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All-cause and cause-specific mortality attributable to educational inequalities in Spain

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Abstract

Background Socioeconomic inequalities in mortality give key information for public health preventive policies. We aim to assess the magnitude of educational inequalities in cause-specific mortality in Spain (2016-21).

Methods We use mortality register and population exposure data for Spain for individuals aged 35–99 years for 2016-21. These data included information on age, sex, educational attainment, and causes of death. We estimated all-cause and age- and cause-specific mortality attributable to educational inequality (death counts, attributable fractions (AF), and years of life lost (YLL)) by treating the high education group as a counterfactual benchmark.

Results There were 426,449 average annual deaths in Spain in 2016-21, and we estimated 82,815 average annual deaths (42,867 males and 39,948 females) attributable to education inequality (AF of 19.5%). Deaths attributable to inequality were highly concentrated at ages 75 and over, yet the proportion of deaths attributable to educational inequality was higher at young ages (50% and 31% at ages 35–39 for males and females, respectively). Circulatory system causes of death were the leading cause in terms of deaths attributable to inequality in females (16,051 deaths, AF = 25.9%, YLL = 174,195) and the second cause in males (10,542 deaths, AF = 19.2%, YLL = 179,744). Neoplasms were the leading cause of death in males (10,868 deaths, AF = 16.1%, YLL = 230,958) but not in females (1,520 deaths, AF = 3.4%, YLL = 45,011).

Conclusions Educational inequality remains a major public health challenge; its population-level impact on mortality is higher compared to the impact of smoking. Public health interventions addressing gender-specific social determinants of inequalities in health have a great potential for reducing mortality.

Key messages

- Counterfactual scenarios on the extent to which socioeconomic inequality impacts mortality offer an overview of the potential mortality penalties implied by varying aspects of well-being and living conditions across social groups.
- This is the first study to estimate deaths attributable to inequality and years of life lost in Spain, a country with very high life expectancy and relatively low educational inequalities in mortality.

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- Assessing the impact of social dimensions on cause-specific mortality gives essential insights into further mortality gains that might be won on the basis of interventions aiming at improving outcomes among the social determinants of health.
- We show that education is an essential dimension to improve overall population health. Compared with the well-known impact of smoking, in terms of mortality, we show that eliminating educational inequality would have a larger absolute impact on reducing mortality, particularly for women, and mainly due to the relative sizes between age-specific population groups (current smokers vs. low educated) than due to the respective mortality penalties.
- Monitoring and tackling health inequalities should continue to be a high priority not only for reducing inequalities themselves but also to improve overall population health.

Keywords Excess mortality, Inequalities, Premature mortality

Introduction

Mortality inequalities are among the most fundamental social inequalities [1]. Research on socioeconomic inequalities in mortality is key to guiding public health policy [2–5]. A wide range of studies on this topic have either quantified absolute and relative inequalities in all-cause and cause-specific mortality, e.g [2, 5–8]., or estimated the contributions of causes of death to inequalities in mortality or life expectancy inequalities, e.g [4, 9–12]. A narrower and more recent research line has explored counterfactual scenarios and estimated potential deaths that could be avoided if socioeconomic inequalities in mortality were reduced.

Population-attributable fractions (AFs) are used to estimate the proportion of mortality that could be prevented if exposure to a given risk factor were eliminated. Such exercises are widely used in epidemiological research, and the results derived from AFs are relatively intuitive to interpret. Findings estimating the impact of socioeconomic inequality in terms of AFs differ in terms of study settings, definition of socioeconomic dimension, and the number of subgroups. Yet, the available evidence points to an important role of socioeconomic components in mortality. Educational attainment has been widely used as a proxy for socioeconomic status in mortality studies [13]. Educational inequality has been found to account for 35–60% of mortality in South Korea [14], and for 11–16% in the 30–79 year-old Japanese population [15]. In the USA, mortality attributable to low education, defined as having less than a bachelor's degree, ranged between 20 and 39% [16]. Some studies used area-level indicators to assess AFs due to socioeconomic inequalities. For example, in the United Kingdom, it was found that 35% of all premature deaths were due to socioeconomic inequality [17], while estimates for all ages in New Zealand and Belgium were 25% and 28%, respectively [18, 19]. Although the study settings differ, these findings consistently highlight the important role of socioeconomic position in determining mortality. However, it is worth noting that Southern European countries, some of which are longevity frontrunners (e.g. Spain or Italy), are overlooked in such analyses, which can lead to a limited understanding of inequalities in ageing societies.

Spain is particularly interesting as life expectancy is one of the highest in the world [20]. Additionally, life expectancy gaps between high and low-educated groups persist [3, 4, 21–25], spanning 5.5 years for males and 3.0 years for females according to a recent study using data for the period 2016-19 [4], although these educational inequalities are lower than those prevailing in several other European countries [2, 7]. Cause-of-death explanations of these socioeconomic gaps typically find that cardiovascular diseases are the main contributor, albeit with substantial heterogeneity [4]. A comprehensive assessment of the potential role of socioeconomic status in reducing overall and subgroup-specific mortality in Spain would help to understand the impact of socioeconomic gradients on population health outcomes.

In this paper, we assess the magnitude of educational inequalities in mortality in Spain for all-cause and cause-specific mortality for 2016-21. We do this by providing estimates of deaths attributable to educational inequality, their corresponding AFs, and years of life lost (YLL).

Methods

We use sex-, age-, education- and cause-specific death counts and all-cause mortality rates by population subgroups for 2016-21 in Spain from the Spanish National Statistics Institute (INE). These data include information on educational attainment, which was linked by INE from several sources, including municipal population registers ("Padrón") and the 2011 census. We group educational attainment into four groups: primary education or less (ISCED-2011 0–1), lower secondary education (ISCED-2011 2), upper secondary education (ISCED-2011 3), and high education (post-secondary vocational and university education, ISCED-2011 4+).

Causes of death are grouped into 16 main cause groups and 71 detailed causes according to the International Classification of Diseases version 10 (ICD-10) chapters and a previous study [16], see Table S1. We restrict our analyses to adults aged 35 to 99 years, corresponding to a total of 2,558,693 deaths. Younger age groups are excluded because educational attainment is not necessarily complete below age 35, and because death counts are low in younger ages. At the upper end of the age spectrum, educational differences in mortality beyond age 100 years are nearly inexistent and challenging to account for due to open-ended age groups smaller population sizes and potentially lower-quality cause-of-death coding.

We divide all-cause death counts by all-cause mortality rates to estimate the population at risk for each age, sex, year, and education group, which is not directly available from INE. We divide the number of deaths by the population at risk to estimate cause-specific mortality rates.

Our analytic approach consists of several consecutive steps. First, we multiply the mortality rates from the high education group by the population at risk for each subpopulation and cause of death (age, sex, and cause of death) to obtain the counterfactual deaths that would have occurred if everyone had the mortality of the high-education group. Second, we estimate deaths attributable to inequality as the difference between observed and counterfactual deaths. Third, we estimate the attributable fraction (AF) to educational inequality as deaths attributable to inequality divided by observed deaths. Finally, we estimate the number of years of life lost (YLL) by multiplying age-specific deaths attributable to inequality by the sex- and age-specific remaining life expectancy for the high educated group and summing up the results. To obtain more stable patterns by causes of death, we present all results in terms of average annual estimates over the period 2016-21. We estimate the 95% uncertainty intervals in deaths attributable to inequality by assuming a Poisson distribution of deaths attributable to inequality and drawing quantiles from 10,000 deviates. All steps and input data are included as R code in our reproducibility repository (https://osf.io/w39vq/?view_only=5920aed6080142d9b343d4ab967b8d68).

Results

A total of 208,425 average annual female deaths and 218,024 annual male deaths aged 35–99 years old occurred in Spain 2016-21 (Table 1). Our analyses suggest that if all subgroups were exposed to the mortality risks of the higher-educated group, the mortality would be reduced by 39,948 (95%CI: 36,155 – 43,703) deaths for females and 42,867 (39,888 – 45,806) deaths for males, corresponding to fractions of avoidable mortality of 19.2% (17.3–21.0) and 19.7% (18.3–21.0), respectively.

Age patterns

The estimated deaths attributable to educational inequality vary considerably between age groups and educational groups (Figs. 1 and 2). In females, 33,037 annual deaths are estimated to have been in the lowest educated group (83% of the total deaths attributable to inequality), whereas this number is lower in males (24,360 deaths, 57%). As expected, the groups with lower secondary and upper secondary education contributed less. A visual inspection of the age patterns suggested those to be highly concentrated at ages 75–99 for females, whereas the age distribution is more spread for males, representing higher levels of mortality due to educational inequality in younger age groups.

A different picture emerges when looking at the proportion of deaths attributable to educational inequality (AF) by age group: younger age groups had a higher proportion of deaths attributable to inequality (49,6% (45.9–53.2) for males and 31,4% (26.5–36.3) for females aged 35–39), while older age groups had the lowest proportion of deaths attributable to inequality (6,9% (4.1–9.6) for males and 11,7% (9.3–14.0) for females aged 95–99). Differences in these figures between education groups are in the expected direction (i.e., higher deaths among the less educated groups).

Cause-of-death patterns

We present cause-of-death results for the total impact of education, i.e., combining all educational groups. In females, causes of death from the circulatory system led the ranking of observed deaths with over 60,000 annual deaths, followed by neoplasms with nearly 45,000 annual deaths and respiratory system disease with nearly 20,000 annual deaths (Table 2). Circulatory system causes of death also led the ranking of mortality attributable to inequality with 16,051 (14,133 – 17,962) annual deaths and over 170,000 years of life lost, followed by endocrine, respiratory, mental, and genitourinary diseases with over 3,000 annual deaths and over 29,000 years of life lost each. The corresponding AF to education inequality for these causes were all over 15%: circulatory diseases (AF = 25.9% (22.8–29.0)), endocrine diseases (46.3% (38.4–53.9)), mental diseases (25.1% (18.8–31.2)), respiratory diseases

Table 1 Average annual observed and estimated deaths attributable to educational inequality in Spain (ages 35–99), 2016-21*

	Observed deaths (*n*)	Deaths attributable to inequality (*n*)	Attributable Fraction (%)
Females	208,425	39,948	19.2
		(36,155 – 43,703)	(17.3–21.0)
Males	218,024	42,867	19.7
		(39,888 – 45,806)	(18.3–21.0)

* 95% uncertainty intervals are shown within brackets

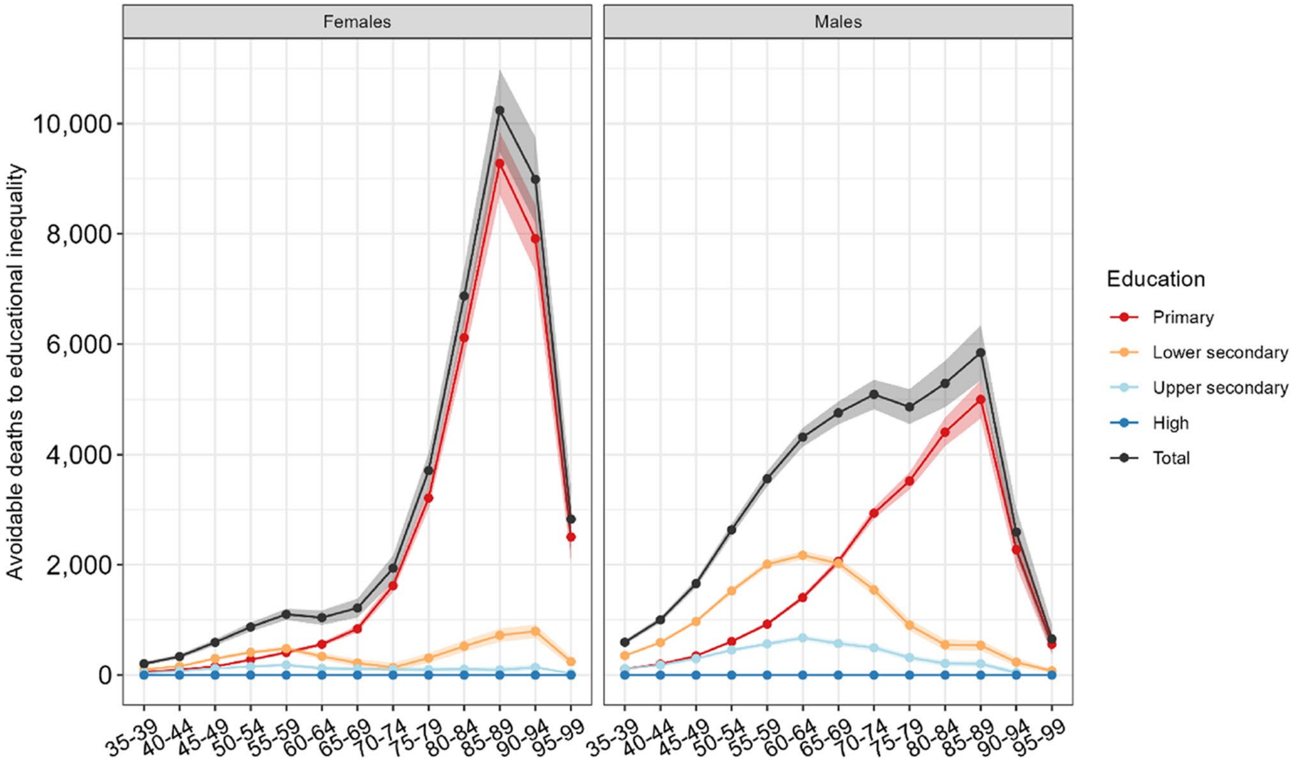

Fig. 1 Annual deaths attributable to educational inequality by sex, age, and educational group in Spain, 2016-21

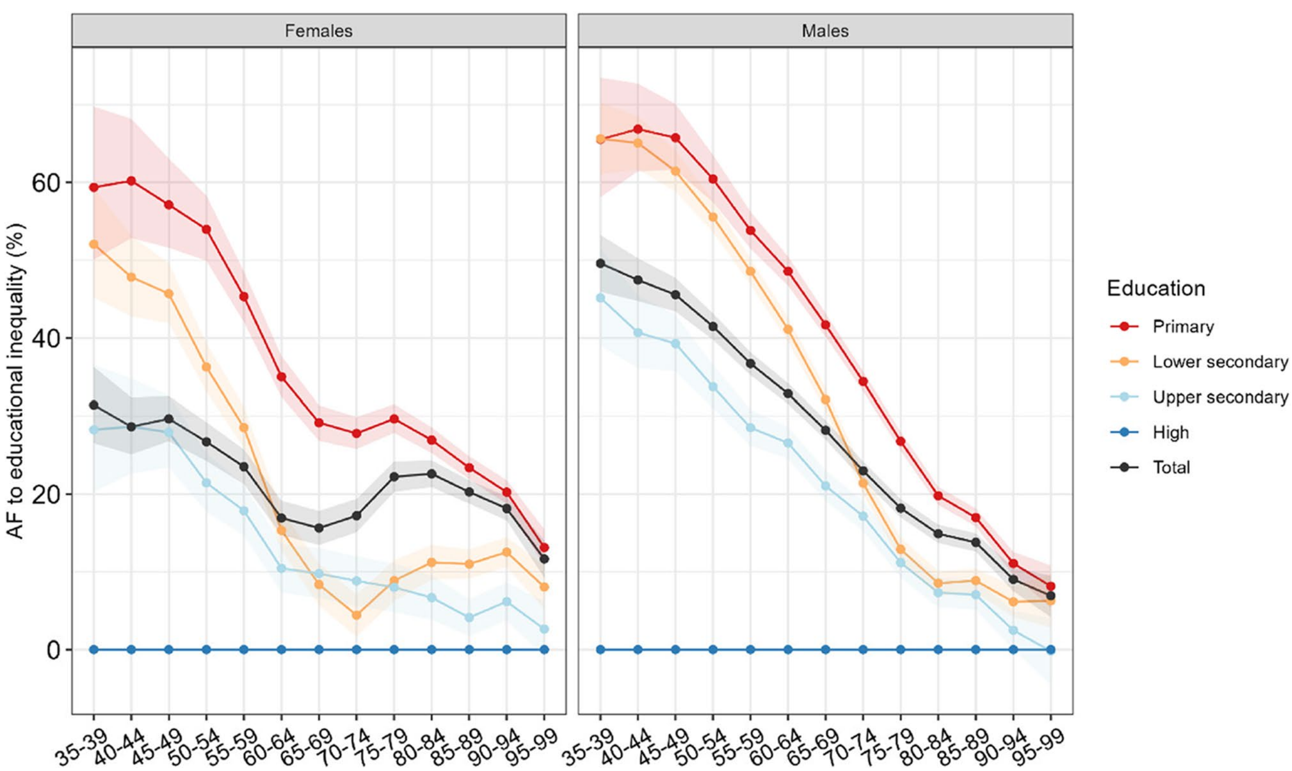

Fig. 2 Attributable fraction (AF, in percentage) of mortality attributable to educational inequality by sex, age, and educational group in Spain, 2016-21

Table 2 Average annual observed and estimated deaths attributable to educational inequality and its contribution to all-cause educational inequality in mortality by sex and cause of death in spain, 2016-21*

Cause of death	Observed deaths (*n*)	Deaths attributable to inequality (*n*)		Attributable Fraction (in %)		Years of Life Lost	
Female							
1. Infectious	3,166	944	(497-1,364)	29.8	(15.7–43.1)	13,420	(7,785 – 18,806)
2. Neoplasms	44,445	1,520	(−343-3,349)	3.4	(−0.8-7.5)	45,011	(14,813 – 75,093)
3. Blood	1,074	215	(−67-473)	20.1	(−6.3-44.0)	2,499	(−824-5,607)
4. Endocrine	7,571	3,504	(2,910-4,084)	46.3	(38.4–53.9)	37,432	(30,637 – 44,034)
5. Mental	13,663	3,428	(2,562-4,261)	25.1	(18.8–31.2)	30,776	(23,291 – 38,090)
6. Nervous	15,556	2,161	(1,110-3,175)	13.9	(7.1–20.4)	29,967	(18,104 – 41,588)
7. Circulatory	61,970	16,051	(14,133 – 17,962)	25.9	(22.8–29.0)	174,195	(152,914 – 195,304)
8. Respiratory	19,763	3,499	(2,347-4,621)	17.7	(11.9–23.4)	42,923	(30,363 – 55,328)
9. Digestive	10,068	2,888	(2,097 – 3,660)	28.7	(20.8–36.4)	40,195	(30,334 – 49,723)
10. Skin	1,116	354	(101–588)	31.7	(9.0-52.7)	3,758	(1,327-5,979)
11. Musculoskeletal	3,204	533	(68–979)	16.6	(2.1–30.6)	6,766	(1,811 – 11,486)
12. Genitourinary	10,475	3,069	(2,290-3,828)	29.3	(21.9–36.5)	31,192	(22,871 – 39,243)
13. Other diseases	250	157	(51–243)	62.9	(20.6–97.4)	4,824	(2,883-6,544)
14. Ill-defined	1,971	293	(−94-652)	14.9	(−4.8-33.1)	4,047	(−484-8,326)
15. External	5,459	982	(339-1,602)	18.0	(6.2–29.4)	18,243	(8,543 – 27,699)
16. Covid-19	8,645	383	(−444-1,190)	4.4	(−5.1-13.8)	12,192	(2,975 – 21,175)
All	208,425	39,948	(36,155 – 43,705)	19.2	(17.3–21.0)	497,336	(448,893 – 545,404)
Males							
Cause of death	**Observed deaths (n)**	**Deaths attributable to inequality (n)**		**AF, (in %)**		**Years of Life Lost**	
1. Infectious	3,062	828	(475-1,163)	27	(15.5-38)	18,281	(13,180-23,254)
2. Neoplasms	67,576	10,868	(9,214-12,500)	16.1	(13.6-18.5)	230,958	(205,900-256,191)
3. Blood	847	102	(-94-289)	12	(-11.1-34.1)	2,059	(-504-4,465)
4. Endocrine	5,971	1,824	(1,370-2,272)	30.6	(22.9-38)	26,254	(20,406-31,974)
5. Mental	7,284	1,714	(1,221-2,196)	23.5	(16.8-30.2)	18,740	(13,978-23,466)
6. Nervous	9,998	662	(8-1,307)	6.6	(0.1-13.1)	17,935	(9,599-26,122)
7. Circulatory	55,000	10,542	(9,057-12,018)	19.2	(16.5-21.9)	179,744	(159,949-199,410)
8. Respiratory	25,391	7,406	(6,470-8,329)	29.2	(25.5-32.8)	95,233	(84,296-106,120)
9. Digestive	11,018	3,572	(2,942-4,188)	32.4	(26.7-38)	68,233	(58,908-77,309)
10. Skin	615	146	(-2-286)	23.8	(-0.3-46.5)	1,822	(138-3,395)
11. Musculoskeletal	1,641	192	(-66-438)	11.7	(-4-26.7)	2,986	(118-5,725)
12. Genitourinary	8,478	1,605	(1,023-2,176)	18.9	(12.1-25.7)	24,859	(17,709-31,891)
13. Other diseases	244	121	(33-200)	49.8	(13.6-82)	3,773	(2,048-5,384)
14. Ill-defined	1,780	445	(170-707)	25	(9.6-39.7)	9,214	(4,973-13,307)
15. External	8,897	2,666	(2,073-3,244)	30	(23.3-36.5)	72,315	(61,361-83,068)
16. Covid-19	10,196	167	(-507-833)	1.6	(-5-8.2)	10,073	(1,481-18,448)
All	218,024	42,867	(39,888-45,806)	19.7	(18.3-21.0)	782,691	(740,998-824,182)

*Minor diseases (codes H, O, P and U–excluding Covid-19- not shown

* 95% uncertainty intervals are shown within brackets

(17.7% (11.0-23.4))) and genitourinary system diseases (29.3% (21.9–36.5)). The AF for neoplasms –the second most common cause of death in terms of overall deaths- was the lowest (3.4% (−0.8-7.5)).

In males, neoplasms were the leading cause of death (around 67,000 annual deaths), followed by circulatory system diseases (around 55,000 annual deaths), and respiratory diseases (more than 25,000 annual deaths). These three causes of death were also the biggest contributors to mortality attributable to inequality, with over 10,000 annual deaths for both neoplasms and circulatory diseases and 7,406 annual deaths for respiratory diseases. The AFs and years of life lost were 16.1% (13.6–18.5) with over 230,000 years for neoplasms, and 19.2% (16.5–21.9) with almost 180,000 years for circulatory diseases.

In supplementary analyses, we restrict the selection to premature deaths (ages 35–74), and we estimate that more than 7,000 female (19.8%) and 23,000 male (31.4%) premature deaths were attributable to educational inequality (Table S2). The composition of these deaths by broad groups of causes of death is led by circulatory causes in females and neoplasms and circulatory causes in males.

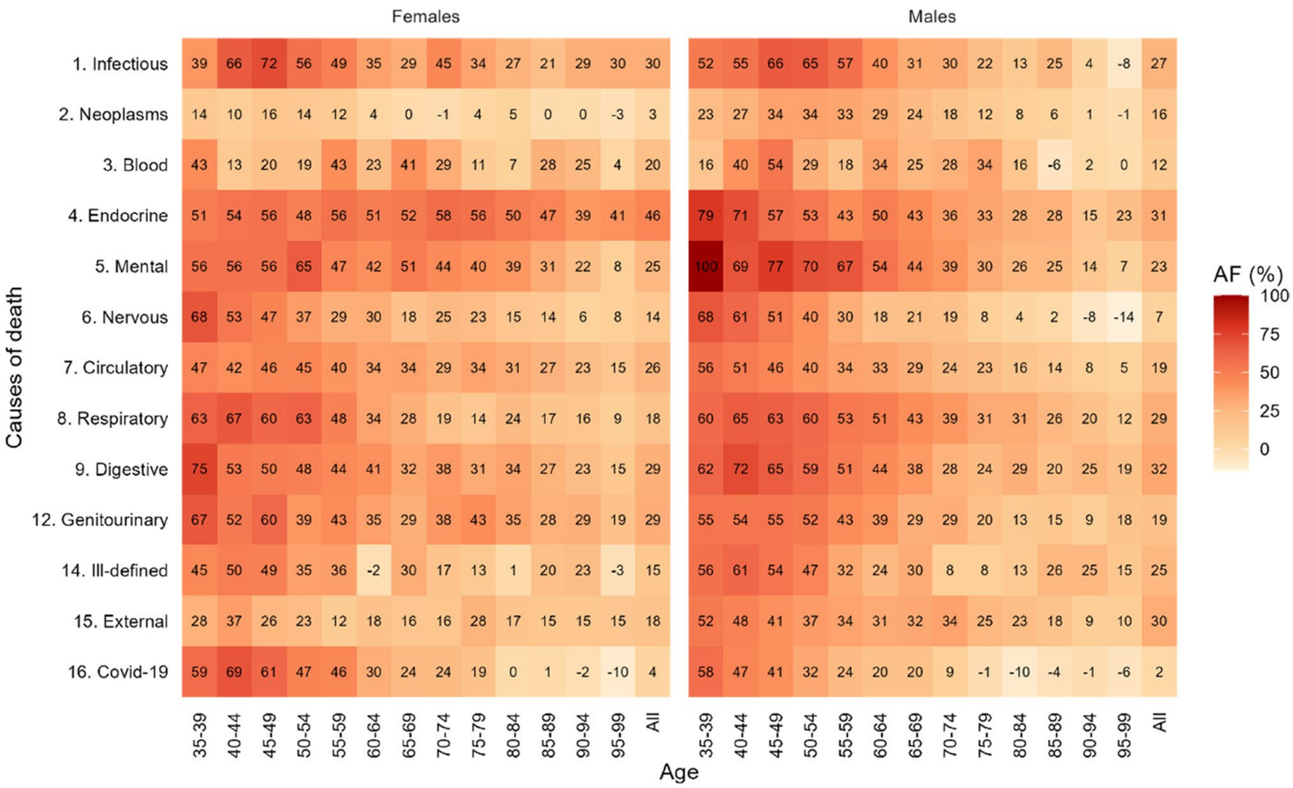

Fig. 3 Attributable fraction (AF) of mortality attributable to educational inequality by sex, age, and major causes of death, ages 35–99, Spain 2016-21. *The categories of skin, musculoskeletal, other diseases, and other minor diseases were not shown due to the low death counts by age groups. AF in males aged 35–39 from mental diseases is not estimated due to the lack of deaths from the highest educated group. Details for these and more detailed cause groupings of deaths can be found in Table S3/Appendix3.

The proportion of deaths attributable to educational inequality varies by age group and tends to decrease with age for most causes (Fig. 3). For example, the AF for digestive disease in women ranges from 75% (ages 35–39) to 15% (ages 95–99), and for endocrine diseases in males, from 79% (35–39) to 15% (90–94). For other causes of death, the age pattern in AF is less pronounced, for example, in females for neoplasms (14% to −3%) or external causes (37–12%).

We present results by more specific causes in Table S3. For some major causes, notable differences between males and females are observed. For example, the AFs to educational inequality for lung cancer were −22% and 23% in females and males, respectively. For other causes, the AFs were closest between males and females, e.g. for all circulatory causes, the AF ranged between 16 and 30%. For dementia and Alzheimer's disease–the two remaining causes with over 10,000 annual deaths- the AFs were in females 25 and 16%, respectively, and in males 21% and 11%.

Discussion

In this study, we estimate the number of deaths, proportions of deaths, and years of life lost attributable to educational inequality using data from Spain. During the study period, there were approximately 420,000 average annual deaths in Spain, of which more than 80,000 were estimated to be attributable to educational inequality (AF = 19,1%). We find important differences between education groups, sexes, age groups, and causes of death. In absolute terms, older groups contributed most to the mortality attributable to educational inequality, while in relative terms, younger age groups had a higher share of deaths attributable to inequality (e.g., 50% in males aged 35–39). This inequality is explained by specific causes of death, led by circulatory diseases in females and by neoplasms and circulatory diseases in males.

Strengths and limitations

Using recent data for the period 2016-21, containing more than 2.5 million deaths, we give details on mortality attributable to educational inequality for broad and granular sets of causes. However, our study relies on an assumption that deserves attention. In our counterfactual, we assume that the whole population would die at the same rate as the highly educated, as has been done similarly in previous studies [14–17]. This is somewhat unrealistic in the short term, but it is possible in the medium term. Such a massive change does not imply population shifts between nominal education groups but rather the elimination of circumstances leading to mortality differences across educational groups. In other words, educational attainment does not necessarily directly kill (or protect) per se, but it is a proxy for or determinant of other variables that are linked to mortality risks (e.g., income, occupation, health behaviours, racism, and myriad others). Our findings are sensitive to the education definitions used: The number and distribution of population and death counts across education groups have a strong impact on the potential number of deaths attributable to inequality. For instance, if we could distinguish more socioeconomic groups, the number of estimated deaths attributable to inequality would tend to increase, and vice versa. Finally, we did not analyse trends over our study period, and we suggest these should be evaluated in further studies.

Comparison and explanation of results

Our results showing that 19% of mortality is attributable to educational inequality are similar to those obtained for the populations of South Korea and the USA [14, 16], but the differences in study settings and educational groupings are a barrier to accurate comparison of estimates. Our estimates of the attributable fractions for ages 35–74 were 19% and 31% for females and males, respectively, and appear to be lower than those derived using area-level socioeconomic indicators in the UK in 2013-18, which found that this explained 33% and 37% [17], respectively, and compared with the Japanese study for ages 30–79, which found that 11–16% of mortality was attributable to educational inequality [15]. Direct comparison of these figures may be misleading due to differences in the choice of socioeconomic variables and groupings, age ranges, group-specific mortality conditions, and population age structures. Yet, our results suggest that in Spain, a country with relatively low (educational) inequalities in mortality [2, 7], the magnitude of these inequalities and the potential for improving mortality at the population level mortality are substantial.

To give a better sense of the magnitudes we report, we translate these results into other intuitive metrics. Estimated mortality due to educational inequality would represent, for instance, the third cause of death for both females and males, with comparable results to those from COVID-19 causes in 2020, which accounted for 16.4% of deaths according to official statistics [26]. Counterfactual remaining life expectancy at age 35 (that of the high education group) would be 52.9 and 48.6 years for females and males, respectively, 1.6 and 5.5 years higher than that observed in 2019 (see Table S4). These life expectancy gaps are equivalent to 10 and 30 years of recent life expectancy progress before the pandemic (2009–2019, and 1989–2019)for females and males, respectively. Additionally, our estimates are higher than those from the COVID-19 pandemic in 2020 [27], mainly due to the younger age profiles for deaths due to education inequality, particularly for males.

Additionally, our results can be put into context by comparing them with estimates of attributable fractions for major risk factors, for instance smoking. According to recent estimates, the AFs of smoking-related mortality were 4.3% and 14.1% in females and males, respectively [28]. These figures contrast with the higher figures (19% for both sexes) we estimate for education, suggesting that reducing educational inequalities in mortality would potentially have a greater beneficial effect on mortality than eliminating smoking-related mortality. Nevertheless, we should acknowledge that the AF difference between smoking and education owes to the relative sizes between age-specific population groups (current smokers vs. low educated) rather than to the relative mortality penalty, which is higher for smoking. Again, although the underlying assumptions used to obtain these estimates are strong and both factors tend to be correlated, these figures help contextualize the large impact of educational inequalities on mortality in Spain.

The detailed cause-of-death information we use in this study allows us to discuss potential health determinants. Cardiovascular causes accounted for an important number of deaths due to inequality for both males and females and were led by ischaemic heart disease and stroke. Although both males and females have relatively similar estimates of mortality attributable to educational inequality, important differences in age patterns and causes of death exist. For females, deaths attributable to inequality occurred at older ages and were led by cardiovascular diseases both in terms of deaths and years of life lost, while male deaths tended to occur at relatively younger ages, and there was more variability in the leading causes (neoplasms and circulatory causes accounted for 56% of all deaths attributable to inequality). Beyond cardiovascular causes, deaths attributable to inequality among females were dominated by Alzheimer's disease (1,800 annual deaths) and other dementias (3,350 annual deaths), genitourinary diseases (over 3,000 annual deaths), and due to diabetes, were dominant (see Table S3). A glance at the cause-of-death contributions to the observed AF reveals these to be largely considered amenable to healthcare or avoidable through primary intervention (e.g. lung cancer, diabetes, hypertensive heart disease, and ischemic heart disease), highlighting the significance of socioeconomic inequality for reducing mortality.

For males, the figures for Alzheimer's disease, other dementias, and genitourinary diseases were less than half the estimates compared to those for females, which is consistent with evidence of sex differences in the prevalence of dementia [29]. On the other hand, male educational gradient is important for causes that are related to smoking behavior: lung cancer or chronic lung diseases, as well as liver diseases and external causes of death (Table S3). Beyond smoking, the magnitude of the described socioeconomic inequalities in mortality suggests that lower socioeconomic classes are exposed to additional risks. Well-established cardiovascular risk factors, such as the prevalence of obesity, hypertension, diabetes, or high blood cholesterol in blood, are among the mechanisms through which socioeconomic gradients exist [30]. In both absolute terms and in attributable fraction terms, hypertension and diabetes have a greater impact on females compared to males. Other mechanisms that may discriminate more against lower socioeconomic groups include food choices, housing quality or health care [3], although their quantification is beyond the scope of this study. Overall, the differential impact of well-established risk factors between males and females seems to be explained by the different composition of mortality, as the differences between males and females in these main factors disappear when focusing on premature mortality (see Table S3).

The AF age patterns, higher at young ages, discernable in Fig. 2 merit some speculation. First, the decreasing pattern over age is driven entirely by the underlying pattern of relative risk (see Figure S1). Second, education outcomes partly depend on health [31], which has the effect of increasing relative risk, and by extension AF, in younger ages. This pattern is seen more broadly over a range of *acquired* health conditions or social statuses, where interactions between socioeconomic status and health are postulated as key drivers [32, 33]. Third, we also know that health selection in the low-education group is increasing over time [34]), such that the age pattern we see could be partly driven by cohort patterns. The health conditions that might co-determine education outcomes and later contribute to elevated younger-age AFs are themselves, to a large degree, socially determined and therefore are indirectly accounted for within our counterfactual.

The rapid educational expansion of the Spanish society in recent decades suggests that, in absolute numbers (i.e. deaths attributable to inequality), the inequalities described in this paper are unlikely to be increasing, and that absolute sex differences seem to be decreasing. That is, the observed and expected changes in the educational composition of the Spanish population [35] are favourable for further reducing absolute educational inequalities and sex differences. However, unhealthy lifestyles among young generations remain a major concern for current and future health dynamics. For instance, several studies have demonstrated the social importance and its impact on the adoption of lifestyles by adolescents, such as binge drinking [36], or the increase in the prevalence of obesity [37, 38], which is associated with parental education and social deprivation [39, 40]. Life course approaches accounting for understanding the role of (cumulative) risk factors and lifestyle exposures and interactions on health outcomes have great potential to influence mid- and long-term population health and mortality outcomes [41]. Further studies should monitor unhealthy lifestyles in younger generations and the impact they may have on current and future all-cause mortality and mortality inequalities.

Education is one of many social determinants of health, and we have shown its power to be substantial in examining socioeconomic inequalities in Spain, in line with findings from previous studies focusing on other countries [14–16]. Our results imply that interventions that shift the education distribution upward represent an indirect form of prevention for various causes of death. Yet, we acknowledge that the potential health effects of further educational shifts may be more important in the mid- and long-term. Similar mechanisms should be expected for any socially equitable intervention, including those that do not contemplate health as an outcome, as has been the case for contemporary educational expansion. Increases in social equality, a goal that is valuable in itself, also act to improve population health and contribute to overall mortality reduction. In the short term, policy interventions improving access and quality of public health care or strengthening the social security system may contribute to narrowing socioeconomic health gaps.

Conclusions

We highlight the role of educational inequality in cause-specific mortality in Spain. In a population undergoing decreasing absolute inequalities and increasing relative inequalities in mortality, we show that education is a key social dimension for reducing inequalities in population health. Even if challenging in the short run, the population-level differences associated with educational attainment would have a substantial impact on preventing mortality. Monitoring and tackling health inequalities and unhealthy behaviors should continue to be a high priority to reduce inequalities and improve population health overall.

Abbreviations

AFs Attributable fractions
INE National Institute of Statistics (Instituto Nacional de Estadistica)
YLL Years of life Lost

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-23661-9.

Supplementary Material 1.

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Authors' contributions
STL: Conceptualization, formal analysis, investigation, methodology, writing - original draft, writing - review and editing, funding acquisition. TR: Investigation, methodology, writing - review and editingUM: Conceptualization, writing - review and editing.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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