Impact of the Covid-19 epidemic on immigrant cause-specific mortality in Spain: a penalty beyond Covid-19

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Abstract

Background: Multiple research has shown that immigrant were more affected than natives by mortality increases during the early Covid-19 epidemic in Europe, their vulnerability being rooted in their social status. However, no study has examined this question for a longer period, and considering detailed causes of death. **Methods:** The present paper employs country-level, cause-specific mortality data from Spain (2020-2022), and decomposes probabilities of dying by age and cause of death contributions. By doing so, it assess the impact of the epidemic on immigrant Covid-19 and non-Covid-19 mortality at adult ages, as compared to natives'. **Results:** First, mortality increased more for non-European immigrants than for natives during the epidemic. This steeper increase occurred at all adult ages and both sexes. Second, immigrants from more socially disadvantaged groups (Latin America, Morocco, Africa and Asia, plus Eastern Europe at working ages) experienced much higher mortality by Covid-19 than natives. Those same groups saw various non-Covid-19 causes of death contributing to a rise in their mortality relative to natives during the epidemic. Those causes include cardiovascular diseases, cancers, or external causes. Mortality by external causes – and notably overdoses – increased sharply for male Moroccan immigrants at ages 20-39. **Conclusion:** Socially-disadvantaged immigrant groups were much more vulnerable to Covid-19 mortality compared to natives. The rise in immigrant relative mortality from non-Covid-19 causes during the epidemic is consistent with Covid-19 misclassification, disruptions of healthcare access, or the adverse social consequences of the epidemic, all of which may have particularly affected some immigrant groups.

Keywords: Mortality, Immigrants, Covid-19, Spain, causes of death, external causes

Introduction

In high-income countries, most immigrant (*i.e.* foreign-born) groups show lower mortality than their native counterparts, despite having a lower socioeconomic status [1]. This, seldom considered a paradox [2], is known as the Migrant Mortality Advantage (MMA), and is more salient for non-Western immigrants [3], adult ages [4], and males [3, 4]. Its main cause is selection effects, as immigrants are not a random sample of the population in the country of origin, but are rather a selective group based on health, among other characteristics [5, 6]. Other factors contributing to the MMA could be negative selection at return [7], differential health behaviours [8], or data artifacts [9]. Such a mortality advantage lays mostly on non-communicable diseases, for which immigrants tend to show a much lower mortality than natives [10]. On the other hand, immigrants typically show a higher vulnerability to infectious diseases [11], that is rooted in their social status, and the labour, residential and healthcare access conditions that it implies.

Indeed, during the first stages of the Covid-19 epidemic, immigrants suffered higher increases in all-cause mortality than their native counterparts in many European countries [12-16] and the United States [17], those increases being essentially linked to a greater exposure to the virus [18]. Such a disproportionate impact of the epidemic on immigrant mortality caused a reduction, a disappearance or even a reversal of the MMA for certain immigrant groups (mainly of Sub-Saharan African origin) in a number of European countries [16, 19]. In Spain, immigrants from Africa, Asia and Latin America suffered more strenuous increases in all-cause mortality than natives in 2020 [19]. However, all the above-cited studies concern at most 2020, while, in Spain, Covid-19 deaths represented 9 and 7 % of all deaths in 2021 and 2022, respectively [20].

On the other hand, the mortality impact of the epidemic was not merely a direct one, as non-Covid-19 causes of death were affected in a number of countries [21]. Increases in mortality by cancers [22], cardiovascular [23-25] or other chronic diseases [24, 26], as well as some external causes [27] were observed in some countries. Misclassification of Covid-19 as a cause of death has been pointed out as a potential mechanism contributing to those increases [28-30], alongside reduced healthcare use [31] and the social dimension of the epidemic [32]. In Spain, though non-Covid-19 mortality did not vary much during the epidemic [21], increases occurred in mortality by external causes, or circulatory diseases, among others [33].

Given the former, this study aims to help answer a number of research questions. First, how the mortality of the different immigrant groups evolved during the three epidemic years (2020-2022) and whether the MMA was modified at various ages. Second, whether mortality by Covid-19 affected differently immigrant populations and natives, and to what degree. Third, how non-Covid-19 causes of deaths were impacted during the epidemic due to the social and healthcare disruptions, and to what extent those impacts differed between immigrant and the natives. Finally, to inquire about the potential explaining mechanisms of differential mortality between immigrants and natives, using age, sex and cause of death decomposition. The discussion of those questions may apply not only to Spain, but to immigrant mortality in Western countries more generally.

Methods

Data

I used exhaustive individual death counts with cause of death from 2015 to 2022, which are of restricted access and were provided by the Spanish Institute of Statistics (INE). Those include individual country of birth, place of death, and residence, alongside with cause of death. The

latter is defined according to the ICD-10 classification. Table 1 in Supplementary Materials lists the causes of death used in this paper and their corresponding ICD-10 codes and subgroups. In addition, individual population records from the Spanish register were employed, covering the period 2015 to 2023. Both datasets (population and death records) are unlinked, so no individual longitudinal analyses were possible.

Groups of immigrants

Countries of birth of immigrants were grouped, according to regions, and size of immigrant populations in Spain. Six groups of countries of birth are employed throughout the paper: Western Europe (WEu), Eastern Europe (EEu), Latin America and the Caribbean (LAC), Other America (OAm), Morocco, and Africa & Asia (AfAs). The detailed composition of those groups ("Group 2") is in Table S2 of Supplementary Materials. An alternative grouping, less detailed ("Group 1" in Table S2), was seldom used for some analyses. EEu, LAC, Morocco and AfAs immigrants are those in lower socioeconomic positions, as measured by their occupational and educational status (Table S3). The group OAm is composed of four countries (Argentina, Cuba, Uruguay, Chile) which, though geographically belonging to the LAC group, produced much different immigrants in Spain (older, and of earlier migration waves)

Methods

The main mortality indicator employed in this paper is the probability of dying between 20 and 80 years old, ${}_{60}q_{20}$. The use of ${}_{60}q_{20}$ instead of more classical indicators, such as life expectancy or standardized death rate, is motivated by the fact that immigrant mortality rates decay at old ages, likely due to data issues. Those have the form of overestimation of population exposures at old ages, that might be the consequence of individuals registered in Spain and not fully residing in the country. Thus, if immigrant mortality rates are very low at old ages, this will have an important effect on life expectancy, but not on ${}_{60}q_{20}$.

Using age- and cause-specific mortality rates, $m_{x,c}$, ${}_{60}q_{20}$ is defined as:

$$ {}_{60}q_{20} = 1 - \prod_{x=20}^{79} \exp\left(- \sum_{\forall c} m_{x,c} \right) \quad (1) $$

where c is each cause of death in a set of mutually exclusive, exhaustive causes of death. An analogous definition can be used for the probability of dying between any other two ages (e.g. ${}_{20}q_{20}$).

Such a definition allows to easily decompose ${}_{60}q_{20}$ by age and cause of death contributions. This was done following the decomposition method introduced by Horiuchi and colleagues [34], which lays uniquely on the assumption of continuous change between two sets of rates, and has the advantage of only producing direct terms, and not indirect or interaction effects. Those decompositions were carried out using the DemoDecomp package in R [35].

In order to obtain confidence intervals for cause-specific contributions to mortality, I used a bootstrap method. Precisely, I performed 1,000 simulations in which the number of deaths for each cause and age (that produces $m_{x,c}$) was re-computed assuming a Poisson distribution with the mean μ being the number of actual observed deaths. Then, the full decomposition was re-calculated and the result stocked. Finally, having 1,000 results from the 1,000 simulations, I computed the 2.5 and 97.5 centiles to obtain the bounds for 95 % confidence intervals.

Additionally, quasi-Poisson models were computed in order to obtain statistically robust estimates of mortality levels of immigrants relative to the native-born, but also variations in mortality within a group of origin and by cause of death. Those have the form:

$$ \log\left(\frac{D}{P}\right) = \alpha + \beta \cdot age + \vec{\gamma} \cdot \vec{X} + \varepsilon \quad (2) $$

where D is a number of deaths, P the exposed population, α and β coefficients, $\vec{\gamma}$ a vector of coefficients, $\vec{X}$ a vector of covariates, and ε the error. The effect on mortality associated with a given covariate X_i (namely, country of birth) is $\exp(\gamma_i)$.

All the analyses in this paper were carried out separately for males and females. First, because of sex differences in absolute mortality, but also due to sex differences in the MMA [3].

Results

Figure 1 shows yearly probabilities of dying between 20 and 80 years old ($_{60}q_{20}$), for the period 2017-2022. There is a sizeable increase in $_{60}q_{20}$ in 2020 respective to 2019 for both natives and immigrants: for the former, this increase is of 0.04 for males and 0.03 for females, while it is as large as 0.13 for males (from LAC) and 0.08 for females (from Morocco) in the case of immigrants. Indeed, all immigrant groups save WEu experienced a bigger 2020 increase than natives in the case of males, and all non-European groups save OAm for females. As of 2022, only females from OAm had retrieved the 2019 mortality level, while, on the other end, for males from AfAs, $_{60}q_{20}$ was still 0.06 above 2019 levels.

Figure 1. Probability of dying between 20 and 80 years old ($_{60}q_{20}$) by year for natives and immigrant groups, males (top panel, a) and females (bottom panel, b). The vertical scale differs for both panels.

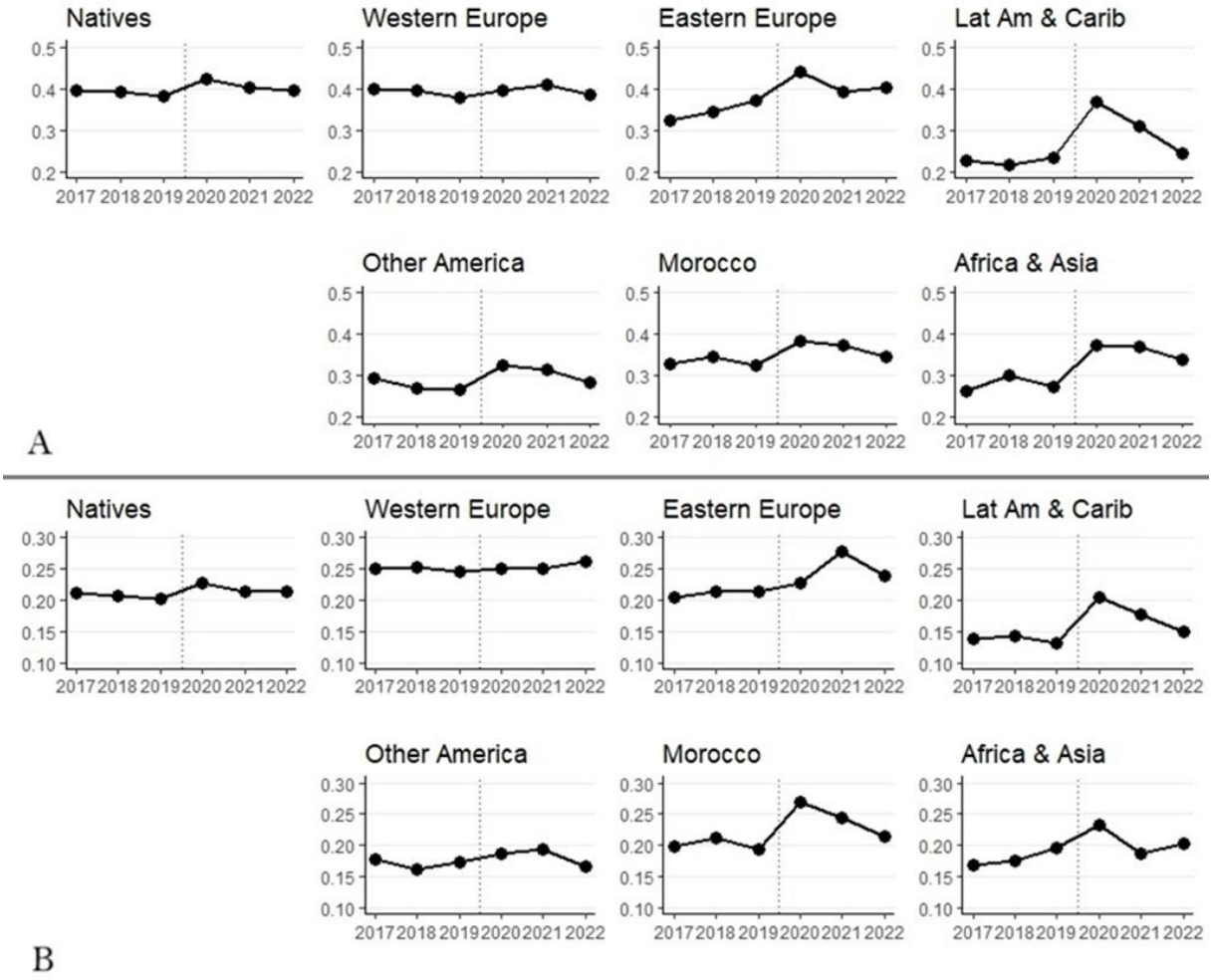
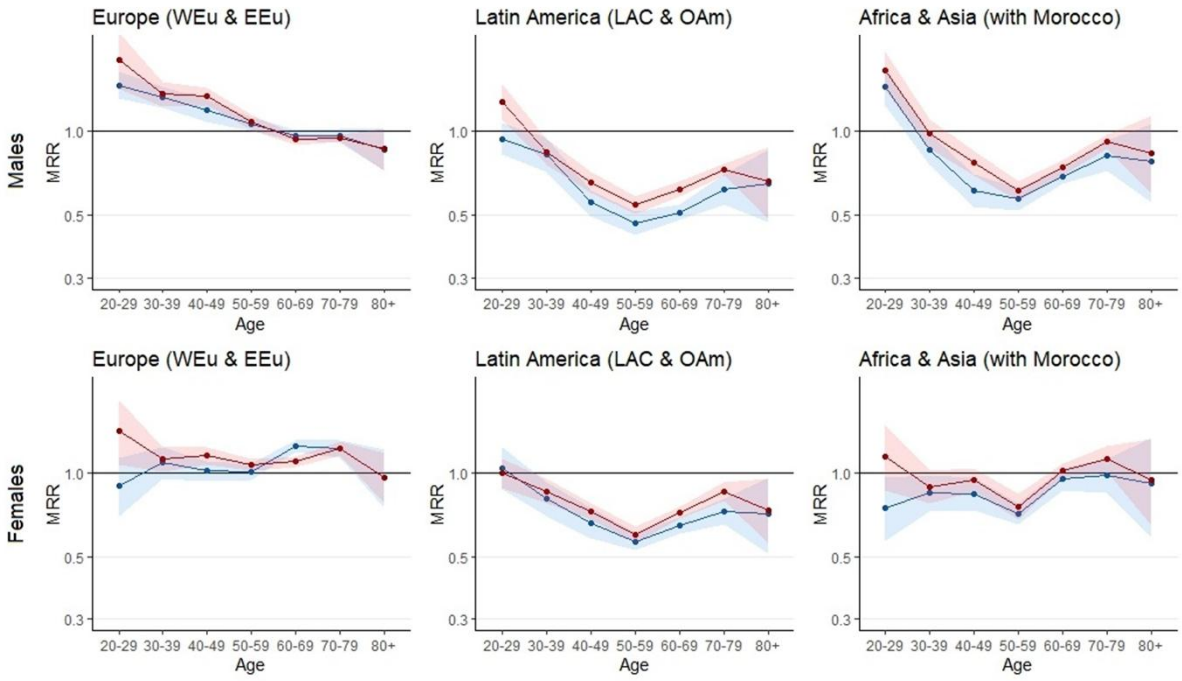


Figure 2 shows mortality relative to the natives by age, for the pre-Covid-19 (2017-2019) and Covid-19 (2020-2022) periods, and for merged immigrant groups (Table S2), from quasi-Poisson models as in (2). Non-European immigrants show typical U-shape profiles, in which the mortality advantage is maximum at adult ages, respective to younger and older ages. This profile is more clear for males. European immigrants have a different profile: relative mortality is stable (females) or decreases with age (males).

There is a general increase in relative mortality during the epidemic, that concerns all ages and both sexes, for non-European immigrants. Those increases in relative mortality are consistent throughout, and are not circumscribed to old ages, but have similar magnitudes for young ages as well. For European immigrants, there are epidemic increases in relative mortality before 50 years old, but not after, where there are even some decreases.

Supplementary analyses within each group (see Figure S1, Table S4 in Supplementary Materials) show that mortality increases before 60 years old are non-existent for natives, but salient for EEu immigrants, and all non-European immigrant groups, save OAm females.

Figure 2. Mortality Rate Ratios (MRR) relative to the Spanish-born by 10-year age group, for three immigrant groups, males (top) and females (bottom), in 2017-2019 (blue) and 2020-2022 (red). Groups of countries of birth are Groups 1 from Table S2 (Africa & Asia includes Morocco).



Figures 3 (males) and 4 (females) show the decomposition by cause of death of mortality differentials between immigrants and natives, before and during the Covid-19 epidemic. They also show the decomposition of changes in relative mortality between both periods.

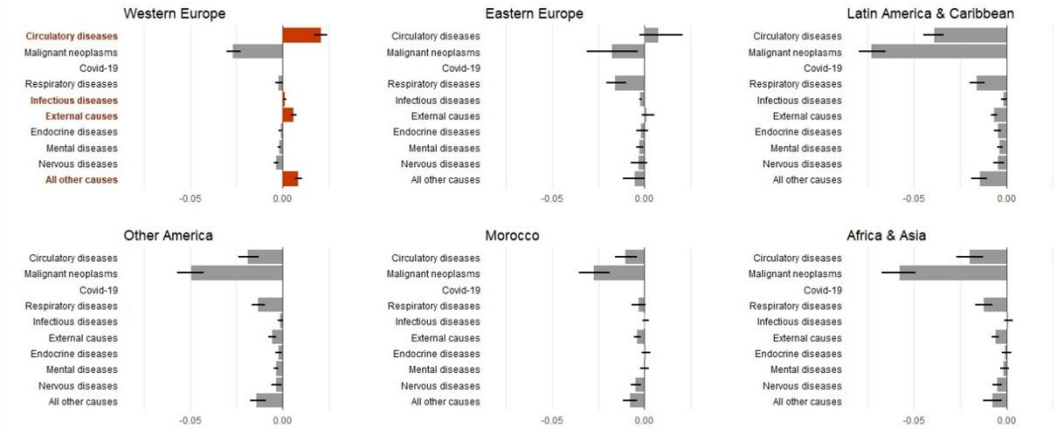
All non-European male immigrant groups present generalized pre-epidemic mortality advantages for all or most causes, those being the strongest for the LAC, and AfAs groups. For females, those pre-epidemic advantages are much milder in the case of Americans, and mostly limited to cancers in the case of Morocco and AfAs. During the epidemic, immigrants of both sexes from LAC, Morocco, and AfAs present strong disadvantages in Covid-19 mortality, particularly LAC males. WEu immigrants present pre-epidemic disadvantages in a number of causes (circulatory diseases, external causes, and the rest of causes for both sexes, plus cancers and respiratory diseases for females). However, they present an advantage by Covid-19 mortality during the epidemic. Males from EEu have a small pre-epidemic mortality advantage sustained by cancers and respiratory diseases, while females show a disadvantage in cancers. They don't show different Covid-19 mortality than natives.

As for change, first, WEu immigrants see a negative contribution of Covid-19 to the change in relative mortality. Individuals from OAm did not experience much of a change. For all other immigrant groups, most important contributions helped increase relative mortality. This is the case of Covid-19 for LAC, Morocco, and AfAs; respiratory diseases for EEu, AfAs males, and females from LAC; cancers for Moroccan females, and AfAs males; circulatory diseases for LAC males, AfAs males, and EEu females; and the residual "all other causes" for EEu and Moroccan males.

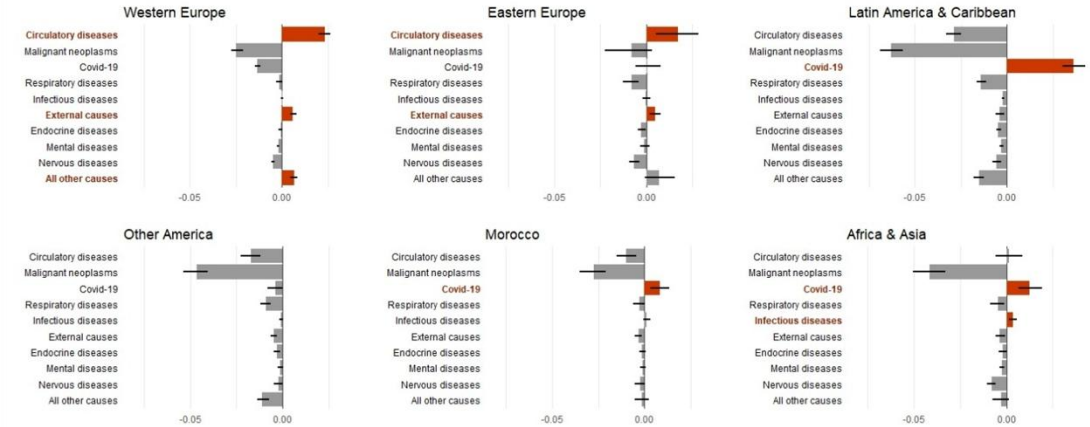
Noticeably, for two groups for which Covid-19 contributed to an increase in relative mortality (i.e. there was an important Covid-19 differential with natives), there were causes contributing more to this increase than Covid-19: this is the case of AfAs males (circulatory diseases, cancers), and Moroccan females (cancers).

Figure 3. [panels a and b] Cause-specific contributions to differentials in ${}_{60}q_{20}$ between immigrants and natives in the pre-Covid-19 (2017-2019) and Covid-19 (2020-2022) periods, with 95 % confidence intervals. [panel c] Cause-specific contributions to the change in relative mortality (immigrants vs. natives) between the pre-Covid-19 and the Covid-19 periods, with 95 % confidence intervals. Males.

a. 2017-2019 (Pre-Covid-19)



b. 2020-2022 (Covid-19)



c. Change (Covid-19 *vs.* pre-Covid-19)

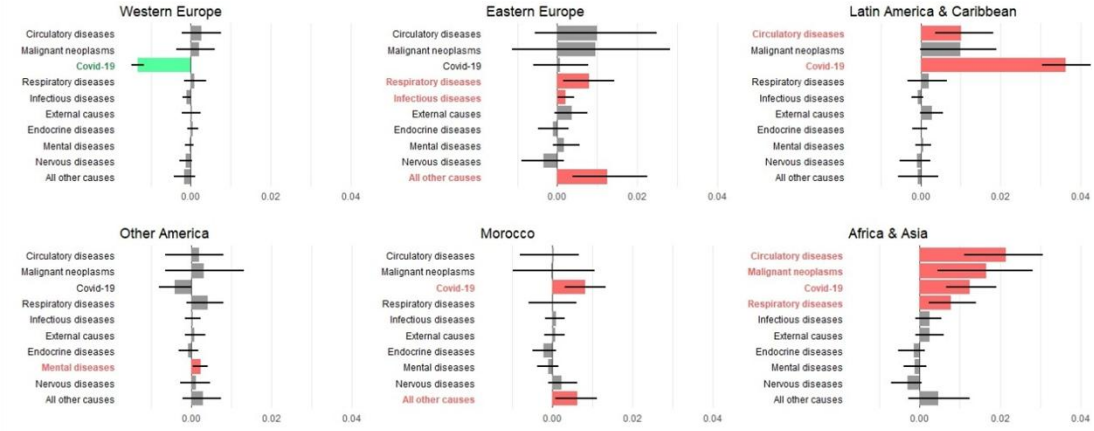
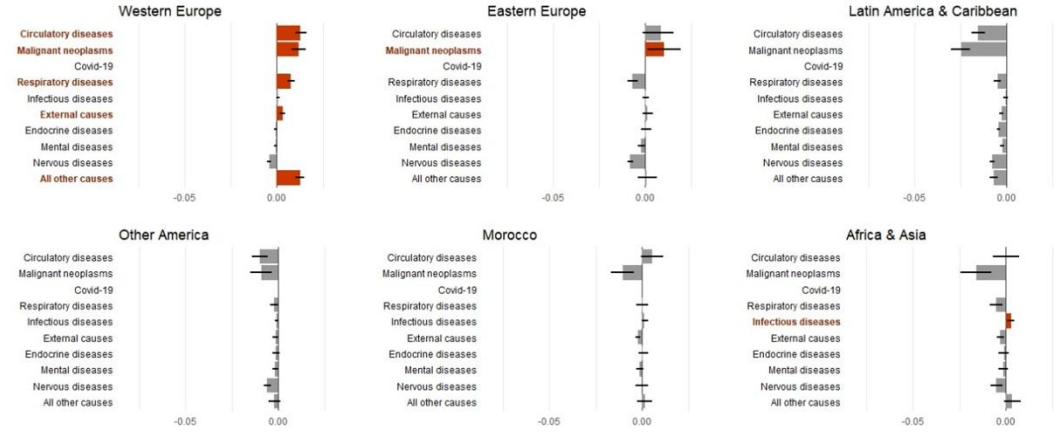
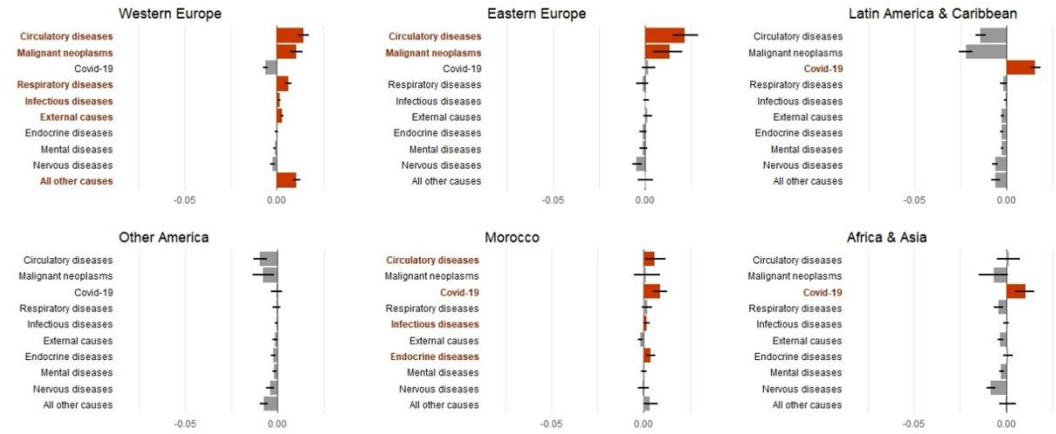


Figure 4. [panels a and b] Cause-specific contributions to differentials in ${}_{60}q_{20}$ between immigrants and natives in the pre-Covid-19 (2017-2019) and Covid-19 (2020-2022) periods, with 95 % confidence intervals. [panel c] Cause-specific contributions to the change in relative mortality (immigrants vs. natives) between the pre-Covid-19 and the Covid-19 periods, with 95 % confidence intervals. Females.

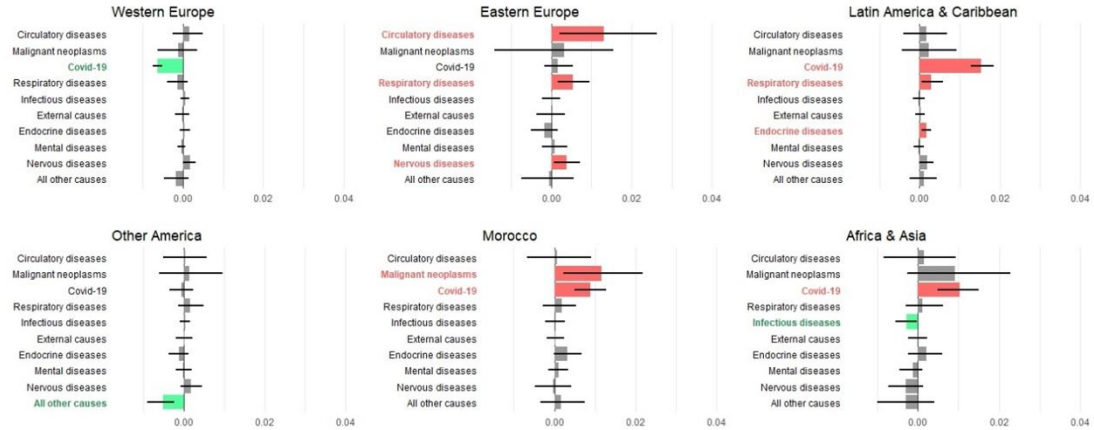
a. 2017-2019 (Pre-Covid-19)



b. 2020-2022 (Covid-19)



c. Change (Covid-19 *vs.* pre-Covid-19)

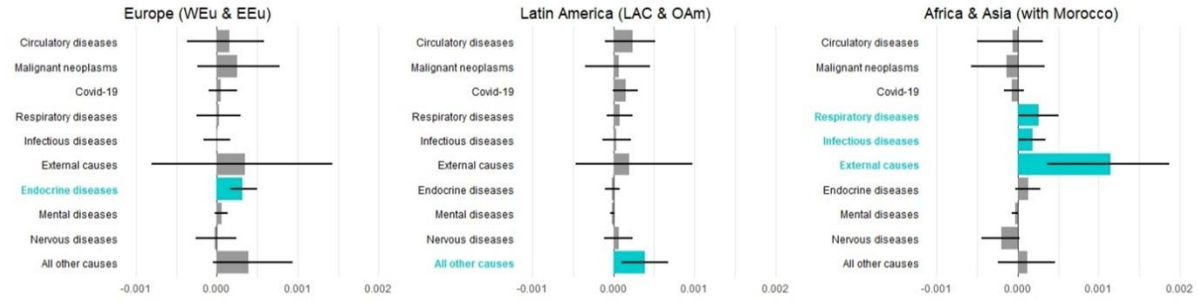


When focusing on young ages (Figure 5, 20 to 40 years old), it seems clear that the main causes behind the increase in relative mortality at young ages seen in Figure 2 do not include Covid-19. External causes account for 85 % of the increase in relative mortality of AfAs males, infectious and respiratory diseases being the other important contributions to the increase for this group. For other groups, cancer, endocrine diseases and the residual group of causes have observable contributions. Though not as big as for AfAs males, external causes have a positive contribution to four of the other five groups (except Latin American females), accounting for between 16 and 45 % of the increase in relative mortality for those groups. Further analyses on the increase of external causes for AfAs males (Figures S2, S4, Table S5) show this is due to Moroccan males, who experience a consequent deterioration in relative mortality by overdose and non-traffic accidents.

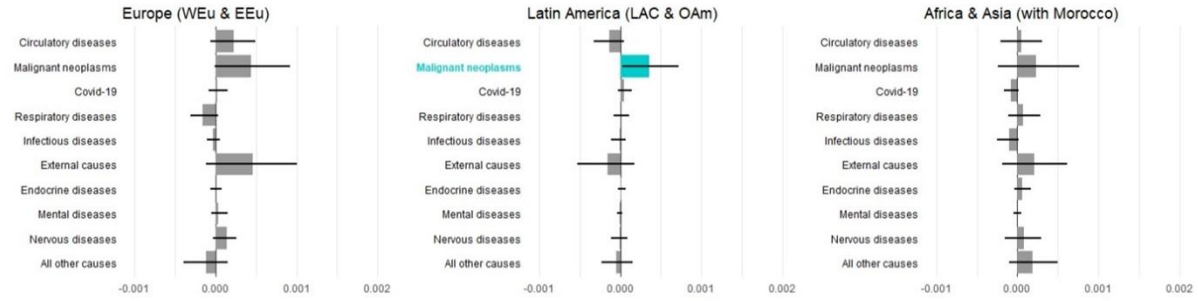
Supplementary analyses on the cause-specific contributions to change in relative mortality by ages (Figure S2, S3) reveal additional regularities. Among those, Covid-19 contributes to an increase in the relative mortality of EEu immigrants at working but not old ages; or cancers have noticeable contributions to increases for Moroccan (only females), AfAs (only males), LAC and EEu immigrants at ages below 60.

Figure 5. Cause-specific contributions to the change in relative mortality (immigrants vs. natives) between 20 and 40 years old (differentials in $_{20}q_{20}$), between the pre-Covid-19 and the Covid-19 periods, with 95 % confidence intervals. Males [panel a] and females [panel b].

a. Males



b. Females



Discussion

The above results lead to a number of inferences. First, the mortality of immigrants relative to natives tended to increase during the Covid-19 epidemic in Spain, as it has been observed in other countries [12-17], and in Spain for the year 2020 alone [19]. As of 2022, mortality had not come back to pre-epidemic levels, neither for immigrants nor for natives.

Second, this relative increase concerned all adult ages, and not only old ages, more typically affected by Covid-19. This has also been the case, for instance, in the United States [17] or France [16], at least during early stages of the epidemic. While the mortality of natives at working ages (below 60) did not change respective to pre-epidemic years, the increases in

non-European groups and Eastern-Europeans point towards immigrant workers from those groups being more vulnerable, either to Covid-19, either to its social and healthcare access consequences.

Third, the disproportionate impact of Covid-19 mortality on the groups with lower SES (LAC, Morocco, and AfAs, and EEu at working ages) confirms the vulnerability of immigrants to infectious diseases [11], and the fact that this vulnerability arises from social conditions [16]. This vulnerability is the consequence of a number of factors, that may include more exposed jobs [18], poverty (Table S3), more dense households, or higher presence in densely populated areas. Moreover, there could have been differences between immigrants and natives in the use of protective measures, namely vaccine uptake. Though data are scarce to non-existent, obstacles for Covid-19 vaccination of immigrants have been reported in Spain, particularly for those in an irregular situation [36]. Studies in other countries report a higher gap among immigrants between willingness and actual vaccine uptake [37].

Fourth, the non-Covid-19 causes of death that were affected by the epidemic could be divided into three groups. The first includes causes in which Covid-19 deaths could be misclassified: infectious diseases, respiratory diseases, all other causes, and circulatory diseases [28-29]. The second, causes than could be affected by the healthcare disruption of the epidemic [31], either because of fear of healthcare use, or because of delayed or cancelled treatments: those may include cancers and circulatory diseases, mainly. Finally, causes that can be affected by the social dimension of the Covid-19 crisis, including unemployment and isolation: mainly external causes.

The results point towards some of those three mechanisms playing a role for immigrants in Spain. For the first, immigrants from EEu suffered noticeable increases in relative mortality due to circulatory, respiratory and infectious diseases, plus the residual group of causes, all those being prone to Covid-19 misclassification. Some other immigrant groups suffered similar

increases for some of those causes. Unrecognised Covid-19 deaths are considered to represent a large fraction of the non-Covid-19 excess mortality in Central Europe [30], often associated with cardiovascular disease as the underlying cause. In the United States, misclassification is thought to have been wider for more disadvantaged minorities [28]. It remains a questions whether immigrants are more prone to cause of death misclassification, due to reasons linked to their access to healthcare (and thus their place of death), among others.

For the second, Moroccan females, and males from LAC and AfAs saw important increases in relative mortality due to cancers, plus circulatory diseases for the two latter. Regarding healthcare use during the epidemic, a study in the Netherlands [31] found stronger reductions in utilization within poorer individuals and immigrants, though not for high urgency in the case of immigrants. Indeed, Morocco, LAC, and AfAs immigrants being among the most socially disadvantaged groups in Spain (Table S3), a steeper decrease in the use of healthcare facilities (including emergency) could have occurred for those groups, increasing their mortality risks.

For the third, external causes strongly contributed to increase the relative mortality of males from Morocco at ages 20 to 40. Such increases in external causes during the Covid-19 years have been widely reported in the United States, particularly for the non-white population, and with drug overdoses playing an important role [27, 32, 38]. During the epidemic, those increased particularly for young males from ethnic minorities [39, 40]. Thought the Spanish context is not comparable to the United States, similar mechanisms of social exclusion could be playing a role here for this particular group, as overdoses are positively contributing to that increase in relative mortality of young Moroccans.

Limitations

Two main limitations of this study must be mentioned. The first concerns the data, and the fact that it does not include covariates that are important for mortality, namely a socioeconomic indicator, such as income or educational attainment. Additionally, the population and mortality data are unlinked, and thus longitudinal analyses cannot be performed.

Second, only the underlying cause of death is used in this paper, and not other contributing causes. This is done in order to simplify the analyses and understanding of the study. However, as it has been shown by other studies [30], further research must be conducted on multiple causes of death during the Covid-19 epidemic.

Despite those limitations, this paper finds non-European immigrants being disproportionately more affected not only by Covid-19 mortality, as past research had done, but also by a number of other causes of death whose origin may be trackable to their socioeconomic status and living conditions, together with the social side effects of the Covid-19 epidemic. By doing so, it represents, to my knowledge, the first contribution studying immigrant mortality by detailed cause of death during the whole Covid-19 epidemic in a high-income country, with robust country-level data.

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Conflict of interest

None declared

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Supplementary Materials

Table S1. List of causes of death used in this paper and their corresponding ICD-10 groups and codes.

Cause of death in this paper	ICD-10 groups	ICD-10 codes
Circulatory diseases	Diseases of the circulatory system	I00-I99
Malignant Neoplasms	Neoplasms	C00-D48
Covid-19	(in Codes for special purposes)	U07.1, U07.2, U10.9
Respiratory diseases	Diseases of the respiratory system	J00-J99
Infectious diseases	Certain infectious and parasitic diseases	A00-B99, R75, U04.9, U07.0
External causes	External causes of morbidity and mortality	V01–Y98
Endocrine diseases	Endocrine, nutritional and metabolic diseases	E00-E90
All other causes	Diseases of the blood and blood-forming organs; Mental and behavioural disorders; Diseases of the nervous system; Diseases of the eye and adnexa; Diseases of the ear and mastoid process; Diseases of the digestive system; Diseases of the skin and subcutaneous tissue; Diseases of the musculoskeletal system and connective tissue; Diseases of the genitourinary system; Pregnancy, childbirth and the puerperium; Certain conditions originating in the perinatal period; Congenital malformations, deformations and chromosomal abnormalities; Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified	D50-D89, F00-F99, G00-H95, K00-K93, L00-L99, M00-M99, N00-N99, O00-O99, P00-P99, Q00-Q99, R00-R99

Table S2. Geographic classification of countries of birth and immigrant population in Spain on January 1st, 2022 by Group 2 of countries of birth.

Group 1	Group 2	Countries	Population, January 1st, 2022
Europe	Western Europe (**WEu**)	Austria, *Belgium*, Denmark, *Finland*, *Ireland*, Luxembourg, *Netherlands*, Germany, *Sweden*, Iceland, Liechtenstein, *Norway*, United Kingdom, *Switzerland*, France, *Portugal*, Italy, Malta, Monaco, Andorra, San Marino	1,175,180
	Eastern Europe (**EEu**)	Bulgaria, Cyprus, Greece, *Hungary*, *Poland*, Romania, Czech Republic, Slovak Republic, Croatia, Slovenia, Albania, Bosnia & Herzegovina, North Macedonia, Serbia, Montenegro, Latvia, Estonia, *Lithuania*, Ukraine, *Moldova*, Belarus, *Georgia*, *Armenia*, *Russia*, Azerbaijan, Kazakhstan, Uzbekistan, Turkmenistan, Tajikistan, Kyrgyzstan	1,051,124
Latin America	Latin America & the Caribbean (**LAC**)	*Mexico*, Antigua and Barbuda, Bahamas, Barbados, Belize, Costa Rica, Dominica, *Salvador*, Granada, *Guatemala*, Haiti, Honduras, Jamaica, *Nicaragua*, Panama, Saint Vincent and the Grenadines, Dominican Republic, Trinidad and Tobago, Saint Lucia, Saint Kitts and Nevis, Bolivia, Brazil, Colombia, Ecuador, Guyana, Paraguay, Peru, Surinam, Venezuela	2,680,449
	Other America (**OAm**)	Cuba, Argentina, *Chile*, *Uruguay*	653,908

Africa & Asia (with Morocco)	**Morocco**	Morocco	984,682
	Africa & Asia (**AfAs**)	Burkina Faso, Angola, Benin, Botswana, Burundi, Cabo Verde, Cameroon, Congo, Côte d'Ivoire, Djibouti, Ethiopia, Gabon, *Gambia*, *Guinea*, Guinea-Bissau, *Equatorial Guinea*, Kenya, Lesotho, Liberia, Madagascar, Malawi, *Mali*, Mauritius, *Mauritania*, Mozambique, Namibia, Niger, *Nigeria*, Central African Republic, South Africa, Rwanda, São Tomé and Príncipe, *Senegal*, Seychelles, Sierra Leona, Somalia, Sudan, Eswatini, Tanzania, Chad, Togo, Uganda, Democratic Republic of the Congo, Zambia, Zimbabwe, Eritrea, South Sudan, *Algeria*, Egypt, Libya, Tunisia, Saudi Arabia, Bahrain, United Arab Emirates, Iraq, *Iran*, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Yemen, Palestine, *Syria*, Turkey, Western Sahara, Afghanistan, *Bangladesh*, Myanmar, China, *Philippines*, *India*, Indonesia, Japan, Cambodia, Laos, Malaysia, Maldives, Mongolia, Nepal, Pakistan, South Korea, North Korea, Singapore, Sri Lanka, Thailand, Vietnam, Brunei, Bhutan, Taiwan	911,688

Countries of birth underlined have a population over 100,000 individuals in Spain. Countries of birth in italics have a population over 10,000 individuals in Spain (January 1st, 2022, Population Register).

Table S3. Socioeconomic characteristics of different immigrant groups in the 2021 Census at 40-59 years old.

Country of birth (Group 2)	Occupation			Education		Migration	
	Managerial and intellectual jobs[1]	Elementary jobs and other[2]	Elementary-managerial ratio	Tertiary education	Primary educ. or less	Average time of residence in Spain[3]	At least 30 years in Spain[4]
Spain	17.8 %	22.4 %	1.26	42.9 %	4.0 %	-	-
Western Europe (WEu)	14.8 %	17.4 %	1.17	39.9 %	15.1 %	22.0	32.7 %
Eastern Europe (EEu)	2.9 %	29.2 %	10.04	20.1 %	26.3 %	13.4	0.6 %
Latin America & the Caribbean (LAC)	5.0 %	34.2 %	6.80	27.0 %	19.0 %	13.9	4.0 %
Other America (OAm)	11.2 %	23.2 %	2.07	40.9 %	11.6 %	15.1	7.9 %
Morocco	1.6 %	27.8 %	17.62	7.9 %	43.0 %	16.8	7.2 %
Africa & Asia (AfAs)	2.8 %	37.5 %	13.29	15.2 %	34.4 %	14.8	4.5 %

[1] Director, managers, scientific and intellectual professionals.

[2] Elementary jobs, workers in food service industry, personal care, security, and salespeople.

[3] The Census provides years of arrival, individual (2016 onwards), in 5-year groups (2011-15), 10 year groups (1981-2010), or before 1981. Each class is imputed, in average, its mid value (*e.g.* 25 years of residence for arrivals in 1991-2000).

[4] Or arrived before 1991.

Fig. S1 Age specific contributions to change in ${}_{60}q_{20}$ between 2017-2019 and 2020-2022, by country of birth and sex

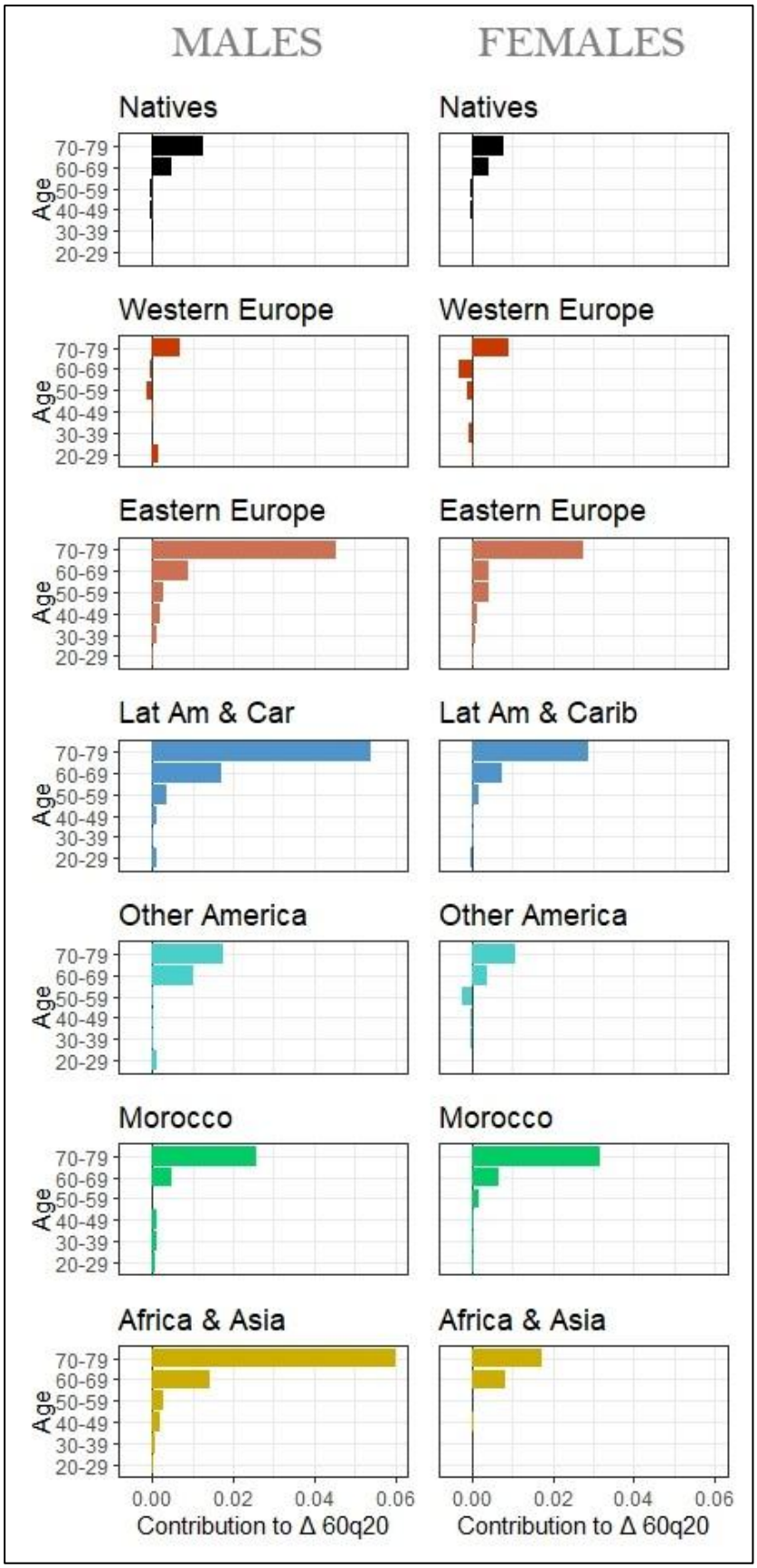

Table S4. Contributions of ages below 60 to change in ${}_{60}q_{20}$ between 2017-2019 and 2020-2022, by country of birth and sex ($\times 10^{-4}$).

	Males	Females
Natives	-1.59	1.97
Western Europe	-0.57	-10.15
Eastern Europe	62.36	65.40
Latin America & the Caribbean	61.50	25.72
Other America	19.50	-31.54
Morocco	29.08	33.29
Africa & Asia	50.47	7.88

Fig. S2 Cause specific contributions to change in immigrant-native differences in ${}_{20}q_x$ between 2017-2019 and 2020-2022, by country of birth and age group. Males

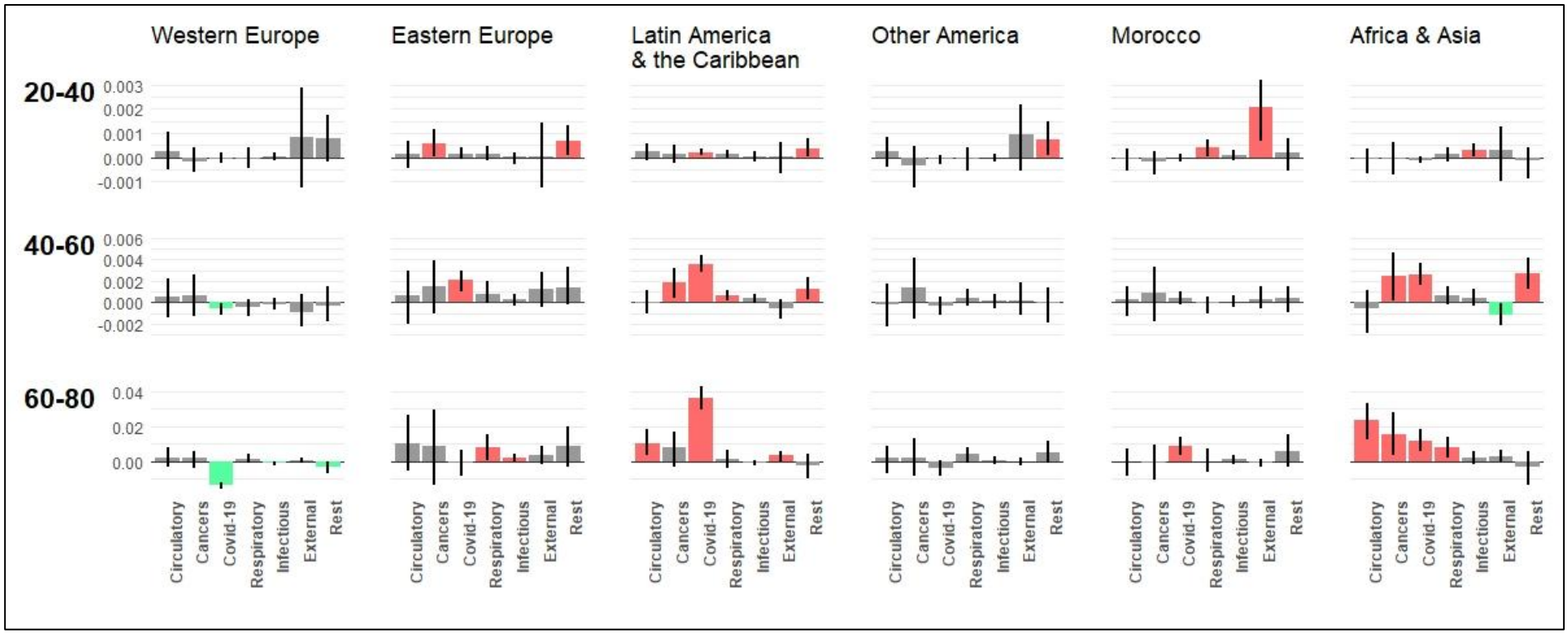

Fig. S3 Cause specific contributions to change in immigrant-native differences in ${}_{20}q_x$ between 2017-2019 and 2020-2022, by country of birth and age group. Females

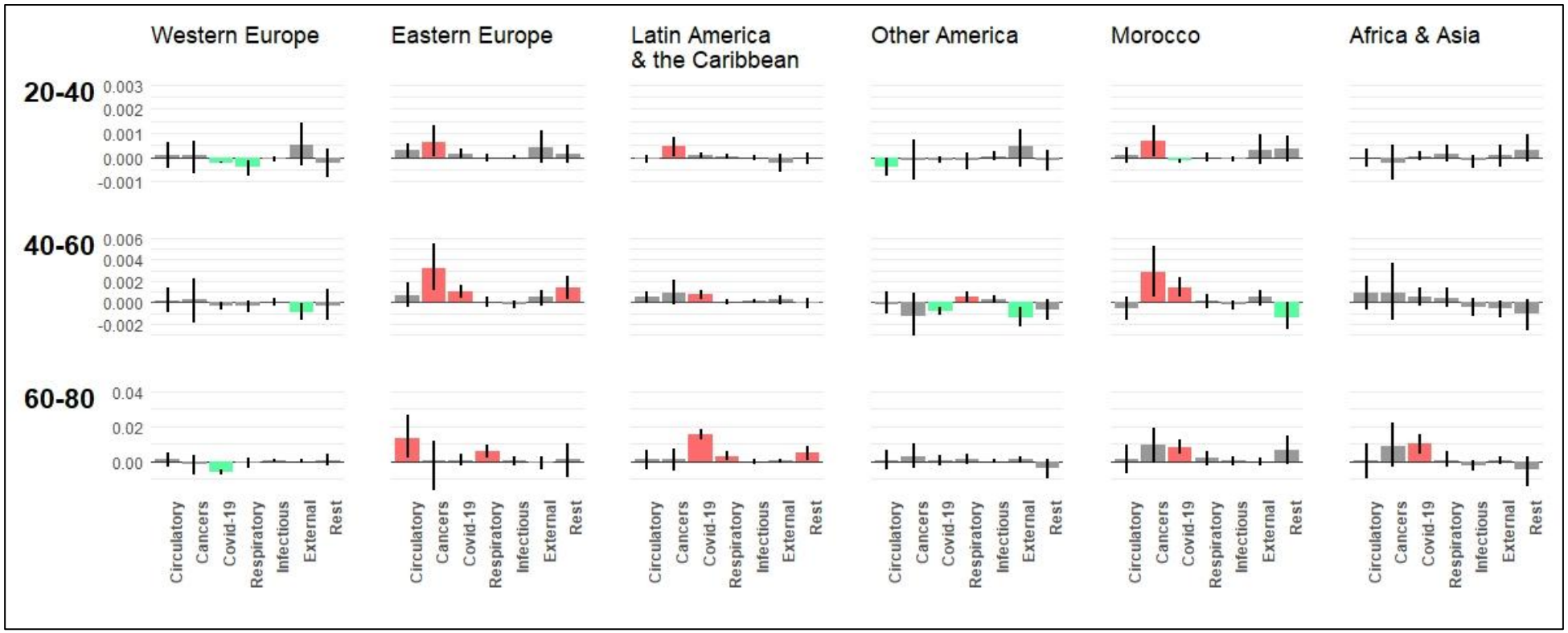

Fig. S4 Contributions of specific external causes to mortality differentials between male Moroccan immigrants and natives aged 20 to 40, pre-pandemic (2017-2019), pandemic (2020-2022) periods and change

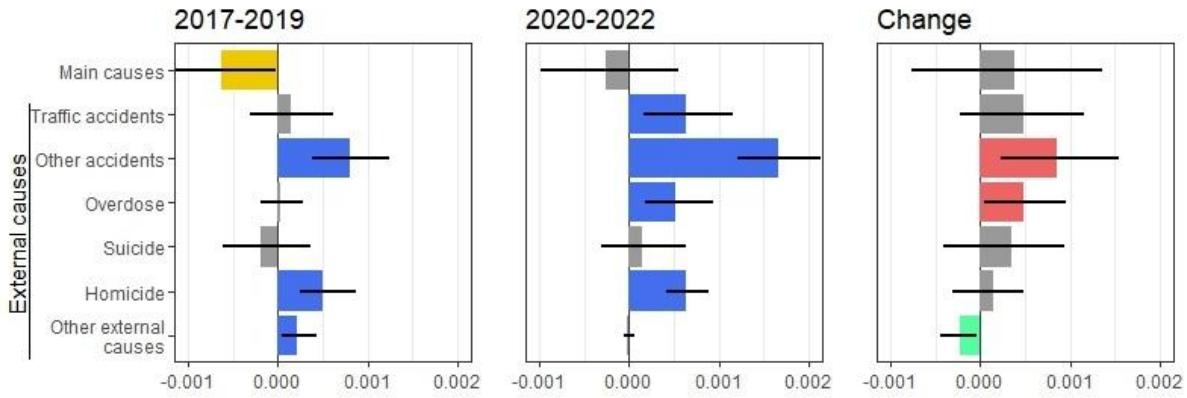

Table S5. Cause-deleted probability of dying from different external causes between 20 and 40 years old (‰), with 95 % confidence intervals from bootstrap. Moroccan immigrants and natives. Males.

Cause	Period	Country of birth	
		Spain	Morocco
Traffic accidents	2017-19	1.54 *[1.43-1.63]*	1.69 *[1.11-2.30]*
	2020-22	1.42 *[1.33-1.50]*	2.06 *[1.61-2.51]*
Other accidents	2017-19	0.70 *[0.64-0.75]*	1.50 *[1.04-2.13]*
	2020-22	0.82 *[0.76-0.89]*	2.50 *[1.99-3.23]*
Overdose	2017-19	0.41 *[0.37-0.46]*	0.45 *[0.20-0.71]*
	2020-22	0.65 *[0.60-0.72]*	1.17 *[0.78-1.64]*
Suicide	2017-19	1.63 *[1.55-1.73]*	1.44 *[1.04-1.96]*
	2020-22	1.80 *[1.68-1.92]*	1.95 *[1.48-2.34]*
Homicide	2017-19	0.15 *[0.12-0.19]*	0.66 *[0.34-1.04]*
	2020-22	0.14 *[0.11-0.18]*	0.79 *[0.49-1.11]*
Other external causes	2017-19	0.05 *[0.03-0.06]*	0.26 *[0.05-0.46]*
	2020-22	0.04 *[0.03-0.06]*	0.03 *[0.00-0.10]*
All external causes	*2017-19*	***4.48*** *[4.32-4.63]*	***5.98*** *[4.95-6.83]*
	2020-22	***4.87*** *[4.69-5.03]*	***8.46*** *[7.54-9.60]*