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Socioeconomic inequalities in mortality among Italian and immigrant residents: A longitudinal population-based study

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ABSTRACT

Background: A socioeconomic mortality gradient, favourable to the most advantaged social groups, has been documented in high migratory pressure (HMPCs) and highly developed countries, including Italy. However, little is known about how this association differs between natives and immigrants. This study aimed to evaluate the association between education level, occupational class and mortality among Italian and immigrant residents.

Methods: Using a longitudinal design, the 2011 Italian Census population was followed up to 2019. All-cause mortality was retrieved by record linkage with the Causes of Death register. The association between education/occupational class and mortality was evaluated in subjects aged 30–64, separately by sex, citizenship/macro area of origin. Mortality rate ratios (MRR) and 95 % confidence intervals were estimated using negative binomial regression models.

Results: Of the 23,572,516 subjects analysed, 7 % were immigrants from HMPCs; of the 410,746 deaths, 3 % were from HMPCs. Among Italians, a mortality gradient by education was observed (low/high adjMRR: 2.37 [2.16–2.60] males; 1.79 [1.64–1.96] females), whereas a weaker association with no trend was found for HMPC immigrants (adjMRR: 1.12 [1.00–1.25] males; 1.12 [1.00–1.26] females). Regarding occupational class, for immigrants from HMPCs, a higher mortality was observed in male "farmers" and "inactives" compared to "non-manual workers" (adjMRR = 1.31 [1.06–1.61] and adjMRR = 1.67 [1.50–1.85], respectively); and in females for "inactive" subjects (adjMRR = 1.48 [1.35–1.62]).

A higher mortality for the less educated was observed for males from Romania, India and China, and for females from Central-Eastern Europe, Sub-Saharan Africa and Central and South America. A lower mortality was found for the least educated from Morocco.

Conclusions: The higher mortality among less educated subjects was confirmed among Italians, while it was less evident among immigrants from HMPCs. However, differences observed between citizenships, macro-areas of origin and sex highlight the need for social policies accounting for specific risk factors and cultural specificities affecting correct lifestyles and health service access.

1. Background

Worldwide, the mortality of immigrants is lower compared to that of the native population. As described in two systematic reviews, this advantage ranges from 18.7 % to 30 %, although they are generally characterized by a lower socioeconomic status, poorer living conditions and lower occupational status, all independent risk factors for morbidity and mortality (Di Napoli et al., 2022; Pacelli et al., 2016; Gadd et al., 2006; Aldridge et al., 2018; Shor and Roelfs, 2021).

This "epidemiological paradox" has been explained by the healthy

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migrant effect (selective migration flows of healthy, young individuals) and by the salmon bias effect (caused by the immigrants re-emigration to their country of origin when elderly or unhealthy) (Razum et al., 2000; Ichou and Wallace, 2019; Abraído-Lanza et al., 1999; Di Napoli et al., 2021; Kristensen and Bjerkedal, 2010; Ruiz et al., 2013). Furthermore, many studies have raised the concern that the survival advantage of immigrants may be a statistical artefact: the mobility of immigrant populations may cause an undercoverage of deaths and/or an overcoverage of the resident population in demographic registers (Wallace and Wilson, 2022; Puschmann et al., 2017; Monti et al., 2020).

However, as the length of stay in the host country increases, immigrants lose their health advantage (exhausted migrant effect) (Mackenbach et al., 1997, 2018; Lara et al., 2005).

Immigrants may still experience a double burden in society, suffering disadvantages due both to their ethnic minority status and to low socioeconomic status (Rostila and Fritzell, 2014). Moreover, the large variability in mortality by ethnic group, age, cause of death, place of destination and length of stay, described in several studies, have highlighted the need for country-specific studies analysing all these factors (Pacelli, 2016; Ikram et al., 2016; Regidor et al., 2008; Singh and Siahpush, 2001).

Education and occupation-based social classes are both relevant dimensions of socioeconomic position used in studies investigating socioeconomic inequalities in health. Education describes cultural resources that could have an impact on health through attitude towards prevention, perception of health problems, the adoption of harmful behaviours and the ability to access health services. Occupation better describes prestige, income, economic well-being and effort-reward mechanism. Specific job positions and working conditions can expose workers to psychosocial stressors as well as to physical, chemical, and biological hazards (Zengarini et al., 2020; Bertuccio et al., 2018; Galobardes et al., 2006a, 2006b).

It can be hypothesized that these mechanisms act differently in specific population subgroups.

In Italy, the history of immigration is relatively recent, with a significant increase since the beginning of 21st century (from <2 million in 2004 to about 5 million in 2020), in particular in those coming from high migratory pressure countries (HMPCs), with a great heterogeneity in terms of countries of origin and settlement patterns across the country (Di Napoli et al., 2022; Pacelli et al., 2016; Istat 2023).

As the migrants residing in Italy now constitutes about 8 % of the population, and because migrants have been singled out as a social category (in 2019, 26.9 % of them lived in a condition of absolute poverty, compared with 5.9 % of Italians) (Istat, 2021) migrants' health and socioeconomic position (SEP) deserves in-depth assesment.

Different studies have analysed the health of immigrants living in Italy, confirming their advantage in terms of mortality, despite considerable heterogeneity by area of origin and cause of death, whereas for other outcomes, such as avoidable hospitalization, an excess of risk has been observed (Di Napoli et al., 2022; Pacelli et al., 2016; Petrelli et al., 2019).

Two previous longitudinal studies, conducted on 4 Italian municipalities, found a flat educational gradient among immigrants, contrary to what was observed among Italians, without any additional contribution of the occupational class, thus supporting the hypothesis of status inconsistency (Zengarini, 2020; Pacelli, 2017).

This study aimed to longitudinally evaluate the association between education level, occupational class and mortality in the Italian and immigrant resident population.

2. Methods

2.1. Data sources, study population and design

The study was conducted on the population cohort conceived within the project "Socioeconomic differences in mortality" (IST 2646), part of the National Statistical Programme (PSN) approved by the Italian Data Protection Authority (SISTAN and Istat, 2017). Using a retrospective longitudinal design, the individuals recorded in the 2011 Italian General Census and resident in Italy, considered as the initial cohort, were followed up from 2012 to 2019, until death, emigration, or end of the follow-up, whichever came first, yielding a maximum of 8 years of follow-up. Information on mortality was retrieved from the Italian National Institute of Statistics (Istat) National Causes of Death Register, which annually collects all deaths occurring in Italy. The Resident Population Register was used to identify exit from the cohort for emigration. The registers were connected through a record linkage using a personal identification number assigned to all residents in Italy at birth or upon immigration.

The performance of the linkage was extremely high and included 97 % of deaths (Alicandro et al., 2020).

For the purpose of this study, all individuals aged 30 to 64 years on 1 January 2012 were evaluated. The choice of the lower age limit was made because education level can be considered sufficiently stable above that age; the restriction of the upper age limit to 64 years was applied in order to focus on the active age group of the population and to exclude older people, who are underrepresented among the immigrant population (Pacelli, 2016; Zengarini, 2020) compared to the native population.

2.2. Outcome, exposure and other variables

The present study analysed all-cause mortality between 2012 and 2019 as the main outcome. Deaths from specific groups of causes (diseases of the circulatory system, neoplasms and external causes of injury and poisoning) were considered as secondary outcomes in the supplementary analysis. The person-years (PY) at risk were calculated from baseline (1 January 2012) until the date of the first of these events: death, attainment of age 65, emigration, or end of follow-up (31 December 2019).

In order to evaluate social inequalities in mortality, the education level was considered as the main exposure and categorized in four levels: university degree (at least 16 years schooling), high school (13 years), middle school (8 years) and elementary school or no education (up to 5 years).

The Erikson–Goldthorpe (EGP) (Erikson and Goldthorpe, 1992) class scheme was used to obtain social class based on occupation category, considered as another indicator of socioeconomic position. The classification is based on the combination of two Census questions, present only in the "long form" version of the questionnaire (administered to all households living in small/medium municipalities – fewer than 20,000 inhabitants - and to a representative sample of one-third of households in the municipalities with 20,000 or more inhabitants) on occupation and type of job (about 75 % of the population) (Zengarini, 2020; Bertuccio, 2018).

For the study aims, the occupational class variable was defined starting from the original EGP variable aggregated into four mutually exclusive categories: "non-manual workers" (routine or upper), "self-employed", "farmers" (farmers and farm labourers), "manual workers" (skilled or unskilled); "inactive" persons were considered as an additional category. People working in armed forces were not considered as it was not possible to define their social class (Zengarini, 2020).

The sex, age class, citizenship and geographic area of residence variables were used to characterize the cohort and as potential sociodemographic factors affecting mortality. In particular, the individuals were classified according to citizenship as Italian or immigrant; these latter were divided into those coming from highly developed countries (HDCs: North America, Europe - except for Central and Eastern Europe - Oceania, Israel and Japan) or from high migratory pressure countries (HMPCs: Central-Eastern Europe, North Africa, Sub-Saharan Africa, Asia - except for Israel and Japan- and Latin America). In agreement with previous research, stateless individuals were also included in the HMPC

immigrant group (Pacelli, 2016).

The information on citizenship was also used to evaluate mortality inequalities according to the macro area of origin or for specific citizenships.

The 20 Italian regions were aggregated in 5 geographic macro areas: North-West (Piedmont, Valle d'Aosta, Lombardy, Liguria), North-East (Trentino Alto Adige, Veneto, Friuli Venetia Giulia, Emilia-Romagna), Centre (Tuscany, Umbria, Marche, Latium), South (Abruzzo, Molise, Campania, Apulia, Basilicata, Calabria) and Islands (Sicily and Sardinia).

2.3. Statistical analysis

Among all individuals aged 30–64 years (29,456,791), we included in the analysis only those for whom we were able to define the information on the occupational class (80 %).

Baseline sociodemographic characteristics of the cohort and of the deaths occurring during the follow-up are described for the two groups compared, i.e., *Italians* and *immigrants*. It must be noted that immigrants from HDCs were included in the *Italians* group as they accounted for only about 5 % of the foreign resident population and, as it has been widely shown, they have a health profile comparable to that of the native population (Malmusi et al., 2010; Zengarini et al., 2020); immigrants from HMPCs made up the *immigrants* group. Differences between Italians and immigrants from HMPCs in the distribution of deaths by the characteristics analysed were evaluated by P-values obtained from Chi-squared test.

The distribution of immigrants from HMPCs in terms of both study population and deaths were also evaluated by area of origin and main citizenships.

The association between education level and all-cause mortality was assessed through mortality rate ratios (MRRs) and relative 95 % confidence intervals (95 %CI), using multivariate negative binomial regression models for overdispersed count data with log link function (Gelman and Hill, 2007). In these models the number of deaths that occurred during the follow up was the dependent variable, estimated as a function of education level, age, occupational class and geographic area of residence as independent covariates. The log person time of follow-up for each group was used as offset term.

Two separate regression models were evaluated: in the first model (Model 1), we tested the adjusted effect of education on mortality, without the occupational class variable; in the second model (Model 2), we included the occupational class variable, aiming to evaluate its potential role in the association between education and mortality. The presence of collinearity and the possible interaction between the 2 socioeconomic variables were tested. The likelihood ratio test (LRT) was used to evaluate models' goodness of fit and to select the best model (Greene, 2018).

In order to asses difference in the association between education level or occupational class and mortality, the interactions between the socioeconomic variable and citizenship (Italian, HMPCs) were evaluated. As all the interactions tested were statistically significant ($p < 0.001$), the regression models were stratified by group of citizenship (Italian, HMPCs). With regard to the group of immigrants from HMPCs, the analysis was further stratified also by area of origin or specific citizenship. All analysis were performed separately for males and for females.

In addition, a supplementary analysis testing the association between education and mortality in the Italian and the HMPC populations was performed considering as outcomes death due to the most frequent groups of causes, namely, deaths from diseases of the circulatory system, neoplasms or external causes of injury and poisoning.

All analysis were performed using SAS® System version 9.3 and R version 4.2.2.

3. Results

Overall, 23,572,516 subjects aged 30–64 years were enrolled in the study population; during follow-up, 410,746 deaths were observed. Immigrants from HMPCs accounted for 7.1 % of the cohort and 2.9 % of deaths.

The baseline characteristics of the cohort and of the deaths are described in Table 1. The Italian population was older than that from HMPCs (42.6 % and 19.6 % aged 50–64 years, respectively), while a similar distribution between the two groups of citizenship was observed by sex and education level. Immigrants from HMPCs were residents mainly in the North of Italy (61 % North-West and North East) and were for the most part classified as manual workers (47.3 %) or inactive (32.1 %). The corresponding percentages for the Italians group were 20 % and 37.9 %, respectively. Concerning deaths, significantly different distributions for all the characteristics analysed were observed between the two groups of citizenships ($p < 0.001$): 45.6 % of immigrants from HMPCs died between the ages of 30 and 49 years (compared to 21.1 % of Italians), and those with an education level of high school diploma or more had a higher proportion of deaths compared to Italians with the same education level. More than half of the deaths among Italians (53.8 %) were of subjects classified as inactive, while the highest proportion of deaths among immigrants (45.6 %) was observed among manual workers.

Table 2 presents the distributions of the study population and of deaths by area of origin and by main citizenships. In the group of Italians and immigrants from HDCs, the latter represented only 0.43 % of the population. Subjects from HMPCs came mainly from Central and Eastern Europe (Romania, Albania and Ukraine), North Africa (Morocco) and West-Central Asia (India); 4.4 % and 2.8 % of immigrants were from China and the Philippines, respectively.

3.1. Analysis for Italians and immigrants from HMPCs

The results of the multivariate regression models for the Italian and the HMPC populations are shown in Tables 3a and 3b for males and females, respectively.

For males in the Italian group, adjusting for age class and area of residence, a strong association was observed between education level and mortality (adjMRR "elementary school or less" vs "university degree or more" = 2.58 $p < 0.001$), with a significant gradient of higher mortality at lower education (Model 1). When including the occupational class variable in the model (Model 2), the association education-to-mortality remained strong, although slightly attenuated.

For immigrants from HMPCs, a slight association between education level and mortality was observed (Model 1). Compared to "university degree or more", all categories of education level showed significantly higher mortality (12 %−16 %), even when considering the model with occupational class (Model 2). The best model for this group was Model 2 (P-value LRT comparing Model 1 and Model 2, <0.001). "Farmers" and "inactive" subjects had a significantly higher mortality compared to "non-manual workers" (adjMRR = 1.31 $p < 0.011$ and adjMRR = 1.67 $p < 0.001$, respectively).

Among Italian females, a gradient of higher mortality at lower education level was observed (Model 1–2). However, the association education-mortality was less strong compared to that in males.

For females from HMPCs, the best model was Model 2 with the occupational class variable. The association education-mortality was not significant except that for the comparison between "elementary school or less" and "university degree or more" (adjMRR = 1.12 $p = 0.051$), and a higher risk of mortality was found for "inactive" subjects (adjMRR = 1.48 $p < 0.001$ compared to "non-manual workers").

No collinearity was detected between education level and occupational class in any model, and no interaction was found for immigrants from HMPCs.

The results of the multivariate analysis considering as outcome

Table 1
Baseline characteristics of cohort and number of deaths for Italians and immigrants from HMPCs, 2012–2019.

	Italians				p*	HMPCs				p*
	Cohort (N)	%	Deaths	%		Cohort (N)	%	Deaths	%	
Total	21,903,021	*92.9*	398,650	*97.1*		1669,495	*7.1*	12,096	2.9	
Characteristics										
Age Class					<0.0001					<0.0001
30–39	5688,737	*26.0*	19,774	*5.0*		792,604	*47.5*	1820	*15.0*	
40–49	6816,149	*31.1*	64,404	*16.2*		550,460	*33.0*	3693	*30.5*	
50–59	6029,871	*27.5*	163,457	*41.0*		270,702	*16.2*	4632	*38.3*	
60–64	3368,264	*15.4*	151,015	*37.9*		55,729	*3.3*	1951	*16.1*	
Sex					<0.0001					<0.0001
Male	10,402,194	*47.5*	243,405	*61.1*		745,794	*44.7*	6851	*56.6*	
Female	11,500,827	*52.5*	155,245	*38.9*		923,701	*55.3*	5245	*43.4*	
Education level					<0.0001					<0.0001
Elementary school or less	2991,565	*13.7*	92,382	*23.2*		266,336	*16.0*	2339	*19.3*	
Middle school	8038,765	*36.7*	165,849	*41.6*		598,780	*35.9*	4337	*35.9*	
High school diploma	7950,375	*36.3*	111,653	*28.0*		613,204	*36.7*	4271	*35.3*	
University degree or more	2922,316	*13.3*	28,766	*7.2*		191,175	*11.5*	1149	*9.5*	
Area of residence					<0.0001					<0.0001
North-West	5746,517	*26.2*	101,345	*25.4*		566,069	*33.9*	3910	*32.3*	
North-East	4330,371	*19.8*	72,699	*18.2*		458,978	*27.5*	3344	*27.6*	
Centre	3934,621	*18.0*	70,448	*17.7*		396,740	*23.8*	2825	*23.4*	
South+Islands	7891,512	*36.0*	154,158	*38.7*		247,708	*14.8*	2017	*16.7*	
Occupational class					<0.0001					<0.0001
Non-manual worker	7388,130	*33.7*	79,761	*20.0*		256,983	*15.4*	1389	*11.5*	
Self-employed	1588,094	*7.3*	24,878	*6.2*		74,734	*4.5*	504	*4.2*	
Farmer	253,879	*1.2*	4576	*1.1*		13,231	*0.8*	129	*1.1*	
Manual worker	4376,168	*20.0*	74,787	*18.8*		789,435	*47.3*	5510	*45.6*	
Inactive	8296,750	*37.9*	214,648	*53.8*		535,112	*32.1*	4564	*37.7*	

* P-values of the comparison of population and deaths by citizenship, obtained from Chi-squared test.

Table 2
Distribution by area of origin and main citizenships of cohort and number of deaths, 2012–2019.

	Cohort (N)	%	Deaths	%
Italians + HDCs				
Total	21,903,021	*92.92*	398,650	*97.06*
Area of origin				
Italy	21,809,405	*99.57*	397,761	*99.78*
EU-15	75,248	*0.34*	717	*0.18*
Other European countries	5625	*0.03*	85	*0.02*
North America	7273	*0.03*	59	*0.01*
Oceania	1149	*0.01*	5	*0.00*
West-Central Asia	706	*0.00*	4	*0.00*
East Asia	3615	*0.02*	19	*0.00*
HMPCs				
Total	1669,495	*7.1*	12,096	2.9
Area of origin				
Central and Eastern Europe	897,246	*53.7*	6884	*56.9*
North Africa	245,209	*14.7*	1552	*12.8*
West-Central Asia	154,040	*9.2*	1035	*8.6*
Central-South America	128,870	*7.7*	685	*5.7*
East Asia	126,178	*7.6*	823	*6.8*
Sub-Saharan Africa	117,773	*7.1*	1114	*9.2*
Stateless	179	*0.0*	3	*0.0*
Main citizenship				
Romania	378,651	*22.7*	2936	*24.3*
Morocco	174,148	*10.4*	1123	*9.3*
Albania	164,438	*9.8*	1174	*9.7*
Ukraine	101,190	*6.1*	684	*5.7*
China	72,846	*4.4*	373	*3.1*
Moldova	57,520	*3.4*	373	*3.1*
India	52,725	*3.2*	423	*3.5*
Poland	47,434	*2.8*	446	*3.7*
Philippines	46,546	*2.8*	410	*3.4*
Other	573,997	*34.4*	4154	*34.3*

deaths by specific cause are shown in the Supplementary Tables 1a-c and 2a-c, for males and females, respectively. In our cohort, deaths for diseases of the circulatory system, for neoplasms and for external causes of injury and poisoning accounted for 49 %, 19 % and 8 % of deaths, respectively, with a similar share among groups of citizenship, except for external causes, which represented 14 % of deaths of people from HMPCs (8 % among Italians). For males in the Italian group, the association education-mortality and the gradient related to education level were found to be consistent with that observed for overall mortality, with slight differences between groups of causes. For females in the Italian group, a stronger association between education and mortality was found for the diseases of the circulatory system, while no differences by education level were observed in mortality from external causes.

For male HMPC immigrants, no association was found for the diseases of the circulatory system and neoplasms, while a higher mortality for external causes was observed for individuals with a lower education. In female HMPC immigrants, the risk of mortality from diseases of the circulatory system for the least educated was almost double that of those with university degree or more.

3.2. Analysis by area of origin

Figs. 1a and 1b show the results of the multivariate regression models applied to male and female immigrants from HMPCs stratified by area of origin. In this analysis, the association of education level and occupational class with mortality was evaluated, taking into account age class and area of residence in all the models (Model 2). In females from Central and South America, the model with only education level is reported (Model 1) due to lack of convergence of the model with occupational class, caused by too small a number of subjects and outcomes in some categories of occupational class (Fig. 1b).

In males, significantly higher mortality was observed for less educated subjects from Central and Eastern Europe ("elementary school or less" vs "university degree or more" adjMRR = 1.46 $p < 0.001$) and Central West Asia ("elementary school or less" vs "university degree or more" adjMRR = 1.45 $p = 0.016$), while no differences by education level were found for the other geographical areas. Instead, for all the areas of origin, a significant increase in mortality was observed for "inactive" subjects compared to "non-manual workers", whereas no differences were found among the other categories of occupational class.

A higher mortality corresponding to lower education was observed in females from all areas of origin, with the exception of those from East

Table 3a
Results of multivariate regression models for Italians and immigrants from HMPCs. Males.

Characteristics	Deaths		Crude Rate *1000 PY	Model1*			Model2 **		
	N	%		MRR	95 % CI	p-value	MRR	95 % CI	p-value
Italians									
Education level									
Elementary school or less	52,137	*21.4*	9.15	**2.58**	**2.21 - 3.03**	**<0.001**	**2.37**	**2.16 - 2.60**	**<0.001**
Middle school	109,116	*44.8*	3.95	**1.80**	**1.55 - 2.10**	**<0.001**	**1.74**	**1.59 - 1.90**	**<0.001**
High school diploma	66,745	*27.4*	2.45	**1.32**	**1.14 - 1.53**	**<0.001**	**1.31**	**1.20 - 1.44**	**<0.001**
University degree or more	15,407	*6.3*	1.69	1			1		
Occupational class									
Non-manual worker	47,864	*19.7*	1.92				1		
Self-employed	20,549	*8.4*	2.62				1.07	0.97 - 1.17	0.194
Agricultural worker	3703	*1.5*	3.15				**1.17**	**1.05 - 1.31**	**0.004**
Manual worker	60,037	*24.7*	2.73				**1.23**	**1.12 - 1.35**	**<0.001**
Inactive, where info not collected	111,252	*45.7*	8.16				**2.83**	**2.60 - 3.09**	**<0.001**
HMPCs									
Education level									
Elementary school or less	1358	*19.8*	1.42	**1.16**	**1.02 - 1.31**	**0.023**	**1.12**	**1.00 - 1.25**	**0.054**
Middle school	2618	*38.2*	1.13	**1.14**	**1.01 - 1.28**	**0.032**	**1.14**	**1.03 - 1.27**	**0.015**
High school diploma	2356	*34.4*	1.18	**1.15**	**1.02 - 1.29**	**0.023**	**1.16**	**1.04 - 1.29**	**0.007**
University degree or more	519	*7.6*	1.07	1			1		
Occupational class									
Non-manual worker	532	*7.8*	0.92				1		
Self-employed	429	*6.3*	0.96				0.91	0.79 - 1.04	0.154
Agricultural worker	114	*1.7*	1.46				**1.31**	**1.06 - 1.61**	**0.011**
Manual workers	3951	*57.7*	1.06				1.06	0.96 - 1.17	0.289
Inactive, where info not collected	1825	*26.6*	1.99				**1.67**	**1.50 - 1.85**	**<0.001**

* Model 1: adjusted for age classes and area of residence.
** Model 2: same as Model 1 with occupational class.

Table 3b
Results of multivariate regression models for Italians and immigrants from HMPCs. Females.

Characteristics	Deaths		Crude Rate *1000 PY	Model1*			Model2 **		
	N	%		MRR	95 % CI	p-value	MRR	95 % CI	p-value
Italians									
Education level									
Elementary school or less	40,245	*25.9*	4.58	**1.92**	**1.69 - 2.19**	**<0.001**	**1.79**	**1.64 - 1.96**	**<0.001**
Middle school	56,733	*36.5*	2.20	**1.31**	**1.16 - 1.47**	**<0.001**	**1.32**	**1.22 - 1.44**	**<0.001**
High school diploma	44,908	*28.9*	1.51	1.12	0.99 - 1.26	0.067	**1.16**	**1.07 - 1.26**	**<0.001**
University degree or more	13,359	*8.6*	1.07	1			1		
Occupational class									
Non-manual worker	31,897	*20.5*	1.09				1		
Self-employed	4329	*2.8*	1.45				1.07	0.97 - 1.17	0.163
Farmer	873	*0.6*	1.64				0.95	0.84 - 1.07	0.367
Manual worker	14,750	*9.5*	1.51				**1.10**	**1.01 - 1.20**	**0.024**
Inactive	103,396	*66.6*	3.02				**1.86**	**1.73 - 2.00**	**<0.001**
HMPCs									
Education level									
Elementary school or less	981	*18.7*	1.00	**1.19**	**1.06 - 1.35**	**0.005**	**1.12**	**1.00 - 1.26**	**0.051**
Middle school	1719	*32.8*	0.72	1.07	0.96 - 1.20	0.219	1.05	0.95 - 1.17	0.319
High school diploma	1915	*36.5*	0.70	1.03	0.92 - 1.15	0.637	1.03	0.93 - 1.15	0.554
University degree or more	630	*12.0*	0.64	1			1		
Occupational class									
Non-manual worker	857	*16.3*	0.60				1		
Self-employed	75	*1.4*	0.64				1.21	0.94 - 1.53	0.119
Farmer	15	*0.3*	0.68				1.12	0.64 - 1.81	0.659
Manual worker	1559	*29.7*	0.68				1.04	0.94 - 1.15	0.419
Inactive	2739	*52.2*	0.85				**1.48**	**1.35 - 1.62**	**<0.001**

* Model 1: adjusted for age classes and area of residence.
** Model 2: same as Model 1 with occupational class.

Asia and North Africa. For the latter, the association was found in the opposite direction, although it did not reach statistical significance (adjMRR "elementary school or less" vs "university degree or more" = 0.71 $p = 0.064$). Concerning occupational class, no significant differences in mortality were found among categories in subjects from Africa. A higher mortality was observed in "inactive" females (compared to "non-manual workers") from Central and Eastern Europe and Asia.

3.3. Analysis by citizenship

The analysis stratified by citizenship is shown in Figs. 2a and 2b, for males and females, respectively. For each citizenship analysed, the results of the regression model with the occupational class variable (Model 2) are reported when possible based on the convergence of the model, without occupational class variable (Model 1) otherwise. For females (Fig. 2b), the results of Model 1 are presented for all the citizenships.

In males, a strong association between education level and mortality

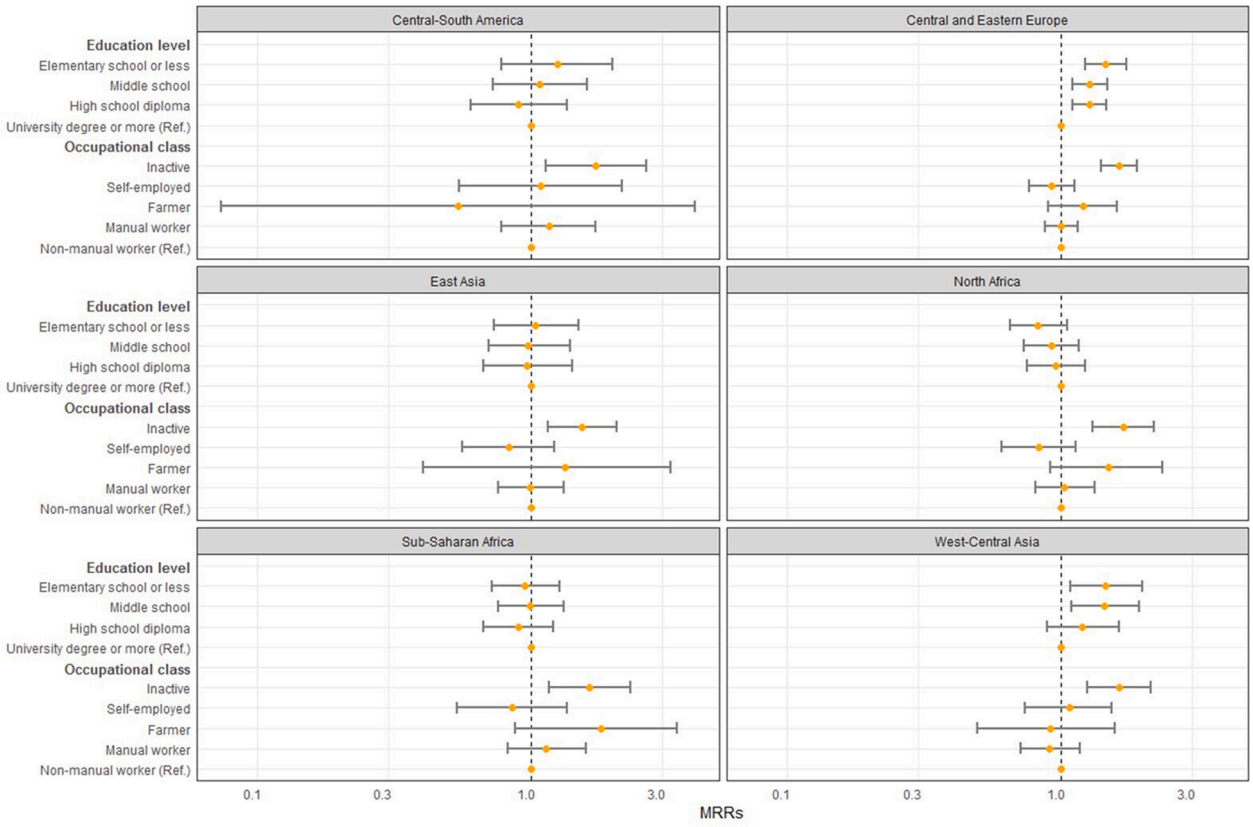

Fig. 1a. Results of multivariate regression models* by area of origin. MRRs displayed on log scale. Males
*Model 2: adjusted for age classes and area of residence, with occupational class.

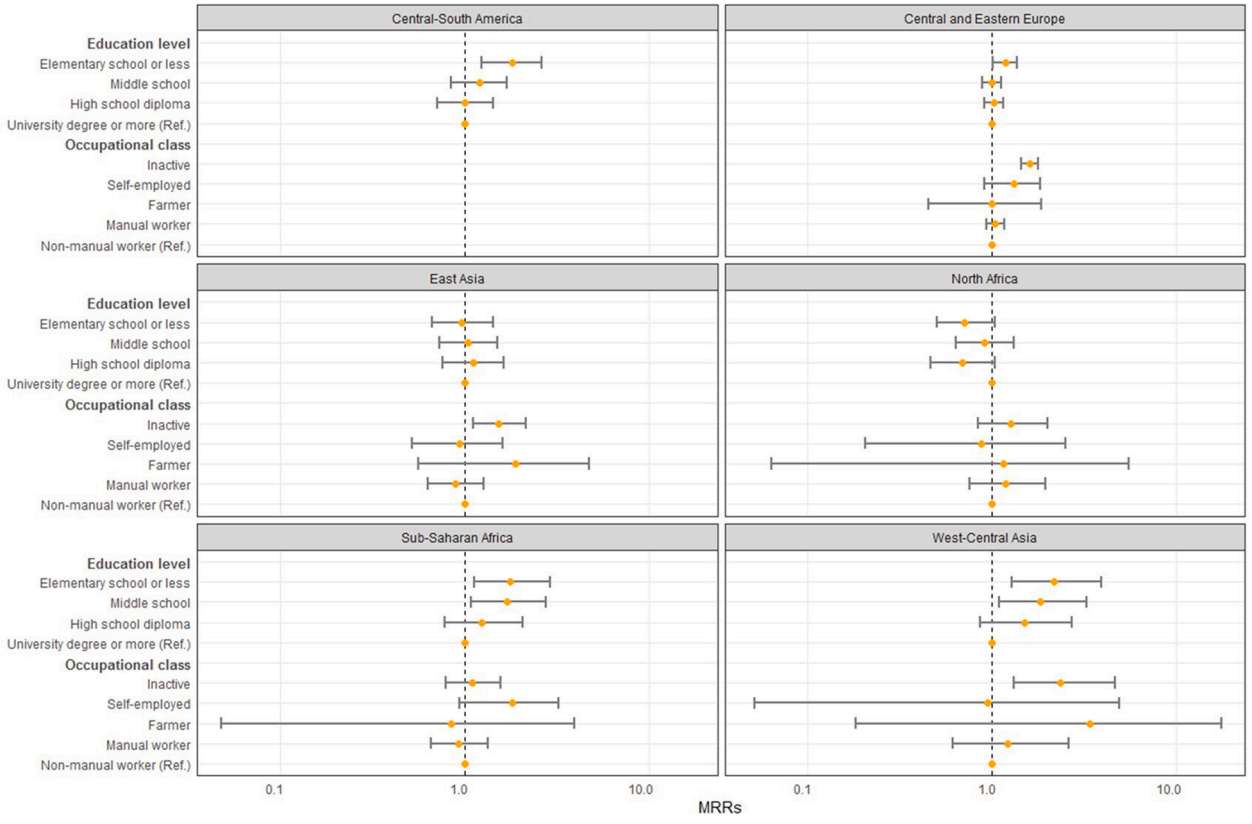

Fig. 1b. Results of multivariate regression models* by area of origin. MRRs displayed on log scale. Females
*Model 2: adjusted for age classes and area of residence, with occupational class. Model 1, for Central-South America: adjusted for age classes and area of residence.

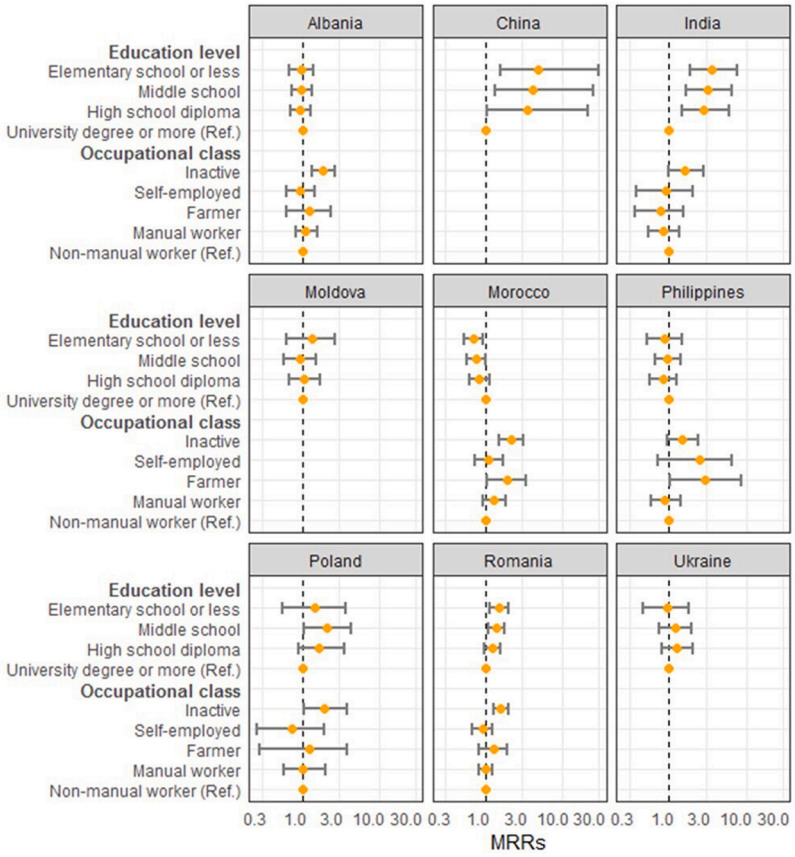

Fig. 2a. Results of multivariate regression models* by citizenship. MRRs displayed on log scale. Males
*Model 2: adjusted for age classes and area of residence, with occupational class. Model 1, for China, Moldova and Ukraine: adjusted for age classes and area of residence.

was found for immigrants from Romania ("elementary school or less" vs "university degree or more" adjMRR = 1.49, $p = 0.007$), China ("elementary school or less" vs "university degree or more" adjMRR = 5.13, $p = 0.022$) and India ("elementary school or less" vs "university degree or more" adjMRR = 3.60, $p < 0.001$). Instead, less educated males from Morocco had lower mortality than the reference group (adjMRR = 0.69, $p = 0.011$). A higher mortality was observed for the "inactive" group compared to "non-manual workers" from all the citizenships.

In females, no association was found between education level and mortality for any citizenship. For immigrants from Morocco, lower mortality was found for less educated females compared to those with "university degree or more" (adjMRR = 0.64, $p = 0.048$).

4. Discussion

This study evaluated the social inequalities, measured through education level and occupational class, in the mortality between Italian and immigrant residents, with a focus on differences among macro areas of origin or specific citizenships.

Our study found a slight excess in mortality for all education levels compared to "university degree or more" among immigrants, whereas a significant gradient of mortality by education level, greater in males than in females, was observed in the Italian population.

The strong inverse gradient between education level and mortality observed for Italians is consistent with European literature (Mackenbach et al., 2019a, 2019b), and is explained by the adoption of harmful behaviours, by a lower access to appropriate health care, such as screening programmes, and to stronger exposure to psychosocial factors. We found a stronger gradient compared to other Italian studies (Petrelli et al., 2018), probably because of the exclution of older people from the study, who generally experience smaller socioeconomic inequalities in health than other age groups.

Our results are consistent with other studies showing a weak education gradient in health among immigrants (Nielsen et al., 2013), although with substantial variability depending on the outcomes and the ethnic group considered (Kimbro et al., 2008; Vable et al., 2018; Khan et al., 2017; Stratton et al., 2012). The slighter gradient in socioeconomic mortality among immigrants could be partly explained by the fact that the "healthy migrant effect'' or the "salmon bias' could be higher among the less educated migrants, resulting in lower socioeconomic inequalities in mortality (Nielsen et al., 2013; Bos et al., 2005). In Italy, the "salmon bias" plays a significant role in explaining immigrant mortality (Di Napoli et al., 2021), and we cannot exclude the possibility of a selection by education level of people involved in these processes, even if this issue cannot be investigated.

Furthermore, the high level of occupational mismatch could at least partly explain the results, because a high percentage of immigrants are overeducated with respect to the educational requirements of their job; education level may therefore be much less indicative of socioeconomic position in the host country for immigrants (Nielsen et al., 2013). This implies that a more integrative view on health disparities between immigrant groups and natives is required, considering the contribution of different indicators of SEP to health differentials among immigrant groups.

The higher risk for less educated people for immigrants from HMPCs was particularly relevant males from Central and Eastern Europe, India and China and for females, except those from North Africa (Morocco) and East Asia. Since these are communities who have lived in Italy for longer, we can hypothesize an emerging acculturation process, resulting

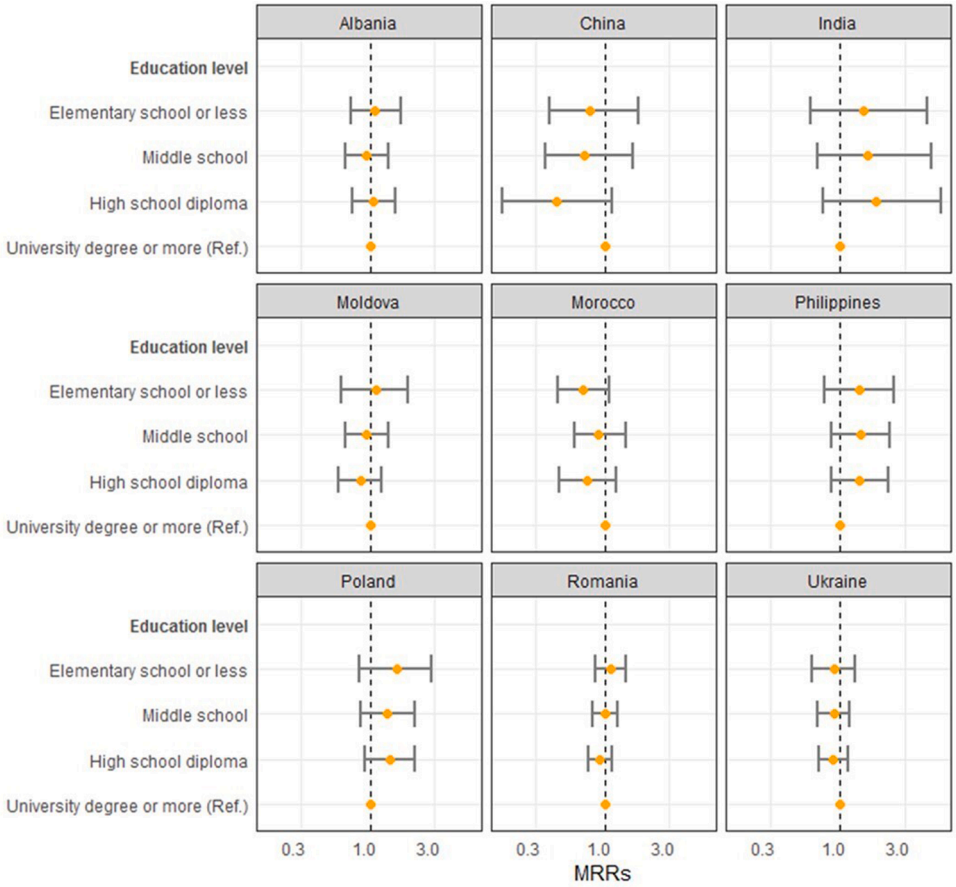

Fig. 2b. Results of multivariate regression models* by citizenship. MRRs displayed on log scale. Females
*Model 1: adjusted for age classes and area of residence.

in a gradient similar to that observed for the Italian population. The other ethnic minority groups are instead relatively recent migrants, and they could have not been in Italy long enough for the socioeconomic gradient to emerge (Agyemang et al., 2010).

The findings concerning immigrants from Morocco suggest the absence of mortality inequalities for this citizenship. For the males specifically, an unexpected protective effect of low education level was found. Although the reason for this finding is unclear, it has been observed that, compared to Italians, immigrants from North Africa of both sexes have very low overall age-adjusted mortality (Di Napoli et al., 2022), which is partly related to the weak association between socioeconomic status and mortality within this group (Bos et al., 2005).

Another important result of our study was the higher risk of mortality for the "inactive" immigrants of both sexes from most of areas of origin. It is known that inactive people present worse health conditions than do active workers (healthy worker effect) (McMichael, 1976). Furthermore, the inactivity status determines an exposure to more vulnerable and deprived living conditions and therefore at a greater risk of worsening health. Moreover, higher mortality was also observed among immigrants working in the agricultural sector. As is well known, underpaid work is widespread in this sector; workers are also very often subjected to particularly strenuous and deprived living and working conditions.

We would like to highlight the result shown in the supplementary analysis regarding cause-specific mortality, with strong differences in cardiovascular mortality unfavourable to less educated people among immigrants from HMPCs, especially among females. Even if the migratory phenomenon increased significantly in Italy at the beginning of the 2000s, and immigrants are generally characterized by better health than Italians, a generalized decline in lifestyles is observed, with an increase in the prevalence of risk factors such as overweight and obesity, becoming higher among immigrants than Italians, an increase in the unhealthy consumption of alcohol and a decrease in the percentage of people who practice physical activity (ISS, 2023; Petrelli et al., 2017a).

Relevant issues should be considered when evaluating socioeconomic differences in health among immigrants.

A general concern refers to how socioeconomic position should be measured when studying immigrants. In fact, to compare the health status of different population groups, the socioeconomic position indicator should have the same construct across population groups and should maintain the same meaning across time (Nielsen et al., 2013). Cumulative effects of socioeconomic factors such as the standard of living, workplace conditions and social networks could result in harming or promoting the individual's health by acting in different ways for different population groups (Krieger et al., 1997; Braveman et al., 2005). The same socioeconomic position may impact immigrants differently than it does the native population; for example, if immigrants have little or no education, this could lead to greater difficulty in learning the language of the host country, a factor strictly linked to poorer jobs and lower income as well as to less appropriate access to health care (Stronks and Kunst, 2009).

In our opinion, this study has considerable strengths.

First, to the best of our knowledge, this is the first study to evaluate socioeconomic differences in mortality between Italians and immigrants from different macro areas of origin or citizenships covering the entire population resident in Italy on the date of the last census.

The longitudinal approach made it possible to avoid any ecological bias and to calculate the exact person-time at risk through a link between individual population records and death registries. Moreover, we can provide a detailed picture of the geographical heterogeneity that takes into account the different areas of origin and citizenships of

immigrants. Finally, the availability of individual information on education level and occupational class allowed us to investigate 2 dimensions of social status.

Nevertheless, our study does have some limitations. Like other studies dealing with mortality among immigrants, our study presents the potential bias of unregistered remigration and deaths of immigrants, which may have determined potential overcoverage and salmon bias. Moreover, our study does not consider irregular immigrants, a particularly vulnerable subpopulation, since our data are based on registers of the resident population. However, the percentage of undocumented immigrants in Italy is estimated to be <1 % of the total resident population (Ismu, 2020). Furthermore, the retrospective design of the cohort does not permit updating baseline information over the follow-up or the analysis of other potential exposures and confounders not collected in the census (Alicandro et al., 2020). This could represent a limitation when studying the relationship between education level and mortality, especially for the younger age groups. Another potential limitation concerns the reliability of the information on education level and on occupation, which could be differential by citizenship or area of origin. The presence of differential misclassification of exposure could lead to a bias in the estimates.

5. Conclusions

Despite a certain heterogeneity among areas or countries of origin, the differences in the association between education level and mortality observed among immigrants were relatively small. Although socioeconomic status is the main risk factor for immigrants' health, the cultural dimension may not be sufficient to capture the impact of social position on the same (Rostila and Fritzell, 2014), in contrast with what has been observed in native populations. In fact, education level, mostly acquired in one's country of origin, may not reflect one's life course, during which many other factors interact with each other in determining the risk of health deterioration, such as employment status, racism and discrimination (Paradies et al., 2015), economic status and living and housing conditions (Nielsen et al., 2013).

As described in a relevant editorial (Nazroo, 2003), in countries such as the United States and the UK, that have a long migration tradition and that are major contributors to the scientific literature on the topic, poverty explains a very high share of the health differences between natives and immigrants. Even a recent Italian study, which analysed the role of different socioeconomic factors on the perceived health of Italians and immigrants, showed that the perception of insufficient economic resources was a strong predictor of poor health among immigrants, whereas no differences were observed by education level (Petrelli, 2017b). Unfortunately, data on individual income are not available for research purposes in Italy, thus excluding the possibility of evaluating a potentially relevant socioeconomic dimension underlying the differences in health among immigrants.

Further knowledge on the effect of this complex set of socioeconomic factors, which may affect immigrant mortality, must therefore be acquired, preferably through studies with a longitudinal design. In particular, the assessment of the magnitude of socioeconomic inequalities among different ethnic groups is crucial to develop culturally tailored prevention policies that aim at improving lifestyle and appropriate access to health care (Bos et al., 2005).

CRediT authorship contribution statement

Martina Ventura: Conceptualization, Data curation, Formal analysis, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. **Alessio Petrelli:** Conceptualization, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing, Project administration. **Anteo Di Napoli:** Conceptualization, Validation, Writing – original draft, Writing – review & editing. **Sara Leone:** Data curation, Formal analysis, Methodology. **Enrico Grande:** Validation, Writing – original draft. **Marilena Pappagallo:** Validation, Writing – original draft. **Luisa Frova:** Conceptualization, Data curation, Project administration, Validation, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jmh.2025.100316.

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