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Mortality impact of the Covid-19 epidemic on immigrant populations in Spain[☆]

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ABSTRACT

Immigrant populations have been shown to display a disproportionately high mortality burden during the Covid-19 epidemic in some high-income countries. Individual civil registration data from Spain, one of the countries with the highest Covid-19 mortality in Europe, was used in order to characterize mortality during the Covid-19 epidemic for different immigrant groups. Individuals born in South America, Sub-Saharan Africa and Asia are shown to have suffered higher mortality impact than the native-born, particularly at working ages (40–59 years old), which could be due to higher proportions of immigrants from these regions among key workers. However, this disproportionate impact is not as high as found in other European countries, like France or Sweden. On the other hand, immigrants born in Europe show a relatively low mortality increment during the epidemic compared to the native-born. In addition, evidence is shown of a generalized and strong migrant mortality advantage for all non-European immigrant groups in Spain, that reduces or even reverses for some groups of countries of birth in 2020.

1. Introduction

During the Covid-19 epidemic, immigrant populations in high-income countries have shown differential mortality patterns compared to native-born. An immigrant is here defined as person born in a country that is not the country of residence, regardless of citizenship and other trajectory considerations. Higher increases of mortality among immigrants compared to the native-born have been reported, among other countries, in France (Khalat et al., 2022), Sweden (Drefahl et al., 2020; Rostila et al., 2021), Italy (Canevelli et al., 2020), Belgium (Vanthomme et al., 2021), Denmark and Norway (Krasnik et al., 2020). Infection risk among immigrants has also been found to be higher than among native-born populations (OECD, 2020).

Spain stands as a particularly relevant context for the study of the impact of the Covid-19 epidemic on immigrant populations. First of all, Spain's population includes high proportions of foreign-born individuals. On January 1st, 2020, 15.2% of the population of the country was born abroad (INE, 2022a), a proportion that is slightly higher than

in other Western countries, such as Italy, France, the United Kingdom or the United States (OECD, 2022). Of those, 31% were born in Europe, 44% were born in America (the highest of any European country), 18% were born in Africa and 7% in Asia (INE, 2022a).

Second, Spain is a relevant context due to the high mortality burden that the epidemic caused in the country during the first two waves (March–May and October–December 2020). Particularly for the first wave of the epidemic, Spain showed a very high excess mortality (about 100 excess deaths per 100,000 population, second highest after England and Wales among 21 industrialized countries, Kontis et al., 2020), while only a part of it was explained by the reported Covid-19 deaths (Aldea-Ramos, 2022).

Last, because Spain presents a considerable gap in the proportion of workers who can work from home according to country of birth (OECD, 2020): while 26% of the native-born workers hold an employment that allows remote working, only 13% of the foreign-born do. This gap of 13 points is smaller than in Italy (19 points) but larger than in France (7), Sweden (10) or the United Kingdom (3). Moreover, this proportion

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could be highly variable among different countries of birth. This, along with other socio-economics disparities between foreign-born and native-born populations in Spain, raises the question of the extent to which immigrant populations were differentially affected by the Covid-19 epidemic in Spain.

In order to describe the mortality of immigrants in Spain during the Covid-19 epidemic, I employ individual population and all-cause mortality data sets in Spain, from 2015 to 2021, that include information on country of birth and region of residence for all individuals.

The goal of this paper is to describe mortality differentials during the Covid-19 epidemic, and to highlight the disparate social conditions that they imply. To do so, I establish mortality increases during the epidemic for several immigrant groups by country of birth. Then, the mortality of different foreign-born groups is compared to that of the Spanish-born, leading to an examination of mortality differentials between immigrants and native-born in Spain prior to the epidemic, but also to how the Covid-19 epidemic has transformed these differentials.

2. Background

2.1. Migrant mortality advantage

Immigrant populations show a mortality advantage (*i.e.* lower mortality rates by age and sex) in a number of high-income countries compared to the native-born (Aldridge et al., 2018; Razum et al., 1998; Shor & Roelfs, 2021; Wallace et al., 2019). This phenomenon is known as the migrant mortality advantage and, while its causes are still discussed, four main explanatory mechanisms emerge in the literature. The first and arguably most important is the "healthy migrant effect" (Abraído-Lanza et al., 1999; Riosmena et al., 2012), consisting in a positive health selection of individuals when internationally migrating in the first place. The second is the "salmon bias" (Abraído-Lanza et al., 1999; Turra & Elo, 2008), or the international out-migration (*i.e.* return migration to the country of origin) of those in poor health, *e.g.* negative health selection at return. This "salmon bias", as arduous to measure as it is (Guillot et al., 2022), has been observed in some countries (Guillot et al., 2022; Turra & Elo, 2008). Third are cultural effects (Blue & Fenelon, 2011; Khlát & Darmon, 2003; Reeske et al., 2009) which could make immigrant populations maintain habits from their country of origin (*i.e.* diet, no smoking, low alcohol consumption) that are healthier than among the native-born. Last, data artifacts could contribute to the migrant mortality advantage (Deboosere & Gadeyne, 2005; Palloni & Arias, 2004), either by the under-registration of deaths of the foreign-born or by the over-registration of foreign-born populations.

2.2. Covid-19, immigrants and mortality

In Western countries, the Covid-19 epidemic has signified the first period in a long run in which infectious diseases have accounted for a considerable part of overall mortality. Though the epidemiological transition had removed infectious diseases as major cause of death, those diseases are liable to reappear periodically (Omran, 1998). Under such circumstances, immigrants have shown higher increases in mortality than the native-born (Khlát et al., 2022; Rostila et al., 2021), removing or even reversing the usual migrant mortality advantage observed in those countries. Historically, when infectious diseases were predominant, immigrants showed higher mortality than the native-born, as it was the case of European immigrants in the United States in the early 20th century (Bakhtiari, 2022). The problem of differential mortality impacts of major epidemics has also been studied for past events, namely, the 1918 influenza epidemic (Eiermann et al., 2022).

This particular impact of infectious diseases on immigrants is not due to a congenital frailty of immigrants themselves, but rather to a set of social conditions that make immigrants more strenuously exposed to those diseases. Those include poverty (Lelkes & Zólyomi, 2011), larger

households (Requena & Sánchez-Domínguez, 2011), higher presence in densely populated areas, jobs that are more exposed to contamination (Gosselin et al., 2022), or worse access to healthcare (Lebano et al., 2020).

Despite the magnitude and mortality burden of the first wave of the Covid-19 epidemic in Spain and the high proportion of foreign-born in the country's population, no research has been carried on the differential impact of Covid-19 on immigrants, barring two cohort studies with different research objectives. The first one employed a small clinical cohort and showed no differential mortality for hospitalized patients born in Latin America (Sempere-Gonzalez et al., 2021). The second studied differential infection risk in a municipality in Madrid, showing higher risk of contracting Covid-19 for those born in Sub-Saharan Africa, Latin America and the Caribbean (Guijarro et al., 2021).

Yet, social conditions under which immigrants live in Spain hint towards a higher exposure to infection and mortality. In 2020, foreigners lived in households occupied by 3.9 people on average, while the households where the Spanish lived counted 3.1 people on average (INE, 2022b). While citizenship and migration status are not equivalent, the 2007 migration survey (INE, 2007) showed immigrants living in households of 3.4 people on average, while those of the Spanish-born were smaller at that time (Requena & Sánchez-Domínguez, 2011). A larger number of individuals in the household could in fact facilitate the transmission of the virus. Immigrants were also over-represented in dense and large urban zones, where the virus could have been more easily spread. Besides, in European countries, immigrant workers were found to occupy jobs that were less suitable for remote working (OECD, 2020), they were more required as essential front line workers (Gosselin et al., 2022) and could rely less on temporary or partial wage subsidies (Gosselin et al., 2022), thus being more exposed even in lockdown periods. Furthermore, low economic status, in which immigrants are over-represented, has been linked to the incapacity to properly adopt and comply with preventive measures and self-isolation guidelines (Atchison et al., 2021).

Considering outcomes after infection and lethality, immigrant status has sometimes been associated with higher rates of Covid-19 comorbidities, namely type 2 diabetes (Agyemang et al., 2021) and asthma (Tobias et al., 2001). However, both the 2017 Spanish Health Survey (INE, 2017) and the 2020 European Health Survey in Spain (INE, 2020), reveal immigrants showing lower rates of chronic illness, hypertension, heart disease, bronchitis, diabetes, malignant neoplasms, and similar rates of asthma than the native-born, all these pathologies being able to increase the risk of a severe outcome of Covid-19 infection (CDC, 2022). Those rates could, however, strongly vary across countries of birth.

Finally, the access of immigrants to general healthcare and primary care was especially impacted by the Covid-19 epidemic (Doan et al., 2021; Knights et al., 2021; Fu et al., 2022), which could have had an effect not only on Covid-19 mortality, but on overall mortality itself, either by delaying diagnoses and treatment, or by preventing treatment for urgent pathologies.

3. Methods

3.1. Population data

The employed population data set is open, and made available by INE (Spanish Institute for Statistics). Those individual data are derived from the Permanent Register (*Padron continuo*¹), and contain information on place of birth, place of residence, age, sex and country of citizenship, among other, for every resident on every January, 1st. In order to

¹ Instituto Nacional de Estadística. Continuous Register Statistics. Results (microdata). https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736177012&menu=resultados&idp=1254734710990#!tabs-1254736195462.

construct exposed populations for the years 2015–2020, I employed population data from January 1st, 2015 to January 1st, 2021, which I interpolated as detailed hereunder.

The registration is compulsory for all residents, and so coverage is essentially exhaustive. However, when considering foreign-born, the Register poses a problem with the registration of migrants. Non-EU migrants must compulsory register every two years, while EU-migrants must do it every 5 years. Thus, it is possible to encounter in the Register a certain number of individuals who have already left the country, hence overestimating their number. There can be also lags of registration for movements within the Spanish territory but this does not have an effect on the results, since most of them concern movements within the same municipality. However, those data issues have been shown to be unlikely to account for the observed mortality differentials (Anson, 2004; Wallace & Kulu, 2014; Wallace & Wilson, 2021).

3.2. Mortality data

The all-cause individual mortality data are also open and published by INE. They are derived from death certificates, and include information on place of birth and residence, type of place of death (i.e. hospital, home ...), age and sex. I employed mortality data for the period between January 1st, 2015 and December 31st, 2020 for residents in Spain (2,584,378 deaths).

Covid-19 mortality presents an age-specific pattern that is more concentrated at older ages than other causes mortality: only 120 (0.4%) of the 28,643 reported Covid-19 deaths until the end of May 2020 in Spain concerned individuals aged under 40. As a comparison, 1.5% of the total deaths in Spain in the year 2019 were of people aged under 40. Because of this age specificity of mortality from Covid-19, I only consider deaths among those aged 40 or older for this study. Individual all-cause counts were aggregated by 5-year age groups (40–44, 45–49, ..., 85 and older), sex, country of birth, province of residence and year and month of death. When country of birth was missing and the person was born abroad, country of citizenship was imputed as country of birth, when it was not Spain: this concerns only 911 deaths, or 0.8% of the deaths of the foreign-born in the 2015–2020 period. For the rest of the missing values (5667 or 0.2% of all deaths in the 2015–2020 period), a multivariate imputation by chained equations was computed in order to retrieve country of birth, based on age at death and place of residence. Those imputations concern a relatively low number of deaths, and sensitive analysis was carried out, showing that they do not affect the observed mortality differentials.

3.3. Country of birth

For confidentiality purposes, the INE does not publish deaths of those born in countries with less than a threshold number of deaths a year, all ages considered. Thus, only countries of birth with deaths included in every year of the period 2015–2020 were selected for the analysis. Consistently, in order to avoid a numerator-denominator mismatch, I only included population counts of individuals born in those selected countries.

Those countries were merged into the following regional groups: Western Europe, Eastern Europe, North Africa, Sub-Saharan Africa, South America, Other America,² and Asia. The complete list of classified countries and their population and death counts is detailed in Table S1. Some regions (particularly, Sub-Saharan Africa) are composed of only a

² Argentina and Uruguay were classified into the "Other America" group, as migrants from those two countries differ from other South American migrants. While most South American migrants arrived to Spain after the year 2000, a considerable part of migrants from Argentina and Uruguay are, in fact, the children of Spanish emigrants during the 20th century, who were born abroad and returned to Spain with their parents before 2000.

few countries: as a consequence, they must not be interpreted as representative of immigrants from the whole region, but rather as a sum of the selected countries in that region.

3.4. Period of study

I considered the first two waves of the Covid-19 epidemic in Spain. The first one (henceforth, wave 1) covers the months of March, April and May 2020. The second one (wave 2), October, November and December 2020. Mortality is compared to the same periods of the years 2015–2019. In order to compute mortality rates, the population is considered at the middle of each period (i.e. April 15th for wave 1, November 15th for wave 2). Exposed populations were obtained by interpolating the populations from the Register of the two adjacent January 1st, for every age group, sex, country of birth and place of residence. Also, complete calendar years were employed for the analysis in model 3.

3.5. Place of residence

Place of residence must be considered for two reasons. First, migrants are not evenly distributed within the Spanish territory, with their proportions by province varying from 4% in Jaén to 25% in the Balearic Islands (source: INE). Second, the Covid-19 epidemic unevenly impacted the Spanish territory: during wave 1, three regions (Madrid, Castilla y Leon and Castilla-La Mancha) accounted for half of the reported Covid-19 deaths, while only hosting 24% of the country's population (Ministerio de Sanidad, 2020).

For the purpose of this study, I defined two regions within Spain: a high-impact (HIR) and a low-impact region (LIR). Those two regions were only defined for wave 1 of the epidemic, as regional differences during wave 2 are much less sharp. The HIR includes all provinces showing a crude mortality rate due to reported Covid-19 deaths above the national average within wave 1 (0.6‰). Sensitivity analysis was performed around this threshold showing no major effects, as the most populated provinces are either far above (Madrid, Barcelona) or far below it (Valencia, Sevilla, Alicante). The distribution of provinces within the two regions for wave 1 is detailed in Table S2.

3.6. Strategy and analysis

3.6.1. Model 1

A first model was computed to evaluate the all-cause mortality increase during the Covid-19 epidemic (direct and indirect mortality impact of the epidemic). The data were stratified by wave, region of birth r and two large age groups g (40–59, and 60 or older). For each stratum, a quasi-Poisson model taking over-dispersion into account was performed to establish mortality rate ratios (MRR) during the epidemic. Age, sex and year of death were employed as control variables, the population being an offset. The model is defined by the equation:

$$\log(d_{g,r}) = \log(pop_{g,r}) + \beta_0 + \sum_{i=1}^n \beta_i \cdot A_i + \beta_{n+1} \cdot S + \sum_{i=1}^n \beta_{n+1+i} \cdot A_i \cdot S + \beta_{2n+2} \cdot YD + \beta_{2n+3} \cdot C19 \tag{1}$$

Where A_i are the n different 5 year-age groups within the two large age groups g , S is a dummy variable equal to 1 for females and 0 for males, YD is the year of death³ (2015–2020) and $C19$ is a dummy variable for Covid-19 equal to 1 when $YD = 2020$ and 0 otherwise. β_{2n+3}

³ As the data are stratified by wave, when the model is applied to wave 1, only data from months March to May of years 2015–2020 is employed. If it is applied to wave 2, data from months October to December of the years 2015–2020.

represents the mortality increment during the Covid-19 epidemic as compared to the expected mortality level for 2020. Thus, the MRR for each region of birth r and large age group g associated with the epidemic is:

$$MRR_{g,r} = \exp(\beta_{2n+3}) \tag{2}$$

Year of death was included in order to separate the diminishing mortality trend in the 2015–2019 period from direct and indirect mortality due to the 2020 epidemic. Eventually, the data were also stratified by region of residence (HIR, LIR) for wave 1, to measure different mortality increases in high and low-impact regions.

3.6.2. Model 2

A second model was built to relate increases in mortality during the epidemic among different groups of countries of birth.⁴ For that matter, a model similar to model 1 (eq. (1)) was constructed, but this time there was no stratification by country of birth, and country of birth was included in the equation, interacting with the C19 dummy variable:

$$\begin{aligned} \log(d_{g,r}) = & \log(pop_{g,r}) + \beta_0 + \sum_{i=1}^n \beta_i \cdot A_i + \beta_{n+1} \cdot S + \sum_{i=1}^n \beta_{n+1+i} \cdot A_i \cdot S + \beta_{n+1} \cdot YD + \\ & \cdot \beta_{2n+3} \cdot C19 + \sum_{i=1}^m \beta_{2n+3+i} \cdot CB_i + \sum_{i=1}^m \beta_{2n+m+3+i} \cdot CB_i \cdot C19 \end{aligned} \tag{3}$$

Thus, β_{2n+3} represents the mean variation of mortality during the Covid-19 epidemic, as in equation (1), β_{2n+4} to β_{2n+3+m} are the mortality levels of every group of countries of birth CB_i compared to the Spanish-born, and thus the increase in mortality of those born in region r relative to the Spanish-born during the epidemic is:

$$MRR_{g,r} = \exp(\beta_{2n+m+3+r}) \tag{4}$$

The model was also run by 10-year age-groups (results are shown in Fig. S2).

3.6.3. Model 3

The third model aims to describe overall mortality of immigrants compared to that of the Spanish-born. Data were stratified by year (y). For each *stratum*, a quasi-Poisson model taking over-dispersion into account was performed to establish mortality rate ratios (MRR) for m migrants groups compared to native-born. Age and sex were employed as control variables but, this time, no large age groups were employed. The model was performed for entire calendar years 2015–2020, and is defined by the equation:

$$\begin{aligned} \log(d_y) = & \log(pop_y) + \beta_0 + \sum_{i=1}^n \beta_i \cdot A_i + \beta_{n+1} \cdot S + \sum_{i=1}^n \beta_{n+1+i} \cdot A_i \cdot S + \\ & + \sum_{i=1}^m \beta_{2n+1+i} \cdot CB_i \end{aligned} \tag{5}$$

Where A_i are the n different 5 year-age groups, S is dummy variable equal to 1 for females and 0 for males, and CB_i are the m different groups of countries of birth, the Spanish-born being the reference. Thus the MRR of migrant group r compared to the native-born for the entire year y is:

$$MRR_{r,y} = \exp(\beta_{2n+1+r}) \tag{6}$$

When performing this model, a supplementary stratification was done by the two large age groups (40–59 and 60+), whose results are shown in Table S5.

4. Results

4.1. Model 1

MRRs from model 1 show higher mortality increases in wave 1 compared to wave 2 (Fig. 1, Table S3). Spanish-born aged 60 and over show a MRR of 1.50 in wave 1, while it is 1.19 for those aged 40 to 59. In wave 2, those MRRs are 1.19 and 1.06, respectively. Western Europeans show small changes in mortality compared to previous years. In wave 2, those aged 60 and over born in Western and Eastern Europe show no mortality increase compared to previous years.

Most of groups born outside Europe show high MRRs, particularly at working ages (40–59 years old). At those ages, during wave 1, all non-European groups (save North Africans) show high MRRs, and those in-

creases are specially sharp for South Americans (MRR = 1.77), Asians (MRR = 1.66) and Sub-Saharan Africans (MRR = 2.81). During wave 2, those three groups plus North Africans show as well the highest MRRs at working ages, even if they are less sharp.

Considering those aged 60 and over, most non-European groups show MRRs of around 1.5 during wave 1. However, the sharp mortality increases of South Americans and Sub-Saharan Africans persist at those ages, with MRRs of 2.46 and 1.85, respectively. In wave 2, all non-European groups show MRRs close to 1.5: those of South Americans, Asians and all Africans are the sharpest.

A supplementary breakdown by region of residence for wave 1 (Fig. S1, Table S4) shows, first, the extremely divergent mortality burden between the two regions (HIR and LIR). In the HIR, all non-European groups show MRRs over 1.4 at working ages (those being higher than 2 for South Americans and Sub-Saharan Africans). For those aged 60 and over, the MRRs are higher than 3 for South Americans and Sub-Saharan Africans. In the LIR, Sub-Saharan Africans show a disproportionately high impact at working ages (MRR = 2.69). Moreover, this breakdown by region of residence shows that the relatively low mortality increase of North Africans in wave 1 (Fig. 1) is partly due to their regional distribution, as they show, in the HIR, mortality increases close to other non-European groups.

4.2. Model 2

The mortality rate ratios from model 2 (Fig. 2) show the relative mortality increases by origin during the epidemic relative to increases for the native-born. For both waves, individuals born in Western Europe have similar increases in mortality than the Spanish-born at working ages, and lower increases over 60 years old. Those born in Eastern Europe have slightly higher increases than the native-born before 60 years old, but increases converge to those of the Spanish-born at older ages.

Individuals from South America have very strong mortality increases compared to the Spanish-born, particularly during wave 1. For this

⁴ Alternatively stated: relative excess mortality rate to Spanish-born.

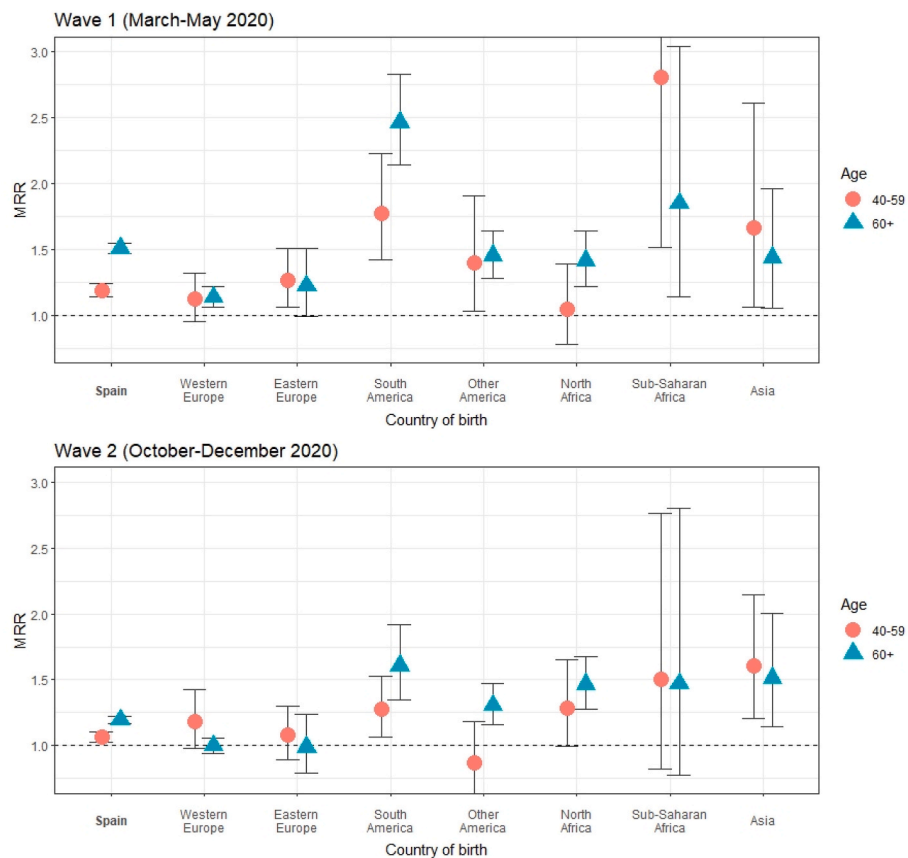


Fig. 1. Mortality rate ratios from model 1 during the Covid-19 epidemic compared to previous years by groups of countries of birth and age group (40–59, and 60 or older) for the two first waves of the epidemic, with 95% confidence intervals.

period, the mortality increase was more than 1.5 times that of the Spanish-born. Even if less sharply, South Americans show during wave 2 quite higher increases than the native-born as well. Those from Other America have strong increases at ages below 60 during wave 1, but they converge to native-born at higher ages.

Individuals from North Africa show slightly lower increases in mortality than the Spanish-born during wave 1 at all ages, but then slightly higher increases during wave 2. The population from Sub-Saharan Africa suffers particularly high increases compared to the Spanish-born at ages below 60. The MRRs associated to those relative increases are higher than 1.5 for wave 1. At older ages, though increases seem as well higher than those of the native-born, the headcount is too small. Finally, those born in Asia show stronger increases than the Spanish-born at all ages during wave 2, while those are not so clear during wave 1.

4.3. Model 3

MRRs relative to the Spanish-born from model 3 show a mortality advantage for all non-European groups of countries of birth (Fig. 3). By contrast, those born in Western Europe show mortality levels similar to those of the native-born.

The year 2020 shows a disruption in the MRRs between groups of countries of birth. Those born in South America and Asia reduce their mortality advantage, while the Sub-Saharan Africa-born completely reverse it. Moreover, individuals born in Sub-Saharan Africa show the highest standardised mortality rate of all origins for the year 2020 (being more than 1.1 than one of the Spanish-born). Natives from North Africa and other America show barely no MRR change respective to Spanish-born. Finally, individuals born in Western Europe show a little mortality advantage in 2020 not present in previous years, while those born in

Eastern Europe keep their mortality levels close to those of the Spanish-born.

Table S5 displays detailed MRRs for every group of origins, large age groups and periods 2015–2019 and 2020. The migrant mortality advantage of non-European groups is more important at working ages (40–59), while Western Europeans show a significant mortality disadvantage at those same ages.

5. Discussion

I find a strong impact of the Covid-19 epidemic on mortality for most immigrant populations in Spain, as well as for the native-born. This increase is found to be stronger during wave 1 of the epidemic compared to wave 2, and for population aged 60 and over compared to those aged 40 to 59. Individuals born in South America and Sub-Saharan Africa are found to have suffered the worst mortality impacts during both waves of the epidemic. On the other hand, individuals born in Europe are shown to display little change in mortality during the epidemic. At working ages, individuals born in Asia suffer as well a disproportionately high impact on mortality during both of the first two waves. This mortality impact refers to both the direct and indirect effects of the Covid-19 epidemic. Thus, the mortality increase could be due to Covid-19, but also to other causes. Other causes of death could have increased due to the disruption of healthcare services during the epidemic. In return, some causes of deaths could have decreased due to lockdown measures, or due to competition with Covid-19.

Thus, consistent with other studies (Drefahl et al., 2020; Khlata et al., 2022), the mortality increase in non-European immigrants due to the Covid-19 epidemic is found to be higher than that of the native-born, particularly at working ages. As there is no evidence of differential mortality after infection between immigrants and the native-born

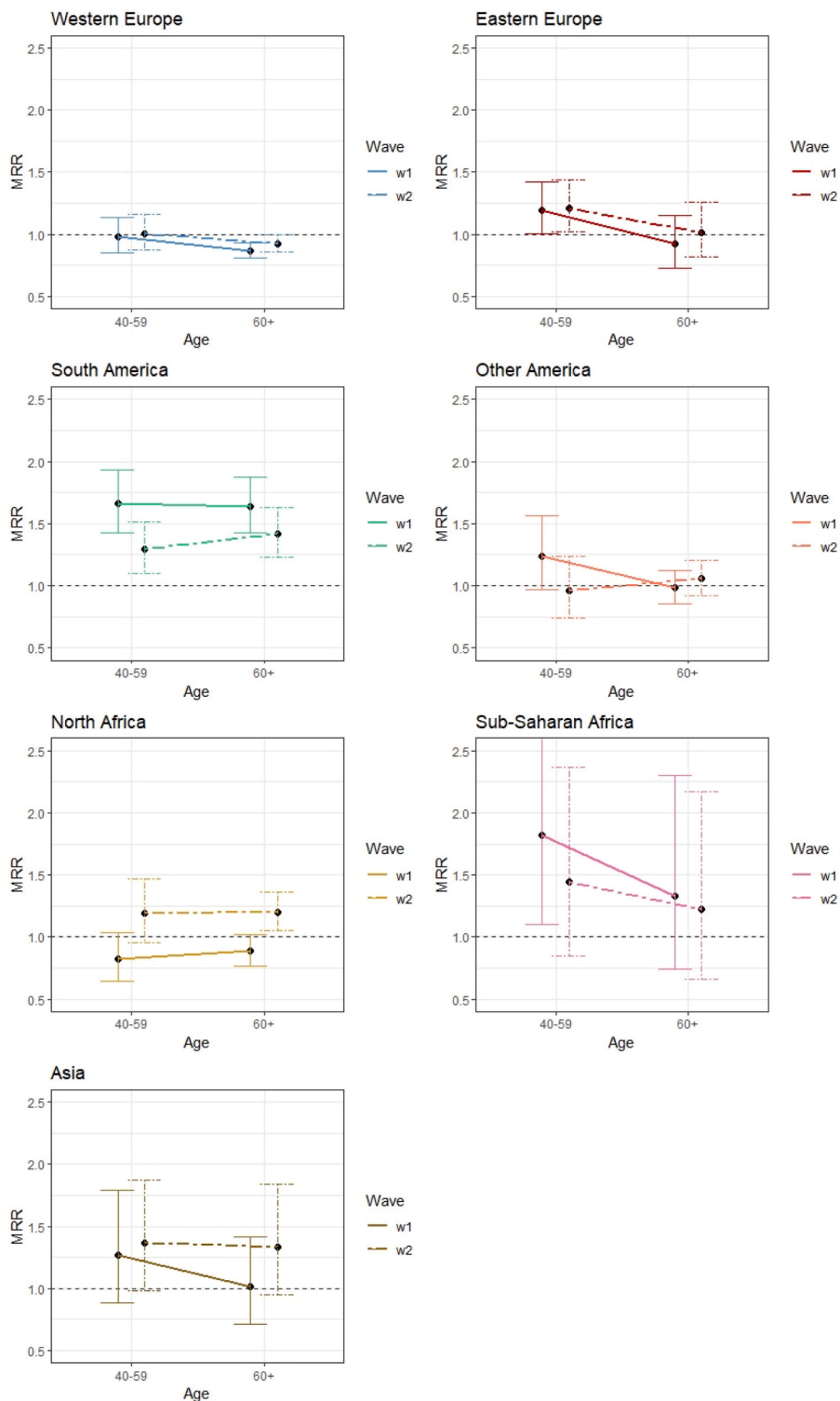


Fig. 2. Mortality rate ratios from model 2 during the Covid-19 epidemic compared to the Spanish-born, with 95% confidence intervals, by groups of country of birth, large age groups (40–59 and 60+) and wave.

(Sempere-Gonzalez et al., 2021; INE, 2017; INE, 2020), this points out the disadvantageous social conditions that make some immigrant groups more prone to infection than the native-born. Among those, the number of immigrants being key workers (Gosselin et al., 2022) stands as a main explanatory mechanism of a higher rate of infection (Hayward et al., 2021; OECD, 2020): in the European Union, 38% of cleaners and helpers and 19% of personal care workers are foreign-born (Fasani et al., 2020). Moreover, those workers are subject to job insecurity: Spain stands as

the EU country with the most temporary contracts among key workers (24%, Fasani et al., 2020). Considering the results of this study, individuals born in South America, Sub-Saharan Africa and Asia seem subject to a more strenuous social marginalization, and relegated to more insecure and exposed jobs due to occupational stratification. Other factor contributing to a disproportionately high risk of infection for non-European immigrants might be larger households: in 2007, 14% of households composed of immigrants born in Africa, Asia or America

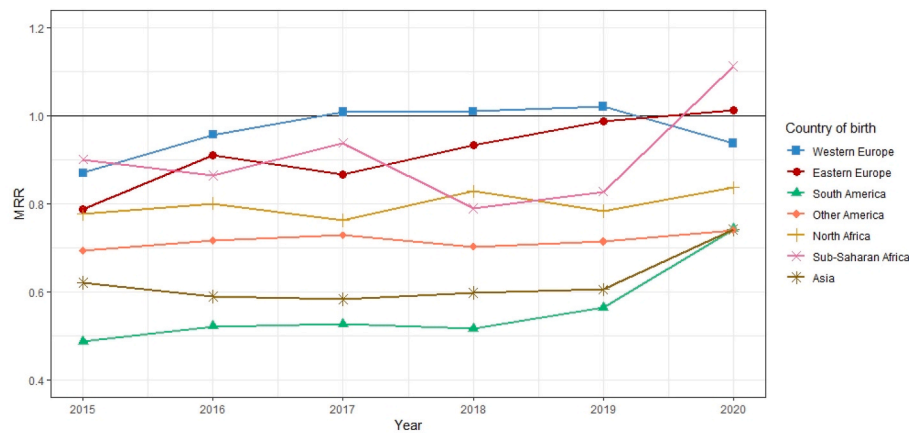


Fig. 3. Mortality rate ratios relative to Spanish-born from model 3, by year and group of country of birth, corrected by age and sex.

counted six or more individuals (INE, 2007), while only 2% of the country's households did.

However, the differentials in the mortality increases by region of birth are not as large as found elsewhere. In France (Khalat et al., 2022), all non-European groups show an excess mortality rate relative to native-born of 2.5 at least, ages 40 to 69. In Sweden, when only considering Covid-19, individuals born in low and middle-income countries show relative mortality risks higher than 2 compared to the native-born (Drefahl et al., 2020). In this study, this relative risk amounts to over 1.5 only for South Americans and Sub-Saharan Africans during wave 1, being under 1.5 for all other non-European immigrant groups. This could be due to more similar labour and economic characteristics between immigrants and natives in Spain than in other countries. For instance, extra-EU migrants and natives in Spain show similar probabilities of being in the upper half of the labour earnings distribution, which is not the case for France (Fasani et al., 2020).

This study also confirms the evidence of the migrant mortality advantage in Spain at the national level. While other studies have looked at the healthy-migrant effect in primary care (Gimeno-Feliu et al., 2015), cause-specific mortality among immigrants in one region (Regidor et al., 2008) or have included Spain in general studies of migrant populations in Europe (Ikram et al., 2015), no study had showed a general mortality advantage for all non-European immigrant groups at working and retirement ages for the whole country. This advantage exists for all groups being born outside Europe in ages over 40 years old. This is consistent with the literature, that reckons such advantages in other high-income countries (Aldridge et al., 2018). The advantages found in this paper are, however, somehow stronger than those found elsewhere. This could be due to the more recent character of immigration in Spain (and thus, lower exposure and higher impact of the healthy migrant effect) or, alternatively, to a certain over-estimation of the size of migrant populations (*i.e.* underestimation of the mortality rate) due to the way the Register works.

This mortality advantage of non-European groups of immigrants reduces for Asians and South Americans and completely reverses for Sub-Saharan Africans in 2020. This disruption is moderate compared to that one found in France, where all non-European groups of migrants reverse their advantage during the first wave of the epidemic (Khalat et al., 2022). However, in the United States, Latinos are found to reduce but not completely reverse their mortality advantage (Saenz & Garcia, 2020).

The case of immigrants born in Europe is quite different. While those at working ages (40–59) show similar mortality increases than the Spanish-born, those aged 60 and over (both from Western and Eastern Europe) suffer lower mortality increases than natives during wave 1, and no mortality increase at all in wave 2. This relatively small effect of the epidemic on the mortality of European immigrants could be due to a

lower exposure: individuals that are registered in Spain could keep a residence in their country of origin. Those two-way residents might have returned to their country in early 2020, as Spain was affected by the epidemic earlier and subject to a stricter lockdown than the United Kingdom, France or Germany. Also, two-way residents that go to Spain in the summer season might not have come at all in 2020 due to the particular virulence of the epidemic in Spain.

5.1. Limitations

This paper presents a number of limitations and shortcomings. First, some immigrant groups present a little number of individuals, particularly at old ages. This is mostly due to immigration in Spain being a recent phenomenon: most of the foreign-born individuals in the country have arrived during the last 20 years (the foreign-born population was 1.47 million in 2000 vs. 7.23 million in 2020). This has two consequences: first, some results are not statistically significant, as it is the case of Sub-Saharan Africans aged 60 and over. Second, individuals from different countries of birth who might present different characteristics and backgrounds had to be merged into large groups that may be heterogeneous to some extent.

Second, by the way individuals register in the *Padron* (*cf.* Methods), the derived populations might not exactly correspond the number of people exposed, particularly for some groups of immigrants. For instance, citizens of the European Union might register and then move back to their countries and they would be counted for five years following the registration, while not being exposed. This situation would lead to an over-estimation of the population and thus an underestimation of mortality rates. There is also the possibility of two-way residents, spending part of the year in Spain and part elsewhere, while being or not registered in the *Padron*. This last case might be particularly affected by the epidemic, as two-way residents could have chosen not to move during 2020.

Third, this paper does not include individual socioeconomic or educational measures, which could help highlight the inequalities that migrant populations might suffer in Spain. The inclusion of this kind of data might be a key factor in order to explain the mortality differentials observed in this study, as lower socioeconomic status has been linked with higher risk of infection and mortality (Politi et al., 2021; Vandentorren et al., 2022).

Finally, further research on causes of death would be relevant in order to separate Covid-19 from all other causes, as migrants have been shown to have higher risk of Covid-19 mortality compared to native-born, but a lower relative risk for all other causes (Drefahl et al., 2020). More generally, migrants have shown higher relative risk of infectious disease mortality, but lower relative risk from other causes (Bakhtiari, 2022).

In spite of these limitations, I find a consistent, disproportionate mortality impact on populations from South America, Sub-Saharan Africa and Asia during the Covid-19 epidemic in Spain, as well as a mortality advantage of non-European populations that reduces during the epidemic.

6. Conclusions

In light of other research on the subject (Sáenz & Garcia, 2020; Drefahl et al., 2020; Khlal et al., 2022), the main goal of this paper was to measure the mortality impact of the Covid-19 epidemic on immigrant populations in Spain, and to compare it with that of the native-born, in order to reveal the differential social conditions that immigrants might experience, and which may result in a higher risk of contamination by infectious diseases, namely, Covid-19. I showed a disproportionately high mortality impact on South American and Sub-Saharan African populations in Spain during the epidemic. Furthermore, those higher mortality impacts on immigrant populations were shown to be higher at working ages. In turn, this paper provides evidence of the migrant mortality advantage in Spain for non-European groups of immigrants, showing that this advantage decreases or reverses under the Covid-19 epidemic. Also, I show a mortality disadvantage of Western-Europeans in Spain at working ages. These results matter in a context of considerable international mobility, where immigrant populations tend to increase in high-income countries.

Finally, the findings of this paper are consistent with the literature on immigrants and Covid-19 mortality, and the migrant mortality advantage. This suggests a common pattern in high-income countries of social conditions under which immigrants live, that leads to differential mortality risks under an infectious epidemic. However, Spain presents distinctive characteristics in the origin and age structure of its immigrants, that lead to unique results, such as the mortality disadvantage of Western Europeans at working ages, or the disproportionate impact of the epidemic on some immigrant populations being milder than in other European countries. Those results must be subsequently considered and explored.

Author statement

Néstor Aldea: Conceptualization, Methodology, Software, Validation, Formal analysis, Writing - Original Draft, Writing - Review & Editing, Visualization.

Ethical statement

I, Néstor Aldea, corresponding and principal author of the paper 'Mortality impact of the Covid-19 epidemic on immigrant populations in Spain' declare that the following conditions are fulfilled:

The material on which the paper is based is the product of the author's own original work and has not been published elsewhere.

The paper is not currently being considered for publication anywhere else.

The paper reflects the author's own research, and all its sections only reflect the results from scientifically conducted analyses. To the researcher's best knowledge nothing from the analysis that is significant and germane to the manuscript's inferences has been ignored or left out.

All sections of the paper and analyses of results are appropriately placed in their context, and relevant past research on the subject is properly credited.

All sources used are properly disclosed and reflected in correct citations. Whenever literal text from other sources is employed, we use quotation marks, and the text is followed by the corresponding citation.

Declaration of competing of interest

The author declares no conflict of interest.

Data availability

Data are of public access

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssmph.2022.101291>.

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