 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.

Third, we combined the cardiovascular conditions and diabetes into a single condition to test the sensitivity of the results to our initial definition of multimorbidity (Table S11). Although the overall patterns remain similar, findings with the redefined grouping show a smaller immigrant-native differential in the estimated number of chronic health conditions in all of the OLS, fixed-effects, and random-effects models. This may imply that the concurrent occurrence of cardiovascular diseases and diabetes is more common in immigrants than in natives across all ages.

Fourth, analyses are done again with the category of “missing” to check the impact of missing values on our results Table S12). According to the results, the overall trend in age-related chronic disease accumulation remains unchanged after including the samples with missing observations. However, in stratified analyses by the immigrant status, including missing observations, the impact of missing information on marital status is significantly related to a lower number of chronic health conditions in natives, while the association is statistically insignificant among immigrants. This shows that the impact of the missing observations might vary depending on the nativity, resulting in a different size

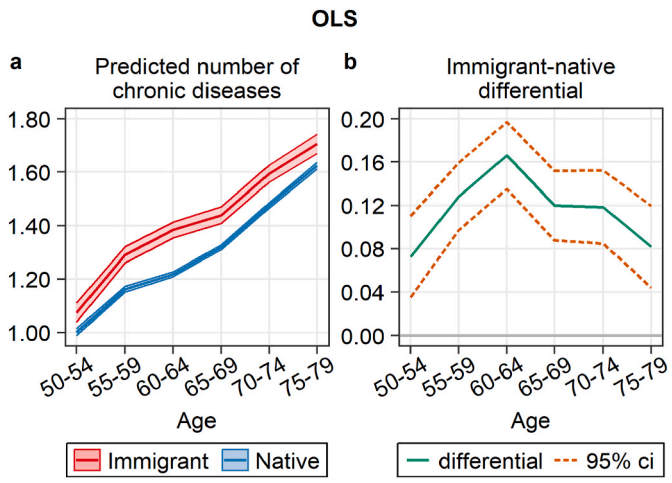


**Fig. 2.** Chronic health condition trajectories from the OLS estimation. **a** predicted number of chronic conditions by immigrant status; **b** immigrant-native differentials from the estimation

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

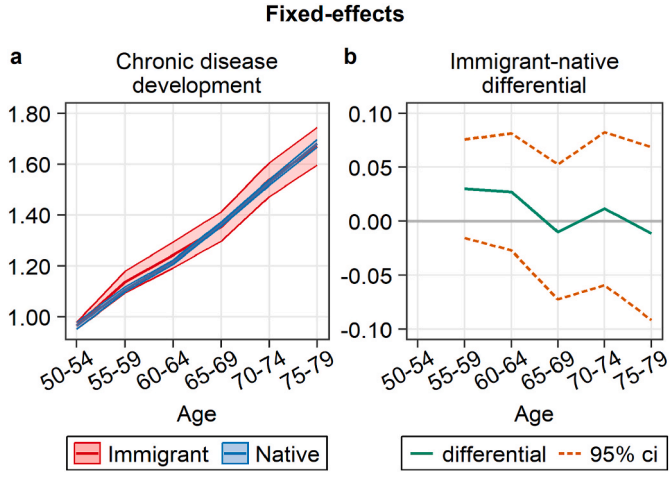


**Fig. 3.** Age effects on the development of chronic health conditions from the fixed-effects estimation. **a** group-specific development of chronic health conditions by immigrant status; **b** immigrant-native differentials from the estimation

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

of bias between immigrants and natives from non-responses.

Finally, we assessed the potential bias from panel attrition in our sample using the inverse probability weights (all-cause attrition: Table S13, Fig. S6; mortality attrition: Table S14; Fig. S7). Although the immigrant-native differential in the chronic disease accumulation becomes less steep in the weighted model for the all-cause drop-out participants, the differences are not large and the qualitative conclusions are the same for both weighted and non-weighted models.

## 4. 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 (Spallek et al., 2011).

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 provided additional insight into the ageing processes in immigrant populations compared to natives by examining pathways between age and multimorbidity progression. 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 self-reported 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 (Bousmah et al., 2019; Giuntella & Mazzonna, 2015; Solé-Auró & Crimmins, 2008). 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 health behaviour. Although immigrants are more likely to adopt unhealthy lifestyles as the length of their stay in the receiving country increases (Ana F. Abraído-Lanza et al., 2005), their likelihood of quitting smoking (Allen et al., 2014; Lopez-Gonzalez et al., 2005; Shelley et al., 2004), reducing their alcohol consumption (Lopez-Gonzalez et al., 2005), and increasing their physical inactivity (Dogra et al., 2010; Mahmood et al., 2019) increases concurrently. This direction of the transition between behaviours, from healthy to unhealthy and vice versa, may also depend on the context of origin and receiving countries, as migrants are known to bring health-related attitudes from the sending countries (Reiss et al., 2015). The 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. However, there are several other instances where this is not the case, as the lifestyle transition can happen the unhealthy to healthy behaviours in some populations from origins with a higher prevalence of lifestyle-related risk factors (Razum & Twardella, 2002).

Another possible explanation for the slower accumulation of reported chronic diseases in immigrants than in natives is the return-migration bias. That is, if immigrants were more likely to attrite from the study than natives due to poor health and/or return migration to their home country, the remaining immigrant group would be healthier than the expected level. Although several studies support that the immigrant health advantage cannot be fully explained by the return migration bias (A F Abraído-Lanza et al., 1999; Turra & Elo, 2008), the better self-reported health status in immigrants who remain in the receiving country compared to those migrate back to the origin country provide support for this hypothesis (Palloni & Arias, 2004).

Our analyses of regional variations by origin 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. This is a trend that is similarly found in previous studies, where immigrants from less developed regions have a much steeper decline in self-assessed mental,

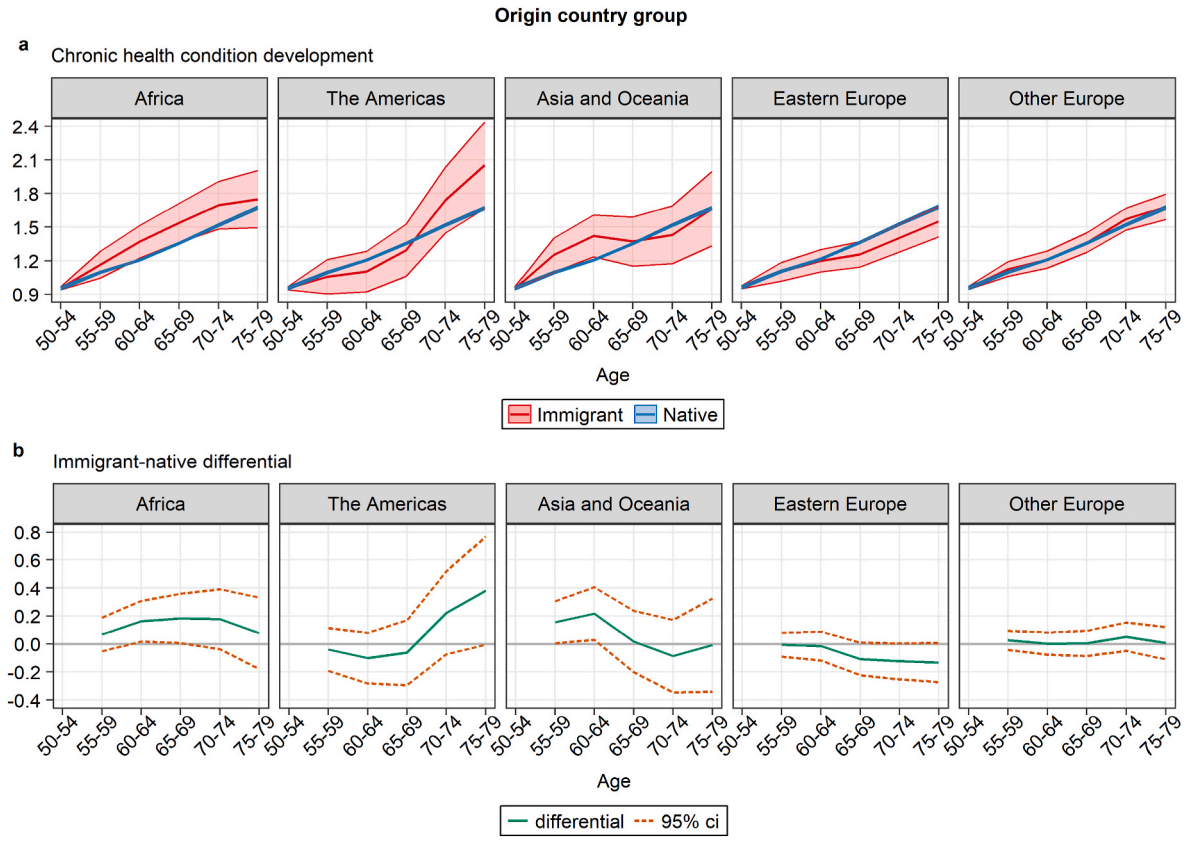


**Fig. 4.** Regional variations in the development of chronic health conditions by immigrant status between origin country groups. **a** group-specific development of chronic health conditions by immigrant status; **b** immigrant-native differentials from the estimation
*Note:* All covariates calculated at the average; shaded areas from panel **a** indicate 95% confidence intervals.

functional, and chronic physical health than natives (Bousmah et al., 2019; Malmusi, 2015). There are studies that try to understand this phenomenon through the occupational factors, that immigrants from the low development areas are more likely 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 (Giuntella & Mazzonna, 2015; Stalker, 1994). Our results on the faster accumulation of chronic diseases in immigrants from Africa and Asia and Oceania at working ages may reflect the association between the work-related burdens of these immigrants and their adverse health outcomes. However, we can only speculate the underlying mechanisms behind the faster accumulation of chronic diseases at the young-old ages of immigrants in our study, which needs further investigation in the future.

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 (Akdede & Giovanis, 2020). 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 (Bhugra & Becker, 2005; Landrine & Klonoff, 2004). 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 (López et al., 2014; Martinez-Miller et al., 2020). Findings from the research that cultural congruity between the origin and the receiving countries leads to better age-related health outcomes may partly explain why immigrants from Eastern Europe report a slower accumulation of chronic diseases in our study.

Our study adds to the literature on chronic disease accumulation and its regional variation among older migrants in Europe. Our analyses by the receiving country group demonstrate that the speed of chronic disease accumulation is largely similar between immigrants and natives in Northern, Southern, and Western Europe. These results contradict the current cross-sectional literature on migrant health in Europe, which suggests that immigrants in Northern and Western Europe are frailer and are more likely to be depressed than native-born persons (Aichberger et al., 2010; Brothers et al., 2014). However, our findings are in line with prior studies which employed a longitudinal approach to study age-related declines in health among immigrants. For example, Walkden et al. showed that immigrants in Eastern Europe are more likely to accumulate frailty at a faster rate than non-migrant populations, while this immigrant health advantage is much less apparent in other European regions (Walkden et al., 2018).

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. Due to the lack of data on lifestyle prior to migration in the survey data, we cannot investigate whether immigrants' adaptation to the unhealthier lifestyles that may be prevalent in the host country underlies faster accumulation of chronic diseases among immigrants compared to natives.

Second, there is an issue of selection bias due to panel attrition in SHARE, which is a common issue in longitudinal designs. As declining

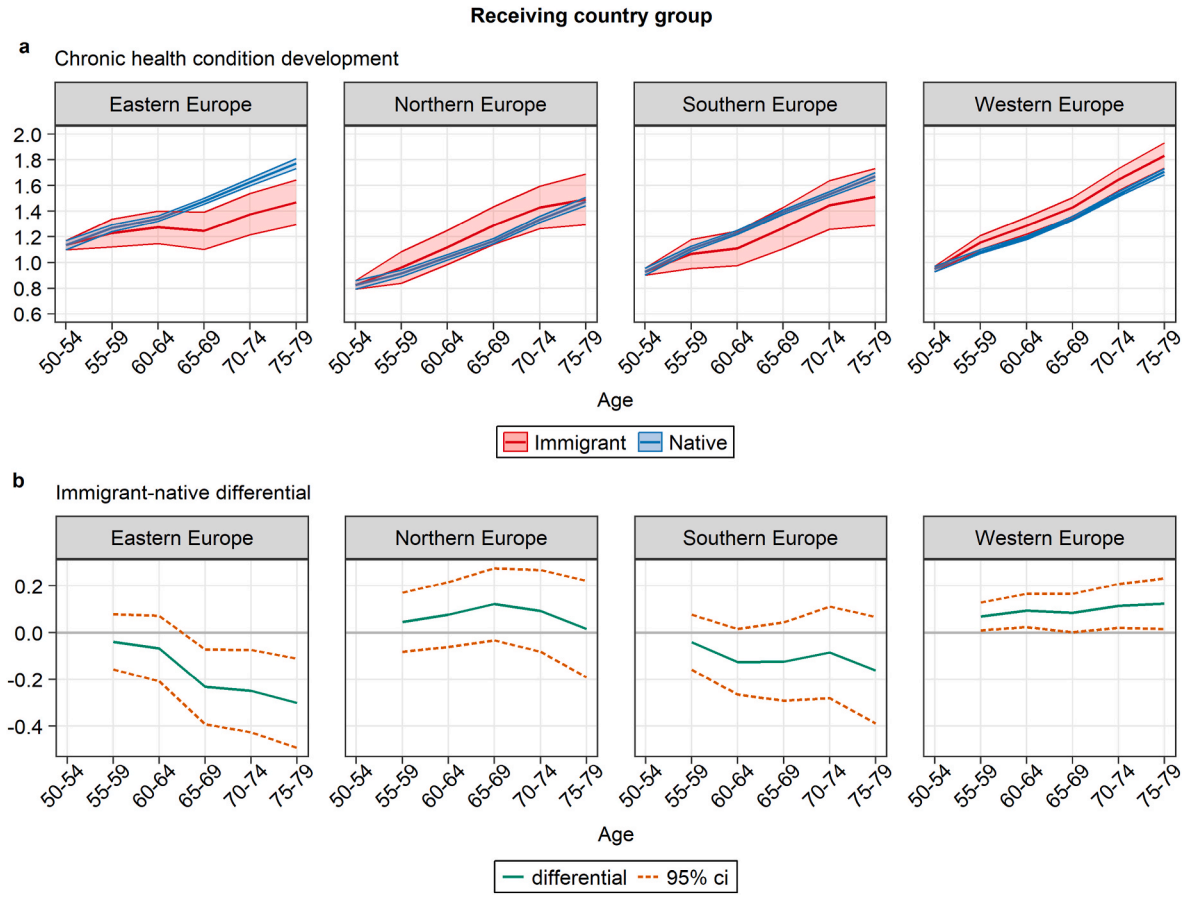


**Fig. 5.** Regional variations in the development of chronic health conditions by immigrant status between receiving country groups. **a** group-specific development of chronic health conditions by immigrant status; **b** immigrant-native differentials from the estimation
*Note:* All covariates calculated at the average; shaded areas from panel **a** indicate 95% confidence intervals.

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 as the return-migration also contributes to the drop-out rates. Our sensitivity analysis showed no significant level of differences between the weighted and non-weighted estimates. 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.

Further, cross-national studies find that the prevalence of chronic disease combinations differs across regions, such as the high burden of cardiovascular diseases and comorbidities in low- and middle-income countries (Bayes-Marin et al., 2020; Garin et al., 2016; Thienemann et al., 2020). This suggests that our results are, to some extent, dependent on the origin and receiving countries. However, due to the limited sample size, we are not able to add the fixed-effects of the origin and the receiving country to our models. Although our stratified analyses by country groups may reveal the regional aspects of the immigrant-native health gap on a general level, characteristics that are specific to each country remain uncontrolled.

Another study limitation may arise from the unevenly distributed samples in our study. As we show in Table 1, the composition of the respondents in each country group is largely imbalanced across regions. In particular, more than 50% of immigrants included in the study are from Western and Central European countries. In SHARE, eight countries (Bulgaria, Cyprus, Finland, Latvia, Lithuania, Malta, Romania, and Slovakia) joined the survey in Wave 7, which gives only a maximum of two-wave observation in participants from these countries (Bergmann et al., 2019). This recent refreshment sample explains the unequal regional distribution of our sample, considering that six out of eight countries are classified as Eastern European countries, while none of them is a Western European country. Thus, our results may be driven by the patterns observed in the Western and Central European countries.

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. The current study indicates that implications of ageing on the health of immigrants may differ across migrant subgroups, suggesting that the public health strategies to maintain individuals' health at older ages should be tailored for each origin and receiving country group rather than being designed for the whole "ageing immigrant" population.

## Author statement

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.

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## Declaration of competing interest

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

## Data availability

This study uses publicly available data from SHARE Waves 1, 2, 3, 4, 5, 6, 7, and 8.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2023.101478.

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